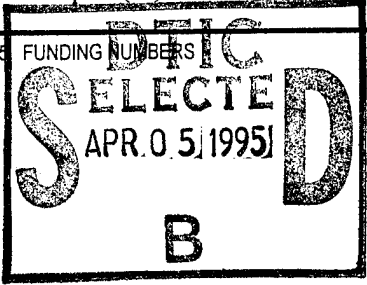


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INSTALLATION RESTORATION PROGRAM

FINAL SITE INVESTIGATION REPORT

181ST FIGHTER GROUP
INDIANA AIR NATIONAL GUARD
HULMAN MUNICIPAL AIRPORT
TERRE HAUTE, INDIANA

VOLUME I

JANUARY 1995



HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
Environmental Restoration and Waste Management Programs
Oak Ridge, Tennessee 37831-7606
managed by MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the U.S. DEPARTMENT OF ENERGY under contract DE-AC05-84OR21400

AIR NATIONAL GUARD
INSTALLATION RESTORATION PROGRAM

FINAL

SITE INVESTIGATION REPORT

VOLUME I

181st Fighter Group
INDIANA AIR NATIONAL GUARD
Hulman MAP
Terre Haute, IN
Task Order Authorization No. Y-01
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Submitted to:

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January 1995

SITE INVESTIGATION REPORT

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LIST OF ACRONYMS AND ABBREVIATIONS

ARARS	Applicable or Relevant and Appropriate Requirements
ANG	Air National Guard
ANGRC	Air National Guard Readiness Center
AWQC	Ambient Water Quality Criteria
base	Hulman 181st Fighter Group Indiana Air National Guard
BKGD	Background
bgs	below ground surface
BTEX	Benzene, Toluene, Ethylene or Xylenes
BCE	Base Civil Engineering
CAA	Clean Air Act
Capt.	Captain
CE	Civil Engineer
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code Federal Regulations
CLP	Contract Laboratory Program
cm/sec	Centimeters Per Second
CWA	Clean Water Act
DD	Decision Document
DDD	dichlorodiphenyldichloroethane
DDE	1,1-dichloro-2,2-bis-(p-chlorophenyl)ethylene
DDT	dichlorodiphenyltrichloroethane
DOD	Department of Defense
DOE	Department of Energy
Dupl.	Duplicate
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
FS	Feasibility Study
FFS	Focused Feasibility Study
ft	Feet
g/mole	Grams Per Mole
gpm	Gallons Per Minute
GW	Groundwater
H	Henry's Law Constant
GC	Gas Chromatograph
HAS	Hazard Assessment Score
HMTC	Hazardous Materials Technical Center
HAZWAP	Hazardous Waste Remedial Actions Program
HEAST	Health Effects Assessment Summary Tables
HM/HW	Hazardous Materials/Hazardous Waste
IAC	Indiana Administrative Code

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

IANG	Indiana Air National Guard
ID	Identification
IDEM	Indiana Department of Environmental Management
IRP	Installation Restoration Program
IRIS	Integrated Risk Information System
JP-4	Jet Fuel
K	Hydraulic Conductivity
MAP	Municipal Airport
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Levels Goal
M&E	Metcalf & Eddy
mg/L	Milligrams Per Liter
MOGAS	Automotive Gasoline
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MSL	Mean Sea Level
MW	Molecular Weight
NA	Not Analyzed
ND	Not Detected
NM	Not Measured
OVA	Organic Vapor Analyzer
Pet.	Petroleum
ppb	Parts per billion
ppm	Parts per million
PA	Preliminary Assessment
PD-680	Stoddard Solvent
PAH	Polyaromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
POL	Petroleum, Oil, and Lubricants
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
R	Rejected
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
RM	Remedial Measures
REPTD	Reported
SARA	SuperFund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SI	Site Investigation

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

SOV	Soil Organic Vapor
SOW	Statement of Work
SW	Surface Water
TDS	Total Dissolved Solids
FG	Fighter Group
TCLP	Toxicity Characteristic Leaching Procedure
TSCA	Toxic Substance Control Act
TSDF	Treatment Storage Disposal Facility
TPH	Total Petroleum Hydrocarbons
$\mu\text{g/kg}$	Microgram Per Kilogram
UST	Underground Storage Tank
VOA	Volatile Organic Analysis
VOCs	Volatile Organic Compounds
WP	Work Plan

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EXECUTIVE SUMMARY

A Site Investigation (SI) was conducted as part of the Installation Restoration Program (IRP) for the 181st Fighter Group of the Indiana Air National Guard, Hulman Field Municipal Airport (MAP), Terre Haute, IN. The SI was conducted in accordance with the SI Work Plan and the SI Sampling and Analysis Plan of September 1990.

The Preliminary Assessment (PA) of the IRP recommended further evaluation of four sites at the base that were potential sources of environmental contamination. Following the SI kickoff meeting in September 1989, a fifth site was also included. Following the PA, Site 3 was recommended for no further work and was not included in the SI.

The purpose of the SI was to obtain data to confirm the presence or absence of environmental contamination at each site, to perform limited quantification of contamination if it was found, and to assess resulting human health and environmental risks. Data at each site were sufficient to support recommendations for either a remedial investigation (RI), feasibility study (FS), focused feasibility study (FFS), interim remedial measures (RM), or a decision document (DD) that would support no further action.

Site investigation activities have been divided into two separate categories: screening activities and confirmatory activities. Screening activities include soil organic vapor (SOV) surveys, and piezometer installation. Confirmatory activities include boring and monitoring well installation and sampling. The objectives of the screening activities were to obtain data that indicated the presence or absence of environmental contamination and obtain water level data. The results of the screening activities were used to implement the confirmatory activities. The primary objectives of the confirmatory activities were to obtain data that assessed the presence or absence of environmental contamination.

Upon approval of the Final Work Plan and Sampling and Analysis Plan on September 17, 1990, SI field work began. Site Investigation field activities included the following: soil gas surveys, piezometer and monitoring well installation, soil boring drilling, and the collection of groundwater, surface soil, boring soil, sediment, and surface water samples from September 17 to November 29, 1990. A second round of groundwater samples were collected, as well as, additional surface soils at Site 6 in January 1992.

Generally, base-wide geology consists of a brown loess overlying sandy clays which overly glacial till. A dense till was encountered at fourteen to eighteen feet below ground surface. The till is believed to act as an aquitard or confining layer.

Groundwater at the base generally flows to the southwest. However, localized flow may vary at Site 4 to the north-northeast and at Site 6 to the south-southeast, south-southwest and southeast. During Round 1 groundwater sampling, MW5-02 was downgradient of Site 5 and Site 6 and during Round 2, MW6-03 was downgradient of Site 5 and Site 6.

A well inventory was conducted using information gathered from the Indiana Department of Environmental Management (IDEM), Division of Water. Twenty-eight water wells are located within 2 miles of the base with eight wells within one mile of the base. One well identified by IDEM as Well No. 530 is within a one mile radius and downgradient of the base. This well was sampled due to its use until 1990 as a potable water supply by Hulman ANG personnel at the base Ammunition Area. Public water became available in this area in 1991 following construction activity. The groundwater samples from this well collected during Rounds 1 and 2 showed no evidence of contamination. However, it should be noted that according to IDEM Water Well records, this well was drilled to a depth of 54 feet. During drilling activities of the Site Investigation, glacial till which may act as an aquitard was encountered at depths from fourteen to eighteen feet below ground surface. The Site Investigation monitoring wells were drilled to a depth of less than 20 feet. Therefore, Well 530 may be screened in a different geologic strata.

Base-wide contaminants were primarily found in sediments and soils. Phthalate esters, phenolic compounds, polyaromatic hydrocarbons (PAHs), metals, and total petroleum hydrocarbons (TPHs) were detected. Groundwater contamination consisted predominantly of metals. Both filtered and unfiltered groundwater samples were collected at Sites 1, 5 and 6 for metals analysis. Elevated concentrations of metals were consistently found in unfiltered groundwater samples relative to filtered groundwater samples.

Present use of the base is non-residential and future residential use is not expected. Workers involved in periodic excavation activities are expected to be the maximally exposed population.

At Site 1, volatile organic compounds and polyaromatic hydrocarbon (PAH) compounds were detected in surface soils and sediments, which may be associated with past base activities. Maximum soil concentrations for some volatile organics and metals and all of the semivolatile organics exceeded background concentrations. Promulgated MCLs and MCLGs were exceeded for pentachlorophenol and bis(2 ethyl hexyl)phthalate, and beryllium, nickel, and lead in unfiltered groundwater in Round 1 and nickel and lead in Round 2. There were no exceedences in filtered groundwater. However, groundwater beneath and west of the base including Well 530 is not used as a potable water supply. In addition, no adverse non-carcinogenic health effects are expected from worker exposure to Site 1 soils and the cancer risk estimate is below the U.S. EPA target range. Thus, no further action is recommended.

At Site 2, volatile organics and PAH compounds were detected in soils that may be attributed to site activities. Maximum soil concentrations for some volatile organics and all of the semivolatile organics exceeded background concentrations. No federal or state MCLs were exceeded for groundwater. No adverse non-carcinogenic health effects are expected from worker exposure to Site 2 soils and the cancer risk estimate from this exposure is below the U.S. EPA target range. Thus, no further action is recommended.

At Site 4, volatile organic compounds, PAHs, and petroleum hydrocarbons were detected in soils and sediments which may be attributed to base activities. Maximum soil concentrations for all volatile and semivolatile organics exceeded background concentrations. Groundwater and surface water contamination was not evident to the southwest or northeast. However, it appears that the groundwater flow direction from the site may vary from flowing toward the northeast to toward the southwest. Therefore, during the second round, groundwater samples were collected from MW4-05 and also Piezometer 4. No groundwater contamination was detected in either sampling round. No adverse non-carcinogenic health effects are expected from worker exposure to Site 4 soils and the cancer risk estimate from this exposure is below the U.S. EPA target range. Thus, no further action is recommended.

At Site 5, phthalate esters, PAH compounds and metals were detected in soils. Maximum soil concentrations for some volatile organics and metals and all of the semivolatile organics, Aroclor-1260, and petroleum hydrocarbons exceeded background concentrations. No standards were exceeded by metal concentrations detected in filtered groundwater. Promulgated federal and state MCLs and MCLGs were exceeded for chromium, nickel, and lead in unfiltered groundwater. Groundwater is not used at the base for drinking water. No adverse noncarcinogenic health effects are expected from exposure to Site 5 soils and the cancer risk estimate is within the U.S. EPA target range. Thus, no further action is recommended.

At Site 6 during Round 1, soils and sediments were characterized by the presence of phthalate esters, PAH compounds, volatile organic compounds and metals. In addition, high concentrations of alkanes were found. This trend was apparent at all depths sampled, however, surface soils indicated the highest concentration of contaminants. During Round 2, the areal extent of surface soil contamination was more fully characterized and concentrations were generally lower than Round 1. Maximum soil concentrations for all of the volatile organics, semivolatile organics, and petroleum hydrocarbons and the majority of pesticides/PCB's and metals exceeded background concentrations. Site contamination was not reflected in the downgradient monitoring wells MW6-03 or MW5-02. During Rounds 1 and 2, no standards

were exceeded by metal concentrations in filtered groundwater. In Round 1, promulgated federal and state MCLs and federal MCLGs were exceeded for nickel and lead in unfiltered groundwater in MW6-03 and lead, chromium, and nickel in unfiltered groundwater in MW5-02. In Round 2, lead exceeded the federal and state MCL and federal MCLG in MW6-03 for unfiltered groundwater. Based on the available data, no adverse non-carcinogenic health effects are expected from worker exposure to Site 6 soils and the cancer risk estimate from this exposure is within the U.S. EPA target range. Although adverse health effects to employees are not expected and downgradient groundwater contamination from Site 6 was not evident, some contaminants were detected in surface and near surface soils. Therefore, since Site 6 is an area of high foot traffic and to further protect human health, it is recommended that the grassy area bordering building 1 to the north and east be covered with concrete. This concrete cover will serve to help mitigate the potential for future transport of contaminants to subsurface soils and groundwater from surface runoff.

Of the five sites investigated, only Site 6 has been recommended for further action.

1.0 INTRODUCTION

The Air National Guard (ANG) has engaged in a wide variety of operations that require the use of industrial chemicals and other hazardous materials. In recognition of potential public health and environmental impacts resulting from these operations, the U.S. Department of Defense (DOD) has implemented a remediation program called the Installation Restoration Program (IRP) to evaluate suspected problems associated with past hazardous waste disposal and spill sites at DOD facilities. The IRP focuses on identifying and cleaning up contamination from past hazardous waste disposal practices and other past activities at military installations.

As part of the IRP, the Air National Guard Readiness Center (ANGRC) has entered into an interagency agreement with the U.S. Department of Energy (DOE) under which DOE provides technical assistance. Martin Marietta Energy Systems, Inc., the DOE operating contractor for the Oak Ridge facilities, is responsible for managing this effort under the interagency agreement through its Hazardous Waste Remedial Actions Program (HAZWRAP) Division.

The ANGRC specifically has requested the support of DOE in assessing the extent of contamination at the following five sites at the 181st Fighter Group (FG), Hulman Field MAP, Terre Haute, Indiana (the base):

- Site 1 - Power Suppressor Pad
- Site 2 - Abandoned Petroleum, Oil, and Lubricants (POL) Stand
- Site 4 - Old Bladder Area
- Site 5 - Vehicle Maintenance Building
- Site 6 - Hangar Building No. 1

Metcalf & Eddy (M&E) has conducted Site Investigation (SI) activities at the base through an existing general order agreement with HAZWRAP.

The general extent and nature of activities conducted at the base was determined from the Preliminary Assessment (PA) report, from discussions held during the September 1989 SI kickoff meeting with representatives from the ANGRC, HAZWRAP, the base, and M&E, and from review of information obtained during that meeting. The information acquired during the meeting included:

- Base maps and aerial photographs
- Subsurface soil and groundwater data collected prior to construction of above ground tanks for the storage of JP-4 in the Old Bladder Area
- Conversations with Base Civil Engineering (BCE) personnel
- IRP Organic Chemical Compounds and Analytical Methods document prepared by the Air National Guard Support Center

The Preliminary Assessment (PA), which the Hazardous Materials Technical Center (HMTTC) completed in December 1987, indicated that the potential existed for contamination of soils, groundwater, surface water, and sediments at the sites under investigation (HMTTC, 1987). The PA report recommended further IRP investigation for Sites 1, 2, 4 and 5.

Site 3, the base supply warehouse may have been considered a potential site since a gasoline leak had occurred on the west side of building no. 3 in 1980. However, the leak was contained almost immediately, and the affected pavement area and underlying soil were subsequently removed. In addition, soil samples collected in the area indicated no contamination. As part of the PA, no further IRP work was recommended. A Decision Document was prepared for Site 3 by ANGRC recommending no further action.

At Site 6, hazardous waste solvents and oils have been stored. Therefore, following a site visit and discussions with BCE personnel, Site 6 was also included in the Site Investigation.

1.1 PURPOSE OF REPORT

The overall objective of the ANGRC Installation Restoration Program (IRP) is to identify and remedy environmental contamination at Air National Guard (ANG) installations. The SI segment confirms and characterizes the presence or absence of potential contamination at hazardous waste disposal and spill sites and evaluates the public health and environmental impacts from the contamination at these sites.

The specific objectives of the SI conducted at the base were to:

- Collect sufficient field data to evaluate the presence or absence of contamination at each of the following sites:
 - Site 1 - Power Suppressor Pad
 - Site 2 - Abandoned POL Stand
 - Site 4 - Old Bladder Area
 - Site 5 - Vehicle Maintenance Building
 - Site 6 - Hangar Building No. 1
- Evaluate the potential human health and environmental risk posed by verified contamination.
- Recommend further evaluation and remedial actions or generate a decision document for no further action.

To accomplish the objectives of this investigation:

- Background conditions were established
- Soil gas surveys were conducted around Sites 1, 2, 4, 5, and 6 to define potential source areas
- Piezometers were installed to verify the groundwater flow direction
- Soil borings were drilled and surface and subsurface soils were collected in potential source areas identified by the soil gas surveys for each site to characterize possible soil contamination

- Surface water and sediment samples were collected to characterize possible runoff
- Monitoring wells were installed outside the source areas to determine potential downgradient groundwater contamination
- A second round of groundwater samples and surface soil were collected for confirmation purposes

Upon completion of the field investigation for each site the data obtained was analyzed to ensure their adequacy to support a recommendation for one of the following alternatives:

- Decision Document - Take no further action or initiate long term monitoring
- Complete a focused feasibility study/remedial measures (FFS/RM)
- Immediate Removal - initiate preparation of engineering plans and specifications for removal of the contamination
- Remedial Investigation/Feasibility Study (RI/FS)

If contamination was not present at a site, a decision document for no further action will be developed. This document summarizes data and information obtained during various investigations, including the SI, and provides the technical approach to field efforts. In addition, the document provides conclusions and recommendations and may support a decision of no further action and subsequent removal of a site from further consideration under the IRP. For sites where contamination has been confirmed, further studies [i.e., Remedial Investigations and Focused Feasibility Studies] will be performed to determine the extent of contamination and to gather sufficient characterization information to develop and evaluate possible remedial responses. Further studies are beyond the scope of this effort and, if necessary, will be addressed in a subsequent work plan.

1.2 REPORT ORGANIZATION

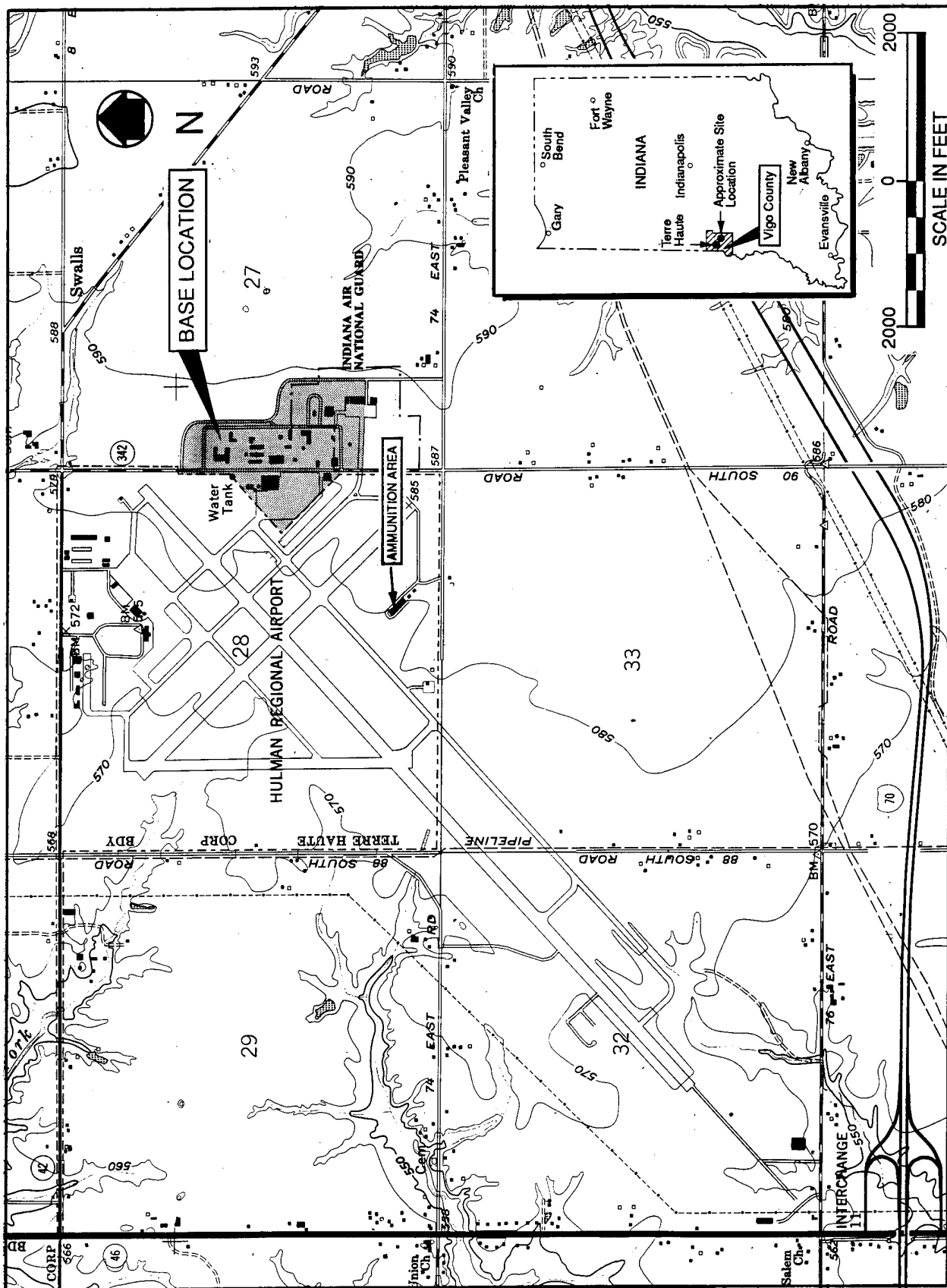
The Site Investigation report is organized into five sections:

- Introduction
- Field Program
- Significance of Results
- Preliminary Risk Evaluation
- Summary and Conclusions

The Introduction outlines the facility background and regional information on the environmental and cultural settings, geology and hydrogeology, as well as background concentrations of compounds. The Field Program section presents approaches taken during various field activities: geologic and hydrogeologic investigations, field screening activities, sampling activities, background sampling, and field waste disposal activities. The significance of Results section provides both the presentation of background and geologic and hydrogeologic conditions and sampling results, data gaps, and an overall discussion for each site. Based on these results, the Preliminary Risk Evaluation for each site identifies and characterizes any possible exposures and the resulting risk of health effects. The Summary and Conclusions section summarizes the findings and discusses data limitations, recommendations for future work, and decision documents if necessary.

1.3 FACILITY BACKGROUND

The 181st Fighter Group (FG) Indiana Air National Guard (ANG) is located at Hulman Field, approximately three miles east of the city of Terre Haute, in Vigo County, Indiana. The base, which is situated 585 feet above mean sea level (MSL), consists of approximately 57 acres designated for exclusive use by the 181st FG. The runways, adjacent to the base, are used jointly with the Hulman Regional Airport. Figure 1-1 illustrates the base property evaluated during the Site Investigation.



SOURCE: USGS TOPOGRAPHIC MAP
SEELYVILLE, IND. 1963.
PHOTOREVISED 1986.

FIGURE 1-1. BASE LOCATION MAP
181ST FG, HULMAN FIELD MAP, TERRE HAUTE, IN

1.3.1 Site Descriptions and Histories

A description of each of the five sites under investigation at the base are presented below. Much of the information was taken from the 1987 Preliminary Assessment (PA) Records Search (HMTC, 1987). The location of each site is presented in Figure 1-2.

1.3.1.1 Site 1 - Power Suppressor Pad (HAS-53). Site 1 is located at the south end of base property adjacent to the Air National Guard taxiway. A below ground oil/water separator tank had been installed at this site in the late 1950s and was used until 1976. While no longer used as a separator, the full tank was left in place. Sometime after 1976, it was reported that a leak occurred in the 500-gallon underground waste oil storage tank which contained waste oil, JP-4, hydraulic fluid, detergent, and solvent. The oil/water separator was removed in 1986, but the amount of waste remaining at the site is unknown. The PA report assigned the Power Suppressor Pad a Hazard Assessment Score (HAS) of 53.

1.3.1.2 Site 2 - Abandoned Petroleum, Oil, and Lubricant (POL) Stand (HAS-53). Site 2 is located in the middle of the base, south of building no. 3. It was formerly used as a storage and transfer area for POL products. Four 25,000 gallon capacity tanks were installed at the site in the 1950s. The tanks remain in place and are located near the ground surface and extend 15-20 feet below ground. In 1987, the four underground storage tanks (USTs) were removed from service. They were filled with water after they were abandoned. In the PA (HMTC, 1987) it was reported that about 5,000 gallons of JP-4 leaked onto the frozen ground in the winter of 1979 and was subsequently all recovered. There have also been other JP-4 spills at the site over the years. Spill control and cleanup measures during these incidents were minimal. The PA report assigned this abandoned POL site a HAS of 53.

1.3.1.3 Site 4 - Old Bladder Area (HAS-53). Site 4, located on the east side of the base, is known as the Pillow Farm or the Old Bladder Area. It is a flat grassy parcel of land 160 feet by 80 feet which was surrounded by an earthen dike about 2 feet high. The area was constructed in 1963 or 1964 to enclose five 50,000-gallon JP-4 storage bladders. These bladders

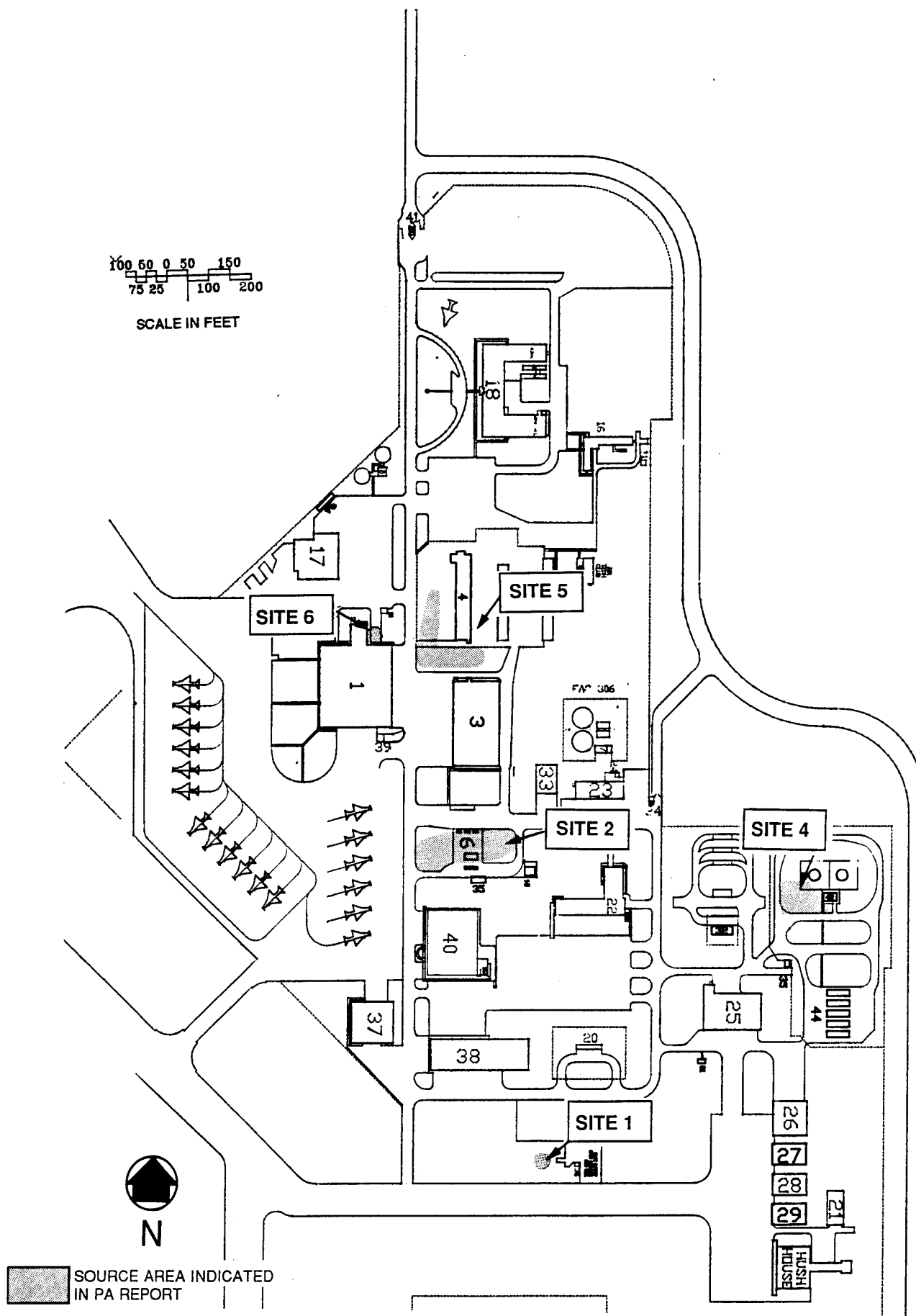


FIGURE 1-2. SITE LOCATIONS
181ST FG, HULMAN MAP, TERRE HAUTE, IN

provided a ready source of fuel for the aircraft housed within the alert barns located at the southeast corner of the base. In 1967 or 1968, the fuel bladders were removed. No fuel spills were ever reported to have occurred at the Old Bladder Area, prior to removal of the fuel bladders.

In March 1978, mixed water and fuel was observed in the bottom 4-1/2 feet of an underground 25,000-gallon JP-4 storage tank at Site 2, located to the west of the Old Bladder Area. In order to inspect this tank, 10,000 gallons of a JP-4 and water mixture were pumped from the tank into the diked area at the Old Bladder Area (Site 4). Because the ground surface within the dike was not level, ponding of the mixture occurred within the southwest corner. This mixture remained within the diked area for approximately 48 hours until a licensed hazardous waste disposal firm arrived, skimmed the floating JP-4 off the water within the dike, and disposed of it at a location off-base.

In the PA report (HMTTC, 1987) it was estimated that the 10,000 gallons held within the diked areas, consisted of 2,500 gallons of water and 7,500 gallons of JP-4. The report also indicated that approximately 90 percent of the JP-4 was recovered, and 750 gallons may have percolated into the underlying soil. The PA report (HMTTC, 1987) assigned the Old Bladder Area an HAS of 53.

In 1986, a Remedial Action (RA) study was performed by HMTTC. Contamination of soil and groundwater by oil and grease was identified. Results are presented in Appendix H. The study concluded that the construction of two above ground tanks mounted on a concrete pad proposed for the area, would effectively cap the site and prevent leachate from forming and migrating from the area.

In 1988, two above ground tanks were constructed on a concrete pad within the Old Bladder Area. During construction, the earthen berm was removed. The tanks, which store JP-4 are located on a concrete base that is bordered with a three foot secondary containment wall. While the RA study indicated that the concrete pad for the tanks would effectively cap the site, it is not

clear whether the entire area, identified in the PA as contaminated by oil and grease, is covered by the pad.

1.3.1.4 Site 5 - Vehicle Maintenance Area (HAS-56). Site 5 is defined by an area to the west, south, and east of building no. 4. There is no visible evidence of hazardous materials/hazardous waste (HM/HW) spills in the area. The PA report (HMTTC, 1987) states that small quantities (usually less than one quart) of waste oils, paint thinners and solvents had occasionally been disposed of in the site area. The wastes were from routine maintenance and clean-up activities conducted at the vehicle maintenance area.

This method of disposal was ceased in 1975. It was estimated that prior activities resulted in less than 1,000 gallons of dumped materials in the area. The PA report (HMTTC, 1987) assigned this Vehicle Maintenance Area Site a HAS of 56.

An underground oil/water separator, extensive buried utilities and an underground motor gas storage tank are all located within the site boundaries.

1.3.1.5 Site 6 - Hangar Building No. 1 (Unscored). Site 6 is located on the west side of the base, near the firehouse and north of the aircraft parking apron. The PA report (HMTTC, 1987) stated that until 1980, most hazardous waste generated by the base was stored at this site prior to collection by a local contractor. No HM/HW spills were recorded and no HAS was assigned.

During the site visit by M&E in September 1989, it was discovered that recently, temporary storage of waste solvents, fuel, and oils had occurred at Site 6 (HMTTC, 1987). An above ground tank, containing PD-680 (Stoddard solvent) for onsite use, was located in this area. Drums containing waste oils, paint stripper, contaminated fuel, waste solvents, and deicing fluid had been stored on pallets in this area. Based on these observations, Site 6 was included in the SI.

1.4 PREVIOUS PROGRAM ACTIVITIES

A Preliminary Assessment (PA) was performed by HMTTC for the Hulman ANG Base in 1987. This effort was largely a records search intended to focus work on the most probable areas of contamination. This work directly preceded the present Site Investigation.

1.5 REGIONAL INVESTIGATION AREA

The base is located in west-central Indiana in Vigo County.

1.5.1 Environmental and Cultural Setting

The base is situated approximately three miles east of the city of Terre Haute, IN. Adjacent land use is primarily agricultural and residential.

The climate in the area is midcontinental. Temperatures generally are high from June through September and coldest in January. Precipitation is moderately heavy and averages 39.44 inches annually.

Most of the drinking water used by Terre Haute and the surrounding communities is from deep wells and the Wabash River. On the base and west of the base, residents use municipal water derived from the Wabash River, while east of the base residents rely on private wells for drinking water.

1.5.1.1 Geographic Setting. The physical and cultural geography are discussed below.

1.5.1.1.1 Physical Geography. Hulman ANG Base is located in Vigo County within the Wabash Lowland physiographic province of west-central Indiana. The Wabash Lowlands are characterized by low relief in comparison with surrounding areas, extensive alluvial plains, and valleys. The prominent physiographic feature in the area is the Wabash River Valley, which is

approximately five to six miles wide and extends the entire length of western Vigo County. The county is predominantly drained by the Wabash River and its tributaries (Cable et al., 1971). The base lies approximately seven miles east of the Wabash River.

The base topography is nearly level with elevation ranging from 580 feet above mean sea level (MSL) on the west to 590 feet MSL on the east. Tributaries to the north and south of the base drain to the Wabash River and those to the southeast of the base drain to the Eel River in neighboring Clay County.

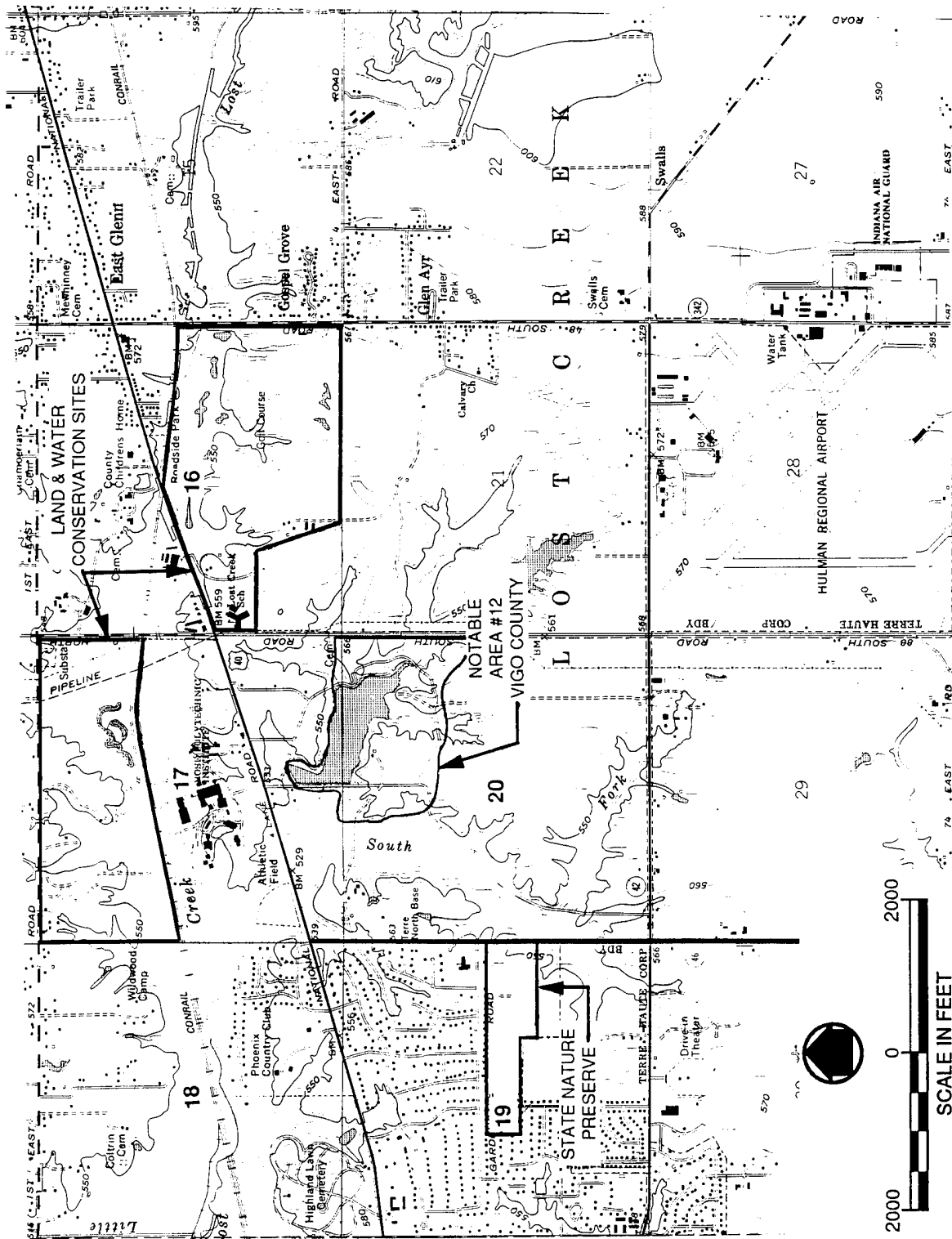
1.5.1.1.2 Cultural Geography. The base is located three miles east of Terre Haute in Vigo County. Vigo County is in the extreme west central part of Indiana and covers an area of 265,000 acres. The land on which the base and the adjoining airport are located is zoned as an open space district, meaning the area can be used for a variety of agricultural, grazing, residential, community, and transportation uses. Surrounding property is not zoned. Approximately 80 percent of the land is classified as farmland (Hartke et al., 1983). Forest and pastures comprise nearly one-fourth of the farmland. Major cash crops in Vigo County include the following: corn, soybeans, small grains and grain sorghum (Montgomery, 1974). Urban areas comprise approximately 10 percent of land-use in the county.

1.5.1.2 Biology and Ecology. As part of the SI, endangered species and environmental sensitive areas in the vicinity were investigated.

1.5.1.2.1 Endangered Species. There is no record of endangered, threatened, or rare species in the vicinity of the base according to information obtained from the Indiana Natural Heritage Program.

1.5.1.2.2 Environmentally Sensitive Areas. According to the Indiana National Heritage Program, the nearest sensitive areas are as follows (Figure 1-3):

- Two federal land and water conservation areas located north of the base in Sections 16 & 17



SOURCE: INDIANA DEPARTMENT
OF NATURAL RESOURCES

FIGURE 1-3. ENVIRONMENTALLY SENSITIVE
AREAS IN THE VICINITY OF HULMAN ANG BASE
181ST FG, HULMAN FIELD MAP, TERRE HAUTE, IN

- The John G. Dobbs Memorial Nature Preserve, located west of the base in Section 19
- A high quality natural area located west of the base in Section 20

1.5.1.3 Climatology and Meteorology. The climate of Vigo County varies on a seasonal as well as annual basis. Air masses with vastly different characteristics impact the Terre Haute area due to it's location near the center of the North America. During the summer months, the Vigo County area is dominated by maritime tropical air from the Gulf of Mexico. Continental polar air from central and northern Canada dominate Vigo County weather in the winter. Data concerning temperature, precipitation, relative humidity, and wind for the Terre Haute area are presented in Table 1-1.

The year-round average maximum daily temperature is 85°F, while the average minimum temperature is 17°F. The mean annual temperature is 53°F. The warmest month typically is July and the coldest is January. Frosts can occur as early as October 14 and as late as April 20.

The water equivalent of 39.44 inches of precipitation falls in the Terre Haute area yearly. June and July are the wettest months and February is normally the driest. Snowfall averages about 19 inches per year. Tornadoes and violent thunderstorms are common due to the frequent changes of air masses occurring in the central United States. The relative humidity in the Terre Haute area is highest in the early morning and a considerably lower by early afternoon year-round. Relative humidity shifts seasonally with the highest humidity occurring in the winter months.

In general, the winds in the Terre Haute area predominate from the south at an average of about nine miles per hour. A secondary wind direction is westerly during the winter months. It should also be noted that the mixing height varies on a diurnal as well as seasonal basis. Mixing

TABLE 1-1. CLIMATE DATA FOR THE 181st FG HULMAN FIELD MAP, TERRE HAUTE, IN

MONTH	MEAN DAILY TEMPERATURE (F)		PRECIPITATION								WIND		MEAN RELATIVE HUMIDITY (%)	
			MEAN SNOW--				TOTAL PRECIP SNOW							
	MAX	MIN	TOTAL (in)	FALL (in)	MONTHLY (in)	MAX MONTHLY (in)	> 0.05 in. (days)	> 1.5 in. (days)	THUNDER-STORM (days)	DIRECTION	SPEED (MPH)	0400	1300	
JANUARY	37	21	2.64	5	10.66	2	1	1	1	W	10.4	83	70	
FEBRUARY	43	25	2.36	3	5.14	2	1	1	1	W	10.4	82	67	
MARCH	52	32	3.76	4	11.03	2	1	3	3	S	10.4	82	62	
APRIL	64	43	3.84	1	10.57	3	0	5	5	S	11.5	82	56	
MAY	75	53	4.15	0	11.94	3	0	7	7	S	9.2	85	54	
JUNE	83	62	4.08	0	12.16	3	0	8	8	SSW	8.1	87	55	
JULY	87	66	3.12	0	12.58	3	0	8	8	SSW	6.9	87	53	
AUGUST	86	64	3.24	0	10.03	2	0	6	6	SSW	6.9	90	54	
SEPTEMBER	79	55	3.65	0	21.36	2	0	4	4	S	6.9	87	51	
OCTOBER	69	45	2.68	0	8.85	2	0	2	2	S	8.1	85	51	
NOVEMBER	52	33	3.07	2	7.62	2	1	1	1	S	9.2	83	63	
DECEMBER	41	25	2.85	4	10.48	2	1	1	1	S	9.2	83	70	
ANNUAL	64	44	39.44	19		28	5	47		S	8.93	84.7	58.8	

Source: Air Force Climatological Data obtained from Chief Morgan, (ANG, 1991),
Air National Guard, 5 February 1991.

heights are typically higher in the summer than in the winter, but both seasons have a high potential for air pollution episodes.

1.5.1.4 Cultural Resources. The historic and archaeological sensitivity at the area in the vicinity of or on Hulman Field is evaluated below to determine the potential impacts of activities in the area. Prehistoric archaeological sensitivity is based primarily on environmental and locational characteristics as well as the presence of nearby known or recorded prehistoric sites. Archaeological sensitivity for historic period resources is generally identified on the basis of known or recorded sites; evidence from documents such as historical maps or deeds; or surface evidence of sites such as surface scatters of artifacts, structures, or features such as cellar holes.

Two archaeological investigations have been made which identified a total of four archaeological sites within one mile of the base (Figure 1-4). For each of these sites, the site form abstracts (Table 1-2) present known characteristics, preliminary evaluations, and recommendations by Glenn A. Black Laboratories of Archaeology at Indiana University.

Many unrecorded archaeological resources may lie within one mile of the base. Archaeological research in Vigo County indicates that the area has probably been occupied for 12,000 years. Several areas of Vigo County and adjacent counties environmentally similar to the base have been studied and produced archaeological site densities ranging from 0.9 to 2.8 archaeological sites per 10 acre area. A number of the documented sites near the base but outside the one mile radius are known to be associated with cultural deposits (such as mounds, middens, human burials, preserved features of various prehistoric cultures, or structural remains of the Pioneer era) that establish their archaeological significance. Based on the density of archaeological sites in the region, it is estimated that previously undisturbed areas within a mile of the base (approximately 1,415 acres) will contain about 127 undocumented sites, rendering the area one with high archaeological potential.

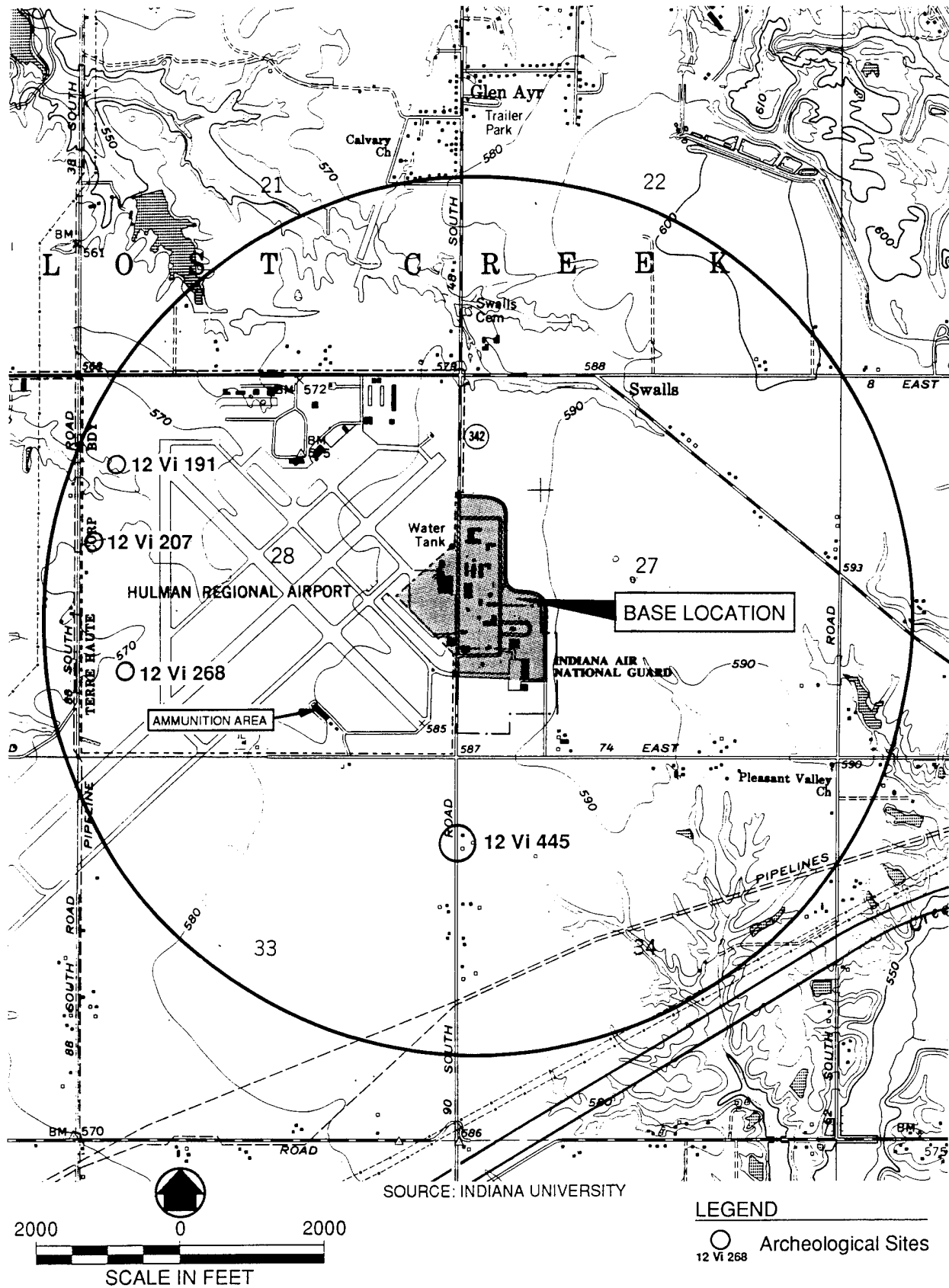


FIGURE 1-4. LOCATION OF ARCHEOLOGICAL SITES
WITHIN ONE MILE OF HULMAN FIELD
181ST FG, HULMAN FIELD MAP, TERRE HAUTE, IN

Table 1-2. ARCHAEOLOGICAL SITE INFORMATION ABSTRACT

SITE DESIGNATION (2)	12 vi 191	12 vi 207	12 vi 268	12 vi 445
TYPE OF SOIL	Camp site	Camp site and refuse scatter	Historic refuse scatter	Historic farmstead
CULTURAL AFFILIATION	Unknown pre-historic	Unknown pre-historic and historic Euro-American	Historic Euro-American	Historic Euro-American
DATES SURVEYED	August 13, 1985	August 13, 1985	August 13, 1985	March 7, 1986
SITE SIZE	20 x 40 ft.	40 x 60 ft.	50 x 80 ft.	1.5 acres
DENSITY OF ARTIFACTS	Light scatter	Light scatter	Light scatter	Unknown
LAND USE	Agriculture	Agriculture	Agriculture	Agriculture
ARTIFACTS	1 Pitted anvil stone 1 Piece of fire cracked	1 Secondary chert flake 1 Historic glass doorknob 1 Historic earthenware rim sherd	1 Porcelain sherd 1 Earthenware sherd Numerous brick fragments Numerous clinkers	None

Source: Black Laboratory of Archaeology at Indiana University.

(2) Refer to Figure 1-5.

1.5.2 Regional Geology and Hydrogeology

Regional geology and hydrogeology in the vicinity of the base are described in the following sections and are summarized in Table 1-3.

1.5.2.1 Geology. The geologic setting, bedrock geology, surficial geology and natural resources of Vigo County are presented in the following sections.

1.5.2.1.1 Geologic Setting. The regional geology in Vigo County can be broadly characterized as unconsolidated glacial and wind blown sediments deposited on Pennsylvanian age bedrock strata. The uplands west and southwest of the Wabash River approximate the furthest advance of the Wisconsin Ice during the Pleistocene. During the retreat of the ice sheets, glacial tills were deposited on the exposed bedrock. After the glacial tills were in place, wind blown sediments (loess) were deposited.

1.5.2.1.2 Bedrock Geology. Vigo County is underlain by Pennsylvanian age sedimentary rocks; consisting of a 700 to 850 foot thick sequence of shale, siltstone, and sandstone; which dip slightly to the west-southwest (Figure 1-5). Limestone and coal are also present but in somewhat smaller amounts. The Pennsylvanian sequence is underlain by older Paleozoic units which rest on a granitic Precambrian basement complex at a depth of approximately 8,000 feet in Vigo County (Hartke et al., 1983).

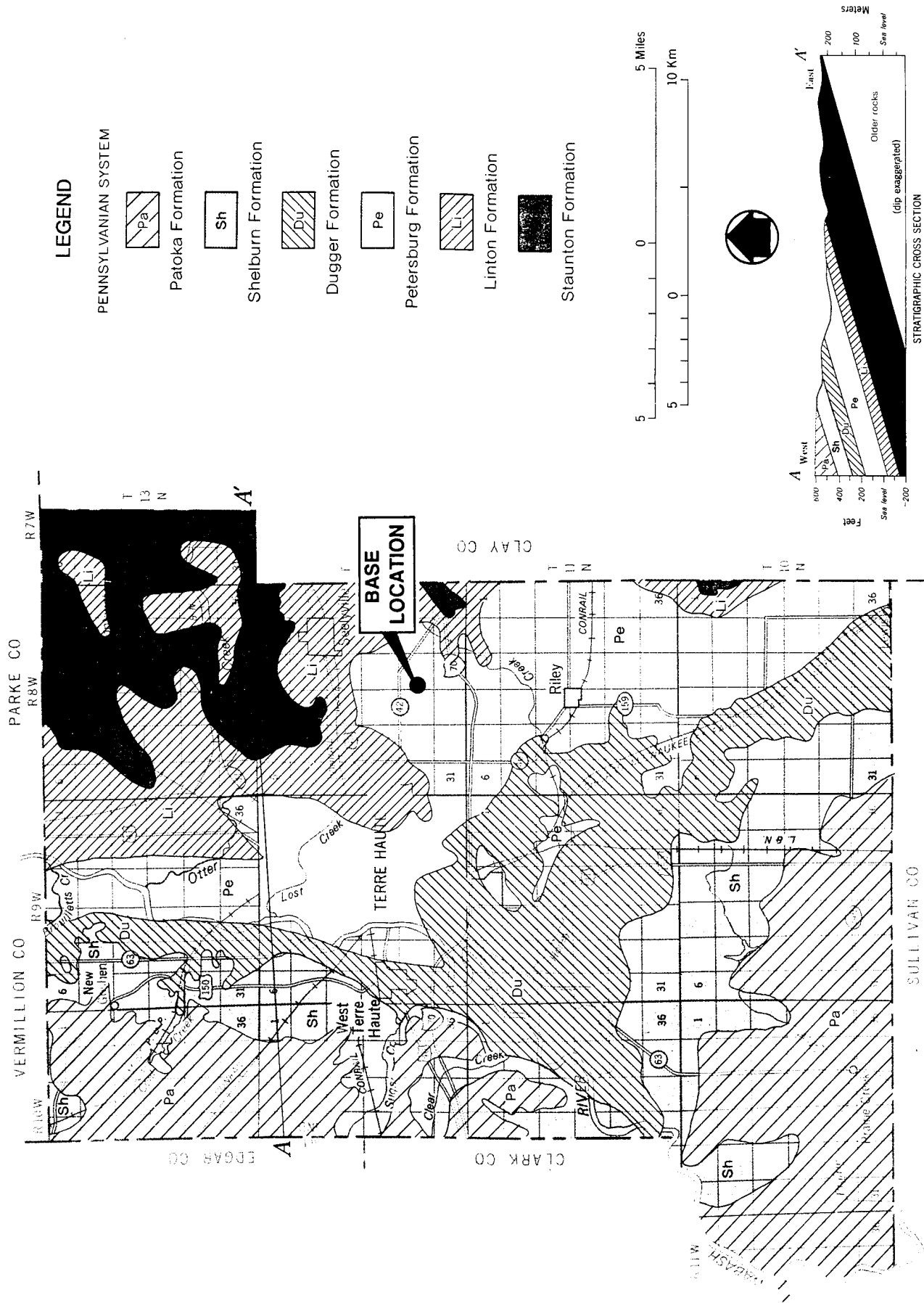
The Petersburg Formation is the bedrock unit that directly underlies Hulman ANG Base. This formation consists of an upper shale member and a lower fine- to medium-grained massive sandstone (Cable et al., 1971). Depth to bedrock in the vicinity of the base ranges from 50 to 75 feet.

1.5.2.1.3 Surficial Geology. Landforms in Vigo County have been modified by glacial activities and consist of floodplains, terraces and uplands. Alluvium forms the floodplains while valley train deposits form the terraces. These materials were deposited by meltwaters flowing

**TABLE 1-3
GENERALIZED STRATIGRAPHIC SECTION AND HYDROLOGIC PROPERTIES
OF VIGO COUNTY**

System	Series	Deposits or Formation	Important Aquifer(s)	Average yield of wells (gpm)	Estimated field coefficient of permeability	Estimated total amount of water in storage in millions of gallons	Estimated uses (mgd)	Potential production considered adequate for:	Quality of Water
Quaternary	Recent	Alluvium	Unconfined Sand and Gravel	660	1,200	367,000	21.4	Large industrial and municipal supplies	Usually very hard and deficient in fluoride. Excessive iron common
	Pleistocene	Glacial	Confined	25	550	370	.8	Moderately large industrial and municipal supplies	
Pennsylvanian	Upper Pennsylvanian	Patoka (of local usage)	None						Shallow water usually similar to that in Quaternary rocks. At depth, water usually soft, frequently high in fluoride, and has higher concentrations of bicarbonate, total dissolved solids and chloride. Excessive iron common at all depths
		Shelburn	Sandstone Unit 6	3.2	23	34			
		Dugger	Sandstone Unit 5*	-----	-----	42			
		Petersburg	Sandstone Unit 4	5	4	52			
	Middle Pennsylvanian	Linton	Sandstone Unit 3	8	14	44	1.8	Domestic, farm, small industrial and small municipal supplies	
		Staunton	None						
		Brazil	None						
			Sandstone						
		Mansfield		7.6	11	264			
	Lower Pennsylvanian		Unit 1	9.4	12	87			
Mississippian	Chester (?)		None						Insufficient data

*No hydrologic data available.
SOURCE: CABLE ET AL, 1971



SOURCE: HARTKE ET AL, 1983

FIGURE 1-5. BEDROCK GEOLOGY OF VIGO COUNTY, INDIANA

from retreating glaciers. The uplands consist of glacial till which was deposited directly by glacial ice. A layer of loess (windblown material) covers much of the area, especially the till upland east of the Wabash River. Figure 1-6 is a map of the surficial geology of Vigo County (Hartke et al., 1983).

In the vicinity of Hulman ANG Base, the upland consists of unconsolidated pre-Wisconsinan glacial till which thins southward and is overlain by Wisconsinan loess. At the base these unconsolidated sediments are 50 to 75 feet thick.

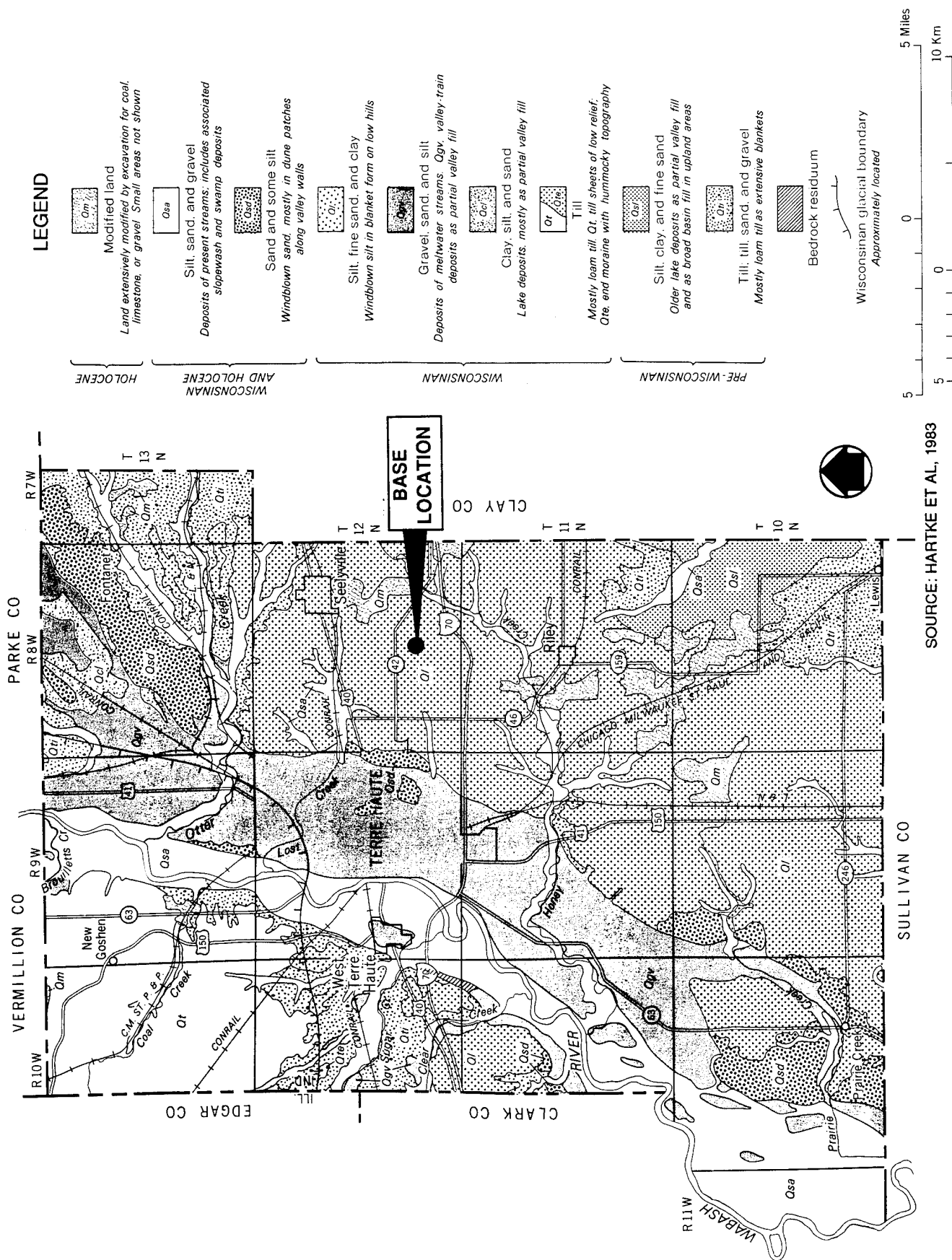
1.5.2.1.4 Coal Resources. The Pennsylvanian rocks (refer to Table 1-3) that underlie Vigo County contain abundant coal reserves, the most important mineral resource in the county. The coal occurs in laterally extensive and nearly horizontal beds that dip to the southwest about 25 to 30 feet per mile.

Five seams (referred to as members) of coal which range from 3 to 6 feet in thickness, are generally considered minable. In ascending stratigraphic sequence these members are Minshall, Seelyville (III), Survant (IV), Springfield (V), and Danville (VII), and are present in the Staunton, Linton, Petersburg, and Dugger formations (Hartke et al., 1983).

In the vicinity of the base, the Survant (IV) coal member has been mined (Figure 1-7). The Survant, which ranges from 3 to 5 feet in thickness in Vigo County, is a black-banded, high-volatile bituminous coal. This coal is overlain by sandstone sandy shale, or black carbonaceous shale each of which provides good roof conditions (Hartke et al., 1983).

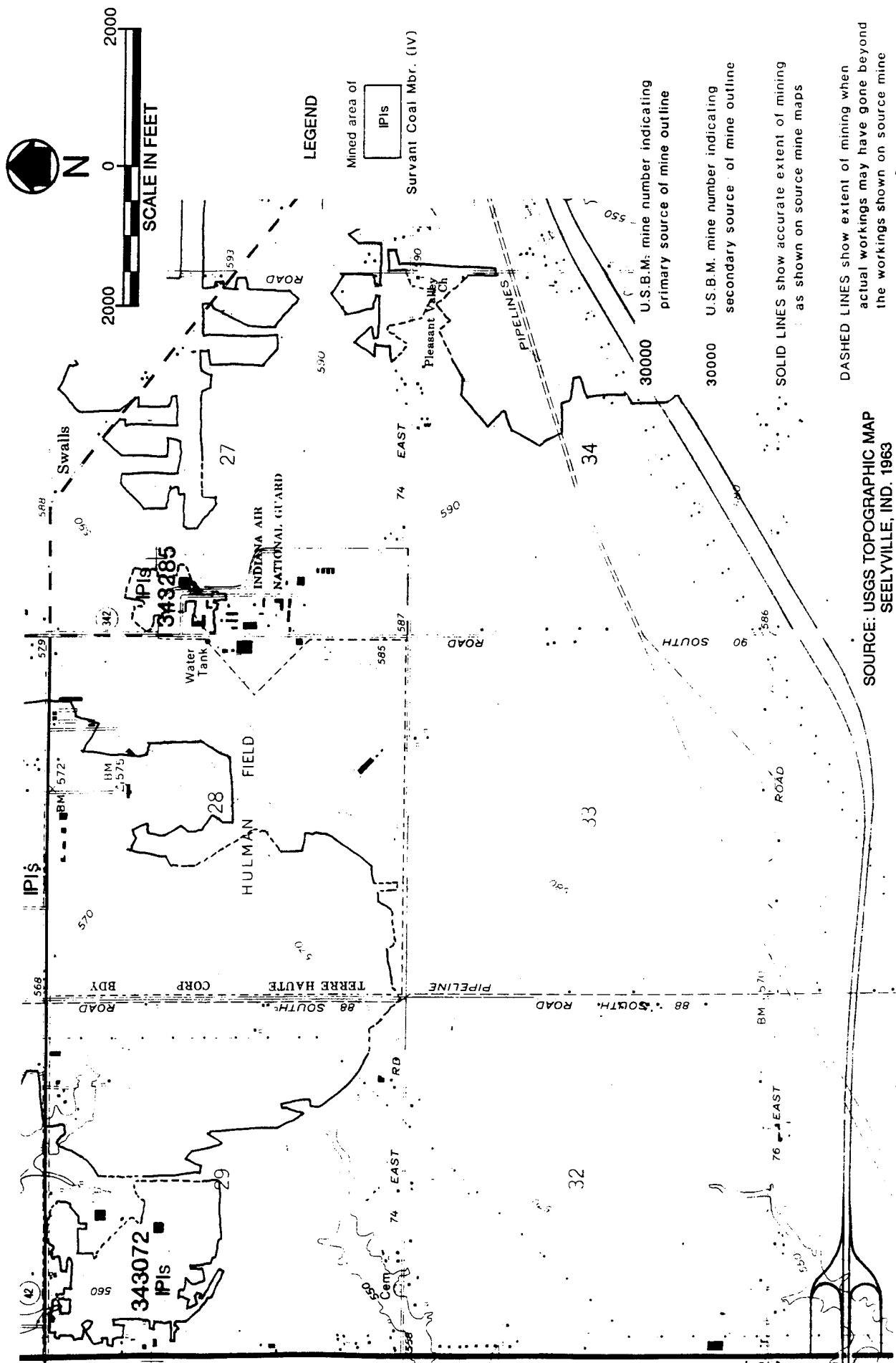
Figure 1-7 shows the locations of abandoned coal mines in the areas surrounding the base. The mines are reportedly 60 to 100 feet below land surface and, as indicated, the mines are in the northern part of the base, not underlying the study areas.

1.5.2.1.5 Petroleum/Oil Resources. Oil was discovered in Vigo County in 1865. Reservoirs are located in several Paleozoic formations that lie at depths of over one thousand feet. These



SOURCE: HARTKE ET AL., 1983

FIGURE 1-6. SURFICIAL GEOLOGY OF VIGO COUNTY, INDIANA
181ST FG, INDIANA ANG, TERRE HAUTE, IN



dome shaped reservoirs are independent structures typically less than a mile and a half in diameter. The potential for discovery of new fields is speculative. Potential for future development exists in all previously developed rock formations. The closest active oil field is about four miles southwest of the base.

1.5.2.1.6 Sand and Gravel Resources. Sand and gravel deposits are also a major resource located in Vigo County. These deposits are a source of aggregate for the construction industry. Most of the sand and gravel is in, or adjacent to, the valleys of the Wabash River, its tributaries, and the Eel River.

1.5.2.2 Groundwater Hydrogeology. Groundwater is encountered in both unconsolidated and bedrock aquifers.

1.5.2.2.1 Unconsolidated Aquifers. Groundwater occurs in the aquifers in the unconsolidated deposits of Vigo County, which consists of relatively clean, coarse-textured sand and gravel that was deposited as glacial outwash. These deposits are mostly of Pleistocene age, with some recent alluvium present, and occur in the Wabash River Valley (Cable et al., 1971). The aquifers are known collectively in the area as the "major unconsolidated aquifer," and yields as high as 2,700 gallons per minute (gpm) have been reported (Hartke et al., 1983). The major unconsolidated aquifer is unconfined in the vicinity of the Wabash River and water table conditions exist. Where the aquifer is covered by glacial tills, artesian conditions prevail (Cable et al., 1971).

Glacial till deposits in the area are generally too poorly sorted and fine grained to be considered as viable water bearing units (Cable et al., 1971). The till deposits are variable, however, and in some areas contain sand gravel lenses of limited horizontal and vertical extent which can support moderate production (Hartke et al., 1983).

1.5.2.2.2 Bedrock Aquifers. Groundwater exists in interconnected pore spaces of the sandstone units (Petersburg, Linton, Dugger, and Shelburn formations) in Vigo County and in

fractures in the coal and shale units. Wells completed in sandstone units typically yield 3 to 10 gpm while wells in the coal and shale units yield less than 5 gpm. The most productive bedrock aquifers in Vigo County are in the thicker sandstone units (Hartke et al., 1983).

The sandstone bodies of the area are generally extensive sheets or channel fill. Where overlain by shale, the sandstone units are commonly confined. Recharge to the bedrock aquifers may occur directly at the surface where the bedrock crops out, or indirectly by downward percolation when bedrock is overlain by unconsolidated deposits.

1.5.2.2.3 Groundwater Quality. Information on regional groundwater quality has been published in the literature (Hartke et al., 1983 and Cable et al., 1971). Although some differences exist between groundwater from the unconsolidated aquifer and the bedrock aquifers, the generalized list of chemical components discussed as being within an aquifer should not be interpreted as exclusive (Hartke et al., 1983).

Unconsolidated Aquifer. Groundwater from the unconsolidated sediments is characterized as a bicarbonate-type solution containing traces of silica, strontium, potassium, magnesium, nitrate, sulfate, manganese, and iron. Analyses conducted by Hartke et al. (1983) and Cables et al. (1971) indicate that the groundwater in the unconsolidated aquifer tends to be harder (higher calcium and magnesium concentrations) and higher in sulfate and nitrates than groundwater from the bedrock. The reported average nitrate concentration in local unconsolidated aquifers is 3.8 ppm (Table 1-5) based on data published by Cables et al. (1971). Nitrate concentrations are of concern in the unconsolidated aquifer since adverse health effects are attributed to elevated concentrations (>40 ppm) of nitrates in water. Nitrate concentrates in groundwater are usually attributed to fertilizers or human and animal wastes. Nitrate loading of groundwater over time is of concern. Iron and magnesium concentrations are variable in Vigo County and may exist at elevated concentrations locally.

Bedrock Aquifers. Groundwater from the bedrock aquifer is generally a sodium bicarbonate-type solution with recurring associations with fluoride, phosphate, carbonate, and chlorides (Hartke et al., 1983). The bedrock aquifers tend to have higher total dissolved solids, fluoride, iron, and magnesium concentrations than does the unconsolidated aquifer. Also, water in coal seams tends to have very high concentrations of sulfate. In areas disturbed by coal mining, iron and magnesium concentrations can be high, exceeding 100 ppm and 15 ppm, respectively (Hartke et al., 1983). In the

vicinity of Hulman ANG Base, coal mining activities were conducted in the past and may result in elevated concentrations of iron and magnesium.

1.5.2.2.4 Groundwater Use. The city of Terre Haute uses the Wabash River as a drinking water supply. Properties west of Route 342 generally use this public supply (see Figure 1-3), while properties east of Route 342, assumed to be upgradient of the base, use private wells. Water supplies county-wide are primarily drawn from groundwater reserves (Hartke et al., 1983). Bedrock aquifers are the primary water source in much of the till covered uplands in the northwestern, northeastern, and southeastern parts of Vigo County (Hartke et al., 1983). In the vicinity of the base, groundwater is drawn primarily from the overburden aquifer.

Water well records for domestic water supply wells to the west, south, and east of Hulman ANG Base indicate yields around 2 to 8 gpm. A well located southwest of the base near the ammunition storage area (No. 530), was observed during the site visit in September 1989. Water well records indicate that the well, drilled in July 1965, was completed to a depth of 54 feet below ground surface, and yields approximately 5 gpm. It is screened in a sand aquifer which occurs at a depth of about 50 feet below ground surface and is overlain by what is described as "brown clay" and "gray sandy hardpan." These descriptions most likely indicate stratified drift deposits overlain by glacial till. The ground elevation at the well is 580 feet above mean sea level, and the static water level was 19 feet below the ground surface. This information indicates that the sand may exist under confined or semiconfined conditions.

The Petersburg Formation, which is the bedrock unit underlying the base, has a basal sandstone unit which is used as an aquifer. The upper part of the Petersburg is shale which, where present, acts as a confining layer for the sandstone. The sandstone aquifer is a source for farm, domestic, small industrial, and municipal water systems in the area (Cable et al., 1971).

1.5.2.2.5 Well and Pump Maintenance. Due to high concentrations of iron and magnesium within Vigo County, mineral precipitation on well materials may result in a need for additional maintenance.

1.5.2.2.6 Well Inventory. The Indiana Department of Natural Resources, Division of Water, was contacted for file information on water wells in the vicinity of the Hulman ANG Base. They provided copies of the Water Well Record forms which are filed whenever a well is drilled. The forms contain information on well construction, location, and hydrogeologic conditions. A well location map with plotted aquifer elevations was also included.

One well was used as a potable water supply on the base. Well No. 530 was used by Hulman ANG personnel at the ammunition storage area located south of the Hulman Field runways (Capt. Martin White, IANG Base Civil Engineer, Personal Communication, February 1991). The water is chlorinated and was used as drinking water. The well has been sampled quarterly and was judged to be suitable for human consumption. It has not been used since 1991, when a new building with public water hookup was constructed (Capt. Martin White, IANG Base Civil Engineer, August 1991 review meeting).

The eight water wells located within or near a one-mile radius from the base are presented in Figure 1-8. Table 1-4 contains a summary of the information available for these eight wells. These wells are screened in the sandstone of the Petersburg Formation. The well logs describe a "gray hardpan" which overlies the sandstone; the "hardpan" corresponds to the dense till which was encountered during site drilling. In the radial area between one and two miles away from the base, twenty five water wells are located in the southeastern quadrant and three wells are in northeastern quadrant.

Review of published hydrogeologic reports (Cable et al., 1981; Hartke et al., 1983) and the area water well data did not define a groundwater gradient for the Petersburg Formation.

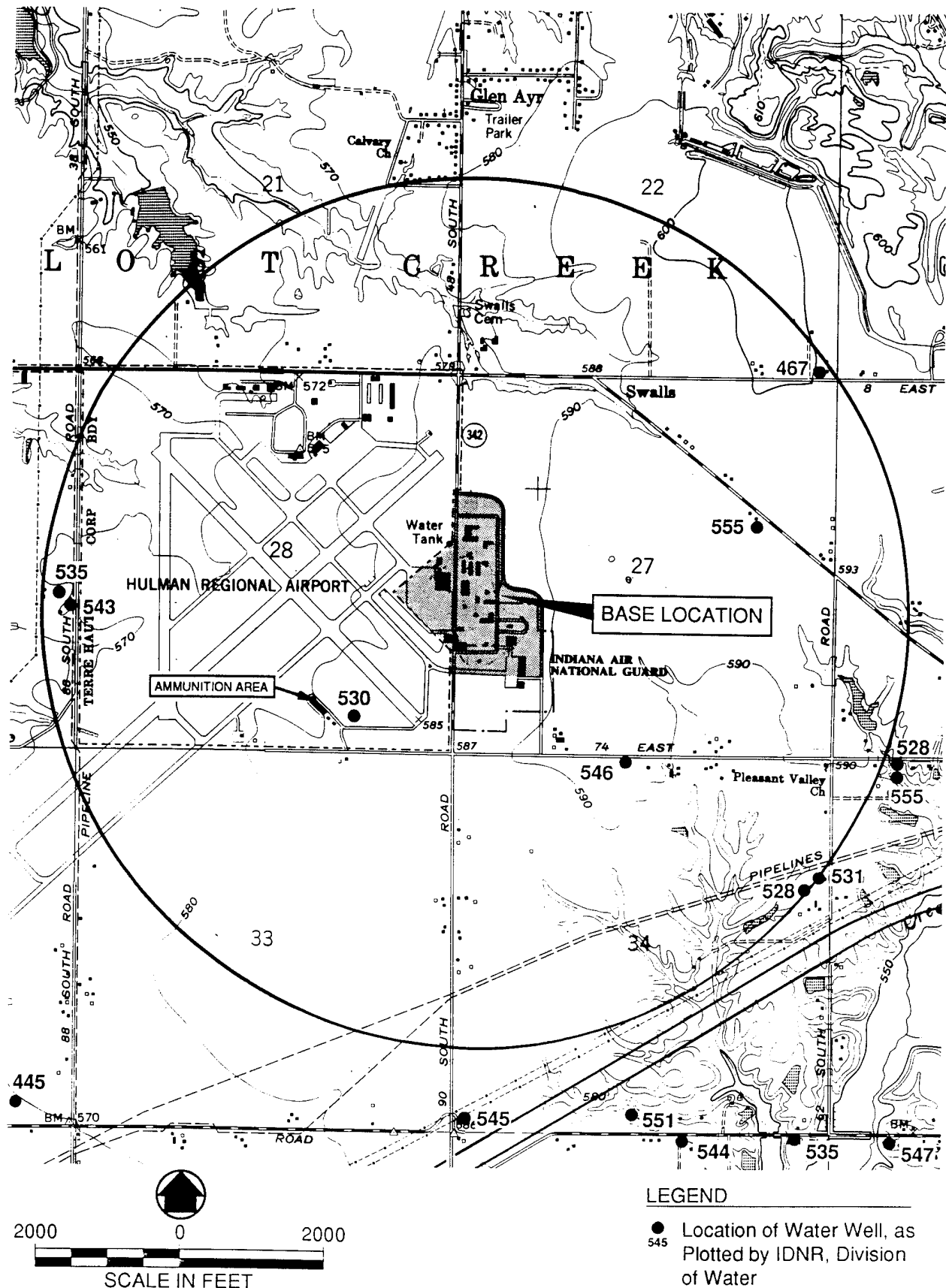


**FIGURE 1-8. LOCATION MAP OF WATER WELLS WITHIN ONE MILE OF HULMAN FIELD
181ST FG, HULMAN FIELD MAP, TERRE HAUTE, IN**

TABLE 1-4. SUMMARY OF WATER WELLS WITHIN ONE MILE

Aquifer Elevation/ Well Designation	Distance from Hulman ANG Base (ft.)	Depth to Static Water Level (ft.)	Elevation of Static Water Level (ft. MSL)	Depth of Screened Interval (ft.)	Depth of Well (ft.)
530	1500 SW	19	561	50-55	55
546	2000 SE	8	583	40-45(a)	45
555	3500 E	15	578	61-65(a)	130
467	5000 NE	45	550	(a)	190
528	5000 SE	50	532	75-80	80
531	5000 SE	24	556	55-59(a)	59
535	6000 W	5	565	30-35(a)	35
543	6000 W	5	567	30(a)	30

(a) Indicates where the information on the well sheet is partially or entirely illegible or not listed.

1.5.2.3 Surface Water Hydrology. The Wabash River is the major surface water feature in Vigo County.

1.5.2.3.1 Surface Water Occurrence. The Wabash River is located west of Hulman ANG Base and flows southerly to the Ohio river. Smaller tributaries within Vigo County have variable flow directions but ultimately discharge to the Wabash River. The base is located between the Honey Creek and Lost Creek drainage basins. Honey Creek flows southwest, while Lost Creek flows northwest.

1.5.2.3.2 Surface Water Quality. Data presented in the literature indicates that several drainage systems in southwest Indiana have been impacted by acid mine drainage from surface mine activities. In low flow conditions, small tributaries in the vicinity of surface mines generally have elevated concentrations of dissolved metals and sulfates. In the vicinity of Hulman ANG Base, this is not expected to occur (see Figure 1-9). Additionally, in agricultural areas, nitrate concentrations may periodically be elevated.

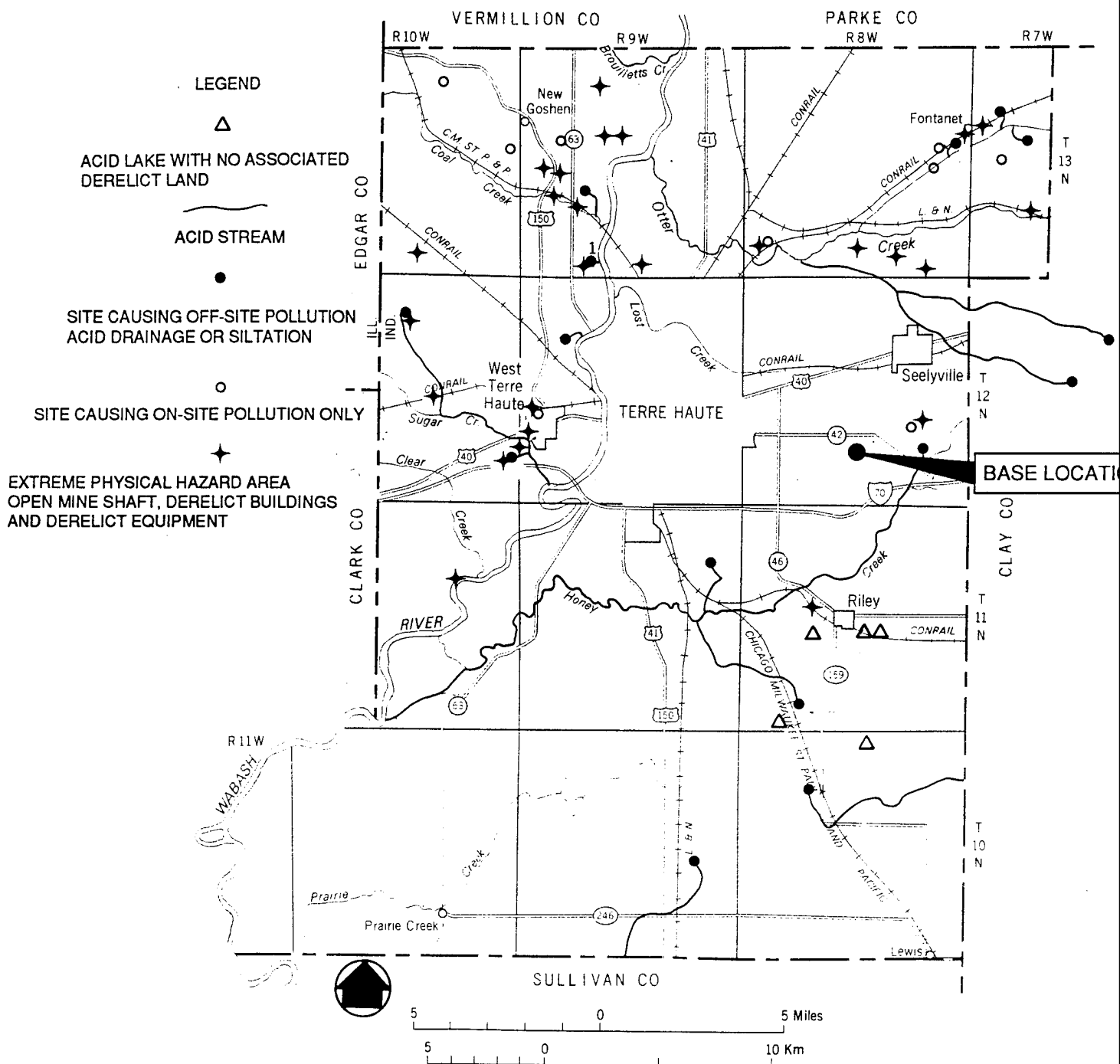
1.5.3 Regional Background Data

Available regional background data of some chemical parameters for groundwater, surface water, and soil are presented in the following sections.

1.5.3.1 Groundwater. The following data (Table 1-5) are averages based on data published by Cable et al. (1971). This data compares favorably with data published by Hartke et al. (1983).

1.5.3.2 Surface Water. The following background data (Table 1-6) was obtained from Martin and Crawford (1987) from stations along the Wabash River. Station WB 194 is south of Terre Haute, Station WB 214 is located at Terre Haute, and Station WB 207 is located approximately 3 miles north of WB 214.

1.5.3.3 Soil. Soil background values could not be obtained from the following local resources: Rose Human College, the Vigo County Extension Service, the Vigo County Soil and Water



SOURCE: HARTKE ET AL, 1983

FIGURE 1-9. MAP OF VIGO COUNTY SHOWING CONTAMINATION FROM ACID MINE DRAINAGE AND HAZARDS ASSOCIATED WITH ABANDONED-MINE SITES

TABLE 1-5. GROUNDWATER DATA FOR LOCAL AQUIFERS

Chemical Parameters	Unconsolidated Aquifer (mg/l)	Consolidated (bedrock) Aquifer (mg/l)
Iron	1.7	3.2
Chloride	6.78	1.50
Total Dissolved Solids (TDS)	336	836
Nitrate	3.8	1.7
Fluoride	0.2	3.3
Sulfate	102	28
Bicarbonate	328	663

TABLE 1-6. SURFACE WATER DATA FOR THE WABASH RIVER

Chemical Parameters	WB207 (mg/l)	WB214 (mg/l)	WI94 (mg/l)
Sulfate	67	NA	70
TDS	112	84	97
Iron	NA	NA	1800
Manganese	NA	NA	150

(Reference: Martin and Crawford 1987).

Conservation Service, and Indiana Geological Survey. Soil background concentrations in the vicinity of Terre Haute collected by Shacklette et al. (1971) are presented in Table 1-7.

Concentrations are given as a range, because large variation is typical from one location to another.

1.5.4 U.S. Background Data for Metals

U.S. Background data for metals in soils as compiled by New Jersey Department of Environmental Protection are listed in Table 1-8.

TABLE 1-7. SOIL DATA FOR THE VICINITY OF TERRE HAUTE

Chemical Parameter	Concentration (mg/kg)
Barium	400-600
Beryllium	< 1
Chromium	40-60
Cobalt	25-40
Iron	17,500-25,000
Lead	17-25

TABLE 1-8. U.S. BACKGROUND CONCENTRATION OF METALS IN SOILS

Metals	Concentration (mg/kg)
Arsenic	1.1-16.7
Cadmium	0.01-1.0
Chromium	1-1,500
Copper	2-200
Lead	2-200
Mercury	0.01-4.6
Nickel	8-550
Selenium	0.01-5.0
Silver	0.01-5.0
Zinc	10-3000

2.0 FIELD PROGRAM

2.1 SUMMARY

The Site Investigation field program consisted of screening and confirmation activities as summarized in Table 2-1. Screening activities consisted of the installation of eight piezometers base-wide and a soil gas survey at each site. Confirmation activities consisted of the drilling of two to four soil borings at each site and one background boring. One monitoring well was installed in the expected downgradient direction of each site. In addition, the background boring was completed as a monitoring well. Based on groundwater levels measured in the piezometers, groundwater flow was expected to be toward the southwest, a northeasterly location was chosen for the Background Area.

During Round 1, surface soil samples were collected from Sites 1, 2, 4, 6 and the background area and three from Site 5. At two samples per boring, eight subsurface soil samples were collected from Sites 2 and 4; four samples from Sites 1, 5, and 6; and two samples from the background area. Surface water and sediment samples were collected from drainage ditches near Site 1, Site 4 and the Background Area and a sediment sample was collected from a drainage basin at Site 6. One groundwater sample was collected from each newly installed monitoring well at each of the five sites and the Background Area. One groundwater sample was also collected from an existing water supply well, No. 530, located downgradient in the Ammunition Area.

During a second sampling round, water levels were collected from all monitoring wells and piezometers except Piezometer 6, MWB-01 and MW5-02. Groundwater samples were collected from MW1-06, MW2-04, MW4-05, MW6-03, Piezometer 4 and Well 530. Five additional surface soil samples were collected at Site 6.

Deviations from the Final Sampling Analysis Plan of September, 1990, or the October, 1991, Scope of Work, sample quantities or locations are as follows: as directed by HAZWRAP, only

Table 2-1. Summary of Site Investigation Activities
181st FG, Hulman Field MAP, Terre Haute, IN

Site	Wells & GW Samples/ Piezometers/Slug Tests/ Surface Water (a)		Soil Gas/Borings/ Surface Soil/ Sediment Samples (b)		Materials of Concern		ANALYTES	
							Water	Soil
Base-wide	* 8	piezometers						
1	+ 1	well (2 GW samples) + 1 slug test + 1 surface water	+ soil gas survey + 2 borings (4 samples) + 2 surface soils + 1 sediment + lithology for wells		waste oil JP-4 hydraulic fluid detergent solvent		volatile organics (dev. water) volatile organics semi-volatile organics total petro. hydrocarbons total metals (PP) dissolved metals (PP) pesticides/PCBs volatile organics (dev. water)	volatile organics semi-volatile organics total petro. hydrocarbons total metals (PP) pesticides/PCBs
2	+ 1	well (2 GW samples) + 1 slug test	* soil gas survey + 4 borings (8 samples) + 2 surface soils + lithology for wells		JP-4		volatile organics semi-volatile organics total petro. hydrocarbons volatile organics (dev. water)	volatile organics semi-volatile organics total petro. hydrocarbons
4	+ 1	well (2 GW samples) + 1 piezometer (2 GW samples) + 1 slug test + 1 surface water	* soil gas survey + 4 borings (8 samples) + 2 surface soils + 1 sediment + lithology for wells		JP-4		volatile organics semi-volatile organics total petro. hydrocarbons volatile organics (dev. water)	volatile organics semi-volatile organics total petro. hydrocarbons

* -- screening activity
+ -- confirmation activity
GW -- groundwater
TCLP -- Toxicity Characteristic Leaching Procedure

PP -- Priority Pollutant (13)
TAL -- Target Analyte List (23)
petro. -- petroleum
Ammo -- Ammunition

(a) One additional groundwater sample was taken during Round 2 (January, 1992) sampling at Sites 1, 2, 4, and 6 and the Ammunition Area. Also during Round 2, two groundwater samples were collected at Piezometer 4, Site 4.
(b) Five additional surface soil samples were taken during Round 2 (January, 1992) sampling at Site 6 - totaling seven surface soil samples in all.

Table 2-1. Summary of Site Investigation Activities
181st FG, Hulman Field MAP, Terre Haute, IN

ANALYTES						
Site	Wells & GW Samples/ Piezometers/Slug Tests/ Surface Water (a)		Soil Gas/Borings/ Surface Soil/ Sediment Samples (b)	Materials of Concern	Water	Soil
5	+ 1 well (1 GW sample)		* soil gas survey + 2 borings (4 samples)	waste oil	volatile organics	volatile organics
	+ 1 slug test		+ 3 surface soils + lithology for wells	paint thinner solvents	semi-volatile organics total petro. hydrocarbons total metals (PP) dissolved metals (PP) volatile organics (dev. water)	semi-volatile organics total petro. hydrocarbons total metals (PP)
6	+ 1 well (2 GW samples)		* soil gas survey + 2 borings (4 samples)	PD-680	volatile organics	volatile organics
	+ 1 slug test		+ 7 surface soils + 1 sediment + lithology for wells	waste oil paint stripper fuel solvents deicing solvent	semi-volatile organics total petro. hydrocarbons total metals (TAL) dissolved metals (TAL) pesticides/PCBs volatile organics (dev. water)	semi-volatile organics total petro. hydrocarbons total metals (TAL) pesticides/PCBs
Background near Bldg. 16	+ 1 well (1 GW sample)		+ 1 borings (2 samples) + 2 surface soils		volatile organics	volatile organics
	+ 1 slug test + 1 surface water		+ 1 sediment + lithology for wells		semi-volatile organics total petro. hydrocarbons total metals (TAL) dissolved metals (TAL) pesticides/PCBs volatile organics (dev. water)	semi-volatile organics total petro. hydrocarbons total metals (TAL) pesticides/PCBs TCLP (soil cuttings)
Ammo Area	2 GW samples				volatile organics semi-volatile organics total petro. hydrocarbons	

- * -- screening activity
+ -- confirmation activity
GW -- groundwater
TCLP -- Toxicity Characteristic Leaching Procedure
- PP -- Priority Pollutant (13)
TAL -- Target Analyte List (23)
petro. -- petroleum
Ammo -- Ammunition
- (a) One additional groundwater sample was taken during Round 2 (January, 1992) sampling at Sites 1,2,4, and 6 and the Ammunition Area. Also during Round 2, two groundwater samples were collected at Piezometer 4, Site 4.
(b) Five additional surface soil samples were taken during Round 2 (January, 1992) sampling at Site 6 - totaling seven surface soil samples in all.

eight piezometers were installed instead of nine and an additional sediment sample was collected at Site 6; and due to field conditions, the background surface water and sediment samples were collected north of the proposed location, since surface water was not visible closer to the background area. In addition, as approved by HAZWRAP, the two foot polyvinylchloride (PVC) sumps below the piezometer screens were omitted during piezometer installation.

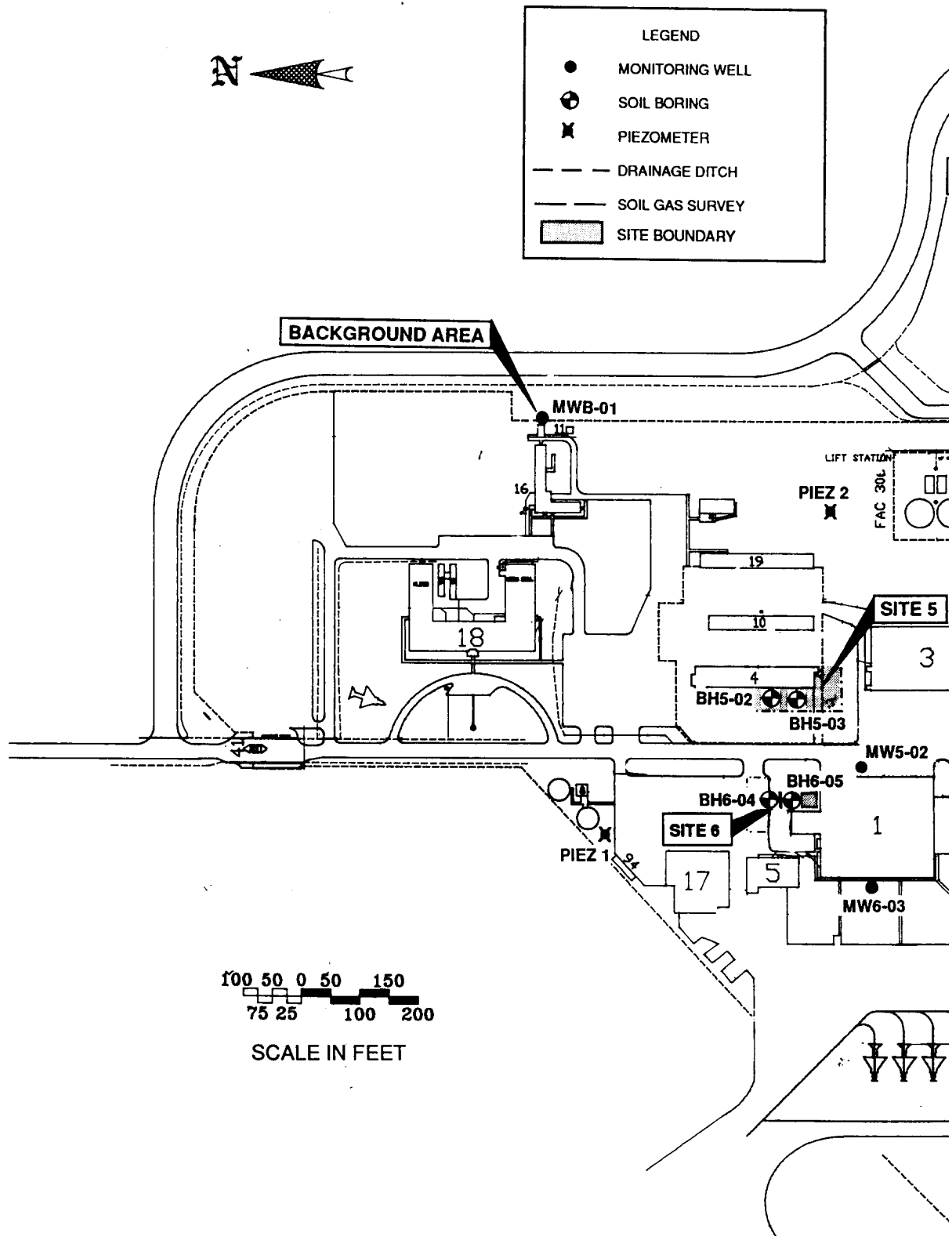
During Round 2, water levels were not measured at MWB-01, Piezometer 6 and MW5-02, since these were destroyed or made inaccessible by base activities. Also groundwater samples were not collected at MWB-01 and MW5-02 during Round 2, since they were not accessible.

The site locations and sampling locations are shown in Figure 2-1.

2.2 GEOLOGIC AND HYDROGEOLOGIC INVESTIGATIONS

Geologic investigations conducted as part of the SI included the installation of piezometers and monitoring wells, and the drilling of soil borings. Hydrogeologic activities included: conducting six sets of water level measurements to determine groundwater flow directions and slug testing on each monitoring well to estimate the rate of groundwater flow. Water levels were measured on October 14 and 16, 1990, November 9, 1990, February 20, 1991, June 27, 1991 and January 17, 1992. Slug tests were conducted in the monitoring wells on November 27 and 28, 1990 to calculate hydraulic conductivity values for the overburden material. The slug test results are discussed in Section 3.

Piezometer installation is discussed in Section 2.3.2 and soil boring drilling and monitoring well installation are discussed in Sections 2.4.1 and 2.4.2.1, respectively. The geologic logs are presented in Appendix A; the piezometer and well construction diagrams are presented in Appendix B; the survey and slug test data are presented in Appendix C; the well development and piezometer worksheets are presented in Appendix D; and computer generated piezometric and ground and till surface contours are presented in Appendix E.



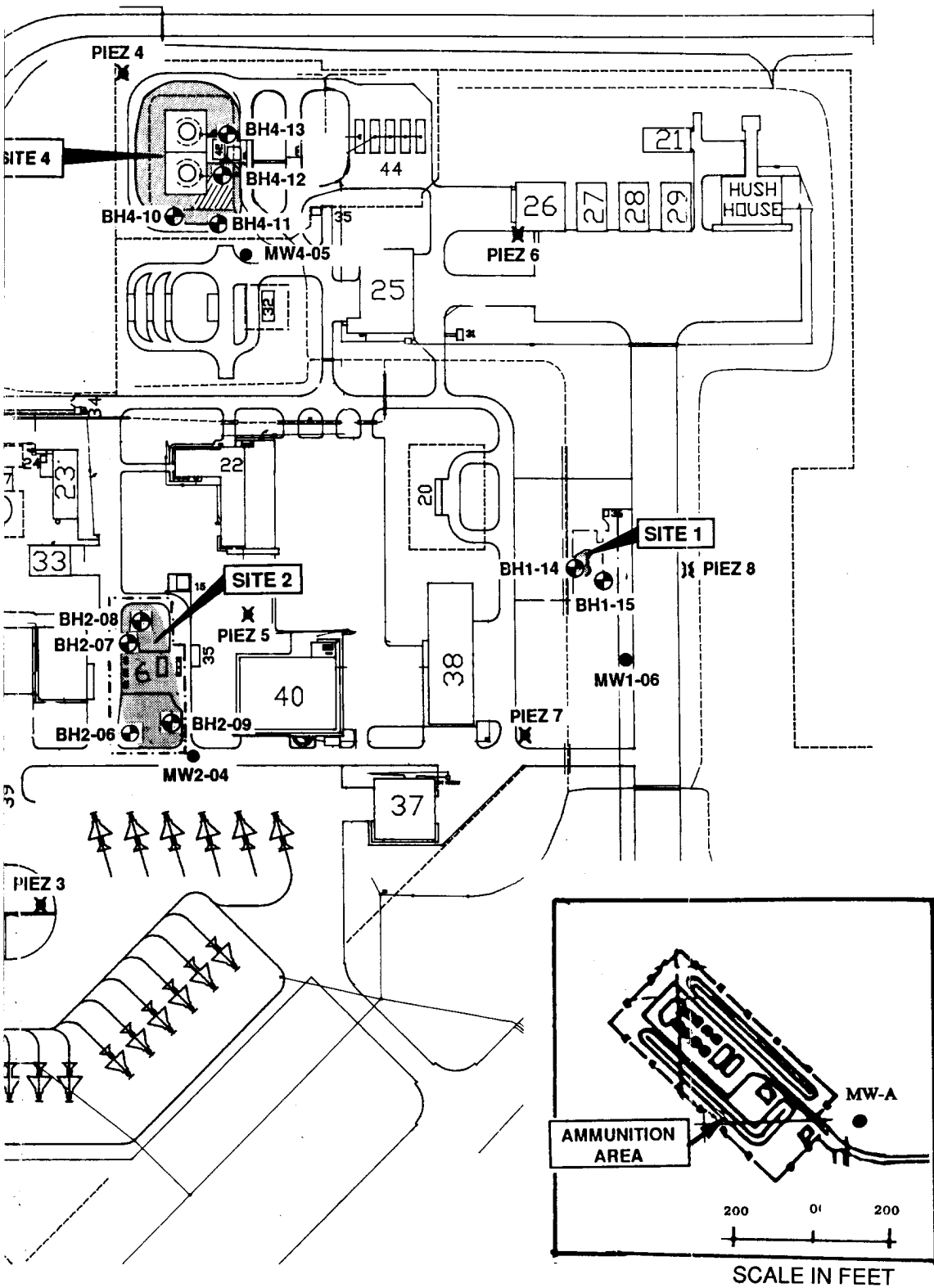


FIGURE 2-1. SI SAMPLING LOCATIONS
181ST FG HULMAN MAP,
TERRE HAUTE, IN

2.3. FIELD SCREENING ACTIVITIES

Field screening activities conducted at Hulman ANG Base consisted of a soil gas survey at each site, as well as, base-wide piezometer installation and monitoring. Methods for each are outlined below.

2.3.1 Soil Gas Survey

The December 1987 Preliminary Assessment (HMTTC) indicated a potential for volatile organic compound contamination at all five sites under investigation. Therefore, soil gas surveys were conducted in the vicinity of Sites 1, 2, 4, 5 and 6 to determine the approximate areal extent of sub-surface contamination and provide data needed for locating soil borings and downgradient monitoring wells.

Perpendicular grid lines were established at 25 foot intervals over the area where a spill or discharge reportedly occurred at each site. Soil gas samples were then collected at the grid intersections. A power driven probe system was used to minimize dilution by ambient air. The probe served as both a driving and sampling probe. The type of flame ionization detector (FID) used at the base was an organic vapor analyzer (OVA). Prior to sampling at each site, a depth profile was performed to determine the depth of maximum volatile organic vapor in soil gas. The profile consisted of analyzing soil gas concentrations at one foot intervals. The depth at which the greatest response was recorded was chosen as the sample depth throughout the soil gas survey at that particular site.

An OVA was used to conduct the soil gas survey for the following reasons:

- 1) A large volume of JP-4 has been discharged to the ground at the sites under investigation.
- 2) The concentration of volatile compounds in JP-4 are greater than the detection limit of the OVA.

- 3) Notes from the soil and groundwater sampling conducted June 10-11, 1986 during the RA investigation at Site 4 indicated that fuel was visible within the soil near the ground surface.
- 4) The purpose for conducting the soil gas survey was to locate the source areas for selecting soil boring drilling locations.

The initial survey with the OVA was beneficial from a data generation and level of effort standpoint. The soil boring locations were chosen on the basis of total volatile organic compound (VOC) concentrations and not necessarily on the basis of compound-specific concentrations in soil gas. A portable gas chromatograph (GC) was used in conjunction with the FID at each of the sites, when the VOC concentrations in soil gas were less than 1 ppm. The portable GC has a detection limit on the order of 100-1000 times lower than that of an FID and was calibrated with headspace standards of benzene, toluene, and JP-4. The soil gas survey data was reviewed by M&E and plotted on a site map. Relative responses from all locations were evaluated to estimate concentration contours and choose sampling locations. Results from these surveys are presented in Section 3.0.

2.3.2 Piezometer Installation

A total of eight piezometers were installed outside of the potential source areas to determine the groundwater gradient. Once determined, the groundwater gradient was utilized to locate a monitoring well down-gradient from each source area. The piezometers were installed at the base beginning September 26, 1990 and were developed on October 1, 1990. The eight piezometers were installed using a truck-mounted drill rig and drilled with 4 1/4-inch I.D. hollow stem augers. The piezometers were constructed following the construction schematic described in the Final Sampling and Analysis Plan of September 1990. All of the piezometers were constructed using 1.5-inch diameter schedule 40 PVC riser and well screen. Ten foot well screens 0.10-inch slots were installed. Geologic logs and piezometer construction diagrams are presented in Appendices A and B, respectively.

The development of the piezometers took place a minimum of 48 hours after installation. Each was purged with a bailer, removing a minimum of three well volumes. During development, successive temperature, pH, and specific conductance readings were within 10 percent. Although the field parameters stabilized, not all the piezometers developed to "clear" water. Piezometer development field data is presented in Appendix D.

2.4 CONFIRMATION AND DELINEATION ACTIVITIES

Confirmation and delineation activities were conducted at each site, the background area, and the ammunition area. These activities included soil boring and sampling, monitoring well installation and sampling, as well as, surface soil, surface water, and sediment sampling. A profile of the number and type of samples collected, analyses used, and QA/QC samples generated for each site is provided in Table 2-2. Appendix F contains a summary of QA/QC results and validation summaries and definitions. A list of those analytes including the laboratory analyses used is presented in Table 2-3. The Contract Laboratory Program Statement of Work (CLP SOW) for Organic Analysis from February 1988 was used and the CLP SOW for Inorganic Analysis from July 1988 was used during the first round of sampling in November 1990. During the second round of sampling in January 1992, the CLP SOW for organics and inorganics from March 1990 was used as per HAZWRAP requirement. Based on past base activities, samples from Sites 2 and 4 were not analyzed for pesticides, PCBs, and metals. In addition, at Site 5, pesticides and PCBs were not analyzed. These decisions were based on the agreement by Region 5 EPA, IDEM, ANGRC and HAZWRAP at the May 1990 SI review meeting. Weston Analytics of Lionville, Pennsylvania conducted the laboratory analyses for both sampling rounds. Each type of confirmation activity is discussed below.

Following boring activities, an Indiana licensed surveyor, V.S. Engineering, surveyed the piezometers, monitoring well and soil boring locations. Surveyed coordinates were etched on metal tags and attached inside the piezometer and monitoring well traffic boxes. Survey coordinates are presented in Appendix C. The site boring, monitoring well, and piezometer locations are shown on Figure 2-1.

TABLE 2.2a SUMMARY OF ROUND 1 CONFIRMATION SAMPLING ACTIVITIES, 181st FG, HULMAN FIELD MAP, TERRE HAUTE, IN

Matrix/Analysis	Method (1)	Environmental Samples						Field QA/QC				Total Samples				
		Site ID Number						Sub- Total	Field Dupl.	Equip. Blanks (2)	Trip Blanks(3)	Field Blanks(4)	MS/ MSD	Soil	Water	
		1	2	4	5	6	BKGD									AA
BOREHOLE SOILS																
Volatile Organic Compounds	CLP – Organic	4	8	8	4	4	2	30	3	3	3	5	3	4	37	11
Semivolatile Organic Compounds	CLP – Organic	4	8	8	4	4	2	30	3	3			3	4	37	6
Total Pet. Hydrocarbons	SW3550/E418.1	4	8	8	4	4	2	30	3	3			3	4	37	6
Pesticides/PCBs	CLP – Organic	4					4	2	10	1	2		3	2	13	5
Total Metals *	SW3050/SW6010	4				4	4	2	14	2	3		3	2	18	6
Arsenic	SW3050/SW7060	4				4	4	2	14	2	3		3	2	18	6
Mercury	SW7471	4				4	4	2	14	2	3		3	2	18	6
Selenium	SW3050/SW7740	4				4	4	2	14	2	3		3	2	18	6
Thallium	SW3050/SW7841	4				4	4	2	14	2	3		3	2	18	6
Moisture Content	ASTM D2216	4	8	8	4	4	2	30	3						33	
SURFACE SOILS																
Volatile Organic Compounds	CLP – Organic	2	2	2	3	2	2	13	2	2		2		2	17	4
Semivolatile Organic Compounds	CLP – Organic	2	2	2	3	2	2	13	2	2				2	17	2
Total Pet. Hydrocarbons	SW3550/E418.1	2	2	2	3	2	2	13	2	2				2	17	2
Pesticides/PCBs	CLP – Organic	2				2	2	6	1	2				2	9	2
Total Metals *	SW3050/SW6010	2				3	2	9	1	2				2	12	2
Arsenic	SW3050/SW7060	2				3	2	9	1	2				2	12	2
Mercury	SW7471	2				3	2	9	1	2				2	12	2
Selenium	SW3050/SW7740	2				3	2	9	1	2				2	12	2
Thallium	SW3050/SW7841	2				3	2	9	1	2				2	12	2
Moisture Content	ASTM D2216	2	2	2	3	2	2	13	2						15	

TABLE 2.2a SUMMARY OF ROUND 1 CONFIRMATION SAMPLING ACTIVITIES, 181st FG, HULMAN FIELD MAP, TERRE HAUTE, IN (CONTINUED)

Matrix/Analysis	Method (1)	Environmental Samples						Field QA/QC					Total Samples				
		1	2	4	5	6	BKGD	AA	Sub- Total	Field Dupl.	Equip. Blanks(2)	Trip Blanks(3)	Field Blanks(4)	MS/ MSD	Soil	Water	
SEDIMENTS																	
Volatile Organic Compounds	CLP – Organic	1		1		1		1	4		1		1		2	7	2
Semivolatlie Organic Compounds	CLP – Organic	1		1		1		1	4		1		1		2	7	1
Total Pet. Hydrocarbons	SW3550/E418.1	1		1		1		1	4		1		1		2	7	1
Pesticides/PCBs	CLP – Organic	1		1		1		1	3		1		1		2	6	1
Total Metals *	SW3050/SW6010	1		1		1		1	3		1		1		2	6	1
Arsenic	SW3050/SW7060	1		1		1		1	3		1		1		2	6	1
Mercury	SW7471	1		1		1		1	3		1		1		2	6	1
Selenium	SW3050/SW7740	1		1		1		1	3		1		1		2	6	1
Thallium	SW3050/SW7841	1		1		1		1	3		1		1		2	6	1
Moisture Content	ASTM D2216	1		1		1		1	4		1					5	

TABLE 2.2a SUMMARY OF ROUND 1 CONFIRMATION SAMPLING ACTIVITIES, 181st FG, HULMAN FIELD MAP, TERRE HAUTE, IN (CONTINUED)

Matrix/Analysis	Method (1)	Environmental Samples										Field QA/QC					Total Samples	
		Site ID Number						Sub- Total	Field Dupl.	Equip. Blanks (2)	Trip Blanks(3)	Field Blanks(4)	MS/ MSD	Soil	Water			
		1	2	4	5	6	BKGD									AA		
GROUNDWATER																		
Laboratory Tests																		
Volatile Organic Compounds	CLP - Organic	1	1	1	1	1	1	1	7	1	1	3	2	2	16			
Semivolatile Organic Compounds	CLP - Organic	1	1	1	1	1	1	1	7	1	1		2	2	13			
Total Pet. Hydrocarbons	E418.1	1	1	1	1	1	1	1	7	1	1		2	2	13			
Pesticides/PCBs	CLP - Organic	1				1	1	1	4	1	1		2	2	10			
Total Metals *	SW3010/SW6010	1		1	1	1	1	1	5	1	1		2	2	11			
Arsenic	SW3020/SW7060	1		1	1	1	1	1	5	1	1		2	2	11			
Lead	SW3020/SW7421	1		1	1	1	1	1	5	1	1		2	2	11			
Mercury	SW7470	1		1	1	1	1	1	5	1	1		2	2	11			
Selenium	SW3020/SW7740	1		1	1	1	1	1	5	1	1		2	2	11			
Thallium	SW3020/SW7841	1		1	1	1	1	1	5	1	1		2	2	11			
Dissolved Metals *	SW3010/SW6010	1		1	1	1	1		4	1	1		2	2	10			
Arsenic	SW3020/SW7060	1		1	1	1	1		4	1	1		2	2	10			
Lead	SW3020/SW7421	1		1	1	1	1		4	1	1		2	2	10			
Mercury	SW7470	1		1	1	1	1		4	1	1		2	2	10			
Selenium	SW3020/SW7740	1		1	1	1	1		4	1	1		2	2	10			
Thallium	SW3020/SW7841	1		1	1	1	1		4	1	1		2	2	10			
AA = AMMO AREA																		

TABLE 2.2a SUMMARY OF ROUND 1 CONFIRMATION SAMPLING ACTIVITIES, 181st FG, HULMAN FIELD MAP, TERRE HAUTE, IN (CONTINUED)

Matrix/Analysis	Method (1)	Environmental Samples						Field QA/QC						Total Samples			
		1	2	4	5	6	BKGD	AA	Sub- Total	Field Dupl.	Equip. Blanks (2)	Trip Blanks(3)	Field Blanks(4)	MS/ MSD	Soil	Water	
Site ID Number																	
SURFACE WATER																	
Laboratory Tests																	
Volatile Organic Compounds	CLP - Organic	1		1				1	3	1		1			2	7	
Semivolatile Organic Compounds	CLP - Organic	1		1				1	3	1		1			2	7	
Total Pet. Hydrocarbons	E418.1	1		1				1	3	1		1			2	7	
Pesticides/PCBs	CLP - Organic	1						1	2	1		1			2	6	
Total Metals *	SW3010/SW6010	1						1	2	1		1			2	6	
		1						1	2	1		1			2	6	
	Arsenic	SW3020/SW7060	1					1	2	1		1			2	6	
	Lead	SW3020/SW7421	1					1	2	1		1			2	6	
	Mercury	SW7470	1					1	2	1		1			2	6	
Selenium	SW3020/SW7740	1						1	2	1		1			2	6	
Thallium	SW3020/SW7841	1						1	2	1		1			2	6	
Dissolved Metals *	SW3010/SW6010	1						1	2	1		1			2	6	
	Arsenic	SW3020/SW7060	1					1	2	1		1			2	6	
	Lead	SW3020/SW7421	1					1	2	1		1			2	6	
	Mercury	SW7470	1					1	2	1		1			2	6	
Selenium	SW3020/SW7740	1						1	2	1		1			2	6	
Thallium	SW3020/SW7841	1						1	2	1		1			2	6	

TABLE 2.2a SUMMARY OF ROUND 1 CONFIRMATION SAMPLING ACTIVITIES, 181st FG, HULMAN FIELD MAP, TERRE HAUTE, IN (CONTINUED)

- * Priority Pollutant Metals include As, Sb, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Ti, and Zn.
At Site 6 and the background monitoring area, the full 23 target compound list metals shall be analyzed. These include: Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Ni, K, Se, Ag, Na, Ti, V, and Zn;
As, Pb (aqueous matrix only); Se and Ti shall be analyzed by graphite furnace AA and Hg shall be analyzed by cold vapor AA.
- ** TCLP Metals include As, Ba, Cd, Cr, Pb, Hg, Se, Ag. Hg shall be analyzed by cold vapor AA.
- (1) 100–500 Methods
Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, March 1983.
- 1000–9000 Methods
Test Methods for Evaluating Solid Waste, SW-846, 3rd edition, USEPA, November 1986.
- ASTM Methods
Annual Book of ASTM Standards, Standard Test Methods for Moisture, Ash, and Organic Matter of Peat Materials, 1987.
- CLP Organic Methods
Contract Laboratory Program Statement of Work for Organic Analysis, Multi-Media/ Multi-Concentration, US EPA, February 1988.
- CLP Inorganic Methods
Contract Laboratory Program Statement of Work for Inorganic Analysis, Multi-Media/ Multi-Concentration, US EPA, July 1988.
- (2) Equipment blanks will be collected at a frequency of one / day of decontamination
Assume the following sampling frequency; 3 wells/day, 3 borings/day (6 SAMPLES), 3 surface waters/day, 3 sediments /day, 5 surface soils /day.
- (3) One trip blank sent / Matrix / sample shipment.
- (4) One field blank / water type (includes tap & deionized water)/ field episode
Assume two field episodes: BORING OPERATIONS AND SAMPLING

TABLE 2.2b SUMMARY OF ROUND 2 CONFIRMATION SAMPLING ACTIVITIES AT THE 181st FG, HULMAN FIELD MAP, TERRE HAUTE, IN

Matrix/Analysis	Environmental Samples										Field QA/QC						Total Samples	
	Method (1)	Site ID Number						Sub- Total	Field Dupl.	Equip. Blanks(2)	Trip Blanks(3)	Field Blanks(4)	MS/ MSD	Soil	Water			
		1	2	4	5	6	BKGD									AA		
SURFACE SOILS																		
Volatile Organic Compounds	CLP – Organic				5			5	1	1	1		2	8	2			
Semivolatile Organic Compounds	CLP – Organic				5			5	1	1			2	8	1			
Total Pet. Hydrocarbons	SW3550/E418.1				5			5	1	1			2	8	1			
Pesticides/PCBs	CLP – Organic				5			5	1	1			2	8	1			
Total Metals *	SW3050/SW6010				5			5	1	1			2	8	1			
Arsenic	SW3050/SW7060				5			5	1	1			2	8	1			
Mercury	SW7471				5			5	1	1			2	8	1			
Selenium	SW3050/SW7740				5			5	1	1			2	8	1			
Thallium	SW3050/SW7841				5			5	1	1			2	8	1			
Moisture Content	ASTM D2216				5			5	1				2	8				

TABLE 2.2b SUMMARY OF ROUND 2 CONFIRMATION SAMPLING ACTIVITIES, 181st FG, HULMAN FIELD MAP, TERRE HAUTE, IN (CONTINUED)

Matrix/Analysis	Method (1)	Environmental Samples						Field QA/QC						Total Samples		
		Site ID Number						Sub- Total	Field Dupe	Equip. Blanks (2)	Trip Blanks(3)	Field Blanks(4)	MS/ MSD	Soil	Water	
		1	2	4	5	6	BKGD									AA
GROUNDWATER																
Laboratory Tests																
Volatile Organic Compounds	CLP - Organic	1	1	3	1	1	1	7	1	2	3	2	2	17		
	CLP - Organic	1	1	3	1	1	1	7	1	2		2	2	14		
Semivolatile Organic Compounds	E418.1	1	1	3	1	1	1	7	1	2		2	2	14		
	CLP - Organic	1				1	1	3	1	2		2	2	10		
Total Pet. Hydrocarbons	SW3010/SW6010	1			1	1	1	3	1	2		2	2	10		
	SW3020/SW7060	1			1	1	1	3	1	2		2	2	10		
Pesticides/PCBs	SW3020/SW7421	1			1	1	1	3	1	2		2	2	10		
	SW7470	1			1	1	1	3	1	2		2	2	10		
Total Metals *	SW3020/SW7740	1			1	1	1	3	1	2		2	2	10		
	SW3020/SW7841	1			1	1	1	3	1	2		2	2	10		
Dissolved Metals *	SW3010/SW6010	1			1	1		2	1	2		2	2	9		
	SW3020/SW7060	1			1	1		2	1	3		2	2	10		
Arsenic	SW3020/SW7421	1			1	1		2	1	3		2	2	10		
	SW7470	1			1	1		2	1	3		2	2	10		
Lead	SW3020/SW7740	1			1	1		2	1	3		2	2	10		
	SW3020/SW7841	1			1	1		2	1	3		2	2	10		
Mercury	SW3010/SW6010	1			1	1		2	1	2		2	2	9		
	SW3020/SW7060	1			1	1		2	1	3		2	2	10		
Selenium	SW3020/SW7421	1			1	1		2	1	3		2	2	10		
	SW7470	1			1	1		2	1	3		2	2	10		
Thallium	SW3020/SW7740	1			1	1		2	1	3		2	2	10		
	SW3020/SW7841	1			1	1		2	1	3		2	2	10		
AA = AMMO AREA																

TABLE 2.2b SUMMARY OF ROUND 2 CONFIRMATION SAMPLING ACTIVITIES, 181st FG, HULMAN FIELD MAP, TERRE HAUTE, IN (CONTINUED)

- * Priority Pollutant Metals include As, Sb, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Ti, and Zn.
At Site 6 and the background monitoring area, the full 23 target compound list metals shall be analyzed. These include: Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Ni, K, Se, Ag, Na, Ti, V, and Zn;
As, Pb (aqueous matrix only); Se and Ti shall be analyzed by graphite furnace AA and Hg shall be analyzed by cold vapor AA.
- (1) 100–500 Methods
Methods for Chemical Analysis of Water and Wastes, EPA 600/4–79–020, March 1983.
- 1000–9000 Methods
Test Methods for Evaluating Solid Waste, SW–846, 3rd edition, USEPA, November 1986.
- ASTM Methods
Annual Book of ASTM Standards, Standard Test Methods for Moisture, Ash, and Organic Matter of Peat Materials, 1987.
- CLP Organic Methods
Contract Laboratory Program Statement of Work for Organic Analysis, Multi– Media/ Multi– Concentration, US EPA, March 1990
- CLP Inorganic Methods
Contract Laboratory Program Statement of Work for Inorganic Analysis, Multi– Media/ Multi– Concentration, US EPA, March 1990
- (2) Equipment blanks will be collected at a frequency of one/every day of decontamination
Assume the following sampling frequency: 3 wells or piezometers/day, 3 surface soils /day.
- (3) One trip blank sent / Matrix / sample shipment.
- (4) One field blank / water type (includes tap & deionized water)/ field episode

TABLE 2-3. ANALYTES INCLUDED IN THE ANALYSIS

VOLATILE ORGANICS:	SEMIVOLATILE ORGANICS (CONT.):	PESTICIDES/PCBS:
Chloromethane	Benzoic acid (a)	Alpha-BHC
Bromomethane	bis(2-Chloroethoxy)methane	Beta-BHC
Vinyl Chloride	2,4-Dichlorophenol	Delta-BHC
Chloroethane	1,2,4-Trichlorobenzene	gamma-BHC (Lindane)
Methylene Chloride	Naphthalene	Heptachlor
Acetone	4-Chloroaniline	Aldrin
Carbon Disulfide	Hexachlorobutadiene	Heptachlor epoxide
1,1-Dichloroethene	4-Chloro-3-methylphenol	Endosulfan I
1,1-Dichloroethane	2-Methylnaphthalene	Dieldrin
1,2-Dichloroethene (total)	Hexachlorocyclopentadiene	4,4'-DDE
Chloroform	2,4,6-Trichlorophenol	Endrin
1,2-Dichloroethane	2,4,5-Trichlorophenol	Endosulfan II
2-Butanone	2-Chloronaphthalene	4,4'-DDD
1,1,1-Trichloroethane	2-Nitroaniline	Endosulfan sulfate
Carbon Tetrachloride	Dimethylphthalate	4,4'-DDT
Vinyl Acetate (a)	Acenaphthylene	Methoxychlor
Bromodichloromethane	2,6-Dinitrotoluene	Endrin ketone
1,2-Dichloropropane	3-Nitroaniline	alpha-Chlordane
cis-1,3-Dichloropropene	Acenaphthene	gamma-Chlordane
Trichloroethene	2,4-Dinitrophenol	Toxaphene
Dibromochloromethane	4-Nitrophenol	Aroclor-1016
1,1,2-Trichloroethane	Dibenzofuran	Aroclor-1221
Benzene	2,4-Dinitrotoluene	Aroclor-1232
Trans-1,3-Dichloropropene	Diethylphthalate	Aroclor-1242
Bromoform	4-Chlorophenyl-phenylether	Aroclor-1248
4-Methyl-2-pentanone	Fluorene	Aroclor-1254
2-Hexanone	4-Nitroaniline	Aroclor-1260
Tetrachloroethene	4,6-Dinitro-2-methylphenol	INORGANICS:
1,1,2,2-Tetrachloroethane	4-Bromophenyl-phenylether	
Toluene	Hexachlorobenzene	
Chlorobenzene	Pentachlorophenol	
Ethylbenzene	Phenanthrene	
Styrene	Anthracene	
Xylene (total)	Di-n-Butylphthalate	
SEMIVOLATILE ORGANICS:	Fluoranthene	
Phenol	Pyrene	
bis(2-Chloroethyl)ether	Butylbenzylphthalate	
2-Chlorophenol	3,3'-Dichlorobenzidine	
1,3-Dichlorobenzene	Benzo(a)anthracene	
1,4-Dichlorobenzene	Chrysene	
Benzyl alcohol (a)	Carbazole (b)	
1,2-Dichlorobenzene	bis(2-Ethylhexyl)phthalate	
2-Methylphenol	Di-n-Octyl phthalate	
bis(2-Chloroisopropyl)ether	Benzo(b)fluoranthene	
4-Methylphenol	Benzo(k)fluoranthene	
N-Nitroso-Di-n-propylamine	Benzo(a)pyrene	
Hexachloroethane	Indeno(1,2,3-cd)pyrene	
Nitrobenzene	Dibenzo(a,h)anthracene	
Isophorone	Benzo(g,h,i)perylene	
2-Nitrophenol	N-Nitrosodiphenylamine	
2,4-Dimethylphenol		
		PETROLEUM HYDROCARBONS

NOTES:

a. Only analyzed for in sampling Round I.

b. Only analyzed for in sampling Round II.

2.4.1 Soil Borings

A total of fifteen soil borings were drilled at the Hulman ANG Base to determine the possible nature and extent of contamination at each of the five sites under investigation. The number of soil borings at each site varied from one at the background location to four at Sites 2 and 4. Locations of the soil borings were determined by evaluating the results of the soil gas survey conducted at each site. Generally, soil borings were located in areas of highest soil gas measurements. However, drill rig access and underground utilities were considered in finalizing locations. The soil borings were drilled from October 11 to 15, 1990. Boring logs are presented in Appendix A. The soil boring locations are shown on Figure 2-1.

The soil borings were drilled using a truck-mounted drill rig with 4¼-inch I.D. hollow stem augers. Soil samples were collected inside of the augers using a 2-foot long, 3-inch diameter California modified split-spoon sampler. Four decontaminated 6-inch stainless steel sleeves were placed inside the split-spoon sampler. The sleeves are designed to reduce possible loss of volatiles during sample processing and shipment.

The samples used for analysis were collected from the middle liners in the split-spoon, where possible. One stainless steel liner per sample was capped and sealed for shipment to the laboratory for volatile analysis. The second middle liner of the sample was composited and placed in a sample bottle for the remainder of the analyses. Split-spoon samples were collected continuously from ground surface to the water table (six feet), then at five-foot intervals until the top of the till or twenty feet was reached.

Once each soil boring was complete, the augers were pulled from the hole and the hole was backfilled using Hole-Plug bentonite pellets. Cuttings were then placed over the top one foot, to facilitate natural cover growth. Additional information on drilling and sampling techniques is presented in the Final Sampling and Analysis Plan (September 1990).

2.4.2 Monitoring Wells

One downgradient monitoring well was installed per site to monitor potential groundwater contamination. The background boring was completed as a monitoring well to provide information regarding upgradient groundwater conditions. Monitoring well locations are shown on Figure 2-1. Slug tests were conducted in the monitoring wells to calculate hydraulic conductivity values for the overburden material.

2.4.2.1 Installation. A total of six monitoring wells were installed at the base. Well locations were determined by review of the piezometric survey results, soil gas survey results, and soil boring locations. Monitoring wells were installed downgradient of potential source areas to identify potential groundwater contamination migrating from the sites. One of the monitoring wells was installed as a background well to be used to determine upgradient groundwater quality. The background monitoring well was installed on October 11, 1990, and the remainder of the wells were installed from October 17 to 18, 1990.

The wells were installed using a truck-mounted drill rig and drilling was conducted using 4¼-inch I.D. hollow stem augers. The monitoring wells were constructed following the procedures and the construction schematic as outlined in the Final Field Sampling Plan and Work Plan of September 1990. All wells were constructed with stainless steel risers and well screens. Ten foot well screens with 0.010-inch slots were installed. The filter pack material consisted of an 0.85-0.95 grade silica sand supplied by Waupaca Materials. Geologic logs and well construction diagrams were completed for each monitoring well and are presented in Appendices A and B, respectively.

Monitoring wells were developed on October 24, 1990, approximately five days after installation, using a Brainard-Kilman (BK) pump. A minimum of three well volumes was removed from each well during development. Not all of the wells developed to "clear water," and some wells were purged slowly due to slow recharge. Measurements of temperature, pH, and conductivity were within 10 percent for the final three successive well volumes. Well

development field data is provided in Appendix D (for additional information on well development, see the Final Sampling and Analysis Plan, September, 1990).

2.4.2.2 Sampling. Additional information on sampling techniques is presented in the Final Sampling and Analysis Plan (September 1990). The monitoring wells at each of the sites, the background area and the ammunition area were sampled November 9 to 11, 1990, and all wells except MWB-01 (background) and MW5-02 were sampled during Round 2, January 15 to 18, 1992. Piezometer 4 was also sampled twice during Round 2. Prior to sampling each monitoring well, three well volumes were purged and temperature, pH, and conductivity were measured. The parameters at each well stabilized, to within 10 percent, by the final well volume. Water-level recoveries in some wells were slow but none were more than 0.5 hours, and none were left to be resumed at a later time. Before sample collection, two additional full bailers of groundwater were discharged. Volatile organic samples were then collected in VOA vials, preserved with hydrochloric acid, and immediately capped. Care was taken to insure that no air remained in the vials upon capping. The remaining sample bottles were filled to the shoulder and preserved shortly after, as necessary. Samples for total petroleum hydrocarbons analysis were preserved with sulfuric acid, and those for metals analysis were preserved with nitric acid. Total metal samples were collected directly from the bailer, while dissolved metal samples were first filtered through a 0.45 μm filter and then preserved. Prior to sampling in the Ammunition Area, water was run from a spigot for approximately 5 minutes. In the Ammunition Area, groundwater samples were collected at a point in the system prior to chlorination.

2.4.3 Surface Soil

Surface soil samples were collected from the top six inches of soil in the potential source area of each site and in the background area in October, 1990, and again at Site 6 in January 1992. The sample locations were selected based upon results of the soil gas survey for all of the sites. However, at Site 6, visible stressed vegetation was also considered.

Round 1 surface soil samples were collected in a stainless steel bowl using a stainless steel trowel. Volatile organic samples were collected by inverting a bottle into the soil before it was disturbed further. The remaining soil was mixed before the other samples were collected. Two background surface soil samples were collected in the background area near building 16 and at least two surface soil samples were collected at each of the sites.

Round 2 surface soil samples collected at Site 6 in January 1992, were determined based on the results of the Round 1 sampling. A total of 5 samples and a duplicate were collected. Due to cold weather conditions, the surface soil sampling procedures were modified. Soil samples to be analyzed for volatile organics were chipped or broken into small pieces to reduce air space in the sample bottles. The soil was then placed into the sample containers. Five samples and a duplicate were collected at Site 6. Two samples were located in areas with high soil gas measurements and three samples and the duplicate were collected in adjacent grassy areas.

2.4.4 Surface Water and Sediments

One sediment and one surface water sample from each of two downgradient drainage ditches in the vicinity of Sites 1 and 4 were collected for analysis. Also, one sediment sample was taken at a drainage basin located near Site 6. Background sediment and surface water samples were collected in the drainage ditch along the road just outside of the base, north of building 18. The surface water samples were collected by first immersing inverted bottles and then tilting them until full. Sample filtration and preservation were conducted following the same procedures discussed for groundwater sampling (Section 2.4.2.2). Sediment samples were then collected in a stainless steel bowl using a stainless steel spoon. Sediment was collected in a cross-section of the ditch being sampled. Samples were collected using the same methods discussed for surface soil sampling (Section 2.4.3).

2.4.5 Site Summaries

A site by site summary of the Site Investigation field activities conducted at the base is presented in the following section. The Site locations and sampling locations are shown on Figure 2-1.

2.4.5.1 Site 1 - Power Suppressor Pad. Several confirmation activities were conducted within and downgradient of the source area to assess the areal and vertical extent of potential contamination. Two soil borings, BH1-14 and BH1-15, were drilled in the source area to a depth of 17 feet, and two analytical samples were collected from each boring. To characterize possible contamination of surface drainage, one sediment and one surface water sample, SE1-04 and SW1-04 respectively, were collected from a drainage ditch just west of Site 1. Two surface soils, SS1-12 and SS1-13, were collected in the source area to determine the potential for health risk from exposure to surface soils. One downgradient monitoring well, MW1-06, was installed and a total of two groundwater samples were collected during the two rounds of sampling for laboratory analysis. A slug test was also conducted in MW1-06 to aid in calculating the hydraulic conductivity of the soils at the base, the results are presented in Section 3.

2.4.5.2 Site 2 - Abandoned POL Stand. Confirmation activities were conducted as follows. Four soil borings, BH2-06, 07, 08 and 09, were drilled in the source area (BH2-06 to 17.5 feet and BH2-07, 08, and 09 to 17 feet) and two analytical samples collected from each boring. Two surface soil samples, SS2-08 and SS2-09, were collected. One monitoring well, MW2-04, was installed downgradient of Site 2. Two groundwater samples were collected (one from each round of sampling) from the monitoring well for laboratory analyses. A slug test was conducted in MW2-04 to calculate the hydraulic conductivity for the overburden material. The test values are discussed in Section 3.

2.4.5.3 Site 4 - Old Bladder Area. Confirmation activities included: the drilling of soil borings, monitoring well installation, and soil, sediment, surface water and groundwater sample collection. Four soil borings, BH4-10, BH4-11, BH4-12 and BH4-13, were drilled (BH4-11 to 17.5 feet and BH4-10, 12, and 13 to 17 feet) and two soil samples were collected from each

boring. Two surface soil samples, SS4-10 and SS4-11, were also collected in the source area. To characterize possible contamination from surface drainage, one sediment sample, SE4-03, and one surface water sample, SW4-03, were collected from a drainage ditch downgradient of Site 4. One downgradient monitoring well, MW4-05, was installed and two groundwater samples were collected (one from each sampling round) for laboratory analyses. Two groundwater samples from Piezometer 4 were also collected during Round 2. A slug test was conducted in MW4-05 to calculate the hydraulic conductivity for the overburden material. The test results are discussed in Section 3.

2.4.5.4 Site 5 - Vehicle Maintenance Area. Confirmation activities included: the drilling of soil borings, the installation of a downgradient monitoring well, and the collection of groundwater, surface soil, and soil boring samples. Two soil borings, BH5-02 and BH5-03, were drilled in the source area (BH5-02 to 17 feet and BH5-03 to 20 feet), and two soil samples were collected from each boring. In addition, three surface soil samples, SS5-03, 04 and 05, were collected in the source area. One groundwater sample was collected from the downgradient monitoring well, MW5-02, and a slug test was conducted to calculate the hydraulic conductivity for the overburden material. The test results are discussed in Section 3.

2.4.5.5 Site 6 - Hangar Building No. 1. Confirmation activities were conducted. Two borings, BH6-04 and BH6-05, were drilled in the source area to a depth of 17 feet, and two analytical samples collected from each boring. In addition, a total of seven surface soil samples, SS6-6, 7, 16, 17, 18, 19 and 20, were collected during two rounds of sampling. One sediment sample, SE6-02, was collected from a drainage basin at Site 6 to characterize possible contamination of surface drainage. One downgradient monitoring well, MW6-03, was installed and two groundwater samples were collected (one from each round of sampling). A slug test was conducted in MW6-03 to calculate the hydraulic conductivity of the overburden material. The results are presented in Section 3.

2.4.5.6 Ammunition Area. A groundwater sample was collected from the well in the Ammunition Area (Well 530).

2.5 BACKGROUND SAMPLING FOR BASELINE DATA

In the area south of building 16, a background boring was drilled and two analytical samples collected. This boring was completed as a monitoring well and one groundwater sample collected. One sediment and one surface water sample were collected from a drainage ditch off-site, north of building 18. In addition, two surface soil samples were collected to assure adequate representation of background conditions.

2.6 DISPOSAL OF WASTES FROM FIELD ACTIVITIES

Wastes from field activities included both solid and liquid wastes.

2.6.1 Solid Waste

2.6.1.1 Soil Cuttings. Soil cuttings generated from soil borings and piezometer and monitoring well installation were screened for volatile organic compounds (VOCs) using an HNu photoionization detector or an organic vapor analyzer. Soil boring cuttings which did not exceed 10 ppm volatile organics were stored on plastic until review of laboratory analyses. Piezometer and monitoring well cuttings were spread on the ground near the boring, since screening results were below 10 ppm volatile organics. Soils in which VOCs were detected above 10 ppm, were drummed, labelled, and stored on base. Base personnel moved and disposed of non-hazardous cuttings at a location designated appropriate by the BCE. M&E personnel completed manifest forms and BCE personnel arranged for disposal at a Treatment Storage Disposal Facility (TSDF) for hazardous materials generated (i.e. waste solvents or acids from decontamination/ sampling activities). Base personnel contacted IDEM for approval of disposal of boring soils.

2.6.1.2 Personnel Protection Equipment. All solid waste such as general trash and personal protective equipment was handled and disposed of as a "non-hazardous" routine base waste. Air monitoring scans for volatile organic compounds (VOCs) were performed on all solid wastes

using an HNu photoionization detector or organic vapor analyzer prior to disposal. Scans did not indicate that the level of contamination in the solid waste were above 10 ppm.

2.6.2 Liquid Waste

2.6.2.1 Decontamination Water. The liquid waste generated on-site during decontamination procedures of drilling and sampling equipment were allowed to drain back on-site. The decontamination areas were designated by BCE personnel. Decontamination liquids containing solvents or acids, were drummed and disposed of at a TSDF. Disposal was arranged by BCE personnel.

2.6.2.2 Well Development Water. The liquid waste generated from well and piezometer development was contained and sampled for volatile organic compounds to determine the potential hazardous nature of such waste. The development water samples were analyzed at a local laboratory (Valley Testing in Terre Haute). Results are listed in Appendix F. Following review of the analytical data by HAZWRAP Project Manager and a discussion with the Indiana Department of Environmental Management, it was determined that the monitoring well purge water could be disposed on-site.

2.6.2.3 Well Sampling Purge Water. Disposal of well sampling purge water was dependent on analytical results obtained from the sampling of well development water. The analytical results indicated that the development water from each well was non-hazardous, so the well sampling purge water was allowed to drain back on site.

3.0 SIGNIFICANCE OF RESULTS

Each site under investigation has been evaluated on the basis of site history, results from SI data collection (laboratory and field survey results), and assessment of site hydrogeology. In this section, SI activities are discussed by site, and laboratory analytical data for soil and groundwater are presented and results are summarized. The significance of the chemical analyses as they relate to existing or potential health risks, and fate and transport issues are discussed in Section 4.0.

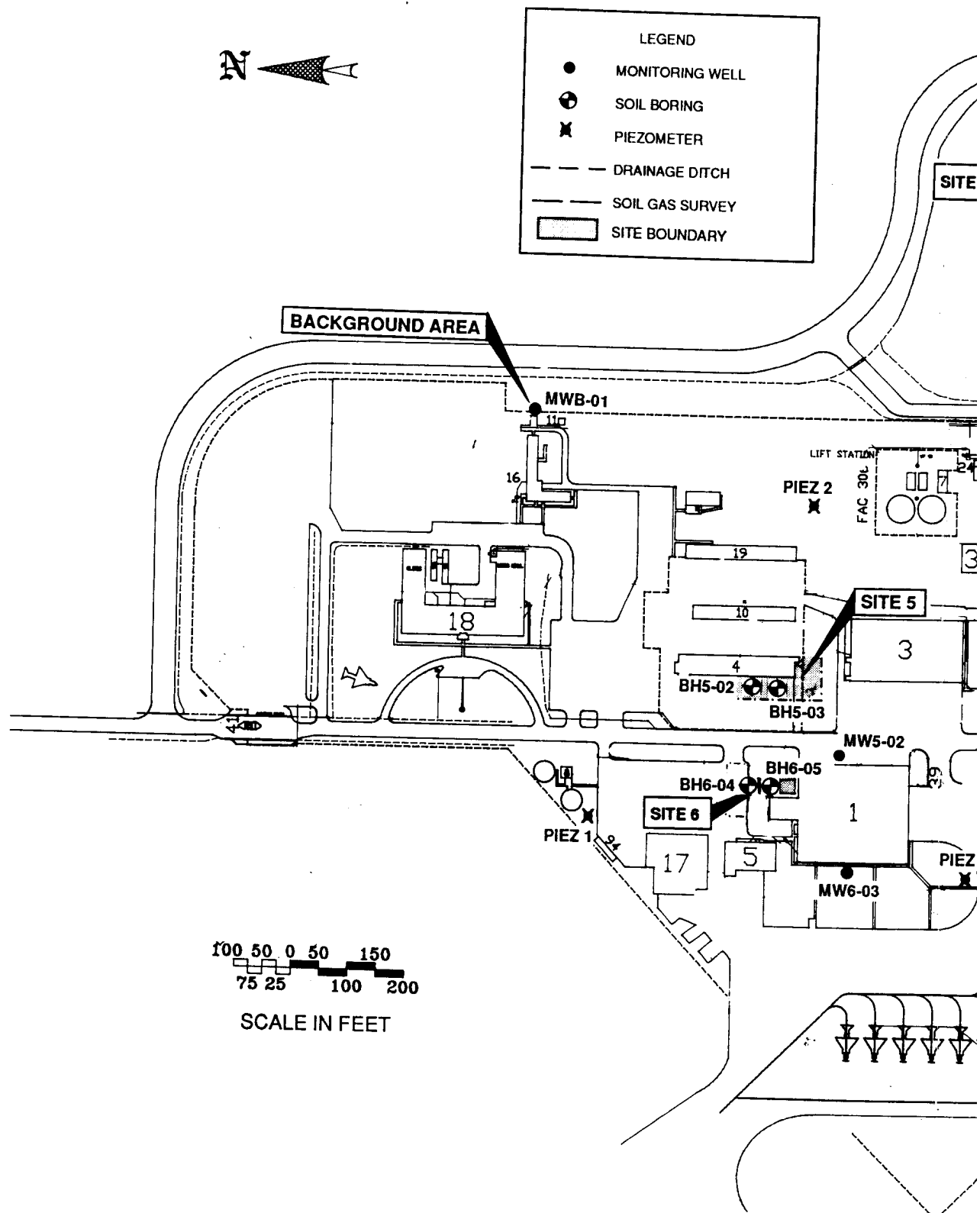
Sampling locations are illustrated in Figure 3-1. The analytical tables and summary tables presented in this section include all samples collected during Round 1 and Round 2 of the SI and those analytes for which there was at least one reported value greater than the instrument detection limit. Appendix F contains a summary of QA/QC results, validation summaries, and definitions for data flags.

The depths and thickness of the subsurface strata indicated on cross sections discussed herein were generalized from and interpolated between test borings. Information on actual subsurface conditions exists only at the specific locations and dates indicated.

3.1 BASE GEOLOGY, GROUNDWATER OCCURRENCE AND MOVEMENT

Generally, the site geology at Hulman ANG Base is relatively consistent with a brown loess deposit overlying clayey sands which in turn overlie glacial till. A dense till was encountered at 14 to 18 feet. According to logs from wells within one mile radius of the site, the depth to bedrock generally ranges from 50 to 70 feet.

Saturated soils were first encountered in the unconsolidated sediments above the dense till at depths of six to twelve feet below ground surface. However, when boreholes were completed



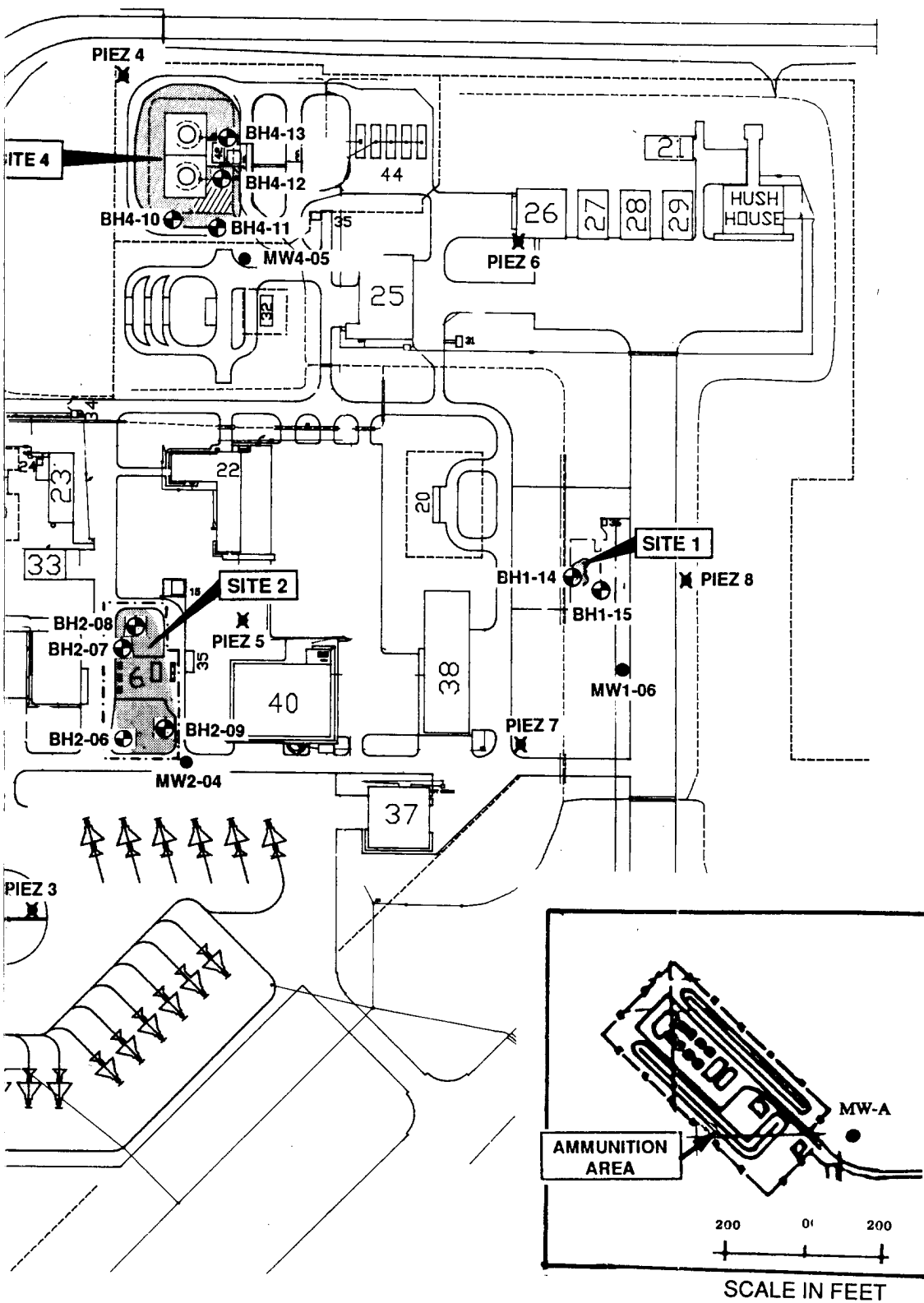


FIGURE 3-1. SI SAMPLING LOCATIONS
181ST FG HULMAN MAP,
TERRE HAUTE, IN

and piezometers and monitoring wells installed, the static water level was one to two feet below ground surface.

The occurrence and movement of groundwater at the site is influenced by the hydraulic properties of the saturated subsurface media. Groundwater in the shallow overburden was found to flow predominantly to the southwest towards the Wabash River, which is approximately 7 miles from the base (Hartke and others, 1983).

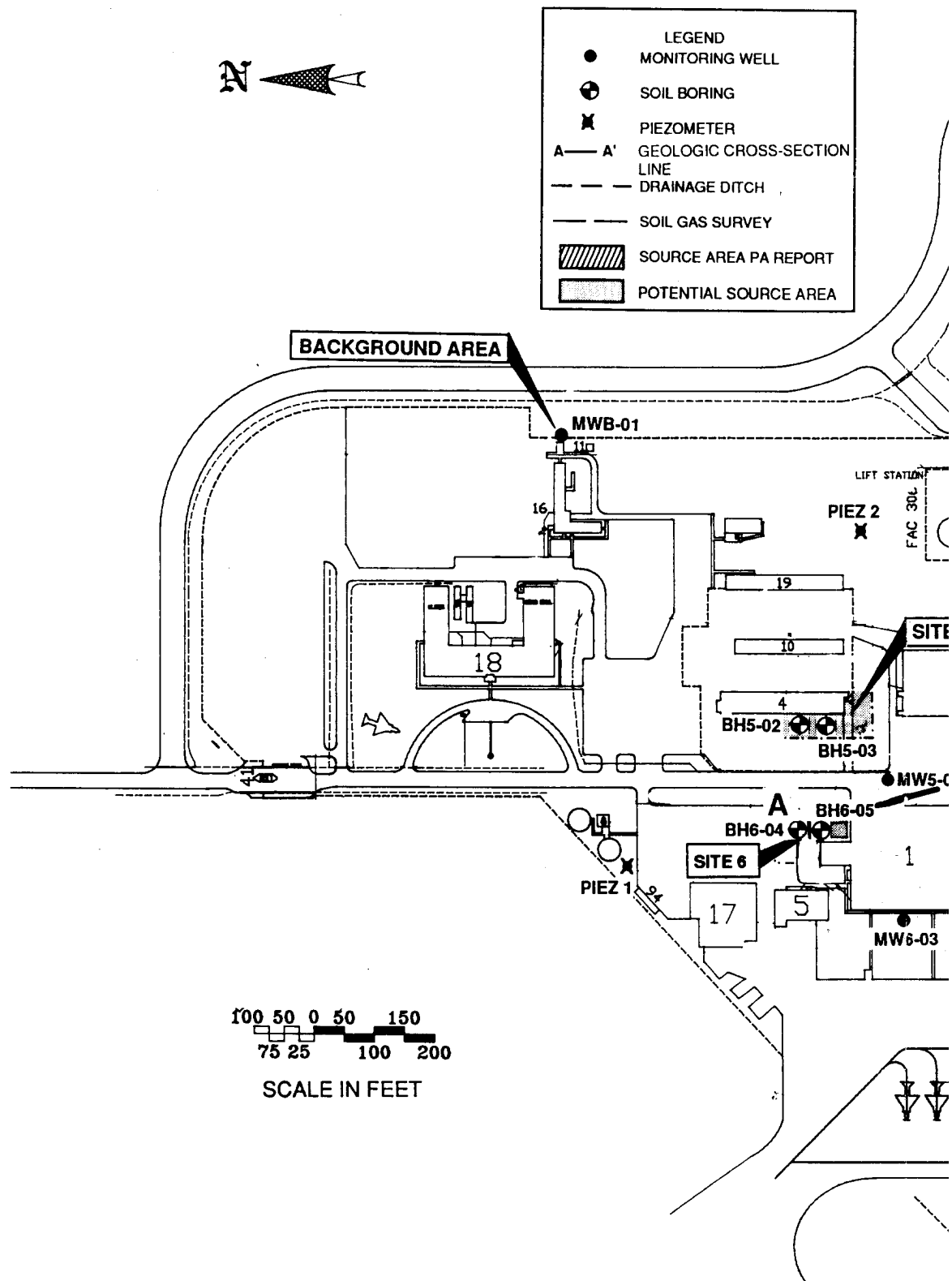
Hydraulic gradients at individual sites ranged between 0.004 and 0.013.

3.1.1 Site Stratigraphy

The soil conditions at each piezometer, monitoring well, and soil boring location are described in boring logs, presented in Appendix A. Two geologic cross sections indicated in Figure 3-2 are illustrated in Figures 3-3 and 3-4. The uppermost bedrock unit beneath the base is the Pennsylvanian age Petersburg Formation. This formation is composed of massive, fine to medium grained sandstone with minor interbedded shale and coals and is 30 to 75 feet thick beneath the base.

A dense glacial till was typically encountered in site borings at depths of 14 to 18 feet. Beneath Hulman ANG Base, the till is a grey, semi-consolidated, poorly sorted silty clay with fine to coarse grained sands and subangular pebbles and gravel. The upper one foot of the till is weathered and saturated. The underlying dense till is typically unsaturated and its occurrence correlated with a sharp increase in blow counts for samples collected during the soil boring program. This dense till may act as a partially confining layer. The till overlies bedrock of the Petersburg Formation in this area.

A thin layer of brown sandy silt clay overlays the weathered till at the base in some locations. The erosional contact is recognizable by the increasing clay content, decreasing pebble content,



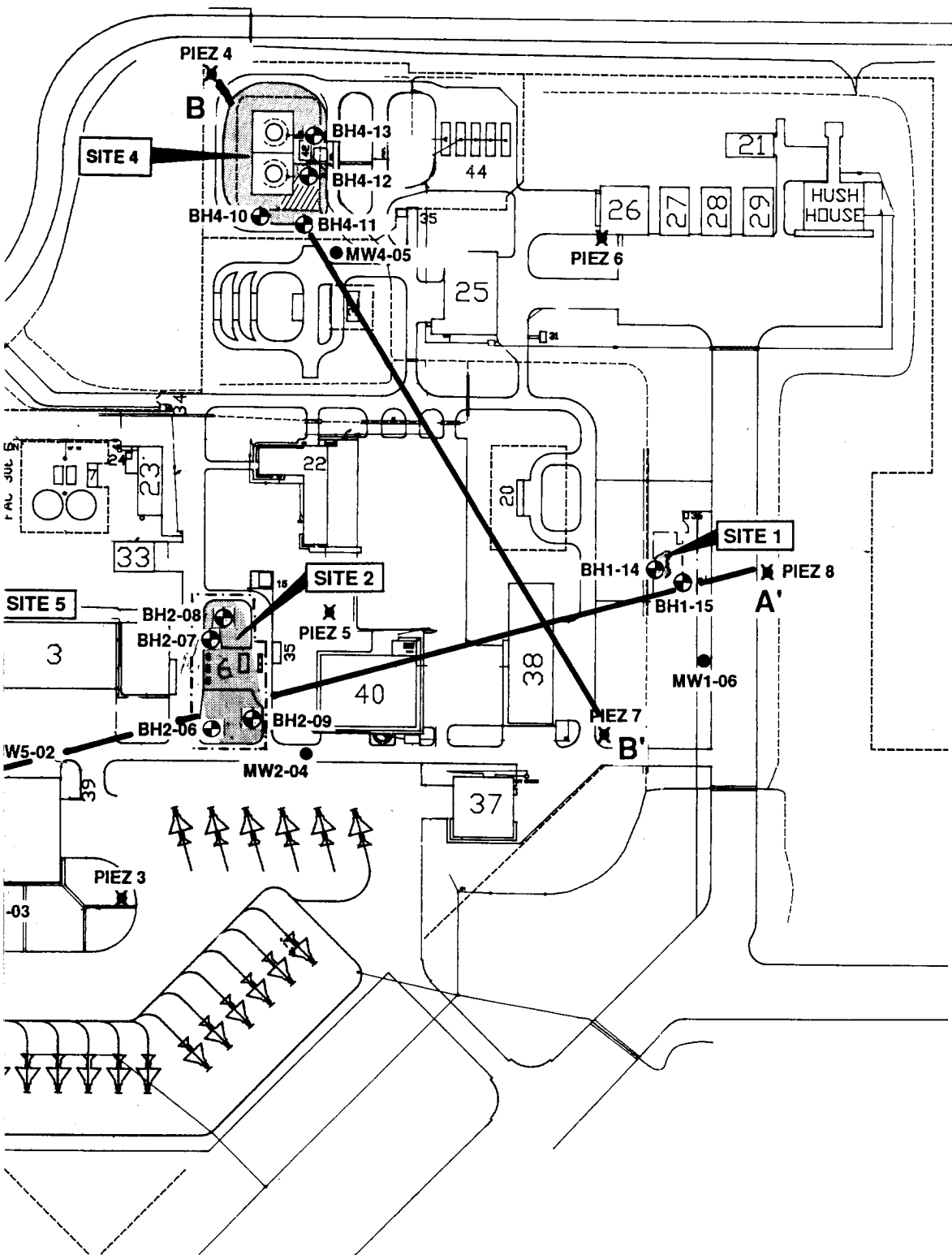


FIGURE 3-2. GEOLOGIC CROSS-SECTION
 LINES A-A', B-B'
 181ST FG, HULMAN FIELD MAP
 TERRE HAUTE, IN

NORTH

A

BH6-04

EI. 585.90

712093.3N

439755.4W

Projected 150' W

MW5-02

EI. 585.2

Projected 115' W

BH2-06

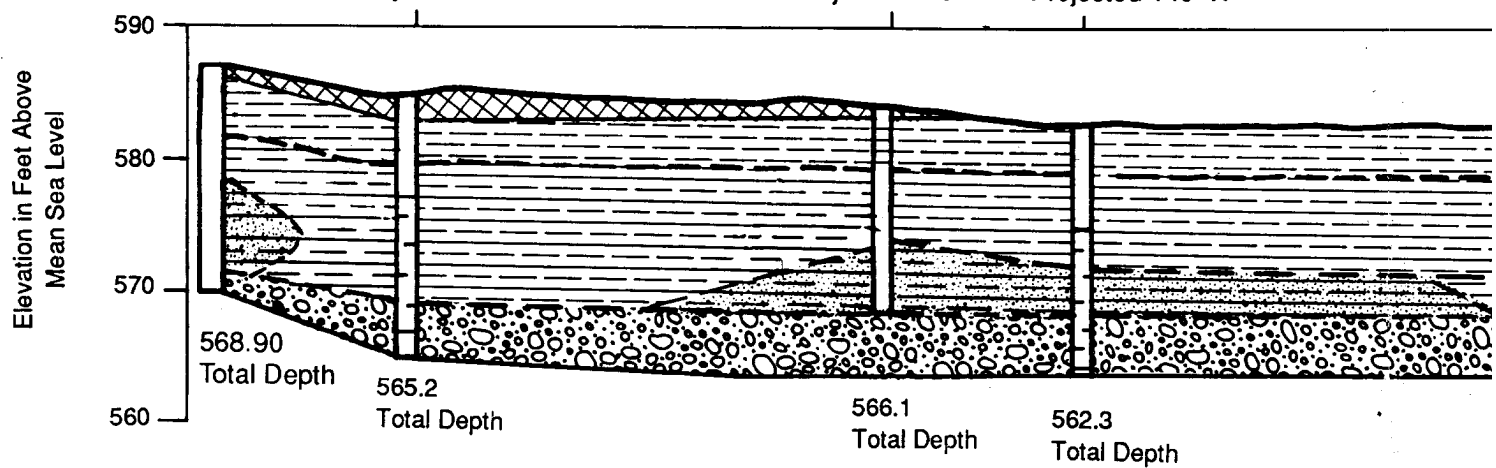
EI. 583.60

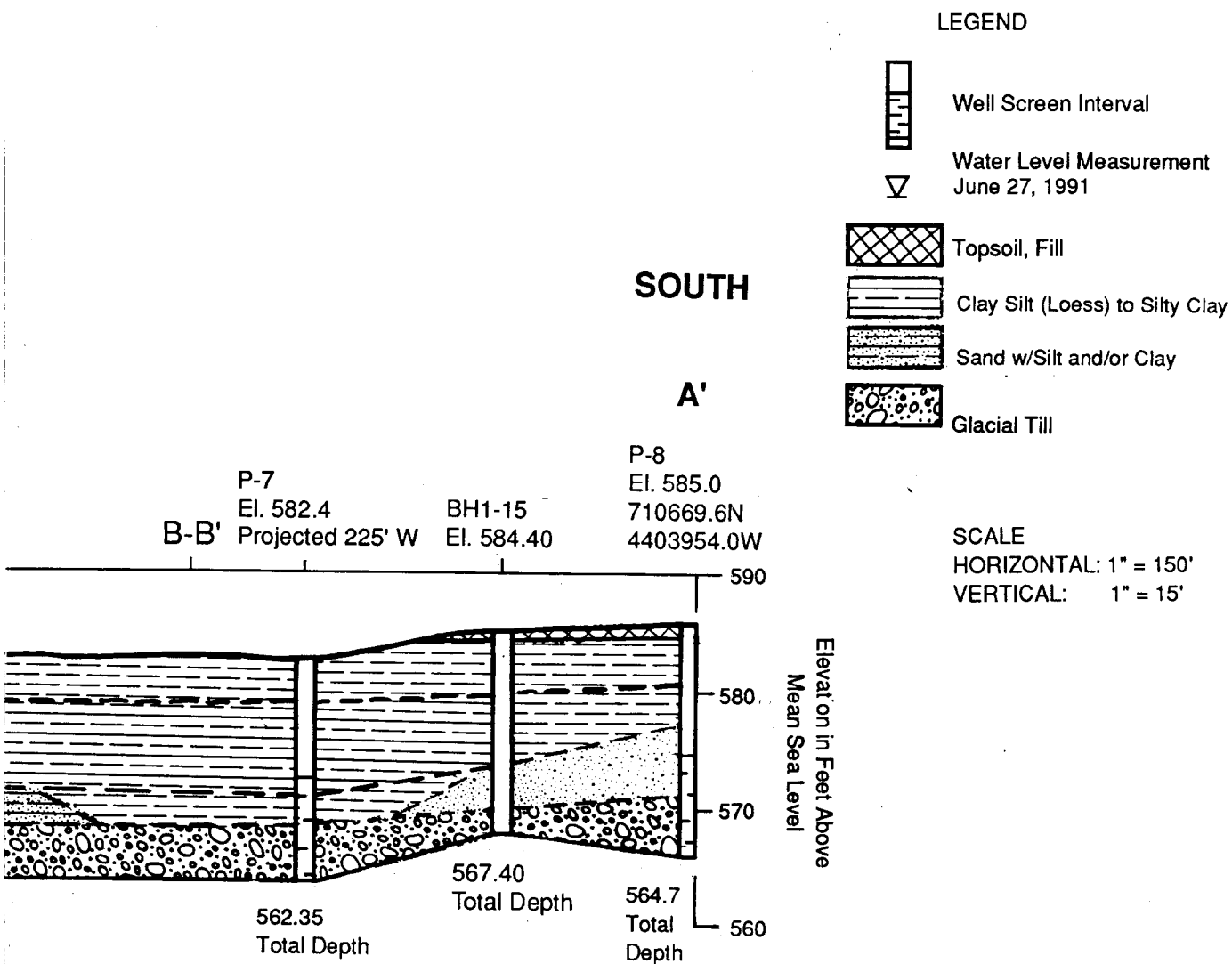
Projected 123' W

MW2-04

EI. 582.4

Projected 140' W



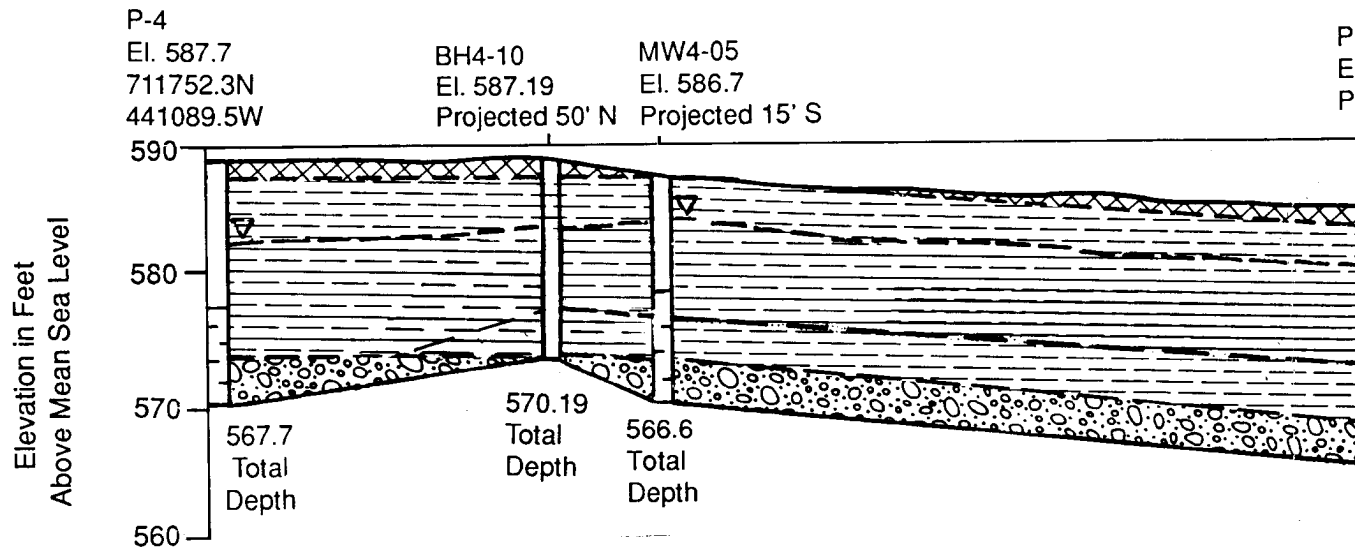


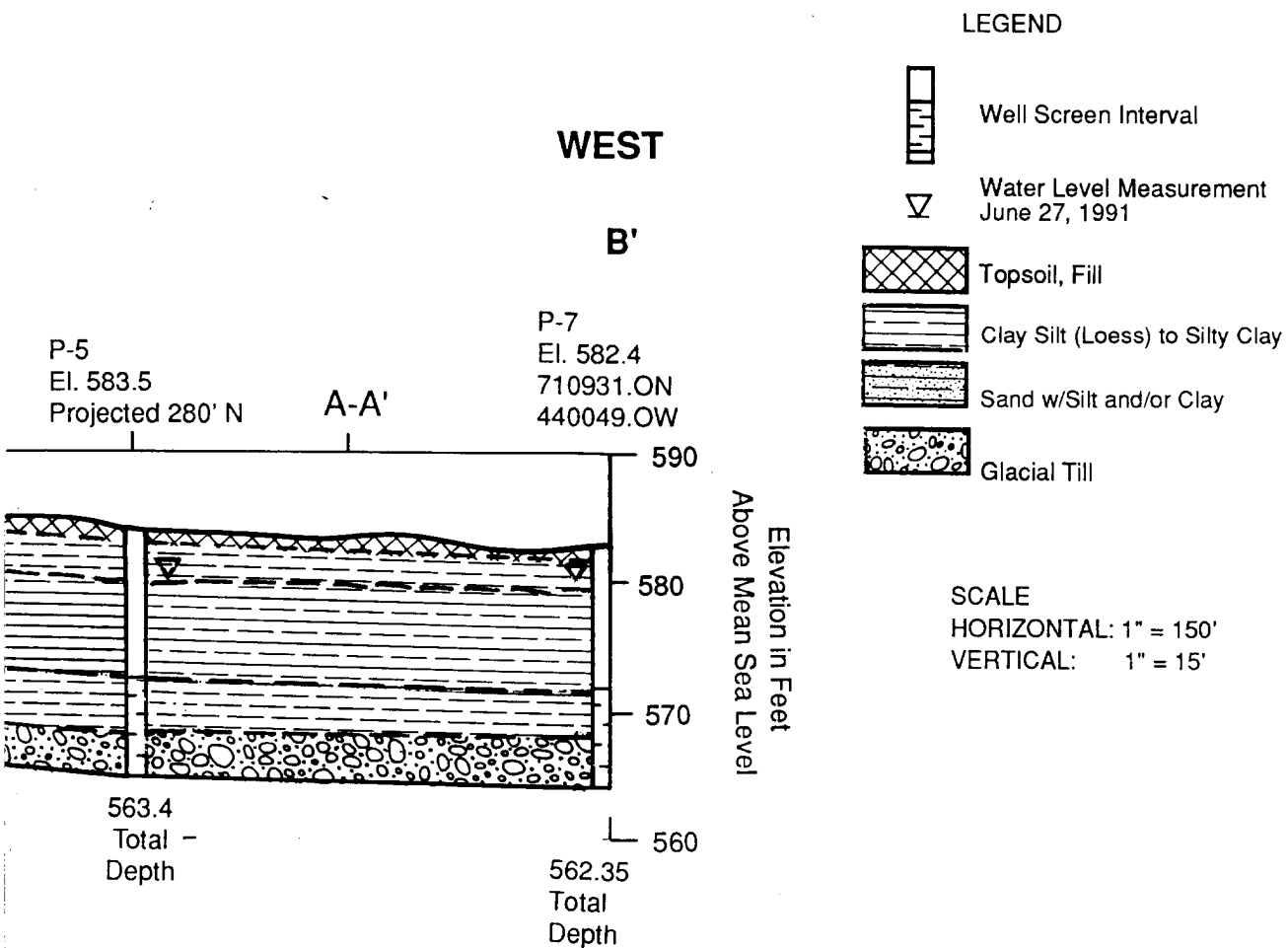
Note: Elevations Reflect Ground Surface and Total Depth of Piezometers, Monitoring Wells and Borings.

FIGURE 3-3.
A-A' GEOLOGIC CROSS SECTION-
HULMAN FIELD, 181ST FG, TERRE HAUTE, IN

EAST

B





Note: Elevations Reflect Ground Surface and Total Depth of Piezometers, Monitoring Wells and Borings.

FIGURE 3-4.
B-B' GEOLOGIC CROSS SECTION-
HULMAN FIELD 181ST FG, TERRE HAUTE, IN

and decreasing heterogeneity associated with the sandy clay. These sandy clays are one to four feet thick with occasional plant fragments and are interpreted as alluvial sediments.

Brown loess is present on top of the alluvial sediments. The loess consists of clayey silts in the upper 10 to 12 feet. Published geologic reports (Hartke et al., 1983; Cable et al., 1971) refer to this silty unit as loess (wind-blown silts), however, the material observed in site borings contained a higher proportion of clay than would be expected in a typical loess.

3.1.2 Site Hydrogeology

Groundwater exists under water table conditions in the unconsolidated sediments above the dense till at the base. Six monitoring wells and eight piezometers were installed in this unit in late September and early October 1990 (see Appendix B). Groundwater level measurements were collected on October 14 and 16, 1990 in the piezometers only (prior to monitoring well installation) on November 9, 1990 in the monitoring wells only, and February 20, 1991, June 27, 1991 and January 17, 1992 in both monitoring wells and piezometers. The elevations determined from these measurements were used to determine the groundwater flow direction in the unconsolidated, water bearing sediments. Table 3-1 presents these measurements as piezometric surface elevations and Figures 3-5 through 3-9 presents the groundwater contours for the six dates.

During the hollow stem augering/split-spoon sampling, saturated soils were typically encountered at depths of six to twelve feet. However, when boreholes were completed with screens and filter packs for use as wells and piezometers, the piezometric surface reflected by the static water level was one to two feet below the ground surface. This indicates that the overlying clayey silt loess unit may act to partially confine water in the upper water bearing sediments.

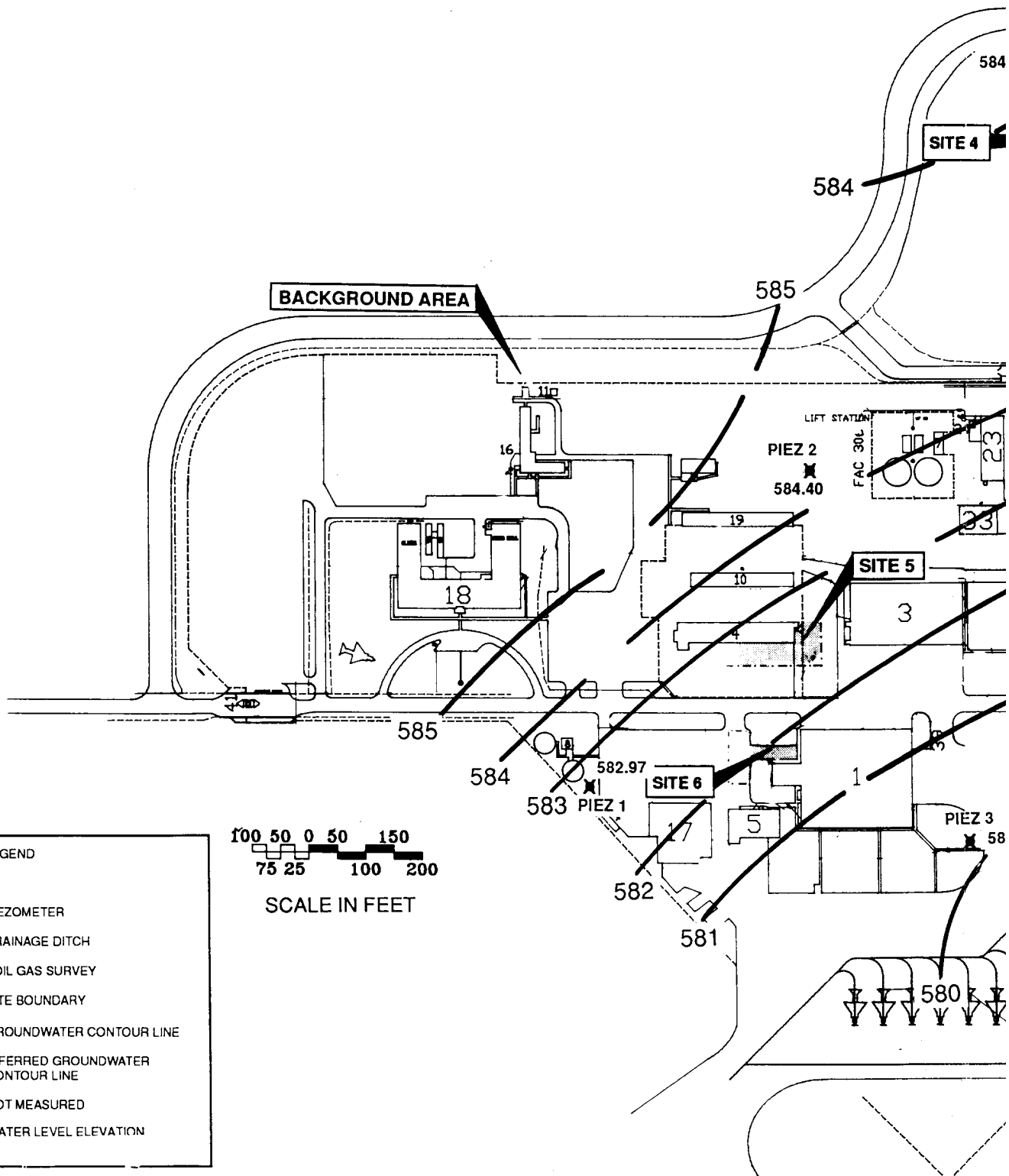
Slug tests were conducted at the base on November 27 and 28, 1990, to determine the hydraulic conductivity (K) for the unconsolidated sediments at each monitoring well location. The hydraulic conductivity ranged from 6.60×10^{-4} to 3.61×10^{-5} cm/sec across the base in this

TABLE 3-1. PIEZOMETRIC SURFACE ELEVATIONS

Piezometer/ Well ID No.	Elevation (ft. MSL)		Piezometric Surface Elevation (ft. MSL)					
	Ground Surface	Top of Well Casing	October 14, 1990	October 16, 1990	November 9, 1990	February 20, 1991	June 27, 1991	January 17, 1992
MW1-06	583.9	583.33	NM ^(a)	NM ^(a)	580.09	581.07	579.61	580.6
MW2-04	582.4	581.89	NM ^(a)	NM ^(a)	579.21	580.02	579.55	579.3
MW4-05	586.7	586.16	NM ^(a)	NM ^(a)	580.82	585.19	583.94	584.2
MW5-02	585.2	584.64	NM ^(a)	NM ^(a)	579.46	579.88	579.36	NM ^(d)
MW6-03	586.4	585.81	NM ^(a)	NM ^(a)	579.39	581.64	581.34	581.1
MWB-01	588.6	588.05	NM ^(a)	NM ^(a)	585.02	> 588.05	585.47	NM ^(d)
P-1	585.7	585.32	582.97	582.65	NM ^(b)	583.78	582.02	583.1
P-2	587.1	586.75	584.40	583.30	NM ^(b)	585.86	582.46	584.1
P-3	585.7	585.06	580.21	580.06	NM ^(b)	581.04	579.68	580.5
P-4	587.7	587.21	584.26	583.91	NM ^(b)	NM ^(c)	582.41	586.8
P-5	583.5	583.09	581.34	581.06	NM ^(b)	581.65	579.94	580.7
P-6	588.5	588.10	585.80	585.48	NM ^(b)	585.82	584.95	NM ^(d)
P-7	582.4	582.02	580.62	580.20	NM ^(b)	581.07	579.30	580.4
P-8	585.0	584.70	581.40	581.23	NM ^(b)	581.93	580.66	581.7

Notes:

- a. Not measured (prior to monitoring well installation)
- b. Not measured during well sampling
- c. Point not measured due to inaccessibility to field personnel for security reasons
- d. Point not measured, as well had been removed or was inaccessible
- > - Actual value is greater than the value shown



CONTOUR INTERVAL = 1 FT.

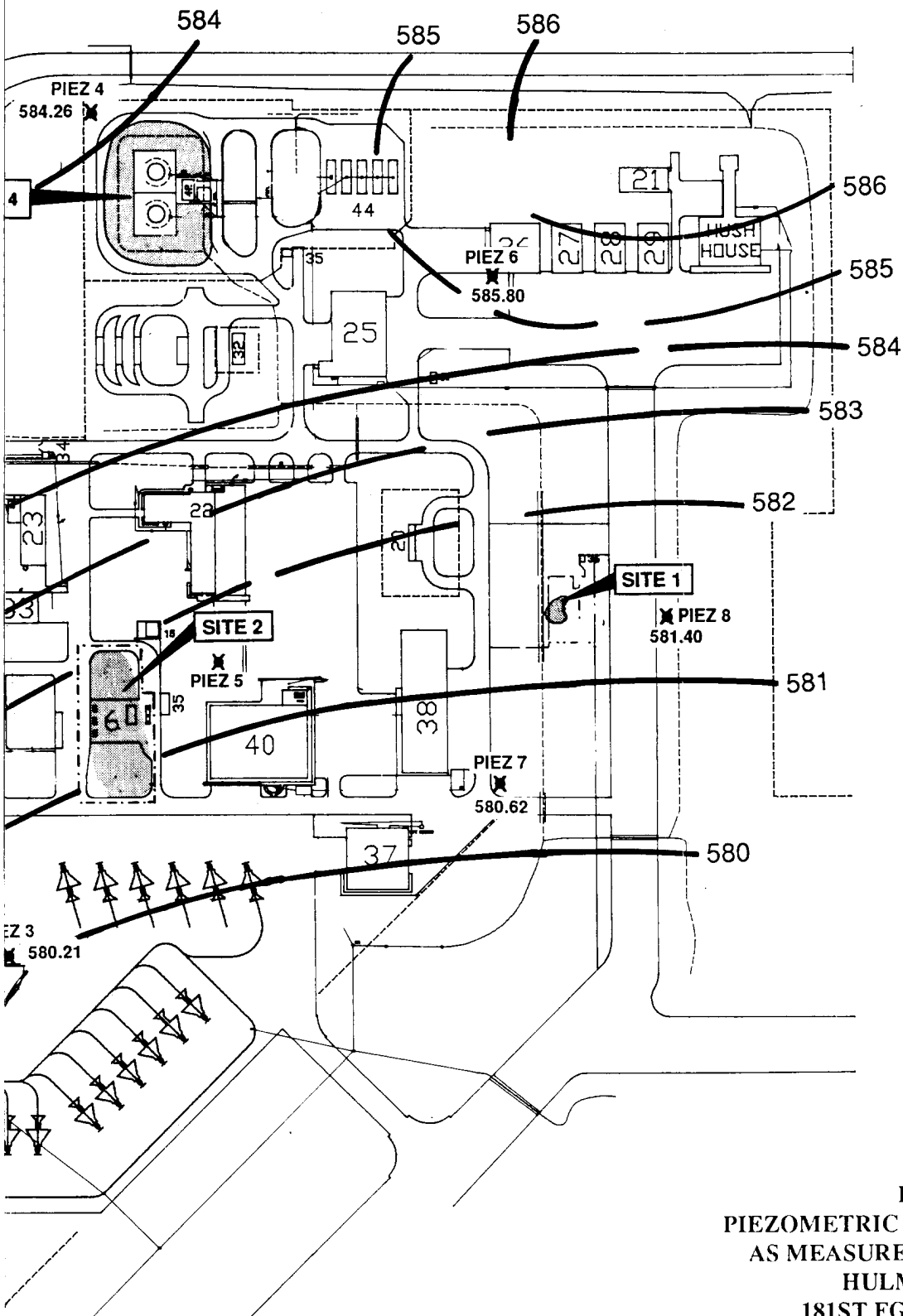
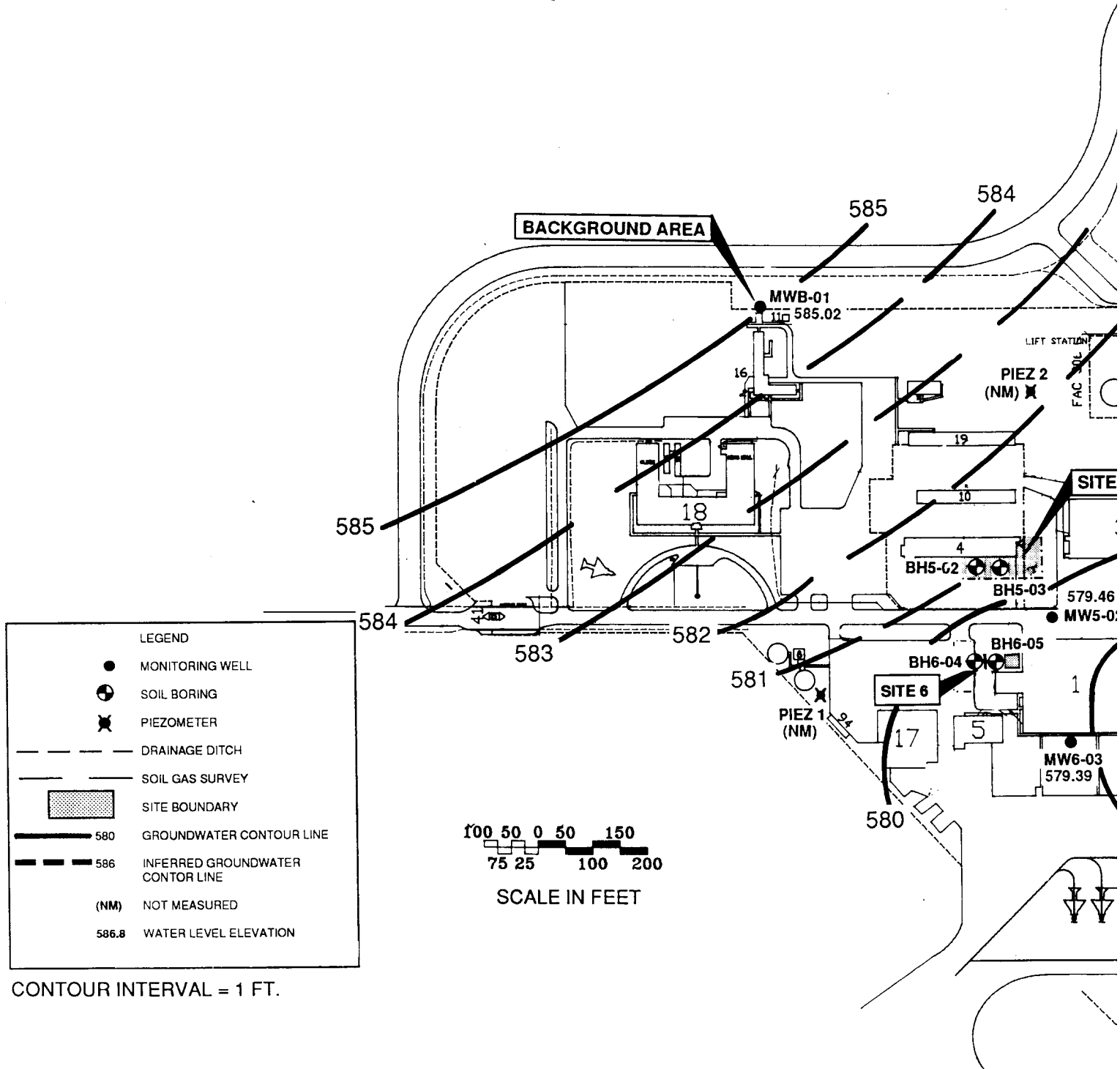


FIGURE 3-5.
PIEZOMETRIC SURFACE CONTOUR MAP
AS MEASURED ON OCTOBER 14, 1990
HULMAN FIELD MAP
181ST FG, TERRE HAUTE, IN



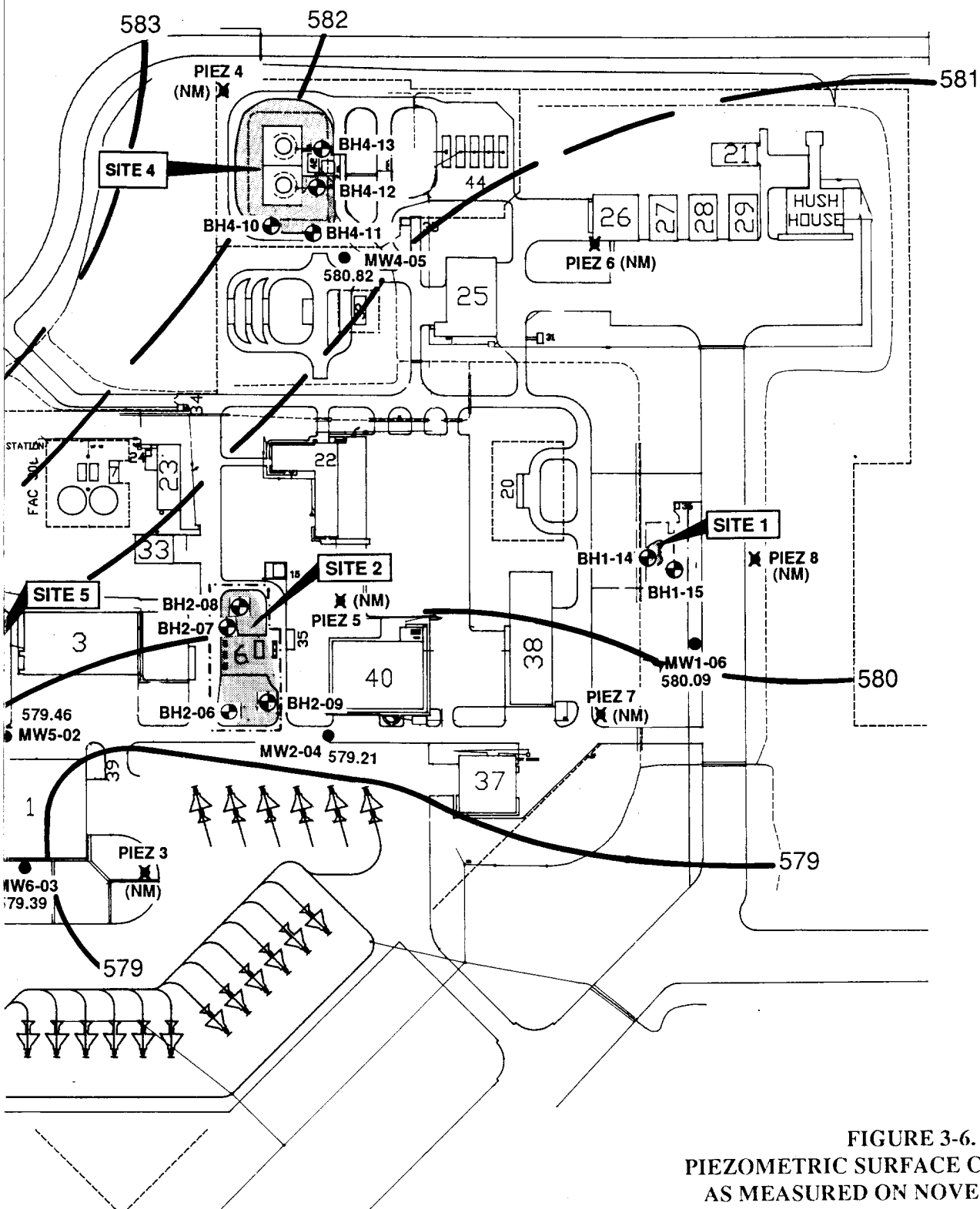


FIGURE 3-6.
PIEZOMETRIC SURFACE CONTOUR MAP
AS MEASURED ON NOVEMBER 9, 1990
HULMAN FIELD MAP
181ST FG, TERRE HAUTE, IN

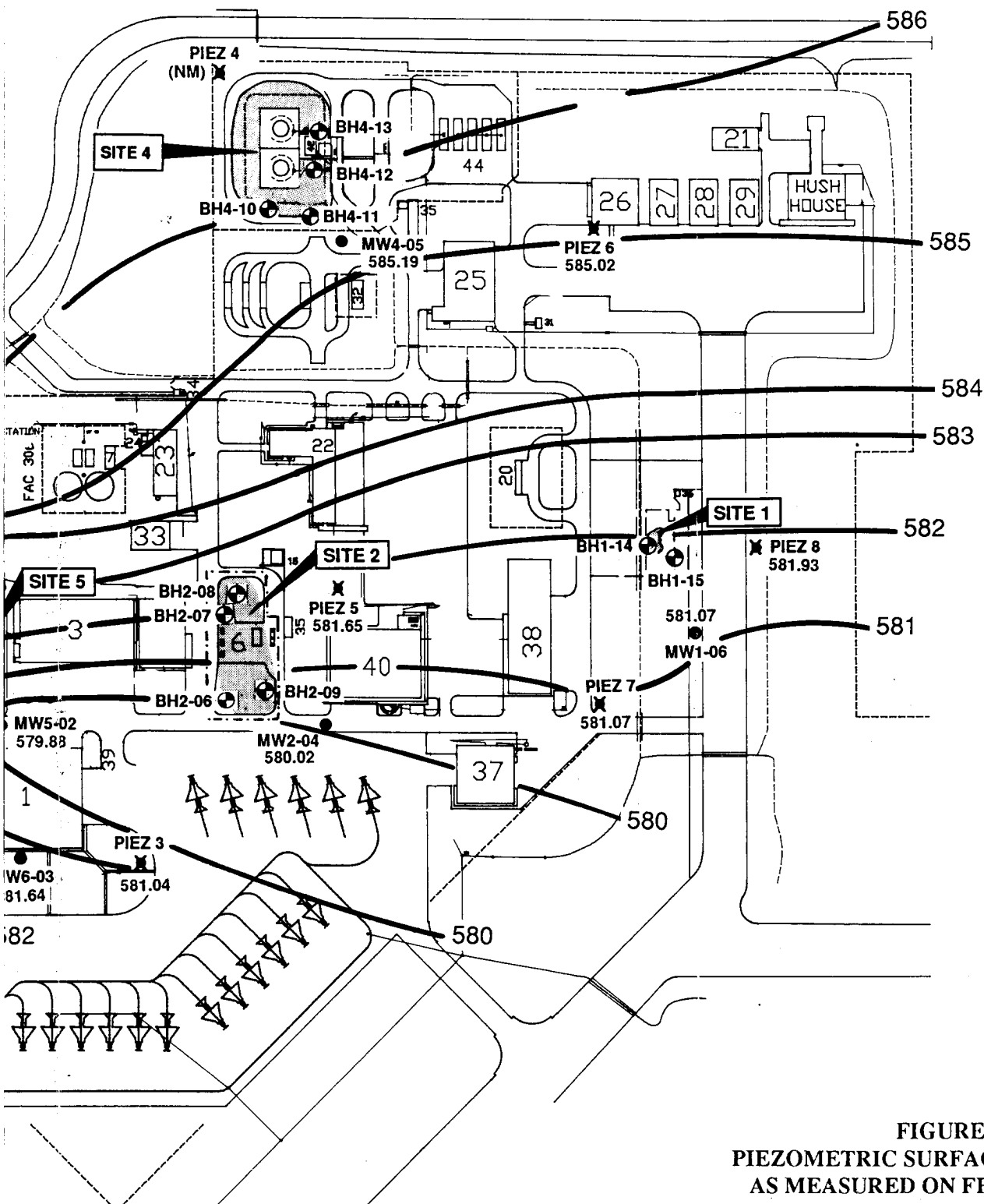
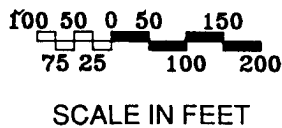
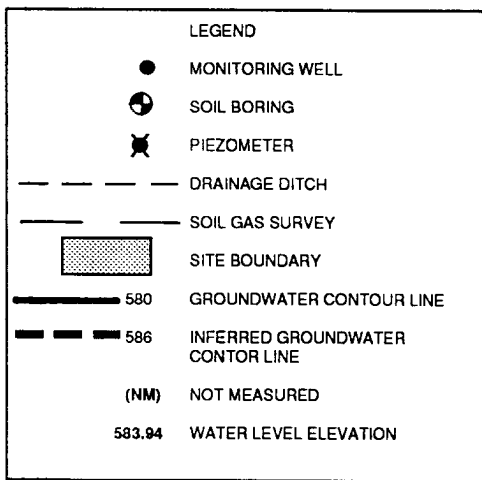
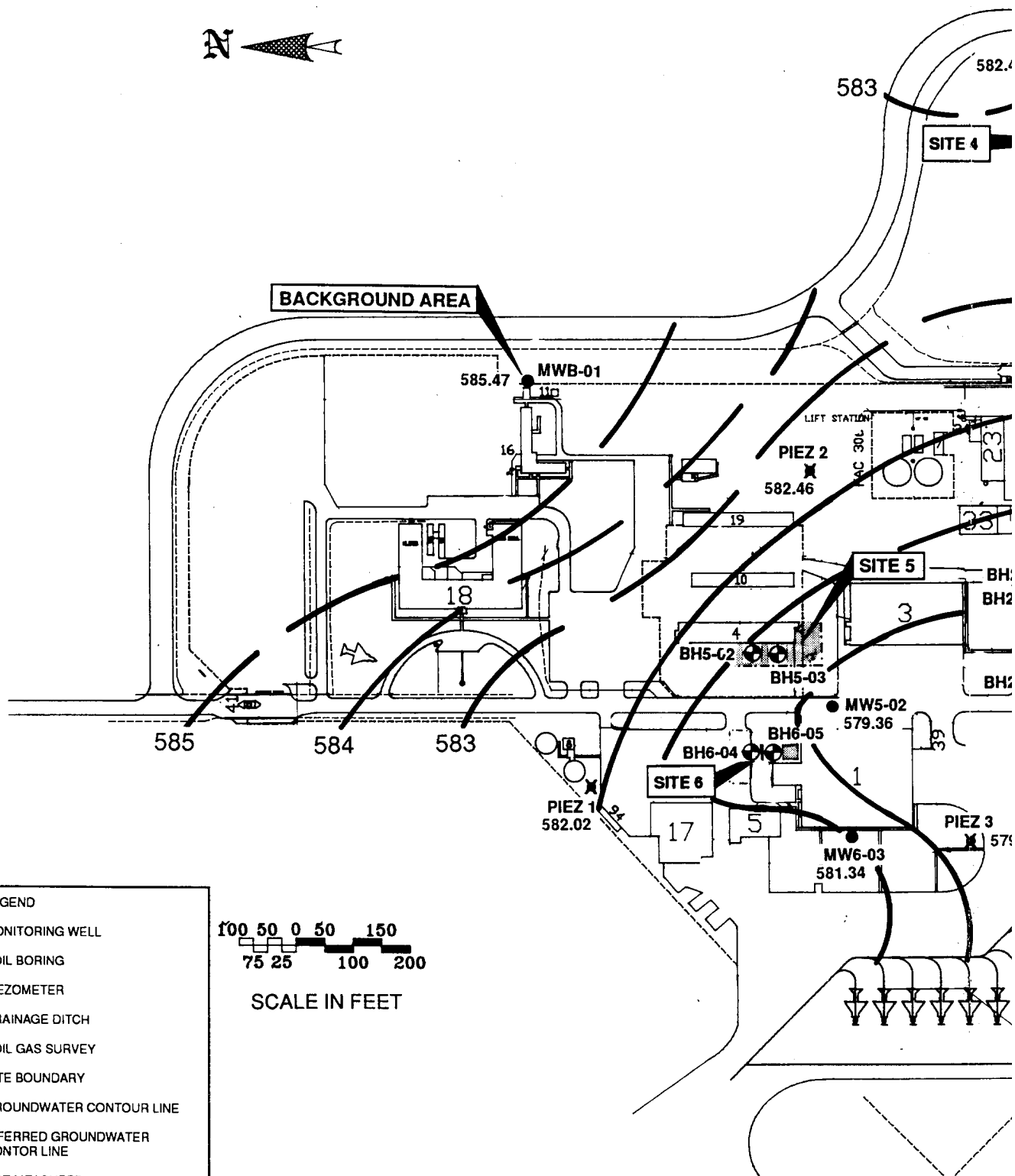


FIGURE 3-7.
 PIEZOMETRIC SURFACE CONTOUR MAP
 AS MEASURED ON FEBRUARY 20, 1991
 HULMAN FIELD MAP
 181ST FG, TERRE HAUTE, IN



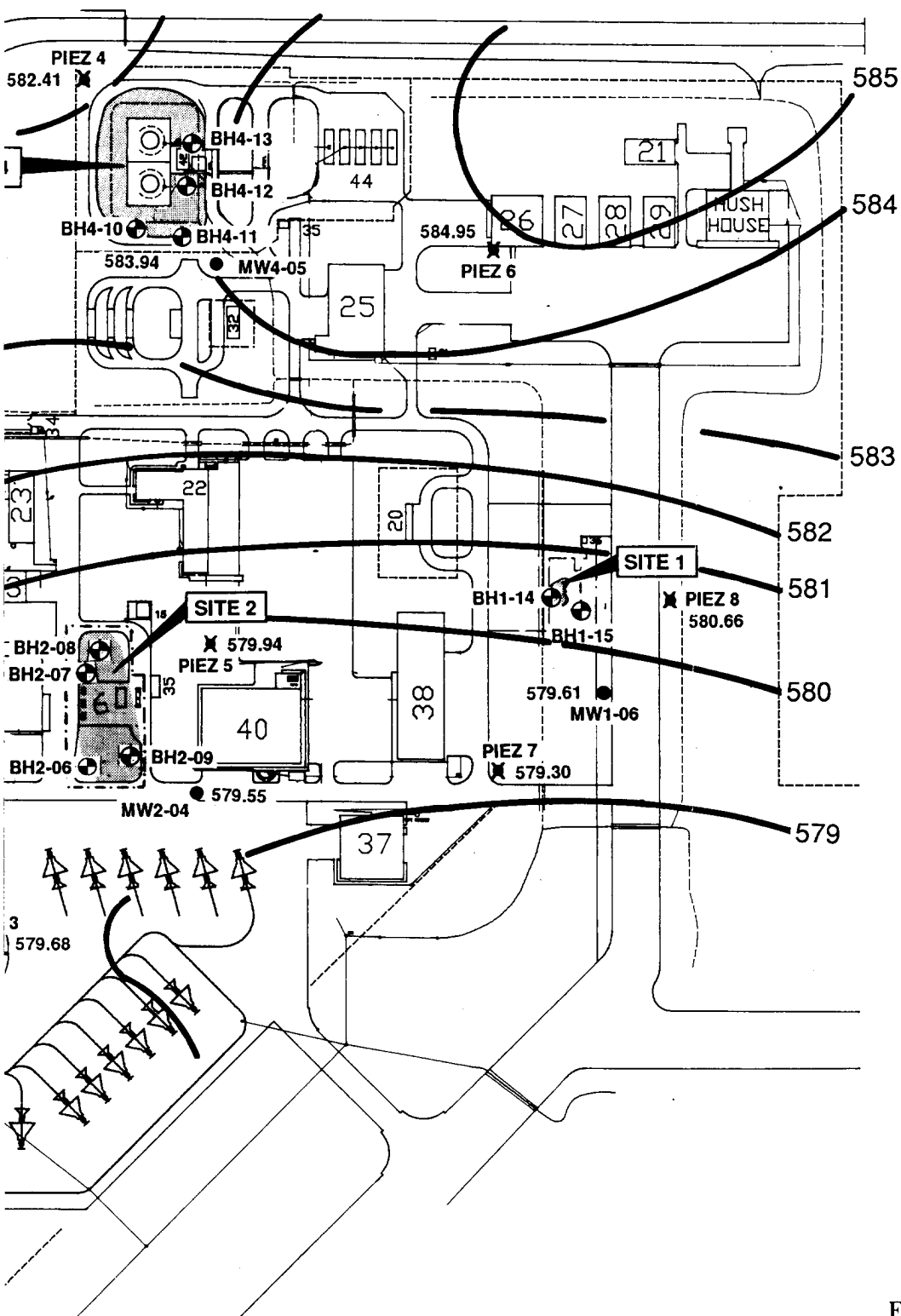
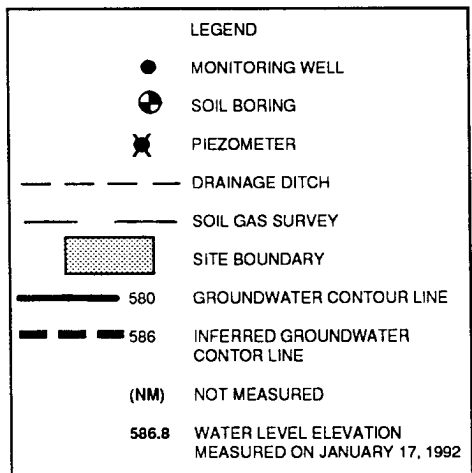
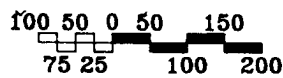


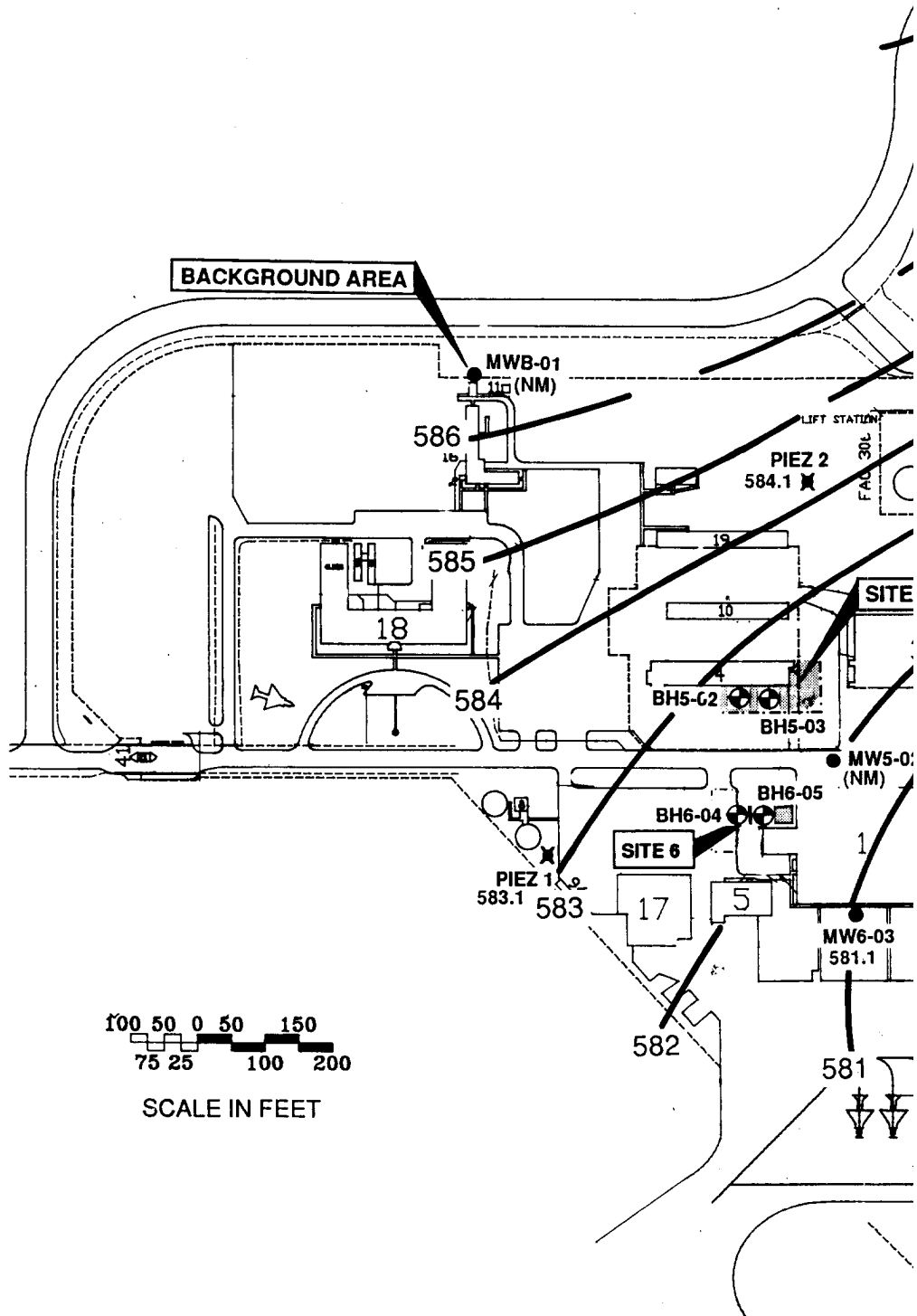
FIGURE 3-8.
 PIEZOMETRIC SURFACE CONTOUR MAP
 AS MEASURED ON JUNE 27, 1991
 HULMAN FIELD MAP 181ST FG, TERRE HAUTE, IN



CONTOUR INTERVAL = 1 FT.



SCALE IN FEET



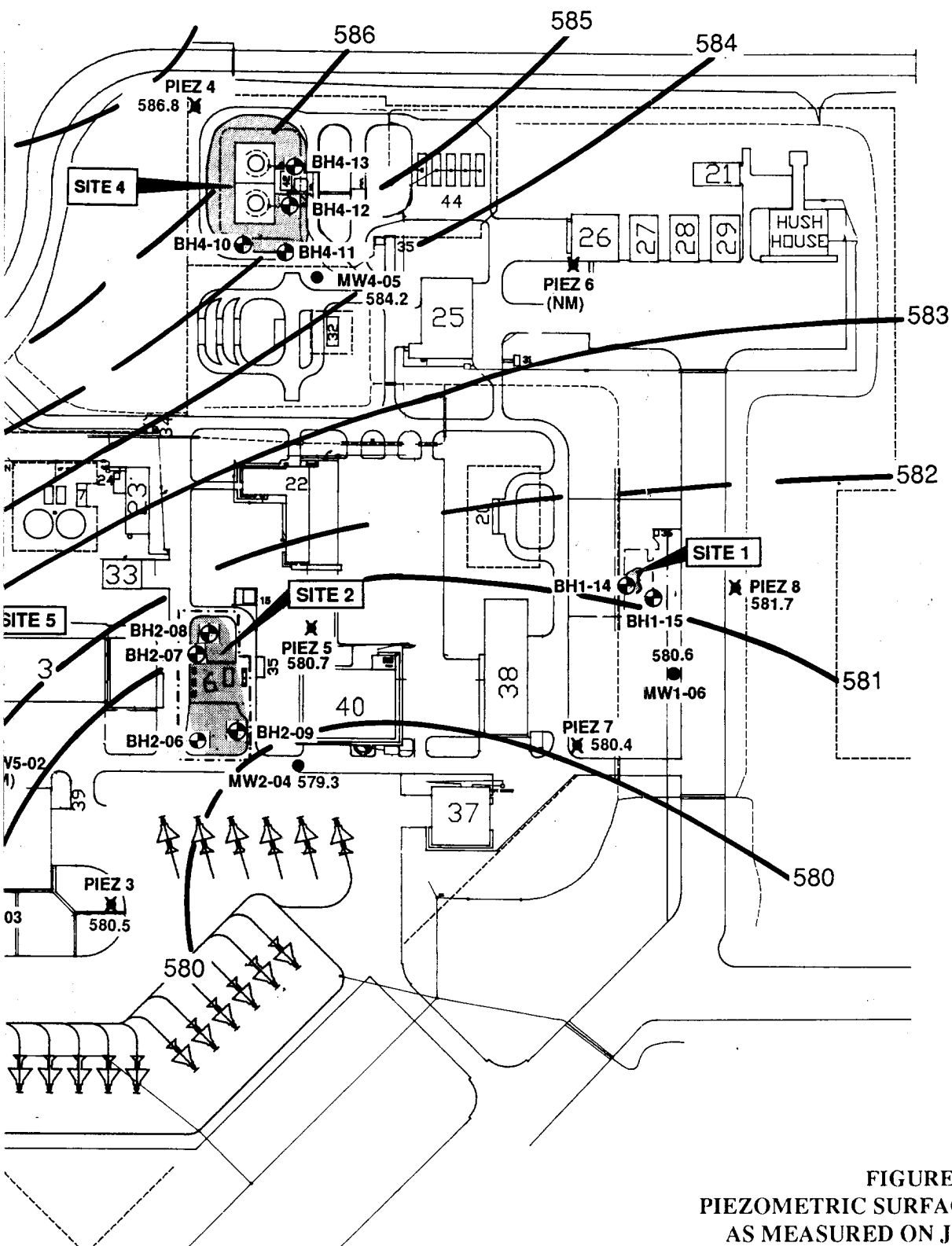


FIGURE 3-9.
PIEZOMETRIC SURFACE CONTOUR MAP
AS MEASURED ON JANUARY 17, 1992
HULMAN FIELD MAP
181ST FG, TERRE HAUTE, IN

upper water-bearing zone. The Bouwer and Rice method (1986) was used to calculate the hydraulic conductivities. The calculations are presented in Appendix C. The individual values are presented on Table 3-2. These calculated values are consistent with published values for similar sediments. Table 3-3 presents the approximate gradient, velocity, and groundwater flow direction for the February 20, 1991, June 27, 1991 and January 17, 1992. Computer generated groundwater contour maps and three dimensional groundwater surface plots included in Appendix E were used to determine these values.

The dense till below the unconsolidated upper water bearing sediments probably acts as a partially confining layer beneath the base. Geologic logs for monitoring wells installed at the base (Appendix A) illustrate that the unweathered till was dry, while the weathered till was saturated to moist. Table 3-4 presents the dry till surface elevations and Figure 3-10 presents a structure contour map, or elevation map, of the unweathered till surface. Computer generated contours of the till and ground surface are also presented in Appendix E. Generally, the till surface and groundwater contours exhibit a similar pattern.

3.2 BACKGROUND SAMPLING RESULTS

Background samples were collected for surface and subsurface soils, groundwater, surface water, and sediments in the expected upgradient portion of the base. Locations for background samples are presented in Figure 3-11. Subsurface soils were collected from one soil boring at depths of 2 to 4 feet, and 4 to 6 feet. The groundwater sample was collected from this boring location, after it was developed into a monitoring well. Surface soil samples were collected adjacent to building 11. The sediment and surface water samples were collected from a drainage ditch north of the area where other background media were sampled. This location was selected since surface water was not present within the ditch near the background locations.

**TABLE 3-2. SUMMARY OF HYDRAULIC CONDUCTIVITY VALUES
FROM SLUG TESTS**

Well ID	Calculated Hydraulic Conductivity (cm/second)
MWB-01	6.60×10^{-4}
MW1-06	6.73×10^{-5}
MW2-04	8.90×10^{-5}
MW4-05	1.90×10^{-4}
MW5-02	3.61×10^{-5}
MW6-03	2.00×10^{-4}

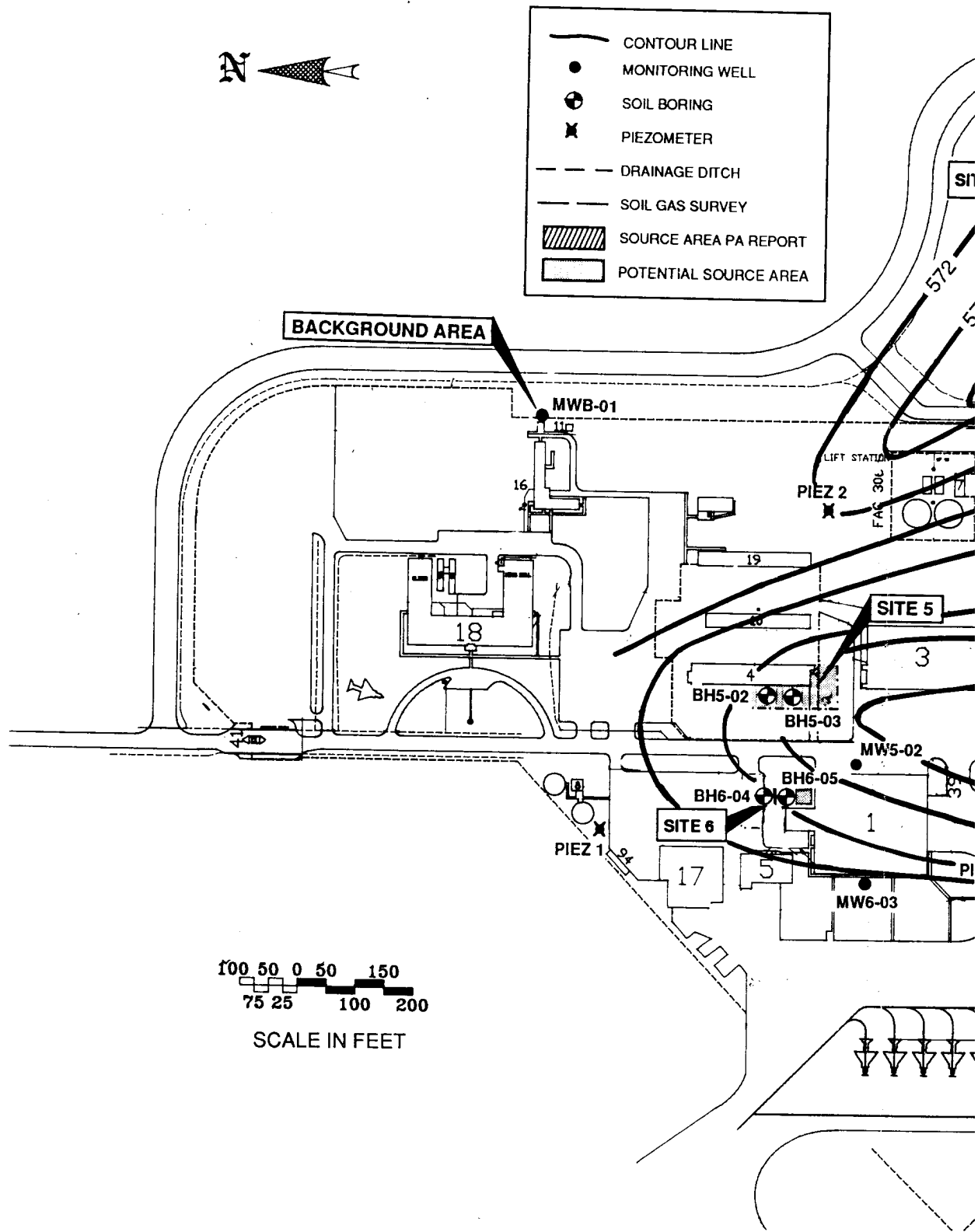
Table 3-3. Groundwater Gradient, Flow Direction and Flow Velocity
181st FG, Hulman Field MAP, Terre Haute, IN

Location	February 20, 1991			June 27, 1991			January 17, 1992					
	Gradient	Flow Direction	Flow Velocity (ft/day)	Gradient	Flow Direction	Flow Velocity (ft/day)	Gradient	Flow Direction	Flow Velocity (ft/day)			
Site 1	0.006	WSW	3.8E-03	1.4	0.007	WSW	4.5E-03	1.6	0.004	W	2.5E-03	0.9
Site 2	0.008	SW	6.7E-03	2.5	0.004	WSW	3.4E-03	1.2	0.007	SW	5.9E-03	2.1
Site 4	0.005	SW	9.0E-03	3.3	0.005	NNE	9.0E-03	3.3	0.006	SW	1.08E-02	3.9
Site 5	0.013	SW	4.4E-03	1.6	0.008	SW	2.7E-03	1.0	0.005	SW	1.7E-03	0.6
Site 6	0.009	SSE	1.05E-02	5.6	0.005	SE	8.6E-03	3.1	0.004	SSW	6.9E-03	2.5

(a) Velocity calculated based on the hydraulic conductivity value determined by slug test. See Appendix C.

TABLE 3-4. DRY TILL SURFACE ELEVATIONS

Piezometer/ Well/Boring No.	Surface Elevation	Top of Well Casing	Elevation of Dry Till	Depth to Dry Till (ft)
P-1	585.7	585.32	570.7	15.0
P-2	587.1	586.75	571.8	15.0
P-3	585.7	585.06	568.7	17.0
P-4	587.7	587.21	572.7	15.0
P-5	583.5	583.09	568.5	15.0
P-6	588.5	588.10	573.5	15.0
P-7	582.4	582.02	567.4	15.0
P-8	585.0	584.70	570.0	15.0
BHB-01/MWB-01	588.6	588.05	573.6	15.5
MW5-02	585.2	584.64	570.2	15.0
MW6-03	586.4	585.81	569.8	16.0
MW2-04	582.4	581.89	567.4	15.0
MW4-05	586.7	586.16	571.7	15.0
MW1-06	583.9	583.33	568.9	15.0
BH1-14	584.80		569.8	15.0
BH1-15	584.40		568.4	16.0
BH2-06	583.60		566.1	17.5
BH2-07	585.60		568.1	17.5
BH2-08	584.60		568.2	16.4
BH2-09	583.40		566.4	17.0
BH4-10	587.19		570.7	16.5
BH4-11	587.20		570.7	16.5
BH4-12	587.60		571.6	16.0
BH4-13	587.94		571.4	16.5
BH5-02	585.39		568.9	16.5
BH6-03	585.80		567.8	18.0
BH6-04	585.90		569.2	16.7
BH6-05	586.37		571.4	15.0



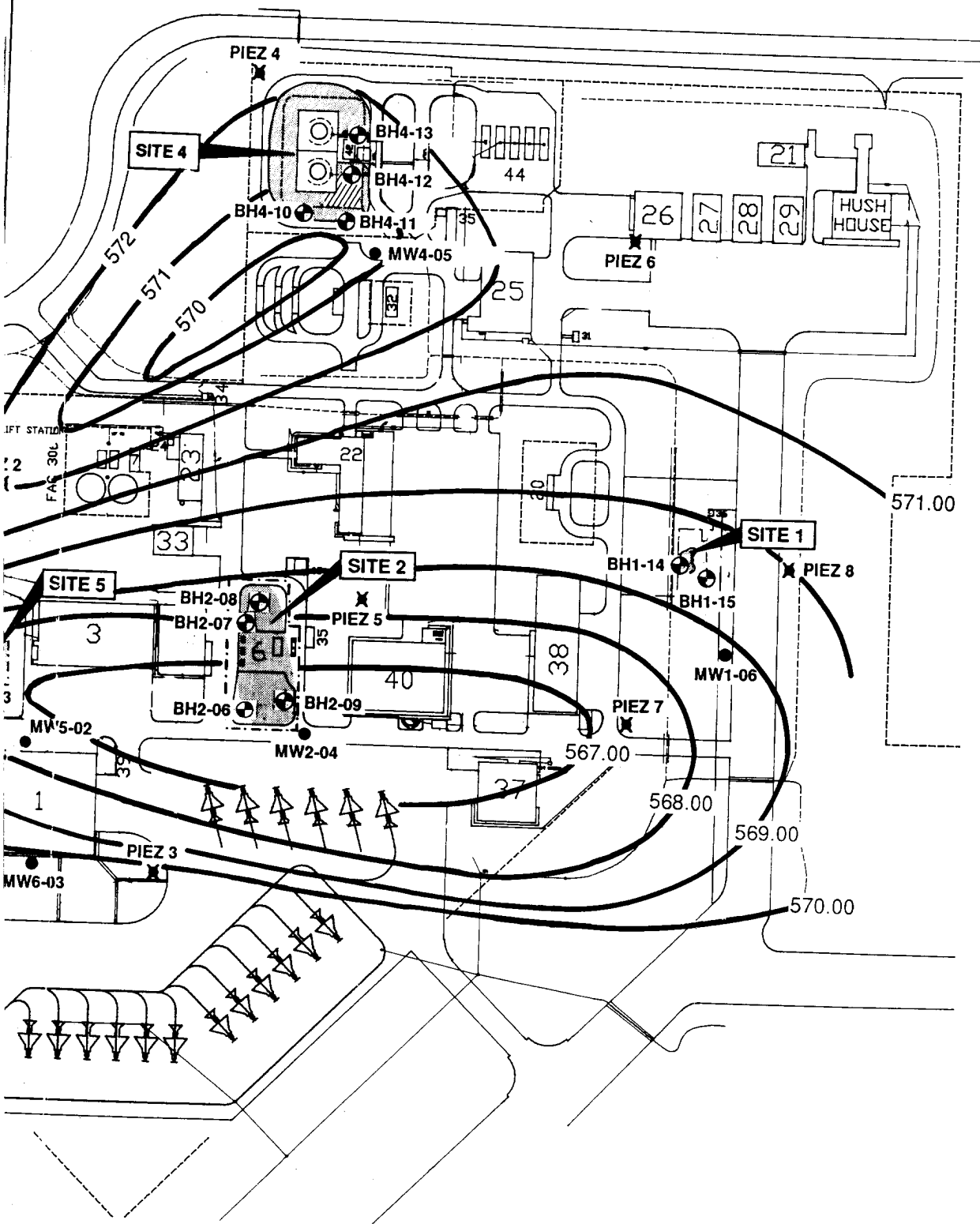


FIGURE 3-10.
STRUCTURE CONTOUR MAP
OF DRY TILL SURFACE
181ST FG, HULMAN FIELD MAP, TERRE HAUTE, IN

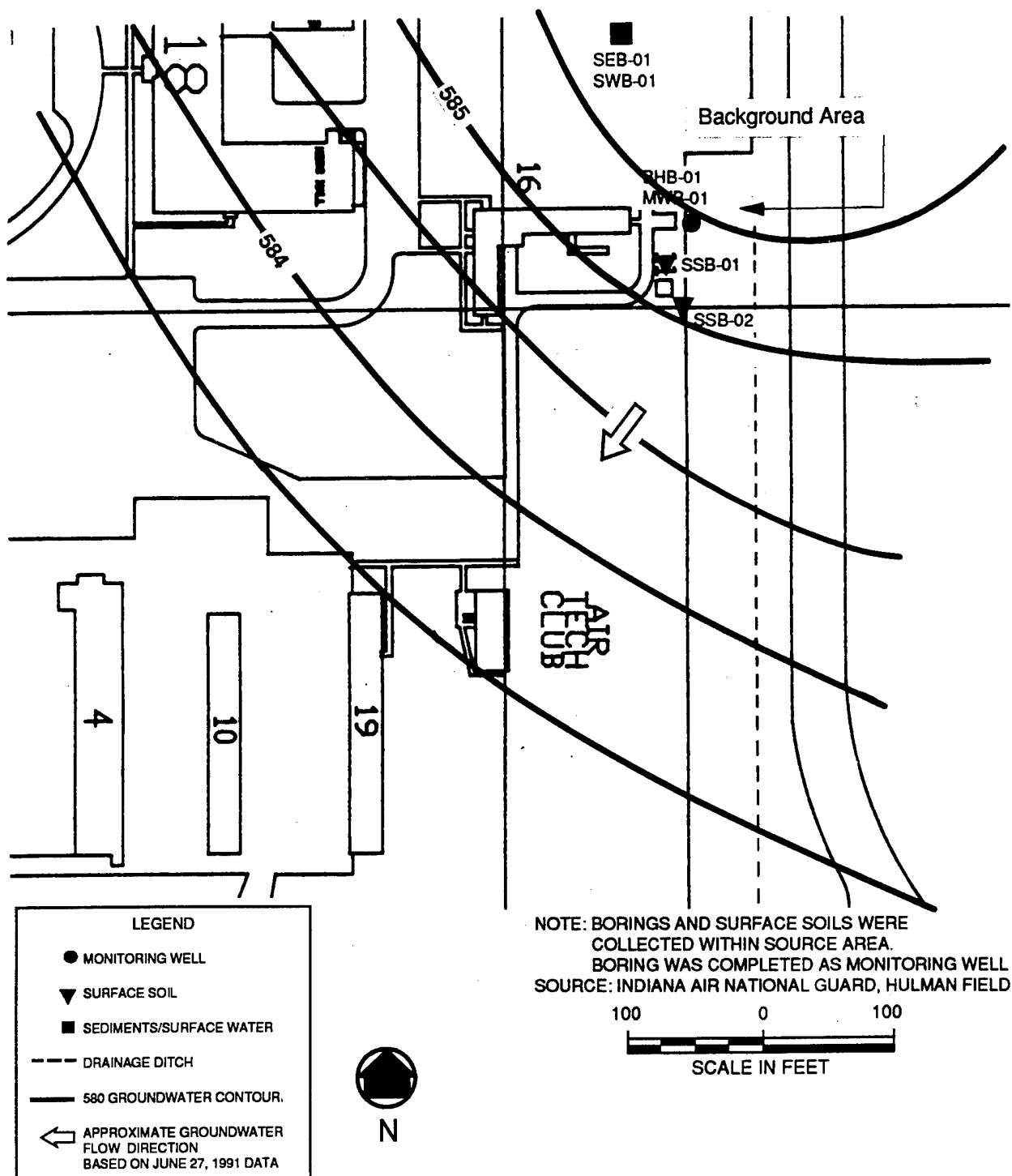


FIGURE 3-11. SAMPLING LOCATIONS, BACKGROUND SITE NEAR BUILDING 16, 181ST FG, HULMAN FIELD MAP, TERRE HAUTE, IN

All background samples were analyzed for volatile and semi-volatile organics, pesticides, PCBs, petroleum hydrocarbons, and metals. Analytical results for each of the media are presented in Tables 3-5a and 3-5b and summarized in Table 3-5c. In general, metals were detected in all media in a wide range of concentrations. A few organic compounds were reported at trace levels (estimated concentrations below the detection limit) in several soils, sediments, and surface water. Petroleum hydrocarbons were also detected in surface soils, surface water, and sediments. Pesticides were detected in one surface soil sample.

Surface Soil. A trace level of tetrachloroethene was reported in one of the surface soils samples (SSB-01). Petroleum hydrocarbons were detected at 100 mg/kg in SSB-02, which was sampled within 25 feet of a road. Traces of DDT, DDD, and DDE were detected in SSB-01. Five mineral forming metals, nine heavy metals, and barium were detected in surface soil samples. Background metal concentrations from soils in the Terre Haute area are available for barium, chromium, cobalt, iron, and lead. Concentrations for these metals in the base background surface soils, subsurface soils and sediments were generally much lower than regional background concentrations. Other metals were generally found to be present in concentrations lower than the average concentrations reported for metals in continental U.S. background soils (Section 1.5.4).

Subsurface Soil. In subsurface soils, di-n-butylphthalate was reported at trace levels in the 4 to 6 foot sample. The types and quantities of metals detected in subsurface soils were similar to those found in surface soils.

Groundwater. Organic compounds and petroleum hydrocarbons were not detected in the groundwater. Metals were detected in both unfiltered (total recoverable forms) and filtered (soluble) forms in groundwater. The largest total recoverable concentrations were detected for the predominantly mineral forming metals (aluminum, calcium, iron, potassium, magnesium, and sodium). Iron concentrations were similar to those found in local aquifers (Table 1-3). Soluble metals were present in lower concentrations. Other metals detected in groundwater were

TABLE 3-5a. BACKGROUND AREA - DETECTED CONTAMINANT CONCENTRATIONS IN SOIL

181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT	LOCATION U - ID Depth, FT LAB ID #	BHB-01 NS - 01 2.0-4.0 9010L110-001	BHB-01 NS - 02 4.0-6.0 9010L110-002	SSB-01 NS - 41 0.0-0.5 9010L110-010	SSB-02 NS - 42 0.0-0.5 9010L110-009	MEAN (b)	MAXIMUM (c)	SEB-01 NS - 91 0.0-0.0 9011L576-001 (d)
VOLATILE ORGANICS											
Tetrachloroethene	CLP	UG/KG	5	6 U	6 U	6 U	3 J	6 U	3 J	3 J	6 U
SEMI-VOLATILE ORGANICS											
Di-n-Butylphthalate	CLP	UG/KG	330	420 U	420 U	44 J	410 U	430 U	44 J	44 J	690 U
Fluoranthene	CLP	UG/KG	330	420 U	420 U	420 U	410 U	430 U	210	ND	110 J
Pyrene	CLP	UG/KG	330	420 U	420 U	420 U	410 U	430 U	210	ND	88 J
Chrysene	CLP	UG/KG	330	420 U	420 U	420 U	410 U	430 U	210	ND	73 J
Benzo(b)fluoranthene	CLP	UG/KG	330	420 U	420 U	420 U	410 U	430 U	210	ND	77 J
PESTICIDES/PCB'S											
4,4'-DDE	CLP	UG/KG	16	20 U	20 U	20 UJ	6.6 J	21 U	6.6 J	6.6 J	15 U
4,4'-DDD	CLP	UG/KG	16	20 U	20 U	20 UJ	2.5 J	21 U	2.5 J	2.5 J	15 U
4,4'-DDT	CLP	UG/KG	16	20 U	20 U	20 UJ	18 J	21 U	12.1 J	18 J	15 U
METALS											
Aluminum, Total	SW6010	MG/KG	40	7490	5130	8050	6562.5	5580	8050	3530	3530
Arsenic, Total	SW7060	MG/KG	2	4.8 J	1.1 J	6.5 J	4.3 J	4.7 J	6.5 J	2.5 J	2.5 J
Barium, Total	SW6010	MG/KG	40	94.9	72.8	105	89.9	86.9	105	60.7	60.7
Calcium, Total	SW6010	MG/KG	1000	6220 J	15400 J	2420 J	7505 J	5980 J	15400 J	2590	2590
Cobalt, Total	SW6010	MG/KG	10	6.7	7.7	12.3	8.3	6.4	12.3	8.4 U	8.4 U
Chromium, Total	SW6010	MG/KG	2	10.7	7.9	10.4	9.1	7.2	10.7	3.5	3.5
Copper, Total	SW6010	MG/KG	5	16.2	13.7	14.2	14.1	12.2	16.2	7.6	7.6
Iron, Total	SW6010	MG/KG	20	14400	13300	15600	13725	11600	15600	6310	6310
Magnesium, Total	SW6010	MG/KG	1000	4910 J	9900 J	2190 J	4995 J	2980 J	9900 J	1160	1160
Manganese, Total	SW6010	MG/KG	3	381	545	643	503.3	444	643	380	380
Sodium, Total	SW6010	MG/KG	1000	110 J	92.8 J	87.2 J	85.3 J	102 UJ	110 J	842 U	842 U
Nickel, Total	SW6010	MG/KG	8	16.3	12.5	11.6	12	7.7	16.3	10 UJ	10 UJ
Lead, Total	SW6010	MG/KG	1	1.6 J	4.5 J	1.8 J	2.5 J	2.2 J	4.5 J	10.7	10.7
Vanadium, Total	SW6010	MG/KG	10	19.8	17.6	24.2	20.6	20.8	24.2	11.1 UJ	11.1 UJ
Zinc, Total	SW6010	MG/KG	4	46.7	37.4	43	53.6	87.2	87.2	50.2	50.2
PETROLEUM HYDROCARBON											
Petroleum Hydrocarbon	E418.1	MG/KG	20	5.1 U	5.1 U	5 U	26.9	100	100	58	58

NOTES:

- a. Four soil samples total: two samples each from one boring and two surface soils. Analyses: volatile organics, semivolatile organics, pesticides/PCBS, metals, and petroleum hydrocarbons (Table 2-3). Analytes not presented were not detected.
- b. The mean concentration for all soil samples is calculated using half the sample quantification detection limit where not detected.
- c. The maximum detected value is used for the mean if the calculated mean is greater than the maximum, where not detected, the mean is based on detection limits only.
- d. Only one background sediment sample taken.

J = Estimated data due to quality control criteria.

U = Compound not detected, value is the sample quantification limit.

UJ = Compound not detected, estimated sample quantification limit.

ND = Not detected.

TABLE 3-5b. BACKGROUND AREA - DETECTED CONTAMINANT CONCENTRATIONS IN GROUNDWATER AND SURFACE WATER
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT	LOCATION U - ID Depth, FT LAB ID #	MWB-01 NS - 70 0.0-0.0 9011L572-006	SWB-01 NS - 83 0.0-0.0 9011L576-006
SEMIVOLATILE ORGANICS						
Di-n-Butylphthalate	CLP	UG/L	10		11 U	2 J
METALS						
Aluminum, Total	SW6010	UG/L	200		27000	15500
Barium, Total	SW6010	UG/L	200		260	247
Calcium, Soluble	SW6010	UG/L	500		73600	145000
Calcium, Total	SW6010	UG/L	500		159000	111000
Chromium, Total	SW6010	UG/L	30		34.2	14.7
Copper, Total	SW6010	UG/L	25		77.7	25 U
Iron, Soluble	SW6010	UG/L	100		100 U	466
Iron, Total	SW6010	UG/L	100		48900	18400
Potassium, Total	SW6010	UG/L	5000		5000 U	7750
Magnesium, Soluble	SW6010	UG/L	5000		39700	66800
Magnesium, Total	SW6010	UG/L	5000		74800	36600
Manganese, Soluble	SW6010	UG/L	15		104	4350
Manganese, Total	SW6010	UG/L	15		1070	2800
Sodium, Soluble	SW6010	UG/L	5000		5350	31300
Sodium, Total	SW6010	UG/L	5000		5850	12900
Lead, Total	SW7421	UG/L	3		16.3 J	26.3 J
Zinc, Total	SW6010	UG/L	20		122	185
PETROLEUM HYDROCARBONS						
Petroleum Hydrocarbon	E418.1	MG/L	1		1.1 U	0.36 J

NOTES:

- a. One background groundwater and surface water sample taken. Analyses: volatile organics, semivolatile organics, pesticides/PCB'S, metals, and petroleum hydrocarbons (Table 2-3). Analytes not presented were not detected.
J = Estimated data due to quality control criteria.
U = Compound not detected, value is the sample quantification limit.

TABLE 3-5c . BACKGROUND AREA - SUMMARY OF ANALYTICAL DETECTIONS
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	SOIL (a)			SEDIMENT(c)	GROUND WATER(c)	SURFACE WATER(c)
	RANGE (b)	MEAN	NUMBER OF DETECTIONS			
VOLATILE ORGANICS	UG/KG	UG/KG				
Tetrachloroethene	3 J	3 J	1 / 4			
SEMIVOLATILE ORGANICS	UG/KG	UG/KG		UG/KG		UG/L
Di-n-Butylphthalate	44 J	44 J	1 / 4	110 J		2 J
Fluoranthene				88 J		
Pyrene				73 J		
Chrysene				77 J		
Benzo(b)fluoranthene						
PESTICIDES/PCB	UG/KG	UG/KG				
4,4'-DDE	6.6 J	6.6 J	1 / 4			
4,4'-DDD	2.5 J	2.5 J	1 / 4			
4,4'-DDT	18 J	12.1 J	1 / 4			
METALS (d)	MG/KG	MG/KG		MG/KG	UG/L	UG/L
Aluminum, Total	5,130 to 8,050	6,563	4 / 4	3,530	27,000	15,500
Arsenic, Total	1.1 J to 6.5 J	4.28 J	4 / 4	2.5 J		
Barium, Total	72.8 to 105	89.9	4 / 4	60.7	260	247
Calcium, Soluble					73,600	145,000
Calcium, Total	2,420 J to 15,400 J	7,505 J	4 / 4	2,590	159,000	111,000
Cobalt, Total	6.4 to 12.3	8.28	4 / 4			
Chromium, Total	7.2 to 10.7	9.05	4 / 4	3.5	34.2	14.7
Copper, Total	12.2 to 16.2	14.08	4 / 4	7.6	77.7	
Iron, Soluble						466
Iron, Total	11,600 to 15,600	13,725	4 / 4	6,310	48,900	18,400
Potassium, Total						7,750
Magnesium, Soluble					39,700	66,800
Magnesium, Total	2,190 J to 9,900 J	4,995 J	4 / 4	1,160	74,800	36,600
Manganese, Soluble					104	4,350
Manganese, Total	381 to 643	503.3	4 / 4	380	1,070	2,800
Sodium, Soluble					5,350	31,300
Sodium, Total	87.2 J to 110 J	85.3 J	3 / 4		5,850	12,900
Nickel, Total	7.7 to 16.3	12.03	4 / 4			
Lead, Total	1.6 J to 4.5 J	2.53 J	4 / 4	10.7	16.3 J	26.3 J
Vanadium, Total	17.6 to 24.2	20.6	4 / 4			
Zinc, Total	37.4 to 87.2	53.58	4 / 4	50.2	122	185
PETROLEUM HYDROCARBON	MG/KG	MG/KG		MG/KG		MG/L
Petroleum Hydrocarbon	100	26.9	1 / 4	58		0.36 J

NOTES:

- Four soil samples total: two samples from one boring and two surface soils.
No value presented means not detected, except for metals (see d.).
- Minimum and maximum detections presented. One value presented usually indicates detected in only one sample.
- Only one sample each for sediment, groundwater, and surface water; results for each presented.
- Soluble metals analysis not run on sediments and soils. Both soluble and total metals were analyzed for water samples.
J = Estimated data due to quality control criteria.

present only in the total recoverable form. These metals consisted of barium and five heavy metals (chromium, copper, manganese, lead, and arsenic).

Surface Water. Di-n-butylphthalate and petroleum hydrocarbons were detected at a trace level in the surface water sample. Concentrations for total recoverable forms of metals were similar to those reported in groundwater. Likewise, only soluble forms of mineral forming metals were reported in surface waters, however, concentrations were higher than reported for total recoverable forms. This occurrence cannot be readily explained as a detailed review of laboratory and field quality control (QC) data does not suggest that these high concentrations resulted from either laboratory or field activities.

Sediment. In the sediment sample, four PAH compounds were detected at trace concentrations. These compounds were not detected in any of the other media sampled.

In the following sections analyte concentrations are compared to background levels. Concentrations twice background levels were considered above background. Those concentrations less than twice background levels were considered within the range of background concentrations. Twice background is an arbitrary cut-off used to delineate between concentrations close to background and those above background. The U.S. EPA guidance manual, Risk Assessment Guidance for Superfund, (U.S. EPA, 1989) recommends the use of statistical methods for background comparisons in Remedial Investigations, however, this investigation is only in the Site Investigation Phase with insufficient data per media to support a statistical analyses. For this reason, the twice background rule is used here.

3.3 SITE 1 - POWER SUPPRESSOR PAD

Site 1 is located at the south end of base property adjacent to the most easterly Hulman Airfield taxiway. A below ground oil/water separator tank had been installed at this site in the late 1950s and was used until 1976. While no longer used as a separator, the full tank was left in place. It was reported that a leak occurred in this 500-gallon underground waste oil storage tank which

contained waste oil, JP-4, hydraulic fluid, detergent, and solvent. The oil/water separator was removed, but the storage tank was left in place. The amount of waste remaining at the site is unknown. This tank is currently scheduled for removal as part of a base-wide removal program.

3.3.1 Screening Activity Results

At Site 1, ten soil gas points were sampled using a flame ionization detector (FID) and four samples were analyzed using a field gas chromatograph (GC). The GC analyses were performed at points SG1-1, -2, -7, and -8. The FID readings are presented in Table 3-6 and the soil gas sampling points are shown in Figure 3-12. The FID results indicated low volatile organic contamination at Site 1. A maximum reading of 2.0 ppm was obtained at SG1-6, and a minimum reading of 0.2 ppm was obtained at SG1-1.

The soil gas survey results were used to establish soil boring and surface soil sampling locations. Soil borings were placed at points SG1-3 and SG1-6. Surface soil samples were collected at SG1-5 and SG1-10. The FID readings at SG1-8 and at SG1-5 were equal, however, SG1-5 was chosen as a surface soil sampling location since it was located on an uncharacterized side of the oil/water separator.

Results from field GC analysis of the 4 points were very similar. Two peaks were prominent in each of these chromatographs, eluting at about 45 seconds. The second peak had a retention time approximately equal to benzene in the standard mix. Both of these peaks, however, were also present in the syringe blank. Therefore, there does not appear to be any detectable levels of benzene, toluene, ethylene, or xylenes, (BTEX) at any of the 4 points analyzed.

TABLE 3-6. SITE 1 - POWER SUPPRESSOR PAD - SOIL GAS SURVEY RESULTS

Point Number	Soil Depth (ft)	FID Reading (ppm)	Point Number	Soil Depth (ft)	FID Reading (ppm)
SG1-1	1	0.6	SG1-4	1	0.5
SG1-1	2	ng	SG1-5	1	0.6
SG1-1	3	ng	SG1-6	1	2.0
SG1-1	4	ng	SG1-7	1	0.4
SG1-1	5	ng	SG1-8	1	0.6
SG1-1a	1	0.2	SG1-9	1	0.5
SG1-2	1	0.4	SG1-10	1	1.4
SG1-3	1	1.6			

Note: ng - No soil gas measured

3.3.2 Confirmation and Delineation Activity Results

Samples collected at Site 1 consisted of two surface soils, four subsurface soil samples from two soil boring locations, two groundwater samples (from two sampling rounds), one surface water, and one sediment sample. Two of the subsurface soils were collected from depths of 2 to 4 feet, and two from 4 to 6 feet. Both the surface water and sediment sample were collected from the same point in an open drainage ditch. Sampling locations for Site 1 are shown in Figure 3-13. All samples submitted to the laboratory were analyzed for volatile organics, semi-volatile organics, pesticides, PCBs, petroleum hydrocarbons, and metals. Analytical results for each media are presented in Tables 3-7a-d and are summarized in Table 3-7e.

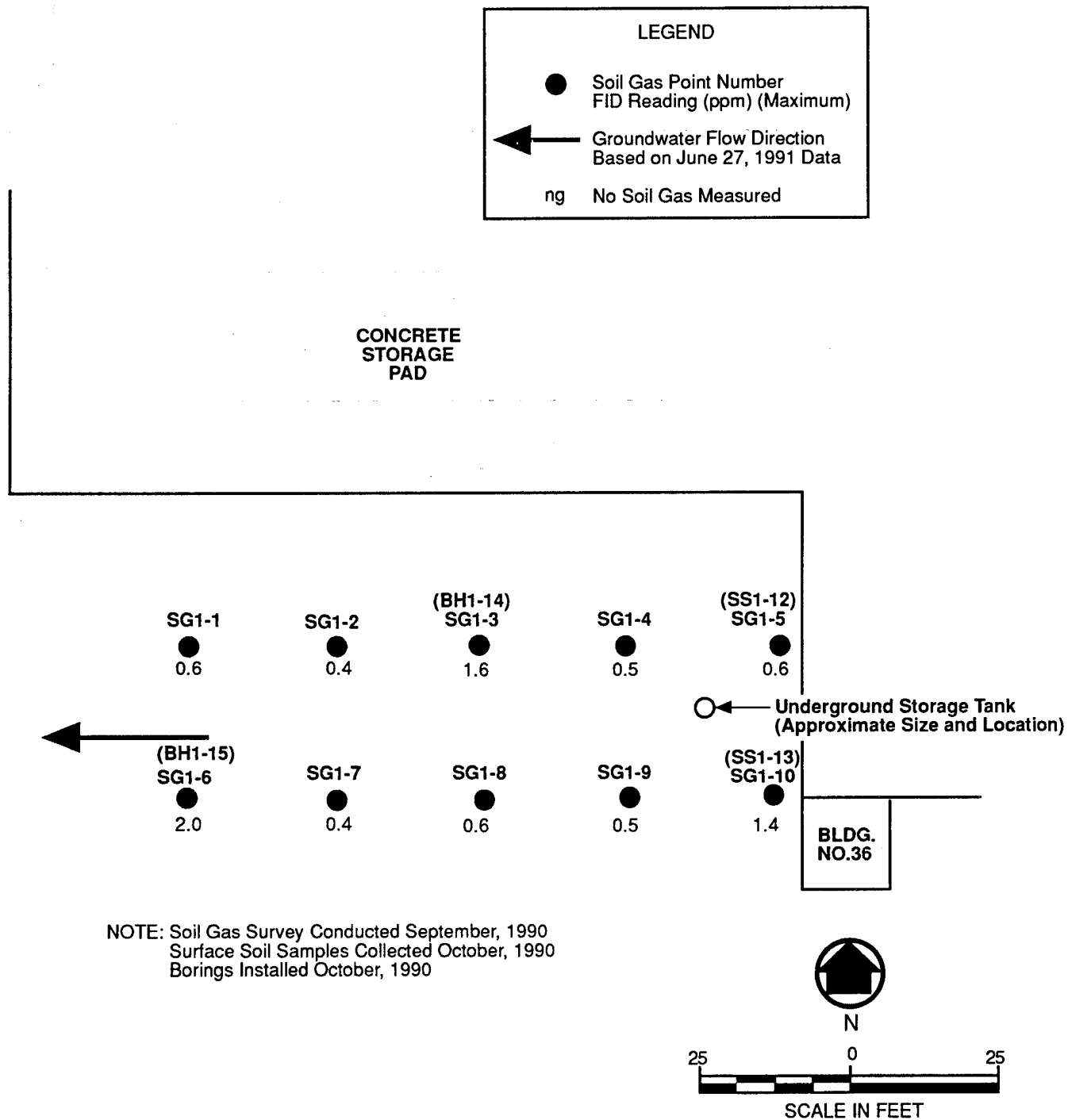


**FIGURE 3-12. SOIL GAS SURVEY LOCATIONS
 SITE 1: POWER SUPPRESSOR PAD
 181st FG, HULMAN FIELD MAP, TERRE HAUTE, IN**

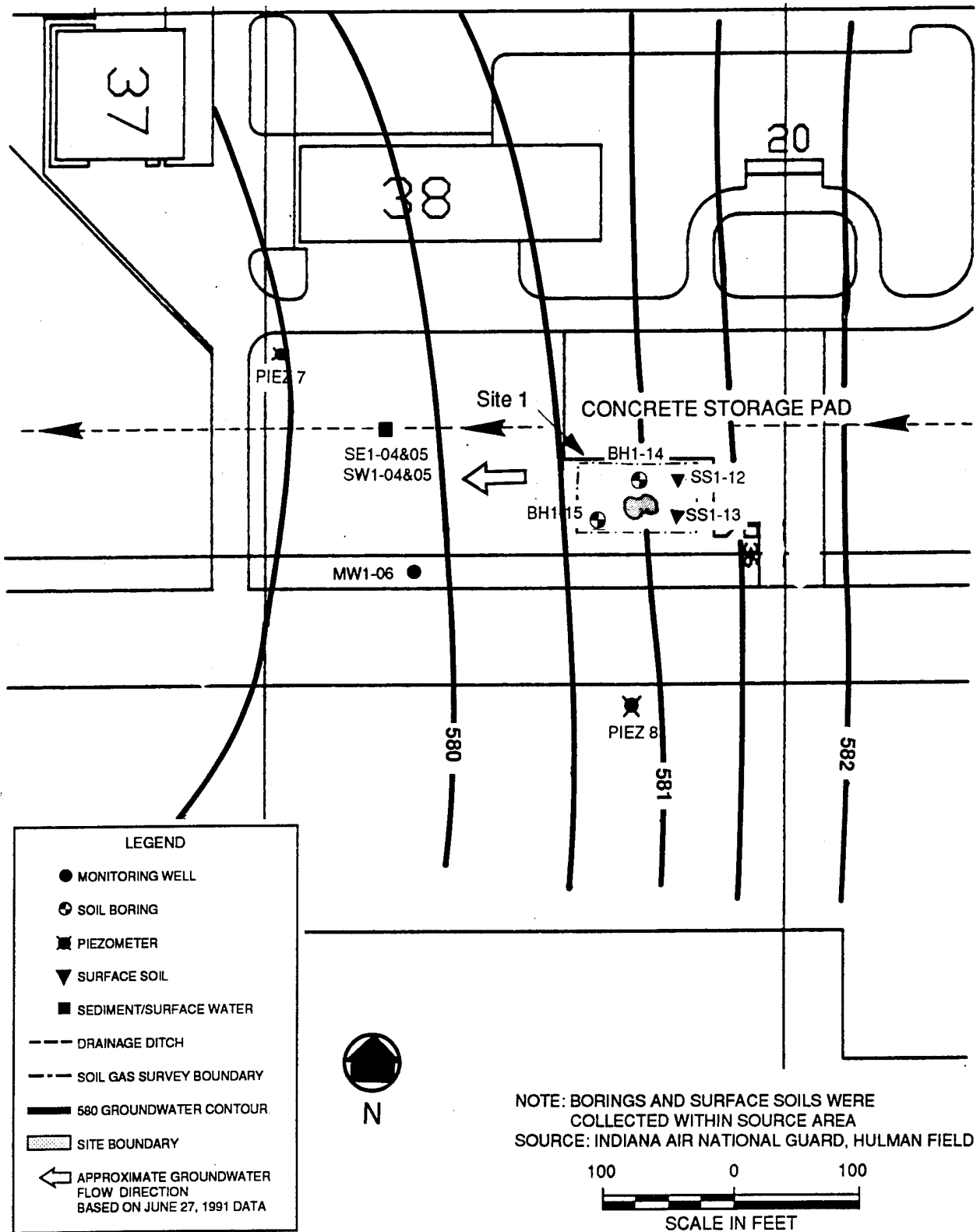


FIGURE 3-13. SAMPLING LOCATIONS,
SITE 1: POWER SUPPRESSOR PAD
181ST FG, HULMAN FIELD MAP, TERRE HAUTE, IN

TABLE 3-7a. SITE 1 - DETECTED CONTAMINANT CONCENTRATIONS IN SOIL

181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT	LOCATION U - ID Depth, FT LAB ID #	BH1-14 NS - 27 2.0-4.0 9010L166-001	BH1-14 NS - 28 4.0-6.0 9010L166-002	BH1-15 NS - 29 2.0-4.0 9010L166-003	BH1-15 NS - 30 4.0-6 9010L166-025	Duplicate Sample BH1-15 NS - 30	Duplicate Mean (b)
VOLATILE ORGANICS										
1,2-Dichlorobenzene	CLP	UG/KG	330		470 U	470 U	460 U	460 U	470 U	465 U
Tetrachloroethene	CLP	UG/KG	5		6 U	6 U	6 U	6 U	6 U	6 U
Toluene	CLP	UG/KG	5		4 J	6 U	6 U	6 U	1 J	1 J
SEMIVOLATILE ORGANICS										
2-Chlorophenol	CLP	UG/KG	330		470 U	470 U	460 U	73 J	470 U	73 J
Phenanthrene	CLP	UG/KG	330		470 U	470 U	460 U	460 U	470 U	465 U
Di-n-Butylphthalate	CLP	UG/KG	330		5400	4600	6400	5100	2400	3750
Fluoranthene	CLP	UG/KG	330		470 U	470 U	460 U	460 U	470 U	465 U
Pyrene	CLP	UG/KG	330		470 U	470 U	460 U	53 J	470 U	53 J
Butylbenzylphthalate	CLP	UG/KG	330		470 U	470 U	460 U	110 J	470 U	110 J
Chrysene	CLP	UG/KG	330		470 U	470 U	460 U	460 U	470 U	465 U
Benzof(b)fluoranthene	CLP	UG/KG	330		470 U	470 U	460 U	460 U	470 U	465 U
Benzok(f)fluoranthene	CLP	UG/KG	330		470 U	470 U	460 U	460 U	470 U	465 U
METALS										
Aluminum, Total	SW6010	MG/KG	40		9490	16000				
Arsenic, Total	SW7060	MG/KG	2		11.5 J	15.4 J	8.5 J	18.8 J	8 J	13.4 J
Barium, Total	SW6010	MG/KG	40		122	126				
Beryllium, Total	SW6010	MG/KG	1		0.56	1	0.7	0.87	0.65	0.76
Calcium, Total	SW6010	MG/KG	1000		2390 J	2830 J				
Cadmium, Total	SW6010	MG/KG	1		1.8 U	2 U	2.2 U	1.8 U	2.1 U	1.95 U
Cobalt, Total	SW6010	MG/KG	10		12.1	7.3				
Chromium, Total	SW6010	MG/KG	2		5.7	8.4	10.9	5	9.2	7.1
Copper, Total	SW6010	MG/KG	5		12.6	16.6	14.3	16	14.3	15.15
Iron, Total	SW6010	MG/KG	20		17800	32800				
Mercury, Total	SW7471	MG/KG	0.1		0.64 J	R		R	R	
Magnesium, Total	SW6010	MG/KG	1000		2340 J	3430 J				
Manganese, Total	SW6010	MG/KG	3		837	269				
Sodium, Total	SW6010	MG/KG	1000		240 J	92.3 J				
Nickel, Total	SW6010	MG/KG	8		16.2	15.6	13.3	20.5	13.4	16.95
Lead, Total	SW6010	MG/KG	1		13.4	14.5	20.6	13.1	11.1	12.1
Vanadium, Total	SW6010	MG/KG	10		19.3	34.4				
Zinc, Total	SW6010	MG/KG	4		57.6	67.9	57.9	54.9	53.4	54.15
PETROLEUM HYDROCARBON										
Petroleum Hydrocarbon	E418.1	MG/KG	20		3.6 UJ	5.7 UJ	4 UJ	3.8 UJ	9.2 UJ	6.5 UJ

TABLE 3-7a. SITE 1 - DETECTED CONTAMINANT CONCENTRATIONS IN SOIL

181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

CONTINUED

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT	LOCATION U - ID Depth, FT LAB ID #	SSI-12 NS - 52 0.0-0.5 9010151-008	SSI-13 NS - 53 0.0-0.5 9010151-009	MEAN (c)	MINIMUM (d)	MAXIMUM (d)	Background Concentration MEAN (c)	Background Concentration MAXIMUM (c)
VOLATILE ORGANICS											
1,2-Dichlorobenzene	CLP	UG/KG	330		110 J	390 U	110 J	110 J	110 J	210	ND
Tetrachloroethene	CLP	UG/KG	5		6 U	1 J	1 J	1 J	1 J	3 J	3 J
Toluene	CLP	UG/KG	5		6 U	6 U	2.8 J	1 J	4 J	3	ND
SEMI-VOLATILE ORGANICS											
2-Chlorophenol	CLP	UG/KG	330		440 U	390 U	73 J	73 J	73 J	210	ND
Phenanthrene	CLP	UG/KG	330		440 U	80 J	80 J	80 J	80 J	210	ND
Di-n-Butylphthalate	CLP	UG/KG	330		840	450	3573.3	450	6400	44 J	44 J
Fluoranthene	CLP	UG/KG	330		93 J	89 J	93 J	89 J	93 J	210	ND
Pyrene	CLP	UG/KG	330		74 J	74 J	74 J	53 J	74 J	210	ND
Butylbenzylphthalate	CLP	UG/KG	330		370 J	260 J	240 J	110 J	370 J	210	ND
Chrysene	CLP	UG/KG	330		51 J	54 J	54 J	51 J	54 J	210	ND
Benzof(b)fluoranthene	CLP	UG/KG	330		57 J	64 J	64 J	57 J	64 J	210	ND
Benzo(k)fluoranthene	CLP	UG/KG	330		52 J	390 U	52 J	52 J	52 J	210	ND
METALS											
Aluminum, Total	SW6010	MG/KG	40				12745	9490	16000	6562.5	8050
Arsenic, Total	SW7060	MG/KG	2		4	3.6	9.4 J	3.6	15.4 J	4.3 J	6.5 J
Barium, Total	SW6010	MG/KG	40		0.75	0.61	124	122	126	89.9	105
Beryllium, Total	SW6010	MG/KG	1		1.9 U	4.4	0.7	0.56	1	0.4	ND
Calcium, Total	SW6010	MG/KG	1000		6.6	7.5	2610 J	2390 J	2830 J	7505 J	15400 J
Cadmium, Total	SW6010	MG/KG	1		6 J	10.4 J	1.6	4.4	4.4	1.06	ND
Cobalt, Total	SW6010	MG/KG	10		0.12 U	0.11 U	9.7	7.3	12.1	8.3	12.3
Chromium, Total	SW6010	MG/KG	2				7.7	5.7	10.9	9.1	10.7
Copper, Total	SW6010	MG/KG	5				12.5 J	6 J	16.6	14.1	16.2
Iron, Total	SW6010	MG/KG	20				25300	17800	32800	13725	15600
Mercury, Total	SW7471	MG/KG	0.1				0.3 J	0.64 J	0.64 J	0.07	ND
Magnesium, Total	SW6010	MG/KG	1000				2885 J	2340 J	3430 J	4995 J	9900 J
Manganese, Total	SW6010	MG/KG	3				553	269	837	503.3	643
Sodium, Total	SW6010	MG/KG	1000				166.2 J	92.3 J	240 J	85.3	110 J
Nickel, Total	SW6010	MG/KG	8				13.6	9.6	16.95	12	16.3
Lead, Total	SW6010	MG/KG	1				14.2	11.5	20.6	2.5 J	4.5 J
Vanadium, Total	SW6010	MG/KG	10				26.9	19.3	34.4	20.6	24.2
Zinc, Total	SW6010	MG/KG	4				54.8	42.3	67.9	53.6	87.2
PETROLEUM HYDROCARBON											
Petroleum Hydrocarbon	E418.1	MG/KG	20		22	11	7.2	11	22	26.9	100

NOTES:

- Six soil samples total: two samples each from two borings and two surface soils. Analytes: volatile organics, semivolatile organics, pesticides/PCB'S, metals, and petroleum hydrocarbons (Table 2-3). Analytes not presented were not detected.
- Refers to the mean of the duplicate samples, if there is only one positive detection this value is used for the mean.
- The mean concentration for all soil samples is calculated using the duplicate mean for duplicate samples and half the sample quantification detection limit where not detected. The maximum detected value is used for the mean if the calculated mean is greater than the maximum.
- Minimum and maximum values do not include those values flagged with a U or UJ.
- Four background soil samples total: two samples from one boring and two surface soils. Mean and maximum background concentrations were calculated in the same manner as above, where not detected, the mean is based on detection limits only.

J = Estimated data due to quality control criteria

ND=Not detected
R = Reject data due to quality control criteriaU =Compound not detected, value is the sample quantification limit.
UJ=Compound not detected, estimated sample quantification limit.

TABLE 3-7b. SITE 1 - DETECTED CONTAMINANT CONCENTRATIONS IN GROUNDWATER

181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT (b)	LOCATION U - ID Depth, FT LAB ID #	MW1-06 NS - 75 0.0-0.0 9011L600-003	MW1-06 (c) NX - 106 0.0-0.0 9201L068-005	MEAN (d)	MINIMUM (e)	MAXIMUM (e)	Background Concentration (f)	MCL (g)
SEMI-VOLATILE ORGANICS											
Benzoic acid	CLP	UG/L	50		2 J	NA		2 J	2 J	55 U	
Pentachlorophenol	CLP	UG/L	50(25)		3 J	28 U	3 J	3 J	3 J	55 U	1
Di-n-Butylphthalate	CLP	UG/L	10		2 J	11 U	2 J	2 J	2 J	11 U	
bis(2-Ethylhexyl)phthalate	CLP	UG/L	10		8 J	11 U	6.7 J	8 J	8 J	2 UJ	4.0p
METALS											
Aluminum, Total	SW6010	UG/L	200		151000	40000 J	95500 J	40000 J	151000	27000	50
Arsenic, Total	SW7060	UG/L	10		14.4 J	10 UJ	9.7 J	14.4 J	14.4 J	10 UJ	2000
Barium, Total	SW6010	UG/L	200		1380	573	976.5	573	1380	260	1.0p
Beryllium, Total	SW6010	UG/L	5		10.5	5 U	6.5	10.5	10.5	5 U	
Calcium, Soluble	SW6010	UG/L	500(5000)		95700	70400	83050	70400	95700	73600	
Calcium, Total	SW6010	UG/L	500(5000)		1100000	363000	731500	363000	1100000	159000	
Cobalt, Total	SW6010	UG/L	50		145	53.5	99.25	53.5	145	50 U	
Chromium, Total	SW6010	UG/L	30(10)		94.7	98.3	96.5	94.7	98.3	34.2	100
Copper, Total	SW6010	UG/L	25		227	126	176.5	126	227	77.7	1300
Iron, Total	SW6010	UG/L	100		497000	153000 J	325000 J	153000 J	497000	48900	
Mercury, Soluble	SW7470	UG/L	0.2		0.32 J	0.20 U	0.21 J	0.32 J	0.32 J	0.2 U	2
Mercury, Total	SW7470	UG/L	0.2		0.50 J	0.30 J	0.40 J	0.30 J	0.50 J	0.2 U	2
Potassium, Total	SW6010	UG/L	5000		13600	5000 U	8050	13600	13600	5000 U	
Magnesium, Soluble	SW6010	UG/L	5000		33200	23300	28250	23300	33200	39700	
Magnesium, Total	SW6010	UG/L	5000		386000	132000	259000	132000	386000	74800	
Manganese, Soluble	SW6010	UG/L	15		858	528	693	528	858	104	
Manganese, Total	SW6010	UG/L	15		21200	7260	14230	7260	21200	1070	
Sodium, Soluble	SW6010	UG/L	5000		12500	12700	12600	12500	12700	5350	
Sodium, Total	SW6010	UG/L	5000		12600	11200	11900	11200	12600	5850	
Nickel, Total	SW6010	UG/L	15(40)		314	106	210	106	314	74.1 UJ	100p
Lead, Total	SW7421	UG/L	3		129 J	60.8	95 J	60.8	129 J	16.3 J	50(15)
Vanadium, Total	SW6010	UG/L	50		352	129	241	129	352	62.2 UJ	
Zinc, Soluble	SW6010	UG/L	20		20 U	33	22	33	33	20 U	
Zinc, Total	SW6010	UG/L	20		798	282	540	282	798	122	

NOTES:

- Two groundwater samples total. Analytes: volatile organics, semivolatile organics, pesticides/PCBs, metals, and petroleum hydrocarbons (Table 2-3). Analytes not presented were not detected.
 - Detection limit for Round 2 sampling located in parentheses if different from Round 1.
 - Sample taken during Round 2 in January 1992, unless noted, all other samples taken during Round 1 in November 1990.
 - The mean concentration for all groundwater samples is calculated using half the sample quantification detection limit where not detected. The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
 - Minimum and maximum values do not include those values flagged with a U or a UJ.
 - One background groundwater sample total.
 - Maximum Contaminant Levels taken from Table 4.3, p= proposed value.
 - J = Estimated data due to quality control criteria.
 - NA=Not analyzed.
- U =Compound not detected, value is the sample quantification limit.
UJ =Compound not detected, estimated sample quantification limit.

TABLE 3-7c. SITE 1 - DETECTED CONTAMINANT CONCENTRATIONS IN SURFACE WATER - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT	LOCATIO U - ID Depth, FT LAB ID #	Duplicate Sample SW1-05 NS - 86	Duplicate Mean (b)	Background Concentration (c)
SEMIVOLATILES							
Di-n-Butylphthalate	CLP	UG/L	10	2 J	11 U	2 J	2 J
METALS							
Calcium, Soluble (d)	SW6010	UG/L	500	78200	79000	78600	145000
Calcium, Total	SW6010	UG/L	500	77700	77000	77350	111000
Iron, Total	SW6010	UG/L	100	360	381	370.5	18400
Magnesium, Soluble (d)	SW6010	UG/L	5000	20100	20400	20250	66800
Magnesium, Total	SW6010	UG/L	5000	20000	19800	19900	36600
Manganese, Soluble	SW6010	UG/L	15	64.6	68.5	66.55	4350
Manganese, Total	SW6010	UG/L	15	72	75.3	73.65	2800
Sodium, Soluble (d)	SW6010	UG/L	5000	11700	10800	11250	31300
Sodium, Total	SW6010	UG/L	5000	10600	10500	10550	12900
Lead, Total	SW7421	UG/L	3	R	R		26.3 J

NOTES:

a. One surface water sample total. Analyses: volatile organics, semivolatile organics, pesticides/PCB'S, metals, and petroleum hydrocarbons (Table 2-3).

Analyses not presented were not detected.

b. Refers to the mean of the duplicate samples, if there is only one positive detection this value is used for the mean.

c. One background surface water sample total.

d. Soluble calcium, magnesium, and sodium concentrations exceeded "total" concentrations for these metals in both samples. These metals appeared to be completely soluble.

The higher concentrations of these metals in the dissolved (soluble) fraction may be due to laboratory dilution effects.

J = Estimated data due to quality control criteria.

R = Reject data due to quality control criteria.

U = Compound not detected, value is the sample quantification limit.

TABLE 3-7d. SITE 1 - DETECTED CONTAMINANT CONCENTRATIONS IN SEDIMENT

181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT	LOCATION U - ID Depth, FT LAB ID #	SEI-04 NS - 94 0.0-0.0 9011LS76-008	Duplicate Sample SEI-05 NS - 94	Duplicate Mean (b)	Background Concentration (c)
VOLATILE ORGANICS								
Methylene Chloride	CLP	UG/KG	5		170 UJ	300	300	99 UJ
Acetone	CLP	UG/KG	10		260	420	340	11 UJ
Carbon Disulfide	CLP	UG/KG	5		30 U	19	19	6 U
2-Butanone	CLP	UG/KG	10		33 J	38 U	33 J	13 U
Toluene	CLP	UG/KG	5		36	19 U	36	6 U
SEMIVOLATILE ORGANICS								
Pyrene	CLP	UG/KG	330		4800 U	520 J	520 J	88 J
Benzo(k)fluoranthene	CLP	UG/KG	330		4800 U	500 J	500 J	690 U
METALS								
Aluminum, Total	SW6010	MG/KG	40		6160	4740	5450	3530
Arsenic, Total	SW7060	MG/KG	2		4.5 J	2.9 J	3.7 J	2.5 J
Barium, Total	SW6010	MG/KG	40		111	78.3	94.7	60.7
Calcium, Total	SW6010	MG/KG	1000		4640	2460	3550	2590
Chromium, Total	SW6010	MG/KG	2		8.4	6.5	7.45	3.5
Copper, Total	SW6010	MG/KG	5		13.8	11.2	12.5	7.6
Iron, Total	SW6010	MG/KG	20		12800	9100	10950	6310
Manganese, Total	SW6010	MG/KG	3		258	158	208	380
Lead, Total	SW6010	MG/KG	1		22.1	11.6	16.85	10.7
Zinc, Total	SW6010	MG/KG	4		178	120	149	50.2
PETROLEUM HYDROCARBON								
Petroleum Hydrocarbon	E418.1	MG/KG	20		1200	190	695	58

NOTES:

- a. One sediment sample total. Analyses: volatile organics, semivolatile organics, pesticides/PCB'S, metals, and petroleum hydrocarbons (Table 2-3). Analytes not presented were not detected.
- b. Refers to the mean of the duplicate samples, if there is only one positive detection this value is used for the mean.
- c. One background sediment sample total.
- J = Estimated data due to quality control criteria.
- U = Compound not detected, value is the sample quantification detection limit.
- UJ = Compound not detected, estimated sample quantification limit.

TABLE 3-7c . SITE 1 - SUMMARY OF ANALYTICAL DETECTIONS - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	SOIL (a)			NUMBER OF DETECTIONS	SEDIMENT (c) UG/KG	GROUNDWATER (d)			NUMBER OF DETECTIONS	SURFACE WATER (e)
	RANGE (b)	MEAN	UG/KG			RANGE (b)	MEAN	UG/L		
	UG/KG	UG/KG				UG/L	UG/L			
VOLATILE ORGANICS										
Methylene Chloride					300					
Acetone					340					
Carbon Disulfide					19					
2-Butanone					33 J					
1,2-Dichlorobenzene	110 J	110 J	1 /	6						
Tetrachloroethene	1 J	1 J	1 /	6						
Toluene	1 J to 4 J	2.8 J	2 /	6	36					
SEMIVOLATILE ORGANICS										
2-Chlorophenol	73 J	73 J	1 /	6						
Phenanthrene	80 J	80 J	1 /	6						
Di-n-Butylphthalate	450 to 6,400	3,573	6 /	6			2 J	2 J	1 /	2 J
Fluoranthene	89 J to 93 J	93 J	2 /	6						
Pyrene	53 J to 74 J	74 J	3 /	6	520 J					
Butylbenzylphthalate	110 J to 370 J	240 J	3 /	6						
Chrysene	51 J to 54 J	54 J	2 /	6						
Benzo(b)fluoranthene	57 J to 64 J	64 J	2 /	6						
Benzo(k)fluoranthene	52 J	52 J	1 /	6	500 J					
Benzoic acid							2 J		1 /	1
Pentachlorophenol							3 J	3 J	1 /	2
bis(2-Ethylhexyl)phthalate							8 J	6.75 J	1 /	2

TABLE 3-7c. SITE 1 - SUMMARY OF ANALYTICAL DETECTIONS - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (CONTINUED)

PARAMETER	SOIL (a)			SEDIMENT (c)	GROUNDWATER (d)			SURFACE WATER (e)
	RANGE (b)	MEAN	NUMBER OF DETECTIONS		RANGE (b)	MEAN	NUMBER OF DETECTIONS	
METALS (f)	MG/KG	MG/KG		MG/KG	UG/L	UG/L		UG/L
Aluminum, Total	9,490 to 16,000	12,745	2 / 2	5,450	40,000 J to 151,000	95500 J	2 / 2	
Arsenic, Total	3.6 to 15.4 J	9.4 J	6 / 6	3.7 J	14.4 J	9.7 J	1 / 2	
Barium, Total	122 to 126	124	2 / 2	94.65	573 to 1380	976.5	2 / 2	
Beryllium, Total	0.56 to 1	0.7	6 / 6		10.5	6.5	1 / 2	
Calcium, Soluble					70,400 to 95700	83050	2 / 2	78,600
Calcium, Total	2,390 J to 2,830 J	2,610 J	2 / 2	3,550	363,000 to 1100000	731500	2 / 2	77,350
Cadmium, Total	4.4	1.55	1 / 6					
Cobalt, Total	7.3 to 12.1	9.7	2 / 2		53.5 to 145	99.25	2 / 2	
Chromium, Total	5.7 to 10.9	7.7	6 / 6	7.45	94.7 to 98.3	96.5	2 / 2	
Copper, Total	6 J to 16.6	12.5 J	6 / 6	12.5	126 to 227	176.5	2 / 2	
Iron, Total	17,800 to 32,800	25,300	2 / 2	10,950	153,000 J to 497000	325000 J	2 / 2	371
Mercury, Soluble					0.32 J	0.21 J	1 / 2	
Mercury, Total	0.64 J	0.3 J	1 / 3		0.30 J to 0.5 J	0.4 J	2 / 2	
Potassium, Total					13,600	8050	1 / 2	
Magnesium, Soluble					23,300 to 33200	28250	2 / 2	20,250
Magnesium, Total	2,340 J to 3,430 J	2,885 J	2 / 2		132,000 to 386000	259000	2 / 2	19,900
Manganese, Soluble					528 to 858	693	2 / 2	66.55
Manganese, Total	269 to 837	553	2 / 2	208	7,260 to 21200	14230	2 / 2	73.65
Sodium, Soluble					12,500 to 12700	12600	2 / 2	11,250
Sodium, Total	92.3 J to 240 J	166 J	2 / 2		11,200 to 12600	11900	2 / 2	10,550
Nickel, Total	9.6 to 16.95	13.6	6 / 6		106 to 314	210	2 / 2	
Lead, Total	11.5 to 20.6	14.2	6 / 6	16.85	60.8 to 129 J	95 J	2 / 2	
Vanadium, Total	19.3 to 34.4	26.9	2 / 2		129 to 352	241	2 / 2	
Zinc, Soluble					33	22	1 / 2	
Zinc, Total	42.3 to 67.9	54.8	6 / 6	149	282 to 798	540	2 / 2	
PETROLEUM HYDROCARBON								
Petroleum Hydrocarbon	11 to 22	7.20	2 / 6	695				

NOTES:

- a. Six soil samples total: two samples each from two borings and two surface soils.
 No value presented means not detected, except for metals (see f.).
 b. Minimum and maximum detections presented. One value presented usually indicates detected in only one sample.
 c. Only one sediment sample taken
 d. Two groundwater samples total. No value presented means not detected.
 e. Only one surface water sample taken
 f. Soluble metals analysis not run on sediments and soils. Both soluble and total metals analyzed for water samples.
 J = Estimated data due to quality control criteria.

Surface Soil. Tetrachloroethene was detected at 1 $\mu\text{g/kg}$ in surface soil (SS1-13), located near Building 36. Trace 1,2-dichlorobenzene was detected in surface soil (SS1-12). Two phthalate compounds di-n-butylphthalate and butylbenzylphthalate were found in both soil samples. These chemicals are potential modifiers of hydraulic oils and lubricants as well as paints. Phthalate compounds are also plasticizers commonly found in numerous types of plastics. While low concentrations of phthalates can sometimes be attributed to laboratory or sample collection activities, an extensive review of laboratory and field QC data determined that the presence of these compounds in samples is not likely to be a laboratory or field artifact. This finding coupled with known base practices, as well as the detection of phthalates at other sites indicates that these compounds probably result from and are consistent with the known storage of fuel and modified oil products at the base. Likewise, in surface soils six PAH compounds were detected in appreciable concentrations, while relatively low levels of petroleum hydrocarbons and neither pesticides nor PCBs were found. The high levels of PAHs may be attributed to semi-combusted jet fuel. Metals were generally found at quantities similar to the base background soils. The detection of beryllium, and higher lead concentrations are noted exceptions. Lead concentrations were within typical regional concentrations (see Table 1-7).

Subsurface Soil. Trace concentrations of toluene were found in two subsurface soils from both soil boring locations. Di-n-butylphthalate was detected in all of the subsurface soil samples at concentrations considerably higher than either surface soils or background soils. Concentrations of this compound did, however, slightly decrease with greater depth. Because phthalates typically have a very strong affinity to organic materials and soil surfaces and are only slightly mobile, it is unclear why they are present at greater depths. In addition, butylbenzylphthalate was also reported in BH1-15 (4-6 feet) along with trace quantities of 2-chlorophenol and pyrene. Pesticides, PCBs, and petroleum hydrocarbons were not detected in any of the subsurface soils. In general, metal concentrations were similar to those reported in surface soils and background soils. Similar to surface soils, lead was slightly elevated. In addition, mercury was detected in BH1-14 at a depth of 2-4 feet.

Groundwater. Volatile organics, pesticides, PCBs, and petroleum hydrocarbons were not detected in the groundwater. During Round 1, trace concentrations of four semi-volatile organics including benzoic acid, pentachlorophenol, di-n-butylphthalate, and bis(2-ethylhexyl)phthalate were found. In addition to mineral forming metals, beryllium, barium, and twelve heavy metals were detected. Relative to background groundwater, mercury and beryllium were detected, while cadmium was not detected in Site 1 groundwater. Mineral forming metals, mercury and manganese were the only metals found in a soluble form. Almost all metal concentrations were elevated compared to background groundwater. A second groundwater sample from MW1-06 collected during Round 2 in January 1992, detected only metals. Concentrations were generally lower than those from Round 1. Arsenic and beryllium were not detected. Mineral forming metals, manganese and zinc were the only metals found in a soluble form.

Surface Water. Volatile organics, petroleum hydrocarbons, pesticides, and PCB compounds were not detected in surface waters, although a trace quantity of di-n-butylphthalate was found. Far fewer metals were found in the surface water sample than either the site groundwater or background surface water. The metals which were detected were primarily mineral forming, as well as manganese. The quantities of the metals were in the same range as measured in the background surface water.

Sediment. Sediment samples contained more volatile organics than any other media with carbon disulfide at 19 $\mu\text{g/kg}$, 2-butanone at 33 $\mu\text{g/kg}$, and toluene at 36 $\mu\text{g/kg}$. Two PAH compounds were also detected at trace levels. More semi-volatile compounds may have actually been present but were not identified due to a large dilution factor which resulted in elevated detection limits ranging from 3,800 to 24,000 $\mu\text{g/kg}$. Elevated petroleum hydrocarbon concentrations were reported, although a large variation in duplicate sample results indicates that concentrations are variable. The metals found in sediments consisted of mineral forming metals, six heavy metals, and barium. Even though the number of metals detected were lower than reported in either site soils or background sediments, concentrations were within a similar range.

3.3.3 Geologic and Hydrogeologic Investigation Results

Monitoring well MW1-06, and soil borings BH1-14 and BH1-15 were installed at Site 1. The geologic logs constructed for this site were consistent with area stratigraphy as described in Section 3.2.1.

Based on water level measurements collected at the piezometers and the monitoring well, groundwater flow at the site was predominantly to the west-southwest (Figure 3-13). The hydraulic gradient ranged from .004 to .007 (Table 3-3) at Site 1. The hydraulic conductivity (K), calculated at MW1-06, was 6.73×10^{-5} cm/second. Assuming a porosity of 0.30, the groundwater at Site 1 will flow to the west-southwest from 2.5×10^{-3} to 4.5×10^{-3} ft/day.

3.3.4 Identification of Data Gaps

No data gaps are apparent.

3.3.5 Summary and Conclusions

Results of the soil gas survey indicated low volatile organic compound contamination at Site 1. BTEX was not detected using the field GC.

Neither pesticides nor PCBs were found in any of the water, soil, or sediment samples collected. All of the volatile organics detected were found in either soils or sediments. Petroleum hydrocarbons were detected in the sediment and two soil samples. The detection of volatile organic compounds and petroleum hydrocarbons suggests that solvents may have been used within this site, in addition to various oil products. Two of the volatiles reported in the higher concentrations, 2-butanone and toluene, were found in drainage ditch sediments. The relatively low volatile organic concentration in soils and groundwater are consistent with the low soil gas values found throughout the site, and the observation that soils appeared free of stains. The detection of numerous PAH compounds, predominantly in surface soils, suggests that these

analytes may be largely associated with asphalt/pavement activities or the remains of semi-combusted jet fuels. Also, the detection of di-n-butylphthalates throughout the soil profile as well as other phthalate compounds in both surface and groundwater and surface soils may have resulted from many past base activities. The sources are difficult to determine because phthalates are ubiquitous. Also, the source of mercury in groundwater and boring soils is not apparent. In addition, the surface water/soil interface appears to be an area of retention for many of the metals found in groundwater and soils.

Groundwater flow at Site 1 is estimated to flow westerly 0.9 to 1.6 feet/year (Table 3-3). The monitoring well, soil borings, and area piezometers were placed in locations which should provide for sufficient Site 1 characterization.

3.4 SITE 2 - ABANDONED PETROLEUM, OIL, AND LUBRICANT (POL) STAND

Site 2 is located near the center of the base, south of building no. 3. It is an abandoned storage and transfer area for POL products. Four 25,000-gallon capacity tanks were installed at the site in the 1950s. The tanks are located near the ground surface and extend 15-20 feet below ground. In the PA (HMTC, 1987) it was reported that about 5,000 gallons of JP-4 leaked onto the frozen ground in the winter of 1979 and, subsequently, most was recovered. There have been other JP-4 spills at the site over the years. Spill control and cleanup measures during these latter incidents were minimal.

3.4.1 Screening Activity Results

Thirty-nine soil gas readings and 19 gas chromatograph (GC) samples were collected at Site 2. The GC samples were collected at points SG2-2, -3, -5, -6, -9 through -15, -20, -23 through -25, -27 through -29, and -32. Table 3-8 presents the flame ionization detector (FID) readings and Figure 3-14 illustrates the sampling points.

TABLE 3-8. SITE 2 - ABANDONED POL STAND SOIL GAS SURVEY RESULTS

Point Number	Soil Depth (ft)	FID Reading (ppm)	Point Number	Soil Depth (ft)	FID Reading (ppm)	Point Number	Soil Depth (ft)	FID Reading (ppm)	Point Number	Soil Depth (ft)	FID Reading (ppm)	Point Number	Soil Depth (ft)	FID Reading (ppm)
SG2-1	1	3.2	SG2-9	1	0.4	SG2-19a	1	ng	SG2-29	1	0.0	SG2-35	1	ng
SG2-2	1	0.4	SG2-10	1	0.6	SG2-20	1	0.8	SG2-30	1	1.0	SG2-35a	1	ng
SG2-2	3	5.0	SG2-11	1	0.4	SG2-21	1	1.1	SG2-30	2	0.0	SG2-36	1	ng
SG2-3	1	ng	SG2-12	1	0.3	SG2-22	1	ng	SG2-30	3	ng	SG2-36	2	ng
SG2-3a	1	0.4	SG2-13	1	0.0	SG2-22a	1	ng	SG2-30	4	ng	SG2-36	3	ng
SG2-3a	2	ng	SG2-14	1	1.0	SG2-23	1	0.0	SG2-30	5	ng	SG2-36	4	ng
SG2-3b	1	0.9	SG2-15	1	0.7	SG2-24	1	ng	SG2-31	1	ng	SG2-36	5	ng
SG2-4	1	ng	SG2-16	1	ng	SG2-24a	1	0.0	SG2-31	1	1.0	SG2-37	1	1.2
SG2-4a	1	ng	SG2-16a	1	2.8	SG2-25	1	0.0	SG2-32	1	0.2	SG2-38	1	ng
SG2-5	1	0.0	SG2-17	1	ng	SG2-26	1	ng	SG2-33	1	ng	SG2-38a	1	ng
SG2-6	1	1.5	SG2-17a	1	ng	SG2-26a	1	ng	SG2-33a	1	ng	SG2-39	1	2.6
SG2-7	1	1.0	SG2-18	1	2.0	SG2-27	1	0.5	SG2-34	1	ng			
SG2-8	1	1.4	SG2-19	1	ng	SG2-28	1	0.6	SG2-34a	1	ng			

Note: ng - no soil gas measured

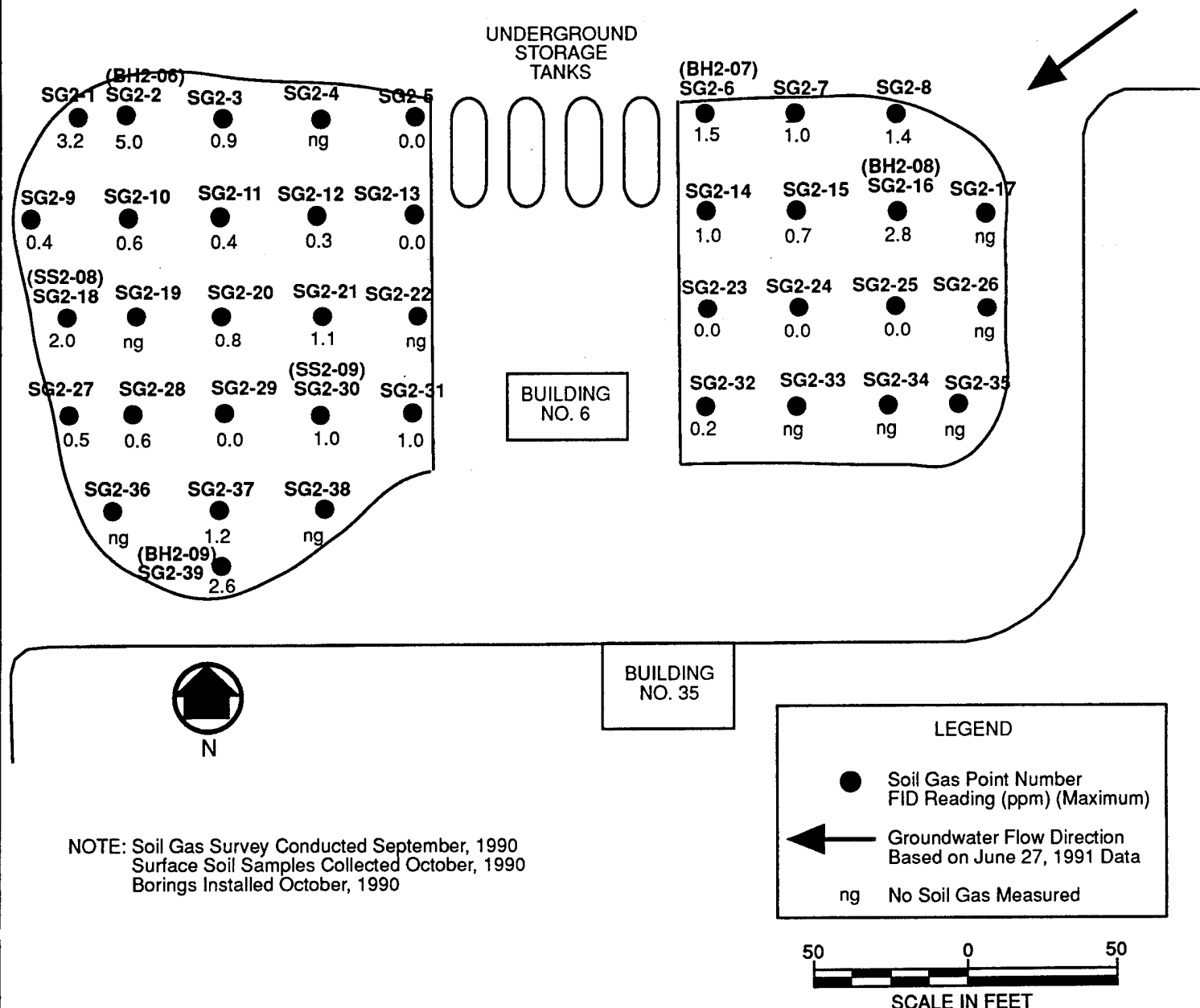


FIGURE 3-14. SOIL GAS SURVEY LOCATIONS
SITE 2: ABANDONED PETROLEUM, OIL, AND LUBRICANTS STAND
181st FG, HULMAN FIELD MAP, TERRE HAUTE, IN

The FID results indicated low level volatile organic contamination exists at Site 2. A maximum reading of 5.0 ppm was obtained at point SG2-2 and a minimum reading of <1.0 ppm was obtained at points SG2-5, -13, -23 through -25, -29, and -30. The readings were used to site the soil boring and surface soil sampling locations. Soil borings were placed at SG2-2, -6, -16, and -39. Surface soil samples were collected at SG2-18 and -30. Although the FID reading at SG2-8 is higher than the reading at SG2-30, SG2-8 was not used for surface soil sample collection due to its closeness to the soil boring at SG2-16. The majority of the readings at SG2-30 were above 1.0 ppm, therefore the confirmation activities were concentrated west of the tanks.

Field GC analyses indicated potential BTEX contamination at points SG2-27, -28 and -29. SG2-29 appeared to have the highest contamination with SG2-28 showing more contamination than SG2-27. Benzene was difficult to identify in SG2-29 and SG2-28 due to matrix interference caused by the presence of coeluting compounds. SG2-29 results were similar to a JP-4 standard run the previous day. Due to the JP-4 standard being run on a different day and that many of the peaks were off the calibration scale, a more definitive identification is difficult.

Sampling points SG2-9, SG2-23 to -25 and SG2-32 indicated the presence of toluene. Samples from SG2-23 to -25 and SG2-32 contained a matrix interference which caused an unknown peak to elute just prior to the toluene peak. The syringe blank injected prior to the analysis of these 4 points also appeared to contain a small amount of toluene, indicating that the toluene detected at these points may have been a result of syringe contamination and not soil gas concentrations.

The chromatographs of points SG2-2 through -6 and -15 all indicated the presence of benzene. However, syringe blanks and ambient air blanks also indicated the presence of benzene. Thus, contamination at these points appears to be unlikely. Heavy equipment operating in the area during sampling may have been the contamination source.

Contamination was not indicated at points SG2-10 to -13 and SG2-20.

3.4.2 Confirmation and Delineation Activity Results

Samples collected at Site 2 consisted of two surface soils, eight subsurface soils from four soil boring locations, and two groundwater samples (from two sampling rounds). One of the subsurface soil samples was collected from a depth of 0 to 2 feet, three from depths of 2 to 4 feet, and four from 4 to 6 feet. Both of the surface soils were collected within a grassy area west of the drum storage area. Sampling locations for Site 2 are shown in Figure 3-15. All samples submitted to the laboratory were analyzed for volatile organics, semi-volatile organics, and petroleum hydrocarbons. No metal or pesticide/PCB analyses were performed (see Section 2.4). Analytical results are presented in Tables 3-9a and 3-9b and summarized in Table 3-9c.

Surface Soil. Tetrachloroethene and bis(2-ethylhexyl)phthalate were detected in surface soil SS2-08. In the same sample, ten PAH compounds were also reported. Petroleum hydrocarbons were detected in both surface soils SS2-08 and SS2-09, although the concentrations in SS2-08 were an order of magnitude higher.

Subsurface Soil. Trace quantities of two volatile organics, trichloroethene and toluene, were detected in subsurface soils taken at BH2-06 (4-6 feet). In comparison, trichloroethene and toluene were present in relatively high concentrations in BH2-06 (2-4 feet) and BH2-07 (4-6 feet), respectively. Detection limits in both BH2-07 soil samples were highly elevated which may have masked the presence of lower volatile organic concentrations. Di-n-butylphthalate was detected in BH2-06 (2-4 feet) and BH2-06 (4-6 feet) at elevated concentrations of 5400 and 4900 $\mu\text{g}/\text{kg}$, respectively. Bis(2-ethylhexyl)phthalate was also reported at trace concentrations in BH2-09 (2-4 feet). PAH compounds were reported in three of the four soil borings. Two PAH compounds were found at BH2-06 (2-4 feet) and BH2-08 (0-2 feet), while eight PAHs at higher concentrations were detected at BH2-07 (2-4 feet). A trace level of benzoic acid was also identified at BH2-07 (2-4 feet). Petroleum hydrocarbons were detected in five of the eight subsurface soil samples. The highest concentrations were associated with the soil collected from 0 to 2 feet in soil boring BH2-08.

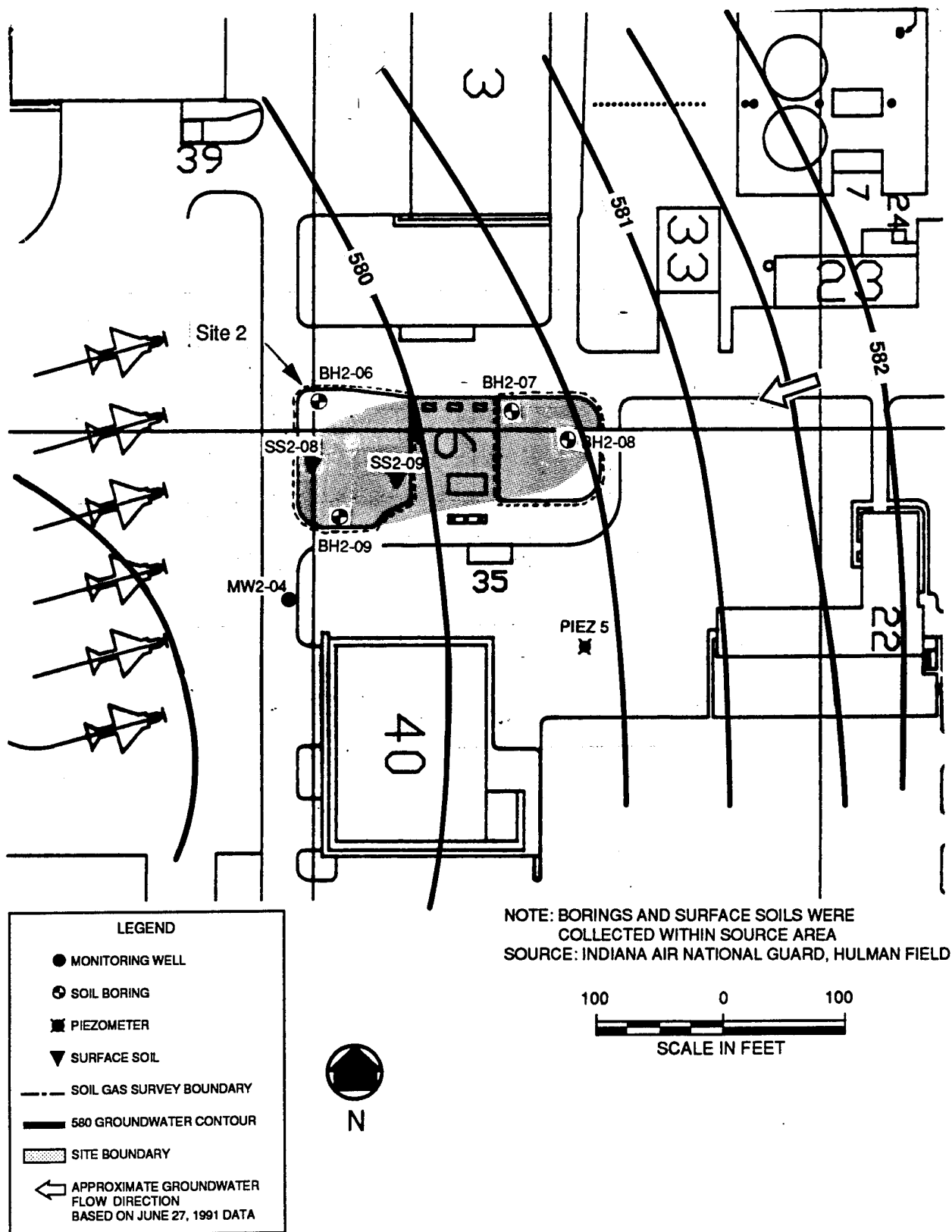


FIGURE 3-15. SAMPLING LOCATIONS,
 SITE 2: ABANDONED PETROLEUM, OIL, AND LUBRICANTS STAND
 181ST FG, HULMAN FIELD MAP, TERRE HAUTE, IN

TABLE 3-9a. SITE 2-DETECTED CONTAMINANT CONCENTRATIONS IN SOIL
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT	LOCATION U - ID Depth, FT LAB ID #	BH2-06 NS - 11 2.0-4.0 9010L166-011	BH2-06 NS - 12 4.0-6.0 9010L166-012	BH2-07 NS - 13 2.0-4.0 9010L152-006	BH2-07 NS - 14 4.0-6.0 9010L152-007	BH2-08 NS - 15 0.0-2.0 9010L152-003	BH2-08 NS - 16 4.0-6.0 9010L152-004	BH2-09 NS - 17 2.0-4.0 9010L152-001	BH2-09 NS - 18 4.0-6.0 9010L152-002
VOLATILE ORGANICS												
Trichloroethene	CLP	UG/KG	5		22	5 J	740 U	770 U	6 U	6 U	6 U	6 U
Tetrachloroethene	CLP	UG/KG	5		6 U	6 U	740 U	770 U	6 U	6 U	6 U	6 U
Toluene	CLP	UG/KG	5		1 J	1 J	740 U	210 J	6 U	6 U	6 U	6 U
SEMIVOLATILE ORGANICS												
Benzoic acid	CLP	UG/KG	1600		2100 U	2200 U	440 J	2000 U	2200 U	2200 U	2100 U	2200 U
Phenanthrene	CLP	UG/KG	330		420 U	440 U	56 J	400 U	440 U	430 U	410 U	450 U
Di-n-Butylphthalate	CLP	UG/KG	330		5400	4900	380 U	400 U	440 U	430 U	410 U	450 U
Fluoranthene	CLP	UG/KG	330		80 J	440 U	87 J	400 U	99 J	430 U	410 U	450 U
Pyrene	CLP	UG/KG	330		85 J	440 U	70 J	400 U	66 J	430 U	410 U	450 U
Benzo(a)anthracene	CLP	UG/KG	330		420 U	440 U	42 J	400 U	440 U	430 U	410 U	450 U
Chrysene	CLP	UG/KG	330		420 U	440 U	49 J	400 U	440 U	430 U	410 U	450 U
bis(2-Ethylhexyl)phthalate	CLP	UG/KG	330		420 U	440 U	380 U	400 U	440 U	430 U	54 J	450 U
Benzo(b)fluoranthene	CLP	UG/KG	330		420 U	440 U	76 J	400 U	440 U	430 U	410 U	450 U
Benzo(k)fluoranthene	CLP	UG/KG	330		420 U	440 U	55 J	400 U	440 U	430 U	410 U	450 U
Benzo(a)pyrene	CLP	UG/KG	330		420 U	440 U	66 J	400 U	440 U	430 U	410 U	450 U
Indeno(1,2,3-cd)pyrene	CLP	UG/KG	330		420 U	440 U	380 U	400 U	440 U	430 U	410 U	450 U
Benzo(g,h,i)perylene	CLP	UG/KG	330		420 U	440 U	380 U	400 U	440 U	430 U	410 U	450 U
PETROLEUM HYDROCARBONS												
Petroleum Hydrocarbon	E418.1	MG/KG	20		6.3 UJ	4 UJ	11	17	62	5.1 U	4.1 J	3.8 J

TABLE 3-9a. SITE 2-DETECTED CONTAMINANT CONCENTRATIONS IN SOIL
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

CONTINUED

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT	LOCATION U - ID Depth, FT LAB ID #	SS2-08 NS - 48 0.0-0.5 9010L110-012	SS2-09 NS - 49 0.0-0.5 9010L110-011	MEAN (b)	MINIMUM (c)	MAXIMUM (c)	Background Concentration MEAN (d)	Background Concentration MAXIMUM (d)
VOLATILE ORGANICS											
Trichloroethene	CLP	UG/KG	5		6 U	6 U	22.0	5 J	22	3	ND
Tetrachloroethene	CLP	UG/KG	5		2 J	6 U	2.0 J	2 J	2 J	3 J	3 J
Toluene	CLP	UG/KG	5		6 U	6 U	60.0 J	1 J	210 J	3	ND
SEMIVOLATILE ORGANICS											
Benzoic acid	CLP	UG/KG	1600		1900 U	2100 U	440.0 J	440 J	440 J	1062.5	ND
Phenanthrene	CLP	UG/KG	330		220 J	420 U	198.1 J	56 J	220 J	210	ND
Di-n-Butylphthalate	CLP	UG/KG	330		380 U	420 U	1195.5	4900	5400	44 J	44 J
Fluoranthene	CLP	UG/KG	330		500	420 U	204.1 J	80 J	500	210	ND
Pyrene	CLP	UG/KG	330		310 J	420 U	180.6 J	66 J	310 J	210	ND
Benzo(a)anthracene	CLP	UG/KG	330		190 J	420 U	190.0 J	42 J	190 J	210	ND
Chrysene	CLP	UG/KG	330		260 J	420 U	201.4 J	49 J	260 J	210	ND
bis(2-Ethylhexyl)phthalate	CLP	UG/KG	330		40 J	420 U	54.0 J	40 J	54 J	210	ND
Benzo(b)fluoranthene	CLP	UG/KG	330		340 J	420 U	212.1 J	76 J	340 J	210	ND
Benzo(k)fluoranthene	CLP	UG/KG	330		390	420 U	215.0 J	55 J	390	210	ND
Benzo(a)pyrene	CLP	UG/KG	330		360 J	420 U	213.1 J	66 J	360 J	210	ND
Indeno(1,2,3-cd)pyrene	CLP	UG/KG	330		340 J	420 U	223.5 J	340 J	340 J	210	ND
Benzo(g,h,i)perylene	CLP	UG/KG	330		380	420 U	227.5	380	380	210	ND
PETROLEUM HYDROCARBONS											
Petroleum Hydrocarbon	E418.1	MG/KG	20		62	5.4	17.3 J	3.8 J	62	26.9	100

NOTES:

- Ten soil samples total: two samples each from four borings and two surface soils. Analyses: volatile organics, semivolatile organics, and petroleum hydrocarbons (Table 2-3). Analytes not presented were not detected.
 - The mean concentration for all soil samples is calculated using half the sample quantification detection limit where not detected. The maximum detected value is used for the mean if the calculated mean is greater than the maximum.
 - Minimum and maximum values do not include those values flagged with a U or UI.
 - Four background soil samples total: two samples from one boring and two surface soils. Mean and maximum background concentrations were calculated in the same manner as above, where not detected, the mean is based on detection limits only. J = Estimated data due to quality control criteria.
- ND= Not detected.
U =Compound not detected, value is the sample quantification limit.
UI=Compound not detected, estimated sample quantification limit.

TABLE 3-9b. SITE 2-DETECTED CONTAMINANT CONCENTRATIONS IN GROUNDWATER
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT (b)	LOCATION U - ID Depth, FT LAB ID #	MW2-04 NS - 73 0.0-0.0 9011L572-007	MW2-04 (c) NS - 104 0.0-0.0 9201L073-005	MEAN (d)	MINIMUM (e)	MAXIMUM (e)	Background Concentration (f)	MCL (g)
VOLATILE ORGANICS											
Chloromethane	CLP	UG/L	10		4 J	10 U	4 J	4 J	4 J	10 U	
1,2-Dichloroethane	CLP	UG/L	5(10)		5 U	2 J	2 J	2 J	2 J	5 U	5.0

NOTES:

- Two groundwater samples total: Analyses: volatile organics, semivolatile organics, and petroleum hydrocarbons (Table 2.3). Analytes not presented were not detected.
 - Detection limit for Round 2 sampling located in parentheses if different from Round 1.
 - Sample taken during Round 2 in January 1992, unless noted, all other samples taken during Round 1 in November 1990.
 - The mean concentration for all groundwater samples is calculated using half the sample quantification detection limit where not detected. The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
 - Minimum and maximum values do not include those values flagged with a U or UJ.
 - One background groundwater sample total.
 - Maximum Contaminant Levels taken from Table 4.3.
- J = Estimated data due to quality control criteria.
U = Compound not detected, value is the sample quantification limit.

TABLE 3-9c. SITE 2, SUMMARY OF ANALYTICAL DETECTIONS
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	SOIL(b)		GROUNDWATER				
	RANGE(c)		MEAN(d)	NUMBER OF DETECTIONS	RANGE	MEAN	NUMBER OF DETECTIONS
	UG/KG		UG/KG		UG/L	UG/L	
VOLATILE ORGANICS							
Trichloroethene	5 J to	22	22	2 / 10			
Tetrachloroethene	2 J		2 J	1 / 10			
Toluene	1 J to	210 J	60 J	3 / 10	4 J	4 J	1 / 2
Chloromethane					2 J	2 J	1 / 2
1,2-Dichloroethane							
SEMIVOLATILE ORGANICS							
Benzoic acid	440 J		440 J	1 / 10			
Phenanthrene	56 J to	220 J	198 J	2 / 10			
Di-n-Butylphthalate	4,900 to	5,400	1,196	2 / 10			
Fluoranthene	80 J to	500	204 J	4 / 10			
Pyrene	66 J to	310 J	181 J	4 / 10			
Benzo(a)anthracene	42 J to	190 J	190 J	2 / 10			
Chrysene	49 J to	260 J	201 J	2 / 10			
bis(2-Ethylhexyl)phthalate	40 J to	54 J	54 J	2 / 10			
Benzo(b)fluoranthene	76 J to	340 J	212 J	2 / 10			
Benzo(k)fluoranthene	55 J to	390	215 J	2 / 10			
Benzo(a)pyrene	66 J to	360 J	213 J	2 / 10			
Indeno(1,2,3-cd)pyrene	340 J		224 J	1 / 10			
Benzo(g,h,i)perylene	380		228	1 / 10			
PETROLEUM HYDROCARBON	MG/KG		MG/KG				
Petroleum Hydrocarbon	3.8 J to	62	17.3 J	7 / 10			

NOTES:

- Ten soil samples total: two samples each from four boring and two surface soils.
 - Minimum and maximum detections presented. One value presented usually indicates detected in only one sample.
 - Two groundwater samples total. No value presented means not detected.
- J = Estimated data due to quality control criteria.

Groundwater. During Round 1, chloromethane was the only organic compound detected in the groundwater sample, measured at trace levels. Semi-volatile and petroleum hydrocarbon compounds were not detected in groundwater. During Round 2, 1,2-dichloroethane was the only organic compound detected in the groundwater sample, also measured at trace levels. Neither semi-volatile nor petroleum hydrocarbon compounds were detected in groundwater, during Round 2.

3.4.3 Geologic and Hydrogeologic Investigation Results

Site 2 was formerly used as a storage and transfer area for POL products. Four 25,000 gallon tanks are currently present in the area. Monitoring well MW2-04 and piezometer P-5 were installed near this area. Soil borings BH2-06, BH2-07, BH2-08, and BH2-09 were also drilled in the Abandoned POL stand. Geologic logs constructed in this area were consistent with the stratigraphy as described in Section 3.2.1.

Based on water level measurements collected at the piezometer and the monitoring well, groundwater flows to the west-southwest (see Figure 3-15). A hydraulic conductivity (K) of 8.90×10^{-5} cm/sec was calculated for monitoring well MW2-04. A hydraulic gradient between .004 and .008 was calculated for Site 2. Assuming a porosity of 0.30, the groundwater at Site 2 flows west-southwest from approximately 3.4×10^{-3} to 6.7×10^{-3} ft/day.

3.4.4 Identification of Data Gaps

No data gaps were identified.

3.4.5 Summary and Conclusions

Soil gas survey results indicated low level volatile organic compound contamination at Site 2. Field GC analyses indicated potential BTEX contamination at the site.

Volatile organics were detected in all media from Site 2. Except for toluene and trichloroethene in two subsurface soils, all other volatile compounds were present at trace concentrations ($<10 \mu\text{g/kg}$). PAH compounds were found in soils at three boring and one surface soil sampling location. While PAH and phthalate compounds tend to be present in the upper four feet of soils, toluene was detected at greater depths. PAH compounds and toluene are likely residuals of past spills of fuel or semi-combusted jet fuels in this area, which appear to be limited to small areas. This is consistent with findings during the soil gas survey and drilling activities. Except for SS2-09, all sampling points were close to asphalt/pavement, which may have contributed to the detection of PAH compounds in surface soils. The source of phthalate compounds is not clearly identified. Petroleum hydrocarbons were measured in seven soil samples in concentrations within the range of background soils.

Groundwater flows west-southwest from Site 2 from 1.2 to 2.5 feet/year. The monitoring well MW2-04, piezometer P-5 and four soil borings installed in the Abandoned POL area were placed in locations which should provide sufficient Site 2 characterization.

3.5 SITE 4 - OLD BLADDER AREA (HAS-53)

Site 4, located on the east side of the base, is known as the Old Bladder Area or the Pillow Farm. The area was constructed in 1963 or 1964 to enclose five 50,000-gallon JP-4 storage bladders. In 1967 or 1968, the fuel bladders were removed. No fuel spills were ever reported to have occurred at the Old Bladder Area prior to removal of the fuel bladders.

In March 1978, mixed water and fuel was observed in the bottom $4\frac{1}{2}$ feet of an underground 25,000-gallon JP-4 storage tank, located to the west of the Old Bladder Area. In order to inspect this tank, 10,000 gallons of a JP-4 and water mixture were pumped from the tank into the diked section of the Old Bladder Area. Because the ground surface within the diked area was not level, ponding of the mixture occurred within the southwest corner. In the PA report (HMTC, 1987) it was estimated that of the 10,000 gallons held within the diked areas, 2,500 gallons was water and 7,500 gallons was JP-4. The report also indicated that

approximately 90 percent of the JP-4 was recovered, and the remaining 750 gallons may have percolated into the underlying soil.

In 1988, two above-ground tanks were constructed on a concrete pad within the Old Bladder Area. During construction the earthen berm was removed. The tanks, which store JP-4 are located on a concrete base that is bordered with a three-foot secondary containment wall. While the PA study indicated that the concrete pad for the tank would effectively cap the site, it is unclear whether the entire area identified in the PA as contaminated by oil and grease is covered by the pad.

3.5.1 Screening Activity Results

Fifty-nine soil gas readings were collected at Site 4 and twenty five gas chromatograph (GC) analyses were run. The GC analyses were conducted at points SG4-1, -3, -4, -5, -9, -11, -12, -13, -16 through -20, -22, -26, -27, -28, -30, -31, -33, -36, -42, -44, -45, -51, -53, and -54. Table 3-10 lists the FID readings and Figure 3-16 illustrates the sampling locations.

The FID results indicated little contamination at Site 4 except at points SG4-43 (10.2 ppm) and SG4-48 (12 ppm) where contamination is moderate. The reading of 12 ppm at SG4-48 was the maximum obtained, and a minimum reading of <1.0 ppm was obtained at points SG4-16, -18, -19, -20, -31, -35, -45, and -54.

The readings were used to site the soil boring and surface soil sampling locations. Soil borings were placed between points SG4-43 and -52, SG4-47 and -56, SG4-24 and -29, and at SG4-48. These locations were chosen to more evenly distribute the borings in the areas of highest VOC concentrations. Surface soil locations were placed at SG4-14 and SG4-58.

The GC results at Site 4 do not definitively indicate any BTEX contamination. Four points (SG4-29, -27, -22 and -13) potentially indicated small amounts of toluene. This is difficult to conclude, however, due to Field GC standard degradation and some retention time drift. Points

TABLE 3-10. SITE 4 - OLD BLADDER AREA SOIL GAS SURVEY RESULTS

Point Number	Soil Depth (ft)	FID Reading (ppm)	Point Number	Soil Depth (ft)	FID Reading (ppm)	Point Number	Soil Depth (ft)	FID Reading (ppm)	Point Number	Soil Depth (ft)	FID Reading (ppm)	Point Number	Soil Depth (ft)	FID Reading (ppm)
SG4-1	1	ng	SG4-12	1	5.4	SG4-24	1	3.0	SG4-35	1	0.0	SG4-47	1.5	4.1
SG4-1a	1	1.1	SG4-13	1.5	ng	SG4-25	1	1.0	SG4-36	1.5	0.5	SG4-48	1.5	12
SG4-2	1	ng	SG4-13a	1	0.2	SG4-25	2	1.0	SG4-37	1	0.2	SG4-49	1.5	5.4
SG4-2a	1	ng	SG4-14	1	2.7	SG4-25	3	ng	SG4-37	1.5	1.0	SG4-50	-	-
SG4-3	1	0.7	SG4-15	1	1.4	SG4-26	1.5	0.4	SG4-38	1.5	2.2	SG4-51	1	0.2
SG4-4	1	ng	SG4-16	1.5	0.0	SG4-27	1	0.6	SG4-39	1.5	2.4	SG4-52	1	7.5
SG4-4a	1	1.7	SG4-17	1.5	ng	SG4-28	1	ng	SG4-40	1.5	2.4	SG4-53	1	0.2
SG4-5	1	3.8	SG4-17a	1	1.3	SG4-28a	1	0.2	SG4-41	1	2.0	SG4-54	1	0.0
SG4-6	1	1.7	SG4-18	1.5	0.0	SG4-29	1	4.2	SG4-42	1	0.6	SG4-55	1.5	2.3
SG4-7	1	1.0	SG4-19	1.5	0.0	SG4-30	1	0.7	SG4-43	1	10.2	SG4-56	1.5	4.0
SG4-8	1	1.8	SG4-20	1.5	0.0	SG4-31	1.5	0.0	SG4-44	1	ng	SG4-57	1.5	4.4
SG4-9	1	0.9	SG4-21	1.5	4.3	SG4-32	1	1.8	SG4-44a	1	0.4	SG4-58	1.5	5.6
SG4-10	1	3.2	SG4-22	1.5	0.2	SG4-33	1	0.9	SG4-45	1.5	0.0	SG4-59	1.5	ng
SG4-11	1	0.2	SG4-23	1	1.6	SG4-34	1	3.7	SG4-46	1.5	2.2	SG4-59a	1	ng

Notes: ng - no soil gas measured

-- data rejected

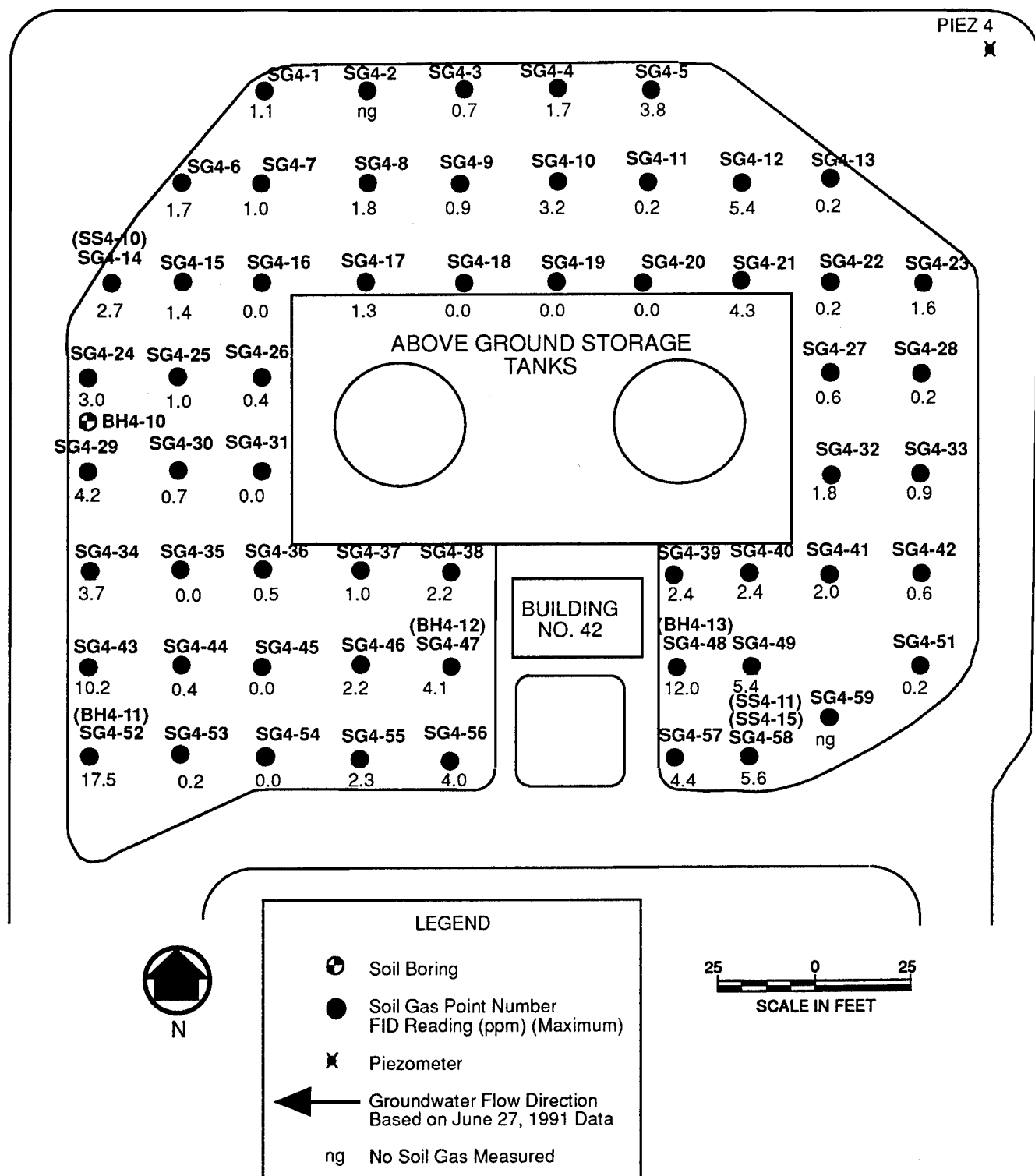


**FIGURE 3-16. SOIL GAS SURVEY LOCATIONS
 SITE 4: OLD BLADDER AREA
 181st FG, HULMAN FIELD MAP, TERRE HAUTE, IN**

SG4-21 and -28 indicated the possible presence of benzene, but drift in retention time and matrix interference made positive identification difficult.

3.5.2 Confirmation and Delineation Activity Results

Samples collected at Site 4 consisted of two surface soils, eight subsurface soils collected from four soil borings, four groundwater samples (from two sampling rounds), one surface water, and one sediment sample. One groundwater sample was collected from MW4-05 in Round 1 and two groundwater samples were collected from Piezometer-4 and one groundwater sample was collected from MW4-05 in Round 2. Samples were analyzed for volatile and semi-volatile organics and TPH. No metal or pesticide/PCB analyses were performed (see Section 2.4). Sample locations are presented in Figure 3-17. Analytical results for each media are presented in Tables 3-11a-c and summarized in Table 3-11d.

Surface Soil. A trace concentration of trichloroethene and 1,2-dichlorobenzene was found in surface soil SS4-10. Three semi-volatile organics, all phthalate compounds, were also detected in this sample. At the other surface soil location, the duplicate samples (SS4-11 and SS4-15) contained similar concentrations of phthalates, and 1,2-dichlorobenzene was also present. Eight PAH compounds were also detected at this location. Petroleum hydrocarbons (6400-33,000 $\mu\text{g/kg}$) were elevated at both locations.

Subsurface Soil. In subsurface soils, a relatively high concentration of trichloroethene was found in BH4-13 (2-4 feet), while trace concentrations were detected in both soil samples taken in borehole BH4-11 (2-4 and 4-6 feet). Benzene was measured at trace levels in BH4-10 (2-4 feet), where the highest toluene concentration (11 $\mu\text{g/kg}$) was detected. Toluene was also detected in four other samples at trace quantities. Di-n-butylphthalate was detected in all subsurface samples at concentrations considerably higher than detection limits. Two other phthalate compounds, butylbenzylphthalate and bis(2-ethylhexyl)phthalate, were found less frequently in subsurface soils. In addition, pyrene and phenol were detected at trace quantities at 2-4 feet in BH4-10 and BH4-12, respectively.

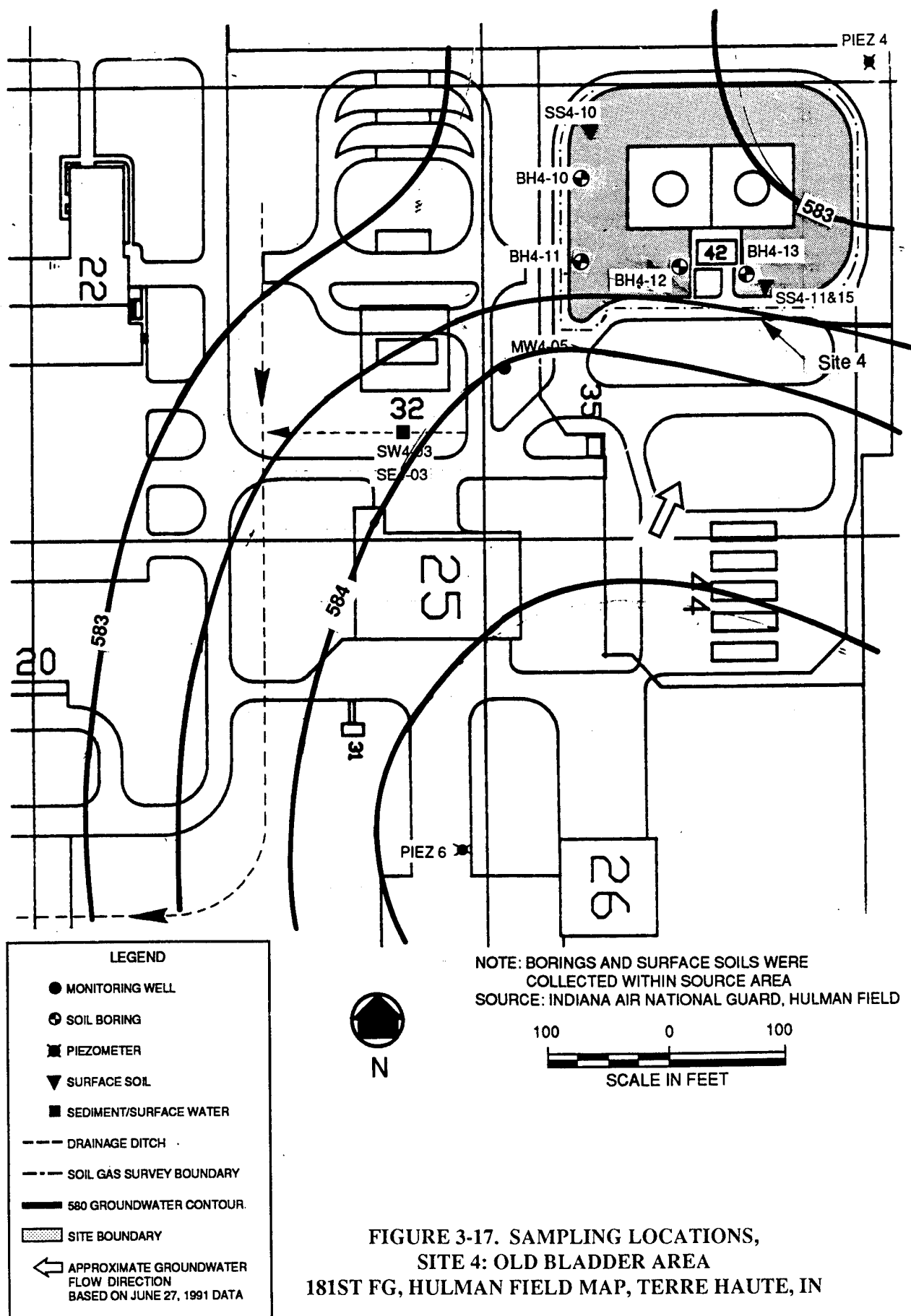


TABLE 3-11a. SITE 4-DETECTED CONTAMINANT CONCENTRATIONS
IN SOIL - 181st HULMAN FIELD MAP,
TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETEC LIMIT	LOCAT. U - ID Depth, FT	BH4-10 NS - 19 4.0-6.0 9010L166-015	BH4-10 NS - 20 2.0-4.0 9010L166-016	BH4-11 NS - 21 2.0-4.0 9010L166-013	Duplicate Sample BH4-11 NS - 22 4.0-6.0 9010L166-014	BH4-12 NS - 23 2.0-4.0 9010L166-017	BH4-12 NS - 24 4.0-6.0 9010L166-018	BH4-13 NS - 25 2.0-4.0 9010L166-019	BH4-13 NS - 26 4.0-6.0 9010L166-020
VOLATILE ORGANICS												
Trichloroethene	CLP	UG/KG	5		6 U	6 U	2 J	4 J	6 U	6 U	38	6 U
Benzene	CLP	UG/KG	5		6 U	1 J	6 U	6 U	6 U	6 U	6 U	6 U
Toluene	CLP	UG/KG	5		3 J	11	2 J	6 U	2 J	6 U	6 U	6 U
1,2-Dichlorobenzene	CLP	UG/KG	330		410 U	410 U	420 U	420 U	420 U	410 U	390 U	410 U
SEMIVOLATILES												
Phenol	CLP	UG/KG	330		410 U	410 U	420 U	420 U	46 J	410 U	390 U	410 U
Phenanthrene	CLP	UG/KG	330		410 U	410 U	420 U	420 U	420 U	410 U	390 U	410 U
Di-n-Butylphthalate	CLP	UG/KG	330		5500	3700	3700	1800	2400	980	3900	5300
Fluoranthene	CLP	UG/KG	330		410 U	410 U	420 U	420 U	420 U	410 U	390 U	410 U
Pyrene	CLP	UG/KG	330		46 J	47 J	420 U	420 U	420 U	410 U	390 U	410 U
Butylbenzylphthalate	CLP	UG/KG	330		410 U	410 U	420 U	420 U	420 U	410 U	390 U	730
Benzo(a)anthracene	CLP	UG/KG	330		410 U	410 U	420 U	420 U	420 U	410 U	390 U	410 U
Chrysene	CLP	UG/KG	330		410 U	410 U	420 U	420 U	420 U	410 U	390 U	410 U
bis(2-Ethylhexyl)phthalate	CLP	UG/KG	330		94 J	2300	420 U	420 U	100 J	410 U	390 U	410 U
Benzo(b)fluoranthene	CLP	UG/KG	330		410 U	410 U	420 U	420 U	420 U	410 U	390 U	410 U
Benzo(k)fluoranthene	CLP	UG/KG	330		410 U	410 U	420 U	420 U	420 U	410 U	390 U	410 U
Benzo(a)pyrene	CLP	UG/KG	330		410 U	410 U	420 U	420 U	420 U	410 U	390 U	410 U
PETROLEUM HYDROC.												
Petroleum Hydrocarbon	B418.1	MG/KG	20		7.8 UJ	3.5 UJ	8.7 UJ	4.5 UJ	3.8 UJ	3.8 UJ	4.4 UJ	4.9 UJ

TABLE 3-11a. SITE 4-DETECTED CONTAMINANT CONCENTRATIONS
IN SOIL - 181st HULMAN FIELD MAP,
TERRE HAUTE, INDIANA (a)

CONTINUED													
PARAMETER	METHOD	UNITS	REPTD DEPTH LIMIT	LOCAT. U - ID Depth, FT LAB ID #	SS4-10 NS - 50 0.0-0.5 9010L151-010	SS4-11 NS - 51 0.0-0.5 9010L151-011	Duplicate Sample SS4-15 NS - 51	Duplicate Mean (b)	MEAN (c)	MINIMUM (d)	MAXIMUM (d)	Background Concentration MEAN (e)	Background Concentration MAXIMUM (e)
VOLATILE ORGANICS													
	CLP	UG/KG	5		3 J	5 U	5 U	5 U	6.3 J	2 J	38	3	ND
	CLP	UG/KG	5		5 U	5 U	5 U	5 U	1.0 J	1 J	1 J	3	ND
	CLP	UG/KG	5		5 U	5 U	5 U	5 U	3.4 J	2 J	11	3	ND
1,2-Dichlorobenzene	CLP	UG/KG	330		67 J	340 U	62 J	62 J	67.0 J	62 J	67 J	210	ND
SEMIVOLATILES													
	CLP	UG/KG	330		340 U	340 U	330 U	335 U	46.0 J	46 J	46 J	210	ND
	CLP	UG/KG	330		340 U	340 U	40 J	40 J	40.0 J	40 J	40 J	210	ND
	CLP	UG/KG	330		390	450	500	475	2979.5	390	5500	44 J	44 J
	CLP	UG/KG	330		340 U	83 J	86 J	84.5 J	84.5 J	84.5 J	84.5 J	210	ND
	CLP	UG/KG	330		340 U	71 J	69 J	70 J	70.0 J	46 J	70 J	210	ND
	CLP	UG/KG	330		230 J	340	380	360	276.0 J	230 J	730	210	ND
	CLP	UG/KG	330		340 U	47 J	40 J	43.5 J	43.5 J	43.5 J	43.5 J	210	ND
	CLP	UG/KG	330		340 U	54 J	49 J	51.5 J	51.5 J	51.5 J	51.5 J	210	ND
	CLP	UG/KG	330		220 J	340 U	350	350	408.9 J	94 J	2300	210	ND
	CLP	UG/KG	330		340 U	56 J	73 J	64.5 J	64.5 J	64.5 J	64.5 J	210	ND
	CLP	UG/KG	330		340 U	43 J	37 J	40 J	40.0 J	40 J	40 J	210	ND
	CLP	UG/KG	330		340 U	48 J	53 J	50.5 J	50.5 J	50.5 J	50.5 J	210	ND
	PETROLEUM HYDROC.												
E418.1	MG/KG	20		6.4	36	33	34.5	6.2	6.4	34.5	26.9	100	

NOTES:

- Ten soil samples total: two samples each from four borings and two surface soils. Analyses: volatile organics, semivolatile organics, and petroleum hydrocarbons (Table 2-3). Analytes not presented were not detected.
- Refers to the mean of the duplicate samples, if there is only one positive detection this value is used for the mean.
- The mean concentration for all soil samples is calculated using the duplicate mean for duplicate samples and half the sample quantification detection limit where not detected. The maximum detected value is used for the mean if the calculated mean is greater than the maximum.
- Minimum and maximum values do not include those values flagged with a U or UI.
- Four background soil samples total: two samples from one boring and two surface soils. Mean and maximum background concentrations were calculated in the same manner as above, where not detected, the mean is based on detection limits only.

J = Estimated data due to quality control criteria.

ND=Not detected

U =Compound not detected, value is the sample quantification limit.

UI=Compound not detected, estimated sample quantification limit.

TABLE 3-11b. SITE 4- DETECTED CONTAMINANT CONCENTRATIONS IN GROUNDWATER AND SURFACE WATER
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT	LOCATION U - ID Depth, FT LAB ID #	MW4-05 NS - 74 0.0-0.0 9011L600-002	MW4-05 (b) NX-105 0.0-0.0 9201L068-002	PZ4-01 (b) NS-109 0.0-0.0 9201L068-001	PZ4-01 (b) NS-110 0.0-0.0 9201L073-004	MEAN (c)	MAXIMUM (d)	Background Concentration (e)	SW4-03 NS - 85 0.0-0.0 9011L576-010	Background Concentration (e)
SEMIVOLATILES													
Di-n-Butylphthalate (f)	CLP	UG/L	10		11 U	11 U	12 U	11 U	5.6 U	ND	11 U	2 J	2 J

NOTES:

- Four groundwater samples and one surface water sample total. Analytes: volatile organics, semivolatile organics, and petroleum hydrocarbons (Table 2-3). Analytes not presented were not detected.
 - Sample taken during Round 2 in January 1992, unless noted, all other samples taken during Round 1 in November 1990.
 - The mean concentration for all groundwater samples is calculated using half the sample quantification detection limit where not detected, where not detected, the mean is based on detection limits only.
 - The maximum value does not include those values flagged with a U or UI.
 - One background groundwater sample and surface water sample total.
 - No Maximum Contaminant Level (MCL) available for Di-n-butylphthalate.
- J = Estimated data due to quality control criteria.
U = Compound not detected, value is the sample quantification detection limit
ND= Not detected.

TABLE 3-11c. SITE 4-DETECTED CONTAMINANT CONCENTRATIONS IN SEDIMENT
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REF'D DETECT LIMIT	LOCATION U - ID Depth, FT LAB ID #	SE4-03 NS - 93 0.0-0.0 9011L576-011	Background Concentrations SEB-01
SEMIVOLATILE ORGANICS						
4-Methylphenol	CLP	UG/KG	330		320 J	690 U
Phenanthrene	CLP	UG/KG	330		170 J	690 U
Fluoranthene	CLP	UG/KG	330		350 J	110 J
Pyrene	CLP	UG/KG	330		360 J	88 J
Benzo(a)anthracene	CLP	UG/KG	330		130 J	690 U
Chrysene	CLP	UG/KG	330		230 J	73 J
Benzo(b)fluoranthene	CLP	UG/KG	330		240 J	77 J
Benzo(k)fluoranthene	CLP	UG/KG	330		150 J	690 U
Benzo(a)pyrene	CLP	UG/KG	330		190 J	690 U
Indeno(1,2,3-cd)pyrene	CLP	UG/KG	330		120 J	690 U
Benzo(g,h,i)perylene	CLP	UG/KG	330		180 J	690 U
PETROLEUM HYDROCARBON						
Petroleum Hydrocarbon	E418.1	MG/KG	20		26	58

NOTES:

- One sediment total. Analyses: volatile organics, semivolatile organic, and petroleum hydrocarbons (Table 2-3). Analytes not presented were not detected.
 - One background sediment sample total.
- J=Estimated data due to quality control criteria.
U=Compound not detected, value is the sample quantification limit.

TABLE 3-11d. SITE 4 - SUMMARY OF ANALYTICAL DETECTIONS
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	SOIL (a)			SEDIMENT (c)	SURFACE WATER (d)	GROUND WATER(e)
	RANGE (b)	MEAN	NUMBER OF DETECTIONS			
VOLATILE ORGANICS	UG/KG	UG/KG				
Trichloroethene	2 J to 38	6.3 J	4 / 10			
Benzene	1 J	1 J	1 / 10			
Toluene	2 J to 11	3.4 J	5 / 10			
1,2-Dichlorobenzene	62 J to 67 J	67 J	2 / 10			
SEMIVOLATILE ORGANICS	UG/KG	UG/KG		UG/KG	UG/L	
Phenol	46 J	46 J	1 / 10			
4-Methylphenol				320 J		
Phenanthrene	40 J	40 J	1 / 10	170 J		
Di-n-Butylphthalate	390 to 5500	2980	10 / 10		2 J	
Fluoranthene	84.5 J	84.5 J	1 / 10	350 J		
Pyrene	46 J to 70 J	70 J	3 / 10	360 J		
Butylbenzylphthalate	230 J to 730	276 J	3 / 10			
Benzo(a)anthracene	43.5 J	43.5 J	1 / 10	130 J		
Chrysene	51.5 J	51.5 J	1 / 10	230 J		
bis(2-Ethylhexyl)phthalate	94 J to 2300	409 J	5 / 10			
Benzo(b)fluoranthene	64.5 J	64.5 J	1 / 10	240 J		
Benzo(k)fluoranthene	40 J	40 J	1 / 10	150 J		
Benzo(a)pyrene	50.5 J	50.5 J	1 / 10	190 J		
Indeno(1,2,3-cd)pyrene				120 J		
Benzo(g,h,i)perylene				180 J		
PETROLEUM HYDROCARBON	MG/KG	MG/KG		MG/KG		
Petroleum Hydrocarbon	6.4 to 34.5	6.2	2 / 10	26		

NOTES:

- Ten soil samples total: two samples each from four borings and two surface soils.
No value presented means not detected.
 - Minimum and maximum detections presented. One value presented usually indicates detected in only one sample.
 - Only one sediment sample taken.
 - Only one surface water sample taken.
 - Three groundwater samples total. No value presented means not detected.
- J = Estimated data due to quality control criteria.

Groundwater. During the first round of sampling, MW4-05 was sampled once and during the second round of sampling MW4-05 was sampled again in addition to the collection of two samples from Piezometer 4. Neither volatile or semi-volatile organics nor TPH were detected in any of the groundwater samples taken during the two rounds of sampling.

Surface Water. The surface water was found to contain a trace of di-n-butylphthalate. No other organic compounds or petroleum hydrocarbons were detected.

Sediment. Trace concentrations of ten PAH compounds and elevated petroleum hydrocarbon (26,000 $\mu\text{g/kg}$) concentrations were present in the sediment. Volatile organic compounds were not detected.

3.5.3 Geologic and Hydrogeologic Investigation Results

Monitoring well MW4-05 and piezometer P-4 were installed in this area. Soil borings BH4-10, BH4-11, BH4-12, and BH4-13 were also advanced in this area. All geologic logs constructed in this area were consistent with the stratigraphy as described in section 3.2.1. As indicated by groundwater level seasonal fluctuation, this area may be more impacted by surface water runoff.

Unlike the southwesterly groundwater flow pattern indicated throughout the base, water level measurements collected from monitoring wells and piezometers on June 27, 1991 indicated that groundwater flows northeast across Site 4 (see Figure 3-17). A hydraulic gradient of between 0.005 and 0.006 and a hydraulic conductivity (K) of 1.90×10^{-4} cm/second were calculated at Site 4. Assuming a porosity of 0.30 and the June 1991 data, the groundwater in this area may flow north-northeast at approximately 9.0×10^{-3} ft/day. However, February 1991 and January 1992 water levels indicated groundwater flow to the southwest in a velocity range of 9.0×10^{-3} to 1.1×10^{-2} ft/day.

3.5.4 Identification of Data Gaps

Due to the potential for localized groundwater flow at Site 4 to the northeast, during Round 1, the potential groundwater contamination may not have been characterized, since MW4-05 was located southwest of Site 4. During Round 2, groundwater samples were collected from Piezometer 4 and MW4-05 and groundwater flow was to the southwest. Groundwater flow in the vicinity of Site 4 appears to vary. Therefore, the actual direction and magnitude of groundwater flow can not be determined from the collected data.

3.5.5 Summary and Conclusions

Soil gas survey results indicated low volatile organic contamination at Site 4, except at two points where moderate contamination was indicated. Field GC results did not definitively indicate BTEX contamination.

Laboratory analyses indicated relatively low levels of volatile organics in soils at this site, which is consistent with soil gas results. The highest soil gas value was obtained at the location where trichloroethene was detected in BH4-13 (2-4 feet). PAH compounds and petroleum hydrocarbons were detected in sediments and infrequently in soils, the detection of numerous PAH compounds and high petroleum hydrocarbons were limited to one surface soil sample collected at SS4-11. Although field observations indicated that the surface water in the storm drain had a fuel-like sheen, surface water contamination was not evident. A possible explanation may be the presence of naturally occurring organically produced compounds. However, the sediments were contaminated and apparently tend to sorb phthalate and PAH compounds, as well as other types of petroleum hydrocarbons. Volatile and semi-volatile organic compounds were found generally higher than background levels in soils and sediments. Petroleum hydrocarbons were within the range found in background samples.

Groundwater did not appear to be impacted by any site contaminants. However, the groundwater flow direction appears to vary toward the north-northeast or southwest. In

February 1991, the inferred groundwater flow direction was to the southwest toward MW4-05 and in June 1991 the groundwater flow direction appeared to be to the northeast toward P-4. However, groundwater showed no evidence of contamination migration from the site in either direction (northeast or southwest), since groundwater samples collected from both MW4-05 and P-4 were not impacted by site contaminants.

There may be variation in the groundwater flow direction, as indicated by the June 1991 and January 1992 groundwater contour maps. Groundwater at Site 4 based on the June 1991 groundwater level measurements appears to be flowing to the north-northeast at approximately 3.3 ft/yr. However, in February 1991 and January 1992 groundwater flow was to the southwest from 3.3 to 3.9 ft/year. However, due to this discrepancy groundwater flow direction and velocity at Site 4 can not be determined from the collected data.

3.6 SITE 5 - VEHICLE MAINTENANCE AREA

Site 5 is defined by an area to the west and south of building 4. There is no visible evidence of Hazardous Materials/Hazardous Waste (HM/HW) spills in the area. The PA report (HMTC, 1987) states that small quantities (usually less than one quart) of waste oils, paint thinners, and solvents had occasionally been disposed of in the site area. The wastes were from routine maintenance and clean-up activities conducted at the vehicle maintenance area.

This method of disposal was ceased in 1975. It was estimated that prior activities resulted in less than 1,000 gallons of dumped materials in the area. An underground oil/water separator, extensive buried utilities and an underground MOGAS storage tank are all located within the site boundaries.

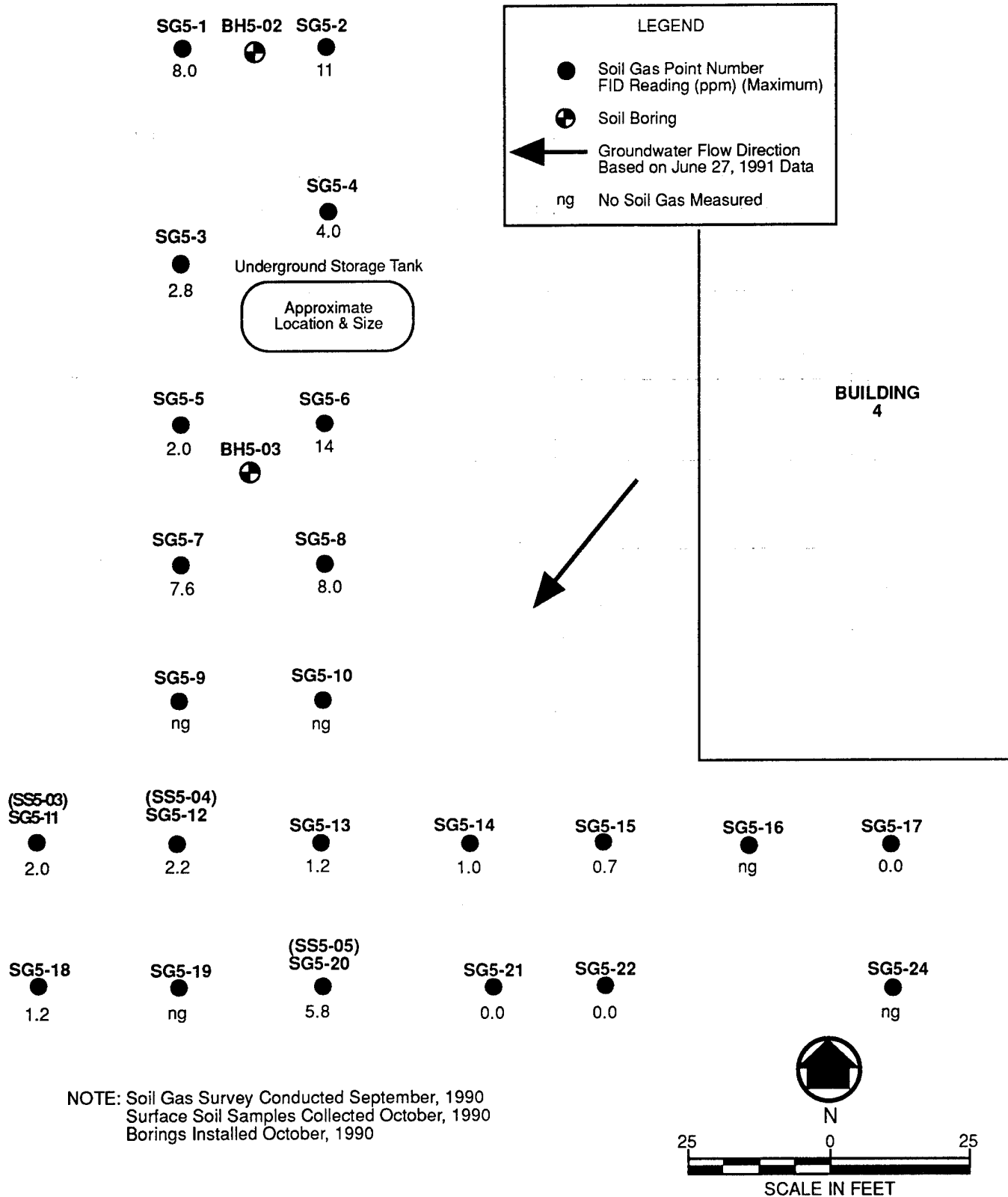
3.6.1 Screening Activity Results

Twenty-four soil gas readings were collected at Site 5 and four analyses were performed using a gas chromatograph (GC). Table 3-12 lists the FID results and Figure 3-18 illustrates the

TABLE 3-12. SITE 5 - VEHICLE MAINTENANCE AREA SOIL GAS SURVEY RESULTS

Point Number	Soil Depth (ft)	FID Reading (ppm)	Point Number	Soil Depth (ft)	FID Reading (ppm)	Point Number	Soil Depth (ft)	FID Reading (ppm)	Point Number	Soil Depth (ft)	FID Reading (ppm)
SG5-1	1	8.0	SG5-8a	2	ng	SG5-16	2	ng	SG5-20	2	5.8
SG5-2	1	11	SG5-9	2	ng	SG5-16a	2	ng	SG5-21	2	0.0
SG5-3	1	2.8	SG5-9a	2	ng	SG5-17	2	0.0	SG5-22	2	ng
SG5-4	1	4.0	SG5-10	2	ng	SG5-18	1	0.6	SG5-22a	2	0.0
SG5-5	1	2.0	SG5-10a	2	ng	SG5-18	2	1.2	SG5-23	-	-
SG5-6	1	14	SG5-11	2	2.0	SG5-18	3	ng	SG5-24	2	ng
SG5-7	1	7.6	SG5-12	2	2.2	SG5-18	4	ng	SG5-24a	2	ng
SG5-7	2	ng	SG5-13	2	1.2	SG5-18	5	ng			
SG5-8	2	ng	SG5-14	2	1.0	SG5-19	1	ng			
SG5-8a	1	8.0	SG5-15	2	0.7	SG5-19a	2	ng			

Notes: ng - no soil gas measured
-- data rejected



NOTE: Soil Gas Survey Conducted September, 1990
Surface Soil Samples Collected October, 1990
Borings Installed October, 1990

**FIGURE 3-18. SOIL GAS SURVEY LOCATIONS
SITE 5: VEHICLE MAINTENANCE AREA
181st FG, HULMAN FIELD MAP, TERRE HAUTE, IN**

sampling point locations. The GC analyses were conducted at points SG5-15, -17, -21, and -22, and the results did not reveal contamination.

The FID results indicate an area of moderate contamination around the underground storage tank (UST) on site. A maximum reading of 14 ppm was obtained at point SG5-6, south of the UST. The next largest detection, 11 ppm, occurred at SG5-2, north of the UST. Both points are located relatively close to the UST. A minimum reading of <1.0 ppm was obtained at points SG5-17, -21, and -22.

The readings were used to site the soil boring and surface soil sampling locations. Soil borings were placed between SG5-1 and -2, and between SG5-6, -7 and -8. Surface soil samples were collected at SG5-11, -12 and -20.

3.6.2 Confirmation and Delineation Activity Results

Samples collected at Site 5 consisted of three surface soils, four subsurface soils from two soil boring locations, and one groundwater. One of the subsurface soils was collected from a depth of 1 to 3 feet, one from a depth of 3 to 5 feet, and two from depths of 5 to 7 feet. Both boring locations and MW5-02 were placed in paved areas. Sampling locations for Site 5 are shown in Figure 3-19. All samples submitted to the laboratory were analyzed for volatile organics, semi-volatile organics, pesticides, PCBs, petroleum hydrocarbons, and metals. Analytical results for each media are presented in Tables 3-13a-b and summarized in Table 3-13c.

Surface Soil. Trace quantities of tetrachloroethene were detected in surface soils, SS5-04 and SS5-05 and trace quantities of toluene in SS5-04. Phthalates, numerous PAH compounds, and petroleum hydrocarbons were found at varying concentrations in all three surface soils. The highest PAH and petroleum hydrocarbon concentrations were detected in SS5-03. High PAH concentrations may indicate semi-combusted jet fuel. Aroclor 1260 was also detected in SS5-03 at 2400 $\mu\text{g/kg}$. Upon further review of the PCB chromatograms for all Site 5 soils, it was found that trace levels of PCBs were also presented in the other two surface soil samples. Mineral

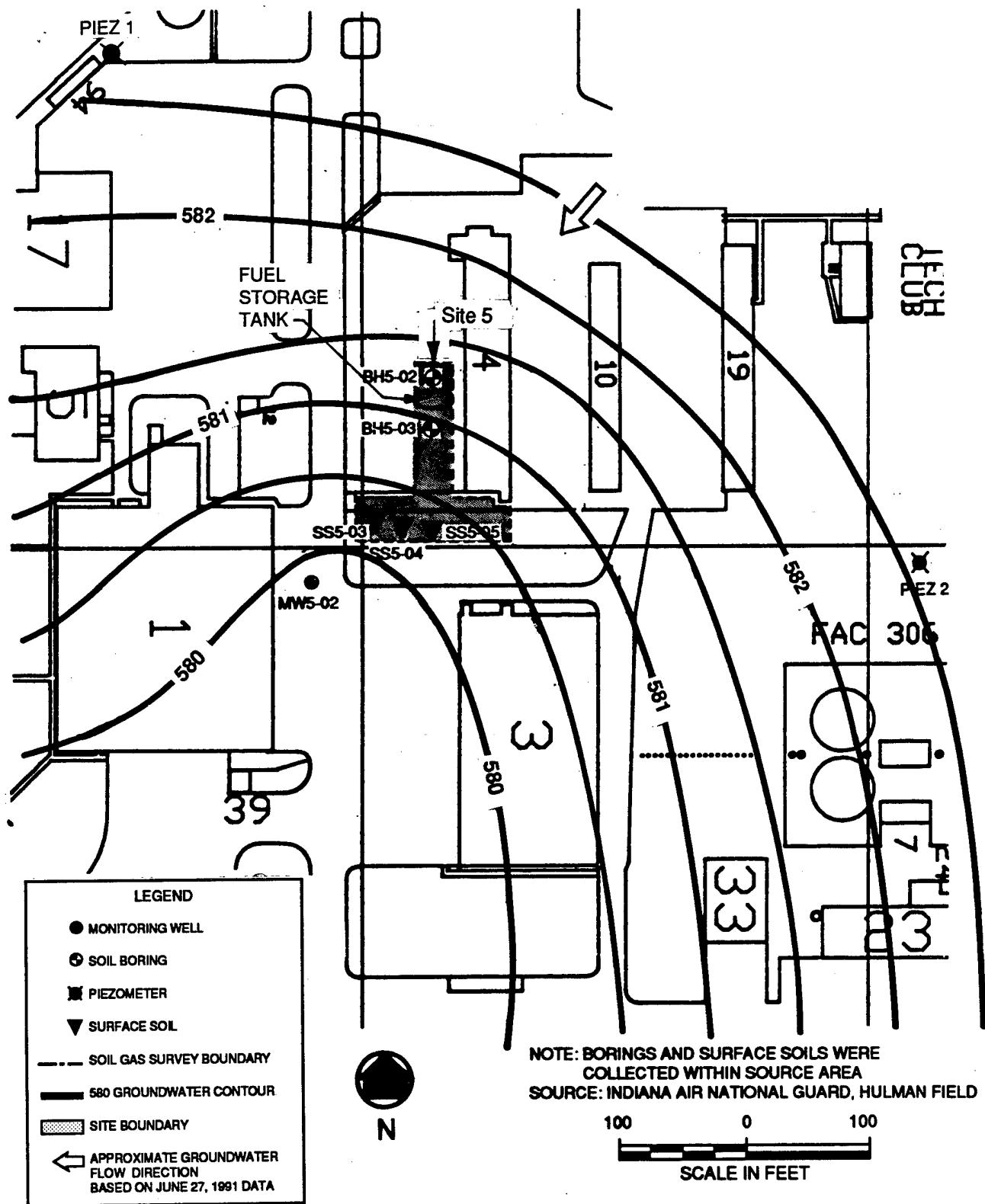


FIGURE 3-19. SAMPLING LOCATIONS,
SITE 5: VEHICLE MAINTENANCE AREA
181ST FG, HULMAN FIELD MAP, TERRE HAUTE, IN

TABLE 3-13a. SITE 5-DETECTED CONTAMINANT CONCENTRATIONS
IN SOIL - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (e)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT	LOCATION U - ID Depth, FT LAB ID #	BH5-02 NS - 03 3.0-5.0 9010L151-004	BH5-02 NS - 04 5.0-7.0 9010L151-005	BH5-03 NS - 05 1.0-3.0 9010L151-006	BH5-03 NS - 06 5.0-7.0 9010L151-007	SS5-03 NS - 43 0.0-0.5 9010L110-004	SS5-04 NS - 44 0.0-0.5 9010L110-005	SS5-05 NS - 45 0.0-0.5 9010L110-006
VOLATILE ORGANICS											
Tetrachloroethene	CLP	UG/KG	5	6 U	6 U	6 U	6 U	6 U	6 U	1 J	1 J
Toluene	CLP	UG/KG	5	6 U	6 U	6 U	6 U	6 U	6 U	1 J	6 U
1,2-Dichlorobenzene	CLP	UG/KG	330	88 J	74 J	80 J	80 J	47 J	2000 U	390 U	390 U
SEMI-VOLATILE ORGANICS											
Acenaphthene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	470 J	390 U	390 U
Fluorene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	400 J	390 U	390 U
Phenanthrene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	6100	230 J	86 J
Anthracene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	810 J	390 U	390 U
Di-n-Butylphthalate	CLP	UG/KG	330	850	470	580	580	390	2000 U	390 U	390 U
Fluoranthene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	9900	430	150 J
Pyrene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	5200	330 J	100 J
Butylbenzylphthalate	CLP	UG/KG	330	200 J	92 J	230 J	230 J	150 J	2000 U	390 U	390 U
Benzo(a)anthracene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	3600	180 J	62 J
Chrysene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	4100	240 J	78 J
1,2-Ethylbenzylphthalate	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	1000 J	59 J	390 U
Benzo(b)fluoranthene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	5200	390	100 J
Benzo(k)fluoranthene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	5000	300 J	100 J
Benzo(e)pyrene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	5600	340 J	100 J
Indeno(1,2,3-cd)pyrene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	3900	260 J	54 J
Dibenz(a,h)anthracene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	1200 J	390 U	390 U
Benzo(g,h,i)perylene	CLP	UG/KG	330	410 U	340 U	460 U	460 U	370 U	4100	300 J	64 J
PESTICIDES/PCB'S											
Aroclor-1260	CLP	UG/KG	160						2400 J	190 U	190 UJ
METALS											
Aluminum, Total	SW6010	MG/KG	40	13.2	6.5	12.2	12.2	3.5	5.4 J	4.7 J	5220
Arsenic, Total	SW7060	MG/KG	2	0.97	0.98	1.3	1.3	0.83	0.62 UJ	0.73 UJ	4.1 J
Barium, Total	SW6010	MG/KG	40								64
Beryllium, Total	SW6010	MG/KG	1								0.75 UJ
Calcium, Total	SW6010	MG/KG	1000								2240 J
Cadmium, Total	SW6010	MG/KG	1	2.4 U	1.8 U	2.3 U	2.3 U	2 U	8.3	1.9 U	1.8 U
Cobalt, Total	SW6010	MG/KG	10	8.9	9.4	11.4	11.4	9.3	91.9	10.8	5.6
Chromium, Total	SW6010	MG/KG	2	16.7 J	11.9 J	15.5 J	15.5 J	7.9 J	48.1	16.1	7.5
Copper, Total	SW6010	MG/KG	5								11.3
Iron, Total	SW6010	MG/KG	20								12200
Magnesium, Total	SW6010	MG/KG	1000								1270 J
Manganese, Total	SW6010	MG/KG	3								236
Nickel, Total	SW6010	MG/KG	8	24.5	11.8	17.5	17.5	10.4	11.9	11.2	7.6
Lead, Total	SW6010	MG/KG	1	6.1	8.4	0.011	0.011	11.7	67.2	57	1.6 J
Vanadium, Total	SW6010	MG/KG	10								21
Zinc, Total	SW6010	MG/KG	4	62.1	37.1	76.4	76.4	31.2	608	306	23.7
PETROLEUM HYDROCARBON											
Petroleum Hydrocarbon	E418.1	MG/KG	20	23	3.8 U	5.1 U	5.1 U	4.2 U	530	37	7.6

TABLE 3-13a. SITE 5-DETECTED CONTAMINANT CONCENTRATIONS
IN SOIL - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

CONTINUED

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT	LOCATION U - ID Depth, FT LAB ID #	MEAN (b)	MINIMUM (c)	MAXIMUM (c)	Background Concentration MEAN (d)	Background Concentration MAXIMUM (d)
VOLATILE ORGANICS									
Tetrachloroethene	CLP	UG/KG	5		1.0 J	1 J	1 J	3 J	3 J
Toluene	CLP	UG/KG	5		1.0 J	1 J	1 J	3	ND
1,2-Dichlorobenzene	CLP	UG/KG	330		88.0 J	47 J	88 J	210	ND
SEMI-VOLATILE ORGANICS									
Acenaphthene	CLP	UG/KG	330		235.7 J	470 J	470 J	210	ND
Fluorene	CLP	UG/KG	330		225.7 J	400 J	400 J	210	ND
Phenanthrene	CLP	UG/KG	330		1016.6 J	86 J	6100	210	ND
Anthracene	CLP	UG/KG	330		284.3 J	810 J	810 J	210	ND
Di-n-Butylphthalate	CLP	UG/KG	330		525.7	390	850	44 J	44 J
Fluoranthene	CLP	UG/KG	330		1591.1 J	98 J	9900	210	ND
Pyrene	CLP	UG/KG	330		898.1 J	97 J	5200	210	ND
Butylbenzylphthalate	CLP	UG/KG	330		230.0 J	92 J	230 J	210	ND
Benzofluoranthene	CLP	UG/KG	330		661.7 J	62 J	3600	210	ND
Chrysene	CLP	UG/KG	330		718.9 J	54 J	4100	210	ND
Benzo(b)fluoranthene	CLP	UG/KG	330		292.0 J	59 J	1000 J	210	ND
Benzofluoranthene	CLP	UG/KG	330		900.9 J	56 J	5200	210	ND
Benzofluoranthene	CLP	UG/KG	330		884.3 J	100 J	5000	210	ND
Benzofluoranthene	CLP	UG/KG	330		975.7 J	100 J	5600	210	ND
Indeno(1,2,3-cd)pyrene	CLP	UG/KG	330		714.9 J	54 J	3900	210	ND
Dibenz(a,h)anthracene	CLP	UG/KG	330		340.0 J	1200 J	1200 J	210	ND
Benzofluoranthene	CLP	UG/KG	330		750.6 J	64 J	4100	210	ND
PESTICIDES/PCB'S									
Aroclor-1260	CLP	UG/KG	160		863.3 J	2400 J	2400 J	101.25	ND
METALS									
Aluminum, Total	SW6010	MG/KG	40			5220	5220	6562.5	8050
Arsenic, Total	SW7060	MG/KG	2		7.1 J	3.5	13.2	4.3 J	6.5 J
Barium, Total	SW6010	MG/KG	40			64	64	89.9	105
Beryllium, Total	SW6010	MG/KG	1		0.7	0.83	1.3	0.4	ND
Calcium, Total	SW6010	MG/KG	1000			2240 J	2240 J	7505 J	15400 J
Cadmium, Total	SW6010	MG/KG	1		2.1	8.3	8.3	1.06	ND
Cobalt, Total	SW6010	MG/KG	10			5.6	5.6	8.3	12.3
Chromium, Total	SW6010	MG/KG	2		21.3	7.5	91.9	9.1	10.7
Copper, Total	SW6010	MG/KG	5		18.2 J	7.9 J	48.1	14.1	16.2
Iron, Total	SW6010	MG/KG	20			12200	12200	13725	15600
Magnesium, Total	SW6010	MG/KG	1000			1270 J	1270 J	4995 J	9900 J
Manganese, Total	SW6010	MG/KG	3			236	236	503.3	643
Nickel, Total	SW6010	MG/KG	8		13.6	7.6	24.5	12	16.3
Lead, Total	SW6010	MG/KG	1		21.7 J	0.011	67.2	2.5 J	4.5 J
Vanadium, Total	SW6010	MG/KG	10		163.5	21	21	20.6	24.2
Zinc, Total	SW6010	MG/KG	4			23.7	608	53.6	87.2
PETROLEUM HYDROCARBON									
Petroleum Hydrocarbon	E418.1	MG/KG	20		86.3	7.6	530	26.9	100

NOTES:

- Seven soil samples total: two samples each from two borings and three surface soils. Analytes: volatile organics, semivolatile organics, pesticides/PCB'S, metals, and petroleum hydrocarbons (Table 2-3). Analytes not presented were not detected.
- The mean concentration for all soil samples is calculated using half the sample quantification detection limit where not detected. The maximum detected value is used for the mean if the calculated mean is greater than the maximum. No mean calculated where only one value given.
- Minimum and maximum values do not include those values flagged with a U or UJ.
- Four background soil samples total: two samples from one boring and two surface soils. Mean and maximum background concentrations were calculated in the same manner as above, where not detected, the mean is based on detection limits only.

J = Estimated data due to quality control criteria.
UJ = Compound not detected estimated sample quantification limit.
ND = Not detected

TABLE 3-13b. SITE 5-DETECTED CONTAMINANT CONCENTRATIONS IN GROUNDWATER
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT	LOCATION U - ID Depth, FT LAB ID #	MW5-02 NS - 71 0.0-0.0 9011L600-004	Duplicate Sample MW5-07 NS - 71	Duplicate Mean (b)	Background Concentration (c)	MCL (d)
METALS									
Aluminum, Total	SW6010	UG/L	200		20800	17600	19200	27000	
Calcium, Soluble	SW6010	UG/L	500		75600	73500	74550	73600	
Calcium, Total	SW6010	UG/L	500		103000	94800	98900	159000	
Chromium, Total	SW6010	UG/L	30		203	183	193	34.2	100
Copper, Total	SW6010	UG/L	25		56.8	50	53.4	77.7	1300
Iron, Total	SW6010	UG/L	100		47600	40400	44000	48900	
Mercury, Soluble	SW7470	UG/L	0.2		0.32 J	0.32 J	0.32 J	0.2 U	2
Mercury, Total	SW7470	UG/L	0.2		0.38 J	0.32 J	0.35 J	0.2 U	2
Potassium, Total	SW6010	UG/L	5000		6160	6340	6250	5000 U	
Magnesium, Soluble	SW6010	UG/L	5000		36100	35100	35600	39700	
Magnesium, Total	SW6010	UG/L	5000		52000	47400	49700	74800	
Manganese, Soluble	SW6010	UG/L	15		439	427	433	104	
Manganese, Total	SW6010	UG/L	15		1210	1050	1130	1070	
Sodium, Soluble	SW6010	UG/L	5000		16000	15500	15750	5350	
Sodium, Total	SW6010	UG/L	5000		16600	16100	16350	5850	
Nickel, Total	SW6010	UG/L	15		175	153	164	74.1 UJ	100p
Lead, Total	SW7421	UG/L	3		26.8 J	46 J	36.4 J	16.3 J	50(15)
Vanadium, Total	SW6010	UG/L	50		50.7 J	50 U	50.7 J	62.2 UJ	
Zinc, Total	SW6010	UG/L	20		180	135	157.5	122	
PETROLEUM HYDROCARBONS									
Petroleum Hydrocarbon	E418.1	MG/L	1		1.1 U	0.31 J	0.31 J	1.1 U	

NOTES:

a. One groundwater sample total. Analyses: volatile organics, semivolatile organics, pesticides/PCB'S, metals, and petroleum hydrocarbons (Table 2-3).

Analyses not presented were not detected.

b. Refers to the mean of the duplicate samples, if there is only one positive detection this value is used for the mean.

c. One background groundwater sample total.

d. Maximum Contaminant Levels taken from Table 4.3, p= proposed value.

J =Estimated data due to quality control criteria.

U =Compound not detected, value is the sample quantification limit.

UJ=Compound not detected, value is the estimated sample quantification limit.

TABLE 3-13c . SITE 5 - SUMMARY OF ANALYTICAL DETECTIONS
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	SOIL (a)			GROUND WATER (c)
	RANGE (b)	MEAN	NUMBER OF DETECTIONS	
VOLATILE ORGANICS	UG/KG	UG/KG		
Tetrachloroethene	1 J	1 J	2 / 7	
Toluene	1 J	1 J	1 / 7	
1,2-Dichlorobenzene	47 J to 88 J	88 J	4 / 7	
SEMIVOLATILE ORGANICS	UG/KG	UG/KG		
Acenaphthene	470 J	236 J	1 / 7	
Fluorene	400 J	226 J	1 / 7	
Phenanthrene	86 J to 6100	1,017 J	4 / 7	
Anthracene	810 J	284 J	1 / 7	
Di-n-Butylphthalate	390 to 850	526	4 / 7	
Fluoranthene	98 J to 9,900	1,591 J	4 / 7	
Pyrene	97 J to 5,200	898 J	4 / 7	
Butylbenzylphthalate	92 J to 230 J	230 J	4 / 7	
Benzo(a)anthracene	62 J to 3,600	662 J	3 / 7	
Chrysene	54 J to 4,100	719 J	4 / 7	
bis(2-Ethylhexyl)phthalate	59 J to 1,000 J	292 J	2 / 7	
Benzo(b)fluoranthene	56 J to 5,200	901 J	4 / 7	
Benzo(k)fluoranthene	100 J to 5,000	884 J	3 / 7	
Benzo(a)pyrene	100 J to 5,600	976 J	3 / 7	
Indeno(1,2,3-cd)pyrene	54 J to 3,900	715 J	3 / 7	
Dibenzo(a,h)anthracene	1,200 J	340 J	1 / 7	
Benzo(g,h,i)perylene	64 J to 4,100	751 J	3 / 7	
PESTICIDES/PCB	UG/KG	UG/KG		
Aroclor-1260	2,400 J	863 J	1 / 3	
METALS (d)	MG/KG	MG/KG		UG/L
Aluminum, Total	5,220		1 / 1	19,200
Arsenic, Total	3.5 to 13.2	7.1 J	7 / 7	
Barium, Total	64		1 / 1	
Beryllium, Total	0.83 to 1.3	0.73	4 / 7	
Calcium, Soluble				74,550
Calcium, Total	2,240 J		1 / 1	98,900
Cadmium, Total	8.3	2.1	1 / 7	
Cobalt, Total	5.6		1 / 1	
Chromium, Total	7.5 to 91.9	21.3	7 / 7	193
Copper, Total	7.9 J to 48.1	18.2 J	7 / 7	53.4
Iron, Total	12,200		1 / 1	44,000
Mercury, Soluble				0.32 J
Mercury, Total				0.35 J
Potassium, Total				6,250
Magnesium, Soluble				35,600
Magnesium, Total	1,270 J		1 / 1	49,700
Manganese, Soluble				433
Manganese, Total	236		1 / 1	1,130
Sodium, Soluble				15,750
Sodium, Total				16,350
Nickel, Total	7.6 to 24.5	13.6	7 / 7	164
Lead, Total	0.011 to 67.2	21.7 J	7 / 7	36.4 J
Vanadium, Total	21		1 / 1	50.7 J
Zinc, Total	23.7 to 608	163.5	7 / 7	157.5
PETROLEUM HYDROCARBON	MG/KG	MG/KG		MG/L
Petroleum Hydrocarbon	7.6 to 530	86.3	4 / 7	0.31 J

NOTES:

a. Seven soil samples total: two samples each from two borings and three surface soils.

No value presented means not detected.

b. Minimum and maximum detections presented. One value presented usually indicates detected in only one sample.

c. Only one sample for groundwater taken. No value presented means not detected, except for metals (see d.).

d. Soluble metals analysis not run for soils. Both soluble and total metals were analyzed for groundwater.

J = Estimated data due to quality control criteria.

forming metals, when present, were at concentrations also found in background soils. Heavy metals consisting of cobalt, nickel, and vanadium were found in concentrations which were generally within the range reported for background soils. However, chromium, copper, lead, and zinc were detected at concentrations above background.

Subsurface Soil. Trace concentrations of 1,2-dichlorobenzene were reported in all four subsurface soils. This chemical may be attributed to base activities because it is often used as a degreasing agent and as a solvent for products such as oils and asphalts. Di-n-butylphthalate and butylbenzylphthalate were detected in all subsurface soils. Five PAH compounds were also detected in BH5-03 (1-3 feet) which was the sample collected closest to the ground surface. Petroleum hydrocarbons were reported in one subsurface soil, BH5-02 (3-5 feet). Six heavy metals and beryllium were detected in all subsurface soils. Only arsenic values, in soils to depths of five feet, were higher than that observed in background soils.

Groundwater. In Round 1 volatile organics, semi-volatile organics, pesticides, and PCBs were not detected in groundwater. Trace concentrations of petroleum hydrocarbons were detected in groundwater. Mineral forming metals were detected at concentrations typically similar to or less than those found in background groundwater. Heavy metals including copper, manganese, and zinc were also found in concentrations similar to background groundwater, whereas chromium and lead were elevated in comparison. Mercury, nickel, and vanadium, not found in background waters, were detected in Site 5 groundwater. Mercury was found in soluble forms at concentrations equivalent to those in total recoverable form, indicating that the mercury present exists as soluble mercury. Manganese was also detected in its soluble form. During Round 2, no groundwater sample was collected, since the well was inaccessible.

3.6.3 Geologic and Hydrogeologic Investigation Results

Site 5 is the vehicle maintenance area. Monitoring well MW5-02 and soil borings BH5-02 and BH5-03 were installed in this area. Geologic logs constructed from Site 5 were consistent with the stratigraphy as described in section 3.2.1.

Water level measurements collected from monitoring wells and piezometers indicated that groundwater flows southwest across Site 5 (see Figure 3-19). A hydraulic gradient from 0.005 and 0.013 and a hydraulic conductivity (K) for MW5-02 of 3.61×10^{-5} cm/sec were calculated at Site 5. Assuming a porosity of 0.30, the groundwater in this area will flow southwest from 1.7×10^{-3} to 4.4×10^{-3} ft/day.

3.6.4 Identification of Data Gaps

No data gaps were identified.

3.6.5 Summary and Conclusions

Soil gas survey results indicated moderate contamination around the underground fuel storage tank. Field GC results in other areas did not reveal contamination.

Elevated arsenic and 1,2-dichlorobenzene levels in soils have probably resulted from site activities. However, the source of mercury in groundwater is not known since mercury was not detected in any of the Site 5 soils. The presence of PCBs appears to be limited to surficial soils at the site. PCBs were extensively used in transformer fluids in the past, however, they were also used in many other products. Generally, semi-volatile organic compound concentrations exceeded, while metal concentrations were similar to base background levels in all media. The presence of PAH compounds in soils suggests the presence of semi-combusted jet fuel.

At Site 5, Water level measurements indicated that groundwater flows southwest from 0.6 to 1.6 ft/year. The monitoring well, piezometer, and soil borings were placed at and groundwater, surface soil and boring soil samples were collected in locations which should provide for sufficient Site 5 characterization.

3.7 SITE 6 - HANGAR BUILDING NO. 1

Site 6 is located on the west side of the base, near the firehouse and north of the aircraft parking apron. In the PA (HMTC, 1987), it was stated that until 1980, most solvent, fuel, and oil wastes generated by the base were stored in drums at this site prior to collection by a local contractor. No HM/HW spills were recorded and no HAS was assigned.

3.7.1 Screening Activity Results

Eleven soil gas readings were collected at Site 6 and four gas chromatographs (GC) analyses were run. The GC analyses were at points SG6-2, -3, -6, and -8. Table 3-14 lists the FID readings and Figure 3-20 shows the sampling point locations.

The FID results indicate an area of high contamination. A maximum reading of 520 ppm was obtained at SG6-9 and a minimum reading of <0.0 ppm was measured at points SG6-2, -6 and -8. The readings were used to site the soil boring and surface soil sample locations. Soil borings were placed between SG6-4 and -9 and at SG6-11. Surface soil samples were collected between SG6-9 and SG6-11 and between SG6-8 and the storm drain. Five additional surface soil samples taken during Round 2, in January 1992, were collected between SG6-9 and -11, SG6-6 and -8, SG6-8 and -3, SG6-6 and -1, and approximately 6 feet south of building 12.

The GC results do not conclusively indicate any contamination. Although each of the 4 chromatographs for these points indicated benzene, the syringe blanks also indicated the presence of benzene. Thus, the benzene measured is most likely the result of the syringe or ambient air contamination.

TABLE 3-14. SITE 6 - HANGAR BUILDING 1 SOIL GAS SURVEY RESULTS

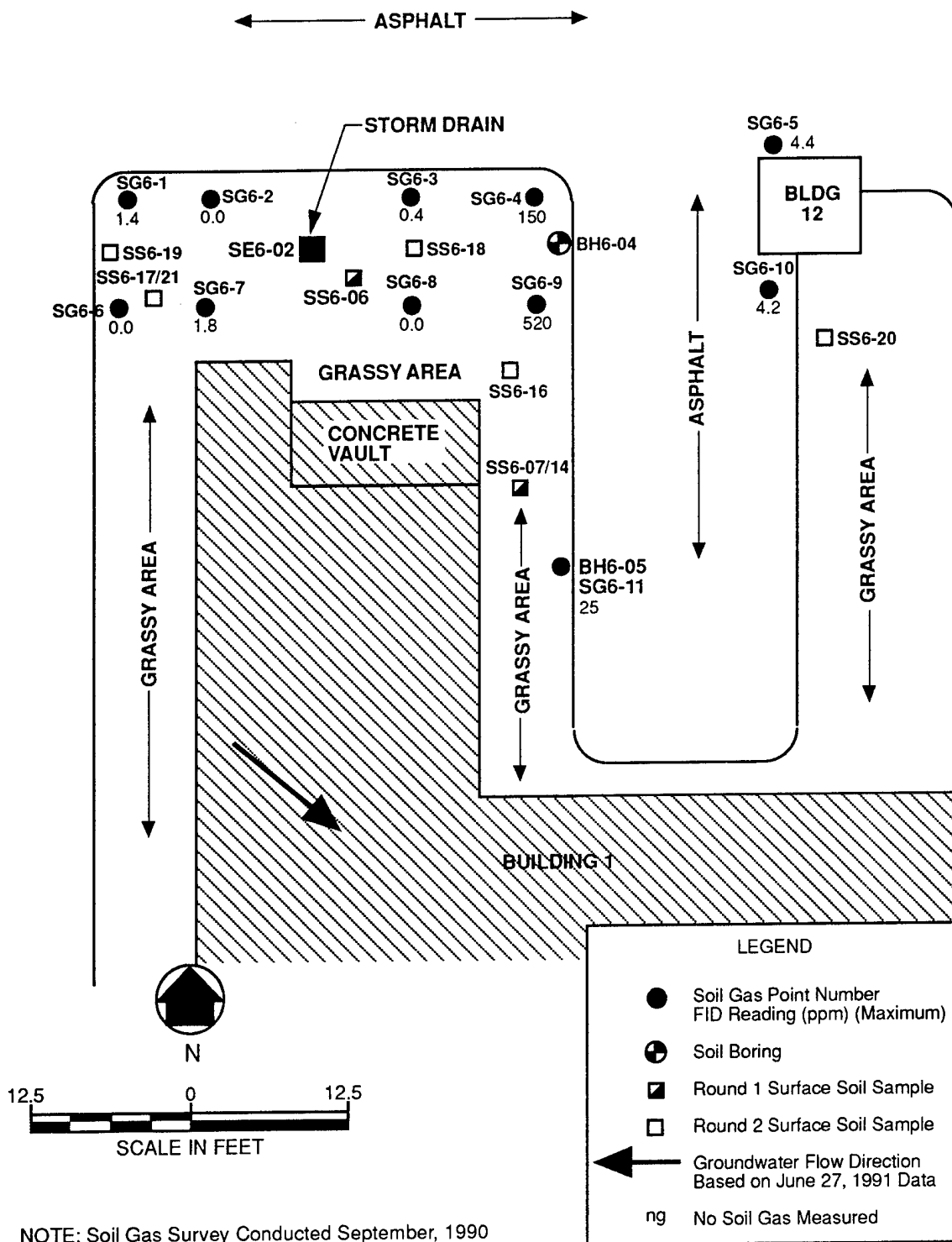
Point Number	Soil Depth (ft)	FID Reading (ppm)	Point Number	Soil Depth (ft)	FID Reading (ppm)
SG6-1	1	ng	SG6-9	1	520
SG6-1a	1	1.4	SG6-9	2	ng
SG6-2	1	0.0	SG6-9	3	ng
SG6-3	1	0.4	SG6-9	4	ng
SG6-4	1	150	SG6-9	5	ng
SG6-5	1	4.4	SG6-10	1	4.2
SG6-6	1	0.0	SG6-11	1	25
SG6-7	1	1.8	SG6-12	-	-
SG6-8	1	0.0			

Notes: ng - No soil gas measured

-- Data rejected

3.7.2 Confirmation and Delineation Activity Results

Samples collected at Site 6 consisted of seven surface soils (from two sampling rounds), four subsurface soils from two soil boring locations, two groundwaters (from two sampling rounds), and one sediment. One of the subsurface soils was collected from a depth of 0 to 2 feet, one from a depth of 2 to 4 feet, and two from a depth of 4 to 6 feet. The sediment sample was collected from a storm sewer located in a depression in the grassy part of the site. Sampling locations for Site 6 are shown in Figure 3-21. All samples submitted to the laboratory were analyzed for volatile organics, semi-volatile organics, pesticides, PCBs, petroleum hydrocarbons,



NOTE: Soil Gas Survey Conducted September, 1990
 Surface Soil Samples Collected October, 1990
 Borings Installed October, 1990

FIGURE 3-20. SOIL GAS SURVEY LOCATIONS
SITE 6: HANGAR BUILDING 1
181st FG, HULMAN FIELD MAP, TERRE HAUTE, IN

and metals. Analytical results for each media are presented in Tables 3-15a-c and summarized in Table 3-15d.

Surface Soil. During Round 1, surface soils taken at SS6-07 (including duplicate sample, SS6-014) contained an elevated concentration of carbon disulfide. Trace levels of trichloroethene and 1,2-dichlorobenzene were reported at SS6-06. PAH compounds (12-14 species) were predominantly found in concentrations ranging from trace quantities to 6800 $\mu\text{g/kg}$. Benzoic acid, butylbenzylphthalate, diethylphthalate, and di-n-butylphthalate were also detected in trace quantities. Elevated petroleum hydrocarbons were detected in both ranging from (610,000 to 1,500,000 $\mu\text{g/kg}$). Mineral forming metals, barium, beryllium, and heavy metals were detected in surface soils. Cadmium and beryllium were found in these soils, above background concentrations. Concentrations of lead were also elevated in comparison to background.

Only one surface soil taken during Round 2 (SS6-19) detected volatile organics, 1,2-dichloroethene (2 $\mu\text{g/kg}$), trichloroethene (20 $\mu\text{g/kg}$) and tetrachloroethene (31 $\mu\text{g/kg}$). Two additional PAH compounds, naphthalene and 2-methylnaphthalene, were detected at relatively low levels during Round 2. Carbazole was also detected during the second round at trace levels. Semi-volatile concentrations detected during Round 2 were generally lower than concentrations detected during Round 1. No pesticides or PCB compounds were detected during Round 1, however, various trace concentrations of six pesticides and Aroclor 1260 were detected in five surface soil samples during Round 2. Petroleum hydrocarbons were detected in all five samples with relatively elevated concentrations in samples (SS6-18 and SS6-19). Beryllium and cobalt were not detected during the second round and cadmium and lead were detected at elevated concentrations relative to background, however, Round 1 samples had higher concentrations of these metals. Generally, analyte concentrations were lowest at SS-19 and SS-20. These samples were collected at the site boundary.

Subsurface Soil. In subsurface soils, relatively high concentrations of chlorinated volatiles; 1,2-dichloroethene, trichloroethene, and tetrachloroethene; were detected in BH6-05 (4-6 feet). A trace of toluene was detected at BH6-04 (4-6 feet). Numerous PAH compounds were reported

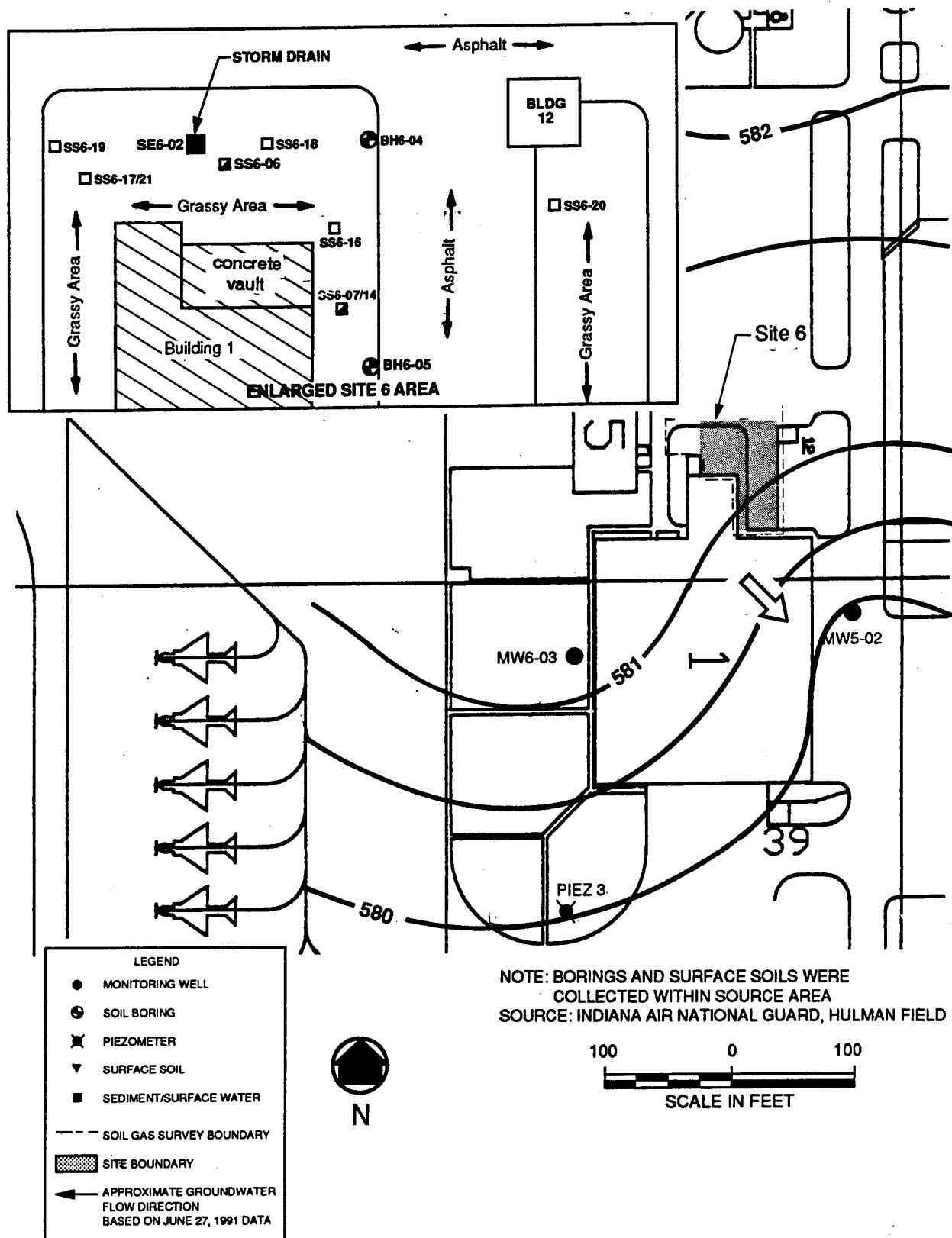


FIGURE 3-21. SAMPLING LOCATIONS,
SITE 6: HANGAR BUILDING 1
181ST FG, HULMAN FIELD MAP, TERRE HAUTE, IN

TABLE 3-15a. SITE 6 - DETECTED CONTAMINANT CONCENTRATIONS IN SOIL
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT (b)	LOCATION U - ID Depth, FT LAB ID #	Duplicate Sample BH6-04 NS-07	BH6-04 NS - 07 2.0-4.0 9010L166-006	Duplicate Mean (c)	BH6-04 NS - 08 4.0-6.0 9010L166-007	BH6-05 NS - 09 0.0-2.0 9010L166-008	BH6-05 NS - 10 4.0-6.0 9010L166-009
VOLATILE ORGANICS										
Carbon Disulfide	CLP	UG/KG	5(10)		6 U	6 U	6 U	6 U	R	26 U
1,2-Dichloroethene (total)	CLP	UG/KG	5(10)		6 U	6 U	6 U	6 U	R	790
1,2-Dichlorobenzene	CLP	UG/KG	330		480 U	460 U	470 U	2400 U	450 U	450 U
Trichloroethene	CLP	UG/KG	5(10)		6 U	6 U	6 U	6 U	550000 UJ	60
Tetrachloroethene	CLP	UG/KG	5(10)		6 U	6 U	6 U	6 U	R	14 J
Toluene	CLP	UG/KG	5(10)		6 U	6 U	6 U	2 J	R	26 U
SEMI-VOLATILE ORGANICS										
2-Chlorophenol	CLP	UG/KG	330		76 J	460 U	76 J	2400 U	450 U	450 U
Benzoic acid	CLP	UG/KG	1600		2400 U	2300 U	2350 U	12000 U	2300 U	2200 U
Naphthalene	CLP	UG/KG	330		480 U	460 U	470 U	2400 U	450 U	450 U
2-Methylnaphthalene	CLP	UG/KG	330		480 U	460 U	470 U	2400 U	450 U	450 U
Acenaphthene	CLP	UG/KG	330		94 J	150 J	122 J	810 J	68 J	450 U
Dibenzofuran	CLP	UG/KG	330		480 U	71 J	71 J	400 J	450 U	450 U
Diethylphthalate	CLP	UG/KG	330		480 U	460 U	470 U	2400 U	450 U	450 U
Fluorene	CLP	UG/KG	330		130 J	170 J	150 J	940 J	57 J	450 U
Phenanthrene	CLP	UG/KG	330		2200	2400	2300	11000	1000	450 U
Anthracene	CLP	UG/KG	330		310 J	370 J	340 J	1900 J	160 J	450 U
Di-n-Butylphthalate	CLP	UG/KG	330		2000	2700	2350	760 J	4700	1200
Carbazole	CLP	UG/KG	330		NA	NA	NA	NA	NA	NA
Fluoranthene	CLP	UG/KG	330		3300	3600	3450	17000	1700	450 U
Pyrene	CLP	UG/KG	330		2300	2200	2250	9000	1100	450 U
Butylbenzylphthalate	CLP	UG/KG	330		480 U	460 U	470 U	2400 U	210 J	450 U
Benzo(a)anthracene	CLP	UG/KG	330		1300	1300	1300	5300	640	450 U
Chrysene	CLP	UG/KG	330		1600	1600	1600	6500	830	450 U
bis(2-Ethylhexyl)phthalate	CLP	UG/KG	330		480 U	460 U	470 U	2400 U	450 U	88 J
Benzo(b)fluoranthene	CLP	UG/KG	330		2200	2100	2150	4600	1100	450 U
Benzo(k)fluoranthene	CLP	UG/KG	330		1600	1900	1750	4400	850	450 U
Benzo(a)pyrene	CLP	UG/KG	330		1900	2100	2000	5300	1100	450 U
Indeno(1,2,3-cd)pyrene	CLP	UG/KG	330		1500	2100	1800	3900	1100	450 U
Dibenzo(a,h)anthracene	CLP	UG/KG	330		480	710	595	1100 J	420 J	450 U
Benzo(g,h,i)perylene	CLP	UG/KG	330		1600	2200	1900	4200	1200	450 U
PESTICIDES/PCB'S										
gamma-BHC (Lindane)	CLP	UG/KG	8(1.7)		26 U	25 U	25.5 U	52 U	25 U	9.6 U
Endosulfan II	CLP	UG/KG	16(3.3)		51 U	50 U	50.5 U	100 U	49 U	19 U
4,4'-DDT	CLP	UG/KG	16(3.3)		51 U	50 U	50.5 U	100 U	49 U	19 U
Methoxychlor	CLP	UG/KG	80(17)		260 U	250 U	255 U	520 U	250 U	96 U
alpha-Chlordane	CLP	UG/KG	80(1.7)		260 U	250 U	255 U	520 U	250 U	96 U
gamma-Chlordane	CLP	UG/KG	80(1.7)		260 U	250 U	255 U	520 U	250 U	96 U
Aroclor-1260	CLP	UG/KG	160(33)		510 U	500 U	505 U	1000 U	490 U	190 U

TABLE 3-15a. SITE 6 - DETECTED CONTAMINANT CONCENTRATIONS IN SOIL
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT (b)	LOCATION U - ID Depth, FT LAB ID #	Duplicate Sample BH6-04 NS-07	BH6-04 NS - 07 2.0-4.0 9010L166-006	Duplicate Mean (c)	BH6-04 NS - 08 4.0-6.0 9010L166-007	BH6-05 NS - 09 0.0-2.0 9010L166-008	BH6-05 NS - 10 4.0-6.0 9010L166-009
METALS										
Aluminum, Total	SW6010	MG/KG	40		16300	17500	16900	16400	17200	12200
Arsenic, Total	SW7060	MG/KG	2		18.7 J	9.7 J	14.2 J	10.8 J	9.2 J	6.8 J
Barium, Total	SW6010	MG/KG	40		135	148	141.5	137	141	123
Beryllium, Total	SW6010	MG/KG	1		1.1	1	1.05	0.98	0.88	0.58
Calcium, Total	SW6010	MG/KG	1000		3410 J	3850 J	3630 J	7830 J	4990 J	3420 J
Cadmium, Total	SW6010	MG/KG	1		2.1 U	2.5 U	2.3 U	2.3 U	2.1 U	2 U
Cobalt, Total	SW6010	MG/KG	10		11.9	11.7	11.8	10.2	11.4	9.5
Chromium, Total	SW6010	MG/KG	2		8.7	10.6	9.65	13.1	10.5	9.1
Copper, Total	SW6010	MG/KG	5		17.4	18.4	17.9	20.6	15.4	14.7
Iron, Total	SW6010	MG/KG	20		27900	29700	28800	28300	22900	17400
Potassium, Total	SW6010	MG/KG	1000		1050 U	1240 U	1145 U	1180 J	1070 U	1000 U
Magnesium, Total	SW6010	MG/KG	1000		4350 J	5020 J	4685 J	5490 J	3720 J	3380 J
Manganese, Total	SW6010	MG/KG	3		657	705	681	557	444	139
Sodium, Total	SW6010	MG/KG	1000		94.9 U	112 U	103.45 U	110 J	96.3 U	90.2 U
Nickel, Total	SW6010	MG/KG	8		31.1	21.8	26.45	24.3	16.1	19.3
Lead, Total	SW6010	MG/KG	1		19.4	13.9	16.65	20.9	17.8	11.8
Vanadium, Total	SW6010	MG/KG	10		35.8	30.6	33.2	31.8	27.1	21.2
Zinc, Total	SW6010	MG/KG	4		80	89.4	84.7	93.5	68.4	65.9
PETROLEUM HYDROCARBONS										
Petroleum Hydrocarbon	E418.1	MG/KG	20		21 UJ	15 UJ	18 UJ	130	24	26

TABLE 3-15a. SITE 6 - DETECTED CONTAMINANT CONCENTRATIONS IN SOIL

181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

CONTINUED

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT (b)	LOCATION U - ID Depth, FT LAB ID #	SS6-06 NS - 46 0.0-0.5 9010L151-013	SS6-07 NS - 47 0.0-0.5 9010L151-014	Duplicate Sample SS6-14 NS-47	Duplicate Mean (c)	SS6-16 (d) NS-111 0.0-0.5 9201L056-009	SS6-17 (d) NS-112 0.0-0.5 9201L056-003	Duplicate Sample SS6-21 NS-112	Duplicate Mean (c)
VOLATILE ORGANICS												
Carbon Disulfide	CLP	UG/KG	5(10)		6 U	180 J	240 J	210 J	12 UJ	12 UJ	12 UJ	12 UJ
1,2-Dichloroethene (total)	CLP	UG/KG	5(10)		6 U	680 U	730 U	705 U	12 UJ	12 UJ	12 UJ	12 UJ
1,2-Dichlorobenzene	CLP	UG/KG	330		68 J	1800 U	1800 U	1800 U	820 UJ	790 UJ	800 UJ	795 UJ
Trichloroethene	CLP	UG/KG	5(10)		2 J	680 U	730 U	705 U	12 UJ	12 UJ	12 UJ	12 UJ
Tetrachloroethene	CLP	UG/KG	5(10)		6 U	680 U	730 U	705 U	12 UJ	12 UJ	12 UJ	12 UJ
Toluene	CLP	UG/KG	5(10)		6 U	680 U	730 U	705 U	12 UJ	12 UJ	12 UJ	12 UJ
SEMI-VOLATILE ORGANICS												
2-Chlorophenol	CLP	UG/KG	330		380 U	1800 U	1800 U	1800 U	820 UJ	790 UJ	800 UJ	795 UJ
Benzoic acid	CLP	UG/KG	1600		53 J	9200 U	9000 U	9100 U	NA	NA	NA	NA
Naphthalene	CLP	UG/KG	330		380 U	1800 U	1800 U	1800 U	820 UJ	790 UJ	800 UJ	795 UJ
2-Methylnaphthalene	CLP	UG/KG	330		380 U	1800 U	1800 U	1800 U	820 UJ	790 UJ	800 UJ	795 UJ
Acenaphthene	CLP	UG/KG	330		50 J	1800 U	1800 U	1800 U	340 J	270 J	310 J	290 J
Dibenzofuran	CLP	UG/KG	330		380 U	1800 U	1800 U	1800 U	140 J	120 J	150 J	135 J
Diethylphthalate	CLP	UG/KG	330		44 J	1800 U	1800 U	1800 U	260 J	230 J	270 J	260 J
Fluorene	CLP	UG/KG	330		50 J	1800 U	1800 U	1800 U	280 J	230 J	290 J	260 J
Phenanthrene	CLP	UG/KG	330		860	3000	2000	2500	3000 J	2800 J	3200 J	3000 J
Anthracene	CLP	UG/KG	330		110 J	490 J	300 J	395 J	440 J	450 J	550 J	500 J
Di-n-Butylphthalate	CLP	UG/KG	330		430	1800 U	1800 U	1800 U	820 UJ	790 UJ	800 UJ	795 UJ
Carbazole	CLP	UG/KG	330		NA	NA	NA	NA	420 J	410 J	430 J	420 J
Fluoranthene	CLP	UG/KG	330		1300	6800	6300	6550	3700 J	3700 J	3800 J	3750 J
Pyrene	CLP	UG/KG	330		1100	5700	5200	5450	2400 J	2500 J	2900 J	2700 J
Butylbenzylphthalate	CLP	UG/KG	330		420	1800 U	1800 U	1800 U	1500 J	1400 J	1500 J	1450 J
Benzo(a)anthracene	CLP	UG/KG	330		550	3100	2500	2800	820 UJ	790 UJ	800 UJ	795 UJ
Chrysene	CLP	UG/KG	330		670	3500	3100	3300	1900 J	1600 J	2000 J	1800 J
bis(2-Ethylhexyl)phthalate	CLP	UG/KG	330		380 U	1800 U	1800 U	1800 U	820 UJ	790 UJ	800 UJ	795 UJ
Benzo(b)fluoranthene	CLP	UG/KG	330		570	3500	2900	3200	1200 J	1000 J	1000 J	1000 J
Benzo(k)fluoranthene	CLP	UG/KG	330		450	2300	2600	2450	1300 J	1100 J	1400 J	1250 J
Benzo(a)pyrene	CLP	UG/KG	330		500	3100	2600	2850	1500 J	1200 J	1400 J	1300 J
Indeno(1,2,3-cd)pyrene	CLP	UG/KG	330		380	2200	1400 J	1800 J	450 J	790 UJ	390 J	390 J
Dibenzo(a,h)anthracene	CLP	UG/KG	330		130 J	730 J	390 J	560 J	1000 J	660 J	880 J	770 J
Benzo(g,h,i)perylene	CLP	UG/KG	330		420	2500	1300 J	1900 J	1000 J	560 J	850 J	705 J
PESTICIDES/PCB'S												
gamma-BHC (Lindane)	CLP	UG/KG	8(1.7)		21 U	39 U	39 U	39 U	2 U	2 UJ	0.82 J	0.82 J
Endosulfan II	CLP	UG/KG	16(3.3)		42 U	79 U	78 U	78.5 U	2.4 J	0.8 J	1.6 J	1.2 J
4,4'-DDT	CLP	UG/KG	16(3.3)		42 U	79 U	78 U	78.5 U	4 U	1.6 J	4.1 U	1.6 J
Methoxychlor	CLP	UG/KG	80(17)		210 U	390 U	390 U	390 U	9.6 J	20 U	9.1 J	9.1 J
alpha-Chlordane	CLP	UG/KG	80(1.7)		210 U	390 U	390 U	390 U	2 U	2 U	2.1 U	2.05 U
gamma-Chlordane	CLP	UG/KG	80(1.7)		210 U	390 U	390 U	390 U	2 U	2 U	2.1 U	2.05 U
Aroclor-1260	CLP	UG/KG	160(33)		420 U	790 U	780 U	785 U	39 U	39 U	40 U	39.5 U

TABLE 3-15a. SITE 6 - DETECTED CONTAMINANT CONCENTRATIONS IN SOIL

181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

CONTINUED

PARAMETER	METHOD	UNITS	REPTID DETECT LIMIT (b)	LOCATION U - ID Depth, FT LAB ID #	SS6-06 NS - 46 0.0-0.5 9010L151-013	SS6-07 NS - 47 0.0-0.5 9010L151-014	Duplicate Sample SS6-14 NS-47	Duplicate Mean (c)	SS6-16 (d) NS-111 0.0-0.5 9201L056-009	SS6-17 (d) NS-112 0.0-0.5 9201L056-003	Duplicate Sample SS6-21 NS-112	Duplicate Mean (c)
METALS												
Aluminum, Total	SW6010	MG/KG	40		7050	3780	4060	3920	5520	6270	5950	6110
Arsenic, Total	SW7060	MG/KG	2		9.8	5.2	6.7	5.95	2.7 J	3.5 J	2.9 J	3.2 J
Barium, Total	SW6010	MG/KG	40		99.9	58.2	58.8	58.5	90.7	86.2	88.7	87.45
Beryllium, Total	SW6010	MG/KG	1		0.55	0.29	0.35	0.32	1.2 U	1.2 U	1.2 U	1.2 U
Calcium, Total	SW6010	MG/KG	1000		127000	216000	214000	215000	13000	5200	5650	5425
Cadmium, Total	SW6010	MG/KG	1		4.9	8.7	9.5	9.1	1.2 U	1.2 U	1.2	1.2
Cobalt, Total	SW6010	MG/KG	10		6.6	4.1 U	4.4 U	4.25 U	12 U	12.1 U	11.8 U	11.95 U
Chromium, Total	SW6010	MG/KG	2		20.7	21.8	20.7	21.25	10.2	11.6	10.7	11.15
Copper, Total	SW6010	MG/KG	5		89.7 J	45.2 J	50 J	47.6 J	14	14.6	25	19.8
Iron, Total	SW6010	MG/KG	20		13100	6890	7480	7185	11800	12900	12800	12850
Potassium, Total	SW6010	MG/KG	1000		944 U	1020 U	1090 U	1055 U	1200 U	1210 U	1180 U	1195 U
Magnesium, Total	SW6010	MG/KG	1000		2640 J	6090 J	6490 J	6290 J	3170	1860	2150	2005
Manganese, Total	SW6010	MG/KG	3		353 J	206 J	283 J	245.5 J	370	375	448	411.5
Sodium, Total	SW6010	MG/KG	1000		85 U	109 J	104 J	106.5 J	1200 U	1210 U	1180 U	1195 U
Nickel, Total	SW6010	MG/KG	8		14.6	7.6	9.3	8.45	11.1	10.9	9.9	10.4
Lead, Total	SW6010	MG/KG	1		132	288	233	260.5	29.6 J	20.9 J	15 J	17.95 J
Vanadium, Total	SW6010	MG/KG	10		21.9	15.2	16.5	15.85	18.2	17.2	17.7	17.45
Zinc, Total	SW6010	MG/KG	4		102	65.8	68.3	67.05	46.9	46.5	44.9	45.7
PETROLEUM HYDROCARBONS												
Petroleum Hydrocarbon	E418.1	MG/KG	20		610	1900	1200	1550	30	14	28	21

TABLE 3-15a. SITE 6 - DETECTED CONTAMINANT CONCENTRATIONS IN SOIL
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

CONTINUED

PARAMETER	METHOD	UNITS	REPORTED DETECT LIMIT (b)	LOCATION U - ID Depth, FT LAB ID #	SS6-18 (d) NS-113 0.0-0.5 9201L056-002	SS6-19 (d) NS-114 0.0-0.5 9201L056-006	SS6-20 (d) NS-115 0.0-0.5 9201L056-004	MEAN (c)	MINIMUM (f)	MAXIMUM (f)	Background Concentration MEAN (g)	Background Concentration MAXIMUM (g)
VOLATILE ORGANICS												
Carbon Disulfide	CLP	UG/KG	5(10)	12 U	12 U	12 U	12 U	26.2 J	210 J	210 J	3	ND
1,2-Dichloroethene (total)	CLP	UG/KG	5(10)	12 U	12 U	2 J	12 U	117.8 J	2 J	790	3	ND
1,2-Dichlorobenzene	CLP	UG/KG	330	390 UJ	400 UJ	400 UJ	410 UJ	68.0 J	68 J	60	210	ND
Trichloroethene	CLP	UG/KG	5(10)	12 U	20	20	12 UJ	60.0	2 J	31	3	ND
Tetrachloroethene	CLP	UG/KG	5(10)	12 U	31 J	31 J	12 UJ	31.0 J	14 J	31 J	3 J	3 J
Toluene	CLP	UG/KG	5(10)	12 U	12 UJ	12 UJ	12 UJ	2.0 J	2 J	2 J	3	ND
SEMI-VOLATILE ORGANICS												
2-Chlorophenol	CLP	UG/KG	330	390 UJ	400 UJ	400 UJ	410 UJ	76.0 J	76 J	76 J	210	ND
Benzoic acid	CLP	UG/KG	1600	NA	NA	NA	NA	53.0 J	53 J	53 J	1062.5	ND
Naphthalene	CLP	UG/KG	330	28 J	400 UJ	400 UJ	410 UJ	72.0 J	22 J	72 J	210	ND
2-Methylnaphthalene	CLP	UG/KG	330	40 J	400 UJ	400 UJ	410 UJ	40.0 J	40 J	40 J	210	ND
Acenaphthene	CLP	UG/KG	330	32 J	400 UJ	400 UJ	410 UJ	282.8 J	32 J	810 J	210	ND
Dibenzofuran	CLP	UG/KG	330	390 UJ	400 UJ	400 UJ	410 UJ	247.0 J	36 J	400 J	210	ND
Diethylphthalate	CLP	UG/KG	330	390 UJ	400 UJ	400 UJ	410 UJ	270.0 J	44 J	270 J	210	ND
Fluorene	CLP	UG/KG	330	31 J	400 UJ	400 UJ	410 UJ	287.4 J	31 J	940 J	210	ND
Phenanthrene	CLP	UG/KG	330	63 J	150 J	150 J	820 J	2265.3 J	63 J	11000	210	ND
Anthracene	CLP	UG/KG	330	390 UJ	400 UJ	400 UJ	410 UJ	415.9 J	110 J	1900 J	210	ND
Di-n-Butylphthalate	CLP	UG/KG	330	390 UJ	400 UJ	400 UJ	410 UJ	1068.0 J	430	4700	44 J	44 J
Carbazole	CLP	UG/KG	330	64 J	400 UJ	400 UJ	410 UJ	242.8 J	64 J	420 J	NA	NA
Fluoranthene	CLP	UG/KG	330	720 J	220 J	220 J	1300 J	3628.6 J	220 J	17000	210	ND
Pyrene	CLP	UG/KG	330	560 J	170 J	170 J	930 J	2353.2 J	170 J	9000	210	ND
Butylbenzylphthalate	CLP	UG/KG	330	300 J	100 J	100 J	510 J	640.9 J	100 J	1500 J	210	ND
Benzo(a)anthracene	CLP	UG/KG	330	390 UJ	400 UJ	400 UJ	410 UJ	1111.1	550	5300	210	ND
Chrysene	CLP	UG/KG	330	380 J	110 J	110 J	640 J	1632.3 J	110 J	6500	210	ND
bis(2-Ethylhexyl)phthalate	CLP	UG/KG	330	390 UJ	400 UJ	400 UJ	410 UJ	88.0 J	88 J	88 J	210	ND
Benzo(b)fluoranthene	CLP	UG/KG	330	300 J	110 J	110 J	450 J	1355.0 J	110 J	4600	210	ND
Benzo(k)fluoranthene	CLP	UG/KG	330	250 J	78 J	78 J	390 J	1217.5 J	78 J	4400	210	ND
Benzo(a)pyrene	CLP	UG/KG	330	270 J	98 J	98 J	500 J	1422.1 J	98 J	5300	210	ND
Indeno(1,2,3-cd)pyrene	CLP	UG/KG	330	390 UJ	400 UJ	400 UJ	160 J	963.6 J	160 J	3900	210	ND
Dibenzo(a,h)anthracene	CLP	UG/KG	330	220 J	120 J	120 J	400 J	503.6 J	120 J	1100 J	210	ND
Benzo(g,h,i)perylene	CLP	UG/KG	330	240 J	120 J	120 J	400 J	1119.1 J	120 J	4200	210	ND
PESTICIDES/PCBS												
gamma-BHC (Lindane)	CLP	UG/KG	8(1.7)	2 U	1.9 U	1.9 U	2.1 U	0.82 J	0.82 J	0.82 J	4.99	ND
Endosulfan II	CLP	UG/KG	16(3.3)	4 U	2.3 J	2.40 J	0.83 J	2.40 J	0.83 J	2.4 J	10.12	ND
4,4'-DDT	CLP	UG/KG	16(3.3)	4 U	3.9 U	3.9 U	4.1 U	1.60 J	1.6 J	1.6 J	12.12 J	18 J
Methoxychlor	CLP	UG/KG	80(17)	20 U	19 U	19 U	5.8 J	9.60 J	5.8 J	9.6 J	49.87	ND
alpha-Chlordane	CLP	UG/KG	80(1.7)	1.6 J	1.9 U	1.9 U	2.1 U	1.60 J	1.6 J	1.6 J	49.87	ND
gamma-Chlordane	CLP	UG/KG	80(1.7)	1.6 J	1.9 U	1.9 U	2.1 U	1.60 J	1.6 J	1.6 J	49.87	ND
Aroclor-1260	CLP	UG/KG	160(33)	160	190	190	41 U	190.00	160	190	101.25	ND

TABLE 3-15a. SITE 6 - DETECTED CONTAMINANT CONCENTRATIONS IN SOIL
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

CONTINUED

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT (b)	LOCATION U - ID Depth, FT LAB ID #	SS6-18 (d) NS-113 0.0-0.5 9201L056-002	SS6-19 (d) NS-114 0.0-0.5 9201L056-006	SS6-20 (d) NS-115 0.0-0.5 9201L056-004	MEAN (c)	MINIMUM (f)	MAXIMUM (f)	Background Concentration MEAN (g)	Background Concentration MAXIMUM (g)
METALS												
Aluminum, Total	SW6010	MG/KG	40		5700	6390	6900	9480.9	3920	17200	6562.5	8050
Arsenic, Total	SW7060	MG/KG	2		8 J	2.9 J	3.2 J	7.0 J	2.7 J	14.2 J	4.3 J	6.5 J
Barium, Total	SW6010	MG/KG	40		91.7	95.8	110	107.0	58.5	141.5	89.9	105
Beryllium, Total	SW6010	MG/KG	1		1.2 U	1.2 U	1.2 U	0.7	0.32	1.05	0.4	ND
Calcium, Total	SW6010	MG/KG	1000		74400	18100	2840	43239.5 J	2840	216000	7505 J	15400 J
Cadmium, Total	SW6010	MG/KG	1		2.7	1.3	3.1	2.5	1.3	9.1	1.06	ND
Cobalt, Total	SW6010	MG/KG	10		11.8 U	11.9 U	12.3 U	7.4	6.6	11.8	8.3	12.3
Chromium, Total	SW6010	MG/KG	2		14.8	26.7	12	14.5	9.1	26.7	9.1	10.7
Copper, Total	SW6010	MG/KG	5		30.6	17.5	43.7	30.1 J	14	89.7 J	14.1	16.2
Iron, Total	SW6010	MG/KG	20		11000	14100	13600	16437.7	7185	28800	13725	15600
Potassium, Total	SW6010	MG/KG	1000		1180 U	1190 U	1250 U	617.7 J	1180 J	1180 J	527	ND
Magnesium, Total	SW6010	MG/KG	1000		11800	2850	1390	4310.9 J	1390	11800	4995 J	9900 J
Manganese, Total	SW6010	MG/KG	3		359	480	740	434.5 J	139	740	503.3	643
Sodium, Total	SW6010	MG/KG	1000		1180 U	1190 U	1250 U	110.0 J	106.5 J	110 J	85.3	110 J
Nickel, Total	SW6010	MG/KG	8		11.5	13.6	11.4	15.2	8.45	26.45	12	16.3
Lead, Total	SW6010	MG/KG	1		75.2 J	25.9 J	54.8 J	60.3 J	11.8	260.5	2.5 J	4.5 J
Vanadium, Total	SW6010	MG/KG	10		24.3	19.6	18.1	22.6	15.85	33.2	20.6	24.2
Zinc, Total	SW6010	MG/KG	4		62.9	61	68.2	69.7	45.7	102	53.6	87.2
PETROLEUM HYDROCARBONS												
Petroleum Hydrocarbon	E418.1	MG/KG	20		530	870	17	347.0	17	1550	26.9	100

NOTES:

- Eleven soil samples total: two samples each from two borings and seven surface soils. Analyses: volatile organics, semivolatile organics, pesticides/PCB'S, metals, and petroleum hydrocarbons (Table 2-3). Analytes not presented were not detected.
- Detection limit for Round 2 sampling located in parentheses if different from Round 1.
- Refers to the mean of the duplicate samples, if there is only one positive detection this value is used for the mean.
- Samples taken during Round 2 in January 1992, unless noted, all other samples taken during Round 1 in November 1990.
- The mean concentration for all soil samples is calculated using the duplicate mean for duplicate samples and half the sample quantification detection limit where not detected. The maximum detected value is used for the mean if the calculated mean is greater than the maximum.
- Minimum and maximum values do not include values flagged with a U or a UJ.
- Four background soil samples total: two samples from one boring and two surface soils. Mean and maximum background concentrations were calculated in the same manner as above, where not detected, the mean is based on detection limits only.
- J = Estimated data due to quality control criteria.
- NA= Not analyzed
- ND= Not detected
- U = Compound not detected, value is the sample quantification limit.
- UJ= Compound not detected, estimated sample quantification limit.
- R = Reject data due to quality control criteria.

TABLE 3-15b. SITE 6 - DETECTED CONTAMINANT CONCENTRATIONS IN GROUNDWATER
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT (b)	LOCATION U - ID Depth, FT LAB ID #	MW6-03 NS - 72 0.0-0.0 9011L600-001	MW6-03 (c) NS-103 0.0-0.0 9201L073-001	Duplicate Sample MW6-07 NS-103	Duplicate Mean (d)	MEAN (e)	MINIMUM (f)	MAXIMUM (f)	Background Concentration (g)	MCL (h)
SEMIVOLATILE ORGANICS	CLP	UG/L	10		10 U	10 U	0.6 J	0.6 J	0.6 J	0.6 J	0.6 J	11 U	
Pyrene													
METALS													
Aluminum, Total	SW6010	UG/L	200		54200	22700 J	29700 J	26200 J	40200 J	26200 J	54200	27000	2000
Barium, Total	SW6010	UG/L	200		552	364	418	391	472	391	552	260	
Calcium, Soluble	SW6010	UG/L	500(5000)		89300	74200	74600	74400	81850	74400	89300	73600	
Calcium, Total	SW6010	UG/L	500(5000)		160000	105000	119000	112000	136000	112000	160000	159000	
Chromium, Total	SW6010	UG/L	30(10)		77.2	86.6	103	94.8	86	77.2	94.8	34.2	100
Copper, Total	SW6010	UG/L	25		134	89.3	103	96.2	115	96.2	134	77.7	1300
Iron, Soluble	SW6010	UG/L	100		100 U	100 U	187	187	119	187	187	100 U	
Iron, Total	SW6010	UG/L	100		81700	38500 J	47600 J	43050 J	62375 J	43050 J	81700	48900	2
Mercury, Soluble	SW7470	UG/L	0.2		0.32 J	0.2 U	0.8	0.8	0.56 J	0.32 J	0.8	0.2 U	2
Mercury, Total	SW7470	UG/L	0.2		0.25 U	0.2 U	0.23 J	0.23 J	0.18 J	0.23 J	0.23 J	0.2 U	2
Potassium, Total	SW6010	UG/L	5000		5430	5000 U	5000 U	5000 U	3965	5430	5430	5000 U	
Magnesium, Soluble	SW6010	UG/L	5000		37100	31700	31900	31800	34450	31800	37100	39700	
Magnesium, Total	SW6010	UG/L	5000		76400	50200	57100	53650	65025	53650	76400	74800	
Manganese, Soluble	SW6010	UG/L	15		546	532	537	534.5	540	534.5	546	104	
Manganese, Total	SW6010	UG/L	15		1670	1130	1250	1190	1430	1190	1670	1070	
Sodium, Soluble	SW6010	UG/L	5000		21100	17500	18700	18100	19600	18100	21100	5350	
Sodium, Total	SW6010	UG/L	5000		19700	16400	17300	16850	18275	16850	19700	5850	
Nickel, Total	SW6010	UG/L	15(40)		110	64.1	74.4	69.3	90	69.3	110	74.1 UJ	100p
Lead, Total	SW7421	UG/L	3		38.7 J	20.7	22.3	21.5	30 J	21.5	38.7 J	16.3 J	50(15)
Vanadium, Total	SW6010	UG/L	50		107	63.4	77.7	70.6	89	70.6	107	62.2 UJ	
Zinc, Soluble	SW6010	UG/L	20		20 U	20 U	45	45	28	45	45	20 U	
Zinc, Total	SW6010	UG/L	20		235	107	125	116	176	116	235	122	

NOTES:

- Two groundwater samples total. Analyses: volatile organics, semivolatile organics, pesticides/PCB'S, metals, and petroleum hydrocarbons (Table 2-3).
Analytes not presented were not detected.
- Detection limit for Round 2 sampling located in parentheses if different from Round 1.
- Samples taken during Round 2 in January 1992, unless noted, all other samples taken during Round 1 in November 1990.
- Refers to the mean of the duplicate samples, if there is only one positive detection this value is used for the mean.
- The mean concentration for all groundwater samples is calculated using the duplicate mean for duplicate samples and half the sample quantification detection limit where not detected.
The maximum detected value is used for the mean if the calculated mean is greater than the maximum.
- Minimum and maximum values do not include those values flagged with a U or a UI.
- One background groundwater sample total.
- Maximum Contaminant Levels taken from Table 4.3, p= proposed value
J = Estimated data due to quality control criteria.
U = Compound not detected, value is sample quantification limit.
UI = Compound not detected, estimated sample quantification limit.

TABLE 3-15c. SITE 6 - DETECTED CONTAMINANT CONCENTRATIONS IN SEDIMENT
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT	LOCATION U - ID Depth, FT LAB ID #	SE6-02 NS - 92 0.0-0.0 9011L600-007	Background Concentration (b)
VOLATILE ORGANICS						
Trichloroethene	CLP	UG/KG	5		8	6 U
SEMIVOLATILE ORGANICS						
Accenaphthene	CLP	UG/KG	330		1200 J	690 U
Dibenzofuran	CLP	UG/KG	330		700 J	690 U
Fluorene	CLP	UG/KG	330		1400 J	690 U
Phenanthrene	CLP	UG/KG	330		24000	690 U
Anthracene	CLP	UG/KG	330		3100 J	690 U
Fluoranthene	CLP	UG/KG	330		39000	110 J
Pyrene	CLP	UG/KG	330		33000	88 J
Benzo(a)anthracene	CLP	UG/KG	330		10000	690 U
Chrysene	CLP	UG/KG	330		21000	73 J
Benzo(b)fluoranthene	CLP	UG/KG	330		23000	77 J
Benzo(k)fluoranthene	CLP	UG/KG	330		16000	690 U
Benzo(a)pyrene	CLP	UG/KG	330		14000	690 U
Indeno(1,2,3-cd)pyrene	CLP	UG/KG	330		13000	690 U
Benzo(g,h,i)perylene	CLP	UG/KG	330		15000	690 U
PESTICIDES/PCB'S						
gamma-BHC (Lindane)	CLP	UG/KG	8		R	7.5 U
Endosulfan II	CLP	UG/KG	16		R	15 U
4,4'-DDT	CLP	UG/KG	16		R	15 U
Methoxychlor	CLP	UG/KG	80		R	75 U
alpha-Chlordane	CLP	UG/KG	80		R	75 U
gamma-Chlordane	CLP	UG/KG	80		R	75 U
Aroclor-1260	CLP	UG/KG	160		R	150 U
METALS						
Aluminum, Total	SW6010	MG/KG	40		4510	3530
Arsenic, Total	SW7060	MG/KG	2		6.2 J	2.5 J
Barium, Total	SW6010	MG/KG	40		86.5	60.7
Calcium, Total	SW6010	MG/KG	1000		15200	2590
Cadmium, Total	SW6010	MG/KG	1		8.9	0.84 U
Chromium, Total	SW6010	MG/KG	2		17.4	3.5
Copper, Total	SW6010	MG/KG	5		62.2	7.6
Iron, Total	SW6010	MG/KG	20		14500	6310
Magnesium, Total	SW6010	MG/KG	1000		3280	1160
Manganese, Total	SW6010	MG/KG	3		880	380
Nickel, Total	SW6010	MG/KG	8		16.8	10 UJ
Lead, Total	SW6010	MG/KG	1		114	10.7
Zinc, Total	SW6010	MG/KG	4		270 J	50.2
PETROLEUM HYDROCARBONS						
Petroleum Hydrocarbon	E418.1	MG/KG	20		610	58

NOTES:

- One sediment sample total. Analyses: volatile organics, semivolatile organics, pesticides/PCB'S, metals, and petroleum hydrocarbons (Table 2-3).
Analytes not presented were not detected.
- One background sediment sample total.
J = Estimated data due to quality control criteria.
R = Reject data due to quality control criteria.
U = Compound not detected, value is the sample quantification limit.
UJ = Compound not detected, estimated sample quantification limit.

TABLE 3-15d. SITE 6 - SUMMARY OF ANALYTICAL DETECTIONS - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	SOIL(a)			NUMBER OF DETECTION	SEDIMENT (c)	GROUNDWATER (d)		NUMBER OF DETECTIONS
	RANGE(b)	MEAN	RANGE (b)			MEAN		
VOLATILE ORGANICS	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/L	UG/L	
Carbon Disulfide	210 J	26.2 J	1 / 10					
1,2-Dichloroethene (total)	2 J to 790	118 J	2 / 10					
1,2-Dichlorobenzene	68 J	68 J	1 / 11					
Trichloroethene	2 J to 60	60 J	3 / 11	8				
Tetrachloroethene	14 J to 31 J	31 J	2 / 10					
Toluene	2 J	2 J	1 / 10					
SEMIVOLATILE ORGANICS	UG/KG	UG/KG	UG/KG	UG/KG	UG/L	UG/L		
2-Chlorophenol	76 J	76 J	1 / 11					
Benzoic acid	53 J	53 J	1 / 6					
Naphthalene	22 J to 72 J	72 J	3 / 11					
2-Methylnaphthalene	40 J	40 J	1 / 11					
Acenaphthene	32 J to 810 J	283 J	8 / 11	1,200 J				
Dibenzofuran	36 J to 400 J	247 J	5 / 11	700 J				
Diethylphthalate	44 J to 270 J	270 J	3 / 11					
Fluorene	31 J to 940 J	287 J	8 / 11	1,400 J				
Phenanthrene	63 J to 11,000	2,265 J	10 / 11	24,000				
Anthracene	110 J to 1,900 J	416 J	8 / 11	3,100 J				
Di-n-Butylphthalate	430 to 4,700	1,068 J	5 / 11					
Carbazole	64 J to 420 J	243 J	4 / 5					
Fluoranthene	220 J to 17,000	3,629 J	10 / 11	39,000				
Pyrene	170 J to 9,000	2,353 J	10 / 11	33,000	0.6 J	0.6 J	1 / 2	
Butylbenzylphthalate	100 J to 1,500 J	641 J	7 / 11					
Benzo(a)anthracene	550 to 5,300	1,111	5 / 11	10,000				
Chrysene	110 J to 6,500	1,632 J	10 / 11	21,000				
bis(2-Ethylhexyl)phthalate	88 J	88 J	1 / 11					
Benzo(b)fluoranthene	110 J to 4,600	1,355 J	10 / 11	23,000				
Benzo(k)fluoranthene	78 J to 4,400	1,218 J	10 / 11	16,000				
Benzo(a)pyrene	98 J to 5,300	1,422 J	10 / 11	14,000				
Indeno(1,2,3-cd)pyrene	160 J to 3,900	964 J	8 / 11	13,000				
Dibenzo(a,h)anthracene	120 J to 1,100 J	504 J	10 / 11					
Benzo(g,h,i)perylene	120 J to 4,200	1,119 J	10 / 11	15,000				
PESTICIDES/PCB'S	UG/KG	UG/KG	UG/KG	UG/KG				
gamma-BHC (Lindane)	0.82 J	0.82 J	1 / 11					
Endosulfan II	0.83 J to 2.4 J	2.4 J	4 / 11					
4,4'-DDT	1.6 J	1.6 J	1 / 11					
Methoxychlor	5.8 J to 9.6 J	9.6 J	3 / 11					
alpha-Chlordane	1.6 J	1.6 J	1 / 11					
gamma-Chlordane	1.6 J	1.6 J	1 / 11					
Aroclor-1260	160 to 190	190	2 / 11					

TABLE 3-15d. SITE 6 - SUMMARY OF ANALYTICAL DETECTIONS - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

CONTINUED

PARAMETER	SOIL (a)			NUMBER OF DETECTION	SEDIMENT (c)	GROUNDWATER (d)			NUMBER OF DETECTIONS
	RANGE (b)		MEAN			RANGE (b)	MEAN		
	MG/KG							MG/KG	
METALS (e)									
Aluminum, Total	3,920	to 17,200	9,481	11 / 11	4,510	26,200 J	to 54200	40200 J	2 / 2
Arsenic, Total	2.7 J	to 14.2 J	7.0 J	11 / 11	6.2 J				
Barium, Total	58.5	to 142	107	11 / 11	86.5	391	to 552	471.5	2 / 2
Beryllium, Total	0.32	to 1.05	0.7	6 / 11					
Calcium, Soluble						74,400	to 89300	81850	2 / 2
Calcium, Total	2,840	to 216,000	43,240 J	11 / 11	15,200	112,000	to 160000	136000	2 / 2
Cadmium, Total	1.3	to 9.1	2.5	6 / 11	8.9				
Cobalt, Total	6.6	to 11.8	7.4	5 / 11					
Chromium, Total	9.1	to 26.7	14.5	11 / 11	17.4	77.2	to 94.8	86	2 / 2
Copper, Total	14	to 89.7 J	30.1 J	11 / 11	62.2	96.2	to 134	115	2 / 2
Iron, Soluble						187		118.5	1 / 2
Iron, Total	7,185	to 28,800	16,458	11 / 11	14,500	43,050 J	to 81700	62375 J	2 / 2
Mercury, Soluble						0.32 J	to 0.8	0.56 J	2 / 2
Mercury, Total						0.23 J		0.17 J	1 / 2
Potassium, Total	1,180 J		618 J	1 / 11		5,430		3965	1 / 2
Magnesium, Soluble						31,800	to 37100	34450	2 / 2
Magnesium, Total	1,390	to 11,800	4,311 J	11 / 11	3,280	53,650	to 76400	65025	2 / 2
Manganese, Soluble						535	to 546	540	2 / 2
Manganese, Total	139	to 740	435 J	11 / 11	880	1,190	to 1670	1430	2 / 2
Sodium, Soluble						18,100	to 21100	19600	2 / 2
Sodium, Total	106.5 J	to 110 J	110.0 J	2 / 11		16,850	to 19700	18275	2 / 2
Nickel, Total	8.5	to 26.5	15.2	11 / 11	16.8	69.3	to 110	90	2 / 2
Lead, Total	11.8	to 260.5	60.3 J	11 / 11	114	21.5	to 38.7 J	30 J	2 / 2
Vanadium, Total	15.9	to 33.2	22.6	11 / 11		70.6	to 107	89	2 / 2
Zinc, Soluble						45		27.5	1 / 2
Zinc, Total	45.7	to 102	69.7	11 / 11	270 J	116	to 235	175.5	2 / 2
PETROLEUM HYDROCARBON					MG/KG				
Petroleum Hydrocarbon	17	to 1,550	347	10 / 11	610				

NOTES:

- Eleven soil samples total: two samples each from two borings and seven surface soils.
No value presented means not detected, except for metals (see e.).
- Minimum and maximum detections presented. One value presented usually indicates detected in only one sample.
- Only one sediment sample taken
- Two groundwater samples total. No value presented means not detected.
- Soluble metals analysis not run on sediments and soils. Both soluble and total metals analyzed for groundwater.
J = Estimated data due to quality control criteria.

in all subsurface soils except BH6-05 (4-6 feet) at concentrations comparably higher than those found in surface soils. Di-n-butylphthalate was present in all samples, while two other phthalate compounds were also detected at lower concentrations. Dibenzofuran and 2-chlorophenol were detected in both subsurface soils collected from BH6-04. Dibenzofuran and PAHS are products of semi-combusted jet fuel. Petroleum hydrocarbons were detected in all samples except BH6-04 (2-4 feet). The types and quantities of metals found in subsurface soils were similar to those reported in surface soils. Two exceptions to this are elevated barium levels, and lower concentrations of lead.

Groundwater. (MW6-03) During Round 1, no organic compounds were identified in groundwater. In addition to mineral forming metals, barium and eight heavy metals including chromium, copper, mercury, manganese, nickel, lead, vanadium, and zinc were reported. Of these metals, mercury, nickel, and vanadium were not found in background waters. Lead and chromium concentrations were elevated in comparison to background. Vanadium is a typical metal found in jet exhaust. During Round 2, a trace of pyrene was detected in groundwater. The metals concentrations were similar to those detected in Round 1, however, total mercury and soluble zinc were detected in Round 2 and not in Round 1. Chromium and lead were elevated relative to background. Since groundwater flow may be flowing to the southeast or as indicated by the June 1992 data (Table 3-3), Site 6 contaminants may impact MW5-02. Therefore, MW5-02 analytical data is presented below.

In Round 1, at MW5-02 volatile organics, semi-volatile organics, pesticides, and PCBs were not detected in groundwater. Trace concentrations of petroleum hydrocarbons were detected in groundwater. Mineral forming metals were detected at concentrations typically similar to or less than those found in background groundwater. Heavy metals including copper, manganese, and zinc were also found in concentrations similar to background groundwater, whereas chromium and lead were elevated in comparison. Mercury, nickel, and vanadium, not found in background waters, were detected in MW5-02 groundwater. Mercury was found in soluble forms at concentrations equivalent to those in total recoverable form, indicating that the mercury present exists as soluble mercury. Manganese was also detected in its soluble form.

Sediment. Trace quantities of trichloroethene and dibenzofuran were found in the sediment. Thirteen PAH compounds were also detected at concentrations ranging from trace to 39,000 $\mu\text{g}/\text{kg}$. These concentrations were greater than those reported for site soils. Petroleum hydrocarbons were also reported at 610 mg/kg . Mineral forming metals were found at concentrations similar to background soils. Heavy metals present consisted of arsenic, cadmium, chromium, copper, manganese, nickel, lead, and zinc. Barium was also detected. Generally, all metals were elevated above background, the lead concentration were ten times the background sediment sample concentration.

3.7.3 Geologic and Hydrogeologic Investigation Results

Monitoring well MW6-03 was installed and soil borings BH6-04 and BH6-05 were also drilled in this area. Geologic logs constructed from this area were consistent with the stratigraphy described in section 3.2.1.

Water level measurements collected on February 1991 and June 1991 from monitoring well, MW5-02 and MW6-03 and piezometers P-1 and P-3, indicate that groundwater may flow south-southeast across Site 6. Water level measurements in January 1992 indicated that groundwater flow may be to the south-southwest. The hydraulic gradient for the site ranged from 0.004 to 0.009 (see Figure 3-21). A hydraulic conductivity (K) of 2.00×10^{-4} was calculated for MW6-03. Assuming a porosity of 0.30, the groundwater in this area will flow south from 6.9×10^{-3} to 1.1×10^{-2} ft/day (Table 3-3).

3.7.4 Identification of Data Gaps

Groundwater contamination was not evident although soil and sediment contamination was measured. Groundwater flow direction appears to vary from the south-southeast to the south-southwest. The effect of the hangar building on local flow patterns is not known. The vertical extent of soil contamination has not been determined.

3.7.5 Summary and Conclusions

The soil gas survey results indicated three points of high concentrations of VOCs at Site 6. The GC results did not conclusively identify contamination.

Soils and sediments at Site 6 were characterized by the presence of elevated phthalate and PAH compounds, petroleum hydrocarbons, and volatile organic compounds. In addition, tentatively identified compounds indicated the presence of high concentrations of alkanes, which are typically found in Stoddard Solvent. This trend was apparent at all depths sampled from the surface to a depth of six feet. The greatest volatile organic concentrations were found in the soil boring and surface soils nearest the hangar building no. 1. Surface soil samples located nearest to the site boundary (SS-19 and SS-20) showed lower contaminant concentrations. During Round 1 field activities, it was necessary to upgrade to level C personal protection equipment during surface soil, and soil boring sample collection. During Round 1, the high semi-volatile organic compound concentrations caused interference in the measurement of volatile organic compounds in the soils as well as elevated detection limits. Round 2 surface soil samples verified the presence of only trace volatile organics.

The organic compounds identified and the presence of heavy metals in elevated concentrations in soils are indicative of the past maintenance type activities conducted at the site, as well as, bi-products of jet exhaust. Heavy metals including mercury levels in groundwater were generally found in higher concentrations than background levels in both MW5-02 and MW6-03. The storm drain where the sediment sample was collected appears to be acting as a catch basin for many of the semi-volatiles found at this site. Downgradient groundwater contamination with volatile and semi-volatile organic compounds was not evident in MW5-02 or MW6-03, although the potential for release of contamination to groundwater is possible due to the shallow groundwater table.

Water level measurements indicated that groundwater in the vicinity of Site 6 flows southerly from 2.5 to 5.6 feet/year. However, the vertical extent of soil contamination has not been fully

characterized. In addition, the downgradient monitoring well MW6-03 may not be providing an accurate representation of potential groundwater contamination associated with the site due to its distance from the source area and also since water level data indicates that groundwater may flow toward MW5-02. The close proximity of the hangar building to the site prevented installation of the down gradient monitoring well, MW6-03 closer to the source area. In addition, the effect of the hangar building on local groundwater flow patterns is not known.

3.8 AMMUNITION AREA

Two groundwater samples (from two sampling rounds) were collected from an on-site water well (530) in the Ammunition Area (Figure 3-22), downgradient of the sites under investigation. The analytical parameters included: volatile and semi-volatile organic compounds, pesticides, PCBs, total metals, and petroleum hydrocarbons. Analytical results are presented in Table 3-16a and summarized in Table 3-16b.

Groundwater. During Round 1, only one trace volatile organic compound, carbon disulfide, was detected. Total metals were detected at concentrations below concentrations found at the site Background Area. Semi-volatiles, petroleum hydrocarbons, pesticides, and PCBs were not detected. During Round 2, no organic compounds were detected. Metals concentrations were similar to those detected in Round 1, however, zinc was detected in Round 2 and not in Round 1, below background concentrations. It should however, be noted that this well was drilled to a depth of approximately 55 feet and screened from 50-55 feet (see Table 1-4). In contrast, the on-site monitoring wells and piezometers were drilled to depths of <20 feet.

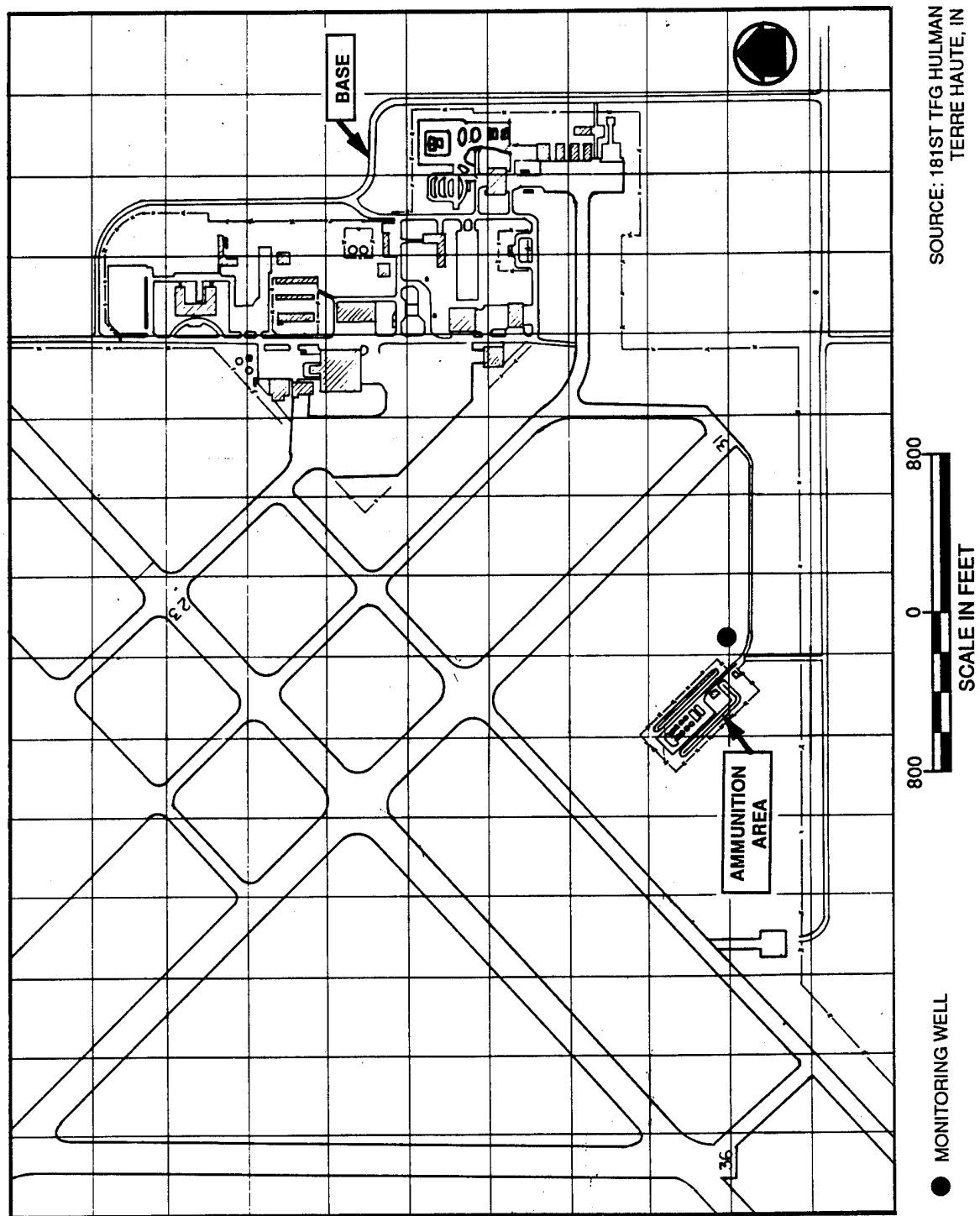


FIGURE 3-22. SAMPLING LOCATION AMMUNITION AREA
181ST FG, HULMAN FIELD MAP, TERRE HAUTE, IN

TABLE 3-16a. AMMUNITION AREA - DETECTED CONTAMINANT CONCENTRATIONS IN GROUNDWATER
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	METHOD	UNITS	REPTD DETECT LIMIT (b)	LOCATION U - ID Depth, FT LAB ID #	MWA-08 NS - 77 0.0-0.0 011L572-004	MWA-08 (c) NS-108 0.0-0.0 9201L030-004/7	MEAN (d)	MINIMUM (e)	MAXIMUM (e)	Background Concentration (f)	MCL (g)
VOLATILE ORGANICS											
Carbon Disulfide	CLP	UG/L	5		1 J	10 U	1 J	1 J	1 J	5 U	
METALS											
Barium, Total	SW6010	UG/L	200		275	264	269.5	264	275	260	2000
Calcium, Total	SW6010	UG/L	500(5000)		55400	55600	55500	55400	55600	159000	
Iron, Total	SW6010	UG/L	100		580	868	724	580	868	48900	
Magnesium, Total	SW6010	UG/L	5000		26300	26500	26400	26300	26500	74800	
Manganese, Total	SW6010	UG/L	15		58.6	56.4	57.5	56.4	58.6	1070	
Sodium, Total	SW6010	UG/L	5000		64900	50000	57450	50000	64900	5850	
Zinc, Total	SW6010	UG/L	20		79.2 U	53.1	46.35	53.1	53.1	122	

NOTES:

- Two groundwater samples total: Analyses: volatile organics, semivolatile organics, pesticides/PCB'S, metals, and petroleum hydrocarbons (Table 2-3).
Analytes not presented were not detected.
- Detection limit for Round 2 sampling located in parentheses if different from Round 1.
- Sample taken during Round 2 in January 1992, unless noted, all other samples taken during Round 1 in November 1990.
- The mean concentration for all groundwater samples is calculated using half the sample quantification detection limit where not detected.
The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
- Minimum and maximum values do not include those values flagged with a J or UJ.
- One background groundwater sample total.
- Maximum Contaminant Levels taken from Table 4.3.
- J = Estimated data due to quality control criteria.
- U = Compound not detected, value is the sample quantification limit.

TABLE 3-16b. AMMUNITIONS AREA - SUMMARY OF ANALYTICAL DETECTIONS
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	GROUNDWATER (a)		
	RANGE (b)	MEAN	NUMBER OF DETECTIONS
VOLATILE ORGANICS	UG/L	UG/L	
Carbon Disulfide	1 J	1 J	1 / 2
METALS	UG/L		
Barium, Total	264 to 275	269.5	2 / 2
Calcium, Total	55,400 to 55600	55500	2 / 2
Iron, Total	580 to 868	724	2 / 2
Magnesium, Total	26,300 to 26500	26400	2 / 2
Manganese, Total	56 to 59	57.5	2 / 2
Sodium, Total	50,000 to 64900	57450	2 / 2
Zinc, Total	53.1	46.35	1 / 2

NOTES:

- a. Two groundwater samples total. Analytes not presented were not detected.
 - b. Minimum and maximum detections presented. One value presented usually indicates detected in only one sample.
- J = Estimated data due to quality control criteria.

4.0 PRELIMINARY RISK EVALUATION

4.1 INTRODUCTION

The potential for risks to human health and the environment associated with contamination detected on the base was evaluated to aid in the determination of how to proceed upon completion of the SI. Base information and data generated during the SI, presented in prior sections of this report, were used. The objective of this evaluation was to provide a first-cut, quantitative risk estimate where adequate data were available and a qualitative evaluation where data were inadequate to support a full quantitative assessment. This evaluation was not a full base-line risk assessment, but was designed to help determine which of four approaches will be taken for each site: 1) No Further Action Decision Document, 2) Immediate Response, 3) Focused Feasibility Study/Remedial Measure, or 4) Remedial Investigation/Feasibility Study.

This evaluation was guided by the Air National Guard Readiness Center's August 1990 draft prototype for a preliminary risk evaluation and the U.S. EPA Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (U.S. EPA, December 1989). Neither the Air National Guard nor the state of Indiana have published final guidelines for the performance of a risk evaluation.

The risk evaluation included the following steps:

- Identification of those contaminants found at concentrations elevated over background concentrations that may pose a threat to human health and the environment
- Characterization of the chemical, physical, and toxicologic properties of the potential contaminants of concern and discussion of their environmental fate and transport properties

- Identification and characterization of human populations presently exposed or with the potential to be exposed in the future
- Comparison of environmental concentrations to appropriate standards and comparison of dose estimates to health criteria for non-carcinogenic and carcinogenic risks
- Identification of any environmental receptors presently exposed or with the potential to be exposed in the future and discussion of possible risks from site contamination
- Discussion of the limitations and uncertainties of the risk evaluation

The approach used for each of these steps and pertinent base information are presented in Sections 4.1.1 through 4.1.7. Site-specific evaluations are as follows: Site 1 - Section 4.2, Site 2 - Section 4.3, Site 4 - Section 4.4, Site 5 - Section 4.5, Site 6 - Section 4.6, Ammunition Area - Section 4.7, and Background Area - Section 4.8. The site-specific analyses utilize pertinent base information presented in Sections 4.1.1 through 4.1.7 and where possible present additional site-specific information concerning populations and land use. The first five subsections of each site evaluation are focused on human exposure and risk, while the sixth subsection addresses environmental risks to threatened, rare, or endangered species and environmentally sensitive areas. Section 4.7, the Ammunition Area evaluation, was limited to a discussion of groundwater and a comparison of detected chemical concentrations in groundwater to standards. Section 4.8, the Background Area evaluation, involved a similar approach to that used for the sites under investigation, but exposure pathways were not screened.

4.1.1 Identification of the Contaminants of Concern

A total of 67 analytes were detected at the base at one or more of the sites, the Ammunition Area, or the Background Area. This includes chemicals detected in soil, groundwater, surface water, and sediment. Analyses for volatile organic compounds, semi-volatile organic compounds, and total petroleum hydrocarbons (TPH) were conducted at all of the sites. At Sites 1, 5, and 6, the Background Area, and the Ammunition Area, pesticides/PCB's and metals

analyses were also conducted. A list of all analytes included in the analysis for each chemical group (i.e., volatiles, semi-volatiles, pesticides/PCBs, and metals) is presented in Table 2-3. Total petroleum hydrocarbons were detected in a number of samples, but data on TPH concentrations were not directly used in this assessment because no toxicity data are available for TPH. Instead, individual volatile and semi-volatile organic analytes, considered to be of greatest toxicological concern for petroleum releases, were evaluated.

Analyte toxicity and site attributability were considered to identify the contaminants of concern. An initial screening conducted to identify potential contaminants of concern resulted in the elimination of those compounds with low toxicity, known to be human nutrients, and those compounds found only in background samples. Five metals detected at the base are human nutrients and are only toxic at extremely high levels: calcium, iron, magnesium, potassium, and sodium. These compounds are generally not considered toxic and were not evaluated for health risks. Trace levels of two pesticides, DDE and DDD, were detected only in one background surface soil sample. Because they were only detected in the Background Area, these pesticides were not evaluated for health risks in any site-specific evaluations.

Site-specific chemicals detected at background concentrations were eliminated from the assessment of site risks. A number of the analytes detected were within the background concentration range for specific media at certain sites (Section 3.0). However, the same analyte was typically not within the background range for all media at all of the sites, so analytes were screened further at each site based on a comparison with background concentrations.

Analytes present at concentrations consistent with background concentrations were eliminated during the identification of contaminants of concern for each site. Concentrations were considered consistent with background concentrations when the average or maximum concentration of a compound in a media was less than twice the average or maximum concentration for the corresponding background sample. Likewise, concentrations were considered elevated above background when the average or maximum concentration was greater

than twice the average or maximum concentration for the corresponding background sample. The following is a list of the sixty potential contaminants of concern for each of the sites:

- **Volatile Organic Compounds:** acetone, 2-butanone, chloromethane, methylene chloride, 1,2-dichloroethane, 1,2-dichloroethene, trichloroethene, tetrachloroethene, carbon disulfide, benzene, toluene, 1,2-dichlorobenzene
- **Phenolic Compounds:** phenol, 4-methylphenol, 2-chlorophenol, pentachlorophenol
- **Phthalate Esters:** diethylphthalate, di-n-butylphthalate, butylbenzylphthalate, bis(2-ethylhexyl)phthalate
- **Polycyclic Aromatic Hydrocarbons (PAHs):** naphthalene, 2-methylnaphthalene, fluorene, acenaphthene, anthracene, phenanthrene, pyrene, fluoranthene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene
- **Other Semi-volatile Organic Compounds:** benzoic acid, dibenzofuran, carbazole
- **Pesticides/Polychlorinated Biphenyls (PCBs):** gamma-BHC(Lindane), Endosulfan II, 4,4'-DDT, methoxychlor, alpha-Chlordane, gamma-Chlordane, Aroclor 1260
- **Metals:** aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, vanadium, zinc

4.1.2 Properties of Potential Contaminants of Concern

An important step in the evaluation of possible risks posed by site contaminants is a characterization of the physical, chemical, and toxicologic properties of each analyte. Physical and chemical characteristics of contaminants were assessed to determine whether a contaminant was expected to migrate or persist in the environment in order to evaluate whether or not exposure to the contaminant may occur. Toxicological properties of contaminants indicate the potential types and likelihood of health effects from a given exposure.

4.1.2.1 Physical and Chemical Properties of Potential Contaminants of Concern. Physical and chemical properties of contaminants help to determine the movement and environmental fate of a contaminant and the subsequent assessment of exposure pathways. The following section discusses the physical and chemical properties of the potential contaminants of concern and how they apply to the transport properties of the various contaminant groups. Properties of the organic compounds and metals found at the Hulman ANG Base are presented in Table 4-1. Each of the properties presented provides some guidance regarding contaminant behavior in a given environment. Only physical state and solubilities are presented for metals, because each may be found in a variety of chemical and physical states with widely varying properties. The properties presented for organic compounds in Table 4-1 are discussed relative to the effects they might have on mobility.

The **water solubility** of a chemical is defined as the maximum concentration of that chemical that will dissolve in pure water at a specific temperature and pH. Neutral pH and temperatures from 20 to 30°C are usually used. Water solubility is a critical property affecting environmental fate (U.S. EPA, October 1986). Highly soluble chemicals can be rapidly leached from wastes or contaminated soils and are generally mobile in both groundwaters and surface waters (U.S. EPA, October 1986). The water solubilities of most common organic compounds fall between 1 and 100,000 mg/l (Lyman et al., 1981).

Vapor pressure and Henry's Law Constant are two measures of chemical volatility and are important factors in evaluating the air exposure pathway.

Vapor pressure is a measure of the volatility of a chemical in its pure state at a specific temperature, generally 20 to 30°C (U.S. EPA, October 1986). The vapor pressures of liquids range from 0.001 to 760 mm Hg (U.S. EPA, October 1986). A higher vapor pressure indicates a greater tendency for movement from water or soil to air.

TABLE 4-1. CHEMICAL AND PHYSICAL PROPERTIES OF THE POTENTIAL CONTAMINANTS OF CONCERN

CHEMICAL AND PHYSICAL PROPERTIES:						
Molecular Weight(MW)	Log Kow	Water Solubility (mg/L)	Koc (ml/g)	Vapor Pressure (mm Hg)	Henry's Law Constant (atm-m ³ /mol)	
	(1,3,4,5,7,9,11,12)	(1,2,3,4,5,7,9,10,11,12)	(1,3,6,7,9,11,12)	(1,3,4,5,6,7,9,10,12)	(1,3,6,7,9,10,11,12)	
VOLATILE ORGANICS						
Acetone	58	-0.24	1.00E+06	2.20E+00 to 1.80E+01	1.86E+02 to 2.70E+02	2.06E-05 to 3.97E-05
2-Butanone	72	0.26 to 0.29	1.36E+05 to 2.68E+05	4.50E+00 to 5.20E+00	7.06E+01 to 9.06E+02	2.74E-05 to 5.77E-05
Chloromethane	50	0.91 to 0.95	4.80E+03 to 7.25E+03	7.40E+01	1.92E+03 to 4.31E+03	4.40E+02 to 8.82E+03
Methylene Chloride	85	0.95 to 1.30	6.50E+03 to 2.00E+04	8.80E+00 to 3.50E+01	2.25E+02 to 5.99E+02	3.19E-03 to 4.40E-02
1,2-Dichloroethene	97	0.48-0.70	3.50E+03 to 6.30E+03	3.00E+01 to 5.90E+01	2.70E+00 to 3.31E+02	4.05E-03 to 7.58E-03
Trichloroethene	132	1.42 to 2.42	1.10E+03	8.72E+01 to 1.26E+02	5.79E+01 to 9.78E+01	8.92E-03 to 2.00E-02
Tetrachloroethene	166	1.17 to 3.40	1.49E+02 to 4.00E+02	2.10E+02 to 3.62E+02	8.10E+00 to 2.58E+01	1.84E-02 to 8.29E-01
Carbon Disulfide	76	1.84 to 2.24	1.19E+03 to 2.94E+03	5.40E-01	1.27E+02 to 3.60E+02	1.22E-02 to 3.03E-02
Benzene	78	1.56 to 2.15	8.20E+02 to 1.80E+03	4.80E+00 to 9.20E+02	1.25E+02 to 9.52E+01	5.43E-03 to 5.59E-03
Toluene	92	2.69 to 2.79	2.20E+02 to 5.35E+02	3.74E+01 to 3.00E+02	2.20E+01 to 3.74E+01	5.93E-03 to 6.66E-03
1,2-Dichlorobenzene	166	3.38-3.60	1.00E+02 to 1.45E+02	1.70E+03	9.60E-01 to 1.97E+00	1.88E-03 to 2.00E-03
1,2-Dichloroethane	99	1.48	8.69E-01 to 8.69E+03	1.40E+01 to 8.00E+01	6.10E+01 to 3.24E+02	9.79E-04 to 4.50E-02
SEMIVOLATILE ORGANICS						
Benzoic Acid	122	1.87	2.70E+03	ND	ND	ND
Phenol	94	1.46	6.70E+04 to 9.30E+04	1.42E+01 to 3.10E+03	3.41E-01 to 5.29E-01	3.33E-07 to 1.89E-05
4-Methylphenol	108	1.94 to 1.97	2.15E+02 to 3.10E+02	4.87E+01 to 2.67E+04	1.10E-01 to 3.75E-01	7.92E-07 to 1.10E-06
2-Chlorophenol	126	2.15 to 3.91	1.14E+04 to 2.85E+04	3.99E+03 to 2.31E+04	2.20E+00 to 2.34E+00	ND
Pentachlorophenol	266	5.00 to 5.12	2.00E+00 to 2.00+01	5.30+04	1.10E-04	2.75E-06 to 3.40E-06
Diethylphthalate	222	1.22 to 6.32	8.96E+02 to 1.08E+03	9.80E+01 to 1.42E+02	3.50E-04 to 3.50E-03	4.50E-07 to 1.14E-06
Di-n-butylphthalate	278	4.57 to 5.60	3.20E+00 to 1.30E+01	1.80E+03 to 1.70E+05	1.00E-05 to 1.00E-01	2.82E-07 to 4.50E-06
Butylbenzylphthalate	312	4.91	2.69E+00 to 2.90E+00	1.70E+04	3.40E-07 to 8.60E-06	1.20E-06 to 1.26E-06
bis(2-Ethylhexyl)phthalate	391	3.98 to 5.30	2.85E-01 to 1.20E+00	8.74E+04	6.20E-08 to 9.75E-06	3.61E-07 to 1.00E-04
Dibenzofuran	ND	4.12	3.10E+00		1.80E-04	1.26E-05
Fluorene	116	4.18 to 4.20	1.69E+00 to 1.98E+00	3.26E+03 to 7.30E+04	7.10E-04 to 1.80E+01	6.42E-05 to 1.17E-04
Carbazole	167.2	ND	ND	ND	ND	ND
Naphthalene	128	3.30 to 3.37	3.00E+01 to 3.44E+01	8.71E+02 to 9.4E+04	4.92E-02 to 2.30E-01	4.26E-04 to 1.15E-03
2-Methylnaphthalene	131	-1.89 to 4.10	2.54E+01	1.30E+03 to 8.50E+03	ND	ND
Acenaphthene	154	3.70 to 3.94	3.93E+00 to 1.61E+01	9.47E+02 to 2.50E+03	9.12E-04 to 2.90E-02	1.13E-05 to 1.48E-03
Anthracene	178	4.45	4.34E-02 to 7.48E-02	6.40E+03 to 5.10E+05	2.67E-06 to 1.95E-04	6.50E-05 to 1.02E-03
Phenanthrene	178	4.46	1.00E+00 to 1.29E+00	1.40E+04 to 2.30E+04	1.12E-04 to 6.80E-04	2.28E-05 to 1.59E-04
Pyrene	202	4.88 to 5.32	1.32E-01 to 1.40E-01	5.97E+03 to 1.30E+05	6.85E-07 to 2.50E-06	5.04E-06 to 1.10E-05
Fluoranthene	202	4.90 to 5.33	2.06E-01 to 2.60E-01	1.20E+04 to 3.80E+04	1.23E-08 to 6.00E-06	1.26E-08 to 6.46E-06
Benzo(a)anthracene	228	5.60	5.70E-03 to 1.40E-02	1.38E+06	5.00E-09 to 2.20E-08	1.16E-06
Chrysene	228	5.61 to 5.66	1.50E-03 to 1.40E-02	1.33E+05 to 2.00E+05	5.00E-09 to 6.30E-09	1.05E-06 to 9.46E-05
Benzo(b)fluoranthene	252	5.06 to 6.84	1.20E-03 to 1.40E-02	5.50E+04 to 5.50E+05	5.00E-07 to 5.50E-04	1.19E-05 to 1.11E-04
Benzo(a)pyrene	252	5.97 to 6.06	1.20E-03 to 3.80E-03	5.07E+06 to 5.50E+06	5.49E-09 to 5.00E-07	4.90E-07 to 1.13E-04
Benzo(k)fluoranthene	252	6.06 to 6.12	5.50E-04 to 4.30E-03	5.10E+04 to 5.50E+05	9.65E-10 to 5.50E-07	4.00E-07 to 3.94E-05

TABLE 4-1. CHEMICAL AND PHYSICAL PROPERTIES OF THE POTENTIAL CONTAMINANTS OF CONCERN

	CHEMICAL AND PHYSICAL PROPERTIES:					Henry's Law Constant (atm-m ³ /mol)
	Molecular Weight(MW)	Log Kow	Water Solubility (mg/L)	Koc (ml/g)	Vapor Pressure (mm Hg)	
REFERENCES:	(1,3,4,5,7,9,11,12)	(1,3,4,5,7,9,11,12)	(1,2,3,4,5,7,9,10,11,12)	(1,3,6,7,9,11,12)	(1,3,4,5,6,7,9,10,12)	(1,3,6,7,9,10,11,12)
Benzo(g,h,i)perylene	276	6.51 to 7.23	2.60E-04 to 7.00E-04	4.06E+05 to 1.60E+06	1.00E-10 to 1.05E-10	5.34E-08 to 1.60E-06
Indeno(1,2,3-c,d)pyrene	276	6.50 to 7.66	2.20E-05 TO 6.20E-02	1.90E+04 to 1.60E+06	1.00E-10	6.86E-08 to 1.60E-06
Dibenz(a,h)anthracene	278	2.29 to 6.84	5.00E-04 to 2.49E-03	5.65E+05 to 3.30E+06	1.00E-10 to 5.00E-09	7.33E-08 to 1.15E-04
PCBs						
Aroclor-1260	258-376	6.04	1.20E-02 to 3.10E-02	1.50E+03 TO 2.29E+06	7.70E-05	1.07E-03 to 8.37E-03
PESTICIDES						
Lindane	291	3.90	7.80E+00	1.08E+03	1.60E-04	7.85E-06
Endosulfan II	407	3.55 to 3.62	ND	3.20E+03	1.00E-05 to 1.33E-03	1.00E-05
DDT	355	3.98 to 6.19	5.00E-03 to 2.60E-02	2.43E+05	7.30E-07 to 5.50E-06	5.13E-04
Methoxychlor	346	ND	4.00E-02	ND	ND	ND
alpha-Chlordane	ND	ND	ND	ND	ND	ND
gamma-Chlordane	410	3.22 to 5.54	5.60E-02 to 1.85E+00	3.10E+03 to 1.40E+05	3.00E-06 to 2.9E-05	9.63E-06 to 4.85E-05

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3. Washeleski, M.C. IRP Organic Chemical Compounds and Analytical Methods.
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9. U.S. PHS, 1987-1990. Toxicological Profiles, Draft Documents.
10. Warner et al., July 1987. Determination of Henry's Law Constants of Selected Priority Pollutants.
11. Howard, 1990a,b
12. EPA, 1990b

TABLE 4-1. CHEMICAL AND PHYSICAL PROPERTIES OF THE POTENTIAL CONTAMINANTS OF CONCERN

CHEMICAL AND PHYSICAL PROPERTIES:					
Molecular Weight(MW)	Physical State	Water Solubility	Solubility in Organics	Solubility in Acids	
(1,2,3,4,5,7,9,10)			(4,8)	(4,8)	
REFERENCES:					
METALS					
Aluminum	27	solid	insoluble	ND	soluble
Arsenic	33	solid	insoluble	ND	ND
Barium	137	solid	decomposes	soluble	ND
Beryllium	9	solid	insoluble	ND	soluble
Cadmium	112	solid	insoluble	variable	ND
Cobalt	59	solid	insoluble	insoluble	ND
Chromium	52	solid	insoluble	insoluble	ND
Copper	64	solid	insoluble	ND	ND
Lead	207	solid	insoluble	insoluble	ND
Manganese	55	solid	decomposes	ND	soluble
Mercury	201	liquid	soluble	soluble	ND
Nickel	59	solid	insoluble	insoluble	ND
Vanadium	51	solid	insoluble	ND	ND
Zinc	65	solid	insoluble	ND	soluble

REFERENCES:

1. U.S.EPA, October 1986. Superfund Public Health Evaluation Manual.
2. Gas Research Institute, October 1987. Management of Manufactured Gas Plant Sites, Volume I - Wastes and Chemicals of Interest.
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10. Warner et al., July 1987. Determination of Henry's Law Constants of Selected Priority Pollutants.
11. Howard, 1990a,b
12. EPA, 1990b

The Henry's Law Constant (H), which considers the interaction between aqueous solubility and vapor pressure, is a more important predictor of volatilization from water (Andelman, 1987). This constant is estimated by the following ratio (U.S. EPA, October 1986):

$$H = \frac{\text{Vapor Pressure (atm)} \times \text{molecular weight (g/mole)}}{\text{Water Solubility (g/m}^3\text{)}}$$

A large Henry's Law Constant, greater than 1×10^{-3} atm-m³/mole, indicates a tendency for a contaminant to move from water to air.

A **log octanol/water partition coefficient (log Kow)** value represents the tendency of a chemical to partition between an organic phase, such as soil or fish, and an aqueous phase. Chemicals with a low log Kow value (e.g. less than 1) may be considered hydrophilic. Hydrophilic compounds tend to remain dissolved in water rather than in non-polar solvents. These compounds also have low organic carbon partition coefficients (Koc). Chemicals with a high log Kow value (e.g. greater than 4) may be considered hydrophobic (Lyman et al., 1981), which indicates they are more likely to remain sorbed to organics in soil than to migrate in water.

The **organic carbon partition coefficient (Koc)** indicates the tendency of an organic chemical to be adsorbed to organic material in soil or sediment. This property is largely independent of soil properties (U.S. EPA, October 1986). The Koc can be expressed as (U.S. EPA, October 1986):

$$K_{oc} = \frac{\text{Chemical adsorbed (mg)/organic carbon (kg)}}{\text{Chemical dissolved (mg)/solution (l)}}$$

For groundwater pathways, a low Koc value indicates that a chemical can be easily leached from the waste source and relatively rapidly transported through the aquifer (U.S. EPA, October 1986). For surface water pathways, a high Koc value indicates that a chemical is tightly bound to soil or sediment and is not likely to dissolve in site run-off. However, the high Koc value also indicates that migration may occur from chemicals sorbed to soil particles. A chemical with a high Koc value may be of great concern if it is detected in surface waters because a high Koc value is usually indicative of a tendency to bioaccumulate (U.S. EPA, October 1986).

The normal range of Koc values is from 1 to 1×10^7 , with higher values indicating greater sorption potential (Lyman et al., 1981). Koc values greater than 1,000 generally indicate immobile compounds or compounds with high sorption potential. A Koc value between 100 and 1,000 is considered intermediate, while a Koc value less than 100 indicates highly mobile compounds in water.

The following sections describe how these properties characterize the mobility or persistence of the contaminant groups comprised of potential contaminants of concern at the base.

Volatile Organic Compounds. Volatile organic compounds tend to have large Henry's Law Constants (H), moderate to high water solubility, and low organic carbon partitioning values (Koc). These properties result in high mobility from water and soil to air and a moderate to high mobility through groundwater. Most of the volatile organic compounds detected, such as the alkanes, chlorinated alkanes, and the benzene ring compounds, follow this pattern. Exceptions to this are 1,2-dichlorobenzene and the ketone compounds. Dichlorobenzene has a higher Koc value making it more likely to sorb to soil. The ketones detected, acetone and 2-butanone, have lower Henry's Law Constants and higher water solubility, indicating that they are less likely to volatilize from water than most volatile organics compounds.

Polycyclic Aromatic Hydrocarbons (PAHs). The PAH compounds include: naphthalene, 2-methylnaphthalene, fluorene, acenaphthene, anthracene, phenanthrene, pyrene, fluoranthene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(k)fluoranthene,

indeno(1,2,3-cd)pyrene, benzo(g,h,i)perylene, and dibenzo(a,h)anthracene. These compounds are characterized by very low to moderate water solubility, high Koc values, and low to moderate Henry's Law Constants. All but those PAHs with the lowest molecular weights (naphthalene, 2-methylnaphthalene, acenaphthene, fluorene, phenanthrene, and anthracene) are highly persistent, tending to sorb strongly to soil particles and not to solubilize into water or volatilize into air. The lower molecular weight PAHs are somewhat more mobile in water and may volatilize from water into air to a limited extent; however, there is very little information available for 2-methylnaphthalene.

Phenolic Compounds, Phthalate Esters, and Other Semi-volatile Organic Compounds.

These groups of semi-volatile organic compounds generally have moderate to low Henry's Law Constants, moderate water solubility, and moderate Koc values. These characteristics indicate that they are somewhat mobile in water with some tendency to sorb to soil. They are not expected to volatilize from water readily and most, especially phthalates, are not expected to volatilize from soil. There is very little chemical and physical properties information available for carbazole.

Pesticides and Polychlorinated Biphenyls (PCBs). The chlorinated pesticides and PCBs tend to partition similarly in the environment. These compounds are characterized by low to moderate water solubility, moderate to high Koc values, and low to moderate Henry's Law Constants. These compounds are generally persistent, tending to sorb to soils. However, physical and chemical properties indicate that they are somewhat more mobile than the PAH compounds.

Metals. The procedures used for metals analyses do not distinguish between chemical forms. Many factors, such as solution pH, salinity, ionic strength, and medium, affect metal concentrations and compositions. This composite of factors makes predicting the environmental fate and transport of metals difficult. It may be assumed that most of the metals at the base are present as part of inorganic compounds. The metals of toxicologic interest are relatively insoluble in the presence of naturally occurring ions such as sulfates and hydroxides. Metals

are generally not volatile except in certain forms, usually involving organic complexation, such as tetraethyl lead.

4.1.2.2 Toxicity Profiles. Toxicological properties of the potential contaminants of concern are provided to give background information on the derivation of public health standards and to present dose-response information. References used to obtain toxicity data include: 1) the Integrated Risk Information System (IRIS) (U.S. EPA, October 1994a), 2) Health Effects Assessment Summary Tables (U.S. EPA, March 1994), 3) the Environmental Criteria and Assessment Office (ECAO) (U.S. EPA, October 1994b), 4) U.S. EPA Health Effects Assessment Documents, 5) U.S. Public Health Service Toxicological Profile Documents, and 6) U.S. EPA Health Advisory for 25 Organic Chemicals. A summary of toxicity data including the reference dose, critical effect, weight of evidence and cancer slope factor of each potential contaminant of concern is presented in Table 4-2. Toxicological properties are discussed in more detail in the toxicity profiles presented in Appendix G.

Reference dose (RfD) values generated by the EPA are based on the assumption that threshold levels exist for non-carcinogenic health effects (U.S. EPA, December 1989). The chronic RfD is considered to be the level unlikely to cause significant adverse health effects in humans exposed for a lifetime. The RfD is used for comparison with calculated intake levels as discussed in the risk characterization (Section 4.1.5). Intake levels less than the RfD are typically not considered to be associated with non-carcinogenic health effects. The severity of health effects used to generate RfDs, the critical effect, varies between compounds, but the RfD value provides a good gauge of relative toxicity for analytes having non-carcinogenic health effects. Compounds with relatively small RfDs are more toxic than compounds with larger RfDs.

Varying degrees of uncertainty are associated with the toxicity data provided for each chemical. Sources of uncertainty come from data gaps in the database for a particular chemical. In an effort to both accurately and efficiently characterize the toxicity of a chemical, high doses of a

TABLE 4-2. TOXICITY VALUES FOR THE POTENTIAL CONTAMINANTS OF CONCERN - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

CHRONIC ORAL REFERENCE DOSES (mg/kg/day):			ORAL SLOPE FACTORS per (mg/kg/day):	
	RfD	CRITICAL EFFECT	(REF)	WEIGHT OF EVIDENCE(b)
VOLATILES				
Acetone	1.0E-01	increased liver/kidney wgt., nephrotox.	1	D
2-Butanone	6.0E-01	decreased fetal birthweight	1	D
Chloromethane				C
Methylene Chloride	6.0E-02	liver toxicity	1	B2
1,2-Dichloroethene(trans)	2.0E-02	increased serum alkaline phosphatase	1	
1,2-Dichloroethene(cis)	1.0E-02	decreased hematocrit, hemoglobin	2	D
Trichloroethene				C-B2
Tetrachloroethene	1.0E-02	hepatotoxicity, weight gain	1	C-B2
Carbon Disulfide	1.0E-01	fetal toxicity, malformations	1	
Benzene				A
Toluene	2.0E-01	changed liver and kidney weights	1	D
1,2-Dichlorobenzene	9.0E-02	no adverse effects observed	1	D
1,2-Dichloroethane				B2
SEMIVOLATILES				
Benzoic Acid	4.0E+00	no adverse effects observed	1	D
Phenol	6.0E-01	decreased fetal body weight	1	D
4-Methylphenol (p-cresol)	5.0E-03	CNS and respiratory effects and maternal death	2	C
2-Chlorophenol	5.0E-03	reproductive effects	1	
Pentachlorophenol	3.0E-02	liver and kidney pathology	1	B2
Diethylphthalate	8.0E-01	decreased growth, food consumption and altered organ weights	1	D
Di-n-butylphthalate	1.0E-01	increased mortality	1	D
Butylbenzylphthalate	2.0E-01	increased liver to body and brain weight ratios	1	C
bis(2-Ethylhexyl)phthalate	2.0E-02	increased relative liver weight	1	B2
Dibenzofuran				D
Carbazole				B2
Naphthalene	4.0E-02	none reported	3	D
2-Methylnaphthalene				
Fluorene	4.0E-02	decreased red blood cells, packed cell volume and hemoglobin	1	D
Acenaphthene	6.0E-02	hepatotoxicity	1	
Anthracene	3.0E-01	no observed effects	1	D
Phenanthrene				D
Pyrene	3.0E-02	kidney effects	1	D
Fluoranthene	4.0E-02	nephropathy, increased liver weight, hematological changes	1	D
Benzo(a)anthracene				B2
Chrysene				B2
Benzo(b)fluoranthene				B2
Benzo(a)pyrene				B2
Benzo(k)fluoranthene				B2
Indeno(1,2,3-cd)pyrene				B2
Benzo(g,h,i)perylene				B2
Dibenzo(a,h)anthracene				B2

TABLE 4-2 (cont.). TOXICITY VALUES FOR THE POTENTIAL CONTAMINANTS OF CONCERN - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

CHRONIC ORAL REFERENCE DOSES (mg/kg/day):			ORAL SLOPE FACTORS per (mg/kg/day):	
PESTICIDES/PCB's	RfD	CRITICAL EFFECT	(REF)	WEIGHT OF EVIDENCE(b)
gamma-BHC (Lindane)	3.0E-04	liver, kidney toxicity	1	C-B2
Endosulfan II	6.0E-03 (e)	decreased weight gain, kidney effects, aneurysms	2	
4,4'-DDT	5.0E-04	liver lesions	1	B2
Methoxychlor	5.0E-03	excessive loss of litters	1	D
Chlordane	6.0E-05 (f)	regional liver hypertrophy	1	B2
Aroclor 1260				B2
METALS				
Aluminum				
Arsenic	3.0E-04	hyperpigmentation, keratosis, possible vascular complications	1	A
Barium	7.0E-02	increased blood pressure	1	
Beryllium	5.0E-03	no adverse effects observed	1	B2
Cadmium	1.0E-03 (food)	significant proteinuria	1	B1
	5.0E-04 (water)	significant proteinuria	1	B1
Chromium III	1.0E+00	no effects observed	1	
Chromium VI	5.0E-03	no effects reported	1	
Cobalt				
Copper	3.7E-02 (h)	local GI irritation	2	D
Lead		childhood CNS effects, blood enzyme effects	1	B2
Manganese	1.4E-01 (food)	CNS effects	1	D
	5.0E-03 (water)	CNS effects	1	D
Mercury	3.0E-04	kidney effects	2	D
Nickel	2.0E-02	decreased body and organ weights	1	
Vanadium	7.0E-03	no effects observed	2	
Zinc	3.0E-01	decrease in blood enzyme	1	D

NOTES:

- Full toxicity profiles for these compounds are presented in Appendix G. Where a compound has no listed dose-response data, a value has not been derived.
- Weights of evidence defined in Table G-1, Appendix G; classifications for trichloroethene and tetrachloroethene although not final are offered by the Science Advisory Board.
- The oral slope factor for chloromethane was derived based on route to route extrapolation.
- Those PAHs considered carcinogenic are evaluated using potency factors relative to the slope factor for benzo(a)pyrene (U.S. EPA, July 1993).
- Toxicity data for Endosulfan applies to Endosulfan II.
- Toxicity data for Chlordane applies to both alpha and gamma isomers.
- The substitute oral slope factor for arsenic was derived from the unit risk of 5e-5 per ug/L based on 2 L/day(ingestion) and a 70 kg (body weight).
- The substitute oral RfD for copper was derived from the drinking water action level of 1.3 mg/L based on 2 L/day(ingestion) and a 70 kg (body weight).

REFERENCES:

- U.S. EPA, October 1994a. Integrated Risk Information System (IRIS)
- U.S. EPA, March 1994. Health Effects Assessment Summary Tables (HEAST), Annual FY-1994.
- U.S. EPA, October 1994b. Provisional toxicity data provided by Superfund Health Risk Technical Support Center, Environmental Criteria and Assessment Office.

chemical are often administered to animals over a short period of time to observe adverse health effects. Toxicity data based on these types of studies are then used to predict potential adverse health effects in humans from exposure to low doses of the chemical over a longer period of time. In order to extrapolate data from animal studies to predict human experiences, the degree of uncertainty in the available data is incorporated into the RfD in the form of a safety factor. As the level of confidence in the toxicity data for a chemical decreases, the safety factor incorporated into the RfD value increases, resulting in a smaller RfD. Brief descriptions of the studies used to generate toxicity data are provided in the toxicity profiles in Appendix G.

The U.S. EPA (December 1989) defines the slope factor for carcinogenic risk as a plausible upper-bound estimate of the probability of carcinogenic response per unit intake of a chemical over a lifetime. Slope factors are often modeled from animal testing. In some cases, as with benzene, the slope factor was calculated by EPA from existing human epidemiologic data. The EPA weight of evidence refers to evidence of carcinogenicity, with Group A signifying a known human carcinogen and Group D signifying no classification (see Table G-1 in Appendix G). In general, the weight of evidence is classified by the EPA without regard to route of exposure, but route-specific information is included in the slope factor determination. A larger slope factor indicates a more potent carcinogen. The slope factor for various carcinogens provides a good relative measure of the strength of a carcinogen.

4.1.3 Identification of Receptors

The most probable receptors of site contaminants were identified by characterizing potentially exposed populations, as well as, present and potential future land use. Both factors are important during exposure screening and the development of an exposure scenario for dose estimates. Hulman ANG Base is not currently on the base closure list. In addition, since the base is in such close proximity to Hulman Regional Airport, residential development of the base is neither anticipated nor recommended. Charles Goodwin at the Hulman Regional Airport confirmed that zoning of the property surrounding the airport is being recommended for commercial development (Hulman Regional Airport, 1992). As a result, it was assumed that

use of the base will remain non-residential in the future and therefore risk was characterized for the adult worker, considered to be the maximally exposed individual. It should be noted however, that if Hulman ANG Base is scheduled for closure at some future date, an evaluation of future use and the risk implications would be conducted at that time as part of the base closure.

4.1.3.1 Populations. There are 112,385 people living in Vigo County, 61,125 of whom reside in Terre Haute. Public drinking water for the city of Terre Haute is drawn from the Wabash River northwest of the base. County residents west of Route 342 have access to city water. Most of the base is supplied with city water although, one groundwater well (No. 530) located in the Ammunition Area was used as a potable water supply until 1990, but is no longer in use. There are no water supply wells at any of the sites under investigation at the base. Water supplies for the rest of the county are primarily drawn from groundwater reserves. Eight groundwater wells exist within a mile radius of the base, including Well No. 530 located in the Ammunition Area (Figure 4-1). Well No. 530 in the Ammunition Area is presently the only well within a mile downgradient of the sites under investigation. During the SI, this well (Well No. 530) was sampled and analyzed for volatile organics, semi-volatile organics, TPH, pesticides/PCBs, and total metals. Present use of the property to the west and southwest of the base by Hulman Airport and the availability of city water in this area limits the possibility of future use of groundwater downgradient of the sites under investigation.

In general, site geology at Hulman ANG Base is relatively consistent with a brown loess deposit overlying clayey sands which in turn overlie glacial till. This dense till below the unconsolidated upper water bearing sediments is believed to act as an aquitard beneath the base, limiting the migration of potential contamination of the shallow groundwater.

The occurrence and movement of groundwater at the base is influenced by the hydraulic properties of the saturated subsurface media. Groundwater at the base was found to flow predominantly to the southwest towards the Wabash River. However, groundwater at Site 6 appears to vary, with a general flow direction to the south. The groundwater flow direction at

Site 4 could not be determined due to the variability in data from different measurement dates. According to the data, groundwater may flow north-northeast or southwest.

Approximately 325 people are employed at the base, many of them civilians. Employees perform a variety of tasks, some of which involve maintenance activities at the base. Maintenance activities that would involve soil exposure include the following: lawn upkeep and new planting, excavation and repair of various underground utilities, building construction, paving activities, and sidewalk construction. Access to the base is limited by a 14-foot chain-link fence and a single entrance with a posted guard. Access to specific sites varies, but most are entirely accessible to anyone on the base. Access to Sites 4 and 5 is somewhat limited by additional fencing. Site-specific access is discussed in more detail in later sections.

Non-employees, including children, have access when accompanied by an authorized employee. There are occasional days when portions of the base are open to the public or to large groups including children. The two obvious recreational areas, a baseball diamond and a picnic area at the Air Tech Club, range from approximately 300 to 1,700 feet from the sites under investigation (Figure 4-2). Should children be left unattended, it is most likely that it would occur at these recreational areas. However, an infrequent exposure by a trespasser, such as a child at the base, is not expected to be the worst case scenario. The preliminary risk evaluation focuses on the worst case scenario and therefore looks at the pathways of greatest potential risk, which is a worker exposure at the sites. A worker exposure is expected to be more frequent and involve intrusive work at the sites, as discussed below. If the worst case scenario shows a risk, it may be important to evaluate other pathways as well.

4.1.3.2 Land Use. Approximately 80% of Vigo County is used for agricultural purposes. Land directly to the north, east, and south of the base is used to grow corn. The Hulman Regional Airport is located to the west and southwest of the base (Figure 4-1). The area on which the base is located is non-specifically zoned as an open space district, meaning that the land can be used for a variety of residential, agricultural, grazing, institutional, or commercial developments (City of Terre Haute, 1991). No one presently resides at the base and there are

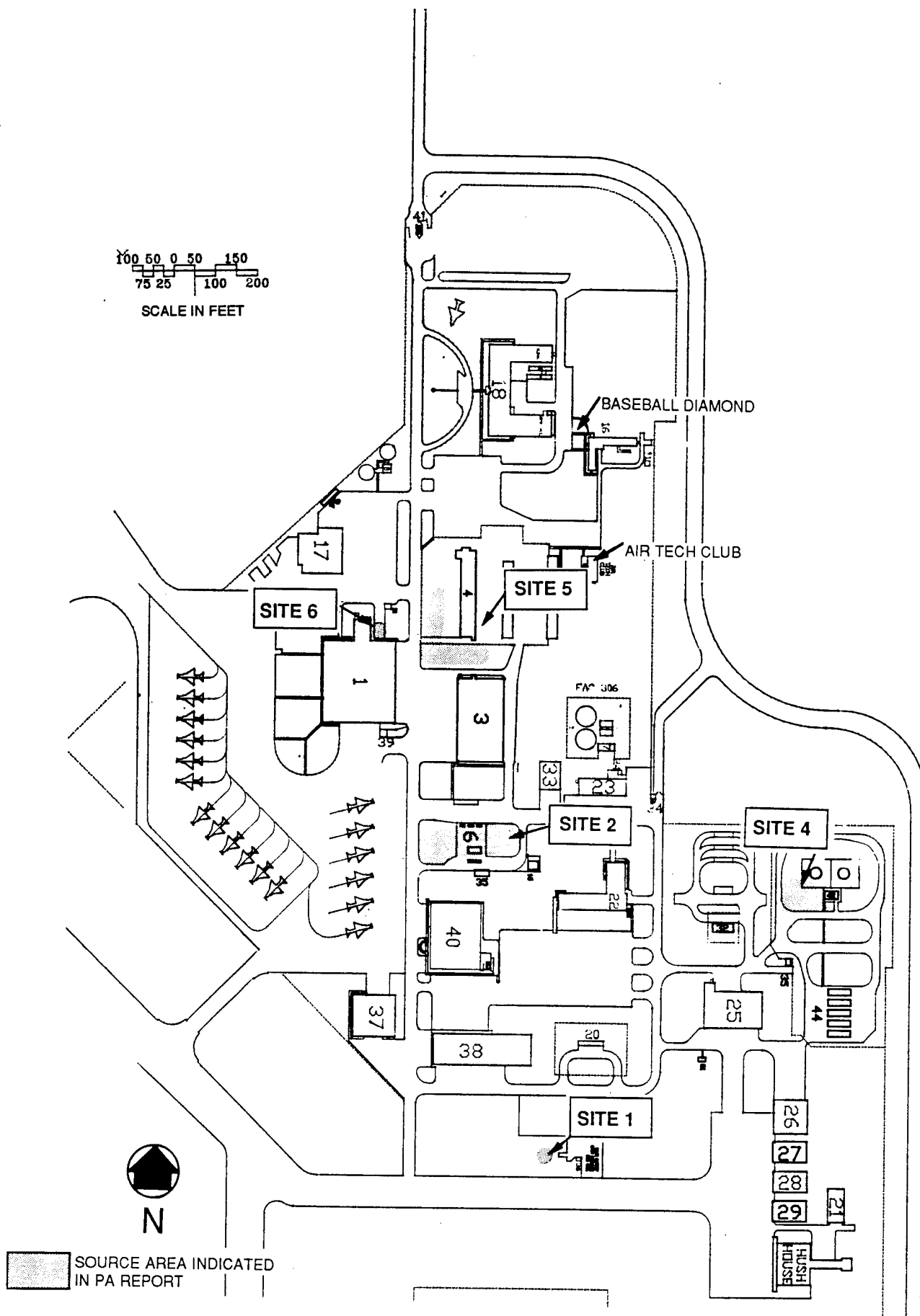


FIGURE 4-2. BASE RECREATIONAL AREAS
181ST FG, HULMAN FIELD MAP, TERRE HAUTE, IN

no plans to close the Hulman ANG Base in the future (Hulman IANG, 1992). According to the zoning manual for Terre Haute (City of Terre Haute, 1991) the property surrounding the base and airport is not currently zoned. However, the airport is strongly recommending zoning of the property surrounding the airport for commercial use to buffer residential development (Hulman Regional Airport, 1992). No base or airport master plans have been located. Based on this information, it is assumed for the purpose of this preliminary risk evaluation that the base will remain non-residential in the future. As a result, potential future land use at the base is expected to be the same as current land use.

The land on which the base is located is presently owned by the Air National Guard and is located approximately three miles east of Terre Haute. The base is in full operation; runways adjacent to the base are used jointly with Hulman Regional Airport. Some of the specific sites under investigation are not used routinely. Most of the sites have utilities present within their boundaries which are generally located underground. For some sites, the handling of drums and utility maintenance may be the only site usage at present. Site-specific land use is discussed in more detail in later sections.

4.1.4 Exposure Assessment

The exposure assessment included the screening of potential exposure pathways, development of exposure scenarios where appropriate, and estimation of dose. Where there were adequate data, dose was estimated for potential present and future exposure pathways. If data were inadequate, but completion of a pathway seemed possible, a qualitative assessment of exposure was conducted. Analytical results from three or fewer samples was not considered an adequate database for a quantitative exposure assessment. Soil was the only medium for which more than three samples were collected and, therefore, was the only medium quantitatively assessed.

4.1.4.1 Exposure Pathway Screening. Potential present and future human exposure pathways for detected contaminants at the base are presented in a screening table as part of each site-specific evaluation. As noted above, each exposure pathway was screened to focus this

preliminary risk evaluation on those pathways likely to present the greatest risk of exposure. Information on the type, quantity, and location of contamination was considered in conjunction with the environmental attributes of the site and the populations that might contact site contamination. A complete human exposure pathway has four parts: 1) a source of contamination, 2) a retention or transport medium or media, 3) a point of potential human contact, and 4) an exposure route for entry into the body (U.S. EPA, December 1989). These factors determine whether or not an exposure seems possible now or in the future.

4.1.4.2 Development of Exposure Scenario. The goal of this process was to estimate the potential exposures that present the greatest risks at the site, or the worst case scenario. For those exposure pathways considered of greatest potential risk, which are complete and for which there were adequate analytical data, exposure scenarios were developed. Focusing on the worst case scenario requires focusing on the most sensitive receptors if a number of populations are exposed, and characterizing the population that is most likely to be exposed to site contaminants.

Characterization of a population involves a number of factors, including the following: physical considerations, such as body weight and skin surface area; demographics, such as age and sex; and behavioral considerations, such as hours worked per day and the amount of hand-to-mouth contact potentially resulting in soil ingestion. This type of characterization was used to establish intake values for the estimation of dose.

4.1.4.3 Calculation of Dose. Exposure scenarios were developed and dose was estimated using exposure assumptions and dose equations presented in U.S. EPA guidance documents. The Risk Assessment Guidance for Superfund: Human Health Evaluation Manual (U.S. EPA, December 1989) was the primary document used for dose equations and exposure assumptions. A U.S. EPA supplemental guidance for the Human Health Evaluation Manual: "Standard Default Exposure Factors" (U.S. EPA, March 1991) and the Exposure Factors Handbook (U.S. EPA, May 1989) were also used for exposure assumptions.

The analytical data used to estimate dose were validated. Data considered to be unsuitable based on blank contamination, matrix interference, or other validation concerns were removed from

the data set. Some of the data were flagged with a "J" indicating that the identification of an analyte was definite, but the concentration was estimated. These data points were incorporated in the assessment.

Dose was estimated for the quantified exposures using both the mean contaminant concentration and maximum detected concentration. The most recent U.S. EPA guidance (December 1989) recommends using only the upper confidence limit (95th percentile) of the arithmetic average concentration. This is an approach recommended by the EPA in an effort to account for the uncertainty that accompanies increased variability in contaminant concentrations. However, the guidance also states that for a screening level analysis such as this preliminary risk evaluation, use of a maximum concentration is sufficient (U.S. EPA, December 1989, pg. 6-22). Dose estimates were generated using average as well as maximum contaminant concentrations to provide a range of dose estimates.

Dose estimates for non-carcinogenic and carcinogenic contaminants were averaged over different time periods. The dose for a chronic exposure to a non-carcinogen was estimated by averaging over the expected duration of exposure. The approach used for carcinogens was to estimate dose by averaging over a lifetime. This is a result of the currently held scientific opinion that non-carcinogens and carcinogens have differing modes of action (U.S. EPA, December 1989). The different averaging times were incorporated during the estimation of dose so that separate non-carcinogenic and carcinogenic doses were estimated for each exposure.

4.1.5 Risk Characterization

The risk characterization is presented in three parts: a comparison of contaminant levels at a site with applicable or relevant and appropriate requirements (ARARs), a comparison of estimated human dose with a reference dose level, and a calculation of increased lifetime cancer risk. The characterization of risk focused on the worst case scenario, defined by the pathways identified in the exposure pathway screening.

For those analytes found in background samples, but detected at concentrations elevated above background concentrations at a site, health risks from exposure to both background concentrations and site concentrations were evaluated. This distinguished site attributable risk from background risk by allowing for a comparison between the two. Background risks are evaluated in Section 4.8 using an approach similar to the approach used for site-specific evaluations.

4.1.5.1 Comparison with Applicable or Relevant and Appropriate Requirements. For evaluating a CERCLA site, the Superfund Amendments and Reauthorization Act of 1986 (SARA) specifies that remedial actions meet or consider applicable or relevant and appropriate requirements (ARARs). ARARs are defined as follows:

Applicable requirements refer to those cleanup standards, standards of control, and other substantive environmental protection standards, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a hazardous waste site.

Relevant and appropriate requirements refer to those cleanup standards, standards of control and other substantive environmental protection standards, criteria, or limitations promulgated under Federal or State law that, while not "applicable", address problems or situations sufficiently similar to those encountered at the site so that their use is well suited to the particular site.

In addition, there is a third category of criteria reviewed, although they are neither applicable nor relevant and appropriate, they are useful when developing cleanup levels; they are referred to as criteria "to be considered."

SARA provides that if a Federal standard under another environmental law, or a more stringent state standard is a legally applicable or relevant and appropriate requirement (ARAR), then the cleanup must meet that standard. While the Hulman ANG Base is not a CERCLA site, chemical-specific ARARs are identified for comparison with analytical data. This section describes the procedures used in the identification and evaluation of chemical-specific ARARs and identifies potential chemical-specific ARARs.

Only potential chemical-specific ARARs have been identified. Table 4-3 lists all potential contaminants of concern detected in groundwater at the base sites that were not screened out in Section 4.1.1. Table 4-3 also presents the corresponding potential chemical-specific ARARs for water. Chemical-specific ARARs exist for some contaminants in surface water and groundwater, but not in soils. Soils criteria are determined by risk-based evaluation. Water criteria are discussed below.

FEDERAL CRITERIA

Safe Drinking Water Act

- Maximum Contaminant Levels (MCL)
- Maximum Contaminant Level Goals (MCLG)

Clean Water Act

- Ambient Water Quality Criteria (AWQC)

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) of 1974, most recently amended in 1986, was established to protect public drinking water supplies. The major elements of the drinking water program include drinking water standards and treatment techniques, filtration and disinfection of surface supplies and disinfection by-product standards, coliform rule, and radionuclide standards.

Section 1412 of the SDWA requires the U.S. EPA to publish Maximum Contaminant Level Goals (MCLGs) and promulgate national drinking water regulations. Under section 1401, EPA must develop enforceable Maximum Contaminant Levels (MCLs) and "criteria and procedures to assure a supply of drinking water which dependably complies" with such MCLs. Under section 1412(b)(7)(A), the use of a best available treatment technique instead of attainment of an MCL is allowed if it is not technically or economically feasible to ascertain the MCL in

TABLE 4-3. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
FOR CONTAMINANTS DETECTED IN GROUNDWATER
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

	DRINKING WATER STANDARDS (MG/L) (a):	
	FEDERAL (b) MCL	INDIANA (c) MCL
VOLATILES		
Chloromethane		
1,2-Dichloroethane	0.005	0
Carbon Disulfide		0.005
SEMIVOLATILES		
Benzoic Acid		
Pentachlorophenol	0.001	0
Di-n-butylphthalate		
bis(2-Ethylhexyl)phthalate	0.006	0
Pyrene		
METALS		
Aluminum		
Arsenic	0.05 (d)	0.05 (d)
Barium	2	2
Beryllium	0.004	0.004
Cadmium	0.005	0.005
Chromium (total)	0.1	0.1
Cobalt		
Copper	1.3 (e)	1.3 (e)
Lead	0.015 (f)	0
Manganese		
Mercury	0.002	0.002
Nickel	0.1	0.1
Vanadium		
Zinc		

NOTES:

- Drinking water standards and goals include Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs).
- Federal MCLs and MCLGs established under the Safe Drinking Water Act (U.S. EPA, May 1994).
- Indiana Drinking Water Standards (MCLs) match federal MCLs where promulgated.
- The MCL for arsenic is under review.
- This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
- This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.

drinking water. Primary Drinking Water Regulations are set forth under 40 CFR Part 141 while 40 CFR Part 142 supplies National Primary Drinking Water Implementation Regulations and 40 CFR Part 143 provides National Secondary Drinking Water Regulations. 40 CFR Part 141 Subparts B and F specify MCLs and MCLGs.

Maximum Contaminant Levels. Maximum contaminant levels (MCLs) are enforceable, chemical-specific drinking water standards developed under the SDWA. MCLs are based on the use of best technology, treatment techniques, and other factors, including cost. MCLs are specified in 40 CFR 141 Subpart B. Because groundwater in the vicinity of the base is used as a drinking water supply via private wells, the SDWA MCLs were considered to be relevant and appropriate standards.

Maximum Contaminant Level Goals. Although the maximum contaminant level goals (MCLGs) are nonenforceable health goals for public water systems, Congress, as part of the Superfund Amendments and Reauthorization Act of 1986 (SARA), elevated them to the status of potential ARARs. Groundwater in the vicinity of the base is used as a drinking water source; therefore, the SDWA MCLGs were considered to be relevant and appropriate.

Federal Clean Water Act

The Federal Water Pollution Control Act as amended by the Clean Water Act (currently referred to as the Clean Water Act or CWA) seeks to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (40 CFR 101(a)). Ambient Water Quality Criteria (AWQC), a component of the CWA, were considered in the evaluation of ARARs for the sites at the base.

Ambient Water Quality Criteria. The CWA as amended sets forth AWQC for the protection of fresh water aquatic life and human health (authorized under CWA Section 304(a)(1) and regulated under 40 CFR 120). Water quality standards are based

on the designated use(s) of the water, and the criteria necessary to protect the designated use(s). Federal AWQC developed under Section 304(a) of the CWA, although unenforceable, are based on the latest scientific information on the effect a constituent concentration has on a particular aquatic species and/or human health.

In determining if AWQC are ARARs, the primary factors to consider are the designated or potential uses of the water, the media affected, and the purposes for which the criteria are intended. AWQC have been established for the protection of human health and for protection of aquatic life. AWQC for protection of human health address both consumption of water and fish and consumption of fish only. AWQC for protection of aquatic life consider both acute and chronic effects.

The AWQC for protection of human health were not considered to be relevant and appropriate, since the surface water at the base is present only in man-made ditches which are not used for drinking water, recreation, or fishing. The AWQC for protection of aquatic life were also not considered to be relevant and appropriate because the surface water in these ditches is questionable with regard to viability to sustain aquatic life. However, they were used in environmental risk characterization sections as a basis for comparison where needed.

STATE CRITERIA

- Indiana Water Quality Standards
- Indiana Drinking Water Standards

Indiana Water Quality Standards. The Indiana Water Quality Standards (Indiana Administrative Code (IAC), Title 327) are applicable to all state waters including surface water and groundwater. These standards were developed to insure no degradation of water quality of recreational surface waters, trout and salmon fisheries, public and industrial water supplies (including groundwater), water for agricultural purposes, and unusual aquatic habitats.

Underground water standards are described in IAC 2-1-7. The standards for chemical constituents in groundwater are listed as the Indiana Drinking Water Standards presented below (Title 327, IAC 8-2). Since surface water at the base is present in man-made ditches only with questionable viability to sustain aquatic life, the water quality standards as they pertain to surface water were not considered ARARs. However, the water quality standards were considered ARARs for groundwater since groundwater in the vicinity of the base is used as a drinking water supply via private wells.

Indiana Drinking Water Standards. As part of the Indiana Drinking Water Standards (Title 327, Article 8), MCLs have been established for some inorganic chemicals (arsenic, barium, cadmium, hexavalent chromium, lead, mercury, nitrate, selenium and silver) and some organic chemicals (endrin, lindane, methoxychlor, toxaphene, 2,4-D and Silvex), as well as for fluoride, color, odor, taste, turbidity, coliform bacteria and radioactive compounds. The Indiana MCLs match the Federal MCLs for the parameters regulated. Because local groundwater is used as a drinking water supply via private wells, the Indiana Drinking Water Standards were considered relevant and appropriate to the base groundwater.

4.1.5.2 Comparison with Reference Doses. The reference dose (RfD) is the dose unlikely to cause significant noncarcinogenic adverse health effects in humans. A dose less than the RfD indicates that adverse health effects are not expected to occur. Only at some dose above the RfD are adverse health effects expected.

A hazard ratio is the ratio of the estimated dose to the RfD; a hazard ratio was calculated for each of the chemicals of concern in soil. A hazard ratio of less than one means the calculated dose is less than the reference dose, and adverse health effects are not likely. Where route-specific RfDs are available they were used. The RfD for ingestion was used to evaluate the hazard associated with both ingestion and dermal exposure to soil. To assess total site hazard, each of the chemical-specific hazard ratios were added. If the total of all the chemical-specific hazard ratios for an exposure is greater than one, critical effects need to be considered. In this case, the hazard ratios for chemicals with the same or similar critical effects would be added to

determine the overall site hazard index for that effect. If the total site hazard index is less than one, the hazard indices for specific critical effects are also less than one.

A hazard ratio or hazard index of greater than one for a specific critical effect indicates that adverse health effects may occur from the exposure, but does not indicate that adverse effects will occur. Margins of safety and/or uncertainty are used in the derivation of the RfDs upon which ratios are based. Safety factors, generally multiples of 10, are incorporated into RfDs to account for the following areas of uncertainty: 1) expected differences in responsiveness between humans and animals in prolonged exposure studies, 2) the variability among individuals within the human population, 3) incomplete data, and 4) extrapolating from a subchronic study to a chronic RfD (U.S. EPA, December 1989).

4.1.5.3 Estimation of Cancer Risk. Increased lifetime cancer risk from exposure to carcinogens was calculated by multiplying the chronic route-specific dose by the route-specific carcinogenic slope factor. This calculation is only valid at low risk levels (less than 1×10^{-2}) where a linear relationship is expected (U.S. EPA, December 1989). Ingestion slope factors were used to assess cancer risk from dermal contact, since slope factors for dermal exposure have not been developed.

The increased individual lifetime cancer risk associated with a given exposure is expressed as a small fraction (e.g., 1×10^{-6} or one in a million). It represents the incremental increase in an individual's lifetime risk or chance of developing cancer that is attributable to the exposure. Another way to view a one-in-a-million risk is that given an exposure to a million persons, one additional cancer is likely to occur from the exposure. The level of increased cancer risk considered negligible is still widely debated, but among scientific and regulatory communities the range of 1×10^{-4} to 1×10^{-6} is often considered the target risk range. This target risk range has been adopted by the U.S. EPA for use with Superfund sites and was used in this assessment as a basis for comparison.

4.1.6 Environmental Risk Evaluation

The risk to environmental receptors, including critical habitats at or within the vicinity of the base, was characterized by first identifying receptors and then addressing any risks posed to these receptors by the contaminants detected at the sites on the base. Because the base is relatively small and the sites are close together, much of the environmental risk is discussed on a base-wide level in the following sections. Site-specific evaluations focused on surface water characterization where surface water was present.

4.1.6.1 Identification of Environmental Receptors. There is no record of endangered, threatened, or rare species in the vicinity of the base according to the Indiana Natural Heritage Program (Section 1.5.1.2.1). The closest environmentally sensitive area identified is approximately a mile northwest of the base (Figure 1-3). Three other areas were identified at greater distances, all to the northwest of the base. The land on which the base is located is completely developed; no stands of trees, natural surface water bodies, or undisturbed open areas were observed at the base during the SI. Surface water is present only in man-made surface drainage ditches and is questionable with regard to viability to sustain aquatic life.

4.1.6.2 Environmental Risk Characterization. Although the surface water on the base is all part of a man-made surface drainage system, concentrations of the contaminants detected in surface water at Sites 1 and 4 and the Background Area were compared to Ambient Water Quality Criteria (AWQC) in site-specific sections. AWQC were not considered ARARs for the surface water in the base drainage system, but were included as a basis for comparison. AWQC are discussed in detail in Section 4.1.5.1.

4.1.7 Limitations and Uncertainty

The uncertainty associated with the risk evaluation is the result of the uncertainty associated with the data, with the assumptions used in developing the exposure scenarios, and with models used to evaluate the exposures. General sources of uncertainty include:

- Environmental sampling
- Analytical chemistry
- Fate and transport assumptions
- Exposure scenario development
- Toxicological data

The first two sources of uncertainty are common to any sampling and measurement routine and are associated with the representativeness of the sampling, as well as the analytical capabilities of the instrumentation.

In developing the exposure scenario, simplifying assumptions, which have been outlined in the text, were used to calculate dose. The assumptions used may have resulted in the overestimation or underestimation of dose; however, conservative assumptions were used to avoid underestimation. For example, the bioavailability of the contaminants was assumed to be 100 percent for ingestion. If in fact not all of the contaminants are absorbed in the gastrointestinal tract, this conservative assumption will have overestimated dose.

Uncertainties associated with toxicological data include uncertainties associated with the animal experimentation, extrapolating high experimental doses to the low doses generally of concern given environmental conditions, and extrapolating human health effects from animal data.

Route-to route extrapolation introduces uncertainty. Susceptibility to systemic effects may vary depending on the route of exposure, due to differences in absorption, metabolism, and distribution. Since reference doses and slope factors are not currently published by EPA for dermal exposures, oral dose-response data were used to evaluate dermal exposures. Additional uncertainty in the assessment exists because local effects from some exposure routes may not be accounted for. For example, the sensitivity of skin tumor formation from dermal contact with carcinogenic PAHs was not assessed here. The oral slope factor for carcinogenic PAHs, developed from rodent feeding studies with benzo(a)pyrene, is not used to predict risks of skin

cancer which have been associated with dermal exposure to PAHs. Instead, the oral slope factor is used to estimate systemic cancer risks, which the feeding studies were used to predict.

Given the variety of uncertainties associated with each step of the risk assessment process, no numerical estimate of uncertainty was made. The evaluation should not be considered a determination of absolute risks, but rather a method to identify the areas of greatest concern and for developing remediation alternatives.

4.1.8 Summary

The findings from human and environmental risk evaluations are summarized for use in the conclusion, Section 5.

4.2 SITE 1 - POWER SUPPRESSOR PAD

Site 1, the Power Suppressor Pad, is an area covered largely with concrete with the remainder covered with grass (Figure 3-13). It is located between a road to the north and a taxiway to the south. Two grassy areas lie to the east and west with a large surface drainage ditch running east-west through the grassy areas of the site. Volatile organic compounds, semi-volatile organic compounds, and metals were detected to varying extents in surface soils, subsurface soils, groundwater, surface water, and sediments at Site 1 (Table 3-7). Much of the organic compound contamination was in soils and sediments, with some trace level detections in water samples. Metals were more ubiquitous, found in soils, sediments, and water samples.

4.2.1 Identification of the Contaminants of Concern

Mean and maximum concentrations of the potential contaminants of concern detected at Site 1 are presented in Table 4-4. All contaminants detected in sediment, surface water, and groundwater samples were considered contaminants of concern. Background concentrations of contaminants were considered during the risk characterization for exposure pathways

TABLE 4-4. SITE 1 - POTENTIAL CONTAMINANTS OF CONCERN
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	SOIL CONCENTRATIONS (b)			SEDIMENT (d)	GROUNDWATER CONCENTRATIONS (e)			SURFACE WATER (d)
	MAXIMUM	MEAN (c)	NUMBER OF DETECTIONS		MAXIMUM	MEAN (c)	NUMBER OF DETECTIONS	
VOLATILE ORGANICS	UG/KG	UG/KG		UG/KG				
Methylene Chloride				300				
Acetone				340				
Carbon Disulfide				19				
2-Butanone				33 J				
Tetrachloroethene	1 J	1 J	1 / 6					
Toluene	4 J	2.8 J	2 / 6	36				
1,2-Dichlorobenzene	110 J	110 J	1 / 6					
SEMIVOLATILE ORGANICS	UG/KG	UG/KG		UG/KG	UG/L			UG/L
2-Chlorophenol	73 J	73 J	1 / 6					
Phenanthrene	80 J	80 J	1 / 6					
Di-n-Butylphthalate	6,400	3,573	6 / 6		2 J	2 J	1 / 2	2 J
Fluoranthene	93 J	93 J	2 / 6					
Pyrene	74 J	74 J	3 / 6	520 J				
Butylbenzylphthalate	370 J	240 J	3 / 6					
Chrysene	54 J	54 J	2 / 6					
Benzo(b)fluoranthene	64 J	64 J	2 / 6					
Benzo(k)fluoranthene	52 J	52 J	1 / 6	500 J				
Benzoic acid					2 J		1 / 1	
Pentachlorophenol					3 J	3 J	1 / 2	
bis(2-Ethylhexyl)phthalate					8 J	6.75 J	1 / 2	
METALS (f)	MG/KG	MG/KG		MG/KG	UG/L			UG/L
Aluminum, Total	16,000	12,745	2 / 2	5,450	151,000	95500 J	2 / 2	
Arsenic, Total	15.4 J	9.4 J	6 / 6	3.7 J	14.4 J	9.7 J	1 / 2	
Barium, Total	126	124	2 / 2	94.65	1,380	976.5	2 / 2	
Beryllium, Total	1	0.7	6 / 6		10.5	6.5	1 / 2	
Cadmium, Total	4.4	1.55	1 / 6					
Cobalt, Total	12.1	9.7	2 / 2		145	99.25	2 / 2	
Chromium, Total	10.9	7.7	6 / 6	7.45	98.3	96.5	2 / 2	
Copper, Total	16.6	12.5 J	6 / 6	12.5	227	176.5	2 / 2	
Mercury, Soluble					0.32 J	0.21 J	1 / 2	
Mercury, Total	0.64 J	0.3 J	1 / 3		0.50 J	0.4 J	2 / 2	
Manganese, Soluble					858	693	2 / 2	66.55
Manganese, Total	837	553	2 / 2	208	21,200	14230	2 / 2	73.65
Nickel, Total	16.95	13.6	6 / 6		314	210	2 / 2	
Lead, Total	20.6	14.2	6 / 6	16.85	129 J	95 J	2 / 2	
Vanadium, Total	34.4	26.9	2 / 2		352	241	2 / 2	
Zinc, Soluble					33	22	1 / 2	
Zinc, Total	67.9	54.8	6 / 6	149	798	540	2 / 2	

NOTES:

- Analyses: volatile organics, semivolatile organics, pesticides/PCBs, metals, and total petroleum hydrocarbons for all media (Table 2-3). Analytes not presented were not detected in any media sampled or were screened out in section 4.1.1. No value presented means not detected, except for metals (see f.).
 - Six soil samples total: two samples each from two borings and two surface soils.
 - Calculated using the mean of duplicate samples and half the sample quantification detection limit where not detected. The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
 - Only one sample each for sediment and surface water; results for each presented.
 - Two groundwater samples total from Site 1 monitoring well, one taken during each of the two sampling rounds.
 - Soluble metals analysis not run on sediments and soils. Both soluble and total metals analyzed for water samples.
- J = Estimated data due to quality control criteria.

quantitatively assessed. Quantitative exposure assessment focused on those contaminants in soil, the media for which there were adequate data for a quantitative assessment. Therefore, further screening of the contaminants of concern based on background concentrations focused on soil contaminants only. Ten analytes were eliminated as contaminants of concern in soils because they were not detected above background levels at Site 1 (Table 3-7): aluminum, barium, chromium, cobalt, copper, manganese, nickel, tetrachloroethene, vanadium, and zinc. These analytes were not included in the soil exposure calculations for Site 1.

4.2.2 Properties of Contaminants of Concern

The contaminants of concern identified for Site 1 include a number of analytes considered to be persistent in the environment with a high tendency to sorb to soils. These contaminants include a variety of systemic and carcinogenic toxins.

4.2.2.1 Physical and Chemical Properties of Contaminants of Concern. Relatively few volatile organic compounds, a few phenolic compounds, some phthalate esters, and many PAHs and metals were detected at Site 1, mostly in soil media. The physical and chemical parameters for these contaminants, as summarized in Table 4-1, indicate that most of the contaminants found tend to persist in soil and sediment. Most are not highly soluble in water and do not volatilize readily. The more mobile phthalate esters and phenolic compounds were detected in water samples. The few volatile organic compounds detected were mostly detected in the sediment sample.

4.2.2.2 Toxicity Profiles. The contaminants found at Site 1 can be absorbed by humans via ingestion, dermal contact, and inhalation. Exposures to high enough levels of the contaminants could result in a variety of systemic and carcinogenic effects (Table 4-2). Detailed descriptions of the toxicological properties of Site 1 contaminants are available in Appendix G.

4.2.3 Identification of Receptors

The most probable receptors of site contaminants were identified by characterizing potentially exposed populations and current and potential future specific site land use.

4.2.3.1 Populations. Site 1, the Power Suppressor Pad, is not presently used routinely and there are no plans for construction at this site. The site is covered with grass, requiring some lawn care by base employees. The underground storage tank at this site and utilities near the site may require workers to excavate areas of the site in certain situations.

The base is not used residentially. Adults are allowed to bring children to the base. The two outdoor recreational areas at the base, a baseball diamond north of building 16 and a picnic area outside of the Air Tech Club (Figure 4-2), are at the opposite end of the base from Site 1. Should children be left unattended for some time, it is not anticipated that they would be in the vicinity of Site 1.

Localized groundwater flow at Site 1 is westerly. No one is presently using the groundwater at Site 1. The Ammunition Area well (Well No. 530) is the closest water supply well to the site, located within a mile downgradient (Figure 4-1). Employees at the Ammunition Area used this well as a potable water supply until 1990.

4.2.3.2 Land Use. Based on the history of Site 1, the underground storage tank is no longer in use, but it is still located at the site. The adjacent concrete area is presently a location for aircraft fuel bladder storage. Site 1 is not in a high-traffic area, there are no buildings nearby and only a taxiway to the south of the site. There are buried utilities near the site but not directly on the site.

The groundwater at the site is not used presently nor does future use seem likely. The groundwater used within a mile of the site is generally taken from below the dense till that acts

as an aquitard beneath the base, limiting the impact of potential contamination of the shallow groundwater at the base.

As noted in Section 4.1.3, residential development of the base is neither anticipated nor recommended. Based on this information, this preliminary risk evaluation assumes that the base will remain non-residential in the future. Therefore, potential future land use at Site 1 is expected to be the same as current land use and separate evaluations are not presented for current and potential future land use.

4.2.4 Exposure Assessment

The exposure assessment began with a screening of the possible exposure pathways for Site 1. Those pathways of concern with inadequate chemical data were discussed qualitatively. Those pathways of concern for which there were adequate data, were evaluated quantitatively. For the quantitative evaluations, an exposure scenario was developed and a dose was estimated based on the assumptions used in the scenario.

4.2.4.1 Exposure Pathway Screening. The exposure pathway screening approach focused on chemical and physical contaminant factors, environmental conditions, and population characteristics as presented in Table 4-5.

Groundwater. Two groundwater samples were collected at Site 1 from (MW1-06), one sample was collected during each of the two sampling rounds in November, 1990, and January, 1992. In the two groundwater samples collected, there were trace concentrations of four semi-volatile organic compounds detected, none of which were PAHs. Although most metals were only detected in unfiltered groundwater, concentrations were generally elevated above background. Metals not found in background groundwater that were detected at Site 1 include arsenic, beryllium, cobalt, mercury, nickel, and vanadium. Groundwater at the site is not used as a water supply and the closest downgradient well in the Ammunition Area, which is no longer in use, showed no evidence of contamination, so no calculation of dose was warranted. However,

TABLE 4-5. SITE 1 - EXPOSURE PATHWAY SCREENING

ROUTE OF EXPOSURE	FACTORS INFLUENCING EXPOSURE			ANALYSIS
	CHEMICAL/PHYSICAL	ENVIRONMENTAL	POPULATION	
GROUNDWATER: ingestion, inhalation, and dermal exposure from use as a potable water supply	-Volatiles, semivolatiles, pesticides, PCBs, and metals analyzed -No volatiles, pesticides, or PCBs detected -Trace concentrations of 4 semi-volatiles detected -Semivolatiles are not highly water soluble or volatile; they tend to sorb to soils -Most metals were elevated relative to background	-Source area is not paved, but is grass-covered -Site groundwater is 1 to 2 ft below grade -Surficial groundwater at Site 1 is flowing W -Overlying clayey silt loess unit may partially confine water in upper sediments -No surface water discharge points are identified directly downgradient	-One well located to the SW of Site 1 in the Ammunition Area was used as a water supply until 1990 -No other wells are located within one mile downgradient of Site 1 -The 8 wells within a 1 mile radius of the Base are typically screened from 45 to 60 ft below grade	Comparison with ARARs only
SURFACE WATER/ SEDIMENTS: ingestion, inhalation, and dermal exposure from recreational use or accidental exposure	-Volatiles, semivolatiles, pesticides, PCBs, and metals analyzed -No pesticides, or PCBs detected -Trace level of di-n-butylphthalate detected in surface water -Fewer metals in surface water than background and site groundwater -Metals in surface water at background concentrations -Volatile organics in sediments between 19 and 340 ppb -PAHs in sediment total up to 1020 ppb -Metals detected in sediments mostly at background concentrations -Organics and metals have partitioned almost entirely to sediments	-Site surface water is a drainage ditch running past Site 4, through Site 1, and toward the airfield to the W -Surface water is about 1 ft deep, 2 ft wide, and stagnant -Storm event may disturb sediment	-There are 325 Base employees -No one resides on Base -Site 1 is presently not used by the Base -Access to the Base is limited, but access to Site 1 is open to anyone on the Base -No fish were observed in the surface water -Children are allowed on the Base, but no recreational areas are near Site 1 -The trench is not used recreationally or otherwise -Exposures to children are unlikely; worker exposure to site soil expected to represent maximum exposure	Qualitative analysis and comparison with ARARs

TABLE 4-5 (cont.). SITE 1 - EXPOSURE PATHWAY SCREENING

ROUTE OF EXPOSURE	FACTORS INFLUENCING EXPOSURE			ANALYSIS
	CHEMICAL/PHYSICAL	ENVIRONMENTAL	POPULATION	
SURFACE SOIL (SS) and SUB-SURFACE SOIL (SSS): dermal and ingestion exposures from excavation	-Volatiles, semivolatiles, pesticides, PCBs, and metals analyzed -trace levels of toluene in SSS and 1,2-dichlorobenzene in SS -No other volatiles detected -A variety of semivolatiles, including di-n-butylphthalate and PAHs, totaling less than 2000 ppb, were detected in SS -Di-n-butylphthalate was found throughout SSS samples with a few other semivolatiles detected at estimated concentrations -Semivolatiles tend to sorb strongly to soils and are generally not highly volatile -Metals generally detected at background levels, elevated arsenic, cadmium, beryllium, mercury and lead concentrations	-The source area is grass-covered -Clay and silt with fine to medium sand was encountered to 15 ft during well installation	-There are 325 Base employees -No one resides on the Base -No construction is presently planned for the site -UST located at the site may require excavation at some time -Personnel do not regularly use the site, but routine maintenance at the site, like lawn mowing, is required -Access to the Base is limited, but access to Site 1 is open to anyone on the Base -Children are allowed on the Base but would not be present during excavation -Worker exposure to site soil expected to represent maximum exposure	Quantitative assessment of worker's dermal and ingestion exposures to soil during excavation
SURFACE SOIL (SS) and SUB-SURFACE SOIL (SSS): inhalation of dust and volatiles from excavation of soil	-Volatiles, semivolatiles, pesticides, PCBs, and metals analyzed -trace levels of toluene in SSS and 1,2-dichlorobenzene in SS -No other volatiles detected -A variety of semivolatiles, including di-n-butylphthalate and PAHs, totaling less than 2000 ppb were detected in SS -Di-n-butylphthalate was found throughout with a few other semi-volatiles detected at estimated concentrations in SSS -Semivolatiles tend to sorb strongly to soils and are generally not highly volatile -Metals generally detected at background levels, elevated arsenic beryllium, cadmium, mercury and lead concentrations	-The source area is grass-covered -Annual precipitation in the area averages about 40 inches -Clay and silt with fine to medium sand was encountered to 15 ft during well installation -Wind is generally out of the S at 9 mph	-There are 325 Base employees -No one resides on the Base -No construction is presently planned for the site -UST located at the site may require excavation at some time -Personnel do not regularly use the site, but routine maintenance at the site, like lawn mowing, is required -Access to the Base is limited, but access to Site 1 is open to anyone on the Base -Children are allowed on the Base but would not be present during excavation -Worker exposure to site soil expected to represent maximum exposure	Qualitative analysis only

because water wells are located within a mile of the site, concentrations of all chemicals detected in groundwater samples except for those screened out in Section 4.1.1, were compared to drinking water standards (Section 4.2.5.1).

Surface Water and Sediment. Site 1 surface water and sediment are located in a surface drainage ditch about one foot deep and two feet wide. The ditch is not suitable for recreational uses such as fishing, swimming, or wading. According to the base Civil Engineer, the water drains toward the airfield, eventually discharging to the Wabash River, over two miles to the west. Storm events may suspend contaminated sediment, but downstream impacts from Site 1 were not expected to be great due to the occasional nature of storm events, the distance to the off-site discharge, and dilution factors.

One trace phthalate ester, detected in Site 1 surface water, and all metals detected were within background surface water concentration ranges. Surface water concentrations were considered relative to aquatic toxicity (Section 4.2.6) but were not expected to pose a human health hazard.

Analyses showed sediments to contain two PAH compounds and metals. The PAHs and metals were also detected in site soil. The metals were generally within background concentration ranges. Volatile organic compounds were detected in the sediment at concentrations summing to less than 1 ppm. Exposure to sediments is possible on an incidental basis for workers or anyone on the base, but routine activity involving sediment contact for workers was not anticipated. Incidental exposures to sediments is likely to involve some rinsing with surface water. Anyone accidentally exposed would be expected to change clothes or dry off soon after, thus removing some of the sediment. Based on the more probable exposure of workers to Site 1 soil, incidental exposure to contaminants in Site 1 sediment was not expected to greatly increase the worker risk estimated for the more frequent soil exposures.

Soil. Site 1 is not a high traffic area. Utilities are located near the site and an underground storage tank is buried in the area of contamination. Some soil exposure to workers involved in excavation of utilities or the tank is possible and was evaluated quantitatively. Exposures by

inadvertent soil ingestion due to hand-to-mouth contact and absorption through the skin during dermal contact were quantified to evaluate risks to workers exposed to contaminated soils during excavation activities. Exposures to workers were evaluated rather than those for children because workers were expected to represent the worst case scenario or the population at greatest risk. Workers have the potential to be exposed to surface and subsurface soils on a much more frequent basis than children. Exposure of a child to surface soil would be difficult entailing some grass removal, and exposure to subsurface soil is very unlikely. Children would not be present during excavation activities.

Air. Exposures to chemicals volatilized into air or inhaled on dust particles were not quantified in this screening level analysis. Dust generation was not expected to be significant during the limited digging required for utilities servicing and tank removal and due to groundwater 1-2 feet below grade. Contamination by volatile organic compounds was limited to trace concentrations. The semi-volatile organic compounds detected in Site 1 soils, mostly PAHs, do not readily volatilize from soil. Therefore, this pathway was not expected to result in a significant additional exposure to workers.

4.2.4.2 Development of Exposure Scenario. The exposure scenario modeled was that of an adult worker at the base that comes in contact with surface and subsurface soils at Site 1 due to periodic excavations at the site. Exposure assumptions included employment at the base over 25 years, during which time an average of 12 days per year involve some excavation at Site 1. Excavation activities could involve digging up utilities, putting in new sidewalks, or lawn-care activities. Soil ingestion occurs from hand-to-mouth contact, such as eating or smoking, after soil contact. For adult workers, 50 mg/day was the rate used to estimate the incidental soil ingestion resulting from hand-to-mouth contact with dirty hands. An additional worker exposure results from direct contact of skin with contaminated soil. To evaluate dermal exposure, it was assumed that a typical worker wears a shirt with no sleeves and an open neck, pants, shoes, and no gloves or hat. The exposed skin was assumed to come in contact with contaminated soil.

4.2.4.3 Calculation of Dose. Dose for these pathways was estimated using U.S. EPA Risk Assessment Guidance for Superfund (December 1989). The following equation was used for dermal absorption from soil:

$$\text{Absorbed Dose (mg/kg/day)} = \frac{\text{CS} \times \text{CF} \times \text{SA} \times \text{AF} \times \text{ABS} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

A similar equation was used for incidental ingestion of soil:

$$\text{Ingested Dose (mg/kg/day)} = \frac{\text{CS} \times \text{CF} \times \text{IR} \times \text{FI} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Values and definitions for the variables used in each equation are presented in Table 4-6. Results from the dose estimates for non-carcinogens and carcinogens are summarized in Table 4-7. The dose from ingestion was below that for dermal absorption by a factor of two for metals, a factor of twenty for semi-volatile organic compounds, and two orders of magnitude for volatile organic compounds.

4.2.5 Risk Characterization

The human health risk from possible exposure to contaminants was characterized in three parts: a comparison of contaminant concentrations to ARARs, a comparison of estimated human doses with reference dose levels, and a calculation of increased lifetime cancer risk. Contaminant concentrations in groundwater samples were compared to federal and state MCLs and federal MCLGs. The total dose estimates for non-carcinogens, from dermal and ingestion exposures to site soils, were compared to chemical-specific reference doses to get a hazard index for the site. The incremental cancer risk from dermal and ingestion exposures to site soils was then estimated by multiplying the dose estimates for carcinogens by the slope factors for the carcinogens.

TABLE 4-6. EXPOSURE ASSUMPTIONS

VARIABLE	DEFINITION	ABSORPTION	REF.	INGESTION	REF.
CS	Analyte concentration in soil (mg/kg)	Surface and subsurface soil data	(1)	Surface and subsurface soil data	(1)
CF	Conversion factor	1×10^{-9} kg/ug or 1×10^{-6} kg/mg		1×10^{-9} kg/ug 1×10^{-6} kg/mg	
SA	Skin surface area exposed	4,120 cm ²	(2)	--	
AF	Soil to skin adherence factor	2.77 mg/cm ²	(3)	--	
ABS	Absorption factors	0.5 volatiles 0.1 semivolatiles 0.1 pesticides/PCBs 0.01 metals	(4) (5) (5)	--	
EF	Exposure frequency	12 days/year	(6)	12 days/year	(6)
ED	Exposure duration	25 years	(7)	25 years	(7)
BW	Body weight	70 kg	(3)	70 kg	(3)
AT	Averaging time	ED x 365 days/year (non-carcinogens) 70 years x 365 days/year (carcinogens)	(3) (3)	ED x 365 days/year (non-carcinogens) 70 years x 365 days/year (carcinogens)	(3) (3)
IR	Ingestion rate	--		50 mg/day	(7)
FI	Fraction ingested from site	--		1	(3)

REFERENCES:

1. Metcalf & Eddy. Site Investigation
2. U.S. EPA, May 1989. Exposure Factors Handbook
3. U.S. EPA, 1989. Risk Assessment Guidance for Superfund - Volume I: Human Health Evaluation Manual
4. U.S. EPA, June 1989, Region I. Supplemental Risk Assessment Guidance for the Superfund Program
5. Ryan et al. 1987. "Assessing risk from dermal exposure at hazardous waste sites"
6. No reference available to estimate EF. Twelve days/year is thought to represent a high frequency of exposure to site soils
7. U.S. EPA, March 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" memorandum

TABLE 4-7. SITE 1 - DOSE ESTIMATES - 181 st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

	SOIL CONCENTRATIONS(a)		DOSE ESTIMATES (mg/kg/day):									
			NON-CARCINOGENIC(c)					CARCINOGENIC(d)				
	MEAN(b)	MAX	ABSORPTION(e)	MEAN	MAX	INGESTION(f)	TOTAL(g)	ABSORPTION(e)	MEAN	MAX	INGESTION(f)	TOTAL(g)
VOLATILE ORGANICS												
	2.8 J	4 J										
	110 J	110 J										
1,2-Dichlorobenzene												
SEMIVOLATILE ORGANICS												
2-Chlorophenol	73 J	73 J										
Di-n-Butylphthalate	3,573	6,400										
Butylbenzylphthalate	240 J	370 J										
Phenanthrene	80 J	80 J										
Pyrene	74 J	74 J										
Fluoranthene	93 J	93 J										
Chrysene	54 J	54 J										
Benzo(b)fluoranthene	64 J	64 J										
Benzo(k)fluoranthene	52 J	52 J										
METALS(h)												
Arsenic	9.4 J	15.4 J										
Beryllium	0.7	1.0										
Cadmium	1.6	4.4										
Lead	14.2	20.6										
Mercury	0.3 J	0.64 J										

NOTES:

- a. Soil concentrations from Table 4-4.
- b. Calculated using half the sample quantification detection limit where not detected. The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
- c. Dose averaged over exposure duration.
- d. Dose averaged over lifetime.
- e. Absorbed Dose = (Soil conc. * CF * Skin surface area * Adherence factor * Absorption factor * Exposure frequency * Exposure duration) / (Body weight * Averaging time)
- f. Ingested Dose = (Soil conc. * CF * Ingestion Rate * Fraction ingested * Exposure frequency * Exposure duration) / (Body weight * Averaging time)
- g. Total Dose = Absorbed Dose + Ingested Dose
- h. All metals are total metals.
- J = Estimated data due to quality control criteria.

4.2.5.1 Comparison with Applicable or Relevant and Appropriate Requirements (ARARs).

Pentachlorophenol and bis(2-ethylhexyl) phthalate exceeded promulgated federal and state MCLs and federal MCLGs although, these contaminants were detected in only one out of two groundwater samples and the concentrations were estimated (Table 4-8). The laboratory detection limit for the analysis of pentachlorophenol in groundwater was above the federal and state MCL of (1.0 µg/L) for sampling rounds 1 and 2. A trace concentration, (3 µg/L), detected during Round 1 sampling, was used for comparison with ARARs (see Section 4.2.7). A number of metals were detected at concentrations above background levels and greater than ARARs in the unfiltered groundwater samples. The maximum concentration from two groundwater samples at MW1-06 exceeded both promulgated federal and state MCLs and federal MCLGs for beryllium, nickel, and lead in unfiltered groundwater.

Most metals were not detected in the filtered samples. Metals that were detected in the filtered samples include mercury, manganese and zinc, none of which exceeded ARARs. Contaminants detected in unfiltered groundwater are expected to include chemicals in the filtered sample, as well as chemicals sorbed to soil particulates and naturally occurring metals in soils. As a result, unfiltered groundwater generally shows higher concentrations of contaminants. Filtered groundwater in which particles are screened out, is generally more indicative of concentrations likely to be found if groundwater from the sites under investigation is used as a potable water source because the water well would be developed to minimize particulates in the groundwater.

4.2.5.2 Comparison with Reference Doses. The total doses from exposure to soil during excavation activities, calculated for non-carcinogenic toxicity, were divided by reference doses (Table 4-9). The resulting chemical-specific hazard ratios were summed to arrive at an upper-bound site hazard index for soil exposures. This is considered upper-bound because hazard indices are usually summed over chemicals with the same critical health effect. If the total upper-bound hazard index does not exceed one, then it is not necessary to sum hazard ratios

TABLE 4-8. SITE 1 - GROUNDWATER COMPARISON WITH ARARs
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	MAXIMUM GROUNDWATER CONCENTRATION (a)	DRINKING WATER STANDARDS (b):			MCL EXCEEDED (e)
		FEDERAL (c) MCL	MCLG	INDIANA (d) MCL	
SEMIVOLATILE ORGANICS	UG/L	UG/L		UG/L	
Di-n-Butylphthalate	2 J				
Benzoic acid	2 J				
Pentachlorophenol	3 J	1	0	1	yes
bis(2-Ethylhexyl)phthalate	8 J	6	0	6	yes
METALS	UG/L	UG/L		UG/L	
Aluminum, Total	151,000				
Arsenic, Total	14.4 J	50 (f)		50 (f)	
Barium, Total	1,380	2000	2000	2000	
Beryllium, Total	10.5	4	4	4	yes
Cobalt, Total	145				
Chromium, Total	98.3	100	100	100	
Copper, Total	227	1300 (g)	1300	1300 (g)	
Mercury, Soluble	0.32 J	2	2	2	
Mercury, Total	0.50 J	2	2	2	
Manganese, Soluble	858				
Manganese, Total	21,200				
Nickel, Total	314	100	100	100	yes
Lead, Total	129 J	15 (h)	0	15 (h)	yes
Vanadium, Total	352				
Zinc, Soluble	33				
Zinc, Total	798				

NOTES:

- a. Maximum concentration presented from two groundwater samples.
 - b. Standards described in section 4.1.5.1. Values taken from Table 4-3.
No value is presented when a standard is not available.
 - c. Safe Drinking Water Act: MCL - Maximum Contaminant Level, MCLG - Maximum Contaminant Level Goal
 - d. Indiana Drinking Water Standards (MCLs) match the federal promulgated MCLs.
 - e. Considers federal and state MCLs
 - f. MCL for arsenic is under review.
 - g. This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
 - h. This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
- J = Estimated data due to quality control criteria.

TABLE 4-9. SITE 1 - RISK ESTIMATES - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

	TOTAL DOSE ESTIMATES (mg/kg/day) (a):				CHRONIC ORAL RD(b) (mg/kg/day)	ORAL SLOPE FACTOR(b) /(mg/kg/day)	HAZARD RATIO(c)		CANCER RISK(d)	
	NON-CARCINOGENIC		CARCINOGENIC				MEAN	MAX	MEAN	MAX
	MEAN	MAX	MEAN	MAX						
VOLATILES										
Toluene	8E-09	1E-08	3E-09	4E-09	2.0E-01		4E-08	5E-08		
1,2-Dichlorobenzene	3E-07	3E-07	1E-07	1E-07	9.0E-02		3E-06	3E-06		
SEMIVOLATILES										
2-Chlorophenol	4E-08	4E-08	1E-08	1E-08	5.0E-03		8E-06	8E-06		
Di-n-Butylphthalate	2E-06	4E-06	7E-07	1E-06	1.0E-01		2E-05	4E-05		
Butylbenzylphthalate	1E-07	2E-07	5E-08	7E-08	2.0E-01		7E-07	1E-06		
Phenanthrene	4E-08	4E-08	2E-08	2E-08						
Pyrene	4E-08	4E-08	1E-08	1E-08	3.0E-02		1E-06	1E-06		
Fluoranthene	5E-08	5E-08	2E-08	2E-08	4.0E-02		1E-06	1E-06		
Chrysene	3E-08	3E-08	1E-08	1E-08		B2			8E-11	8E-11
Benzo(b)fluoranthene	4E-08	4E-08	1E-08	1E-08		B2			9E-09	9E-09
Benzo(k)fluoranthene	3E-08	3E-08	1E-08	1E-08		B2			8E-10	8E-10
METALS(e)										
Arsenic	7E-07	1E-06	3E-07	4E-07	3.0E-04	A	2E-03	4E-03	5E-07	7E-07
Beryllium	6E-08	8E-08	2E-08	3E-08	5.0E-03	B2	1E-05	2E-05	9E-08	1E-07
Cadmium	1E-07	3E-07	4E-08	1E-07	5.0E-04 (h)		2E-04	7E-04		
Lead	1E-06	2E-06	4E-07	6E-07						
Mercury	2E-08	5E-08	7E-09	2E-08	3.0E-04		6E-05	2E-04		
	HAZARD INDEX(f):						3E-03	5E-03	ILCR(g):	
NOTES:									5E-07	9E-07

NOTES:

a. Total dose estimates taken from Table 4-7.

b. Values taken from Table 4-2. Weight of evidence given with slope factor for carcinogens.

c. Hazard Ratio = Total Dose Estimate / RfD

d. Cancer Risk = Total Dose Estimate * Slope Factor

e. All metals are total metals.

f. Hazard Index = Sum (Chemical-specific Hazard Ratios)

g. Increased Lifetime Cancer Risk = Sum (Chemical-specific Cancer Risks)

h. The more conservative RfD for water ingestion used.

by critical effect. This was the case for Site 1, where soil ingestion and dermal exposure have an upper-bound hazard index well below one. No adverse non-carcinogenic health effects are expected from exposures to Site 1 soil.

4.2.5.3 Estimation of Cancer Risk. The cancer risk resulting from ingestion and dermal exposure to Site 1 soil was also estimated (Table 4-9). Chemical-specific risk was generated by multiplying the dose calculated for carcinogenic toxicity by the slope factor. These risks were then summed over all site contaminants based on the assumption that incremental cancer risk is additive. The increased lifetime cancer risk estimates for Site 1 range from 5×10^{-7} based on mean soil concentrations to 9×10^{-7} based on maximum soil concentrations. This risk is attributable to carcinogenic PAHs and beryllium and arsenic in soil. Only arsenic was also detected in background soils. The risk estimate generated for the background concentration is approximately three times smaller (Section 4.8.5.3). As a result, the estimated site risk is considered predominantly site attributable. This cancer risk range is below the U.S. EPA target risk range, 1×10^{-4} to 1×10^{-6} .

4.2.6 Environmental Risk Evaluation

No threatened or endangered species or critical habitats were identified at Site 1 or in the vicinity of the base. This was addressed on a base-wide level in Section 4.1.6.

The drainage ditch at Site 1 is only a marginally habitable surface water body. Ambient Water Quality Criteria (AWQC) were considered, but no AWQC for aquatic organisms were available for those analytes detected in surface water.

4.2.7 Limitations and Uncertainty

The laboratory detection limit for pentachlorophenol exceeded the federal and state MCL for this chemical (see Table 3-7b), therefore, concentrations of pentachlorophenol above the federal and state MCL may not have been detected at the site. The risks from exposure to Site 1

contaminants have been reasonably well characterized and conservatively estimated, as appropriate for a screening level assessment. See additional information in Section 4.1.7.

4.2.8 Summary

Most of the contaminants of concern at Site 1 are persistent, tending to sorb strongly to soil.

The Ammunition Area well, which is no longer in use, is the only water supply well located within a mile downgradient of Site 1. No organic contaminants from Site 1 were detected in this well. None of the metals detected at the Ammunition Area well were elevated above background or exceeded ARARs. Concentrations of the following organic compounds detected in Site 1 groundwater exceeded one or more of the drinking water standards: pentachlorophenol and bis(2-ethylhexyl) phthalate. These compounds were detected in only one of the two groundwater samples at estimated concentrations. Concentrations of the following metals in unfiltered Site 1 groundwater exceeded one or more of the drinking water standards: beryllium, lead, and nickel. Both promulgated federal and state MCLs and federal MCLGs for beryllium, nickel, and lead were exceeded in unfiltered groundwater. No future residential use of Site 1 is expected. Site 1 is not presently used by base personnel, but worker exposure to site soil during future excavation activities seems likely and was thought to pose the greatest potential for exposure to site contaminants. The dermal absorption and incidental ingestion of contaminants resulting from worker contact with site soil was estimated. No adverse non-carcinogenic health effects are expected from worker exposure to Site 1 soil. The maximum cancer risk estimate from this exposure, 9×10^{-7} , is considered predominantly attributable to the site and is below the U.S. EPA target risk range.

No threatened, rare, or endangered species were identified at Site 1 or in the vicinity of the base. The closest sensitive environmental area is approximately 1 mile northwest of the base. The only surface water at Site 1 is present in the drainage ditch. No ARARs were available to evaluate chemical concentrations in surface water.

4.3 SITE 2 - ABANDONED POL STAND

Site 2, Abandoned POL Stand, is partially covered by gravel (Figure 3-15). Another part of the site is covered with concrete while about half is covered with grass. Further to the south, north, and east are grassy areas but the area to the west is entirely paved. Groundwater and soil at Site 2 were analyzed for volatile organic compounds, semi-volatile organic compounds, and total petroleum hydrocarbons (Table 3-9). Analytes were detected in soils from each compound group while only two trace levels of volatile organic compounds were detected in groundwater samples.

4.3.1 Identification of Contaminants of Concern

Mean and maximum concentrations of the potential contaminants of concern for Site 2 are presented in Table 4-10. All contaminants detected in groundwater samples were considered contaminants of concern. Background concentrations of contaminants were considered during the risk characterization for any exposure quantitatively assessed. The quantitative exposure assessment focused on those contaminants in soil, the media for which there were adequate data for a quantitative assessment. Therefore, further screening of the contaminants of concern based on background concentrations focused on soil contaminants only. One analyte, tetrachloroethene, was eliminated as a contaminant of concern for soils because it was not found above background levels at Site 2 (Table 3-9). This analyte was not included in the soil exposure calculations for Site 2.

4.3.2 Properties of Contaminants of Concern

Contaminants of concern identified for Site 2 included infrequently detected mobile organic compounds and a variety of persistent semi-volatile organic compounds, including phthalate esters and PAHs. Contaminants were detected almost entirely in soil and include non-carcinogenic and carcinogenic toxins.

TABLE 4-10. SITE 2 - POTENTIAL CONTAMINANTS OF CONCERN
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	SOIL CONCENTRATIONS (b)			GROUNDWATER CONCENTRATIONS (d)		
	MAXIMUM	MEAN(c)	NUMBER OF DETECTIONS	MAXIMUM	MEAN (c)	NUMBER OF DETECTIONS
VOLATILE ORGANICS	UG/KG			UG/L		
Chloromethane				4 J	4 J	1 / 2
Trichloroethene	22	22	2 / 10			
Tetrachloroethene	2 J	2 J	1 / 10			
Toluene	210 J	60 J	3 / 10			
1,2-Dichloroethane				2 J	2 J	1 / 2
SEMIVOLATILE ORGANICS	UG/KG					
Benzoic acid	440 J	440 J	1 / 10			
Phenanthrene	220 J	198 J	2 / 10			
Di-n-Butylphthalate	5,400	1,196	2 / 10			
Fluoranthene	500	204 J	4 / 10			
Pyrene	310 J	181 J	4 / 10			
Benzo(a)anthracene	190 J	190 J	2 / 10			
Chrysene	260 J	201 J	2 / 10			
bis(2-Ethylhexyl)phthalate	54 J	54 J	2 / 10			
Benzo(b)fluoranthene	340 J	212 J	2 / 10			
Benzo(k)fluoranthene	390	215 J	2 / 10			
Benzo(a)pyrene	360 J	213 J	2 / 10			
Indeno(1,2,3-cd)pyrene	340 J	224 J	1 / 10			
Benzo(g,h,i)perylene	380	228	1 / 10			

NOTES:

- Analyses: volatile organics, semivolatile organics, and total petroleum hydrocarbons for all media (Table 2-3). Analytes not presented were not detected in any media sampled or were screened out in section 4.1.1. No value presented means not detected.
 - Ten soil samples total: two samples each from four borings and two surface soils.
 - Calculated using the mean of duplicate samples and half the sample quantification detection limit where not detected.
The maximum detected value is used for the mean if the calculated mean was greater than the maximum.
 - Two groundwater samples total from Site 2 monitoring well, one taken during each of the two sampling rounds.
- J = Estimated data due to quality control criteria

4.3.2.1 Physical and Chemical Properties of Contaminants of Concern. Metals were not included in the Site 2 analyses and therefore have not been discussed relative to this site. The physical and chemical parameters for the volatile organic compounds, phthalate esters, and PAHs detected are summarized in Table 4-1. While volatile organic compounds are expected to be mobile in the environment, moving from soil or water to air, phthalates and PAHs are highly immobile. These compounds are expected to persist in soil.

4.3.2.2 Toxicity Profiles. The contaminants found at Site 2 can be absorbed by humans via ingestion, dermal contact, and inhalation. Exposures to high enough levels of the contaminants could result in a variety of systemic and carcinogenic effects (Table 4-2). Detailed descriptions of the toxicological properties of Site 2 contaminants are available in Appendix G.

4.3.3 Identification of Receptors

The most probable receptors of site contaminants were identified by characterizing potentially exposed populations and current and potential future specific site land use.

4.3.3.1 Populations. Site 2 is no longer routinely used by base employees, but occasional non-routine work seems likely. Base employees and visitors are not expected to pass through the site, even though it is not fenced, because there are a number of rather imposing signs at the edge of the site warning people to extinguish flames, because of the presence of flammables in the vicinity. There are walkways on two sides of the site and a road at the eastern edge for people to use rather than walking through the site. Picnic tables are located just behind (east of) building 40, south of the site (Figure 3-15). The most likely employees to be exposed at Site 2 are those involved in any non-routine utility repair or paving at the site.

The base is not used residentially. Adults are allowed to bring children to the base. The two outdoor recreational areas at the base, a baseball diamond north of building 16 and a picnic area outside of the Air Tech Club (Figure 4-2), are not adjacent to Site 2. Should children be left unattended for some time, it is not anticipated that they would be in the vicinity of Site 2.

Localized groundwater flow at Site 2 is west-southwest. No one is presently using the groundwater at Site 2. The Ammunition Area well (Well No. 530), which is no longer in use, is the only well located within a mile downgradient of the site (Figure 4-1). Employees at the Ammunition Area used this well as a potable water supply until 1990.

4.3.3.2 Land Use. Site 2 has been used for drum storage. According to base engineering, there are a number of underground utilities at the site. These utilities may require servicing at some time. The parts of Site 2 that are grass-covered require lawn care.

The groundwater at Site 2 is not used presently nor does future use seem likely. Groundwater within a mile of the site is generally drawn from below the dense till that acts as an aquitard beneath the base, limiting the impact of potential contamination of the shallow groundwater at the base.

As noted in Section 4.1.3, residential development of the base is neither anticipated nor recommended. Based on this information, this preliminary risk evaluation assumes that the base will remain non-residential in the future. Therefore, potential future land use at Site 2 is expected to be the same as current land use and separate evaluations are not presented for current and potential future land use.

4.3.4 Exposure Assessment

The exposure assessment began with a screening of the possible exposure pathways for Site 2. Those pathways of concern with inadequate chemical data were discussed qualitatively. Those pathways of concern for which there were adequate data, were evaluated quantitatively. For the quantitative evaluations, an exposure scenario was developed and a dose was estimated based on the assumptions used in the scenario.

4.3.4.1 Exposure Pathway Screening. Factors considered in the exposure pathway screening focused on chemical and physical contaminant factors, environmental conditions, and population characteristics for each potential route of exposure as presented in Table 4-11.

TABLE 4-11. SITE 2 - EXPOSURE PATHWAY SCREENING

ROUTE OF EXPOSURE	FACTORS INFLUENCING EXPOSURE			ANALYSIS
	CHEMICAL/PHYSICAL	ENVIRONMENTAL	POPULATION	
GROUNDWATER: ingestion, inhalation, and dermal exposure from use as a potable water supply	-Volatiles, semivolatiles analyzed -Chloromethane and 1,2-dichloroethane detected at trace levels -No other volatiles detected -Semivolatiles not detected	-Source area is mostly grass-covered with a cement pad and gravel in the center and asphalt paving around the perimeter -Site groundwater is 1 to 2 ft below grade and flowing SW -Overlying clayey silt loess unit may partially confine water in upper sediments -No surface water discharge points identified downgradient	-One well located to the SW of Site 2 in the Ammunition Area was used as a water supply until 1990 -No other wells are located within one mile downgradient of Site 2 -The 8 wells within a 1 mile radius of the Base are typically screened from 45 to 60 ft below grade	Comparison with ARARs only
SURFACE SOIL (SS) and SUB-SURFACE SOIL (SSS): dermal and ingestion exposures from excavation	-Volatiles, semivolatiles, and analyzed -Volatiles detected in 3 of 8 SSS and 1 of 2 SS samples at 210 ppb or below -Highest volatile detection occurred at 4-6 ft; toluene at 210 ppb -A variety of semivolatiles detected in SSS and SS total 6000 ppb per sample or lower	-Source area is mostly grass-covered with a cement pad and gravel in the center and asphalt paving around the perimeter -Yellow to grey clay and silt with calcium nodules were encountered to 16 ft during well installation	-There are 325 Base employees -No one resides on the Base -No construction is presently planned for the site -Utilities located at the site may require excavation at some time -Personnel do not regularly use the site, but routine maintenance at the site, like lawn mowing, is required -Access to the Base is limited, but access to Site 2 is open to anyone on the Base -Children are allowed on the Base but would not be present during excavation; worker exposure to site soil expected to represent maximum exposure	Quantitative assessment of worker's dermal and ingestion exposures to soil during excavation
SURFACE SOIL (SS) and SUB-SURFACE SOIL (SSS): inhalation of dust and volatiles from excavation of soil	-Volatiles, semivolatiles, and analyzed -Volatiles detected in 3 of 8 SSS and 1 of 2 SS samples at 210 ppb or below -Highest volatile detection occurred at 4-6 ft; toluene at 210 ppb -A variety of semivolatiles detected in SSS and SS total 6000 ppb per sample or lower -Expect volatilization of the more volatile organics to air from exposed soil	-Source area is mostly grass-covered with a cement pad and gravel in the center and asphalt paving around the perimeter -Annual precipitation in the area averages about 40 inches -Yellow to grey clay and silt with calcium nodules were encountered to 16 ft during well installation -Based on average rainfall and groundwater depth, dust generation is not expected to be great	-There are 325 Base employees -No one resides on the Base -No construction is presently planned for the site -Utilities located at the site may require excavation at some time -Personnel do not regularly use the site, but routine maintenance at the site, like lawn mowing, is required -Access to the Base is limited, but access to Site 2 is open to anyone on the Base	Qualitative analysis only

Groundwater. Two groundwater samples were collected at Site 2 from (MW2-04), one sample was collected during each of the two sampling rounds in November, 1990, and January, 1992. The two groundwater samples collected contained two trace organic compounds, chloromethane and 1,2-dichloroethane. Groundwater at the site is not used as a water supply and the closest downgradient well in the Ammunition Area, which is no longer in use, showed no evidence of contamination, so no calculation of dose was warranted. However, because potable water supply wells are located within a mile of the site, the detected concentrations of chloromethane and 1,2-dichloroethane were compared to drinking water standards (Section 4.3.5.1).

Soil. Site 2 is not a high traffic area. Utilities are located in the area of contamination. Some soil exposure to workers involved in the excavation of utilities at Site 2 is possible and was evaluated quantitatively. Exposures by inadvertent soil ingestion due to hand-to-mouth contact and absorption through the skin during dermal contact were quantified to evaluate risk to workers exposed to contaminated soils during routine maintenance of utilities. Exposures to workers were evaluated rather than those for children because workers were expected to represent the worst case scenario or the population at greatest risk. Workers have the potential to be exposed to surface and subsurface soil on a much more frequent basis than children. Exposure of a child to surface soil at Site 2 would be difficult involving the removal of some grass first. Exposure of a child to subsurface soils is highly unlikely because children would not be present during excavation activities.

Air. Exposures to chemicals volatilized into air or inhaled on dust particles were not quantified in this screening level analysis. Dust generation was not expected to be significant during the limited digging required for utilities servicing and due to groundwater 1 to 2 feet below grade. Contamination by volatile organic compounds has been detected to a limited extent. The concentrations of volatile organic compounds totalled less than 250 ppb. Although some volatilization of these compounds would be expected during excavation, the additional worker exposure to volatile organic compounds was not expected to be great due to dilution and dispersion in ambient air. The semi-volatiles detected in Site 2 soils, mostly phthalate esters and

PAHs, do not readily volatilize from soil. Therefore, this pathway was not expected to result in a significant additional exposure to workers.

4.3.4.2 Development of Exposure Scenario. The exposure scenario modeled was that of an adult worker at the base that comes in contact with surface and subsurface soils at Site 2 due to periodic excavations at the site. Exposure assumptions included employment at the base over 25 years, during which time an average of 12 days per year involve some excavation at Site 2. Excavation activities could involve digging up utilities, putting in new sidewalks, or lawn-care activities. Soil ingestion occurs from hand-to-mouth contact, such as eating or smoking, after soil contact. For adult workers, 50 mg/day was the rate used to estimate the incidental soil ingestion resulting from hand-to-mouth contact with dirty hands. An additional worker exposure results from direct contact of skin with contaminated soil. To evaluate dermal exposure, it was assumed that a typical worker wears a shirt with no sleeves and an open neck, pants, shoes, and no gloves or hat. The exposed skin was assumed to come in contact with contaminated soil.

4.3.4.3 Calculation of Dose. Dose for these pathways was estimated using U.S. EPA Risk Assessment Guidance for Superfund (December 1989). The following equation was used for dermal absorption from soil:

$$\text{Absorbed Dose (mg/kg/day)} = \frac{\text{CS} \times \text{CF} \times \text{SA} \times \text{AF} \times \text{ABS} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

A similar equation was used for incidental ingestion of soil:

$$\text{Ingested Dose (mg/kg/day)} = \frac{\text{CS} \times \text{CF} \times \text{IR} \times \text{FI} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Values and definitions for the variables used in each equation are presented in Table 4-6. Results from the dose estimates are summarized in Table 4-12. The dose estimates for ingestion were below those for dermal adsorption by approximately a factor of twenty for semi-volatile organic compounds and two orders of magnitude for volatiles organic compounds.

4.3.5 Risk Characterization

The human health risk from possible exposure to contaminants was characterized in three parts: a comparison of contaminant concentrations to ARARs, a comparison of estimated human doses with reference dose levels, and a calculation of increased lifetime cancer risk. Contaminant concentrations in groundwater samples were compared to federal and state MCLs and federal MCLGs. The total dose estimates for non-carcinogens, from dermal and ingestion exposures to site soils, were compared to chemical-specific reference doses to get a hazard index for the site. The incremental cancer risk from dermal and ingestion exposures to site soils was then estimated by multiplying dose estimates for carcinogens by the slope factors for the carcinogens.

4.3.5.1 Comparison with Applicable or Relevant and Appropriate Requirements (ARARs).

Groundwater at Site 2 was analyzed for volatile organic compounds, semi-volatile organic compounds, and total petroleum hydrocarbons. Only two chemicals were detected, trace levels of chloromethane and 1,2-dichloroethane, each in one of the two groundwater samples at Site 2. No drinking water standard is available for chloromethane. The detected trace concentration of 1,2-dichloroethane ($2\text{J } \mu\text{g/L}$) was below the federal and state MCL of $5.0 \mu\text{g/L}$. No organic compounds were found to exceed standards in Site 2 groundwater.

4.3.5.2 Comparison with Reference Doses. The total dose estimates from exposure to soil during excavation activities, calculated for non-carcinogenic toxicity, were divided by reference doses to arrive at chemical-specific hazard ratios. The hazard ratios and the summed upper-bound site hazard index are all well below one for Site 2 (Table 4-13). This indicates that no adverse non-carcinogenic health effects are expected from worker exposure to contaminants in Site 2 soil.

TABLE 4-12. SITE 2 - DOSE ESTIMATES - 181st HULMAN FIELD MAP,
TERRE HAUTE, INDIANA

	SOIL CONCENTRATIONS(a) MEAN(b)	MAX	DOSE ESTIMATES (mg/kg/day):						CARCINOGENIC(d)					
			NON-CARCINOGENIC(c)			TOTAL(g)			ABSORPTION(e)			INGESTION(f)		
			MEAN	MAX		MEAN	MAX		MEAN	MAX		MEAN	MAX	TOTAL(g) MEAN MAX
VOLATILE ORGANICS														
Trichloroethene	22	22	6E-08	6E-08	5E-10	5E-10	6E-08	6E-08	2E-08	2E-08	2E-08	2E-10	2E-10	2E-08
Toluene	60	210	2E-07	6E-07	1E-09	5E-09	6E-07	6E-07	6E-08	2E-07	6E-08	5E-10	2E-09	6E-08
SEMIVOLATILE ORGANICS														
Benzoic acid	440	440	2E-07	2E-07	1E-08	1E-08	2E-07	2E-07	8E-08	8E-08	9E-08	4E-09	4E-09	9E-08
Di-n-Butylphthalate	1,196	5400	6E-07	3E-06	3E-08	1E-07	7E-07	3E-06	2E-07	1E-06	2E-07	1E-08	5E-08	2E-07
bis(2-Ethylhexyl)phthalate	54	54	3E-08	3E-08	1E-09	1E-09	3E-08	3E-08	1E-08	1E-08	1E-08	5E-10	5E-10	1E-08
Phenanthrene	198	220	1E-07	1E-07	5E-09	5E-09	1E-07	1E-07	4E-08	4E-08	4E-08	2E-09	2E-09	4E-08
Pyrene	181	310	1E-07	2E-07	4E-09	7E-09	1E-07	1E-07	3E-08	6E-08	4E-08	2E-09	3E-09	6E-08
Fluoranthene	204	500	1E-07	3E-07	5E-09	1E-08	1E-07	1E-07	4E-08	1E-07	4E-08	2E-09	4E-09	1E-07
Benzo(a)anthracene	190	190	1E-07	1E-07	4E-09	4E-09	1E-07	1E-07	4E-08	4E-08	4E-08	2E-09	2E-09	4E-08
Chrysene	201	260	1E-07	1E-07	5E-09	6E-09	1E-07	1E-07	4E-08	5E-08	4E-08	2E-09	2E-09	5E-08
Benzo(b)fluoranthene	212	340	1E-07	2E-07	5E-09	8E-09	1E-07	1E-07	4E-08	7E-08	4E-08	2E-09	3E-09	7E-08
Benzo(a)pyrene	213	360	1E-07	2E-07	5E-09	8E-09	1E-07	1E-07	4E-08	7E-08	4E-08	2E-09	3E-09	7E-08
Benzo(k)fluoranthene	215	390	1E-07	2E-07	5E-09	9E-09	1E-07	1E-07	4E-08	7E-08	4E-08	2E-09	3E-09	8E-08
Indeno(1,2,3-cd)pyrene	224	340	1E-07	2E-07	5E-09	8E-09	1E-07	1E-07	4E-08	7E-08	4E-08	2E-09	3E-09	7E-08
Benzo(g,h,i)perylene	228	380	1E-07	2E-07	5E-09	9E-09	1E-07	1E-07	4E-08	7E-08	5E-08	2E-09	3E-09	8E-08

NOTES:

- Soil concentrations from Table 4-10.
- Calculated using half the sample quantification detection limit where not detected. The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
- Dose averaged over exposure duration.
- Dose averaged over lifetime.
- Absorbed Dose = (Soil conc. * CF * Skin surface area * Adherence factor * Absorption factor * Exposure frequency * Exposure duration) / (Body weight * Averaging time)
See Table 4-6 for variable values.
- Ingested Dose = (Soil conc. * CF * Ingestion Rate * Fraction ingested * Exposure frequency * Exposure duration) / (Body weight * Averaging time)
See Table 4-6 for variable values.
- Total Dose = Absorbed Dose + Ingested Dose
J = Estimated data due to quality control criteria.

TABLE 4-13. SITE 2 - RISK ESTIMATES - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

	TOTAL DOSE ESTIMATES (mg/kg/day) (a):				CHRONIC ORAL RfD(b) (mg/kg/day)	ORAL SLOPE FACTOR(b) /(mg/kg/day)	HAZARD RATIO(c)		CANCER RISK(d)	
	NON-CARCINOGENIC MEAN	NON-CARCINOGENIC MAX	CARCINOGENIC MEAN	CARCINOGENIC MAX			MEAN	MAX	MEAN	MAX
VOLATILE ORGANICS										
Trichloroethene	6E-08	6E-08	2E-08	2E-08					2E-10	2E-10
Toluene	2E-07	6E-07	6E-08	2E-07	2.0E-01	C-B2	8E-07	3E-06		
SEMIVOLATILE ORGANICS										
Benzoic acid	2E-07	2E-07	9E-08	9E-08	4.0E+00		6E-08	6E-08		
Di-n-Butylphthalate	7E-07	3E-06	2E-07	1E-06	1.0E-01		7E-06	3E-05		
bis(2-Ethylhexyl)phthalate	3E-08	3E-08	1E-08	1E-08	2.0E-02		2E-06	2E-06		
Phenanthrene	1E-07	1E-07	4E-08	4E-08		B2			2E-10	2E-10
Pyrene	1E-07	2E-07	4E-08	6E-08	3.0E-02		7E-06	6E-06		
Fluoranthene	1E-07	3E-07	4E-08	1E-07	4.0E-02					
Benzo(a)anthracene	1E-07	1E-07	4E-08	4E-08		B2	7.3E-07		3E-08	3E-08
Chrysene	1E-07	1E-07	4E-08	5E-08		B2	7.3E-07		3E-10	4E-10
Benzo(b)fluoranthene	1E-07	2E-07	4E-08	7E-08		B2	7.3E-07		3E-08	5E-08
Benzo(a)pyrene	1E-07	2E-07	4E-08	7E-08		B2	7.3E-07		3E-07	5E-07
Benzo(k)fluoranthene	1E-07	2E-07	4E-08	8E-08		B2	7.3E-07		3E-09	6E-09
Indeno(1,2,3-cd)pyrene	1E-07	2E-07	4E-08	7E-08		B2	7.3E-07		3E-08	5E-08
Benzo(g,h,i)perylene	1E-07	2E-07	5E-08	8E-08		B2	7.3E-07			
						HAZARD INDEX(e):	2E-05	5E-05	ILCR(f):	7E-07

NOTES:

- a. Total dose estimates taken from Table 4-12.
b. Values taken from Table 4-2. Weight of evidence given with slope factor for carcinogens.
c. Hazard Ratio = Total Dose Estimate / RfD
d. Cancer Risk = Total Dose Estimate * Slope Factor
e. Hazard Index = Sum (Chemical-specific Hazard Ratios)
f. Increased Lifetime Cancer Risk = Sum (Chemical-specific Cancer Risks)

4.3.5.3 Estimation of Cancer Risk. Also presented in Table 4-13 are the cancer risk estimates for ingestion of and dermal contact with contaminated Site 2 soil. The increased lifetime cancer risk estimated for those compounds considered carcinogens was calculated by multiplying the carcinogenic dose by the slope factor. These risk estimates were then added for all the compounds present in soil to arrive at the incremental increased lifetime cancer risk for the site. The estimates for Site 2 range from 4×10^{-7} based on mean soil concentrations to 7×10^{-7} based on maximum soil concentrations. All but the smallest portion of this risk is attributable to the carcinogenic PAHs. None of the carcinogens evaluated for Site 2 were detected in background soil, so this risk is considered site attributable. Both of the cancer risk estimates are below the U.S. EPA target risk range of 1×10^{-4} to 1×10^{-6} .

4.3.6 Environmental Risk Evaluation

No threatened or endangered species or critical habitats were identified at Site 2 or within the vicinity of the base. This was addressed on a base-wide level in Section 4.1.6. No surface water was present at Site 2, so no comparison to AWQC was possible. Contamination at Site 2 poses no apparent threat to the environment at Site 2 or the base.

4.3.7 Limitations and Uncertainty

The risks from exposure to organic contaminants at Site 2 have been reasonably well characterized and conservatively estimated, as appropriate for a screening level assessment. See additional information in Section 4.1.7.

4.3.8 Summary

Most of the contaminants of concern detected at Site 2 are persistent, sorbing strongly to soil. Presently, Site 2 is not regularly used by base personnel.

The Ammunition Area well, which is no longer in use, is the only water supply well located within a mile downgradient of Site 2. No contaminants detected at Site 2 were detected in this

well. Analysis of Site 2 media included volatile organic compounds, semi-volatile organic compounds, and total petroleum hydrocarbons. No organics exceeded drinking water standards in the groundwater sample, however, the concentration of 1,2-dichloroethane did exceed the federal MCLG. No future residential use of Site 2 is expected. Site 2 is not regularly used by base personnel at the present time. However, worker exposure to site soil during future excavation activities is possible and was thought to represent the greatest potential for exposure to site contaminants. The dermal absorption and incidental ingestion of contaminants resulting from worker contact with site soil was estimated. No adverse non-carcinogenic health effects are expected from worker exposure to Site 2 soil. The maximum cancer risk estimate from this exposure, 7×10^{-7} , is considered to be attributable to the site and is below the U.S. EPA target risk range.

No threatened, rare, or endangered species were identified at Site 2 or within the vicinity of the base. The closest environmentally sensitive area is approximately one mile to the northwest.

4.4 SITE 4 - OLD BLADDER AREA

Site 4, the Old Bladder Area, is mostly grass-covered with an asphalt access road around the tanks (Figure 3-17). The tanks are set on a concrete pad in the center of the site. There is a concrete wall around the concrete pads, about four feet high, on which the tanks sit. A small building is also located at the site. Surface drainage runs from this area to the southeast, and subsequently along the road in front of building 32. Site 4 groundwater, surface water, sediment, and soil were analyzed for volatile organic compounds, semi-volatile organic compounds, and total petroleum hydrocarbons (Table 3-11). Most contaminants were detected in soil and sediment media. There was one trace level of a semi-volatile organic compound detected in surface water, and no organic compounds in groundwater.

4.4.1 Identification of Contaminants of Concern

The mean and maximum concentrations of the potential contaminants of concern for Site 4 are presented in Table 4-14. All contaminants detected in sediment, surface water, and groundwater

TABLE 4-14. SITE 4 - POTENTIAL CONTAMINANTS OF CONCERN
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	SOIL CONCENTRATIONS (b)		NUMBER OF DETECTIONS	SEDIMENT (d)	SURFACE WATER (d)	GROUND WATER (e)
	MAXIMUM	MEAN (c)				
VOLATILE ORGANICS	UG/KG					
Trichloroethene	38	6.3 J	4 / 10			
Benzene	1 J	1 J	1 / 10			
Toluene	11	3.4 J	5 / 10			
1,2-Dichlorobenzene	67 J	67 J	2 / 10			
SEMIVOLATILE ORGANICS	UG/KG			UG/KG	UG/L	
Phenol	46 J	46 J	1 / 10			
4-Methylphenol				320 J		
Phenanthrene	40 J	40 J	1 / 10	170 J		
Di-n-Butylphthalate	5500	2980	10 / 10		2 J	
Fluoranthene	84.5 J	84.5 J	1 / 10	350 J		
Pyrene	70 J	70 J	3 / 10	360 J		
Butylbenzylphthalate	730	276 J	3 / 10			
Benzo(a)anthracene	43.5 J	43.5 J	1 / 10	130 J		
Chrysene	51.5 J	51.5 J	1 / 10	230 J		
bis(2-Ethylhexyl)phthalate	2300	409 J	5 / 10			
Benzo(b)fluoranthene	64.5 J	64.5 J	1 / 10	240 J		
Benzo(k)fluoranthene	40 J	40 J	1 / 10	150 J		
Benzo(a)pyrene	50.5 J	50.5 J	1 / 10	190 J		
Indeno(1,2,3-cd)pyrene				120 J		
Benzo(g,h,i)perylene				180 J		

NOTES:

- Analyses: volatile organics, semivolatile organics, and total petroleum hydrocarbons for all media (Table 2-3). Analytes not presented were not detected in any media sampled or were screened out (sec. 4.1.1). No value presented means not detected.
 - Ten soil samples total: two samples each from four borings and two surface soils.
 - Calculated using the mean of duplicate samples and half the sample quantification detection limit where not detected.
The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
 - Only one sample each for sediment and surface water; results for each presented.
 - Four groundwater samples total, two samples taken from Site 4 monitoring well, one during each sampling round; and two samples taken during Round 2, at Piezometer 4.
- J = Estimated data due to quality control criteria.

samples were considered contaminants of concern. Background concentrations of contaminants were considered during the risk characterization for any exposure quantitatively assessed. The quantitative exposure assessment focused on those contaminants in soil, the media for which there were adequate data. Therefore, further screening of the contaminants of concern based on background concentrations focused on soil contaminants only. No analytes were eliminated as contaminants of concern in Site 4 soil on the basis of comparison with concentrations in background soils (Table 3-11).

4.4.2 Properties of Contaminants of Concern

The contaminants of concern for Site 4 include a range of mobile and immobile organic compounds almost entirely detected in soil and sediment. These contaminants include systemic and carcinogenic toxins.

4.4.2.1 Physical and Chemical Properties of Contaminants of Concern. The physical and chemical parameters for the organics detected are summarized in Table 4-1. Those volatile organic compounds detected are expected to migrate readily through the environment, while the phenols, phthalates, and PAHs are expected to be more persistent. The data indicate that the organics have mostly partitioned to the soil and sediment and have not solubilized.

4.4.2.2 Toxicity Profiles. The contaminants found at Site 4 can be absorbed by humans via ingestion, dermal contact, and inhalation. Exposures to high enough levels of the contaminants could result in a variety of systemic and carcinogenic effects (Table 4-2). Detailed descriptions of the toxicological properties of Site 4 contaminants are available in Appendix G.

4.4.3 Identification of Receptors

The most probable receptors of site contaminants were identified by characterizing potentially exposed populations and current and potential future specific site land use.

4.4.3.1 Populations. Site 4 is surrounded by a fence that is locked when the area is not in use, so only authorized workers have access to the site. Workers are on-site daily filling up tanker trucks with fuel for the planes. Activities involved with filling up tanker trucks are generally brief. Other workers at Site 4 may include those involved in lawn maintenance and those involved in utilities servicing. Although lawn care would involve some contact with site soil, workers involved in the excavation of underground utilities stand the greatest chance of exposure to soil contaminants.

The base is not used residentially. Adults are allowed to bring children to the base. The two outdoor recreational areas at the base, a baseball diamond north of building 16 and a picnic area outside of the Air Tech Club (Figure 4-2), are not adjacent to Site 4. Should children be left unattended for some time, it is not anticipated that they would be in the vicinity of Site 4.

Localized groundwater flow direction at Site 4 may vary from flowing north-northeast or southwest according to data from June, 1991, and January, 1992. The Ammunition Area well (Well No. 530), which is no longer in use, is located to the southwest within a mile (Section 3.8). The two downgradient water supply wells located to the northeast within a mile are approximately 3,500 feet (Well No. 555) and 5,000 feet (Well No. 467) from the site (Figure 4-1). No information on the use of these water wells was available from the IDEM well inventory. The land northeast of Site 4 is privately owned indicating that additional placement of wells downgradient of Site 4 is possible. However, no one is presently using the groundwater at Site 4 and no future ingestion of groundwater from the upper aquifer is expected.

4.4.3.2 Land Use. The tanks at Site 4 are used to hold jet fuel, and there are underground utilities at the site. The area where surface water and sediment samples were collected is not fenced and is across the road from building 25, adjacent to three roads and a work area.

The groundwater at the site is not presently used and future use does not seem likely. Groundwater used within a mile of the site is generally taken from below the dense till that acts as an aquitard beneath the base, limiting the impact of potential contamination of the shallow groundwater at the base.

As noted in Section 4.1.3, residential development of the base is neither anticipated nor recommended. Based on this information, this preliminary risk evaluation assumes that the base will remain non-residential in the future. Therefore, potential future land use at Site 4 is expected to be the same as current land use and separate evaluations are not presented for current and potential future land use.

4.4.4 Exposure Assessment

The exposure assessment began with a screening of the possible exposure pathways for Site 4. Those pathways of concern with inadequate chemical data were discussed qualitatively. Those pathways of concern for which there were adequate data, were evaluated quantitatively. For the quantitative evaluations, an exposure scenario was developed and a dose was estimated based on the assumptions used in the scenario.

4.4.4.1 Exposure Pathway Screening. The exposure pathway screening approach focused on chemical and physical contaminant factors, environmental conditions, and population characteristics as presented in Table 4-15.

Groundwater. Four groundwater samples were collected at Site 4. During Round 1, in November, 1991, one groundwater sample was collected at MW4-05, located to the southwest. During Round 2, in January, 1992, a second groundwater sample was collected at MW4-05 and two groundwater samples were collected at Piezometer 4, located northeast of the site. The groundwater samples collected showed no detected contaminants and no calculation of dose or comparison to standards was possible. Therefore, groundwater at the site does not present a potential exposure pathway.

Surface Water and Sediment. Site 4 surface water and sediment are located in a surface drainage ditch that is about one foot deep and three feet wide. The ditch is not suitable for recreational uses such as fishing, swimming, or wading. According to the base Civil Engineer, the drainage water travels through Site 1 and toward the airfield, eventually discharging to the Wabash River which is over two miles west of the base. Storm events may suspend

TABLE 4-15. SITE 4 - EXPOSURE PATHWAY SCREENING

ROUTE OF EXPOSURE	FACTORS INFLUENCING EXPOSURE			ANALYSIS
	CHEMICAL/PHYSICAL	ENVIRONMENTAL	POPULATION	
GROUNDWATER: ingestion, inhalation, and dermal exposure from use as a potable water supply	-Volatiles, semivolatiles analyzed -No organic compounds detected -Site soils contained semivolatiles and low level volatile organics	-Source area is generally grass-covered with a cement pad in the middle and paving around periphery -Site groundwater is 1 to 2 ft below grade and flow varies to the NE and SW, site monitoring well is SW and piez. 4 is NE of the source area -Overlying clayey silt loess unit may partially confine water in upper sediments	-Two wells are located to the NE of Site 4 within a mile radius of the Base -No information available on use of the Base -Ammunition Area well, SW of the site, was used until 1990 -The 8 wells within a 1 mile radius of the Base are typically screened from 45 to 60 ft below	No analysis
SURFACE WATER/ SEDIMENTS: ingestion, inhalation, and dermal exposure from recreational use or accidental exposure	-Volatiles, semivolatiles analyzed -No volatile organics and only 1 semivolatile detected in the surface water -No volatiles detected in sediments -A variety of semivolatiles, totalling 2500 ppb, detected in sediments -Organics have partitioned almost entirely to sediment	-Site surface water is a drainage ditch to the W of Site 4, running past the site, from N to S, then E to W, to the N of Building 25 -Surface water is about 1 ft deep, 3 ft wide, and stagnant -Storm event may disturb sediment	-There are 325 Base employees -No one resides on Base -Site 4 is used throughout the day as is the road to the S of the ditch and Building 25 -No fish were observed in the surface water -Children are allowed on the Base, but no recreational areas are near Site 4 -Exposures to children would be incidental; worker exposure to soil expected to represent maximum exposure	Qualitative analysis and comparison with ARARs

TABLE 4-15 (cont.). SITE 4 - EXPOSURE PATHWAY SCREENING

ROUTE OF EXPOSURE	FACTORS INFLUENCING EXPOSURE			ANALYSIS
	CHEMICAL/PHYSICAL	ENVIRONMENTAL	POPULATION	
SURFACE SOIL (SS) and SUB-SURFACE SOIL (SSS): dermal and ingestion exposures from excavation	-Volatiles, semivolatiles analyzed -Some trace detections of volatiles in SSS and SS, summing to 125 ppb -Di-n-butylphthalate was detected in all SSS and SS samples at concentrations up to 5500 ppb -A few other semivolatiles were detected in SSS samples -SS generally showed a much greater number of semivolatile organic detections than SSS	-Source area is generally grass-covered with a cement pad in the middle and asphalt paving around the periphery -Clay and silt was encountered to 16 ft during well installation	-There are 325 Base employees -No one resides on Base -No construction is presently planned for the site -Utilities located at the site may require excavation at some time -Personnel enter the site regularly to empty and fill tank trucks; routine maintenance is required -Access to the Base is limited and Site 4 is locked when not in use -Children are allowed on the Base but would not be present during excavation -Worker exposure to soil expected to represent maximum exposure	Quantitative assessment of worker's dermal and ingestion exposures to soil during excavation
	SURFACE SOIL (SS) and SUB-SURFACE SOIL (SSS): inhalation of dust and volatiles from excavation of soil	-Volatiles, semivolatiles analyzed -Some trace detections of volatiles in SSS and SS, summing to 125 ppb -Di-n-butylphthalate was detected in all SSS and SS samples at concentrations up to 5500 ppb -A few other semivolatiles were detected in SSS samples -SS generally showed a much greater number of semivolatile organic detections than SSS -Semi-volatiles tend to sorb strongly to soil and not volatilize into air	-Source area is generally grass-covered with a cement pad in the middle and asphalt paving around the periphery -Annual precipitation in the area averages about 40 inches -Clay and silt was encountered to 16 ft during well installation -Wind is generally out of the S at 9 mph	-There are 325 Base employees -No one resides on Base -No construction is presently planned for the site -Utilities located at the site may require excavation at some time -Personnel enter the site regularly to empty and fill tank trucks; routine maintenance is required -Access to the Base is limited and Site 4 is locked when not in use -Children are allowed on the Base but would not be present during excavation -Worker exposure to soil expected to represent maximum exposure

contaminated sediment, but downstream impacts from Site 4 were not expected to be great due mostly to the distance to an off-site discharge, but also to the occasional nature of storm events and dilution factors.

One trace phthalate ester was detected in Site 4 surface water. The concentration was considered relative to aquatic toxicity (Section 4.4.6) but was not expected to pose a human health hazard in the event of an exposure to surface water.

Analyses of sediment contained a variety of PAH compounds and one phenolic compound. The PAHs were also detected in site soil but at lower concentrations. No volatile organic compounds were detected in the sediment. Exposure to sediments is possible on an incidental basis for workers or anyone on the base. Routine activity involving sediment contact for workers was not anticipated. The Site 4 surface water trench is not fenced off and some lawn-care activities were expected nearby. It was expected, however, that because the sediment is below the surface water, any incidental exposure to sediment is likely to involve some rinsing with surface water. Anyone exposed would be expected to dry off, thus removing some of the sediment. Based on the more probable exposure of workers to Site 4 soil, it was thought that an incidental exposure to contaminants in Site 4 sediment would not greatly increase the worker risk estimated for the more frequent soil exposures.

Soil. Site 4 is not in a high traffic area aside from fuel tank-related activities. Underground utilities are located near the area of contamination. Workers involved with filling or emptying tanker trucks would not be exposed to site soils on a regular basis. The areas of the site where trucks are operated is paved, while the rest of the site is covered with grass or concrete. Exposure to workers involved in soil excavation for utilities servicing at Site 4 is possible and was evaluated quantitatively. Exposures by inadvertent soil ingestion due to hand-to-mouth contact and absorption through the skin during dermal contact were quantified to evaluate risk to workers exposed to contaminated soils during routine maintenance of utilities. Exposures to workers were evaluated rather than those for children because access to the site is limited. Even the incidental exposure of a child is improbable. Workers were expected to represent the worst case scenario or the population at greatest risk.

Air. Exposures to chemicals volatilized into air or inhaled on dust particles were not quantified in this screening level analysis. Dust generation was not expected to be significant during the limited digging required for utilities servicing and due to groundwater 1 to 2 feet below grade. Contamination by volatile organic compounds has been detected at low concentrations in soil. Some volatilization of these compounds was expected during excavations, but because of the low concentrations, the additional exposure was not expected to be great due to dilution and dispersion in ambient air. The semi-volatile organic compounds detected in Site 4 soils (including phenols, phthalates, and PAHs) do not readily volatilize from soil. This pathway was not expected to result in a significant additional exposure to workers.

4.4.4.2 Development of Exposure Scenario. The exposure scenario modeled was that of an adult worker at the base that comes in contact with surface and subsurface soils at Site 4 due to periodic excavations at the site. Exposure assumptions included employment at the base over 25 years, during which time an average of 12 days per year involve some excavation at Site 4. Excavation activities could involve digging up utilities, putting in new sidewalks, or lawn-care activities. Soil ingestion occurs from hand-to-mouth contact, such as eating or smoking, after soil contact. For adult workers, 50 mg/day was the rate used to estimate the incidental soil ingestion resulting from hand-to-mouth contact with dirty hands. An additional worker exposure results from direct contact of skin with contaminated soil. To evaluate dermal exposure, it was assumed that a typical worker wears a shirt with no sleeves and an open neck, pants, shoes, and no gloves or hat. The exposed skin was assumed to come in contact with contaminated soil.

4.4.4.3 Calculation of Dose. Dose for these pathways was estimated using U.S. EPA Risk Assessment Guidance for Superfund (December 1989). The following equation was used for dermal absorption from soil:

$$\text{Absorbed Dose (mg/kg/day)} = \frac{\text{CS} \times \text{CF} \times \text{SA} \times \text{AF} \times \text{ABS} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

A similar equation was used for incidental ingestion of soil:

$$\text{Ingested Dose (mg/kg/day)} = \frac{\text{CS} \times \text{CF} \times \text{IR} \times \text{FI} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Values and definitions for the variables are presented in Table 4-6. Results from the dose estimates are summarized in Table 4-16. The dose estimates for dermal absorption were larger than those for ingestion exposure by approximately a factor of twenty for semi-volatile compounds and two orders of magnitude for volatile organic compounds.

4.4.5 Risk Characterization

The human health risk from possible exposure to contaminants was characterized in three parts: a comparison of contaminant concentrations to ARARs, a comparison of estimated human doses with reference dose levels, and a calculation of increased lifetime cancer risk. The total dose estimates for non-carcinogens, from dermal and ingestion exposures to site soils, were compared to chemical-specific reference doses to get a hazard index for the site. The incremental cancer risk from dermal and ingestion exposures to site soils was then estimated by multiplying the dose estimates for carcinogens by the slope factors for the carcinogens.

4.4.5.1 Comparison with Applicable or Relevant and Appropriate Requirements (ARARs).

Groundwater sampled from the monitoring well at Site 4 and Piezometer 4 were analyzed for volatile organic compounds, semi-volatile organic compounds, and total petroleum hydrocarbons. No organic compounds were detected, so drinking water standards for organics were not exceeded. Impacts to water supply wells downgradient from Site 4 are, therefore, not anticipated.

4.4.5.2 Comparison with Reference Doses. Estimated non-carcinogenic doses were divided by chronic oral reference doses to arrive at hazard ratios (Table 4-17). The sum of the hazard ratios, the upper-bound hazard index for soil exposures, is well below one based on both mean

TABLE 4-16. SITE 4 - DOSE ESTIMATES - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

	SOIL CONCENTRATIONS(a) MEAN(b) MAX	DOSE ESTIMATES (mg/kg/day):									
		NON-CARCINOGENIC(c)					CARCINOGENIC(d)				
		ABSORPTION(c)		INGESTION(f)		TOTAL(g)	ABSORPTION(c)		INGESTION(f)		TOTAL(g)
		MEAN	MAX	MEAN	MAX		MEAN	MAX	MEAN	MAX	
VOLATILE ORGANICS											
Trichloroethene	UG/KG 6.3 J 38	2E-08	1E-07	1E-10	9E-10	2E-08	6E-09	4E-08	5E-11	3E-10	6E-09
Benzene	1 J 1 J	3E-09	3E-09	2E-11	2E-11	3E-09	1E-09	1E-09	8E-12	8E-12	1E-09
Toluene	3.4 J 11	9E-09	3E-08	8E-11	3E-10	9E-09	3E-09	1E-08	3E-11	9E-11	3E-09
1,2-Dichlorobenzene	67 J 67 J	2E-07	2E-07	2E-09	2E-09	2E-07	6E-08	6E-08	6E-10	6E-10	6E-08
SEMIVOLATILE ORGANICS											
Phenol	UG/KG 46 J 46 J	2E-08	2E-08	1E-09	1E-09	3E-08	9E-09	9E-09	4E-10	4E-10	9E-09
Di-n-Butylphthalate	2980 5500	2E-06	3E-06	7E-08	1E-07	2E-06	6E-07	1E-06	2E-08	5E-08	6E-07
Butylbenzylphthalate	276 J 730	1E-07	4E-07	6E-09	2E-08	2E-07	5E-08	1E-07	2E-09	6E-09	6E-08
bis(2-Ethylhexyl)phthalate	409 J 2300	2E-07	1E-06	1E-08	5E-08	2E-07	8E-08	4E-07	3E-09	2E-08	8E-08
Phenanthrene	40 J 40 J	2E-08	2E-08	9E-10	9E-10	2E-08	8E-09	8E-09	3E-10	3E-10	8E-09
Pyrene	70 J 70 J	4E-08	4E-08	2E-09	2E-09	4E-08	1E-08	1E-08	6E-10	6E-10	1E-08
Fluoranthene	84.5 J 84.5 J	5E-08	5E-08	2E-09	2E-09	5E-08	2E-08	2E-08	7E-10	7E-10	2E-08
Benzo(a)anthracene	43.5 J 43.5 J	2E-08	2E-08	1E-09	1E-09	2E-08	8E-09	8E-09	4E-10	4E-10	9E-09
Chrysene	51.5 J 51.5 J	3E-08	3E-08	1E-09	1E-09	3E-08	1E-08	1E-08	4E-10	4E-10	1E-08
Benzo(b)fluoranthene	64.5 J 64.5 J	3E-08	3E-08	2E-09	2E-09	4E-08	1E-08	1E-08	5E-10	5E-10	1E-08
Benzo(a)pyrene	50.5 J 50.5 J	3E-08	3E-08	1E-09	1E-09	3E-08	1E-08	1E-08	4E-10	4E-10	1E-08
Benzo(k)fluoranthene	40 J 40 J	2E-08	2E-08	9E-10	9E-10	2E-08	8E-09	8E-09	3E-10	3E-10	8E-09

NOTES:

- Soil concentrations from Table 4-14.
- Calculated using half the sample quantification detection limit where not detected. The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
- Dose averaged over exposure duration.
- Dose averaged over lifetime.
- Absorbed Dose = (Soil conc. * CF * Skin surface area * Adherence factor * Absorption factor * Exposure frequency * Exposure duration) / (Body weight * Averaging time)
- Ingested Dose = (Soil conc. * CF * Ingestion Rate * Fraction ingested * Exposure frequency * Exposure duration) / (Body weight * Averaging time)
- Total Dose = Absorbed Dose + Ingested Dose
- Estimated data due to quality control criteria.

TABLE 4-17. SITE 4 - RISK ESTIMATES - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

TABLE 4-17. SITE 4 - RISK ESTIMATES - 10151 HOLMAN FIELD MFG. PARK, FERRIS HILLS, INDIANA										
	TOTAL DOSE ESTIMATES (mg/kg/day) (a):				CHRONIC ORAL RfD (b) (mg/kg/day)	ORAL SLOPE FACTOR (b) /(mg/kg/day)	HAZARD RATIO (c)		CANCER RISK (d)	
	NON-CARCINOGENIC		CARCINOGENIC				MEAN	MAX	MEAN	MAX
	MEAN	MAX	MEAN	MAX						
VOLATILE ORGANICS										
Trichloroethene	2E-08	1E-07	6E-09	4E-08		C-B2	1.1E-02		7E-11	4E-10
Benzene	3E-09	3E-09	1E-09	1E-09		A	2.9E-02		3E-11	3E-11
Toluene	9E-09	3E-08	3E-09	1E-08	2.0E-01			5E-08		
1,2-Dichlorobenzene	2E-07	2E-07	6E-08	6E-08	9.0E-02			2E-06	2E-06	
SEMIVOLATILE ORGANICS										
Phenol	3E-08	3E-08	9E-09	9E-09	6.0E-01			4E-08	4E-08	
Di-n-Butylphthalate	2E-06	3E-06	6E-07	1E-06	1.0E-01			2E-05	3E-05	
Butylbenzylphthalate	2E-07	4E-07	6E-08	1E-07	2.0E-01			8E-07	2E-06	
bis(2-Ethylhexyl)phthalate	2E-07	1E-06	8E-08	5E-07	2.0E-02	B2	1.4E-02	1E-05	6E-05	6E-09
Phenanthrene	2E-08	2E-08	8E-09	8E-09						
Pyrene	4E-08	4E-08	1E-08	1E-08	3.0E-02			1E-06	1E-06	
Fluoranthene	5E-08	5E-08	2E-08	2E-08	4.0E-02			1E-06	1E-06	
Benzo(a)anthracene	2E-08	2E-08	9E-09	9E-09		B2	7.3E-01		6E-09	6E-09
Chrysene	3E-08	3E-08	1E-08	1E-08		B2	7.3E-03		8E-11	8E-11
Benzo(b)fluoranthene	4E-08	4E-08	1E-08	1E-08		B2	7.3E-01		9E-09	9E-09
Benzo(a)pyrene	3E-08	3E-08	1E-08	1E-08		B2	7.3E+00		7E-08	7E-08
Benzo(k)fluoranthene	2E-08	2E-08	8E-09	8E-09		B2	7.0E-02		6E-10	6E-10
						HAZARD INDEX (e):			ILCR (f):	
								3E-05	1E-04	9E-08
										1E-07

NOTES:

- a. Total dose estimates taken from Table 4-16.
b. Values taken from Table 4-2. Weight of evidence given with slope factor for carcinogens.
c. Hazard Ratio = Total Dose Estimate / RfD
d. Cancer Risk = Total Dose Estimate * Slope Factor
e. Hazard Index = Sum (Chemical-specific Hazard Ratios)
f. Increased Lifetime Cancer Risk = Sum (Chemical-specific Cancer Risks)

and maximum concentrations. A hazard index below one indicates that the dose estimated is below the level at which an adverse health effect might be expected. Although reference doses were not available for all of the site contaminants, the hazard index indicates that non-carcinogenic hazard is not a concern.

4.4.5.3 Estimation of Cancer Risk. Cancer risk was estimated for those organics detected in soil considered to be carcinogens (Table 4-17). These risk numbers were estimated by multiplying the dose calculated for carcinogens by the oral slope factor. These risk values were summed over all of the compounds to arrive at an increased lifetime cancer risk from exposure to contaminants in Site 4 soil. Increased lifetime cancer risk estimates range from 9×10^{-8} based on mean soil concentrations to 1×10^{-7} based on maximum soil concentrations. None of the carcinogens evaluated for Site 4 were detected in background soil, so the risk estimate is considered site attributable. This risk is below the U.S. EPA target risk range of 1×10^{-4} to 1×10^{-6} .

4.4.6 Environmental Risk Evaluation

No threatened or endangered species or critical habitats were identified at Site 4 or within the immediate vicinity of the base. This was addressed on a base-wide level in Section 4.1.6.

The drainage ditch at Site 4 is only a marginally habitable surface water body. The di-n-butylphthalate concentration in surface water was not compared to AWQC because none were available for aquatic organisms.

4.4.7 Limitations and Uncertainty

The risks from exposure to contaminants detected in Site 4 soil have been reasonably well characterized and conservatively estimated. Section 4.1.7 presents additional information.

4.4.8 Summary

Most of the contaminants of concern detected at Site 4 are persistent, sorbing strongly to soil. Some mobile contaminants were detected in soil.

Analyses conducted on site media were for volatile organic compounds, semi-volatile organic compounds, and total petroleum hydrocarbons. Groundwater flow direction could not be determined at Site 4 from the available data. Groundwater may flow to the north-northeast or southwest. The Site 4 monitoring well to the southwest and piezometer 4 to the northeast were sampled, and no contaminants were detected in the groundwater samples. Therefore, groundwater does not appear to be impacted by the site. Site 4 is presently used by base personnel involved in fueling activities, but present contact with site soil is limited. Future worker exposure to soil during utilities servicing is possible and was thought to represent the greatest potential exposure pathway to site contaminants. Dermal absorption and incidental ingestion of contaminants resulting from worker contact with site soil was estimated. No adverse non-carcinogenic health effects are expected from worker exposure. The maximum cancer risk estimate from this exposure, 1×10^{-7} , is considered site attributable and is below the U.S. EPA target risk range.

No threatened, rare, or endangered species were identified at the site or in the vicinity of the base. The closest environmentally sensitive area is about one mile to the northwest. The only surface water at the site is present in a surface drainage ditch, no natural surface water bodies are present. No ARARs were available to evaluate chemical concentrations in surface water.

4.5 SITE 5 - VEHICLE MAINTENANCE BUILDING

The portion of Site 5 to the west of building 4 is asphalt covered, but the area south of the building was grass covered (Figure 3-19). During field work there was a dumpster located adjacent to the grassy portion of Site 5. Soil and groundwater samples from Site 5 were analyzed for volatile organic compounds, semi-volatile organic compounds, pesticide/PCBs, total petroleum hydrocarbons, and metals (Table 3-13). Soils were found to contain mostly

semi-volatile organic compounds, metals, and petroleum hydrocarbons, with Aroclor 1260 in surface soils only. The groundwater sample contained only metals with a trace of total petroleum hydrocarbons.

4.5.1 Identification of Contaminants of Concern

Mean and maximum concentrations of the potential contaminants of concern for Site 5 are presented in Table 4-18. All contaminants detected in groundwater samples were considered contaminants of concern. Background concentrations of contaminants were considered during the risk characterization for any exposure quantitatively assessed. The quantitative exposure assessment focused on those contaminants in soil, the media for which there were adequate data. Therefore, further screening of the contaminants of concern based on background concentrations focused on soil contaminants only. Aluminum, barium, cobalt, manganese, nickel, tetrachloroethene, and vanadium were eliminated as contaminants of concern in soils because they were not detected above background concentrations in Site 5 soil (Table 3-13). These analytes were not included in the soil exposure calculations for Site 5.

4.5.2 Properties of Contaminants of Concern

The contaminants of concern for Site 5 include a number of analytes considered to be persistent in the environment with a high tendency to sorb to soils. These contaminants include a variety of systemic and carcinogenic toxins.

4.5.2.1 Physical and Chemical Properties of Contaminants of Concern. Three volatile organic compounds, three phthalate esters, and a large number of PAHs and metals were detected at Site 5, mostly in soil samples. The physical and chemical parameters for these contaminants, as summarized in Table 4-1, indicate that almost all of the contaminants detected tend to persist in soil. Most are not highly soluble in water and do not volatilize readily. No organic compounds were detected in the groundwater sample.

TABLE 4-18. SITE 5 - POTENTIAL CONTAMINANTS OF CONCERN
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a).

PARAMETER	SOIL CONCENTRATIONS (b)			GROUND WATER (d)
	MAXIMUM	MEAN (c)	NUMBER OF DETECTIONS	
VOLATILE ORGANICS	UG/KG			
Tetrachloroethene	1 J	1 J	2 / 7	
Toluene	1 J	1 J	1 / 7	
1,2-Dichlorobenzene	88 J	88 J	4 / 7	
SEMIVOLATILE ORGANICS	UG/KG			
Acenaphthene	470 J	236 J	1 / 7	
Fluorene	400 J	226 J	1 / 7	
Phenanthrene	6100	1,017 J	4 / 7	
Anthracene	810 J	284 J	1 / 7	
Di-n-Butylphthalate	850	526	4 / 7	
Fluoranthene	9,900	1,591 J	4 / 7	
Pyrene	5,200	898 J	4 / 7	
Butylbenzylphthalate	230 J	230 J	4 / 7	
Benzo(a)anthracene	3,600	662 J	3 / 7	
Chrysene	4,100	719 J	4 / 7	
bis(2-Ethylhexyl)phthalate	1,000 J	292 J	2 / 7	
Benzo(b)fluoranthene	5,200	901 J	4 / 7	
Benzo(k)fluoranthene	5,000	884 J	3 / 7	
Benzo(a)pyrene	5,600	976 J	3 / 7	
Indeno(1,2,3-cd)pyrene	3,900	715 J	3 / 7	
Dibenzo(a,h)anthracene	1,200 J	340 J	1 / 7	
Benzo(g,h,i)perylene	4,100	751 J	3 / 7	
PESTICIDES/PCB	UG/KG			
Aroclor-1260	2,400 J	863 J	1 / 3	
METALS (e)	MG/KG			UG/L
Aluminum, Total	5,220		1 / 1	19,200
Arsenic, Total	13.2	7.1 J	7 / 7	
Barium, Total	64		1 / 1	
Beryllium, Total	1.3	0.73	4 / 7	
Cadmium, Total	8.3	2.1	1 / 7	
Cobalt, Total	5.6		1 / 1	
Chromium, Total	91.9	21.3	7 / 7	193
Copper, Total	48.1	18.2 J	7 / 7	53.4
Mercury, Soluble				0.32 J
Mercury, Total				0.35 J
Manganese, Soluble				433
Manganese, Total	236		1 / 1	1,130
Nickel, Total	24.5	13.6	7 / 7	164
Lead, Total	67.2	21.7 J	7 / 7	36.4 J
Vanadium, Total	21		1 / 1	50.7 J
Zinc, Total	608	163.5	7 / 7	157.5

NOTES:

- Analyses: volatile organics, semivolatile organics, pesticides/PCBs, metals, and total petroleum hydrocarbons for all media (Table 2-3). Analytes not presented were not detected in any media sampled or were screened out in section 4.1.1. No value presented means not detected, except for metals (e).
 - Seven soil samples total: two samples each from two borings and three surface soils.
 - Calculated using the mean of duplicate samples and half the sample quantification detection limit where not detected. The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
 - Only one groundwater sample taken from the Site 5 monitoring well, during sampling Round 1.
 - Soluble metals analysis not run for soils. Both soluble and total metals were analyzed for groundwater.
- J = Estimated data due to quality control criteria.

4.5.2.2 Toxicity Profiles. The contaminants found at Site 5 can be absorbed by humans via ingestion, dermal contact, and inhalation. Exposures to high enough levels of the contaminants could result in a variety of systemic and carcinogenic effects (Table 4-2). Detailed descriptions of the toxicological properties of Site 5 contaminants are available in Appendix G.

4.5.3 Identification of Receptors

The most probable receptors of site contaminants were identified by characterizing potentially exposed populations and current and potential future specific site land use.

4.5.3.1 Populations. Most of Site 5 is encompassed by a fence which is locked when the Vehicle Maintenance Building, or motor pool, is not open. The motor pool is used during regular business hours. Gas pumps are located in front of the building and personnel using base vehicles make occasional visits to the site to refuel and have vehicles serviced. Employees at the motor pool work 8 hour days and 40-hour work-weeks. The work performed is generally not strenuous but may be on occasion. Workers involved in lawn care are occasionally required to work in this area. Some excavation at Site 5 is possible based on the presence of underground utilities that could require servicing.

The base is not used residentially. Adults are allowed to bring children to the base. The two outdoor recreational areas at the base, a baseball diamond north of building 16 and a picnic area outside of the Air Tech Club (Figure 4-2), are 200 to 400 feet from Site 5. Should children be left unattended for some time, it is not anticipated that they would be in the vicinity of Site 5. This area is adjacent to a parking lot and the base access road and would probably not provide an attractive play area for children.

Localized groundwater flow at Site 5 is southwest. No one is presently using the groundwater at Site 5. The Ammunition Area well (Well No. 530) is the closest downgradient well, located within a mile of the site (Figure 4-1). Employees at the Ammunition Area used this well as a potable water supply until 1990.

4.5.3.2 Land Use. The motor pool is the service area for all of the base vehicles. This is also the location of the base gasoline pumps. The vicinity of Site 5 is a high-traffic area. There are buried utilities located at Site 5. Underground fuel storage tanks are located in the paved area of Site 5.

The groundwater at Site 5 is not used presently nor does future use seem likely. The groundwater used within a mile of the site is generally drawn from below the dense till that acts as an aquitard beneath the base, limiting the impact of potential contamination of the shallow groundwater at the base.

As noted in Section 4.1.3, residential development of the base is neither anticipated nor recommended. Based on this information, this preliminary risk evaluation assumes that the base will remain non-residential in the future. Therefore, potential future land use at Site 5 is expected to be the same as current land use and separate evaluations are not presented for current and potential future land use.

4.5.4 Exposure Assessment

The exposure assessment began with a screening of the possible exposure pathways for Site 5. Those pathways of concern with inadequate chemical data were discussed qualitatively. Those pathways of concern for which there were adequate data, were evaluated quantitatively. For the quantitative evaluations, an exposure scenario was developed and a dose was estimated based on the assumptions used in the scenario.

4.5.4.1 Exposure Pathway Screening. The exposure pathway screening approach focused on chemical and physical contaminant factors, environmental conditions, and population characteristics as presented in Table 4-19.

Groundwater. Only one groundwater sample was collected at Site 5, during Round 1, in November, 1990. The one groundwater sample collected showed no detected organic contaminants. Metals were mostly detected in unfiltered groundwater, and concentrations for

TABLE 4-19. SITE 5 - EXPOSURE PATHWAY SCREENING

ROUTE OF EXPOSURE	FACTORS INFLUENCING EXPOSURE			ANALYSIS
	CHEMICAL/PHYSICAL	ENVIRONMENTAL	POPULATION	
GROUNDWATER: ingestion, inhalation, and dermal exposure from use as a potable water supply	-Volatiles, semivolatiles, pesticides PCBs, metals analyzed -Only metals detected -Chromium and lead were detected at concentrations above background -Mercury, nickel, and vanadium were detected on-site and not in background	-Source area is paved W of Building 4 and grass-covered to the S -Site groundwater is 1 to 2 ft below grade and flowing SW -Overlying clayey silt loess unit may partially confine water in upper sediments -No surface water discharge points were identified downgradient	-One well located to the SW of Site 5 in the Ammunition Area, was used as a water supply until 1990 -No other wells are located within one mile downgradient of Site 5 -The 8 wells within a 1 mile radius of the Base are typically screened from 45 to 60 ft below grade	Comparison with ARARs only
SURFACE SOIL (SS) and SUB-SURFACE SOIL (SSS): dermal and ingestion exposures from excavation	-Volatiles, semivolatiles, pesticides PCBs, and metals analyzed -Trace volatiles detected in SSS and SS samples -Phthalates and PAHs were detected in SSS and SS totalling from 600 to 57,000 ppb per sample -Aroclor 1260 was detected in one SS sample at 2400 ppb -Some metals elevated above background concentrations	-Source area is paved W of Building 4 and grass-covered to the S -Yellow to grey mottled clay and silt was encountered to 15 ft during well installation	-There are 325 Base employees -No one resides on Base -Construction planned for the grassy area between Buildings 3 and 4 -Personnel work in both Buildings 3 and 4 and pass over and near Site 5 -The motor pool (Bldg.3) is open during the day and locked at night; -the grassy area S is not secured -Children are allowed on the Base; -the picnic area is nearby but, would not be present during excavation -Worker exposure to site soil expected to represent minimum exposure	Quantitative assessment of worker's dermal and ingestion exposures to soil during excavation
SURFACE SOIL (SS) and SUB-SURFACE SOIL (SSS): inhalation of dust and volatiles from excavation of soil	-Volatiles, semivolatiles, pesticides PCBs, metals analyzed -Trace volatiles detected in SSS and SS samples -Phthalates and PAHs were detected in SSS and SS totalling from 600 to 57,000 ppb per sample -Aroclor 1260 was detected in one SS sample at 2400 ppb -Some metals elevated above background concentrations -Semivolatiles tend to sorb tightly to soils -Expect volatilization of more volatile organics to air from exposed soil	-Source area is paved W of Building 4 and grass-covered to the S -Annual precipitation in the area averages about 40 inches -Yellow to grey mottled clay and silt was encountered to 15 ft during well installation -Based on average rainfall and groundwater depth, dust generation is not expected to be great	-There are 325 Base employees -No one resides on Base -Construction planned for the grassy area between Buildings 3 and 4 -Personnel work in both Buildings 3 and 4 and pass over and near Site 5 -Access to the Base is limited -The motor pool (Bldg.3) is open during the day and locked at night; -the grassy area S is not secured -Children are allowed on the Base; -the picnic area is nearby but, would not be present during excavation -Worker exposure to site soil expected represent maximum exposure	Qualitative analysis only

a number of them were elevated over background concentrations. Metals detected at Site 5 and not in the Background Area include mercury, nickel, and vanadium. Groundwater at the site is not presently used and the closest downgradient water well, in the Ammunition Area, which is no longer used, showed no contamination, so no calculation of dose was warranted. However, because water wells are located within a mile of the site, detected concentrations of all chemicals in groundwater samples, except for those screened out in Section 4.1.1, were compared to drinking water standards (Section 4.5.5.1).

Soil. Site 5 is located in a high-traffic area. The employees at the motor pool who are at Site 5 all day are not regularly exposed to site soil because most of the site is paved. Employees involved in utilities servicing in the area of contamination would be exposed to site soil. Exposure to workers involved in soil excavation at Site 5 was evaluated quantitatively. Exposures by inadvertent soil ingestion due to hand-to-mouth contact and absorption through the skin during dermal contact were quantified to evaluate risk to workers exposed to contaminated soils during routine maintenance of utilities. Exposures to workers were evaluated rather than those for children because workers were expected to represent the worst case scenario or the population at greatest risk. Workers have the potential to be exposed to both surface and subsurface soil on a much more frequent basis than children. Exposure of a child to site surface soil would involve grass removal and subsurface soil is inaccessible to children.

Air. Exposures to chemicals volatilized into air or inhaled on dust particles were not quantified in this screening level analysis. Dust generation was not expected to be significant during the limited digging required for utilities servicing. More extensive construction could result in some dust generation, but the soil is expected to be moist due to the high water table and year-round precipitation. Contamination by volatile organic compounds was limited to trace levels of concentrations. The semi-volatile organic compounds detected in Site 5 soil, mostly phthalate esters and PAHs, do not readily volatilize from soil. This pathway was not expected to result in a significant additional exposure to workers.

4.5.4.2 Development of Exposure Scenario. The exposure scenario modeled was that of an adult worker at the base that comes in contact with surface and subsurface soils at Site 5 due to

periodic excavations at the site. Exposure assumptions included employment at the base over 25 years, during which time an average of 12 days per year involve some excavation at Site 5. Excavation activities could involve digging up utilities, putting in new sidewalks, or lawn-care activities. Soil ingestion occurs from hand-to-mouth contact, such as eating or smoking, after soil contact. For adult workers, 50 mg/day was the rate used to estimate the incidental soil ingestion resulting from hand-to-mouth contact with dirty hands. An additional worker exposure results from direct contact of skin with contaminated soil. To evaluate dermal exposure, it was assumed that a typical worker wears a shirt with no sleeves and an open neck, pants, shoes, and no gloves or hat. The exposed skin was assumed to come in contact with contaminated soil.

4.5.4.3 Calculation of Dose. Dose for these pathways was estimated using U.S. EPA Risk Assessment Guidance for Superfund (December 1989). The following equation was used for dermal absorption from soil:

$$\text{Absorbed Dose (mg/kg/day)} = \frac{\text{CS} \times \text{CF} \times \text{SA} \times \text{AF} \times \text{ABS} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

A similar equation was used for incidental ingestion of soil:

$$\text{Ingested Dose (mg/kg/day)} = \frac{\text{CS} \times \text{CF} \times \text{IR} \times \text{FI} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Values and definitions for the variables used in each equation are presented in Table 4-6. Results from the dose estimates are summarized in Table 4-20. The dose from ingestion was estimated to be below that for dermal absorption by approximately a factor of two for metals, a factor of twenty for semi-volatile organic compounds, and two orders of magnitude for volatile organic compounds.

TABLE 4-20. SITE 5 - DOSE ESTIMATES - 181st HULMAN FIELD MAP, TEERE HAUTE, INDIANA

	DOSE ESTIMATES (mg/kg/day):																	
	SOIL CONCENTRATION(a) MEAN(b)		UG/KG		NON-CARCINOGENIC(c)										CARCINOGENIC(d)			
					ABSORPTION(c)		INGESTION(f)		TOTAL(g)		ABSORPTION(e)		INGESTION(f)		TOTAL(g)			
	MEAN	MAX			MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX	MEAN	MAX
VOLATILE ORGANICS																		
Toluene	1 J	1 J	3E-09	3E-09	2E-11	2E-11	3E-09	3E-09	3E-09	3E-09	2E-07	2E-07	1E-09	1E-09	8E-12	8E-12	1E-09	1E-09
1,2-Dichlorobenzene	88 J	88 J	2E-07	2E-07	2E-09	2E-09	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07	8E-08	8E-08	7E-10	7E-10	8E-08	8E-08
SEMIVOLATILE ORGANICS																		
Di-n-Butylphthalate	526	850	3E-07	5E-07	1E-08	2E-08	3E-07	5E-07	3E-07	5E-07	5E-07	5E-07	1E-07	2E-07	4E-09	7E-09	1E-07	2E-07
Butylbenzylphthalate	230 J	230 J	1E-07	1E-07	5E-09	5E-09	1E-07	1E-07	1E-07	1E-07	1E-07	1E-07	4E-08	4E-08	2E-09	2E-09	5E-08	5E-08
bis(2-Ethylhexyl)phthalate	292 J	1,000 J	2E-07	5E-07	7E-09	2E-08	2E-07	5E-07	2E-07	6E-07	2E-07	6E-07	6E-08	2E-07	2E-09	8E-09	6E-08	2E-07
Fluorene	226 J	400 J	1E-07	2E-07	5E-09	9E-09	1E-07	2E-07	1E-07	2E-07	1E-07	2E-07	4E-08	8E-08	2E-09	3E-09	5E-08	8E-08
Acenaphthene	236 J	470 J	1E-07	3E-07	6E-09	1E-08	1E-07	3E-07	1E-07	3E-07	1E-07	3E-07	5E-08	9E-08	2E-09	4E-09	5E-08	9E-08
Anthracene	284 J	810 J	2E-07	4E-07	7E-09	2E-08	2E-07	5E-07	2E-07	5E-07	2E-07	5E-07	5E-08	2E-07	2E-09	7E-09	6E-08	2E-07
Phenanthrene	1,017 J	6,100	5E-07	3E-06	2E-08	1E-07	6E-07	3E-06	6E-07	3E-06	6E-07	3E-06	2E-07	1E-06	9E-09	5E-08	2E-07	1E-06
Pyrene	898 J	5,200	5E-07	3E-06	2E-08	1E-07	5E-07	3E-06	5E-07	3E-06	5E-07	3E-06	2E-07	1E-06	8E-09	4E-08	2E-07	1E-06
Fluoranthene	1,591 J	9,900	9E-07	5E-06	4E-08	2E-07	9E-07	5E-06	9E-07	5E-06	4E-07	2E-06	3E-07	2E-06	1E-08	8E-08	3E-07	2E-06
Benzo(a)anthracene	662 J	3,600	4E-07	2E-06	2E-08	8E-08	4E-07	2E-06	4E-07	2E-06	4E-07	2E-06	1E-07	7E-07	6E-09	3E-08	1E-07	7E-07
Chrysene	719 J	4,100	4E-07	2E-06	2E-08	1E-07	4E-07	2E-06	4E-07	2E-06	4E-07	2E-06	1E-07	8E-07	6E-09	3E-08	1E-07	8E-07
Benzo(b)fluoranthene	901 J	5,200	5E-07	3E-06	2E-08	1E-07	5E-07	3E-06	5E-07	3E-06	5E-07	3E-06	2E-07	1E-06	8E-09	4E-08	2E-07	1E-06
Benzo(a)pyrene	976 J	5,600	5E-07	3E-06	2E-08	1E-07	5E-07	3E-06	5E-07	3E-06	5E-07	3E-06	2E-07	1E-06	7E-09	4E-08	2E-07	1E-06
Benzo(k)fluoranthene	884 J	5,000	5E-07	3E-06	2E-08	1E-07	5E-07	3E-06	5E-07	3E-06	4E-07	2E-06	1E-07	7E-07	6E-09	3E-08	1E-07	8E-07
Indeno(1,2,3-cd)pyrene	715 J	3,900	4E-07	2E-06	2E-08	9E-08	4E-07	2E-06	4E-07	2E-06	4E-07	2E-06	1E-07	8E-07	6E-09	3E-08	1E-07	8E-07
Benzo(g,h,i)perylene	751 J	4,100	4E-07	2E-06	2E-08	1E-07	4E-07	2E-06	4E-07	2E-06	4E-07	2E-06	1E-07	8E-07	6E-09	3E-08	1E-07	8E-07
Dibenzo(a,h)anthracene	340 J	1,200 J	2E-07	6E-07	8E-09	3E-08	2E-07	6E-07	2E-07	7E-07	8E-09	3E-08	7E-08	2E-07	3E-09	1E-08	7E-08	2E-07
PESTICIDES/PCBs																		
Aroclor 1260	863 J	2,400 J	5E-07	1E-06	2E-08	6E-08	5E-07	1E-06	5E-07	1E-06	2E-08	6E-08	2E-07	5E-07	7E-09	2E-08	2E-07	5E-07
METALS(h)																		
Arsenic	7.1 J	13.2	4E-07	7E-07	2E-07	3E-07	4E-07	7E-07	5E-07	1E-06	2E-07	3E-07	1E-07	3E-07	6E-08	1E-07	2E-07	4E-07
Beryllium	0.73	1.3	4E-08	7E-08	2E-08	3E-08	4E-08	7E-08	6E-08	1E-07	2E-08	3E-08	1E-08	2E-08	6E-09	1E-08	2E-08	4E-08
Cadmium	2.1	8.3	1E-07	4E-07	5E-08	2E-07	1E-07	4E-07	2E-07	6E-07	5E-08	2E-07	4E-08	2E-07	2E-08	7E-08	6E-08	2E-07
Chromium	21.3	91.9	1E-06	5E-06	5E-07	2E-06	1E-06	5E-06	2E-06	7E-06	5E-07	2E-06	4E-07	2E-06	2E-07	8E-07	6E-07	3E-06
Copper	18.2 J	48.1	1E-06	3E-06	4E-07	1E-06	1E-06	3E-06	1E-06	4E-06	5E-07	1E-06	3E-07	9E-07	2E-07	4E-07	5E-07	1E-06
Lead	21.7 J	67.2	1E-06	4E-06	5E-07	2E-06	1E-06	4E-06	2E-06	5E-06	5E-07	2E-06	4E-07	1E-06	2E-07	6E-07	6E-07	2E-06
Zinc	163.5	608	9E-06	3E-05	4E-06	1E-05	9E-06	3E-05	1E-05	5E-05	4E-06	1E-05	3E-06	1E-05	1E-06	5E-06	5E-06	2E-05

NOTES:

- Soil concentrations from Table 4-18.
- Calculated using half the sample quantification detection limit where not detected. The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
- Dose averaged over exposure duration.
- Dose averaged over lifetime.
- Absorbed Dose = (Soil conc. * CF * Skin surface area * Adherence factor * Absorption factor * Exposure frequency * Exposure duration)/(Body weight * Averaging time) See Table 4-6 for variable values.
- Ingested Dose = (Soil conc. * CF * Ingestion Rate * Fraction ingested * Exposure frequency * Exposure duration)/(Body weight * Averaging time) See Table 4-6 for variable values.
- Total Dose = Absorbed Dose + Ingested Dose
- All metals are total metals.
- J = Estimated data due to quality control criteria.

4.5.5 Risk Characterization

The human health risk from possible exposure to contaminants was characterized in three parts: a comparison of contaminant concentrations to ARARs, a comparison of estimated human doses with reference dose levels, and a calculation of increased lifetime cancer risk. Contaminant concentrations in groundwater samples were compared to federal and state MCLs and federal MCLGs. The total dose estimates for non-carcinogens, from dermal and ingestion exposures to site soils, were compared to chemical-specific reference doses to get a hazard index for the site. The incremental cancer risk from dermal and ingestion exposures to site soils was then estimated by multiplying the dose estimate for carcinogens by the slope factors for the carcinogens.

4.5.5.1 Comparison with Applicable or Relevant and Appropriate Requirements (ARARs).

No organic compounds were detected in groundwater from Site 5. Both the federal and the state MCLs and federal MCLGs for chromium, nickel and lead were exceeded in unfiltered groundwater (Table 4-21).

Metals were primarily detected in the unfiltered sample. Only mercury and manganese were detected in their soluble forms, neither of which exceeded ARARs. Contaminants detected in the unfiltered groundwater sample are expected to include chemicals in the filtered samples, as well as chemicals sorbed to soil particulates and naturally occurring metals in soils. As a result, unfiltered groundwater generally shows higher concentrations of contaminants. Filtered groundwater in which particles are screened out, is generally more indicative of concentrations likely to be found if groundwater from the sites under investigation is used as a potable water supply because the water well would be developed to minimize particulates in the groundwater.

4.5.5.2 Comparison with Reference Doses. Non-carcinogenic dose estimates from exposures to soils at Site 5 were compared to reference dose values as presented in Table 4-22. The resulting hazard ratios were summed to arrive at an upper-bound site hazard index for both mean

TABLE 4-21. SITE 5 - GROUNDWATER COMPARISON WITH ARARs
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	MAXIMUM GROUNDWATER CONCENTRATION (a)	DRINKING WATER STANDARDS (b):			MCL EXCEEDED(e)
		FEDERAL (c) MCL	MCLG	INDIANA (d) MCL	
METALS	UG/L	UG/L		UG/L	
Aluminum, Total	19,200				
Chromium, Total	193	100	100	100	yes
Copper, Total	53.4	1300 (f)	1300	1300 (f)	
Mercury, Soluble	0.32 J	2	2	2	
Mercury, Total	0.35 J	2	2	2	
Manganese, Soluble	433				
Manganese, Total	1,130				
Nickel, Total	164	100	100	100	yes
Lead, Total	36.4 J	15 (g)	0	15 (g)	yes
Vanadium, Total	50.7 J				
Zinc, Total	157.5				

NOTES:

- One groundwater sample taken at Site 5; results presented.
 - Standards described in Section 4.1.5.1. Values taken from Table 4-3.
No value is presented when a standard is not available.
 - Safe Drinking Water Act: MCL - Maximum Contaminant Level, MCLG - Maximum Contaminant Level Goal
 - Indiana Drinking Water Standards (MCLs) match the federal promulgated MCLs.
 - Considers federal and state MCLs
 - This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
 - This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
- J = Estimated data due to quality control criteria

TABLE 4-22. SITE 5 - RISK ESTIMATES - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

	TOTAL DOSE ESTIMATES (mg/kg/day) (a):			CHRONIC ORAL RfD ^(b) (mg/kg/day)	ORAL SLOPE FACTOR ^(b) / (mg/kg/day)	HAZARD RATIO ^(c)		CANCER RISK ^(d)	
	MEAN	MAX	MEAN			MEAN	MAX	MEAN	MAX
VOLATILE ORGANICS									
Toluene	3E-09	3E-09	1E-09	2.0E-01		1E-08	1E-08		
1,2-Dichlorobenzene	2E-07	2E-07	8E-08	9.0E-02		3E-06	3E-06		
SEMIVOLATILE ORGANICS									
Di-n-Butylphthalate	3E-07	5E-07	1E-07	1.0E-01		3E-06	5E-06		
Butylbenzylphthalate	1E-07	1E-07	5E-08	2.0E-01		6E-07	6E-07		
bis(2-Ethylhexyl)phthalate	2E-07	6E-07	6E-08	2.0E-02	B2	8E-06	3E-05	8E-10	3E-09
Fluorene	1E-07	2E-07	5E-08	4.0E-02		3E-06	6E-06		
Acenaphthene	1E-07	3E-07	5E-08	6.0E-02		2E-06	4E-06		
Anthracene	2E-07	5E-07	6E-08	3.0E-01		5E-07	2E-06		
Phenanthrene	6E-07	3E-06	2E-07	1E-06					
Pyrene	5E-07	3E-06	2E-07	3.0E-02		2E-05	1E-04		
Fluoranthene	9E-07	6E-06	3E-07	4.0E-02		2E-05	1E-04		
Benzo(a)anthracene	4E-07	2E-06	1E-07	7E-07	B2	7.3E-01		1E-07	5E-07
Chrysene	4E-07	2E-06	1E-07	8E-07	B2	7.3E-03		1E-09	6E-09
Benzo(b)fluoranthene	5E-07	3E-06	2E-07	1E-06	B2	7.3E-01		1E-07	8E-07
Benzo(a)pyrene	5E-07	3E-06	2E-07	1E-06	B2	7.3E+00		1E-06	8E-06
Benzo(k)fluoranthene	5E-07	3E-06	2E-07	1E-06	B2	7.3E-02		1E-08	7E-08
Indeno(1,2,3-cd)pyrene	4E-07	2E-06	1E-07	8E-07	B2	7.3E-01		1E-07	6E-07
Benzo(g,h,i)perylene	4E-07	2E-06	1E-07	8E-07					
Dibenzo(a,h)anthracene	2E-07	7E-07	7E-08	2E-07	B2	7.3E+00		5E-07	2E-06
PESTICIDES/PCBs									
Aroclor 1260	5E-07	1E-06	2E-07	5E-07	B2	7.7E+00		1E-06	4E-06
METALS ^(e)									
Arsenic	5E-07	1E-06	2E-07	3.0E-04	A	1.75E+00	3E-03	3E-07	6E-07
Beryllium	6E-08	1E-07	2E-08	5.0E-03	B2	4.3E+00	2E-05	9E-08	2E-07
Cadmium	2E-07	6E-07	6E-08	5.0E-04 ^(h)			3E-04	1E-03	
Chromium	2E-06	7E-06	6E-07	5.0E-03 ⁽ⁱ⁾			3E-04	1E-03	
Copper	1E-06	4E-06	5E-07	3.7E-02			4E-05	1E-04	
Lead	2E-06	5E-06	6E-07	2E-06					
Zinc	1E-05	5E-05	5E-06	2E-05					
					HAZARD INDEX ^(f) :	4E-05	2E-04	ILCR ^(g) :	
						3E-03	7E-03	4E-06	2E-05

NOTES:

- a. Total dose estimates taken from Table 4-20.
b. Values taken from Table 4-2. Weight of evidence given with slope factor for carcinogens.
c. Hazard Ratio = Total Dose Estimate / RfD
d. Cancer Risk = Total Dose Estimate * Slope Factor
e. All metals are total metals.
f. Hazard Index = Sum (Chemical-specific Hazard Ratios)
g. Increased Lifetime Cancer Risk = Sum (Chemical-specific Cancer Risks)
h. RfD for water ingestion used.
i. RfD for chromium VI used.

and maximum concentrations. These hazard indexes are well below one and no adverse, non-carcinogenic health effects are expected from exposures to Site 5 soils.

4.5.5.3 Estimation of Cancer Risk. The cancer risk estimates generated for dermal and ingestion exposure to Site 5 soil are also presented in Table 4-22. For maximum soil concentrations, the total estimated increased lifetime cancer risk is 2×10^{-5} , while the risk for mean soil concentrations is 4×10^{-6} . Only arsenic was also detected in background soil. The risk estimate generated for the background concentration is approximately two times smaller (Section 4.8.5.3). As a result, the estimated site risk is considered predominantly site attributable. Both estimates are within EPA's target risk range of 1×10^{-4} to 1×10^{-6} .

4.5.6 Environmental Risk Evaluation

No threatened or endangered species or critical habitats were identified at Site 5 or within the vicinity of the base. This was addressed on a base-wide level in Section 4.1.6. No surface water is present at Site 5, and no comparison to AWQC was possible. Contamination at Site 5 poses no apparent threat to the environment at Site 5 or within the immediate vicinity of the base.

4.5.7 Limitations and Uncertainty

The risks from exposure to Site 5 contaminants have been reasonably well characterized and conservatively estimated, as appropriate for a screening level assessment. See additional information in Section 4.1.7.

4.5.8 Summary

Most of the contaminants of concern detected at Site 5 are persistent, sorbing strongly to soil.

The Ammunition Area well, which is no longer in use, is the only water supply well located within a mile downgradient of Site 5. None of the metals detected at this well were elevated

above background or exceeded ARARs. At Site 5, concentrations of chromium, nickel, and lead in unfiltered site groundwater exceeded state and federal MCLs and federal MCLGs. No future residential use of Site 5 is expected. Site 5 is the location of the motor pool and is presently used by base personnel, but contact with site soil is limited. Future exposure to workers involved in excavation activities is likely during utilities and tank servicing and was thought to pose the greatest potential exposure pathway to site soil contaminants. The dermal absorption and incidental ingestion of contaminants resulting from worker contact with site soil was estimated. No adverse non-carcinogenic health effects are expected from worker exposure to Site 5 soil. The maximum cancer risk estimate from this exposure, 2×10^{-5} , is considered predominantly site attributable and is within the U.S. EPA target risk range.

No threatened, rare, or endangered species were identified at Site 5 or in the vicinity of the base. The closest environmentally sensitive area is approximately one mile northwest of the base.

4.6 SITE 6 - HANGAR BUILDING NO. 1

Approximately half of Site 6 is covered with grass and some gravel. The other half is covered by a concrete vault (Figure 3-21). A runoff drain is located at a low point in the grassy area. Contamination was detected in soil and sediment samples at Site 6. The monitoring well for Site 6 (MW6-03) was placed southwest of the site on the opposite side of building 1. Because of the distance from the site to MW6-03, the shallowness of the groundwater, and the unknown foundation depth of building 1, any resulting contamination from Site 6 may not be fully characterized by Site 6 groundwater data. This is also indicated by the fact that many water soluble contaminants found in soil and sediment samples were not detected in groundwater (Table 3-15). Volatile organic compounds, semi-volatile organic compounds, TPH and metals were detected in sediments, surface soil, and subsurface soils at Site 6. One trace semi-volatile organic compound and metals were detected in groundwater. Pesticides and one PCB were detected in surface soil samples only.

4.6.1 Identification of Contaminants of Concern

Mean and maximum concentrations of potential contaminants of concern for Site 6 are presented in Table 4-23. All contaminants detected in sediment and groundwater samples were considered contaminants of concern. Background concentrations of contaminants were considered during the risk characterization for any exposure quantitatively assessed. The quantitative exposure assessment focused on those contaminants in soil, the media for which there were adequate data for a quantitative assessment. Therefore, further screening of the contaminants of concern based on background concentrations focused on soil contaminants only. Seven analytes were eliminated as contaminants of concern in soils because they were not detected above background levels at the site: DDT, barium, cobalt, manganese, nickel, vanadium, and zinc (Table 3-15). These analytes were not included in the soil exposure calculations for Site 6.

4.6.2 Properties of Contaminants of Concern

The contaminants of concern for Site 6 include infrequently detected mobile organic compounds, and a number of analytes considered to be persistent in the environment with a high tendency to sorb to soil. These contaminants include a variety of systemic and carcinogenic toxins.

4.6.2.1 Physical and Chemical Properties of Contaminants of Concern. Volatile organic compounds, phenolic compounds, phthalate esters, PAHs, other semi-volatile organic compounds, pesticides/PCBs, and metals were detected at Site 6, mostly in soil and sediment. The physical and chemical parameters for these contaminants, as summarized in Table 4-1, indicate that most of the contaminants found tend to be persistent in soil and sediment. Most are not highly soluble in water and do not volatilize readily. The volatile organic compounds detected were all detected in soil samples and tend to migrate more rapidly in groundwater and volatilize readily.

4.6.2.2 Toxicity Profiles. The contaminants found at Site 6 can be absorbed by humans via ingestion, dermal contact, and inhalation. Exposures to high enough levels of the contaminants could result in a variety of systemic and carcinogenic effects (Table 4-2).

TABLE 4-23. SITE 6 - POTENTIAL CONTAMINANTS OF CONCERN
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)										
PARAMETER	SOIL CONCENTRATION (b)			SEDIMENT(d)	GROUNDWATER CONCENTRATION (e)					
	MAXIMUM	MEAN (c)	NUMBER OF DETECTIONS		MAXIMUM	MEAN (c)	NUMBER OF DETECTIONS			
VOLATILE ORGANICS	UG/KG			UG/KG						
Carbon Disulfide	210 J	26.2 J	1 / 10	8						
1,2-Dichloroethene (total)	790	118 J	2 / 10							
Trichloroethene	60	60 J	3 / 11							
Tetrachloroethene	31 J	31 J	2 / 10							
1,2-Dichlorobenzene	68 J	68 J	1 / 11							
Toluene	2 J	2 J	1 / 10							
SEMIVOLATILE ORGANICS	UG/KG			UG/KG	UG/L					
2-Chlorophenol	76 J	76 J	1 / 11	1,200 J 700 J						
Benzoic acid	53 J	53 J	1 / 6							
Acenaphthene	810 J	283 J	8 / 11							
Dibenzofuran	400 J	247 J	5 / 11							
Diethylphthalate	270 J	270 J	3 / 11							
Naphthalene	72 J	72 J	3 / 11	1,400 J 24,000 3,100 J						
2-Methylnaphthalene	40 J	40 J	1 / 11							
Carbazole	420 J	243 J	4 / 5							
Fluorene	940 J	287 J	8 / 11							
Phenanthrene	11,000	2,265 J	10 / 11							
Anthracene	1,900 J	416 J	8 / 11	39,000 33,000	0.60 J	0.6 J	1 / 2			
Di-n-Butylphthalate	4,700	1,068 J	5 / 11							
Fluoranthene	17,000	3,629 J	10 / 11							
Pyrene	9,000	2,353 J	10 / 11							
Butylbenzylphthalate	1,500 J	641 J	7 / 11							
Benzo(a)anthracene	5,300	1,111	5 / 11	10,000						
Chrysene	6,500	1,632 J	10 / 11	21,000						
bis(2-Ethylhexyl)phthalate	88 J	88 J	1 / 11	23,000 16,000 14,000 13,000						
Benzo(b)fluoranthene	4,600	1,355 J	10 / 11							
Benzo(k)fluoranthene	4,400	1,218 J	10 / 11							
Benzo(a)pyrene	5,300	1,422 J	10 / 11							
Indeno(1,2,3-cd)pyrene	3,900	964 J	8 / 11							
Dibenzo(a,h)anthracene	1,100 J	504 J	10 / 11	15,000						
Benzo(g,h,i)perylene	4,200	1,119 J	10 / 11							
PESTICIDES/PCB'S	UG/KG									
gamma-BHC (Lindane)	0.82 J	0.82 J	1 / 11							
Endosulfan II	2.4 J	2.4 J	4 / 11							
4,4'-DDT	1.6 J	1.6 J	1 / 11							
Methoxychlor	9.6 J	9.6 J	3 / 11							
alpha-Chlordane	1.6 J	1.6 J	1 / 11							
gamma-Chlordane	1.6 J	1.6 J	1 / 11							
Aroclor-1260	190	190	2 / 11							
METALS (f)	MG/KG			MG/KG	UG/L					
Aluminum, Total	17,200	9,481	11 / 11	4,510	54,200	40200 J	2 / 2			
Arsenic, Total	14.2 J	7.0 J	11 / 11	6.2 J	552	471.5	2 / 2			
Barium, Total	142	107	11 / 11	86.5						
Beryllium, Total	1.05	0.7	6 / 11	8.9						
Cadmium, Total	9.1	2.5	6 / 11							
Cobalt, Total	11.8	7.4	5 / 11							
Chromium, Total	26.7	14.5	11 / 11	17.4	94.8	86	2 / 2			
Copper, Total	89.7 J	30.1 J	11 / 11	62.2	134	115	2 / 2			
Mercury, Soluble					0.8	0.56 J	2 / 2			
Mercury, Total					0.23 J	0.23 J	1 / 2			
Manganese, Soluble					546	540	2 / 2			
Manganese, Total	740	435 J	11 / 11	880	1,670	1430	2 / 2			
Nickel, Total	26.45	15.2	11 / 11	16.8	110	90	2 / 2			
Lead, Total	260.5	60.3 J	11 / 11	114	38.7 J	30 J	2 / 2			
Vanadium, Total	33.2	22.6	11 / 11		107	89	2 / 2			
Zinc, Soluble					45	27.5	1 / 2			
Zinc, Total	102	69.7	11 / 11	270 J	235	175.5	2 / 2			

NOTES:

- Analyses: volatile organics, semivolatile organics, pesticides/PCBs, metals, and total petroleum hydrocarbons for all media (Table 2-3). Analytes not presented were not detected in any media sampled or were screened out (sec. 4.1.1). No value presented means not detected, except for metals (see f.).
- Eleven soil samples total: two samples each from two borings and seven surface soils (five of the surface soils taken during Round 2).
- Calculated using the mean of duplicate samples and half the sample quantification detection limit where not detected. The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
- Only one sample for sediment; results presented. No surface water sample taken at Site 6.
- Two groundwater samples total from the Site 6 monitoring well, one taken during each of the two sampling rounds.
- Soluble metals analysis not run on sediments and soils. Both soluble and total metals analyzed for groundwater.

J = Estimated data due to quality control criteria.

Drums formerly located at Site 6 were reportedly used for the disposal of waste solutions, many of which are expected to be partially composed of solvents. Also, stoddard solvent was stored at Site 6. This past site usage in addition to a number of tentatively identified compounds during Round 1 and 2 indicate that additional volatile organic compounds may be present that were not analyzed for. The tentatively identified compounds in Site 6 soil showed elevated concentrations of alkanes. Alkanes in general have a variety of toxicologic effects and can be absorbed by inhalation, ingestion, and dermal contact. Many are central nervous system depressants, but other effects include neurotoxicity and pulmonary edema (Clayton, 1981). No alkanes are known to be carcinogenic (Clayton, 1981). Detailed descriptions of the toxicological properties of Site 6 contaminants are available in Appendix G.

4.6.3 Identification of Receptors

The most probable receptors of site contaminants were identified by characterizing potentially exposed populations, and current and potential future specific site land use.

4.6.3.1 Populations. Presently, no employees regularly work at the site. However, non-routine maintenance of utilities or construction activities seem probable.

The base is not used residentially. Adults are allowed to bring children to the base. Both of the outdoor recreational areas are adjacent to the Background Area, 400 feet from Site 6. Site 6 is in a high traffic area, adjacent to the access road to the base, a parking lot, and two buildings. People pass through it to get to or from buildings 17, 5, and 1. Although children brought to the base by an adult might also pass through Site 6, it seems unlikely that a child would play or spend much time in the area. The proximity of a parking lot and a road make Site 6 an unlikely area in which to leave a child unattended.

Localized groundwater flow at Site 6 is generally to the south. Water level measurements taken on different dates showed variation to the south-southeast and southwest. No one is presently using the groundwater at Site 6. The Ammunition Area well (Well No. 530), the closest

downgradient well, is located within a mile of the site (Figure 4-1). Employees at the Ammunition Area used this well as a potable water supply until 1990.

4.6.3.2 Land Use. During the field activities of the SI, it became apparent that a number of underground utilities are present at Site 6. Many of the utilities for hangar building 1 pass through this site. The paved portion of Site 6 is a driveway for a loading dock area for building 1. Drums of waste chemicals have been stored in this area in the past.

The groundwater at Site 6 is not used presently nor does future use seem likely. The groundwater used within a mile of the site is generally drawn from below the dense till which acts as an aquitard located beneath the base, limiting the impact of potential contamination of the shallow groundwater at the base.

As noted in Section 4.1.3, residential development of the base is neither anticipated nor recommended. Based on this information, this preliminary risk evaluation assumes that the base will remain non-residential in the future. Therefore, potential future land use at Site 6 is expected to be the same as current land use and separate evaluations are not presented for current and potential future land use.

4.6.4 Exposure Assessment

The exposure assessment began with a screening of the possible exposure pathways for Site 6. Those pathways of concern with inadequate chemical data for a quantitative assessment were discussed qualitatively. Those pathways of concern for which there was adequate data, were evaluated quantitatively. For the quantitative evaluations, an exposure scenario was developed and a dose was estimated based on the assumptions used in the scenario.

4.6.4.1 Exposure Pathway Screening. Factors influencing exposure focused on chemical and physical contaminant factors, environmental conditions, and population characteristics for each potential route of exposure, as presented in Table 4-24.

TABLE 4-24. SITE 6 - EXPOSURE PATHWAY SCREENING

ROUTE OF EXPOSURE	FACTORS INFLUENCING EXPOSURE			ANALYSIS
	CHEMICAL/PHYSICAL	ENVIRONMENTAL	POPULATION	
GROUNDWATER: ingestion, inhalation, and dermal exposure from use as a potable water supply	-Volatiles, semivolatiles, pesticides, PCBs, and metals analyzed -Pyrene detected at trace levels -Most metals elevated above background concentrations -Lead concentrations were elevated in comparison to background -Mercury, nickel, and vanadium were not found in background groundwater, but were in Site 6 groundwater	-Source area is partially paved, grass-covered, and bare -Site groundwater is 1 to 2 ft below grade -Surficial groundwater flow at Site 6 varies, flowing SW and SE -Overlying clayey silt loess unit may partially confine water in upper sediments -No surface water discharge point for groundwater was identified downgradient	-One well located to the SSW of Site 6 in the ammunition depot was used as a water supply until 1990 -No other wells are located within one mile downgradient of Site 6 -The 5 wells within a 1 mile radius are E of the Base and are typically screened from 45 to 60 ft below grade	Comparison with ARARs only
SURFACE RUNOFF/ SEDIMENTS: ingestion, inhalation, and dermal exposure from recreational use or accidental exposure at discharge point or during maintenance	-Volatiles, semivolatiles, pesticides, PCBs, and metals analyzed -No surface water sample collected -One trace volatile detected in sediment -Thirteen PAHs and dibenzofuran detected at concentrations ranging from trace to 39,000 ppb in sediments -Metals detected in sediments elevated relative to background concentrations	-Site surface runoff migrates to drainage basin which connects with drainage ditch runoff to the W -Storm event may transport some site surface soil, especially from the barren areas	-There are 325 Base employees -No one resides on Base -Site 6 was used as a drum storage area and is in a highly traversed area -Site 6 is accessible to all people on the Base; the entire Base is secured by a fence -Children are allowed on the Base; there are no recreational areas near Site 6, exposure unlikely -Worker exposure to site soils expected to represent maximum exposure	Qualitative analysis only

TABLE 4-24 (cont.). SITE 6 - EXPOSURE PATHWAY SCREENING

ROUTE OF EXPOSURE	FACTORS INFLUENCING EXPOSURE			ANALYSIS
	CHEMICAL/PHYSICAL	ENVIRONMENTAL	POPULATION	
SURFACE SOIL (SS) and SUB-SURFACE SOIL (SSS): dermal and ingestion exposures from excavation	-Volatiles, semivolatiles, pesticides, PCBs, and metals analyzed -Volatiles, up to 790 ppb 1,2-DCE, were detected in SSS while trace volatiles also detected in SS -A variety of semivolatiles, mostly PAHs and phthalates, were detected in SS and SSS from trace concentrations to 17 ppm -Semivolatiles sorb to soil -Low levels of 5 pesticides and Aroclor 1260 detected in SS only -Some metals elevated relative to background concentrations -Beryllium and cadmium detected in site soils - and not in background soils -SS lead elevated over background	-Source area is partially paved, grass-covered, and bare -Clay and silt was encountered to 15 ft during well installation	-There are 325 Base employees -No one resides on Base -No construction is presently planned for the site -Utilities located at the site may require excavation at some time -Personnel regularly use the site and it is located in a high traffic area -Access to the Base is limited, but access to Site 6 is open to anyone on the Base -Children are allowed on the Base but would not be present during excavation -Worker exposure to site soil expected to represent maximum exposure	Quantitative assessment of worker's dermal and ingestion exposures to soil during excavation
SURFACE SOIL (SS) and SUB-SURFACE SOIL (SSS): inhalation of dust and volatiles from excavation of soil	-Volatiles, semivolatiles, pesticides, PCBs, and metals analyzed -Volatiles, up to 790 ppb 1,2-DCE, were detected in SSS while trace volatiles also detected in SS -A variety of semivolatiles, mostly PAHs and phthalates, were detected in SS and SSS from trace concentrations to 17 ppm -Semivolatiles sorb to soil -Low levels of 5 pesticides and Aroclor 1260 detected in SS only -Some metals elevated relative to background concentrations -Beryllium and cadmium detected in site soils and not in background soils -SS lead elevated over background	-Source area is partially paved, grass-covered, and bare -Annual precipitation in the area averages about 40 inches -Clay and silt was encountered to 15 ft during well installation -Wind is generally out of the S at 9 mph	-There are 325 Base employees -No one resides on Base -No construction is presently planned for the site -Utilities located at the site may require excavation at some time -Personnel regularly use the site and it is located in a high traffic area -Access to the Base is limited, but access to Site 6 is open to anyone -Children are allowed on the Base but would not be present during excavation -Worker exposure to site soil expected to represent maximum exposure	Qualitative analysis only

Groundwater. Two groundwater samples were collected at the Site 6 monitoring well (MW6-03), one sample was collected during each of the two sampling rounds in November, 1990, and January, 1992. However, due to the variation in groundwater flow, MW6-03 may have been downgradient of the site only during Round 2. In the groundwater sample collected at MW6-03 during sampling Round 2, one trace semi-volatile organic, pyrene, was detected. Although most metals were only detected in unfiltered groundwater, some concentrations were elevated above background. Metals not detected in background groundwater that were found in Site 6 groundwater include mercury, nickel, and vanadium.

During sampling Round 1, in November, 1990, the monitoring well at Site 5 (MW5-02), may have been located downgradient of Site 6, due to possible variation in groundwater flow direction to the southwest and south-southeast. Groundwater contamination in monitoring well (MW5-02) (Section 4.5.5.1) showed elevated metal concentrations. No exposure seems likely because groundwater is not used at Site 6 and the closest downgradient well in the Ammunition Area, which is no longer in use, showed no contamination, so no calculation of dose was warranted. However, because potable water wells are located within a mile of the site, detected concentrations of all chemicals in groundwater, except for those screened out in Section 4.1.1, were evaluated by comparison to drinking water standards (Section 4.6.5.1).

Sediment and Runoff. Although not sampled, it is possible that runoff generated during storm events is contaminated as indicated by the contaminated sediments around the storm drain. Potential exposure to contaminated runoff and sediments is discussed qualitatively.

This discussion focuses on two potential exposures to runoff and/or sediment from Site 6, both on-site and following migration off-site. Sediment concentrations of PAHs were often two to five times the maximum detected concentration in soil samples. Evaluation of worker risk from exposures to maximum soil concentrations using highly conservative exposure assumptions was expected to account for an infrequent worker exposure to sediments in addition to soils. Exposures to people other than workers were expected to be incidental in nature resulting in a much lower risk than that for workers. The evaluation of worker exposure to Site 6 soil incorporated a number of highly conservative assumptions. Additional risk from infrequent

exposure to sediment as compared to soil is expected to be relatively minimal. Sediment data can be included in the soil exposure calculations, however, this would be very conservative since exposure to sediment is expected to be substantially less frequent. Therefore, sediment data was not included here. This evaluation was thought to conservatively address the exposures presenting the greatest risk.

The runoff from the site goes to the drain in the grassy area of the site, where the sediment sample was collected. The base utilities map indicated that this drain is connected to the base surface water drainage system. This system is reported to eventually combine base runoff and direct it west and off-site, toward the Wabash River. Although some Site 6 contaminants are expected in the site runoff during storm events, the dilution from the combination of base-wide runoff is expected to be a significant factor in reducing possible contaminant concentrations. Also, particulates were expected to settle out over the more than two miles to the Wabash River.

Soil. Site 6 is in a high traffic area with buildings nearby and underground utilities located at the site. The employees walking through Site 6 or using the adjacent loading area are exposed to Site 6 soils where the site is not covered with grass. Based on the presence of underground utilities, exposure of workers to contaminated soil during excavation activities seems likely. A worker involved in excavation is expected to be the maximally exposed individual, and this exposure was evaluated quantitatively. Exposures by inadvertent soil ingestion due to hand-to-mouth contact and absorption through the skin during dermal contact were quantified to evaluate risk to workers exposed to contaminated soils during routine maintenance of utilities. Exposures to workers were evaluated rather than those for children because workers have the potential to be exposed on a much more frequent basis than children and were expected to represent the worst case scenario or the population at greatest risk.

Air. Exposures to chemicals volatilized into air or inhaled on dust particles were not quantified in this screening level analysis. Dust generation was not expected to be significant during the limited digging required for utilities servicing and due to groundwater 1 to 2 feet below grade. Contamination of soil by volatile organic compounds was detected to a limited extent (790 $\mu\text{g}/\text{kg}$ of 1,2-dichloroethene). During Round 1, the presence of tentatively identified compounds,

elevated detection limits, and the sampling FID results (Section 3.7) indicated that the soil data may have been incomplete.

Volatile organic compound concentrations detected in soil summed to approximately 1 ppm. Prior investigation involving volatile organic compounds in soils indicates that, because of dilution and dispersion in ambient air, this concentration would result in rather minimal air concentrations. These air concentrations would only be of concern if exposure continued over an extended period. No employees are presently working at the site regularly and long-term exposures were not expected from present site usage. The grass cover and pavement over most of Site 6 is also expected to limit volatile emissions from site soils. During excavation, volatilization of contaminants from soil would be maximized and dispersion would be minimized in an excavation. The assumptions used to estimate dermal absorption and incidental soil ingestion are very conservative and were expected to account for some of the additional inhalation exposure to workers.

A second round of surface soil sampling occurred in January, 1992, to fully characterize volatile contamination and the aerial extent of soil contamination at the site. The second round of surface soil samples showed low levels or no presence of volatile organic compounds. The semi-volatile organic compounds detected in Site 6 soils do not readily volatilize from soil. Exposure to surface soil only was not expected to result in a significant additional exposure to workers.

4.6.4.2 Development of Exposure Scenario. The exposure scenario modeled was that of an adult worker at the base that comes in contact with surface and subsurface soils at Site 6 due to periodic excavations at the site. Exposure assumptions included employment at the base over 25 years, during which time an average of 12 days per year involve some excavation at Site 6. Excavation activities could involve digging up utilities, putting in new sidewalks, or lawn-care activities. Soil ingestion occurs from hand-to-mouth contact, such as eating or smoking, after soil contact. For adult workers, 50 mg/day was the rate used to estimate the incidental soil ingestion resulting from hand-to-mouth contact with dirty hands. An additional worker exposure results from direct contact of skin with contaminated soil. To evaluate dermal exposure, it was

assumed that a typical worker wears a shirt with no sleeves and an open neck, pants, shoes, and no gloves or hat. The exposed skin was assumed to come in contact with contaminated soil.

4.6.4.3 Calculation of Dose. Dose for these pathways was estimated using U.S. EPA Risk Assessment Guidance for Superfund (December 1989). The following equation was used for dermal absorption from soil:

$$\text{Absorbed Dose (mg/kg/day)} = \frac{\text{CS} \times \text{CF} \times \text{SA} \times \text{AF} \times \text{ABS} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

A similar equation was used for incidental ingestion of soil:

$$\text{Ingested Dose (mg/kg/day)} = \frac{\text{CS} \times \text{CF} \times \text{IR} \times \text{FI} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Values and definitions for the variables used in each equation are presented in Table 4-6. The dose estimates generated using these equations for the contaminants in Site 6 soil are presented in Table 4-25. The dose estimated for dermal absorption exceeds that for ingestion by approximately a factor of two for metals, a factor of twenty for semi-volatile organic compounds, and two orders of magnitude for volatile organic compounds.

4.6.5 Risk Characterization

The human health risk from possible exposure to contaminants was characterized in three parts: a comparison of contaminant concentrations to ARARs, a comparison of estimated human doses with reference dose levels, and a calculation of increased lifetime cancer risk. Contaminant concentrations in groundwater samples were compared to federal and state MCLs and federal

TABLE 4-25. SITE 6 - DOSE ESTIMATES - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

	DOSE ESTIMATES (mg/kg/day):									
	SOIL CONCENTRATIONS(a)		NON-CARCINOGENIC(c)				CARCINOGENIC(d)			
			MEAN(b)	MAX	ABSORPTION(e)	INGESTION(f)	TOTAL(g)	MEAN	MAX	TOTAL(g)
VOLATILE ORGANICS		UG/KG								
1,2-Dichloroethene (total)	118 J	790	3E-07	2E-06	3E-09	2E-08	3E-07	2E-06	2E-07	1E-07
Trichloroethene	60	60	2E-07	2E-07	1E-09	1E-09	2E-07	2E-07	2E-07	6E-08
Tetrachloroethene	31 J	31 J	8E-08	8E-08	7E-10	7E-10	8E-08	8E-08	3E-10	3E-08
Carbon Disulfide	26.2 J	210 J	7E-08	6E-07	6E-10	5E-09	7E-08	6E-07	2E-09	3E-08
Toluene	2 J	2 J	5E-09	5E-09	5E-11	5E-11	5E-09	5E-09	2E-11	2E-09
1,2-Dichlorobenzene	68 J	68 J	2E-07	2E-07	2E-09	2E-09	2E-07	2E-07	6E-10	7E-08
SEMIVOLATILE ORGANICS		UG/KG								
Benzoic acid	53 J	53 J	3E-08	3E-08	1E-09	1E-09	3E-08	3E-08	4E-10	1E-08
2-Chlorophenol	76 J	76 J	4E-08	4E-08	2E-09	2E-09	4E-08	4E-08	6E-10	2E-08
Diethylphthalate	270 J	270 J	1E-07	1E-07	6E-09	6E-09	2E-07	2E-07	2E-09	5E-08
Di-n-Butylphthalate	1,068 J	4,700	6E-07	3E-06	3E-08	1E-07	6E-07	3E-06	9E-07	2E-07
Butylbenzylphthalate	641 J	1,500 J	3E-07	8E-07	2E-08	4E-08	4E-07	8E-07	5E-09	1E-07
bis(2-Ethylhexyl)phthalate	88 J	88 J	5E-08	5E-08	2E-09	2E-09	5E-08	5E-08	7E-10	2E-08
Naphthalene	72 J	72 J	4E-08	4E-08	2E-09	2E-09	4E-08	4E-08	6E-10	1E-08
2-Methylnaphthalene	40 J	40 J	2E-08	2E-08	9E-10	9E-10	2E-08	2E-08	3E-10	8E-09
Carbazole	243 J	420 J	1E-07	2E-07	6E-09	1E-08	1E-07	2E-07	2E-09	5E-08
Dibenzofuran	247 J	400 J	1E-07	2E-07	6E-09	9E-09	1E-07	2E-07	2E-09	5E-08
Fluorene	287 J	940 J	2E-07	5E-07	7E-09	2E-08	2E-07	5E-07	2E-09	6E-08
Acenaphthene	283 J	810 J	2E-07	4E-07	7E-09	2E-08	2E-07	5E-07	2E-09	6E-08
Anthracene	416 J	1,900 J	2E-07	1E-06	1E-08	4E-08	2E-07	1E-06	3E-09	8E-08
Phenanthrene	2,265 J	11,000	1E-06	6E-06	5E-08	3E-07	1E-06	6E-06	2E-08	5E-07
Pyrene	2,353 J	9,000	1E-06	5E-06	6E-08	2E-07	1E-06	5E-06	2E-08	5E-07
Fluoranthene	3,629 J	17,000	2E-06	9E-06	9E-08	4E-07	2E-06	1E-05	3E-08	7E-07
Benzo(a)anthracene	1,111	5,300	6E-07	3E-06	3E-08	1E-07	6E-07	3E-06	9E-09	2E-07
Chrysene	1,632 J	6,500	9E-07	3E-06	4E-08	2E-07	9E-07	4E-06	1E-08	3E-07
Benzo(b)fluoranthene	1,355 J	4,600	7E-07	2E-06	3E-08	1E-07	8E-07	3E-06	1E-08	3E-07
Benzo(k)pyrene	1,422 J	5,300	8E-07	3E-06	3E-08	1E-07	8E-07	3E-06	1E-08	3E-07
Indeno(1,2,3-cd)pyrene	1,218 J	4,400	7E-07	2E-06	3E-08	1E-07	7E-07	2E-06	4E-08	2E-07
Benzo(g,h,i)perylene	964 J	3,900	5E-07	2E-06	2E-08	9E-08	5E-07	2E-06	8E-09	2E-07
Dibenzo(a,h)anthracene	1,119 J	4,200	6E-07	2E-06	3E-08	1E-07	6E-07	2E-06	9E-09	2E-07
	504 J	1,100 J	3E-07	6E-07	1E-08	3E-08	3E-07	6E-07	4E-09	1E-07

Continued

TABLE 4-25. SITE 6 - DOSE ESTIMATES - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

	SOIL CONCENTRATIONS(a) MEAN(b) MAX	DOSE ESTIMATES (mg/kg/day):						CARCINOGENIC(d)					
		NON-CARCINOGENIC(c)			TOTAL(g)			ABSORPTION(c)			INGESTION(f)		
		MEAN	MAX	MEAN	MEAN	MAX	MAX	MEAN	MAX	MAX	MEAN	MAX	MAX
PESTICIDES/PCB's gamma-BHC (Lindane) Endosulfan II Methoxychlor alpha-Chlordane gamma-Chlordane Aroclor 1260	UG/KG	0.82 J	0.82 J	4E-10	2E-11	2E-11	5E-10	2E-10	2E-10	7E-12	7E-12	2E-10	2E-10
	2.4 J	2.4 J	1E-09	1E-09	6E-11	6E-11	1E-09	5E-10	5E-10	2E-11	2E-11	5E-10	5E-10
	9.6 J	9.6 J	5E-09	5E-09	2E-10	2E-10	5E-09	2E-09	2E-09	8E-11	8E-11	2E-09	2E-09
	1.6 J	1.6 J	9E-10	9E-10	4E-11	4E-11	9E-10	3E-10	3E-10	1E-11	1E-11	3E-10	3E-10
	1.6 J	1.6 J	9E-10	9E-10	4E-11	4E-11	9E-10	3E-10	3E-10	1E-11	1E-11	3E-10	3E-10
	190	190	1E-07	1E-07	4E-09	4E-09	1E-07	4E-08	4E-08	2E-09	2E-09	4E-08	4E-08
METALS(h) Aluminum Arsenic Beryllium Cadmium Chromium Copper Lead	MG/KG	9,481	17,200	5E-04	2E-04	4E-04	7E-04	2E-04	3E-04	8E-05	1E-04	3E-04	5E-04
	7.0 J	14.2 J	4E-07	8E-07	2E-07	3E-07	5E-07	1E-07	3E-07	6E-08	1E-07	2E-07	4E-07
	0.7	1.05	4E-08	6E-08	2E-08	2E-08	6E-08	1E-08	2E-08	6E-09	9E-09	2E-08	3E-08
	2.5	9.1	1E-07	5E-07	6E-08	2E-07	2E-07	5E-08	2E-07	2E-08	8E-08	7E-08	3E-07
	14.5	26.7	8E-07	1E-06	3E-07	6E-07	1E-06	3E-07	5E-07	1E-07	2E-07	4E-07	7E-07
	30.1 J	89.7 J	2E-06	5E-06	7E-07	2E-06	2E-06	6E-07	2E-06	3E-07	8E-07	8E-07	2E-06
	60.3 J	260.5	3E-06	1E-05	1E-06	6E-06	5E-06	1E-06	5E-06	5E-07	2E-06	2E-06	7E-06

NOTES:

- a. Soil concentrations from Table 4-23.
b. Calculated using half the sample quantification detection limit where not detected. The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
c. Dose averaged over exposure duration.
d. Dose averaged over lifetime.
e. Absorbed Dose = (Soil conc. * CF * Skin surface area * Adherence factor * Absorption factor * Exposure frequency * Exposure duration)/(Body weight * Averaging time) See Table 4-6 for variable values.
f. Ingested Dose = (Soil conc. * C F * Ingestion Rate * Fraction ingested * Exposure frequency * Exposure duration)/(Body weight * Averaging time) See Table 4-6 for variable values.
g. Total Dose = Absorbed Dose + Ingested Dose
h. All metals are total metals.
J = Estimated data due to quality control criteria.

MCLGs. The total dose estimates for non-carcinogens from dermal and ingestion exposures to site soils, were compared to chemical-specific reference doses to get a hazard index for the site. The incremental cancer risk from dermal and ingestion exposures to site soils was then estimated by multiplying the dose estimate for carcinogens by the slope factors for the carcinogens.

4.6.5.1 Comparison with Applicable or Relevant and Appropriate Requirements (ARARs).

The Site 6 monitoring well (MW6-03) may have been downgradient of Site 6 only during Round 2. One trace semi-volatile organic, pyrene, was detected during Round 2 in the Site 6 groundwater sample, but no standard is available. The lead concentration in the unfiltered groundwater sample from MW6-03 during Round 2, did exceed the federally promulgated and state MCL, and the federal MCLG (Table 4-26).

Most metals were not detected in the filtered samples. Metals that were detected in the filtered samples include manganese, mercury and zinc, none of which exceeded ARARs. Contaminants detected in unfiltered groundwater are expected to include chemicals in the filtered sample, as well as chemicals sorbed to soil particulates and naturally occurring metals in soils. As a result, unfiltered groundwater generally shows higher concentrations of contaminants. Filtered groundwater in which particles are screened out, is generally more indicative of concentrations likely to be found if groundwater from the sites under investigation is used as a potable water source because the water well would be developed to minimize particulates in the groundwater.

During Round 1, the Site 5 monitoring well (MW5-02) may have been downgradient of Site 6 due to apparent variation in groundwater flow direction. Groundwater contamination at Site 5 (Section 4.5.5.1) was similar to that detected at Site 6. However, at Site 5, unfiltered groundwater also exceeded the federal and state MCLs and federal MCLGs for chromium and nickel. Only manganese and mercury were detected in the filtered groundwater.

4.6.5.2 Comparison with Reference Doses. In Table 4-27, the total doses for soil exposures, as calculated for non-carcinogenic toxicity, were divided by contaminant reference doses. The hazard ratios for all of the contaminants are well below one. Although not all of the contaminants have the same critical effect, the hazard ratios were summed to give an

TABLE 4-26. SITE 6 - GROUNDWATER COMPARISON WITH ARARs
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	MAXIMUM GROUNDWATER CONCENTRATION (a)	DRINKING WATER STANDARDS (b):			MCL EXCEEDED(e)
		FEDERAL (c) MCL	MCLG	INDIANA (d) MCL	
SEMIVOLATILE ORGANICS	UG/L	UG/L		UG/L	
Pyrene	0.6 J				
METALS	UG/L	UG/L		UG/L	
Aluminum, Total	54,200				
Barium, Total	552	2000	2000	2000	
Chromium, Total	94.8	100	100	100	
Copper, Total	134	1300 (f)	1300	1300 (f)	
Mercury, Soluble	0.8	2	2	2	
Mercury, Total	0.23 J	2	2	2	
Manganese, Soluble	546				
Manganese, Total	1,670				
Nickel, Total	110	100	100	100	yes *
Lead, Total	38.7 J	15 (g)	0	15 (g)	yes
Vanadium, Total	107				
Zinc, Soluble	45				
Zinc, Total	235				

NOTES:

- Maximum concentration presented for two groundwater samples.
 - Standards described in Section 4.1.5.1. Values taken from Table 4-3.
No value is presented when a standard is not available.
 - Safe Drinking Water Act: MCL - Maximum Contaminant Level, MCLG - Maximum Contaminant Level Goal
 - Indiana Drinking Water Standards (MCLs) match the federal promulgated MCLs.
 - Considers federal and state MCLs
 - This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
 - This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
- * = The MCL for nickel was exceeded only during the first sampling round at Site 6
J = Estimated data due to quality control criteria

TABLE 4-27. SITE 6 - RISK ESTIMATES - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

	TOTAL DOSE ESTIMATES (mg/kg/day) (a):				CHRONIC ORAL RfD ^(b) (mg/kg/day)	ORAL SLOPE FACTOR ^(b) / (mg/kg/day)	HAZARD RATIO ^(c)		CANCER RISK ^(d)	
	NON-CARCINOGENIC		CARCINOGENIC				MEAN	MAX	MEAN	MAX
	MEAN	MAX	MEAN	MAX						
VOLATILE ORGANICS										
1,2-Dichloroethene (total)										
Trichloroethene	3E-07	2E-06	1E-07	8E-07	1.0E-02 (h)	C-B2	3E-05	2E-04	6E-10	6E-10
Tetrachloroethene	2E-07	2E-07	6E-08	6E-08		C-B2	8E-06	8E-06	2E-09	2E-09
Carbon Disulfide	8E-08	8E-08	3E-08	3E-08	1.0E-02		7E-07	6E-06		
Toluene	7E-08	6E-07	3E-08	2E-07	1.0E-01		3E-08	3E-08		
	5E-09	5E-09	2E-09	2E-09	2.0E-01		2E-06	2E-06		
1,2-Dichlorobenzene	2E-07	2E-07	7E-08	7E-08	9.0E-02					
SEMIVOLATILE ORGANICS										
Benzoic acid	3E-08	3E-08	1E-08	1E-08	4.0E+00		7E-09	7E-09		
2-Chlorophenol	4E-08	4E-08	2E-08	2E-08	5.0E-03		9E-06	9E-06		
Diethylphthalate	2E-07	2E-07	5E-08	5E-08	8.0E-01		2E-07	2E-07		
Di-n-Butylphthalate	6E-07	3E-06	2E-07	9E-07	1.0E-01		6E-06	3E-05		
Butylbenzylphthalate	4E-07	8E-07	1E-07	3E-07	2.0E-01		2E-06	4E-06		
bis(2-Ethylhexyl)phthalate	5E-08	5E-08	2E-08	2E-08	2.0E-02	B2	2E-06	2E-06	2E-10	2E-10
Naphthalene	4E-08	4E-08	1E-08	1E-08	4.0E-02		1E-06	1E-06		
2-Methylnaphthalene	2E-08	2E-08	8E-09	8E-09						
Carbazole	1E-07	2E-07	5E-08	8E-08		B2			1E-09	2E-09
Dibenzofuran	1E-07	2E-07	5E-08	8E-08						
Fluorene	2E-07	5E-07	6E-08	2E-07	4.0E-02		4E-06	1E-05		
Acenaphthene	2E-07	5E-07	6E-08	2E-07	6.0E-02		3E-06	8E-06		
Anthracene	2E-07	1E-06	8E-08	4E-07	3.0E-01		8E-07	4E-06		
Phenanthrene	1E-06	6E-06	5E-07	2E-06						
Pyrene	1E-06	5E-06	5E-07	2E-06	3.0E-02		4E-05	2E-04		
Fluoranthene	2E-06	1E-05	7E-07	3E-06	4.0E-02		5E-05	2E-04		
Benzo(a)anthracene	6E-07	3E-06	2E-07	1E-06		B2			2E-07	8E-07
Chrysene	9E-07	4E-06	3E-07	1E-06		B2			2E-09	9E-09
Benzo(b)fluoranthene	8E-07	3E-06	3E-07	9E-07		B2			2E-07	7E-07
Benzo(a)pyrene	8E-07	3E-06	3E-07	1E-06		B2			2E-06	8E-06
Benzo(k)fluoranthene	7E-07	2E-06	2E-07	9E-07		B2			2E-08	6E-08
Indeno(1,2,3-cd)pyrene	5E-07	2E-06	2E-07	8E-07		B2			1E-07	6E-07
Benzo(g,h,i)perylene	6E-07	2E-06	2E-07	8E-07		B2				
Dibenzo(a,h)anthracene	3E-07	6E-07	1E-07	2E-07		B2			7E-07	2E-06

Continued

TABLE 4-27. SITE 6 - RISK ESTIMATES - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

	TOTAL DOSE ESTIMATES (mg/kg/day) (a):			CHRONIC ORAL RfD(b) (mg/kg/day)	ORAL SLOPE FACTOR(b) /(mg/kg/day)	HAZARD RATIO(c)		CANCER RISK(d)	
	NON-CARCINOGENIC		CARCINOGENIC			MEAN	MAX	MEAN	MAX
	MEAN	MAX	MEAN						
PESTICIDES/PCB's									
gamma-BHC (Lindane)	5E-10	5E-10	2E-10	3.0E-04	C-B2	2E-06	2E-06	2E-10	2E-10
Endosulfan II	1E-09	1E-09	5E-10	6.0E-03 (i)		2E-07	2E-07		
Methoxychlor	5E-09	5E-09	2E-09	5.0E-03		1E-06	1E-06		
alpha-Chlordane	9E-10	9E-10	3E-10	6.0E-05 (j)	B2	1E-05	1E-05	4E-10	4E-10
gamma-Chlordane	9E-10	9E-10	3E-10	6.0E-05 (j)	B2	1E-05	1E-05	4E-10	4E-10
Aroclor 1260	1E-07	1E-07	4E-08		B2	7.7E+00		3E-07	3E-07
METALS(e)									
Aluminum	7E-04	1E-03	3E-04	5E-04					
Arsenic	5E-07	1E-06	2E-07	4E-07	A	2E-03	4E-03	3E-07	7E-07
Beryllium	6E-08	8E-08	2E-08	3E-08	B2	1E-05	2E-05	9E-08	1E-07
Cadmium	2E-07	7E-07	7E-08	3E-07		4E-04	1E-03		
Chromium	1E-06	2E-06	4E-07	7E-07		2E-04	4E-04		
Copper	2E-06	7E-06	8E-07	2E-06		6E-05	2E-04		
Lead	5E-06	2E-05	2E-06	7E-06	HAZARD INDEX(f):	3E-03	6E-03	ILCR(g): 4E-06	1E-05

NOTES:

- a. Total dose estimates taken from Table 4-25.
b. Values taken from Table 4-2. Weight of evidence given with slope factor for carcinogens.
c. Hazard Ratio = Total Dose Estimate / RfD
d. Cancer Risk = Total Dose Estimate * Slope Factor
e. All metals are total metals.
f. Hazard Index = Sum (Chemical-specific Hazard Ratios)
g. Increased Lifetime Cancer Risk = Sum (Chemical-specific Cancer Risks)
h. RfD for 1,2-dichloroethene (dis) used.
i. RfD for Endosulfan used.
j. RfD for Chlordane used.
k. RfD for water ingestion used.
l. RfD for Chromium VI used.

upper-bound hazard index for the site. The hazard indexes are well below one for mean and maximum contaminant concentrations indicating that no adverse, non-carcinogenic effects are expected from exposures to Site 6 soils.

4.6.5.3 Estimation of Cancer Risk. Estimated Site 6 cancer risks are presented in Table 4-27. The estimated increased lifetime cancer risk from potential exposures to Site 6 soils are as follows: 4×10^{-6} for mean soil concentrations and 1×10^{-5} for maximum soil concentrations. The site cancer risk for these pathways is primarily attributable to carcinogenic PAHs, as seen from the chemical-specific cancer risk estimates for these compounds. Two carcinogens evaluated, tetrachloroethene and arsenic, were also detected in background soils. The risk estimates generated for the background concentrations are approximately 2.5 to 60 times smaller (Section 4.8.5.3). As a result, the estimated site risk is considered predominantly site attributable. Both mean and maximum cancer risk estimates are within the U.S. EPA target risk range of 1×10^{-4} to 1×10^{-6} .

4.6.6 Environmental Risk Evaluation

No threatened or endangered species or critical habitats were identified at Site 6 or within the vicinity of the base. This was addressed on a base-wide level in Section 4.1.6. No comparison to AWQC was possible. Contamination at Site 6 poses no apparent threat to the environment at Site 6 or in the vicinity of the base.

4.6.7 Limitations and Uncertainty

The risks from exposure to contaminants detected in Site 6 soil have been conservatively estimated. Additional soil contaminants may be present based on the detection of tentatively identified compounds thought to be alkanes. See additional information in Section 4.1.7.

4.6.8 Summary

Most of the contaminants of concern detected at Site 6 are persistent, tending to sorb strongly to soil.

The Ammunition Area well, which is no longer in use, is the only water supply well located within a mile downgradient of Site 6. None of the metals detected at this well were elevated above background or exceeded ARARs. Monitoring well (MW6-03) may have been downgradient of Site 6 during Round 2 only. The lead concentration in the unfiltered groundwater sample did exceed the promulgated federal and state MCL and the federal MCLG. Concentrations of metals in the unfiltered groundwater sample from MW5-02, which may have been downgradient of Site 6 during Round 1, exceeded the drinking water standards for chromium, nickel, and lead. No future residential use of Site 6 is expected. Site 6 is in a high traffic area but is not regularly used. Future worker exposure to soil contaminants during excavation activities is possible and was thought to pose the greatest potential exposure pathway to site contaminants. The dermal absorption and incidental ingestion of contaminants resulting from worker contact with site soil was estimated. No adverse non-carcinogenic health effects are expected from the evaluated worker exposure to Site 6 soil. The maximum cancer risk estimate from this exposure, 1×10^{-5} , is within the U.S. EPA target risk range and is considered predominantly site attributable.

No threatened, rare, or endangered species were identified at the site or in the vicinity of the base. The closest environmentally sensitive area is approximately one mile northwest of the base.

4.7 AMMUNITION AREA WELL

A water supply well (Well No. 530) was identified in the Ammunition Area at the southeastern edge of the base property (Figure 4-1). The well provided a potable water supply to personnel at the Ammunition Storage Area on the base until 1990. The water was chlorinated and used as drinking water. Two unfiltered groundwater samples were collected from a tap at the water

pump and analyzed for volatile organics, semi-volatile organics, pesticides/PCB's, metals, and petroleum hydrocarbons. Maximum contaminant concentrations detected in groundwater are compared to drinking water standards in Table 4-28. No federal or state MCLs or federal MCLGs were exceeded.

4.8 BACKGROUND AREA

Contaminants of concern for the base sites which were also detected in background samples were evaluated for the Background Area using the same approach used for the sites under investigation. The exposure scenario was assumed to be the same as that used at the sites. Only analytes selected as base-wide contaminants of concern were evaluated for the Background Area even though contaminants were detected in background samples that were not detected elsewhere on the base. This provides a background risk estimate against which to evaluate risks estimated for the sites under investigation. This exercise is performed to quantify the amount of background risk which was included in the risk estimates for the sites under investigation. The background concentrations of those contaminants which were evaluated at each of the sites are included in this section.

The approach taken was to first calculate doses based on the exposure scenario developed for sites at the base. Risk was then characterized by a comparison with ARARs, a comparison with reference doses, an estimation of cancer risk, and an evaluation of environmental risks. The assessment focused on the quantitative evaluation in order to provide a basis for comparison.

4.8.1 Identification of the Contaminants of Concern

Those analytes included as base-wide potential contaminants of concern in Section 4.1.1 are summarized for the Background Area in Table 4-29. All contaminants detected in sediment, surface water, and groundwater samples were included as contaminants of concern. The quantitative exposure assessment focused on those contaminants in soil, the media for which there were adequate data for a quantitative assessment. Therefore, further screening of the contaminants of concern for the Background Area focused on soil contaminants only. Six

TABLE 4-28. AMMUNITION AREA - GROUNDWATER COMPARISON WITH ARARs
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	MAXIMUM GROUNDWATER CONCENTRATION (a)	DRINKING WATER STANDARDS (b):			MCL EXCEEDED (e)
		FEDERAL (c)		INDIANA (d)	
		MCL	MCLG	MCL	
VOLATILE ORGANICS	UG/L	UG/L		UG/L	
Carbon Disulfide	1 J				
METALS					
Barium, Total	275	2,000	2,000	2000	
Manganese, Total	59				
Zinc, Total	53				

NOTES:

- Maximum concentration presented from two groundwater samples(one sample taken at Ammunition Area during each of the two sampling rounds.
 - Standards described in Section 4.1.5.1. Values taken from Table 4-3.
No value is presented when a standard is not available.
 - Safe Drinking Water Act: MCL - Maximum Contaminant Level, MCLG - Maximum Contaminant Level Goal
 - Indiana Drinking Water Standards (MCLs) match the federal promulgated MCLs.
 - Considers federal and state MCLs
- J = Estimated data due to quality control criteria

TABLE 4-29. BACKGROUND AREA - POTENTIAL CONTAMINANTS OF CONCERN
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA (a)

PARAMETER	SOIL CONCENTRATIONS (b)		NUMBER OF DETECTIONS	SEDIMENT (d)	GROUND WATER (d)	SURFACE WATER (d)
	MAXIMUM	MEAN (c)				
VOLATILE ORGANICS	UG/KG	UG/KG				
Tetrachloroethene	3 J	3 J	1 / 4			
SEMIVOLATILE ORGANICS	UG/KG	UG/KG		UG/KG		UG/L
Di-n-Butylphthalate	44 J	44 J	1 / 4	110 J		2 J
Fluoranthene				88 J		
Pyrene				73 J		
Chrysene				77 J		
Benzo(b)fluoranthene						
PESTICIDES/PCB's	UG/KG	UG/KG				
4,4'-DDT	18 J	12.1 J	1 / 4			
METALS (e)	MG/KG	MG/KG		MG/KG	UG/L	UG/L
Aluminum, Total	8,050	6,563	4 / 4	3,530	27,000	15,500
Arsenic, Total	6.5 J	4.3 J	4 / 4	2.5 J		
Barium, Total	105	90	4 / 4	60.7	260	247
Cobalt, Total	12.3	8.3	4 / 4			
Chromium, Total	10.7	9.1	4 / 4	3.5	34.2	14.7
Copper, Total	16.2	14.1	4 / 4	7.6	77.7	
Manganese, Soluble					104	4,350
Manganese, Total	643	503	4 / 4	380	1,070	2,800
Nickel, Total	16.3	12.0	4 / 4			
Lead, Total	4.5 J	2.5 J	4 / 4	10.7	16.3 J	26.3 J
Vanadium, Total	24.2	20.6	4 / 4			
Zinc, Total	87.2	53.6	4 / 4	50.2	122	185

NOTES:

- Analyses: volatile organics, semivolatile organics, pesticides/PCBs, metals, and total petroleum hydrocarbons for all media (Table 2-3). Analytes not presented were not detected in any media sampled or were screened out (sec. 4.1.1). No value presented means not detected, except for metals (see c.).
 - Four soil samples total: two samples from one boring and two surface soils.
 - Calculated using the mean of duplicate samples and half the sample quantification detection limit where not detected. The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
 - Only one sample each for sediment, groundwater, and surface water (samples taken during Round 1 only); results for each presented.
 - Soluble metals analysis not run on sediments and soils. Both soluble and total metals analyzed for water samples.
- J = Estimated data due to quality control criteria

analytes were eliminated as contaminants of concern because they were not detected above background levels at any of the sites and were not selected as base-wide contaminants of concern: DDT, barium, cobalt, manganese, nickel, and vanadium.

4.8.2 Properties of Contaminants of Concern

The base-wide contaminants of concern detected in Background Area samples are persistent in the environment. Exposure to elevated concentrations of the analytes detected can result in systemic and carcinogenic health effects.

4.8.2.1 Physical and Chemical Properties of Contaminants of Concern. One mobile organic compound was detected in soil. Fewer phthalate esters and PAHs and no phenols were detected relative to site soil and sediment samples. Those detected, as well as the metals detected, tend to sorb strongly to soil.

4.8.2.2 Toxicity Profiles. The contaminants found in the Background Area can be absorbed by humans via ingestion, dermal contact, and inhalation. Exposures to high enough levels of the contaminants could result in a variety of systemic and carcinogenic effects (Table 4-2). Detailed descriptions of the toxicological properties of Background Area contaminants are available in Appendix G.

4.8.3 Identification of Receptors

The most probable receptors were assumed to have the same characteristics as those evaluated for each site at the base for comparison purposes.

4.8.4 Exposure Assessment

Possible exposures were not screened for the Background Area. The exposure pathways evaluated for the sites at the base were evaluated for the Background Area for comparison purposes.

4.8.4.1 Development of Exposure Scenario. The excavation scenario developed for the site evaluations was also used to evaluate the Background Area. The exposure scenario modeled was that of an adult worker at the base who comes in contact with surface and subsurface soils at the Background Area due to periodic excavations. Exposure assumptions included employment at the base over 25 years, during which time an average of 12 days per year involve some excavation at the Background Area. Excavation activities could involve digging up utilities, putting in new sidewalks, or lawn-care activities. Soil ingestion occurs from hand-to-mouth contact, such as eating or smoking, after soil contact. For adult workers, 50 mg/day was the rate used to estimate the incidental soil ingestion resulting from hand-to-mouth contact with dirty hands. An additional worker exposure results from direct contact of skin with contaminated soil. To evaluate dermal exposure, it was assumed that a typical worker wears a shirt with no sleeves and an open neck, pants, shoes, and no gloves or hat. The exposed skin was assumed to come in contact with contaminated soil.

4.8.4.2 Calculation of Dose. The exposure scenario and dose estimate approach used for the sites at the base was also used for the Background Area in order to provide comparable risk estimates for a background exposure. Dose for these pathways was estimated using U.S. EPA Risk Assessment Guidance for Superfund (December 1989). The following equation was used for dermal absorption from soil:

$$\text{Absorbed Dose (mg/kg/day)} = \frac{\text{CS} \times \text{CF} \times \text{SA} \times \text{AF} \times \text{ABS} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

A similar equation was used for incidental ingestion of soil:

$$\text{Ingested Dose (mg/kg/day)} = \frac{\text{CS} \times \text{CF} \times \text{IR} \times \text{FI} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Values and definitions for the variables used in each equation are presented in Table 4-6. Results from the dose estimates for non-carcinogens and carcinogens are summarized in Table 4-30. The dose from ingestion was below that for dermal absorption by a factor of two for metals, a factor of twenty for the semi-volatile organic compounds, and two orders of magnitude for the volatile organic compounds.

4.8.5 Risk Characterization

The human health risk from possible exposure to contaminants was characterized in three parts: a comparison of contaminant concentrations to ARARs, a comparison of estimated human doses with reference dose levels, and a calculation of increased lifetime cancer risk. Contaminant concentrations in groundwater samples were compared to federal and state MCLs and federal MCLGs. The total dose estimates for non-carcinogens, from dermal and ingestion exposures to site soils, were compared to chemical-specific reference doses to get a hazard index for the Background Area. The incremental cancer risk from ingestion and dermal exposures to Background Area soils was then estimated by multiplying the carcinogenic dose estimates by the slope factors for the carcinogens.

4.8.5.1 Comparison with Applicable or Relevant and Appropriate Requirements (ARARs).

One background groundwater sample was taken, during Round 1, in November, 1990. The concentrations of contaminants of concern detected in the background groundwater sample were compared to ARARs (Table 4-31). No organic compounds were detected and most metals were detected in unfiltered groundwater only. Only manganese was detected in the filtered groundwater. Only lead was detected at a concentration exceeding any ARARs. The lead concentration detected exceeds the presently promulgated federal and state MCL and the federal MCLG.

4.8.5.2 Comparison with Reference Doses. A comparison of total non-carcinogenic dose estimates for the ingestion and dermal absorption of background contaminants in soil with reference doses is presented in Table 4-32. The total hazard index is well below one for these exposures and no adverse health effects are expected.

TABLE 4-30. BACKGROUND - DOSE ESTIMATES - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

	SOIL CONCENTRATION(a) MEAN(b) MAX	NUMBER OF DETECTIONS	DOSE ESTIMATE (mg/kg/day):									
			NON-CARCINOGENIC(c)					CARCINOGENIC(d)				
			ABSORPTION(c)	MEAN	MAX	INGESTION(f)	MEAN	MAX	TOTAL(g)	MEAN	MAX	TOTAL(g)
VOLATILES												
Tetrachloroethene	UG/KG 3 J	1 / 4	2E-09	2E-09	2E-09	7E-11	7E-11	2E-09	2E-09	6E-10	3E-11	6E-10
SEMIVOLATILES												
Di-n-Butyphthalate	UG/KG 44 J	1 / 4	2E-08	2E-08	2E-08	1E-09	1E-09	2E-08	2E-08	8E-09	4E-10	9E-09
METALS(h)												
Aluminum	MG/KG 6,563	4 / 4	4E-04	4E-04	4E-04	2E-04	2E-04	6E-04	6E-04	1E-04	6E-05	2E-04
Arsenic	4.28 J	4 / 4	2E-07	3E-07	3E-07	1E-07	1E-07	5E-07	5E-07	8E-08	4E-08	1E-07
Chromium	9.05	4 / 4	5E-07	6E-07	6E-07	2E-07	2E-07	8E-07	8E-07	2E-07	8E-08	2E-07
Copper	14.1	4 / 4	8E-07	9E-07	9E-07	3E-07	3E-07	1E-06	1E-06	3E-07	1E-07	4E-07
Lead	2.53 J	4 / 4	1E-07	2E-07	2E-07	6E-08	6E-08	3E-07	3E-07	5E-08	2E-08	7E-08
Zinc	53.6	4 / 4	3E-06	5E-06	5E-06	1E-06	1E-06	7E-06	7E-06	1E-06	4E-07	1E-06

NOTES:

- a. Soil concentrations from Table 4-29.
b. Calculated using half the detection limit where not detected. The maximum detected value was used for the mean if the calculated mean was greater than the maximum.
c. Dose averaged over exposure duration.
d. Dose averaged over lifetime.
e. Absorbed Dose = (Soil conc. * Skin surface area * Adherence factor * Absorption factor * Exposure frequency * Exposure duration) /
(Body weight * Averaging time)
See Table 4-6 for variable values.
f. Ingested Dose = (Soil conc. * Ingestion Rate * Fraction ingested * Exposure frequency * Exposure duration) /
(Body weight * Averaging time)
See Table 4-6 for variable values.
g. Total Dose = Absorbed Dose + Ingested Dose
h. All metals are total metals.
J = Estimated data due to quality control criteria

TABLE 4-31. BACKGROUND AREA – GROUNDWATER COMPARISON WITH ARARs
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	MAXIMUM GROUNDWATER CONCENTRATION (a)	DRINKING WATER STANDARDS (b):			MCL EXCEEDED (e)
		FEDERAL (c) MCL	MCLG	INDIANA (d) MCL	
METALS	UG/L	UG/L		UG/L	
Aluminum, Total	27,000				
Barium, Total	260	2000	2000	2000	
Chromium, Total	34.2	100	100	100	
Copper, Total	77.7	1300 (f)	1300	1300 (f)	
Manganese, Soluble	104				
Manganese, Total	1,070				
Lead, Total	16.3 J	15 (g)	0	15 (g)	yes
Zinc, Total	122				

NOTES:

- a. One groundwater sample taken at Background Area; results presented.
- b. Standards described in Section 4.1.5.1. Values taken from Table 4-3.
No value is presented when a standard is not available.
- c. Safe Drinking Water Act: MCL – Maximum Contaminant Level, MCLG – Maximum Contaminant Level Goal
- d. Indiana Drinking Water Standards (MCLs) match the federal promulgated MCLs.
- e. Considers federal and state MCLs
- f. This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
- g. This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
- J = Estimated data due to quality control criteria

TABLE 4-32. BACKGROUND - RISK ESTIMATES - 181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

	TOTAL DOSE ESTIMATES (mg/kg/day) (a):			CHRONIC ORAL RfD (b) (mg/kg/day)	ORAL SLOPE FACTOR (b) /(mg/kg/day)	HAZARD RATIO (c)		CANCER RISK (d)	
	NON-CARCINOGENIC MEAN	NON-CARCINOGENIC MAX	CARCINOGENIC MEAN	CARCINOGENIC MAX		MEAN	MAX	MEAN	MAX
VOLATILES Tetrachloroethene	2E-09	2E-09	6E-10	6E-10	1.0E-02	2E-07	2E-07	3E-11	3E-11
SEMIVOLATILES Di-n-Butylphthalate	2E-08	2E-08	9E-09	9E-09	1.0E-01	2E-07	2E-07		
METALS (e) Aluminum	5E-04	6E-04	2E-04	2E-04	A	1.75E+00	2E-03	2E-07	3E-07
Arsenic	3E-07	5E-07	1E-07	2E-07					
Chromium	7E-07	8E-07	2E-07	3E-07					
Copper	1E-06	1E-06	4E-07	4E-07					
Lead	2E-07	3E-07	7E-08	1E-07					
Zinc	4E-06	7E-06	1E-06	2E-06					
					HAZARD INDEX (f):	1E-03	2E-03	ILCR (g): 2E-07	3E-07

NOTES:

- a. Total dose estimates taken from Table 4-30.
b. Values taken from Table 4-2. Weight of evidence given with slope factor for carcinogens.
c. Hazard Ratio = Total Dose Estimate / RfD
d. Cancer Risk = Total Dose Estimate * Slope Factor
e. All metals are total metals.
f. Hazard Index = Sum (Chemical-specific Hazard Ratios)
g. Increased Lifetime Cancer Risk = Sum (Chemical-specific Cancer Risks)
h. RfD for chromium VI used.

4.8.5.3 Estimation of Cancer Risk. The carcinogenic dose from the two carcinogenic contaminants of concern detected in background soil, tetrachloroethene and arsenic, were multiplied by their slope factors to estimate cancer risk (Table 4-32). This risk range, 2×10^{-7} to 3×10^{-7} , is below the U.S. EPA target risk range of 1×10^{-4} to 1×10^{-6} .

4.8.6 Environmental Risk Evaluation

No AWQC were exceeded in the background surface water sample.

4.8.7 Limitations and Uncertainties

The risks from exposure to base-wide contaminants of concern present in the Background Area have been reasonably well characterized. See additional information in Section 4.1.7.

4.8.8 Summary

A few, mostly persistent, base-wide contaminants of concern were detected in the Background Area.

Contaminants were evaluated as if detected at one of the sites under investigation. The lead concentration in unfiltered groundwater exceeded the federal MCLG and state and federal MCL. Exposure to workers involved in excavation activities was evaluated by estimating dermal absorption and incidental ingestion of contaminants resulting from worker contact with background soil. No adverse non-carcinogenic health effects are expected based on this exposure. The maximum cancer risk estimate, 3×10^{-7} , is below the U.S. EPA target risk range and is entirely attributable to tetrachloroethene and arsenic.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This section contains a brief summary of base-wide results and individual site conclusions and recommendations.

5.1 BASE-WIDE SUMMARY

Generally base-wide geology consists of a brown loess deposit overlying sandy clays which overlay glacial till. A dense till was encountered at fourteen to eighteen feet, which is believed to act as an aquitard beneath the base. Saturated soils were encountered from six to twelve feet below ground surface. However, static water level following piezometer and monitoring well installation was one to two feet below ground surface.

Groundwater at the base generally flows to the southwest. However, localized flow around Site 4 appears to vary to the northeast and to the southwest. At Site 6, groundwater flow appears to vary from the southwest to south-southeast. According to piezometric surface contours, the background area near building 16 appears to be upgradient of the five sites.

Eight water wells are located within one mile of the base. However, residents west of the base have access to city water from the Wabash River, while residents east of the base use groundwater as their drinking water supply. The intake on the Wabash River for the city of Terre Haute drinking water is northwest of the base and upgradient.

Sixty analytes were evaluated as potential contaminants of concern for the sites under investigation as part of the preliminary risk evaluation. Phthalate esters, phenolic compounds, PAH compounds, and metals were the contaminants predominantly detected at the base. Most contamination was present in soil and sediment. Contaminants in groundwater consisted primarily of metals which were generally detected in unfiltered samples. Contaminants detected in unfiltered groundwater are expected to be sorbed to sediments in the water and, therefore,

unfiltered groundwater generally shows higher concentrations of contaminants due to sediment contamination. Filtered groundwater in which particles are screened out, is generally more indicative of concentrations likely to be found if groundwater from the sites under investigation is used as a potable water source because the water well would be developed to minimize sediments in the groundwater.

Groundwater is not presently used at any of the sites, but wells are located within a mile of the base. Well No. 530 in the Ammunition Area is within a one mile radius and downgradient of the sites under investigation. This well was sampled due to its use until 1990 as a potable water supply, by base personnel at the Ammunition Area. No contamination from the sites under investigation was detected in Well No. 530 and placement of another well between the Ammunition Area and the base is unlikely, since city water is currently available. The groundwater flow direction at Site 4 is not known. Water level measurements on different dates indicated a northeasterly and southwesterly direction of groundwater flow. Groundwater and surface water contamination was not evident to the southwest or northeast.

As part of the preliminary risk evaluation, potential human receptors and plausible exposure pathways were based upon current land use. Presently, use of the base is non-residential and future residential use is unlikely. Thus, continued present use of the base was assumed. Sites varied with regard to accessibility and present use by base personnel. Most site contaminants were detected in soils and presently personnel are expected to have only limited contact with site soils. Workers involved with periodic excavation activities were expected to be the population to experience the greatest exposure to contaminants in site soil. Children are occasionally present on the base. However, the sites under investigation are generally grass-covered and/or paved, are not located near base recreational areas, and are not likely locations for children to be left unattended. Exposures to children are unlikely and would be incidental in nature. Risks to frequently exposed construction workers are expected to reflect the greatest risks of exposure to site contaminants.

No threatened, rare, or endangered species were identified at or within the vicinity of the base. The closest environmentally sensitive area is located approximately one mile to the northwest. Other areas are located further northwest as described in Section 1.0. No stands of trees, undisturbed natural areas, or natural surface water bodies were identified at the base.

5.2 SITE 1 - POWER SUPPRESSOR PAD

Site 1 is located in a grassy area at the southern end of the base property adjacent to the most easterly Hulman Airfield taxiway.

5.2.1 Conclusions

Results of the soil gas survey indicated low volatile organic compound contamination at Site 1. BTEX was not detected using the field GC.

Volatile organic compounds and petroleum hydrocarbons were detected in sediments and surface soils, which suggests that solvents may have been used within the site, in addition to various oil products. The detection of numerous PAH compounds predominately in surface soils suggests that these analytes may be associated with asphalt/pavement activities or the remains of incomplete combustion of jet fuel.

The direction of groundwater flow from Site 1 appears to be west-southwest. The monitoring well, MW1-06, was installed downgradient of Site 1. The two soil borings were drilled and the groundwater, surface water, sediment, surface soils, and boring soil samples were collected in locations to provide adequate Site 1 characterization.

Site 1 unfiltered groundwater from Round 1 exceeded federal and state MCLs and federal MCLGs for pentachlorophenol, bis(2-Ethylhexyl) phthalate, beryllium, nickel and lead. During Round 2, unfiltered groundwater exceeded federal and state MCLs and federal MCLGs for nickel and lead. Most metals were not detected in filtered groundwater, those that were detected

include mercury and manganese in Round 1 and manganese and zinc in Round 2. These results are presented in Table 5-1. There were no standards exceeded for filtered groundwater. Filtered groundwater is more indicative of concentrations likely to be found if the groundwater at Site 1 is used as a potable water supply as a result of well development and the subsequent removal of sediments.

Dermal and ingestion exposures of workers to excavated soils seems likely and was thought to represent the greatest potential exposure pathway. No adverse non-carcinogenic health effects are expected from this worker exposure to Site 1 soil. The maximum cancer risk estimate for this exposure is 9×10^{-7} and is below the U.S. EPA target risk range of 1×10^{-4} to 1×10^{-6} .

In Summary:

- Contamination was found in soils and sediments and consisted mostly of environmentally persistent analytes
- Contamination in the drainage ditch partitioned almost entirely to sediments
- Groundwater at Site 1 flows westerly
- Organic contaminants from Site 1 were not evident in downgradient groundwater
- Elevated metals in groundwater were generally limited to unfiltered samples
- Some metals exceeded drinking water standards in unfiltered groundwater samples but not in filtered groundwater samples
- Adverse health effects to employees from soil exposures at Site 1 are not anticipated.

5.2.2 Recommendations

No further action at this site is recommended.

TABLE 5-1. SITE 1 - GROUNDWATER COMPARISON WITH ARARs AND BACKGROUND CONCENTRATIONS
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	MAXIMUM GROUNDWATER CONCENTRATION (a)	DRINKING WATER STANDARDS (b):			MCL EXCEEDED(e)	Background Groundwater(f)
		FEDERAL (c) MCL	MCLG	INDIANA (d) MCL		
SEMIVOLATILE ORGANICS	UG/L	UG/L		UG/L		UG/L
Di-n-Butylphthalate	2 J					11 U
Benzoic acid	2 J					55 U
Pentachlorophenol	3 J	1	0	1	yes	55 U
bis(2-Ethylhexyl)phthalate	8 J	6	0	6	yes	2 UJ
METALS	UG/L	UG/L		UG/L		UG/L
Aluminum, Total	151,000					27000
Arsenic, Total	14.4 J	50 (g)		50 (g)		10 UJ
Barium, Total	1,380	2000	2000	2000		260
Beryllium, Total	10.5	4	4	4	yes	5 U
Cobalt, Total	145					50 U
Chromium, Total	98.3	100	100	100		34.2
Copper, Total	227	1300 (h)	1300	1300 (h)		77.7
Mercury, Soluble	0.32 J	2	2	2		0.2 U
Mercury, Total	0.50 J	2	2	2		0.2 U
Manganese, Soluble	858					104
Manganese, Total	21,200					1070
Nickel, Total	314	100	100	100	yes	74.1 UJ
Lead, Total	129 J	15 (i)	0	15 (i)	yes	16.3 J
Vanadium, Total	352					62.2 UJ
Zinc, Soluble	33					20 U
Zinc, Total	798					122

NOTES:

- Maximum concentration presented from two groundwater samples.
 - Standards described in section 4.1.5.1. Values taken from Table 4-3.
No value is presented when a standard is not available.
 - Safe Drinking Water Act: MCL - Maximum Contaminant Level, MCLG - Maximum Contaminant Level Goal
 - Indiana Drinking Water Standards (MCLs) match the federal promulgated MCLs.
 - Considers federal and state MCLs
 - Results presented from the one groundwater sample taken at the Background Area monitoring well.
 - MCL for arsenic is under review.
 - This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
 - This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
- J = Estimated data due to quality control criteria.
U = Compound not detected, value is the sample quantification detection limit
UJ = Compound not detected, estimated sample quantification detection limit

5.3 SITE 2 - ABANDONED PETROLEUM, OIL, AND LUBRICANT STAND

Site 2 is located near the center of the base, south of building no. 3. It is an abandoned storage and transfer area for JP-4 and POL products.

5.3.1 Conclusions

Soil gas survey results indicated low level volatile organic compound contamination at Site 2. Field GC analysis indicated potential BTEX contamination, which is consistent with the presence of JP-4 at the site.

Volatile organic compounds were detected in all media at Site 2. Toluene and trichloroethene were detected in boring soils and PAH compounds were measured in boring soils and one surface soil sample. PAH compounds and toluene are likely residuals of past spills of fuel or incomplete combustion of jet fuels. Petroleum hydrocarbons were measured in seven soil samples within the range of background soils. However, concentrations of semi-volatile and volatile organic compounds, except tetrachloroethene, exceeded background levels.

The direction of groundwater flow from Site 2 appears to be toward the southwest or west-southwest. The monitoring well, MW2-04, was installed downgradient of Site 2. The four soil borings were drilled, and the groundwater, surface soils and boring soil samples were collected in locations to provide adequate Site 2 characterization.

At Site 2, analyses of site media included volatile organic compounds, semivolatile organic compounds, and total petroleum hydrocarbons. No federal or state drinking water standards for groundwater were exceeded in either of the two sampling rounds.

Most of the contaminants of concern detected at Site 2 are persistent, sorbing strongly to soil. Dermal and ingestion exposures of workers to excavated soil seems likely and was thought to represent the greatest exposure pathway to site contaminants. No adverse non-carcinogenic health effects are expected from this worker exposure to Site 2 soils. The maximum cancer risk estimate from this exposure to site soils, 7×10^{-7} , is below the U.S. EPA target risk range.

In Summary:

- Contamination was predominantly detected in soils and consisted of mostly environmentally persistent analytes with some, more mobile, volatile organic compounds detected
- Groundwater at Site 2 flows southwest or west-southwest
- Organic contaminants from Site 2 were not evident in downgradient groundwater and no drinking water standards were exceeded
- Adverse health effects to employees from soil exposures at Site 2 soil are not anticipated

5.3.2 Recommendations

No further action at this site is recommended.

5.4 SITE 4 - OLD BLADDER AREA

Site 4 is located on the east side of the base and is known as the Old Bladder Area. The Site is currently used for the aboveground storage of JP-4 jet fuel.

5.4.1 Conclusions

Soil gas survey results and laboratory analysis indicated generally low levels of volatile organic compounds in soils. PAH compounds and petroleum hydrocarbons were detected in sediments and infrequently in soils, limited to one surface soil. Although no analytes were detected in surface water, the sediments were contaminated because they appear to sorb phthalate and PAH compounds as well as types of petroleum hydrocarbons. Volatile and semi-volatile organics were found generally higher in soils and sediments than background levels. Analytical results are consistent with the known storage of fuels and modified oil products at the site. PAH compounds may be attributed to the incomplete combustion of jet fuel.

Localized groundwater flow in the vicinity of Site 4 is not certain. The monitoring well, MW4-05, did not appear to be downgradient of Site 4, according to water level data collected on June 27, 1991, since groundwater flow direction was to the northeast. Variation may occur at this site in groundwater flow direction, as seen in the January 17, 1992 data, which shows a southwestern flow direction. A groundwater sample was collected from monitoring well, MW4-05, during Rounds 1 and 2. However, to fully characterize the site, two groundwater samples were also collected at Piezometer 4, located northeast of the site, during Round 2. The four soil borings were drilled and the groundwater, surface water, sediment, surface soils, and boring soil samples were collected in locations to provide adequate Site 4 characterization.

At Site 4, analyses of site media include volatile organic compounds, semivolatile organic compounds, and total petroleum hydrocarbons. No groundwater contamination was evident at MW4-05 or Piezometer 4.

Most of the contaminants of concern detected at Site 4 are persistent, sorbing strongly to soil, however, some mobile contaminants were detected. Dermal and ingestion exposures of workers to excavated soil seems likely and was thought to represent the greatest potential exposure pathway to site contaminants. No adverse non-carcinogenic health effects are expected from this worker exposure to Site 4 soils. The maximum cancer risk estimate from this exposure, 1×10^{-7} , is below the U.S. EPA target risk range of 1×10^{-4} to 1×10^{-6} .

In Summary:

- Contamination was predominantly detected in soils and sediments and consisted of mostly environmentally persistent analytes
- Contamination in the surface drainage ditch partitioned almost entirely to sediments
- The direction and magnitude of groundwater flow cannot be determined from the collected data
- No contamination was detected in groundwater at Site 4
- Adverse health effects to employees from exposures to Site 4 soil are not anticipated

5.4.2 Recommendations

No further action at this site is recommended.

5.5 SITE 5 VEHICLE MAINTENANCE AREA

Site 5 is located west and south of building 4, the Vehicle Maintenance Area.

5.5.1 Conclusions

Soil gas survey results indicated moderate contamination around the underground fuel storage tank. Elevated arsenic and 1,2 dichlorobenzene detected in soils may have resulted from past site activities, since small quantities of waste oils, paint thinners and solvents has reportedly been disposed of at the site. However, the source of mercury in groundwater and PCBs in surface soils is not evident. Semi-volatile organic compounds exceeded background concentrations. The presence of PAH compounds in soils suggests the occurrence of incomplete combustion of jet fuel.

Groundwater flow in the vicinity of Site 5 appears to be toward the southwest. The monitoring well, MW5-02, was installed downgradient of Site 5. The two soil borings were drilled and groundwater, surface soils and boring soil samples were collected to provide adequate Site 5 characterization. Only one groundwater sample was collected from Site 5. During Round 2, MW5-02 was made inaccessible due to base activities and a groundwater sample was not collected.

At Site 5 no organic compounds were detected in groundwater. Both the federal and state MCLs and federal MCLGs for chromium, nickel and lead were exceeded in unfiltered groundwater. Metals were primarily detected in the unfiltered sample, only mercury and manganese were detected in the filtered sample. The soluble mercury was below the federal and state MCL and MCLG and no standards exist for manganese. These results are presented in Table 5-2.

TABLE 5-2. SITE 5 - GROUNDWATER COMPARISON WITH ARARs AND BACKGROUND CONCENTRATIONS
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	MAXIMUM GROUNDWATER CONCENTRATION (a)	DRINKING WATER STANDARDS (b):			MCL EXCEEDED(e)	Background Groundwater(f)
		FEDERAL (c) MCL	MCLG	INDIANA (d) MCL		
METALS	UG/L	UG/L		UG/L		UG/L
Aluminum, Total	19,200					27000
Chromium, Total	193	100	100	100	yes	34.2
Copper, Total	53.4	1300 (g)	1300	1300 (g)		77.7
Mercury, Soluble	0.32 J	2	2	2		0.2 U
Mercury, Total	0.35 J	2	2	2		0.2 U
Manganese, Soluble	433					104
Manganese, Total	1,130					1070
Nickel, Total	164	100	100	100	yes	74.1 UJ
Lead, Total	36.4 J	15 (h)	0	15 (h)	yes	16.3 J
Vanadium, Total	50.7 J					62.2 UJ
Zinc, Total	157.5					122

NOTES:

- a. One groundwater sample taken at Site 5; results presented.
 - b. Standards described in Section 4.1.5.1. Values taken from Table 4-3.
No value is presented when a standard is not available.
 - c. Safe Drinking Water Act: MCL - Maximum Contaminant Level, MCLG - Maximum Contaminant Level Goal
 - d. Indiana Drinking Water Standards (MCLs) match the federal promulgated MCLs.
 - e. Considers federal and state MCLs
 - f. Results presented from the one groundwater sample taken at the Background Area monitoring well.
 - g. This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
 - h. This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
- J = Estimated data due to quality control criteria
U = Compound not detected, value is the sample quantification detection limit
UJ = Compound not detected, estimated sample quantification detection limit

Filtered groundwater is more indicative of concentrations likely to be found if the groundwater at Site 5 is used as a potable water supply as a result of well development and the subsequent removal of sediments.

Future worker exposure to site soil contaminants seems likely during excavations and was thought to pose the greatest exposure pathway to site contaminants. No adverse non-carcinogenic health effects are expected from worker dermal and ingestion exposure to Site 5 soil. The maximum cancer risk estimate from this exposure, 2×10^{-5} , is within the U.S. EPA target risk range.

In Summary:

- Contamination was predominantly detected in soils and consisted of mostly environmentally persistent analytes
- Groundwater at Site 5 flows southwest
- Organic contaminants from Site 5 were not evident in downgradient groundwater
- Elevated metals in groundwater were generally limited to unfiltered samples
- Some metals exceeded drinking water standards in unfiltered groundwater samples but not for filtered groundwater samples
- Adverse health effects to employees from exposures to Site 5 soil are not anticipated

5.5.2 Recommendations

No further action at this site is recommended.

5.6 SITE 6 - HANGAR BUILDING NO. 1

Site 6 is located on the west side of the base, near the firehouse and north of the aircraft parking apron.

5.6.1 Conclusions

The soil gas survey indicated three locations of high contamination at Site 6. Soils and sediments at Site 6 were characterized by the presence of elevated phthalates, PAHs, and volatile organic compounds. In addition, tentatively identified compounds indicated the presence of high concentrations of alkanes, which are typically found in stoddard solvent (PD-680). This trend was apparent at all depths sampled. Thus, vertical extent of soil contamination has not been fully characterized.

Five additional surface soil samples were collected during Round 2 to aid in characterizing the aerial extent of soil contamination at Site 6. The three soil samples placed nearest to the site boundary (SS6-18, 19, and 20) showed lower concentrations of organic contamination. The organic compounds identified and the presence of heavy metals in elevated concentrations in soils are indicative of the past maintenance type activities conducted at the site, as well as, bi-products of jet exhaust. The second round of surface soil samples were also collected at Site 6 to fully characterize volatile organic contamination because, during Round 1, the presence of high semivolatile organic compound concentrations in soils elevated detection limits of the volatile organic compounds. The five surface soil samples, during Round 2, showed low levels or no presence of volatile organic compound contamination. Low levels of pesticides were also detected in the second round of surface soil samples and are probably the result of sampling in grassy areas where lawn care activities include pesticide use.

Heavy metals including mercury in groundwater were generally found in higher concentrations relative to background levels. The storm drain where the sediment sample was collected appears to be acting as a catch basin for many of the semi-volatiles found at this site.

Groundwater flow in the vicinity of Site 6 appears to be varying from the southwest or south-southeast. Therefore, during Round 1, MW5-02 may have been downgradient of both Sites 5 and 6. In addition, the effect of the hangar building on localized groundwater flow is unknown. The two soil borings were drilled and groundwater, surface soils, boring soils and sediment samples were collected to provide adequate Site 6 characterization.

During Round 1, groundwater contamination with volatile and semi-volatile organic compounds was not evident in MW6-03, although the potential for release of contamination to groundwater is possible due to the shallow groundwater table. Although the location of MW6-03 was dictated by the proximity of the hangar building to the site, the well may not be providing an accurate representation of potential groundwater contamination.

Based on the June 1991 water level measurements, MW5-02 may have been downgradient of Site 6 during the first round of sampling. No organic compounds were detected in MW5-02 groundwater. Both the federal and state MCLs and federal MCLGs for chromium, nickel and lead were exceeded in unfiltered groundwater. Metals were primarily detected in the unfiltered sample, only mercury and manganese were detected in the filtered sample. The soluble mercury was below the federal and state MCL and MCLG and no standards exist for manganese.

During Round 2, MW6-03 appeared to be downgradient of Site 6. One trace volatile organic compound was detected in groundwater. Only lead exceeded the federal and state MCL and federal MCLG. Metals detected in filtered groundwater included mercury, manganese, and zinc. These results are presented in Table 5-3. There were no standards exceeded for filtered groundwater.

Filtered groundwater is more indicative of concentrations likely to be found if the groundwater at Site 6 is used as a potable water supply as a result of well development and the subsequent removal of sediments.

TABLE 5-3. SITE 6 – GROUNDWATER COMPARISON WITH ARARs AND BACKGROUND CONCENTRATIONS
181st HULMAN FIELD MAP, TERRE HAUTE, INDIANA

PARAMETER	MAXIMUM GROUNDWATER CONCENTRATION (a)	DRINKING WATER STANDARDS (b):			MCL EXCEEDED(e)	Background Groundwater(f)
		FEDERAL (c) MCL	MCLG	INDIANA (d) MCL		
SEMIVOLATILE ORGANICS	UG/L	UG/L		UG/L		UG/L
Pyrene	0.6 J					11 U
METALS	UG/L	UG/L		UG/L		UG/L
Aluminum, Total	54,200					27000
Barium, Total	552	2000	2000	2000		260
Chromium, Total	94.8	100	100	100		34.2
Copper, Total	134	1300 (g)	1300	1300 (g)		77.7
Mercury, Soluble	0.8	2	2	2		0.2 U
Mercury, Total	0.23 J	2	2	2		0.2 U
Manganese, Soluble	546					104
Manganese, Total	1,670					1070
Nickel, Total	110	100	100	100	yes *	74.1 UJ
Lead, Total	38.7 J	15 (h)	0	15 (h)	yes	16.3 J
Vanadium, Total	107					62.2 UJ
Zinc, Soluble	45					20 U
Zinc, Total	235					122

NOTES:

- Maximum concentration presented for two groundwater samples.
 - Standards described in Section 4.1.5.1. Values taken from Table 4-3.
No value is presented when a standard is not available.
 - Safe Drinking Water Act: MCL – Maximum Contaminant Level, MCLG – Maximum Contaminant Level Goal
 - Indiana Drinking Water Standards (MCLs) match the federal promulgated MCLs.
 - Considers federal and state MCLs
 - Results presented from the one groundwater sample taken at the Background Area monitoring well.
 - This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
 - This is a non-enforceable action level for tap water, with a treatment technique requirement if repeatedly exceeded.
- * = The MCL for nickel was exceeded only during the first sampling round at Site 6
- J = Estimated data due to quality control criteria
- U = Compound not detected, value is the sample quantification detection limit
- UJ = Compound not detected, estimated sample quantification detection limit

Dermal and ingestion exposures of workers to excavated soil is possible and was thought to pose the greatest potential exposure pathway to site contaminants. No adverse non-carcinogenic health effects are expected from worker dermal and ingestion exposure to Site 6 soil. The maximum cancer risk estimate for this exposure, 1×10^{-5} , is within the U.S. EPA target range of 1×10^{-4} to 1×10^{-6} .

In Summary:

- Contamination was predominantly detected in soils and sediments and consisted of mostly environmentally persistent analytes
- Groundwater flow direction at Site 6 exhibits variation from the southeast to the south-southwest
- Elevated metals were limited to the unfiltered groundwater samples
- Some metals exceeded drinking water standards in the unfiltered groundwater samples but not for the filtered groundwater samples
- Adverse health effects to employees from exposure to contaminants in Site 6 soils are not anticipated

5.6.2 Recommendations

Although adverse health effects to employees are not expected and downgradient groundwater contamination from Site 6 was not evident, some contaminants were detected in surface and near surface soils. Therefore, since Site 6 is an area of high foot traffic and to further protect human health, it is recommended that the grassy area bordering building 1 to the north and east be covered with concrete. This concrete cover will serve to help mitigate the potential for future transport of contaminants to subsurface soils and groundwater from surface runoff.

5.7 BACKGROUND AREA

The Background Area was located near building 16 in the expected upgradient portion of the base in an area where contamination was not expected.

5.7.1 Conclusions

In general, metals were detected in all media in a wide range of concentrations in the Background Area. A few organic compounds were reported at trace levels (estimated concentrations below the detection limit) in several soils, sediments, and surface water. Petroleum hydrocarbons were also detected in surface soils, surface water, and sediments. Pesticides were detected in one subsurface soil sample. Concentrations of barium, chromium, cobalt, iron and lead in the base background surface soils, subsurface soils and sediments were generally much lower than regional background concentrations. Other metals were generally found to be present in concentrations lower than the average concentrations reported for metals in continental U.S. background soils.

In the groundwater sample collected in Round 1, no organic compounds were detected and most metals were detected in unfiltered groundwater only. Only lead was detected at a concentration above the federal and state MCL and federal MCLG. This well was destroyed by base activities and was not sampled during Round 2. However, since concentrations of groundwater contaminants were generally lower in Round 2 relative to Round 1, the absence of background groundwater data did not impact the Round 2 data evaluation. Dermal absorption and incidental ingestion from worker contact with background soil was estimated. No adverse non-carcinogenic health effects are expected from worker exposure to background soils. The maximum cancer risk estimate from exposure to background soils is 3×10^{-7} , which is below the U.S. EPA target risk range of 1×10^{-4} to 1×10^{-6} . This risk is predominantly attributable to arsenic in background soils.

In Summary:

- The background area was upgradient relative to the sites under investigation
- Concentrations of analytes in background samples appeared to adequately represent background conditions at the base

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