United States Air Force

Environmental Restoration Program

Work Plan for the Groundwater Impact Study

Volume 1 of 2

Fire Training Site (FT-002)

Plattsburgh Air Force Base
Clinton County, New York

January 1996

G2192

GROUNDWATER IMPACT STUDY

FOR THE

FIRE TRAINING SITE (FT-002)

WORK PLAN

PLATTSBURGH AIR FORCE BASE

CLINTON COUNTY, NEW YORK

Prepared for:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

Prepared by:

URS CONSULTANTS, INC.

JANUARY 1996

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PREFACE

This Work Plan describes field activities, outlines the approach to data analysis, and identifies the deliverables that will support the Groundwater Impact Study for the Fire Training Area (FT-002) at Plattsburgh Air Force Base (AFB).

The purpose of the study is to evaluate the most appropriate action or actions necessary to protect human and ecological receptors from risks associated with aqueous phase contaminants in groundwater present as a result of past activities at FT-002. A conceptual site model is shown on Figure 2-5. To accomplish this, potential downgradient receptors will be identified including potable groundwater users along Route 9 and potentially sensitive ecological populations in drainageways existing at the base, in the Salmon River, and in nearby Lake Champlain. Numerical groundwater and surface water flow and chemical transport modeling will be used to estimate future contaminant concentrations at these receptors. To support the modeling effort, existing hydrologic, geologic, and chemical data will be compiled and additional field work will be performed. Based on the results of the model, risks to human health and the environment will be evaluated and appropriate remediation goals developed. The draft-final FT-002 Feasibility Study will be revised and an appropriate remedial action recommended for implementation.[1]

This document is divided into four parts as described below.

- Part I (Work Plan) - This plan gives background information regarding the site, describes the work to be performed, and provides a rationale for the work elements.
- Part II (Sampling and Analysis Plan) - This plan describes the quality assurance and field sampling procedures that will be employed to collect data during investigation field activities. To avoid redundancy, procedures described in approved Plattsburgh AFB Project Plans are referenced, where possible.
- Part III (Community Relations Plan) - This plan specifies general procedures for obtaining easements for offbase data collection and for the potable water well survey.
- Part IV (Health and Safety Plan) - This plan amends the existing Plattsburgh AFB Installation Restoration Program (IRP) Health & Safety Plan to provide site-specific details and guidance for personnel performing onsite field activities.

In addition, laboratory SOP's have been included as an Appendix, bound separately.

The Installation Restoration Program (IRP) at Plattsburgh AFB is being implemented according to an interagency Federal Facilities Agreement (Docket No. II-CERCLA-FFA-10201) between the United States Air Force (USAF), the United States Environmental Protection Agency (USEPA), and the New York State Department of Environmental Conservation (NYSDEC).

Mr. Jason Johnson of HQ AFCEE/ERB is the Contracting Officer Representative for this project.

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1 If a Record of Decision (ROD) is issued that addresses the FT-002 Groundwater Operable Unit, then the Feasibility Study will not be revised. Instead, the selected remedy presented in the ROD will be reviewed in light of the results of the Groundwater Impact Study.

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PART I

WORK PLAN

1.0 INTRODUCTION

This Work Plan describes field activities, outlines the approach of data analysis, and identifies deliverables that will support the Groundwater Impact Study for the Fire Training Area (FT-002) at Plattsburgh Air Force Base (AFB). Plattsburgh AFB is located in northeastern New York State. It is bordered by the City of Plattsburgh to the north, Lake Champlain to the east, lake shore communities to the southeast, the Salmon River and agricultural land to the south, and Interstate 87 to the west. The base, formerly the home of the 380th Air Refueling Wing, was closed in 1995 by the United States Air Force (USAF).

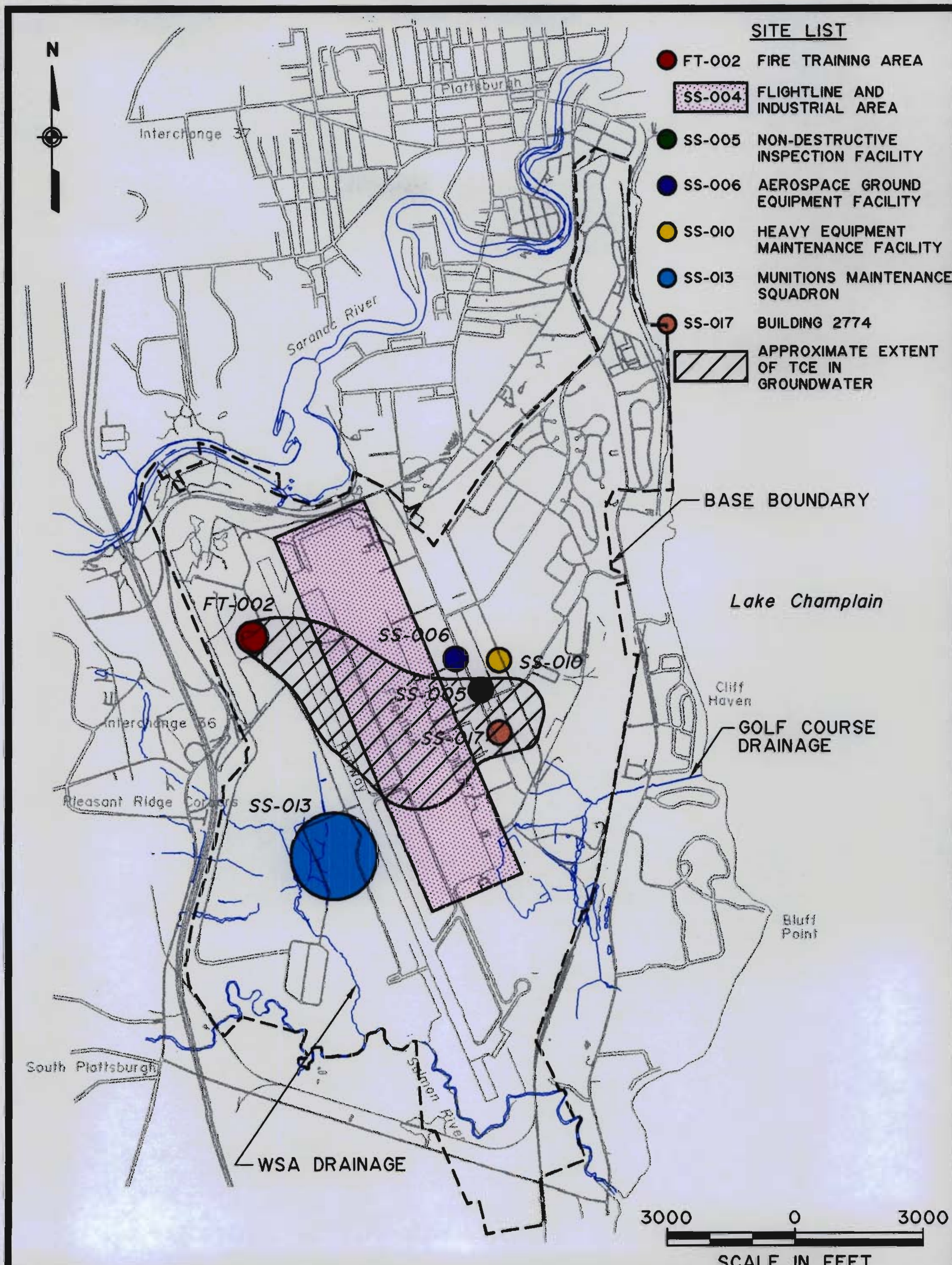
The FT-002 Groundwater Impact Study is being conducted at Plattsburgh AFB as part of USAF's Installation Restoration Program (IRP). The IRP was developed as a component of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. On November 21, 1989, Plattsburgh AFB was placed on the National Priorities List (NPL) by the United States Environmental Protection Agency (USEPA). On September 21, 1991, USAF entered into an interagency Federal Facilities Agreement (Docket No.: II - CERCLA - FFA - 10201) with the USEPA and the New York State Department of Environmental Conservation (NYSDEC) in order to implement the IRP. The Air Force Base Conversion Agency (AFBCA) is responsible for administering the IRP at Plattsburgh AFB. The Air Force Center for Environmental Excellence (AFCEE) is executing the FT-002 Groundwater Impact Study on behalf of AFBCA.

1.1 Site Description

The FT-002 site is located approximately 500 feet west of the runway and 500 feet from the base's western boundary (Figure 1-1). From the mid-to late-1950s through 1989, the site was used to meet the training requirements of the base fire department. During these training exercises, fires were ignited in fire training pits on site. As a result of spillage of combustible liquids into the pits, the soil and groundwater have become contaminated with a variety of organic chemicals, as indicated by the findings of previous studies. Groundwater contamination consists primarily of fuel-related compounds and chlorinated hydrocarbons (used as cleaning solvents and degreasers). The fuel-related compounds are naturally biodegradable in groundwater and are attenuating below detection within less than 3,000 feet downgradient of the source. The chlorinated hydrocarbons, which are considerably less biodegradable, have been detected over 6,000 feet downgradient of the source. The extent of contamination can reasonably be shown by the extent of trichloroethene (TCE) as indicated on Figure 1-1. TCE contamination extends into Plattsburgh AFB's industrial corridor where contaminants from other sources within the corridor mix with contaminants from the upgradient FT-002 site.

1.2 Previous Investigations

Three remedial investigations (RIs) have focused on evaluating of the nature and extent of contamination attributable to FT-002. These investigations are documented in the *FT-002 Soil Remedial Investigation Report* (URS & ABB-ES 1993), the *FT-002 Groundwater Remedial Investigation Report* (URS & ABB-ES 1994a), and the *Flightline(SS-004) Remediation Investigation Report* (URS 1995a).



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LOCATION OF FT-002 AND DOWN GRADIENT IRP SITES

FIGURE 1-1

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Two feasibility studies (FSs) were prepared to evaluate alternatives for remediation of FT-002's operable units (OUs) including Operable Unit One (Soil) and Operable Unit Two (Groundwater). These documents have been issued as final (URS 1995b) and draft-final (URS 1995c), respectively.

The *Intrinsic Remediation Engineering Evaluation/Cost Analysis for the FT-002 Site* (Parsons 1995) focused on biodegradation of the FT-002 plume's core of fuel-related compounds. This report provides valuable data concerning the size and strength of the contaminant source, the observed mechanics of biodegradation of fuel, possible co-metabolism of chlorinated hydrocarbons, and the extent of contamination.

Additional geologic, hydrologic, and chemical data are available from other studies performed basewide as part of IRP activities. Much of this information will be accessed for the Groundwater Impact Study.

1.3 Existing Remedial Actions

Two removal actions are underway to address the source of contamination at FT-002. The first, which began in 1993, consists of: free product skimming with aquifer drawdown; free product disposal; aqueous phase treatment by metals pretreatment, air stripping, and carbon polishing; and discharge of the aqueous phase to surface water. Product and aqueous-phase liquid are pumped to a treatment facility located immediately south of the FT-002 source area. To date, the system successfully has recovered more than 10,000 gallons of free product from FT-002, however, the current recovery rate has dropped to only one to two gallons per day.

The second removal action focuses on removal of residual product and sorbed contaminants in the soil column. In-situ treatment of soil will consist of bioventing, soil vapor extraction, and water table level control to enable treatment of contaminants adhered to soil below the water table surface. The capacity of the existing treatment facility will be expanded to meet the additional groundwater pumping requirements and as a contingency for pumping a portion of the aqueous phase plume. This removal action is scheduled to begin in the summer of 1996.

1.4 Project Objectives

The primary objective of the Groundwater Impact Study is to evaluate the most appropriate action or actions necessary to protect human and ecological receptors from risks associated with aqueous phase contaminants present in groundwater downgradient of FT-002. To accomplish this, the following investigation goals have been established.

- Develop a 3-dimensional numerical flow and transport model to predict the movement of contaminants in groundwater from FT-002 over time.
- Evaluate the potential disposition of contaminants once they enter surface water bodies.
- Based on the model, evaluate the potential future impact of the contaminant plume on existing human and ecological receptors.

- Identify groundwater users downgradient of the plume and evaluate the potential provision of well-head treatment or extension of the public water supply as alternatives for their protection.

1.5 Work Plan Organization

This document is divided into the following four parts:

- Part I (Work Plan) - Provides background information regarding the site, describes the work to be performed, and provides a rationale for the work elements.
- Part II (Sampling and Analysis Plan) - Describes the quality assurance and field sampling procedures that will be employed to collect data during investigation field activities. To avoid redundancy, procedures described in approved Plattsburgh AFB Project Plans are referenced where possible.
- Part III (Community Relations Plan) - Specifies general procedures for obtaining easements for offbase data collection and for the potable water well survey.
- Part IV (Health and Safety Plan) - Amends the approved Plattsburgh AFB IRP Health & Safety Plan to provide site-specific details and guidance for personnel performing onsite field activities for this program.

In addition, the laboratory SOPs have been included as an Appendix, bound separately.

2.0 SUMMARY OF EXISTING INFORMATION

2.1 Environmental Setting

2.1.1 Hydrogeology

Four geologic units underlie Plattsburgh AFB. From top to bottom, these are sand, clay, glacial till, and bedrock. This stratigraphic sequence is consistent basewide, although the thickness of the individual units vary. The sand unit decreases in thickness from west to east and is entirely absent to the southeast. The clay unit averages approximately 10 feet in thickness and is exposed at the surface within the base golf course (southeast of the flightline ramp). The glacial till varies widely in texture, from clays and silts to gravels and cobbles, and in thickness, from a few feet to more than 40 feet. The Ordovician Period carbonate bedrock is block faulted under the base, which may contribute to the observed undulations in bedrock topography. One fault has been positively identified on base (see Figure 2-1), roughly trending along the golf course drainage to Lake Champlain. South of the fault, bedrock is exposed at the surface. Outcrops are common along Route 9 and at the topographic rise near Bluff Point. To the north of the fault, a varying thickness of overburden overlies bedrock.

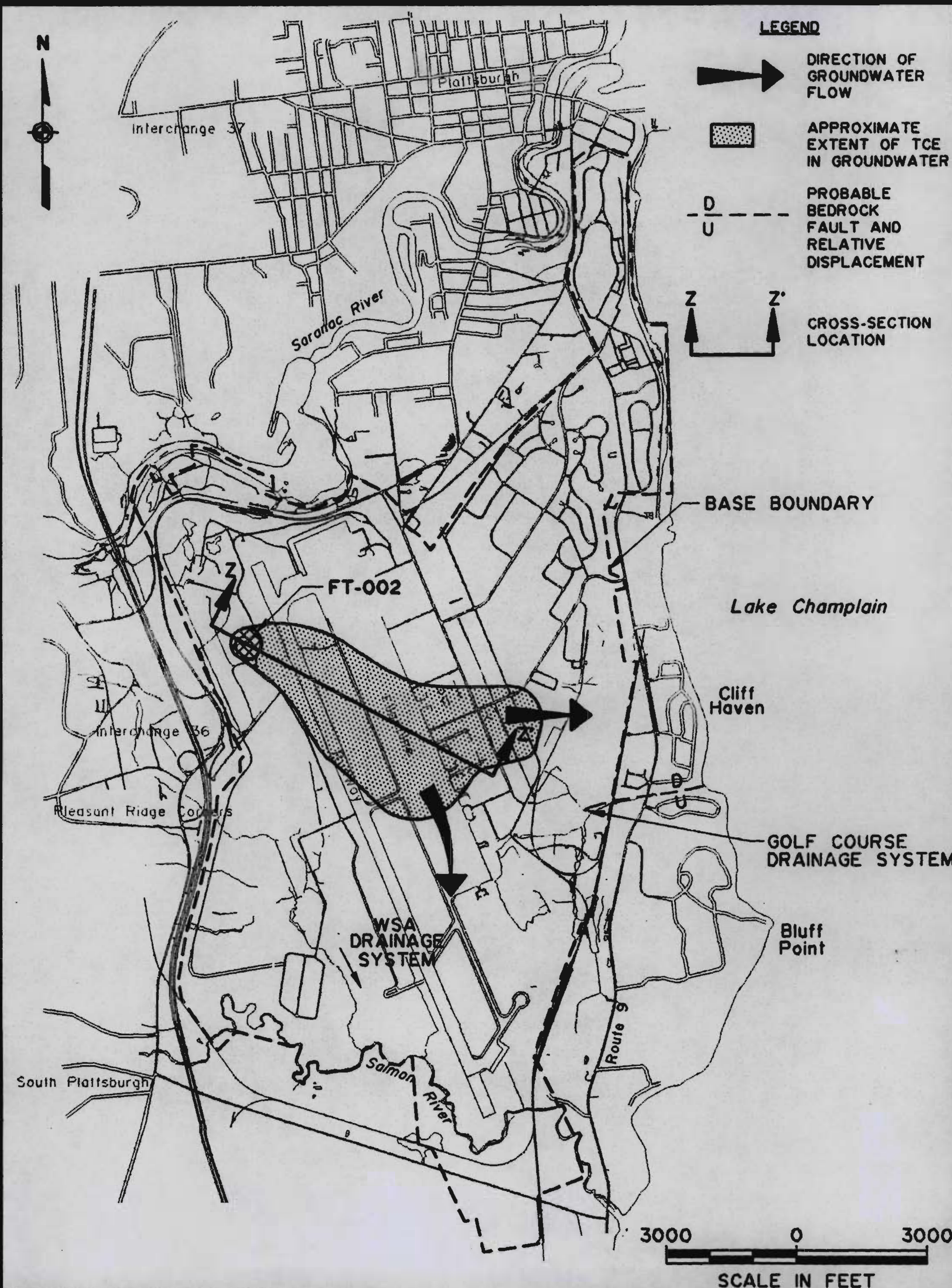
Hydrologically, the geologic sequence is divided into the following units:

- Unsaturated Zone - This zone lies between the ground surface and the water table. The unsaturated thickness varies from 35 feet in the western portion of the base to nearly zero in areas between the flightline ramp and Lake Champlain. The zone lies entirely within the sand unit except to the southeast, where the water table surface intersects clay and bedrock.

- Unconfined Aquifer - The unconfined saturated system reaches a maximum thickness of over 50 feet immediately southeast of the FT-002 site, thinning to 20 feet northwest of FT-002 and to less than 10 feet south and east of the flightline. Groundwater flow is generally southeastward toward Lake Champlain at an average hydraulic gradient of 0.010 ft/ft. Basewide, there are northerly and southerly components of flow due to the effects of the Saranac and Salmon Rivers, respectively. The direction of the vertical gradients in the unconfined aquifer is variable, suggesting possible localized influences, including the presence of surface discharge features and vertical heterogeneity of the sediments.

  Values for hydraulic conductivity (K) determined for the unconfined aquifer ranged from 10^{-5} to 10^{-2} cm/sec. K values are observed to decrease slightly with depth as a function of a decrease in grain size and/or increase in compaction of the materials.

- Confining Layers - The clay and till layers together form a relatively impermeable confining unit that separates the sandy unconfined aquifer above, from the confined bedrock aquifer below. Vertical hydraulic conductivity of the clay unit was measured to range from 1.19×10^{-8} to 4.49×10^{-8} cm/sec. The hydraulic conductivity of the till is likely on the order of 10^{-7} cm/sec.



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CROSS-SECTION LOCATION

FIGURE 2-1

- Confined Aquifer - Ordovician carbonate bedrock underlies the till. The degree of fracturing and hydraulic conductivity of the bedrock is unknown. Groundwater in the confined aquifer flows eastward towards Lake Champlain.

2.1.2 Contaminant Sources and Contamination

The primary source of aqueous contamination in groundwater at Plattsburgh AFB is contaminated soil and light non-aqueous phase liquid at FT-002. The extent of aqueous phase groundwater contamination from FT-002, assuming no other downgradient sources, can be represented by the extent of the chlorinated hydrocarbon TCE, as shown on Figure 2-1. Within the contaminated area, the distribution of the primary groups of contaminants (BTEX or fuel-related compounds and chlorinated hydrocarbons) is different. The chlorinated hydrocarbons have spread considerably farther than the fuel-related fraction--a phenomenon attributable to the greater biodegradability of the fuel-related compounds and to differences in retardation between the chemical groups. This difference in extent is shown on successive cross sections (Figures 2-2 and 2-3). The section line is depicted on Figure 2-1. The highest concentrations of chlorinated hydrocarbons appear to occur near the midpoint of the saturated zone.

As groundwater contaminants enter the industrial area east of the flightline ramp and travel southward near the weapons storage area, they become difficult to distinguish from groundwater contaminants from secondary contaminant sources located in these areas. Potential sources of groundwater contamination downgradient from FT-002 were investigated at IRP sites SS-004, SS-005, SS-006, SS-010, SS-013, and SS-017. A list of chemicals detected in wells installed as part of investigations performed at FT-002 and at IRP sites downgradient from FT-002 is given on Table 2-1. As yet unidentified potential sources also may be associated with "slop" tanks located along the flightline ramp and in the industrial corridor.

2.1.3 Surface Water

The local base level for groundwater flow at Plattsburgh AFB is Lake Champlain, located east of the base at an elevation of approximately 95 feet above sea level. The Salmon River likely serves as the southern hydrologic boundary for groundwater flow in the unconfined aquifer at the base; while the Saranac River, located to the north of the base, serves as the northern hydrologic boundary. Two additional significant surface water drainageways are located downgradient of FT-002. To the east, surface water in a series of drainageways cuts through the base golf course before flowing to Lake Champlain. To the south, surface water in a series of drainageways west of the runway cuts through the former Weapons Storage Area before flowing to the Salmon River.

2.1.4 Ecology

Terrestrial and aquatic habitats at Plattsburgh AFB are described in the *Step I Habitat Assessment Report* for the base (URS 1994b). Palustrine systems (wetlands) are described in the *Wetlands Delineation Report* (URS 1994c). In these two reports, riverine and lacustrine habitat systems were identified and described in general terms. Aquatic habitats that may be impacted by groundwater contaminants from FT-002 are located in the major surface water bodies on and near the base.

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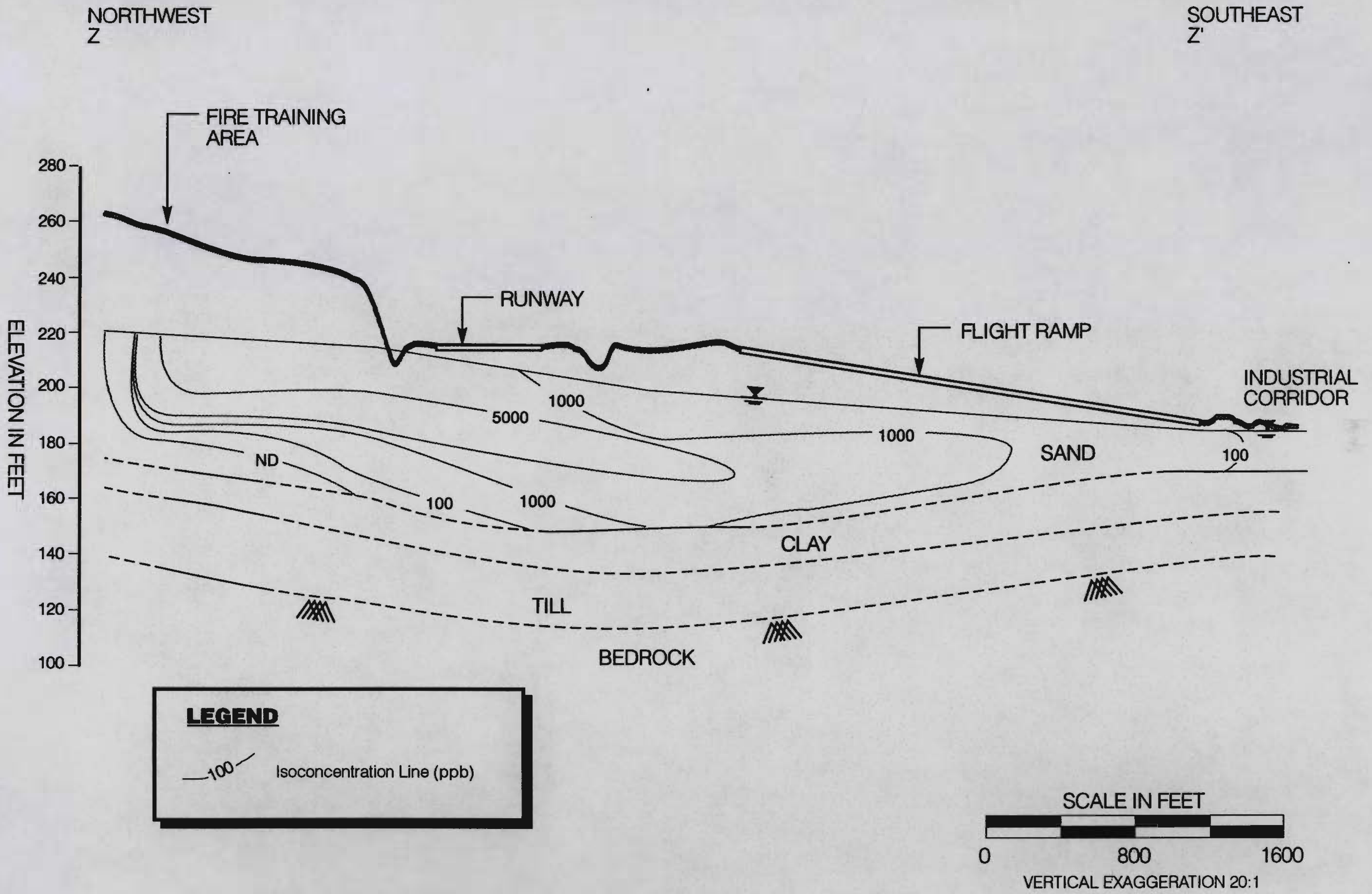

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PROFILE ALONG MAJOR PLUME AXIS - SEPTEMBER 1991
EXTENT OF VOLATILE CHLORINATED HYDROCARBON CONTAMINATION

FIGURE 2-2

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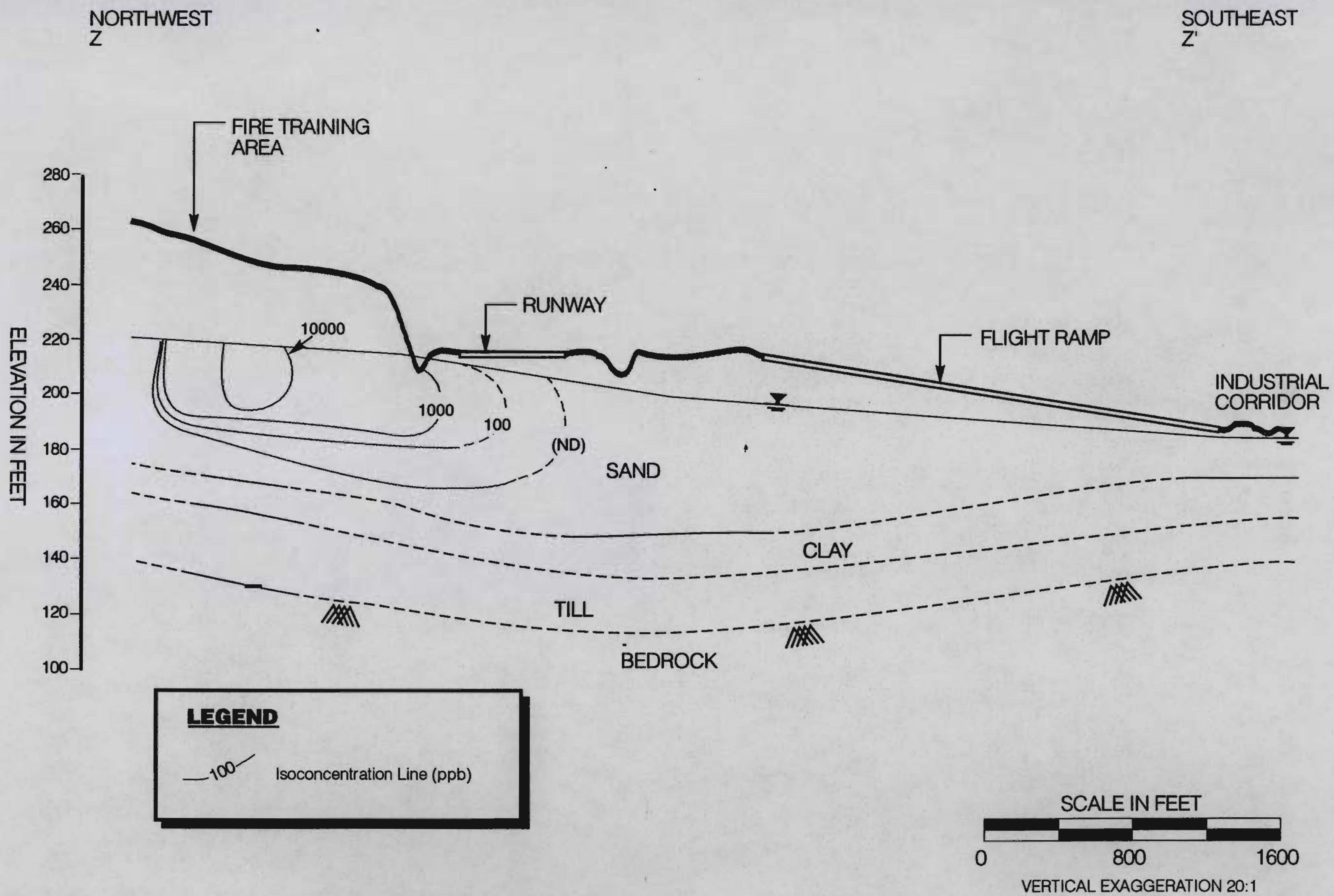

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PROFILE ALONG MAJOR PLUME AXIS - SEPTEMBER 1991
EXTENT OF BTEX (FUEL RELATED) VOLATILE CONTAMINATION

FIGURE 2-3

TABLE 2-1

ORGANIC CHEMICALS DETECTED IN GROUNDWATER
FT-002 AND IRP SITES DOWNGRADIENT FROM FT-002
FT-002 GROUNDWATER IMPACT STUDY

COMPOUND	MAXIMUM CONCENTRATION (µg/l)	FREQUENCY OF DETECTION	SITE OF MAXIMUM CONCENTRATION	FT-002	SS-004	SS-005	SS-006	SS-010	SS-013	SS-017
Chloromethane	19	10/118	SS-010					X	X	
Chloroethane	1.5	1/118	SS-010					X		
Vinyl Chloride	53	3/118	SS-013	X					X	
Methylene Chloride	300	4/118	SS-017	X				X		X
Acetone	130	9/118	FT-002	X	X			X	X	X
Carbon Disulfide	280	7/118	FT-002	X	X			X		
Carbon Tetrachloride	0.1	1/118	SS-005			X				
1,1-Dichloroethane	3	1/118	FT-002	X						
1,1-Dichloroethene	140	5/118	FT-002	X	X					
Bromodichloromethane	0.9	1/118	SS-005			X				
1,2-Dichloroethene (total)	18,000	42/118	FT-002	X					X	X
cis-1,2-Dichloroethene	0.8	1/10	SS-017							X
trans-1,2-Dichloroethene	2,700	4/10	SS-017							X
1,2-Dichloroethane	45	14/118	FT-002	X				X	X	X
2-Butanone	690	9/118	FT-002	X						
Trichloroethene	3,900	43/118	FT-002	X	X	X	X			X
1,1,2-Trichloroethane	19	1/118	FT-002	X						
Benzene	720	18/118	FT-002	X	X	X		X		X
4-Methyl-2-Pentanone	70	1/118	FT-002	X						
2-Hexanone	96	1/118	FT-002	X						
Tetrachloroethene	52	3/118	FT-002	X						X
Bromoform	0.1	1/118	SS-005			X				
Toluene	4,200	23/118	FT-002	X	X	X	X		X	X
Chlorobenzene	1,800	6/118	SS-017	X		X				X
Ethylbenzene	1,400	28/118	FT-002	X	X				X	X
Styrene	2	2/118	SS-013						X	
Xylene (total)	13,000	35/118	FT-002	X	X			X	X	X

TABLE 2-1

ORGANIC CHEMICALS DETECTED IN GROUNDWATER
FT-002 AND IRP SITES DOWNGRADIENT FROM FT-002
FT-002 GROUNDWATER IMPACT STUDY

COMPOUND	MAXIMUM CONCENTRATION (µg/l)	FREQUENCY OF DETECTION	SITE OF MAXIMUM CONCENTRATION	FT-002	SS-004	SS-005	SS-006	SS-010	SS-013	SS-017
Phenol	110	4/101	FT-002	X						
2-Chlorophenol	130	2/101	FT-002	X						X
1,2-Dichlorobenzene	1,500	3/101	SS-017	X						X
1,3-Dichlorobenzene	490	2/101	SS-017							X
1,4-Dichlorobenzene	730	2/101	SS-017							X
1,2,4-Trichlorobenzene	14	1/101	FT-002	X						
2-Methylphenol	150	5/101	SS-017	X						X
4-Methylphenol	180	10/101	SS-017	X						X
2,4-Dimethylphenol	1,500	11/101	SS-017	X					X	X
Naphthalene	3,700	17/101	FT-002	X				X	X	X
4-Chloro-3-Methylphenol	42	2/101	FT-002	X			X			
2-Methylnaphthalene	9,600	14/101	FT-002	X					X	X
Acenaphthalene	2	1/101	SS-013						X	
Acenaphthene	780	3/101	FT-002	X					X	
4-Nitrophenol	150	1/101	FT-002	X						
Pentachlorophenol	140	1/101	FT-002	X						
Carbazole	53	3/101	SS-013			X			X	
Di-n-octylphthalate	0.8	3/101	SS-017			X				X
Di-n-butylphthalate	1	7/101	SS-005			X	X			X
Fluorene	22	2/101	SS-013						X	
Fluoranthene	0.1	1/101	SS-005			X				
Pyrene	0.2	2/101	SS-005			X	X			
Diethylphthalate	0.6	3/101	SS-017				X			X
Butylbenzylphthalate	2	5/101	SS-010			X	X			X
Dibenzofuran	33	4/101	SS-013						X	X
Phenanthrene	1,700	2/101	FT-002	X					X	
bis(2-Ethylhexyl)phthalate	1,100	17/101	FT-002	X	X	X	X	X		X

Lake Champlain is a dimictic oligotrophic lake, or a large, deep, cold water lake that becomes thermally stratified twice a year--once in the summer, and again in the winter after ice forms on the surface. As an oligotrophic lake, Champlain has a low level of nutrients and as a result, supports sparse plankton populations and low density growths of macrophytes. The lake supports populations of fish species including Atlantic Salmon, Lake Trout, Cisco, Lake Whitefish, Mooneye, Longnose Dace, Burbot, Log perch, and Walleye.

The Saranac and Salmon Rivers are midreach streams with substrates that are generally bedrock, cobbles, gravel, or sand. Small backwaters, seeps, wetlands, and waterfalls are associated with the mainstream habitats. Temporary slackwater regions are associated with snags, debris, and beaver dams. Expected fish species include Rainbow Trout, Brown Trout, White Sucker, Silver Redhorse, and Common Shiner.

The drainage system that runs through the former Weapons Storage Area, a tributary of the Salmon River, can be described as a marsh headwater stream. This system supports extensive wetland habitats and permanent aquatic habitats, even in dry weather, in pools that provide refuge for fish and macroinvertebrates. Typical fish species may include Brook Trout, Creek Chub, Johnny Darter, Common Shiner, Bluntnose Minnow, and Blacknose Dace.

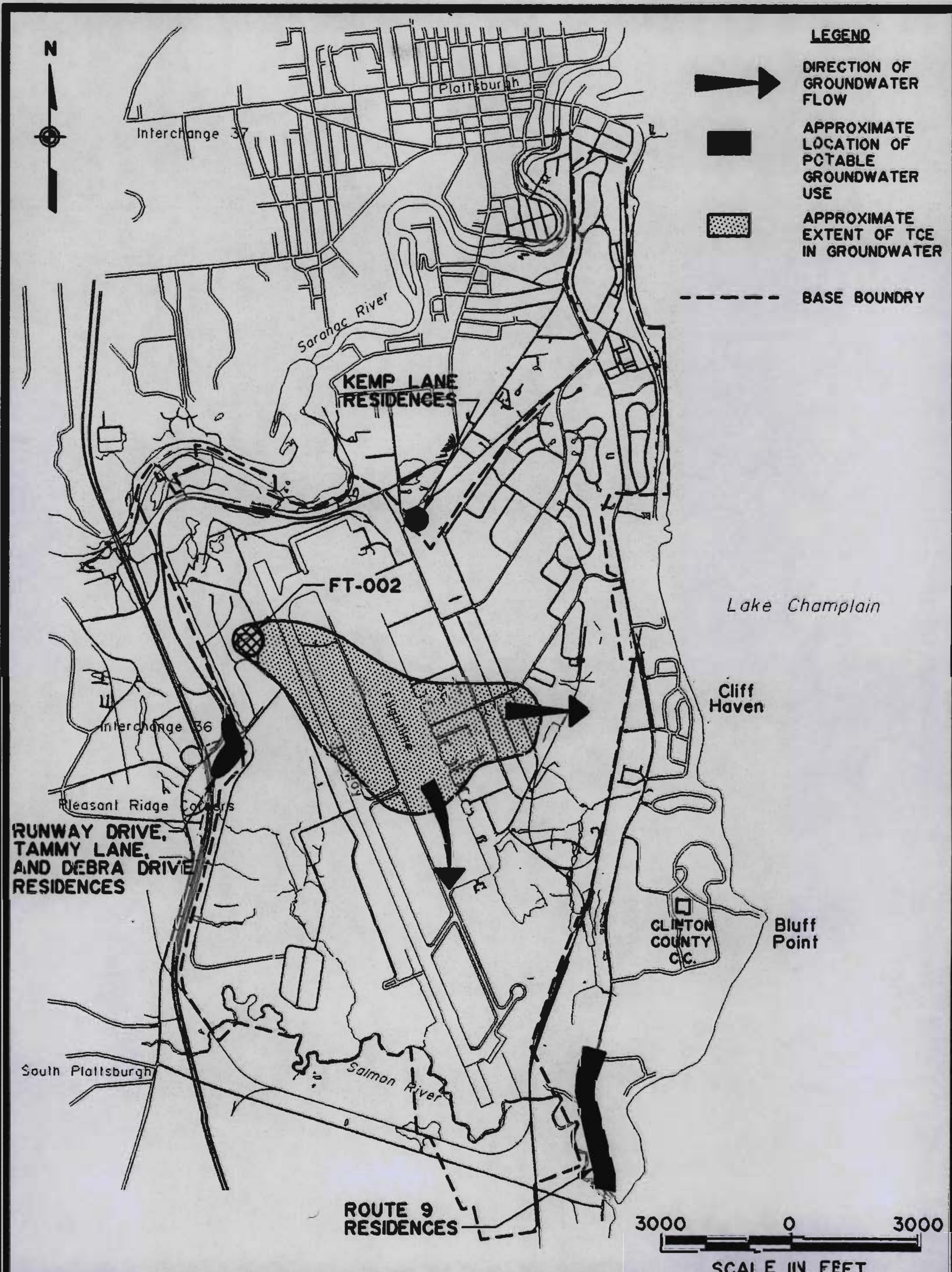
The drainage system that runs through the base golf course can be described as an intermittent stream, or a stream that may not support a permanent aquatic habitat in dry weather. As the stream exits the base toward Lake Champlain, permanent habitats may exist and the stream may better be described as a marsh headwater stream. Several large wetlands habitats are associated with the headwater of this drainage system.

2.1.5 Potable Groundwater Use

Plattsburgh AFB obtains its potable water from the City of Plattsburgh municipal water system. Some residents adjacent to the base rely on private wells for drinking water. These residences include homes along Kemp Lane (near the base's North Gate), a residential development off of Old Route 22 (Runway Drive, Tammy Lane, and Debra Drive), and residences and businesses southeast of the base along Route 9 (Figure 2-4). The Kemp Lane and Route 22 residences should not be influenced by groundwater flow from FT-002. However, the residences and businesses using groundwater along Route 9 lie downgradient of FT-002. Approximately 50 properties are located in this area, a number of which likely rely on water from Lake Champlain, rather than groundwater, for potable water supply. It should be noted that the Cliff Haven residential community, with the exception of one residence, and the Clinton County Community College, located near Bluff Point, are supplied with municipal water. The location of potable water well users along Route 9 will be verified by a house-to-house survey.

2.2 Conceptual Site Model

Groundwater contamination from FT-002 is fully contained within the base boundaries and groundwater is not used on base. Consequently, there is no threat to human health or the environment posed by groundwater contaminants from FT-002. Depending on the migration of the site contaminants, human or ecological exposure may be possible in the future. Preliminary future exposure pathways are illustrated in Figure 2-5 and outlined in Table 2-2. Contaminants of concern are volatile chlorinated



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LOCATIONS OF OFF-BASE RESIDENCES UTILIZING GROUNDWATER FOR POTABLE USE

FIGURE 2-4

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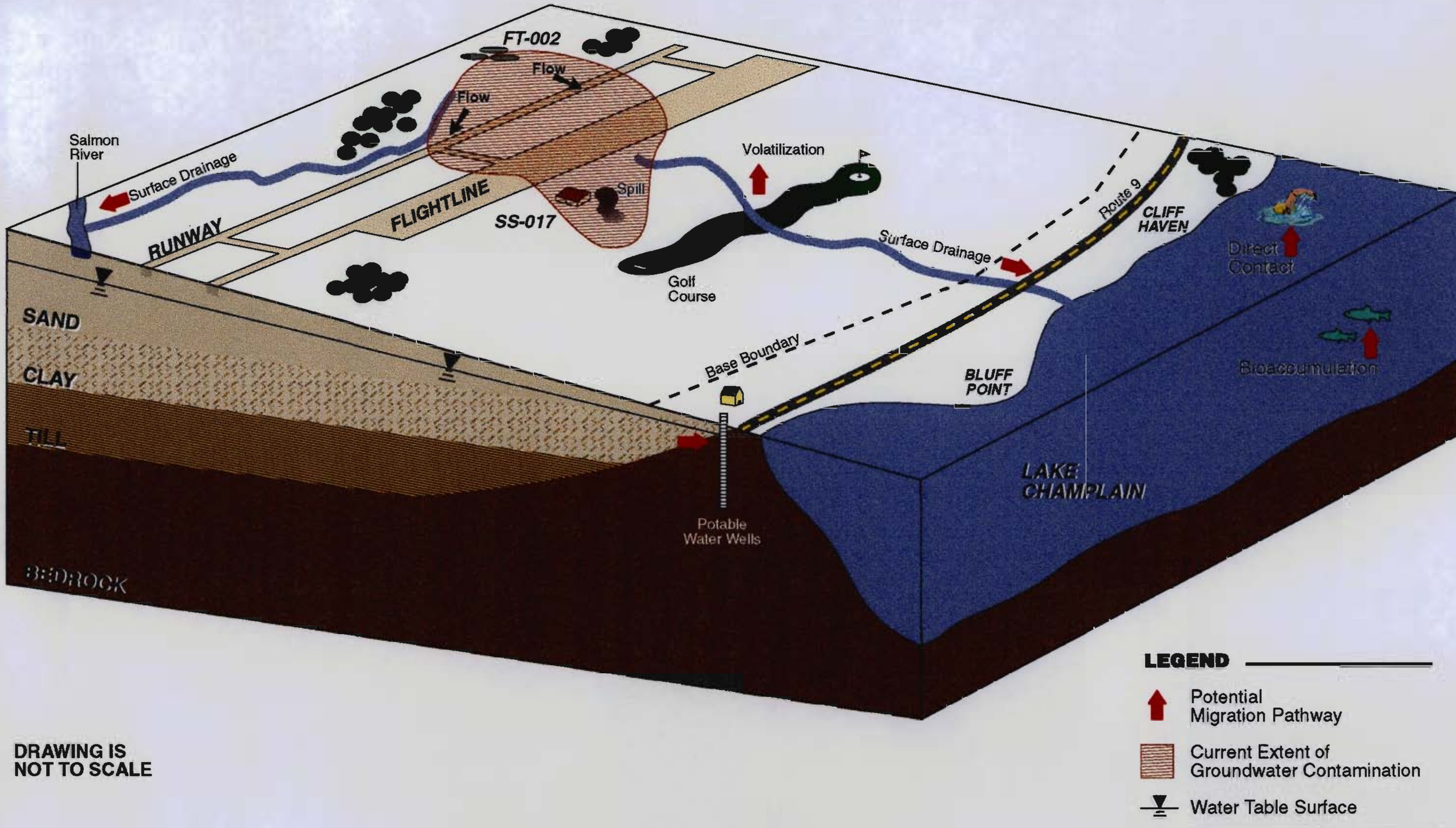

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CONCEPTUAL SITE MODEL
FT-002 GROUNDWATER OPERABLE UNIT

FIGURE 2-5

TABLE 2-2

CONCEPTUAL SITE MODEL - PRELIMINARY EXPOSURE PATHWAYS

Migration Pathway	Potentially Exposed Population	Potential Exposure Route
Contaminant Transport in Groundwater	Potable Groundwater Users	• Ingestion • Dermal Contact • Inhalation of Vapors While Showering
Surface Water	Recreational Users	• Dermal Contact • Ingestion • Inhalation of Vapors • Fish Ingestion

hydrocarbons and related compounds that are environmentally persistent and migrate readily in groundwater. This preliminary model will be revised based on the results of this study.

2.3 Data Needs

Further investigation will focus on the acquisition of six additional data elements required to develop the groundwater flow and chemical transport model and to address the other goals of the study. Specifically, the information includes:

1. Data to develop the hydrologic definition of the northern, western, and southern boundary conditions of the model. Construction of borings and piezometers in each of these areas will address this data requirement.

2. A more in-depth description of the geology and hydrology of the area between Lake Champlain and the easternmost extent of TCE in groundwater. Additional subsurface investigation is needed to enable the prediction of groundwater flow and chemical movement into this area.

3. More specific information regarding potential human and ecological receptors. Data will be obtained by house-to-house identification of potable water users and by a focused ecological survey, respectively.

4. An identification of the nature of chemical contamination in the aquifer underlying the flightline ramp. This is critical in understanding the transition from anaerobic (where extensive bioattenuation is occurring) to aerobic conditions within the FT-002 plume. There are four well clusters located in the northern portion of the ramp, but additional data is required south of these existing wells.

5. A compilation of basewide chemical and hydrologic data that has been collected by a number of separate investigators over a period of several years. Data relevant to this study, such as volatile organic compound concentrations and groundwater elevation data, will be compiled to develop input parameters for the model and also to calibrate the results.

6. Additional chemical and geotechnical data collection required to define model parameters such as biodegradation and retardation.

3.0 GROUNDWATER IMPACT STUDY TASKS

3.1 Consolidation of Existing Data

To date, IRP sites on base have been examined primarily on a site-by-site basis, and in the case of FT-002, broken into multi-phased operable units. The investigations have been performed by different consultants and implemented by several federal agencies. To support the flow and transport model, available hydrologic, geologic, and pertinent analytical data, basewide, will be consolidated into a single data base. This data base will then be analyzed to determine trends, such as vertical and horizontal hydraulic conductivity variations within the unconfined sand aquifer, and changes in chemical concentrations at individual well locations over time. The data base also will be reviewed to determine if there is sufficient existing hydrogeologic and chemical data to support the model. If data gaps are identified, the current planned field data collection effort will be modified to address the gaps, especially with regard to location of wells and piezometers, and the selection of wells and borings that will be analytically sampled.

3.2 Field Investigations

Field investigations designed to evaluate geologic, hydrologic, chemical, demographic, and ecologic conditions for the Groundwater Impact Study are detailed below. Field and laboratory methodologies that will be used are discussed in Part II, Sampling and Analysis Plan.

3.2.1 Potable Well Survey

A house-to-house survey of residences and commercial establishments will be conducted to obtain relevant details regarding potable wells including date installed, installation contractor, well depth, screened interval, pumping rate, static water level, and any available stratigraphic data. Although primarily a tool to identify households that potentially may be impacted by contaminants that could be transported to potable groundwater wells, this survey also will provide geologic (i.e., depth to bedrock, bedrock type) and hydrologic (i.e., well yield, water level) information. An initial search of Town of Plattsburgh Water Department records indicated that approximately 50 land parcels are located downgradient of the FT-002 plume near Route 9 and are not serviced by the Town water supply. These parcels will be the object of the house-to-house survey. General survey procedures are described in the Community Relations Plan (Part III).

3.2.2 Ecological Survey

A baseline ecological survey will be conducted to evaluate the impact of the FT-002 groundwater plume on ecological receptors. The survey will be concerned primarily with areas where groundwater discharges to surface drainages at potential points of exposure. Drainageways of concern include those exiting the base (especially the golf course drainage), the Salmon River, and Lake Champlain. URS will make use of the considerable amount of habitat data already available in previous reports. This existing data base will be expanded by reviewing pertinent literature, by contacting appropriate local, state, and federal governmental agencies, and by performing field surveys to validate the literature search and to fill data gaps.

3.2.3 Geophysical Surveys

Two types of geophysical surveys will be conducted to expand upon the bedrock information currently available at Plattsburgh AFB: seismic refraction surveys to gather depth to bedrock data; and azimuthal resistivity surveys to obtain bedrock structure and fracture orientation data. This information will supplement previous investigative findings, assist in well location selection for additional investigations, and provide input to the groundwater flow and contaminant transport model.

Approximately 6,500 linear feet of seismic refraction survey was undertaken from December 9-12, 1995 to provide information on the bedrock/overburden interface in the area along the eastern base boundary near Cliff Haven. This data was collected prior to submittal of the Work Plan so it could be used to better focus the spring of 1996 drilling and geophysical programs in this area. This data will be used to supplement the existing seismic refraction data base available for the base. Survey lines were established and cleared by URS. The survey was conducted by Gartner Lee, Inc. of Niagara Falls, New York. Seismic refraction data was collected with geophones spaced at 15 foot intervals and monitored with a 24-channel seismograph. The data will be processed using the generalized reciprocal method and the results included in the Conceptual Site Model Report.

Square array azimuthal resistivity surveys will be completed by Gartner-Lee at seven locations selected by URS. These surveys will yield data regarding the spacial orientation of water-conducting fractures in bedrock. Three surveys of various array size will be completed at each of these seven locations (survey depths are determined by array spacing). The depth of investigation for the surveys will not exceed 150 feet. Resistivity surveys are tentatively scheduled for the spring of 1996. Survey locations will be determined following a review of available geologic and hydrogeologic data.

3.2.4 Boring and Monitoring Well Installation

Three soil borings, 22 monitoring wells, 2 pumping wells, and 6 piezometers, as summarized in Table 3-1 and shown on Figures 3-1 through 3-4, will be installed onbase and offbase in areas where supplementary geologic, hydrogeologic, and/or chemical data are needed to support the groundwater flow and contaminant transport model. Two monitoring wells, MW-02-050 and- 051, and one boring, B-02-501, were installed during December 14-19, 1995 to provide information to re-evaluate the locations of the remaining wells and borings which will be installed in the spring of 1996. These wells and boring were installed prior to submittal of the Work Plan to ensure that the information could be gained prior to the onset of severe winter weather. After reviewing available basewide hydrogeologic information, and that collected in December 1995, data gaps may be identified that will require monitoring wells in other areas of the base. All monitoring well locations are considered tentative pending that review. Only selected monitoring wells will be sampled during this study, but all wells will be monitored for groundwater elevation data. Monitoring wells MW-02-052, 053, and 054 may serve as "sentry" wells, or early warning wells for residences utilizing groundwater along Route 9 downgradient from the base. Well-borings advanced into bedrock will be sampled continuously using an NX-size core barrel. Bedrock well-borings will be advanced 20 feet into rock. Drilling will be performed by Adirondack Environmental Associates, Inc. of Plattsburgh, New York.

TABLE 3-1

SUMMARY OF PROPOSED MONITORING WELLS AND BORINGS
FT-002 GROUNDWATER IMPACT STUDY

ID#	Monitored Aquifer		Screen Depth		Comments
	Overburden	Bedrock	Water Table	Intermediate	
MW-02-050	X		X		Provides geologic and hydrologic data from an area immediately downgradient from the easternmost extent of TCE contamination. **Was installed in December 1995.**
MW-02-051	X			X	Provides geologic and hydrologic data from an area immediately downgradient from the easternmost extent of TCE contamination. **Was installed in December 1995.**
MW-02-052		X	X		Located between base and downgradient well users. **May serve as a "sentry" well for downgradient well users.**
MW-02-053		X	X		Located between base and downgradient well users. **May serve as a "sentry" well for downgradient well users.**
MW-02-054		X	X		Located between base and downgradient well users. **May serve as a "sentry" well for downgradient well users.**
MW-02-055	X		X		Will provide hydraulic head and geologic data from an area north of the southern hydrologic boundary (the Salmon River). May not be necessary to sample for chemical analyses.
MW-02-056		X		X	Bedrock well paired with existing overburden well MW-04-005 in a critical area downgradient of the plume.
MW-02-057	X		X		Will provide hydraulic head and chemical data from a data gap in the flightline ramp.
MW-02-058	X		X		Will provide geologic, hydrologic, and chemical data from an area immediately downgradient from easternmost extent of TCE contamination.

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TABLE 3-1 (Cont.)

SUMMARY OF PROPOSED MONITORING WELLS AND BORINGS
FT-002 GROUNDWATER IMPACT STUDY

ID#	Monitored Aquifer		Screen Depth		Comments
	Overburden	Bedrock	Water Table	Intermediate	
MW-02-059	X		X		Will provide hydraulic head and geologic information near northern boundary of modeled area. Not likely to require sampling for chemical analyses.
MW-02-060	X		X		Will provide hydraulic head and geologic information near northern boundary of modeled area. Not likely to require sampling for chemical analyses.
MW-02-061	X		X		Will provide hydraulic head and geologic information near northern boundary of modeled area. Not likely to require sampling for chemical analyses.
MW-02-062	X		X		Will provide hydraulic head and geologic information near northern boundary of modeled area. Not likely to require sampling for chemical analyses.
MW-02-063	X		X		Defines hydrologic western boundary of model. Not likely to require sampling for chemical analyses.
MW-02-064		X		X	Defines hydrologic western boundary of model. Not likely to require sampling for chemical analyses.
MW-02-065	X		X		Defines hydrologic western boundary of model. Not likely to require sampling for chemical analyses.
MW-02-066	X		X		Defines hydrologic western boundary of model. Not likely to require sampling for chemical analyses.
MW-02-067	X		X		Tentatively located in Cliffhaven to monitor flow to Lake Champlain, downgradient of base.
MW-02-068		X		X	Tentatively located in Cliffhaven to monitor flow to Lake Champlain, downgradient of base.

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TABLE 3-1 (Cont.)

SUMMARY OF PROPOSED MONITORING WELLS AND BORINGS
FT-002 GROUNDWATER IMPACT STUDY

ID#	Monitored Aquifer		Screen Depth		Comments
	Overburden	Bedrock	Water Table	Intermediate	
MW-02-069	X			X	As yet unspecified location. Will be paired with an existing well where a vertical data gap exists within the overburden aquifer.
MW-02-070	X			X	As yet unspecified location. Will be paired with an existing well where a vertical data gap exists within the overburden aquifer.
MW-02-071	X			X	As yet unspecified location. Will be paired with an existing well where a vertical data gap exists within the overburden aquifer.
PT-02-01	X		X		Overburden pumping test well.
PZ-02-01	X		X		Piezometer for overburden pump test.
PZ-02-02	X		X		Piezometer for overburden pump test.
PT-02-02		X	X		Bedrock pumping test well.
PZ-02-03		X	X		Piezometer for bedrock pump test.
PZ-02-04		X	X		Piezometer for bedrock pump test.
B-02-501	X		---	---	Provides geologic data from an area where the overburden thinand bedrock is exposed immediately to the east. **Was installed in December 1995.**
B-02-502	X		---	---	Will provide geological data from an area north of the southern hydrologic boundary (the Salmon River).
B-02-503	X		---	---	Will provide geologic data from an area north of the southern hydrologic boundary (the Salmon River).

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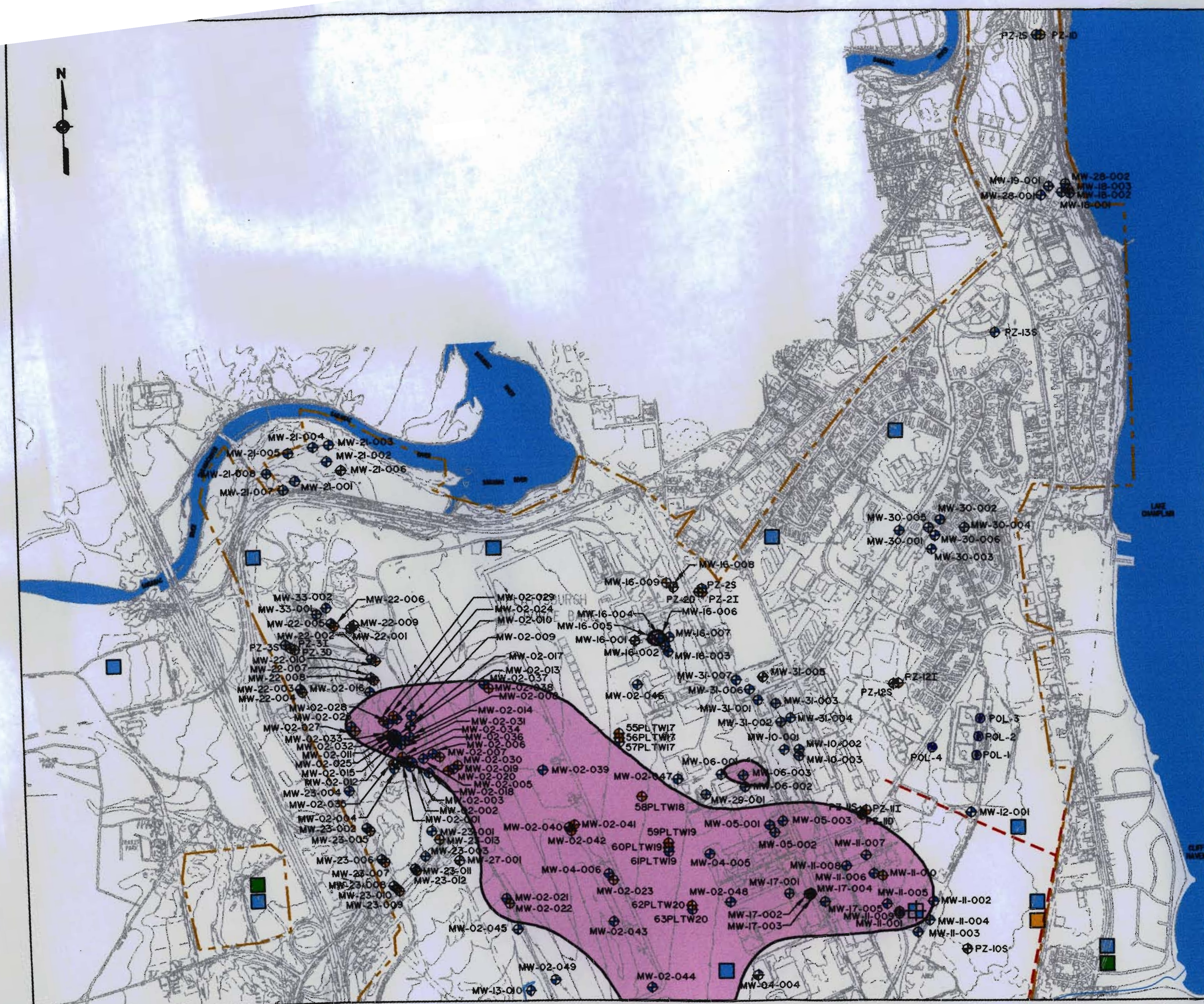


KEY

MAP A

MAP B

LEGEND

- OVERBURDEN AQUIFER WELL - SCREENED ACROSS WATER TABLE
- OVERBURDEN AQUIFER WELL - SCREENED BELOW WATER TABLE OR ON BOTTOM OF AQUIFER
- BEDROCK WELL
- LIKELY OVERBURDEN WELL - CONSTRUCTION UNKNOWN
- LIKELY BEDROCK WELL - CONSTRUCTION UNKNOWN
- PROPOSED OVERBURDEN AQUIFER WELL - SCREENED ACROSS WATER TABLE
- PROPOSED OVERBURDEN AQUIFER WELL - SCREENED ON BOTTOM OF AQUIFER
- PROPOSED OVERBURDEN PUMPING TEST WELL (ASSOCIATED PIEZOMETERS NOT SHOWN)
- PROPOSED BEDROCK WELL
- PROPOSED BEDROCK PUMPING TEST WELL (ASSOCIATED PIEZOMETERS NOT SHOWN)
- PROPOSED SOIL BORING LOCATION
- SEISMIC REFRACTION SURVEY LINE
- BASE BOUNDARY
- APPROXIMATE EXTENT OF TCE IN GROUNDWATER

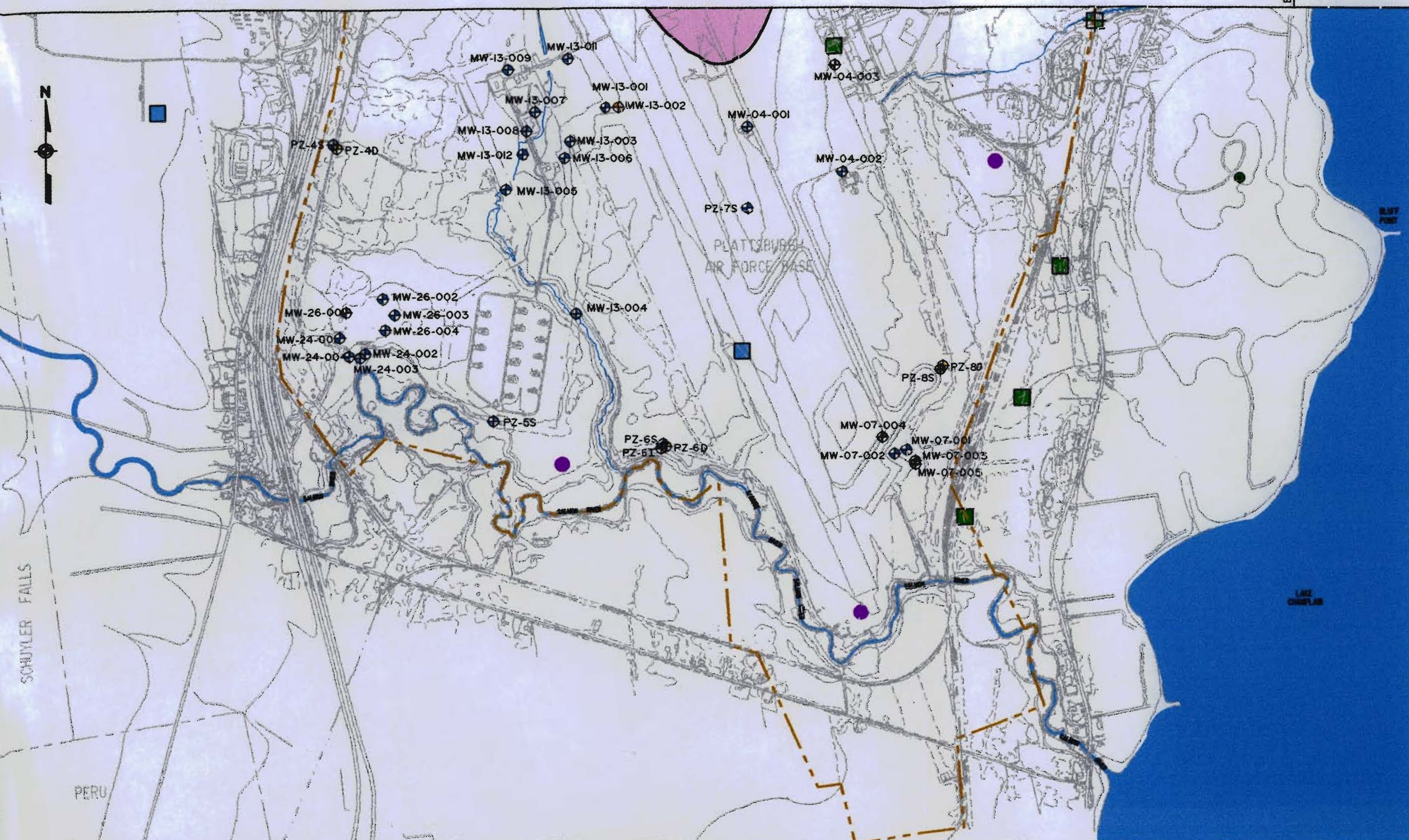
1500 0 1500

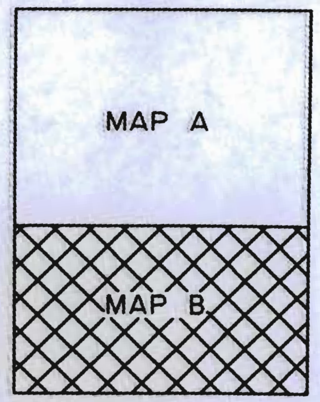
SCALE IN FEET

EXISTING AND PROPOSED WELL LOCATIONS

URS CONSULTANTS, INC.

FIGURE





LEGEND

- OVERBURDEN AQUIFER WELL - SCREENED ACROSS WATER TABLE
- OVERBURDEN AQUIFER WELL - SCREENED BELOW WATER TABLE OR ON BOTTOM OF AQUIFER
- BEDROCK WELL
- LIKELY OVERBURDEN WELL - CONSTRUCTION UNKNOWN
- LIKELY BEDROCK WELL - CONSTRUCTION UNKNOWN
- PROPOSED OVERBURDEN AQUIFER WELL - SCREENED ACROSS WATER TABLE
- PROPOSED OVERBURDEN AQUIFER WELL - SCREENED ON BOTTOM OF AQUIFER
- PROPOSED OVERBURDEN PUMPING TEST WELL (ASSOCIATED PIEZOMETERS NOT SHOWN)
- PROPOSED BEDROCK WELL
- PROPOSED BEDROCK PUMPING TEST WELL (ASSOCIATED PIEZOMETERS NOT SHOWN)
- PROPOSED SOIL BORING LOCATION
- SEISMIC REFRACTION SURVEY LINE
- BASE BOUNDARY
- APPROXIMATE EXTENT OF TCE IN GROUNDWATER

1500 0 1500

SCALE IN FEET

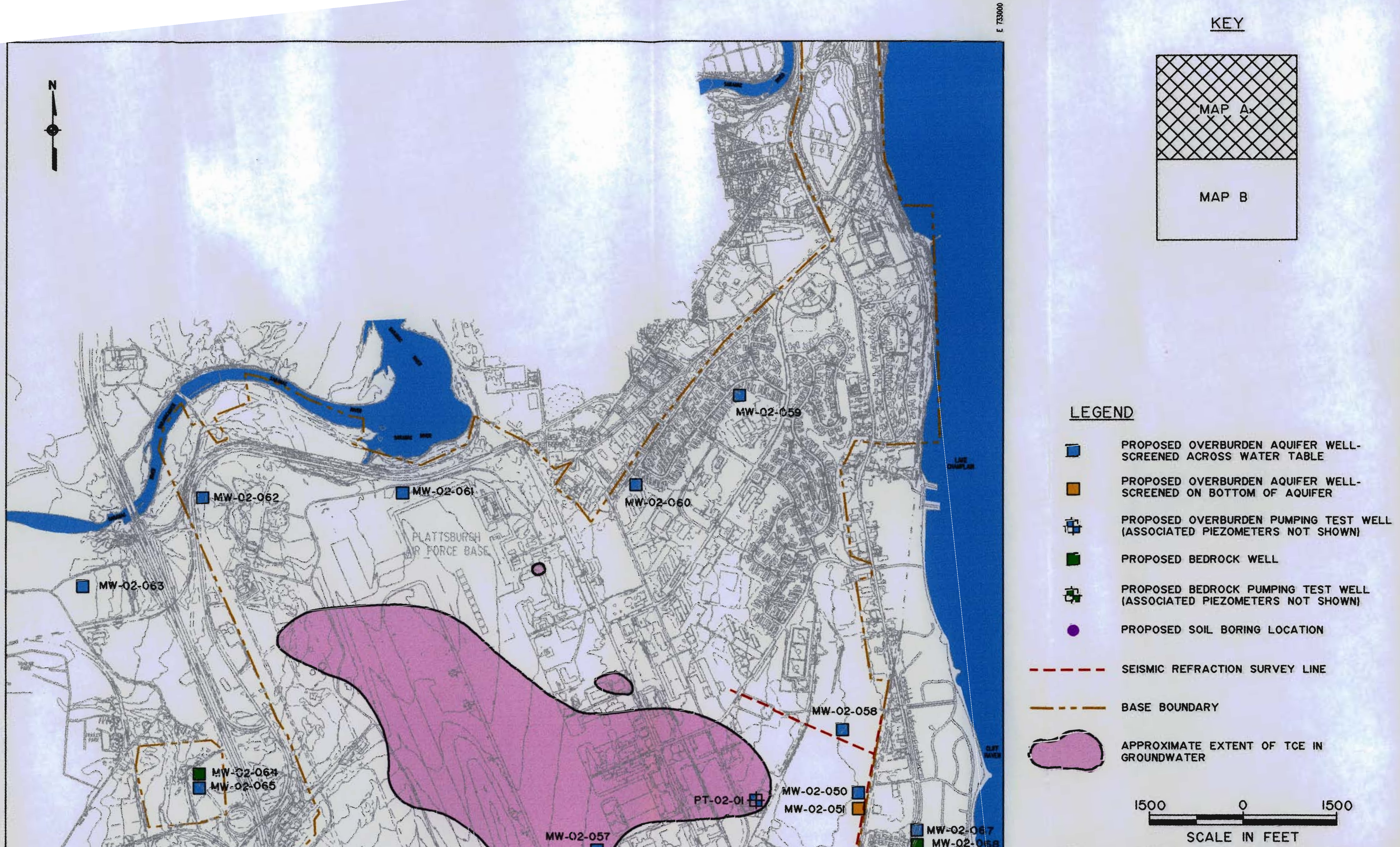
AS YET UNSPECIFIED LOCATION:

- MW-02-069
- MW-02-070
- MW-02-071

EXISTING AND PROPOSED WELL LOCATIONS

URS CONSULTANTS, INC.

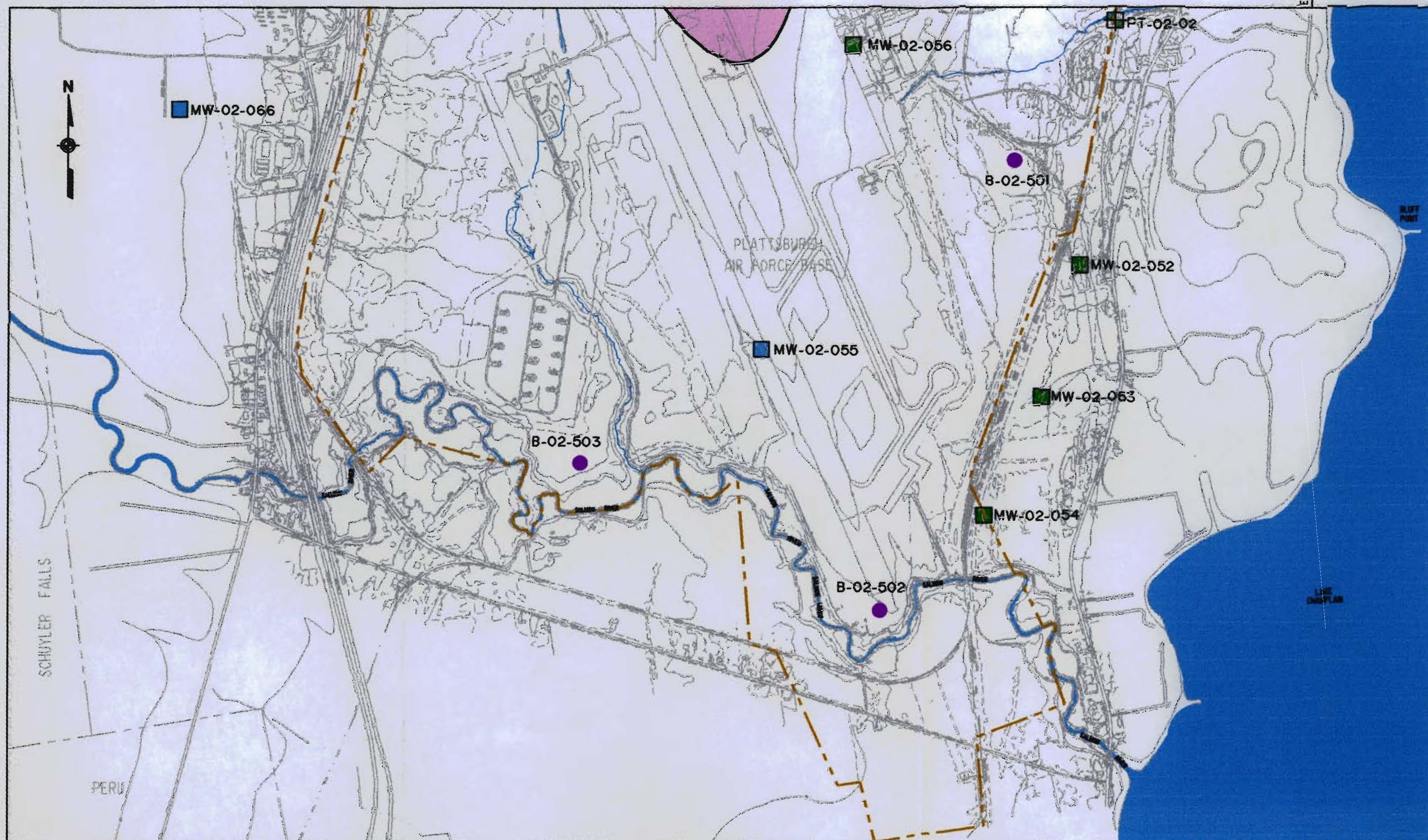
FIGURE 7-?



PROPOSED WELL LOCATIONS

URS CONSULTANTS, INC.

FIGURE 7-



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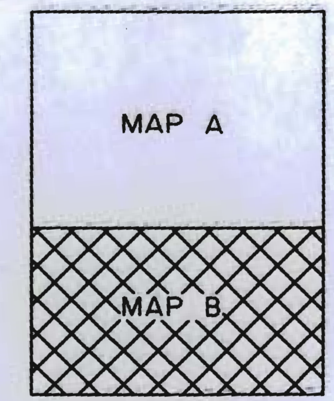

LEGEND

- PROPOSED OVERBURDEN AQUIFER WELL-SCREENED ACROSS WATER TABLE
- PROPOSED OVERBURDEN AQUIFER WELL-SCREENED ON BOTTOM OF AQUIFER
- PROPOSED OVERBURDEN PUMPING TEST WELL (ASSOCIATED PIEZOMETERS NOT SHOWN)
- PROPOSED BEDROCK WELL
- PROPOSED BEDROCK PUMPING TEST WELL (ASSOCIATED PIEZOMETERS NOT SHOWN)
- PROPOSED SOIL BORING LOCATION
- SEISMIC REFRACTION SURVEY LINE
- BASE BOUNDARY
- APPROXIMATE EXTENT OF TCE IN GROUNDWATER

1500 0 1500
SCALE IN FEET

AS YET UNSPECIFIED LOCATION:

- MW-02-069
- MW-02-070
- MW-02-071

PROPOSED WELL LOCATIONS

URS CONSULTANTS, INC

FIGURE

3.2.5 Aquifer Testing

To better quantify hydraulic characteristics of the bedrock and overburden aquifers, several types of testing will be conducted in the newly installed wells.

3.2.5.1 Packer Testing

Aquifer tests by packer interval will be performed in all newly drilled rock holes to provide estimates of the fracture permeability in the rock.

3.2.5.2 Slug Testing

Aquifer testing by raising (falling head) and lowering (rising head) the water level with slugs will be performed in all newly installed monitoring wells screened in the overburden to provide estimates of the horizontal hydraulic conductivity of the unit screened. Only rising head tests will be performed in the cases where the well-screen intersects the water table surface.

3.2.5.3 Aquifer Pumping Tests

Two aquifer pumping tests will be conducted, one in the bedrock aquifer and one in the overburden aquifer. The work will take place in two phases. The first phase will include development and analytical sampling of each pumping well. If determined necessary by the NYSDEC consequent to their review of analytical data, the effluent from the well development and pumping tests will be treated by air stripping and carbon polishing before discharge to the storm drainage system. The second phase will consist of a step drawdown and 48-hour constant rate pumping test at each location. Logistical support (i.e., provision of air stripping unit, work lights, and electrical hookup) will be provided by HM2, Inc. of Plattsburgh, New York

3.2.6 Hydrologic Data Collection

URS will develop piezometric surface maps for the unconfined overburden aquifer and confined bedrock aquifer using groundwater elevation data gathered from all available monitoring wells on and off base. Both spring and summer conditions will be mapped. Discharge measurements will be made in streams exiting the base and in the Salmon River concurrently with the groundwater elevation measurements. This data also will be used to calibrate the groundwater flow model.

3.2.7 Geologic Data Collection

In order to develop an accurate groundwater flow and transport model for the site, stratigraphic and structural geologic information must be accurately determined and mapped. Gaps in this data exist on the base and little information is available for bedrock, especially around the base boundaries. Field reconnaissance, bedrock fracture mapping, and geologic mapping are necessary in the Salmon and Saranac River drainages, along the Lake Champlain shoreline, and to the west of Plattsburgh AFB to establish boundary conditions for the groundwater flow and transport model. This information will be combined with the geophysical survey results, bedrock coring data, and all existing investigative data to yield a comprehensive picture of the geohydrology beneath and surrounding Plattsburgh AFB.

3.2.8 Environmental Sampling

URS will collect soil and groundwater samples to provide physical and chemical parameter input to the groundwater flow and transport model (Table 3-2). Groundwater samples will be collected from up to 70 new and existing monitoring wells, and analyzed for Target Compound List (TCL) volatile organic compounds, dissolved oxygen (by real-time meter), nitrate and phosphate (to help estimate biodegradation rates), and selected cations and anions (only 10 samples). Wells that will be sampled will be selected following review of pertinent available hydrologic, geologic, and chemical data. In addition, initial groundwater samples collected from the pumping test wells will be analyzed for TCL volatile organic compounds, TCL semivolatile organic compounds, and TAL metals to evaluate the treatment system necessary to handle water generated during the pumping tests.

Soil samples will be collected from selected borings and analyzed to estimate retardation of contaminant transport due to sorption on organic matter and clay particles. Both batch and column sorption analyses will be performed. Total organic carbon and grain size analyses also will be performed on the samples selected. The retardation data will be input into the groundwater flow and contaminant transport model.

3.2.9 Surveying and Topographic Mapping

All new monitoring wells, borings, geophysical survey lines, and any other necessary data points will be surveyed by URS using a combination of conventional surveying (angles, distances, differential leveling) and Global Positioning Systems (GPS satellites) methodologies. Primary horizontal control will be based upon the New York State Plane Coordinate System (1983 adjustment), and primary vertical control will be based upon the North American Vertical Datum of 1988. All surveying will be conducted under the direct supervision of a New York State-licensed land surveyor and will meet or exceed standards referenced in the *AFCEE Handbook* (AFCEE 1993).

Additionally, an approximately 900 acre area located between the eastern Plattsburgh AFB boundary and Lake Champlain will be topographically mapped at a scale of 1 inch = 200 feet with 5-foot contours using aerial photography to be obtained in the spring of 1996. Ground control surveying will be performed by URS, and the aerial photography and map preparation will be performed by Air Survey Corporation of Sterling, Virginia.

3.3 Groundwater and Surface Water Flow and Transport Modeling

Groundwater flow will be analyzed using MODFLOW EM distributed by the Scientific Software Group of Washington, D.C. Once the groundwater flow model is calibrated, contaminant transport will be modeled using MT3D, a three dimensional solute transport model, to simulate the current contaminant pattern and to predict the future transport of contaminants to surface water bodies and potable groundwater users. Particle path analysis by MODPATH also will be part of the modeling effort. The rate of biodegradation of chlorinated hydrocarbons both inside (anaerobic) and outside (aerobic) the biodegrading BTEX fraction of the FT-002 plume will be evaluated by comparing predicted and actual migration rates, and the presence or absence of breakdown products.

TABLE 3-2
ENVIRONMENTAL SAMPLING AND ANALYSIS SUMMARY
FT-002 GROUNDWATER IMPACT STUDY

Analysis	Medium Groundwater	Number	Purpose
TCL Volatile Organic Compounds (VOC)	Groundwater	70	Extent of Contamination
Nitrate	Groundwater	70	Determination of Rate of Biodegradation
Phosphate	Groundwater	70	Determination of Rate of Biodegradation
Hardness as Calcium Carbonate	Groundwater	10	Calibration of Geochemical Model
Chloride	Groundwater	10	Calibration of Geochemical Model
Sulfate	Groundwater	10	Calibration of Geochemical Model
Bromide	Groundwater	10	Calibration of Geochemical Model
Calcium	Groundwater	10	Calibration of Geochemical Model
Magnesium	Groundwater	10	Calibration of Geochemical Model
Sodium	Groundwater	10	Calibration of Geochemical Model
Potassium	Groundwater	10	Calibration of Geochemical Model
Iron	Groundwater	10	Calibration of Geochemical Model
Silicon	Groundwater	10	Calibration of Geochemical Model
Ethylene Glycol	Groundwater	10	Requested by NYSDEC
COD (Chemical Oxygen Demand)	Groundwater	10	Evaluation of Constructed Wetlands Alternative

TABLE 3-2 - cont'd

Analysis	Medium Groundwater	Number	Purpose
BOD (Biological Oxygen Demand)	Groundwater	10	Evaluation of Constructed Wetlands Alternative
Dissolved Oxygen	Groundwater	70	Determination of Rate of Biodegradation
TCL Volatile Organic Compounds (VOC)	Groundwater	4	Pump test discharge requirements
TCL Semivolatile Organic Compounds (SVOC)	Groundwater	4	Pump test discharge requirements
TAL Metals	Groundwater	2	Pump test discharge requirements
Total Organic Carbon	Soil	10	Determination of Retardation
Retardation by Column Experiment	Soil	3	Determination of Retardation
Batch Sorption	Soil	10	Determination of Retardation
Grain Size and Hydrometer	Soil	13	Determination of Retardation

If groundwater modeling indicates that surface water bodies (i.e., Lake Champlain and the Salmon River) will be impacted, the fate of contaminants in these water bodies will be modeled to provide input to the human and ecological risk assessments. An analytical model based on the conductive/diffusion equation will be utilized for surface water modeling. Surface water discharge measurements will be taken as indicated in Section 3.2.6 to provide input to the modeling.

3.4 Risk Assessment

The first step in assessing potential risk posed to human and ecological receptors will be to revise the conceptual site model based on the results of the groundwater and surface water contaminant fate and transport modeling. The revised conceptual model will identify all exposure pathways shown to be potentially complete.

The baseline human health risk assessment performed as part of the FT-002 groundwater RI (URS and ABB-ES 1994a) evaluated risk posed by groundwater contaminants given current conditions. Since no complete exposure pathway exists given current conditions, there is no current risk posed by contaminated groundwater. The assessment also examined risk given a hypothetical scenario that assumed potable groundwater use on base within the contaminated area. The assessment concluded that there are unacceptable carcinogenic and noncarcinogenic risks associated with potable use of groundwater within the existing plume boundaries. These scenarios will not be revisited in the Groundwater Impact Study.

The human health risk assessment (HRA) will include an evaluation of appropriate exposure pathways given potential future exposure of existing human receptors to chemical constituents of the FT-002 groundwater plume. Exposure will be assessed only for those contaminants shown to be sufficiently mobile and persistent to be transported to the potential points of exposure.

Exposure concentrations for these pathways will be developed using the results of groundwater and surface water modeling as input into further analytical models to determine concentrations in air or fish. The HRA will be performed in accordance with USEPA's *Risk Assessment Guidance for Superfund (USEPA 1989)* and the *AFCEE Handbook* (AFCEE 1993) and will include: an exposure assessment that identifies the population exposed and quantification of contaminant intake; a toxicity assessment that will specify carcinogenic and noncarcinogenic toxicity values utilizing the USEPA's hierarchy of toxicity information; a risk characterization or quantification of risk; and an uncertainty analysis that will identify factors of uncertainty in the HRA and their potential impact on the calculated risk (i.e., over- or underestimation of risk).

The ecological risk assessment (ERA) will include: identification of target species based on observation and a literature survey; a toxicity evaluation based on a review of appropriate sources such as Eisler's chemical specific reviews of hazards to fish, wildlife, and invertebrates published by the U.S. Fish and Wildlife Service and the ATSDR toxicological profiles; an exposure characterization which includes an estimate of bioaccumulation and subsequent concentration of contaminants in prey items and calculation of the target species' contaminant intake; and a risk characterization using the hazard quotient approach. The ERA will concentrate on the potential impact of contaminants in aquatic species since the impact of groundwater on Lake Champlain and the Salmon River is of major concern. Future concentrations of contaminants in these water bodies will be estimated by modeling in conjunction with discharge measurements.

3.5 Feasibility Study

The *Draft Final Feasibility Study for FT-002 Operable Unit 2 (Groundwater)* (URS 1994c) will be revised based on the results of groundwater fate and transport modeling and the risk assessment. Major work items include:

- Revising remedial goals
- Re-evaluating the remedial alternatives presented in the *Draft Final Feasibility Study*
- A conceptual design for one new technology (e.g., passive treatment wall or constructed wetland treatment)
- Calculating restoration time frames for the various alternatives using the groundwater model
- Conceptual design and cost estimate for extending existing waterlines to off base homes potentially impacted by groundwater contamination
- Conceptual design and cost estimate for individual home treatment systems for off base homes potentially impacted by groundwater contamination
- Revising the conceptual design and cost estimate for groundwater capture and treatment alternatives based on modeling results and revised restoration time frames

If a Record of Decision (ROD) is issued that addresses the FT-002 Groundwater Operable Unit, then the Feasibility Study will not be revised. Instead, the selected remedy presented in the ROD will be reviewed in light of the results of the Groundwater Impact Study.

4.0 REPORTING REQUIREMENTS

The *Groundwater Impact Study Report* will be made up of three parts: the Conceptual Site Model, the Human and Ecological Baseline Risk Assessment, and the revised Feasibility Study. The Conceptual Site Model Report will summarize data collection efforts, redefine the nature and extent of groundwater contamination using chemical, hydrologic, and geologic data from this and previous relevant studies, present the results of groundwater and surface water fate and transport modeling, identify and describe human and ecological receptors, and present human and ecological pathway analysis. This deliverable will be reviewed by AFCEE and AFBCA and revised based upon their comments.

The Human and Ecological Baseline Risk Assessment will use the results of the Conceptual Site Model to assess risk posed by the FT-002 plume. This deliverable also will be reviewed by AFCEE and AFBCA and revised based upon their comments.

The revised Feasibility Study will use results of the Baseline Risk Assessment to establish remedial goals, will evaluate remedial alternatives, and will select an appropriate remedial action. The development of a Record of Decision (ROD) for the FT-002 Groundwater Operable Unit, prior to completion of this study, has been discussed between AFBCA, USEPA, and NYSDEC. If a ROD is developed, the Feasibility Study will not be revised. Instead, an evaluation of the remedy presented in the ROD, in light of the study data, will be performed and included in the Groundwater Impact Study Report. The Conceptual Site Model, the Risk Assessment, and the revised Feasibility Study or assessment of the remedy selected by the ROD will be integrated into a single *Groundwater Impact Study Report,* reviewed by the USAF, and amended based on USAF comments before submission to the NYSDEC and USEPA.

5.0 PROJECT SCHEDULE

A complete schedule for the Groundwater Impact Study is included as Plate 1 at the back of this volume. This schedule will be updated periodically to reflect any changes.

Data collection supporting the Groundwater Impact Study, described in Section 4, will be phased to expedite and focus the effort. Field work is scheduled from December 1995 through the spring of 1996. Major data collection work elements will be phased as indicated below. The schedule for field work is highly dependent on weather conditions.

Work Element	**Approximate Time Frame**
Installation of Two Monitoring Wells and One Soil Boring	December 1995
Seismic Refraction Survey	December 1995
Consolidate Existing Data	November 1995 through February 1996
House-to-House Potable Well Survey	February 1996
Flyover/Mapping	March-April 1996
Remaining Fieldwork	April 1996 through June 1996

PART II

SAMPLING AND ANALYSES PLAN

6.0 QUALITY ASSURANCE PROJECT PLAN

6.1 Introduction

This Quality Assurance Project Plan (QAPP) provides an overview of the quality assurance and quality control (QA/QC) procedures and programs to be followed during the investigation activities described in the Work Plan. The QAPP describes the specific methods and QA/QC procedures for sample collection, chemical analysis, and physical testing of environmental samples. It addresses overall QA/QC issues such as sampling protocols, sample handling and shipment, and laboratory standard operating procedures (SOPs).

6.1.1 The U.S. Air Force Installation Restoration Program

The history of USAF's IRP at Plattsburgh AFB is described in Sections 1.0 and 1.2 of the Work Plan (PART I).

6.1.2 Purpose and Scope

This QAPP is a supplement to the approved *Chemical Data Acquisition Plan (CDAP) for Environmental Investigations at Plattsburgh Air Force Base, Plattsburgh, New York* (Malcolm Pirnie 1992b). To avoid redundancy, procedures described in the *CDAP* are referenced to the extent possible. The laboratory's Standard Operating Procedures (SOPs) for this project are included as an Appendix, bound separately.

Specific QA/QC objectives of the various program elements are discussed in the following sections. These objectives will be attained by strict adherence to the Work Plan, QAPP, Field Sampling Plan (FSP), and Health and Safety Plan (HASP),as well as by utilizing trained and experienced personnel to perform all tasks.

6.2 Project Description

6.2.1 Project Background, Scope, and Objectives

Sections 1.1 and 1.2 of the Work Plan summarize the contamination history at FT-002 and the findings from previous IRP investigations. An outline of the project scope and objectives is provided in Section 1.4 of the Work Plan.

Data quality objectives (DQOs) are developed to achieve the level of data quality required for the anticipated data use and are implemented so that the data is legally and scientifically defensible for each task. To be considered defensible, the data must enable the federal government to protect itself against claims filed by interested parties (e.g., project personnel or offsite receptors). The USEPA has established DQOs in *Data Quality Objectives Process for Superfund, Interim Final Guidance* (USEPA 1993) and has published *Guidance for the Data Quality Objectives Process* (USEPA 1994).

Utilizing these two documents, DQOs for this project have been developed with the intention of maintaining consistency between historical data and data which will be collected for this project. DQOs fall under two Superfund descriptive data categories, namely screening data with definitive confirmation and definitive data. Screening data are generated using rapid, less precise analytical methods that do not involve extensive sample preparation and usually allow for rapid turnaround of results. On the other hand, definitive data are generated using rigorous analytical methods. These data are in the form of paper printouts or computer-generated results. The data category for this project will be definitive data for all laboratory and geotechnical analyses excluding the dissolved oxygen analysis which will be screening data without definitive confirmation (as shown on Table 6-2) and batch sorption which will be confirmed by column sorption. Definitive confirmation for dissolved oxygen will not be performed because of the holding time constraints (i.e., the method requires that the analysis be performed immediately).

6.2.2 Subcontractors

Subcontractors will be used to perform laboratory analysis, geophysics, drilling, and aerial photography. The subcontractors to be used and the tasks they will perform are identified in Figure 6-1.

6.3 Project Organization and Responsibility

URS is committed to following a firm wide quality assurance policy and creating a work setting in which all personnel collaborate on environmental programs to produce the type and quality of results expected. This section defines an organizational structure and management methodology within which the project and quality assurance are planned and implemented with a clear delineation of the responsibility and authority of the personnel and organizations involved. The URS project organization for this project is shown on Figure 6-1.

The Program Manager, as the coordinator of all client and contractual activities, is directly responsible for assuring the quality of the work. As a member of senior URS management, the Program Manager has direct access to corporate resources and the authority to commit personnel, facilities, and support services to the AFCEE contract.

The QA Coordinator is responsible for assessing the project's compliance with quality assurance policy. Authorities of this position cut across all levels of program management and function to examine and ultimately ensure that a quality product is produced for delivery. The QA Coordinator will coordinate and communicate directly with the Project Team on quality assurance matters relating to the AFCEE contract, thus providing an independent assessment.

The Project Manager is responsible for the progress and quality of all work performed. The Project Manager has two goals: (1) to provide senior leadership and expertise to the Project Team, and (2) to ensure that the objectives of individual projects are consistent with long-term remediation goals.

The Technical Leads report to the Project Manager, and each is responsible for monitoring and documenting the quality of all work produced by the Project Team. The fundamental goal of these positions is to produce a quality work product within the allotted schedule and budget. Their duties include executing all phases of a specific project and efficiently applying the full resources of the Project Team.

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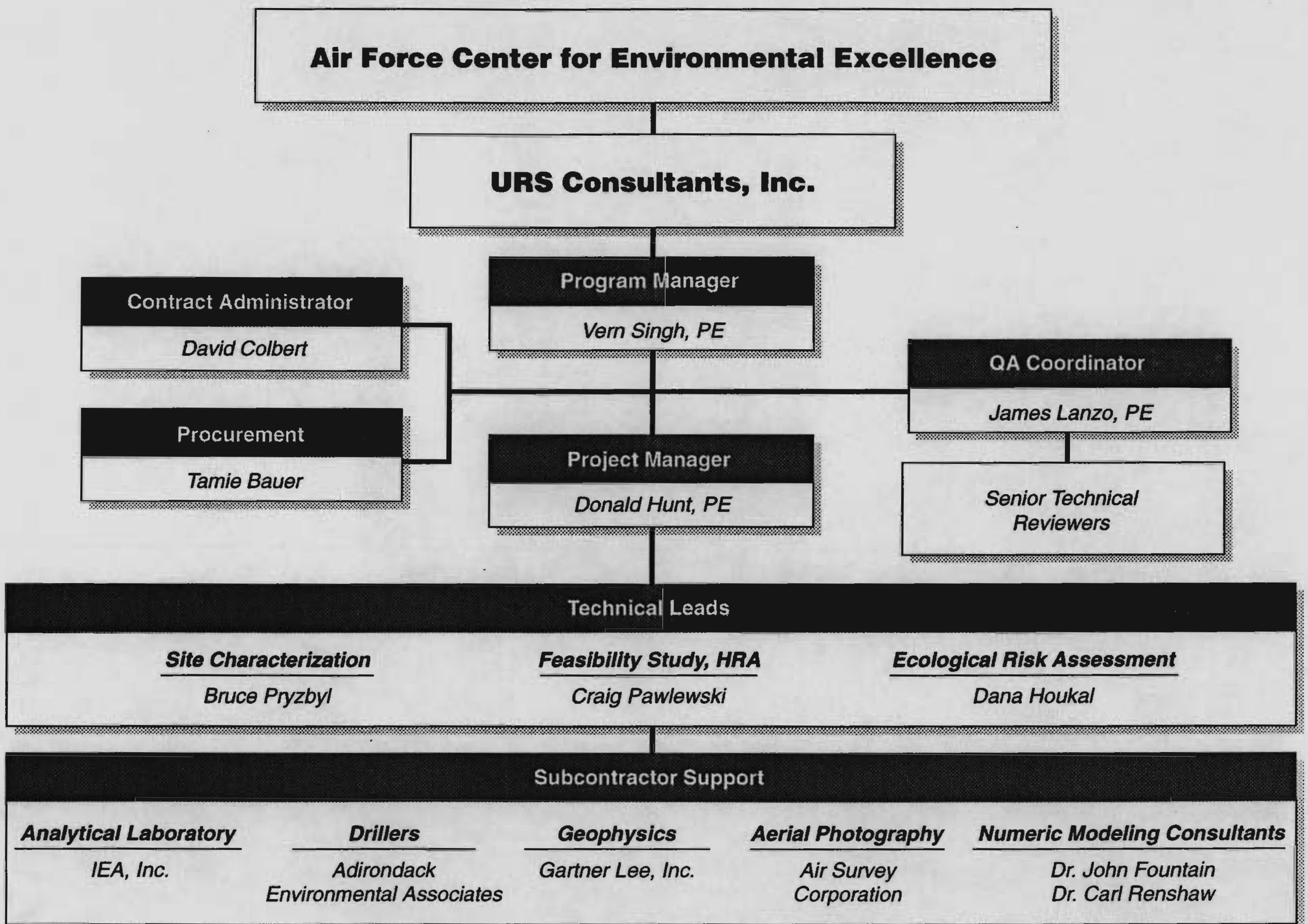

URS CONSULTANTS, INC.	PROJECT ORGANIZATION CHART - GROUNDWATER IMPACT STUDY	FIGURE 6-1

The Project Manager will select a Senior Chemist, acceptable to the QA Coordinator, to serve as Project Chemist. The Project Chemist's responsibilities include administration of the analytical laboratory's compliance with the QA program as designed for this project. Under the supervision of the Site Characterization Technical Lead, the Project Chemist will maintain communications between URS and the laboratory on a daily basis. The laboratory will transmit a daily status report on all samples with information such as holding time dates to ensure all analyses requested are accurate and within holding times. The Project Chemist will be contacted by the laboratory when analytical problems are encountered or the QA program is not in compliance. This will be done in order to facilitate the quick resolution of nonconformance that may arise during the course of the project.

All work performed of a substantive nature or identified as a deliverable will undergo an independent technical review by experienced and qualified personnel. The Project Manager is responsible for selecting reviewers that are independent from actual work or decision making on the tasks or activities being reviewed, and possess technical qualifications sufficient for conducting the in-depth review. A written record of the review and resolution of the review findings will be incorporated into the project files. Independent technical reviews will be conducted in a variety of areas throughout the AFCEE contract across all lines of management and involving all appropriate technical disciplines.

6.4 Quality Assurance Objectives for Measurement Data

Quality Assurance (QA) objectives are qualitative and quantitative statements which define the quality of the data required to support decisions made during investigative activities. The QA objectives for the Plattsburgh AFB FT-002 Groundwater Impact Study were developed following the guidelines presented in *Data Quality Objectives Process for Superfund* (USEPA 1993) and designed to meet the Project Objectives (Section 1.4) and the Data Quality Objectives (Section 6.2.1).

Whether or not these QA objectives are met can be determined by the use of quality control elements which measure precision, accuracy, representativeness, completeness and comparability. Each of the QC elements is discussed in the following sections.

6.4.1 Precision

Precision is evaluated using analyses of a field duplicate and/or a laboratory matrix spike/matrix spike duplicate (MS/MSD) which not only exhibit sampling and analytical precision but indicate analytical precision through the reproducibility of the analytical results. Relative percent difference (RPD) is used to evaluate precision by the following formula:

$$RPD = \frac{[(C_1 - C_2)]}{((C_1 + C_2)/2)} x\ 100\%$$

Where:

C_1 = Concentration of the compound or element in the sample

C_2 = Concentration of the compound or element in the duplicate

Precision will be determined through the use of field duplicates, MS/MSD for organics analysis, and matrix duplicates (MD) for inorganic analysis. RPD criteria for this project must meet the method-specific criteria.

6.4.2 Accuracy

Accuracy is defined as the degree of difference between the measured or calculated value and the true value. The closer the numerical value of the measurement comes to the true value or actual concentration, the more accurate the measurement is. Analytical accuracy is expressed as the percent recovery of a compound or element that has been added to the environmental sample as known concentrations before analysis. The following equation is used to calculate percent recovery:

$$Percent\ Recovery = \frac{(A_r - A_o)}{A_f} \times 100\%$$

Where:

A_r = Total amount detected in spiked sample

A_o = Amount detected in unspiked sample

A_f = Spike amount added to sample

The primary indicator of accuracy will be determined in the laboratory through the use of MS/MSD samples. For volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs) and pesticide/PCB analyses, surrogate recovery results will also be measured. For metal analyses, accuracy will be determined using the MS sample. Percent recovery must meet the method-specific criteria.

6.4.3 Representativeness

Representativeness is defined as the degree to which the data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is a qualitative parameter relating to the proper design of a sampling program. It is ensured by collecting sufficient samples of a particular medium properly distributed with respect to location and time (i.e., seasonally). Representativeness is attained in the laboratory by proper sample storage, analysis, and extraction/digestion within the project-required holding times, and acceptable instrument calibration and operation.

6.4.4 Completeness

Completeness is expressed as the percentage of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. For the data generated, a goal of 90% is required for completeness (or usability) of the analytical data. If this goal is not met, the Project Manger and QA Coordinator, after consulting with the AFCEE representative, will determine whether the deviations might cause the data to be rejected.

Completeness will be calculated by the following equation:

$$\% \ Completeness = \frac{(DP_t)-(DP_i)}{DP_t} \ x \ 100\%$$

Where:

DP_t = Total quality control data points (by media and fraction)

DP_i = Invalid (i.e., rejected) data points (by media and fraction)

6.4.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Analytical results are comparable to results from other laboratories because of the following procedures/programs: instruments standards traceable to National Institute of Standards & Technology (NIST) or USEPA sources; use of standard or validated methodology; reporting of results from matrices in consistent units; and participation, as appropriate, in interlaboratory studies to document laboratory performance. By using traceable standards and validated methods, the analytical results can be compared to other laboratories operating similarly.

6.5 Sampling Protocols and Handling

Sampling procedures and collection techniques include a wide range of operating procedures and will be in accordance with the CDAP (Malcolm Pirnie 1992b) which is in general agreement with the *Handbook for the Installation Restoration Program (IRP) Remedial Investigations and Feasibility Studies (RI/FS)* (AFCEE 1993) and consistent with USEPA guidelines. The number of samples required to meet the project objectives, locations of sampling points, and/or methods of determining sampling locations during field activities are discussed in the Work Plan (Section 3.0) and Field Sampling Plan, Section 7.0.

Field equipment, containers and supplies, and sampling and preservation procedures will remain the same as described in Section 4.0 of the *CDAP* (Malcolm Pirnie 1992b) to maintain consistency with the historical data. A summary table of the sample container, preservation, and holding time requirements is included as Table 6-1.

6.6 Sample Custody

Proper documentation of sample collection and the methods used to control these documents are referred to as chain-of-custody procedures. Chain-of-custody procedures are essential for presentation of sample analytical results as evidence in litigation or at administrative hearings held by

TABLE 6-1

SAMPLE CONTAINER, PRESERVATION, AND HOLDING TIME REQUIREMENTS
FT-002 GROUNDWATER IMPACT STUDY

ANALYSIS	METHOD(S)	CONTAINER	PRESERVATION	HOLDING TIME*
GROUNDWATER				
Volatile Organic Compounds (VOC)	CLP OLM03.1	3 - 40 ml VOA vial	4°C	10 days from VTSR
Ethylene glycol	SW846 8015 Modified	3 - 40 ml VOA vial	4°C, HCl to pH<2	14 days
Nitrate and Phosphate	SW846 9056	1 L plastic	4°C	48 hours
Biochemical Oxygen Demand(BOD)	MCAWW 405.1			
Chemical Oxygen Demand(COD)	MCAWW 410.4	125 ml plastic	4°C, H2SO4 to pH<2	28 days
Chloride, Sulfate, and Bromide	SW846 9056	1 L plastic	4°C	28 days
Calcium, Magnesium, Sodium, Potassium, Iron and Silicon	CLP ILM03.0	1 L plastic	4°C, HNO3 to pH<2	6 months from VTSR
Hardness as Calcium Carbonate	MCAWW 130.1			
SOIL				
Sorption by Column Experiment and Batch Sorption	Section 6.8.2	16 oz plastic or glass jar	None	NA
Grain Size and Hydrometer	ASTM D-422			
Total Organic Carbon (TOC)	SW846 9060	8 oz plastic or glass jar	4°C	28 days
AQUIFER PUMP TESTS (Groundwater)				
Volatile Organic Compounds (VOC)	SW846 8260	3 - 40 ml VOA vial	4°C	7 days
Semivolatile Organic Compounds (SVOA)	SW846 8270A	2 - 1L glass	4°C	7 days to extract 40 days to analyze
TAL Metals(excluding Mercury)	SW846 6010A	1L plastic	4°C, HNO3 to pH<2	6 months(excluding Mercury)
Mercury	SW846 7470			28 days for Mercury

NOTES:

* - Holding times are from the date of sample collection, unless noted otherwise.

VTSR - Validated Time of Sample Receipt

NA - Not Applicable

regulatory agencies. Chain-of-custody procedures also serve to minimize loss or misidentification of samples and to ensure that unauthorized persons do not tamper with collected samples.

Sample custody during the field investigations at Plattsburgh AFB will be performed in three phases. The first phase involves field custody procedures employed during sample collection, pre-laboratory treatment procedures (preservation), packaging, and shipping. The second custody phase concerns documentation of sample shipment including mode of shipment, airbill numbers, and shipment dates and times. The third phase involves the custody procedures employed by the laboratories.

All three phases of the sample custody will be performed to provide that:

- All samples are uniquely identified
- The correct samples are tested and are traceable to their source
- Important sample characteristics are preserved
- Samples are protected from loss or damage
- Any alteration of samples from preservation or filtration is documented
- A record of sample integrity is established and maintained throughout the entire custody process

Custody and shipping procedures are in accordance with U.S. Army Corps of Engineers Guidance Document ER 1100-1-263, *Chemical Data Quality Management for Hazardous Waste Remedial Activities* and are modeled after standard USEPA procedures. Field custody procedures, sample identification, sample labels, chain-of-custody procedures, shipping procedures, and laboratory custody procedures are described in detail in Section 5.0 of the *CDAP* (Malcolm Pirnie 1992b). However, the chain-of-custody form has been modified from the original chain-of-custody form in the *CDAP* (Malcolm Pirnie 1992b) to accommodate information required for Installation Restoration Program Information Management System (IRPIMS) data base submissions. IRPIMS is further discussed in Section 6.9 of this QAPP. A sample of the modified chain-of-custody form has been included as Figure 6-2.

6.7 Calibration Procedures and Frequency for Field Test Equipment

Specific guidelines for calibration procedures and frequency of field test equipment are described in Section 6.3 of the *CDAP* (Malcolm Pirnie 1992b).

6.8 Analytical Procedures

6.8.1 Identification of Methods

Table 6-2 lists the proposed analytical methods and QA/QC samples for the Groundwater Impact Study. These methods are described in the following documents:

- *CLP Statement of Work, Organic Analysis; OLM03.1*
- *CLP Statement of Work, Inorganic Analysis; ILM03.0*
- *Test Methods for Evaluating Solid Waste*, USEPA Office of Solid Waste, SW-846, 3rd Edition, Updates I, II, IIA and IIB, March 1995

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CHAIN OF CUSTODY RECORD

URS
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PROJECT NO. | SITE NAME

SAMPLERS (PRINT/SIGNATURE)

DELIVERY SERVICE:________ AIRBILL NO.:________

LAB ________

COOLER ______ of ______

PAGE ______ of ______

TESTS

BOTTLE TYPE AND PRESERVATIVE

LOCATION IDENTIFIER	DATE	TIME	COMP/ GRAB	SAMPLE ID	MATRIX	TOTAL NO.# OF CONTAINERS									REMARKS	SAMPLE TYPE	BEGINNING DEPTH (IN FEET)	ENDING DEPTH (IN FEET)	FIELD LOT NO.# (IRPIMS ONLY)

MATRIX CODES

AA - AMBIENT AIR
SE - SEDIMENT
SH - HAZARDOUS SOLID WASTE
SL - SLUDGE
WP - DRINKING WATER
WW - WASTE WATER
WG - GROUND WATER
SO - SOIL
DC - DRILL CUTTINGS
WL - LEACHATE
GS - SOIL GAS
WC - DRILLING WATER
WO - OCEAN WATER
WS - SURFACE WATER
WQ - WATER FIELD QC
LH - HAZARDOUS LIQUID WASTE
LF - FLOATING/FREE PRODUCT ON GW TABLE

SAMPLE TYPE CODES

TB# - TRIP BLANK
SD# - MATRIX SPIKE DUPLICATE
RB# - RINSE BLANK
FR# - FIELD REPLICATE
N# - NORMAL ENVIRONMENTAL SAMPLE
MS# - MATRIX SPIKE
(# - SEQUENTIAL NUMBER (FROM 1 TO 9) TO ACCOMMODATE MULTIPLE SAMPLES IN A SINGLE DAY)

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	DATE	TIME	SPECIAL INSTRUCTIONS
RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED FOR LAB BY (SIGNATURE)	DATE	TIME	

Distribution: Original accompanies shipment, copy to coordinator field files

URSF-075C/1 OF 1/CoICR/GM

URS
CONSULTANTS, INC.

IRPIMS CHAIN OF CUSTODY RECORD

FIGURE 6-2

TABLE 6-2

ANALYTICAL METHODS AND QA/QC SAMPLES
FT-002 GROUNDWATER IMPACT STUDY

ANALYSIS	MEDIUM	METHOD	DATA CATEGORY	NUMBER OF SAMPLES	QA/QC SAMPLES			
					MS/MSD	RINSE BLANKS	DUPLICATES	TRIP BLANKS
TCL Volatile Organic Compounds (VOC)	Groundwater	USEPA CLP SOW OLMO3.1	Definitive	70	4	1	4	5
Nitrate	Groundwater	SW846 9056	Definitive	70	—	1	4	—
Phosphate	Groundwater	SW846 9056	Definitive	70	—	1	4	—
Hardness as Calcium Carbonate	Groundwater	MCAWW 130.1	Definitive	10	—	1	1	—
Biochemical Oxygen Demand (BOD)	Groundwater	MCAWW 405.1	Definitive	10	—	1	1	—
Chemical Oxygen Demand (COD)	Groundwater	MCAWW 410.4	Definitive	10	—	1	1	—
Ethylene glycol	Groundwater	SW846 8015 Modified	Definitive	10	1	1	1	—
Chloride	Groundwater	SW846 9056	Definitive	10	—	1	1	—
Sulfate	Groundwater	SW846 9056	Definitive	10	—	1	1	—
Bromide	Groundwater	SW846 9056	Definitive	10	—	1	1	—
Calcium	Groundwater	USEPA CLP SOW ILMO3.0	Definitive	10	1	1	1	—
Magnesium	Groundwater	USEPA CLP SOW ILMO3.0	Definitive	10	1	1	1	—
Sodium	Groundwater	USEPA CLP SOW ILMO3.0	Definitive	10	1	1	1	—
Potassium	Groundwater	USEPA CLP SOW ILMO3.0	Definitive	10	1	1	1	—
Iron	Groundwater	USEPA CLP SOW ILMO3.0	Definitive	10	1	1	1	—
Silicon	Groundwater	SW846 6010A	Definitive	10	1	1	1	—
Dissolved Oxygen	Groundwater	YSI Model 50B DO Meter	Screening	70	—	—	—	—
Sorption by Column Experiment	Soil	See Section 6.8.2	Definitive	3	—	—	*	—
Batch Sorption	Soil	See Section 6.8.2	Screening	10	—	—	*	—
Total Organic Carbon (TOC)	Soil	SW846 9060	Definitive	10	—	—	1	—
Grain Size & Hydrometer	Soil	ASTM D-422	Definitive	13	—	—	—	—
Aquifer Pump Tests								
TCL Volatile Organic Compounds (VOC)	Groundwater	SW846 8260	Definitive	4	—	—	—	2
TCL Semivolatile Organic Compounds (SVOA)	Groundwater	SW846 8270A	Definitive	4	—	—	—	—
TAL Metals	Groundwater	SW846 6010A/7470	Definitive	2	—	—	—	—

* Sorption will be determined by both column and batch methods for one soil sample.

- *Methods for Chemical Analysis of Water and Wastes* (MCAWW), USEPA, March 1983
- *American Society for Testing and Materials* (ASTM) Standard D422-63

The field and analytical programs shall be carried out in a manner consistent with the *Final Work Plan Remedial Investigation/Feasibility Study* and Section 6.0 of the *CDAP* (Malcolm Pirnie 1992a; Malcolm Pirnie 1992b). However, following consultation with Plattsburgh AFB, NYSDEC, and USEPA, some modifications have been made to the sampling and analytical program in the *CDAP* (Malcolm Pirnie 1992b). These modifications include:

- Hexane shall be eliminated as a rinse agent during the decontamination of sampling equipment--only a methanol solvent rinse shall be used.
- Monitoring wells shall be developed using a hydro-lift pump equipped with dedicated and disposable polyethylene tubing. A submersible pump shall not be used.

6.8.2 Geotechnical Testing Procedures

Total Organic Carbon

The QA/QC for measurements of total organic carbon in soil boring samples will be assured by following the standardized test procedures in method SW846 9060.

Grain Size and Hydrometer

The QA/QC for physical measurements of soil boring samples subjected to grain size and hydrometer analysis will be ensured by following the standardized test procedures in ASTM D-422.

Sorption by Column Experiment and Batch Sorption

The transport velocity of contaminants in groundwater is a function of their sorption on the soil. Sorption is in turn a function of the fraction of solid organic matter in the soil and of clay content. While sorption, and thence contaminant retardation, can be estimated from organic carbon and clay content, direct determination through batch and column experiments provides a better determination.

Batch experiments are quicker and less costly than column experiments and are used to determine sorption isotherms by varying contaminant concentration. Column experiments include kinetic limitations, thus providing a more realistic estimate of contaminant retardation. The conventional approach, described here, involves determinations of sorption coefficient (Kd) via a column experiment.

Batch experiment methodology: A vial (typically an "EPA" 40 ml vial with Teflon-lined septa) is filled (no headspace) with 10 grams of soil and a TCE solution of known concentration. The vials immediately are capped and shaken for 48 hours to allow the TCE solution to equilibrate with the soil. The vials are then allowed to stand to permit the soil to settle. Samples of the original solution and the liquid from the vials after equilibration are analyzed by gas chromatography. The sorption coefficient, Kd, is calculated from the amount sorbed per gram of soil. The experiment is repeated using different initial TCE concentrations; a sorption isotherm can be produced from a plot of the resulting sorption versus TCE concentration data.

Column experiments are used to test sorption on a larger sample and include kinetic considerations. A cylindrical column (typically 2.5 cm in diameter and 30 cm in length) is packed with soil and sealed with porous Teflon endplates. The column is first saturated with water and then pumped with bromide tracer to determine its pore volume. Finally, a TCE solution of known concentration is pumped through the column at a fixed rate. The effluent is monitored for TCE (samples analyzed by gas chromatography) and pumping continues until the TCE appears in the effluent at the same concentration as the influent. A Kd value can be calculated directly from observed retardation factor.

6.8.3 Practical Quantitation Limits

A practical quantitation limit (PQL) is defined as the lowest detectable analyte concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. PQLs must be supported by a method detection limit (MDL) study in which the determined MDL must be lower than the relevant PQL. An MDL is defined as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. The subcontract laboratories have completed MDL studies for the analytical methods in this QAPP. The MDL studies are completed by following the requirements as listed in the analytical methods. PQLs are presented on Tables 6-3 through 6-6 and were obtained from either the laboratory's standard operating procedures (SOPs) found in the Appendix or in the analytical method.

6.9 Data Reduction, Validation, and Reporting

Specific guidelines for data reduction, validation, and reporting are described in Section 6.6 of the *CDAP* (Malcolm Pirnie 1992b). Data validation will be performed by URS environmental chemists under the supervision of the QA Coordinator. Validation guidelines that will be followed include USEPA Region II CLP Organics Data Review No. HW-6 Revision #8 and Evaluation of Metals Data for the CLP based on SOW 3/90 HW-2, Revision XI. The primary deviation from the *CDAP* is the inclusion of data in IRPIMS format.

IRPIMS is a data management system designed to accommodate all types of data collected for IRP projects. Specific codes and data forms have been developed to allow consistent and efficient input of information to the system. The data base information will be provided via ASCII files in specified IRPIMS format on diskettes. The information will include all required technical data such as site information, well characteristics, and hydrogeologic, physical, and chemical analysis results. Electronic data formats and requirements are given in the *IRPIMS Data Loading Handbook, Version 2.3* (AFCEE 1994).

6.10 Internal Quality Control Checks for Field and Laboratory Operations

Specific guidelines for field and laboratory quality control are described in Section 6.4 of the *CDAP* (Malcolm Pirnie 1992b).

TABLE 6-3

PRACTICAL QUANTITATION LIMITS (PQL)
TCL VOLATILE ORGANIC COMPOUNDS
FT-002 GROUNDWATER IMPACT STUDY

Target Analyte	Water	
	SW846 8260 (µg/L)	CLP OLM03.1 (µg/L)
Chloromethane	10	10
Bromomethane	10	10
Vinyl Chloride	10	10
Chloroethane	10	10
Methylene Chloride	5	10
Acetone	10	10
Carbon Disulfide	5	10
1,1-Dichloroethene	5	10
1,1-Dichloroethane	5	10
1,2-Dichloroethene (total)	5	10
Chloroform	5	10
1,2-Dichloroethane	5	10
2-Butanone	10	10
1,1,1-Trichloroethane	5	10
Carbon Tetrachloride	5	10
Bromodichloromethane	5	10
1,2-Dichloropropane	5	10
cis-1,3-Dichloropropene	5	10
Trichloroethene	5	10
Dibromochloromethane	5	10
1,1,2-Trichloroethane	5	10
Benzene	5	10
trans-1,3-Dichloropropene	5	10
Bromoform	5	10
4-Methyl-2-Pentanone	10	10
2-Hexanone	10	10
Tetrachloroethene	5	10
1,1,2,2-Tetrachloroethane	5	10
Toluene	5	10
Chlorobenzene	5	10
Ethylbenzene	5	10
Styrene	5	10
Xylene (total)	5	10

Note:

Contract Required Quantitation Limits (CRQL) replace PQLs in the USEPA CLP Statement of Work.

TABLE 6-4

PRACTICAL QUANTITATION LIMITS (PQL)
TCL SEMIVOLATILE ORGANIC COMPOUNDS
FT-002 GROUNDWATER IMPACT STUDY

Target Analyte	Water SW846 8270 (µg/L)
Base Neutral Extractables:	
bis(2-Chloroethyl)ether	10
1,3-Dichlorobenzene	10
1,4-Dichlorobenzene	10
1,2-Dichlorobenzene	10
2,2'-oxybis(1-Chloropropane)	10
N-Nitroso-di-n-propylamine	10
Hexachloroethane	10
Nitrobenzene	10
Isophorone	10
bis(2-Chloroethoxy)methane	10
1,2,4-Trichlorobenzene	10
Naphthalene	10
4-Chloroaniline	10
Hexachlorobutadiene	10
2-Methylnaphthalene	10
Hexachlorocyclopentadiene	10
2-Chloronaphthalene	10
2-Nitroaniline	25
Dimethylphthalate	10
Acenaphthylene	10
2,6-Dinitrotoluene	10
3-Nitroaniline	25
Acenaphthene	10
Dibenzofuran	10
2,4-Dinitrotoluene	10
Diethylphthalate	10
4-Chlorophenyl-phenylether	10
Fluorene	10
4-Nitroaniline	20
N-Nitrosodiphenylamine	10
4-Bromophenyl-phenylether	10
Hexachlorobenzene	10
Phenanthrene	10
Anthracene	10

TABLE 6-4

PRACTICAL QUANTITATION LIMITS (PQL)
TCL SEMIVOLATILE ORGANIC COMPOUNDS
FT-002 GROUNDWATER IMPACT STUDY

Target Analyte	Water SW846 8270 (µg/L)
Carbazole	NA
Di-n-butylphthalate	10
Fluoranthene	10
Pyrene	10
Butylbenzylphthalate	10
3,3'-Dichlorobenzidine	10
Benzo(a)anthracene	10
Chrysene	10
bis(2-Ethylhexyl)phthalate	10
Di-n-octylphthalate	10
Benzo(b)fluoranthene	10
Benzo(k)fluoranthene	10
Benzo(a)pyrene	10
Indeno(1,2,3-cd)pyrene	10
Dibenz(a,h)anthracene	10
Benzo(g,h,i)perylene	10
Acid Extractables:	
Phenol	10
2-Chlorophenol	10
2-Methylphenol	10
4-Methylphenol	10
2-Nitrophenol	10
2,4-Dimethylphenol	10
2,4-Dichlorophenol	25
4-Chloro-3-methylphenol	10
2,4,6-Trichlorophenol	25
2,4,5-Trichlorophenol	25
2,4-Dinitrophenol	10
4-Nitrophenol	25
4,6-Dinitro-2-methylphenol	25
Pentachlorophenol	25

TABLE 6-5

CONTRACT REQUIRED DETECTION LIMITS (CRDL)
TAL METALS (METHODS 6010A/7470A/7471A)
FT-002 GROUNDWATER IMPACT STUDY

Target Analyte	Method	Water	
		CRDL (µg/L)	IDL (µg/L)
Aluminum	6010	200	17
Antimony	6010	60	3.0
Arsenic	6010	10	3.0
Barium	6010	200	1.0
Beryllium	6010	5.0	1.0
Cadmium	6010	5.0	1.0
Calcium	6010	5000	14
Chromium	6010	10	1.0
Cobalt	6010	50	1.0
Copper	6010	25	2.0
Iron	6010	100	15
Lead	6010	3.0	2.0
Magnesium	6010	5000	6.0
Manganese	6010	15	1.0
Mercury	7470/7471	0.20	0.20
Nickel	6010	40	1.0
Potassium	6010	5000	29
Selenium	6010	5.0	2.0
Silver	6010	10	1.0
Sodium	6010	5000	42
Thallium	6010	10	1.0
Vanadium	6010	50	1.0
Zinc	6010	20	1.0

TABLE 6-6

PRACTICAL QUANTITATION LIMITS (PQL)
MISCELLANEOUS PARAMETERS
FT-002 GROUNDWATER IMPACT STUDY

Target Analyte	Method	Water PQL (mg/L)
Hardness	MCAWW 130.1	1.0
Biochemical Oxygen Demand (BOD)	MCAWW 405.1	2.0
Chemical Oxygen Demand (COD)	MCAWW 410.4	10
Ethylene Glycol	SW846 8015 (Modified)	0.001
Nitrate	SW846 9056	0.10
Phosphate	SW846 9056	0.10
Chloride	SW846 9056	0.10
Sulfate	SW846 9056	0.10
Bromide	SW846 9056	0.10

Target Analyte	Method	Soil PQL (mg/kg)
Total Organic Carbon (TOC)	SW846 9060	100

6.11 Performance and System Audits

Specific guidelines for performance and system audits are described in Section 6.5 of the *CDAP* (Malcolm Pirnie 1992b).

6.12 Preventative Maintenance

Specific guidelines for preventative maintenance are described in Section 6.2 of the *CDAP* (Malcolm Pirnie 1992b).

6.13 Field and Laboratory Procedures Used to Assess Chemical Data Precision, Accuracy, and Compliance

The laboratory shall evaluate analytical method performance by examining the criteria of precision, accuracy, representativeness, completeness, and comparability where:

- Precision is the ability to replicate a value
- Accuracy is a measure of the closeness of an individual measurement to the true or expected value
- Representativeness expresses the degree to which data accurately represents the media and conditions being measured
- Completeness is a measure of the quantity of valid data acquired from a measurement process compared to the amount that was expected to be acquired under the measurement conditions
- Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another.

The methods by which to evaluate these criteria are detailed in Section 6.4.

6.14 Corrective Action

Corrective actions will be initiated if the validity of the data should become suspect during performance of the QA/QC procedures. The actual trigger, as well as the form of appropriate corrective action, is dependent on the specific method/procedures, time at which the error was detected, and the type of error that has occurred. Specific guidelines for corrective action are described in Section 6.6.5 of the *CDAP* (Malcolm Pirnie 1992b).

6.15 Quality Assurance Reports

Specific guidelines for the quality assurance reports are described in Section 6.7 of the *CDAP* (Malcolm Pirnie 1992b).

7.0 FIELD SAMPLING PLAN

The Field Sampling Plan (FSP) provides requirements and procedures for all field work to be conducted during the FT-002 Groundwater Impact Study. Methods for conducting the field operations and collecting field data generally will be based upon procedures outlined in the *Final Work Plan Remedial Investigation/Feasibility Study* (Malcolm Pirnie 1992a), *Final Chemical Data Acquisition Plan (CDAP) for Environmental Investigations at Plattsburgh Air Force Base, Plattsburgh, New York* (Malcolm Pirnie 1992b), *Final Site Safety and Health Plan for Environmental Investigations at Plattsburgh Air Force Base, Plattsburgh, New York* (Malcolm Pirnie 1992c), *Final Monitoring Well Installation Plan* (Malcolm Pirnie 1992d), and the *AFCEE Handbook for Installation Restoration Program Remedial Investigations and Feasibility Studies* (AFCEE 1993). Methods and procedures that will be followed are detailed in the following sections.

7.1 Site Reconnaissance, Preparation and Restoration Procedures

Prior to mobilization, a site reconnaissance of potential drilling and geophysical locations will be conducted to identify areas requiring clearing for vehicle access, easements, and utilities clearance. It is anticipated that only minor brush removal (by hand) will be required at all locations except for the geophysical survey lines, which will be cleared by a subcontractor. Onbase utilities clearances will be facilitated through AFBCA personnel. Offbase utilities clearances will be coordinated through the Underground Facilities Protection Organization.

In the spring of 1996, a field office trailer and a storage trailer will be mobilized on base to the open field west of Idaho Avenue near Building 2597. Utilities connections will be arranged by URS Consultants, Inc. Subcontractor equipment and vehicles also will be staged and decontaminated in this area. Following completion of the field activities, the trailers and equipment will be removed from the site and the site will be restored to its original condition.

7.2 Geophysical Surveys

Two types of geophysical surveys will be conducted to expand upon the bedrock information currently available at Plattsburgh AFB: seismic refraction surveys to gather depth to bedrock data and azimuthal resistivity surveys to obtain bedrock structure and fracture orientation data.

7.2.1 Seismic Refraction Survey

Approximately 6,500 linear feet of seismic refraction surveying was conducted to provide information on the bedrock/overburden interface in the area along the eastern base boundary near Cliff Haven, as indicated on Figure 3-3. Survey lines were established by URS and cleared by a subcontractor and URS. The survey was conducted by Gartner Lee, Inc. of Niagara Falls, New York in December 1995.

Seismic data was collected utilizing a geophone spacing of 15 feet. The survey was performed with a Bison Instruments Model 9048, 48 channel, portable engineering seismograph. The seismograph had digital instantaneous floating point amplifiers and a built-in data logger to assist in acquiring data with high precision. This allowed for data to be subsequently transmitted to a laptop computer for storage and analysis.

Data was measured with a single 14 Hz vertical geophone per channel. The seismic sources were a truck mounted elastic wave generator (EWG1) and a sledge hammer and steel plate.

The refraction survey was conducted by using a spread of 48 geophones spaced 15 feet apart. Shots were made in both a forward direction and a reverse direction. In addition, shots were made within the spread to aid in the determination of the velocities of the upper layers. Each seismic spread was overlapped by three to four geophones with the previous spread for QA/QC and data analysis requirements. For the far offset shots it was necessary to stack first arrivals. Stacking involves generating repeated seismic signals in order to amplify the refracted response. Data was measured utilizing the in-line refraction profiling technique. Each seismic line was surveyed for elevation and location by URS.

The Generalized Reciprocal Method (GRM) will be used to analyze the refraction data. The GRM determines the depth to undulating refractors by analyzing refracted first arrivals at each geophone. The resulting velocity and depth analysis will be displayed as interpreted cross-sections of the overburden/bedrock interface. The interpretation of subsurface materials will be correlated with subsurface data from nearby soil borings.

7.2.2 Azimuthal Resistivity Survey

A total of 21 azimuthal resistivity surveys will be performed to provide information on the orientation of fractures and joint sets in bedrock. Seven survey locations within the base boundaries will be established and cleared by URS. Three azimuthal resistivity surveys will be performed at varying depths at each of the 7 locations by Gartner Lee, Inc. in the spring of 1996.

An azimuthal resistivity survey is performed by rotating an electrode array around a fixed center point and measuring the apparent resistivity values. The geophysical "target" will be anomalous resistivity zones within the azimuthal projection that will be indicative of fluid filled fractures.

The results of the azimuthal resistivity survey can be visualized as an elliptical shape. This elliptical shape is referred to as the apparent resistivity ellipse (Taylor and Flemming 1988). For a square array, the major axis of the apparent resistivity ellipse is perpendicular with the strike of the joints and fractures.

To collect data onsite, a four-electrode square array is rotated in a circular grid and measurements are taken at 15° azimuthal projection intervals. The square array utilizes two pairs of current and potential electrodes laid out in a square pattern. The array size (A) is equal to the length of a side of the square. Generally, the depth of the investigation for a square array survey is approximately the distance of the "A-spacing."

A surveyors' transit and a tape measure will be utilized to establish a circular reference grid for rotating the square array. The "A-spacing" and azimuthal resistivity survey locations will be determined based upon the topography and access. An Iris R1 Plus Resistivity Meter or equivalent will be used to acquire apparent resistivity data. Data will be presented in plan view azimuthal projections.

7.3 Boring and Monitoring Well Installation

Thirty-one soil borings will be performed in December 1995 (3 were completed) and the spring of 1996 by Adirondack Environmental Associates, Inc. of Plattsburgh, New York under the supervision of a URS geologist. The borings will provide stratigraphic, hydrologic, and chemical data and will permit the installation of 28 monitoring wells/piezometers/pumping wells as summarized in Table 3-1 and Figures 3-3 and 3-4. Drilling, sampling, and well installation procedures are detailed in Sections 7.3.1 through 7.3.4.

7.3.1 Borehole Drilling

Drill rigs equipped with 4¼-inch ID, 6¼-inch ID, and 10¼ inch ID hollow stem augers (HSA) and 6-inch ODEX will be used for overburden drilling and sampling. Overburden well and piezometer borings will be advanced with 6¼-inch HSA to permit well/piezometer installation. For bedrock monitoring well borings, 10¼-inch ID HSA (or 12-inch ID casing) will be advanced two feet into the clay confining unit. An 8-inch ID casing will be grouted into the clay confining layer as the 10¼-inch ID HSA are removed. The grout will be allowed to set for at least 24 hours prior to continuing the boring 3 feet into bedrock using 6" ODEX drilling. Soil samples will be collected with 2-inch or 3-inch split spoon samplers in accordance with ASTM D1586-84. Sampling frequency will be at 5-foot intervals and at changes in subsurface material or as directed by the URS supervising geologist. The soil samples will be screened with an HNu PI-101 photoionization detector and a Ludlum Model 2 radiation survey meter.

Bedrock borings will be advanced using an NX core barrel inside the 6-inch ODEX casing. The core hole then will be reamed with a 5¾-inch roller bit or 6-inch ODEX to permit well installation.

Most borings will be converted to either monitoring wells or piezometers as detailed in Section 7.3.2. Boreholes requiring abandonment will be tremie grouted from termination depth to the ground surface with bentonite or cement-bentonite grout.

In addition to monitoring wells and piezometers, the investigation includes installation of an 8-inch diameter overburden well and a 6-inch diameter open-hole bedrock well using 10¼-inch ID HSA or 12-inch casing. Both wells, which will be used for aquifer pumping tests, will be installed utilizing the previously described methodologies.

7.3.2 Well Construction

All well riser and screen shall be steam-cleaned prior to installation. Overburden monitoring wells and piezometers will be constructed of 2-inch ID Schedule 40 threaded flush-joint PVC riser pipe and 0.010-inch slot screen. End caps for screens will be threaded. Overburden well screens will be fully penetrating if the unconfined aquifer saturated thickness is less than 15 feet. Otherwise, the well screens will be 10 feet long and set at a depth intersecting the water table surface. A sand pack, consisting of clean well rounded silica sand with a grain size distribution and uniformity coefficient compatible with the formation materials and screen, will be installed from 1 foot below the screen to 2 feet above the screen. A minimum 2-foot bentonite seal will be placed above the sandpack and the remainder of the borehole backfilled with cement/bentonite grout (Figure 7-1).

The bedrock monitoring wells will be constructed in a similar manner. Two-inch ID Schedule 40 threaded flush-joint PVC riser pipe and 0.010-inch slot screen equipped with a threaded end cap will be inserted through the 6-inch ODEX casing into the 6-inch rock hole. A sandpack, consisting of clean well rounded silica sand with a grain size distribution and uniformity coefficient compatible with the formation materials and screen, will be installed around and 2 feet above the top of the screen. A 3-foot thick (minimum) timed-released bentonite pellet seal will be installed above the sandpack and allowed to hydrate as per the manufacturer's instructions. The remainder of the rock hole and overburden borehole will be tremie backfilled with cement-bentonite (Figure 7-2).

The large diameter borehole for the overburden pump test well will be completed with 8-inch Schedule 40 threaded flush joint PVC riser and screen. In all other aspects, this well will be constructed in the same manner described for the overburden monitoring wells and piezometers. The bedrock pump testing well will be constructed in the same manner as bedrock monitoring wells and piezometers except the rock hole will be left open with no screen.

Following construction, each well and piezometer will be supplied with a protective casing with lockable cap. A vent hole will be placed in the well casing. The protective casing will be set in a 3-foot diameter circular concrete pad 4 inches thick. Additionally, wells in highly trafficked areas also will be supplied with 3 guard posts spaced evenly apart and set in concrete outside of the concrete pad.

7.3.3 Temporary Capping

Any well that is to be left incomplete overnight or due to a delay in construction shall be capped with a watertight cap and equipped with a vandal-proof cover.

7.3.4 Well Plumbness and Alignment

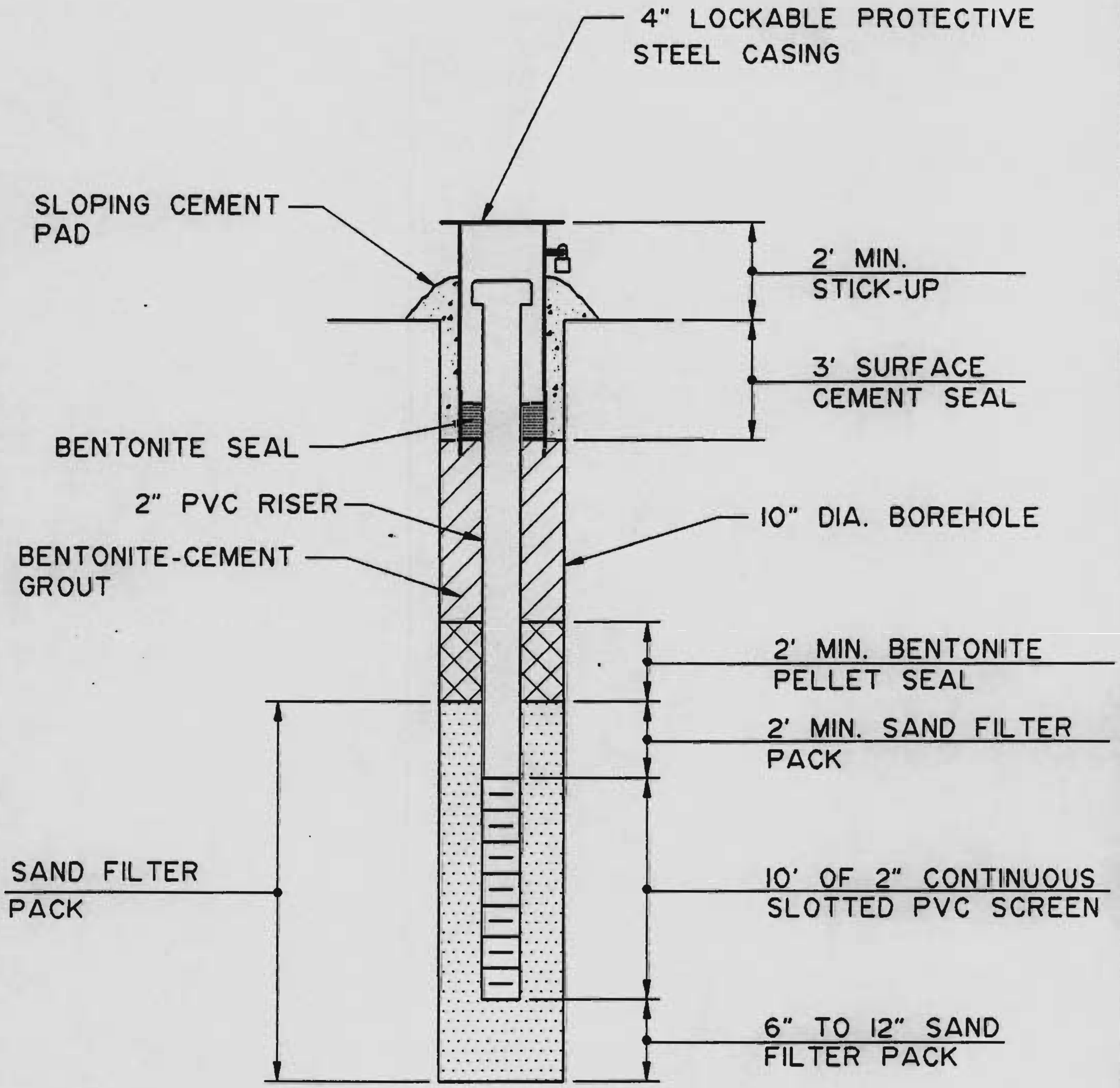
All well risers and screens will be set round, plumb, and true to line. A 5-foot long section of pipe 0.5 inches smaller in diameter than the inside diameter of the well will be run through the entire length of the well to check the alignment. The alignment test pipe will be decontaminated by steam-cleaning prior to use in each well. URS will conduct this test to determine if the well is acceptable. If this test cannot be passed, the well will not be accepted and the contractor will redrill the well.

7.4 Aquifer Testing

To better quantify hydraulic characteristics of the bedrock and overburden aquifers, several borehole permeability tests and two aquifer pumping tests will be conducted in the newly installed wells.

7.4.1 Packer Testing

Packer tests will be performed on the newly installed bedrock monitoring wells according to the procedures outlined in USBR 7310-89 to provide estimates of the fracture permeability in the rock. Prior to bedrock well installation, the open bedrock hole will be tested at 10-foot intervals over its entire exposure. The drilling subcontractor will perform the tests under the supervision of URS personnel.

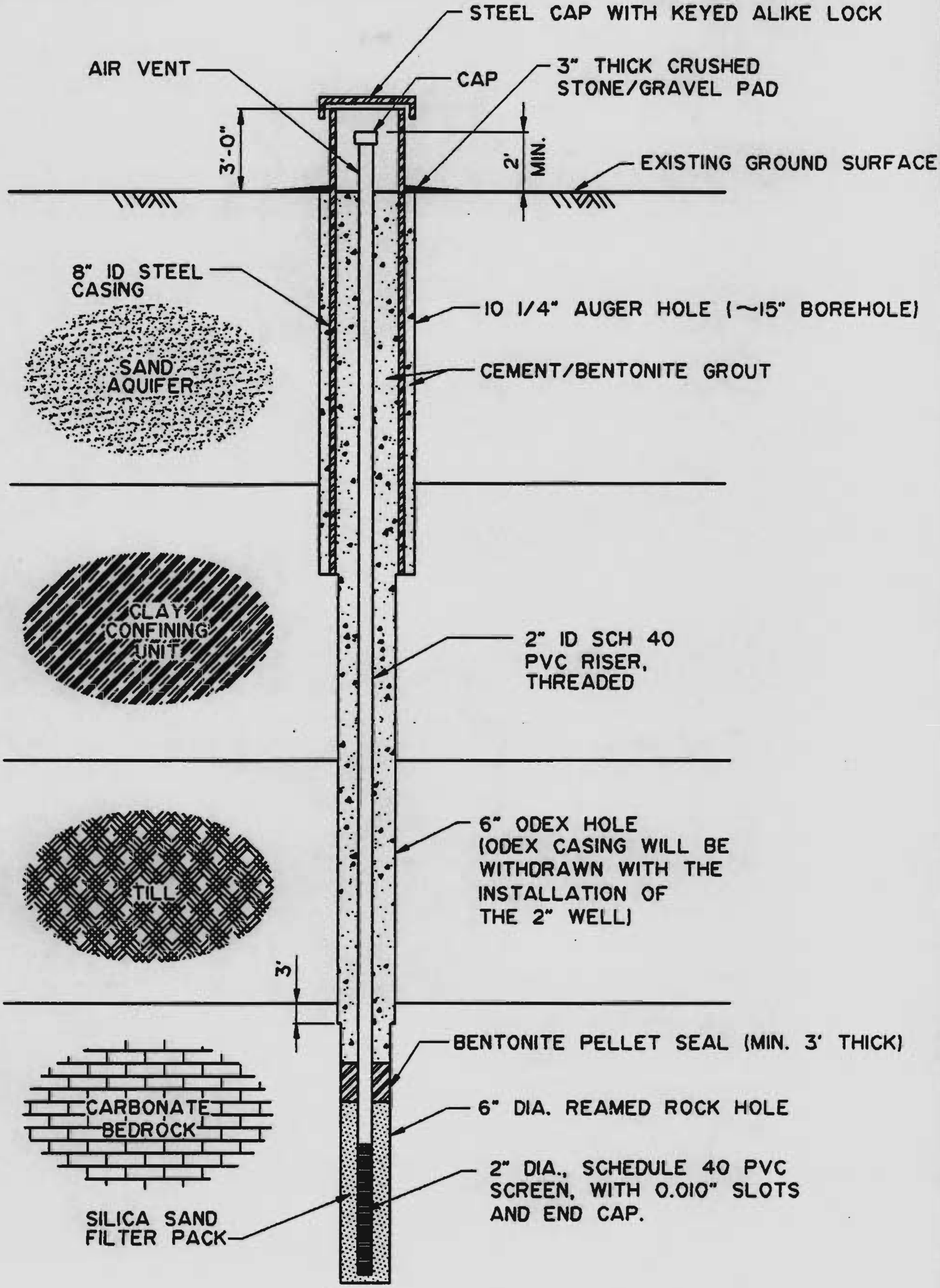


SOURCE:
MALCOLM PIRNIE, 1992d

URS CONSULTANTS, INC.

TYPICAL OVERBURDEN MONITORING WELL CONSTRUCTION DETAIL

FIGURE 7-1



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URS CONSULTANTS, INC.

TYPICAL BEDROCK MONITORING WELL CONSTRUCTION DETAIL

FIGURE 7-2

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The packer test apparatus consists of two inflatable packers separated by a perforated pipe. After the apparatus is tested for leaks, it is inserted into the borehole to the desired depth and the packers are inflated. Water is then pumped into the apparatus at a known pressure and the rate of water loss to the formation is calculated. Parameters necessary to convert raw packer test data to hydraulic conductivity (permeability) values include length of interval tested, water pressure, distance from flow meter to the ground, distance from the ground to the water table, test duration, total flow, and borehole radius. These data will be used to calculate hydraulic conductivity values for the bedrock wells.

7.4.2 Slug Testing

Slug testing will be performed in all newly installed monitoring wells screened in the overburden to provide estimates of the horizontal hydraulic conductivity of the unit screened. Slug testing will be performed in accordance with the procedures described in Section 7.0 of the *Monitoring Well Installation Plan* (Malcolm Pirnie, 1992) except that 1-inch OD slugs will be used rather than 1.8-inch OD slugs. Only rising head tests (slug out) will be performed in the cases where the well-screen intersects the water table surface.

7.4.3 Aquifer Pumping Tests

Two aquifer pumping tests, one in the bedrock aquifer and one in the overburden aquifer, will be conducted near the downgradient extent of FT-002 groundwater contamination to evaluate various hydraulic parameters for input to the groundwater flow and contaminant transport model. The work will take place in two phases. The first phase will include development and analytical sampling of each pumping well to determine whether the effluent from the development and pumping tests will require treatment by air stripping and carbon polishing before discharge to the storm drainage system. The second phase will consist of a step drawdown and a 48-hour constant rate pumping test at each location. Logistical support (i.e., provision of air stripping unit, work lights, and electrical hookup) will be provided by HM2, Inc. of Plattsburgh, New York.

The pumping tests will be performed using an electric submersible pump set near the bottom of each test well. The pumping rate will be controlled by adjusting the pump speed (using a variable rate pump) and/or a ball valve on the discharge line. To monitor early drawdown data, a data logger and pressure transducer will be used to measure water levels within the pumping well. A flow meter/totalizer will be installed in the discharge line to monitor pumping rates.

Step drawdown tests will be conducted to determine the pumping rates that the test wells can sustain for the 48-hour, constant rate aquifer tests. The step drawdown tests will be conducted by pumping the wells for approximately 1.5 hours at several pumping rates. Water levels within the wells will be recorded throughout the tests using a pressure transducer and data logger. Four discharge rates will be used to evaluate the long-term pumping rates for the wells.

48-hour constant rate pumping tests will be conducted after the step drawdown tests. Water levels will be monitored in the pumping test well and the surrounding monitoring wells/piezometers using a data logger. Water levels will also be measured manually using electronic water level probes to verify the data logger readings. Water level measurements will be made at intervals which increase as the test advances. After 48 hours, the aquifer will be allowed to recover. Groundwater level measurements will be made until the aquifer returns to static conditions.

7.5 Surveying

All new monitoring wells, borings, geophysical survey lines, and any other necessary data points will be surveyed by URS using a combination of conventional surveying (angles, distances, differential leveling) and Global Positioning Systems (GPS satellites) methodologies. Primary horizontal control will be based upon the New York State Plane Coordinate System (1983 adjustment), and primary vertical control will be based upon the North American Vertical Datum of 1988. All surveying will be conducted under the direct supervision of a New York State Licensed Land Surveyor and will meet or exceed standards referenced in the *AFCEE Handbook.*

Additionally, an approximately 900 acre area located between the eastern Plattsburgh AFB boundary and Lake Champlain will be topographically mapped at a scale of 1" = 200' with 5-foot contours using aerial photography to be flown in the spring of 1996. Photo control surveying will be performed by URS and the aerial photography and map preparation will be performed by Air Survey Corporation of Sterling, Virginia.

7.6 Geologic and Hydrologic Data Collection

Field reconnaissance for the purpose of mapping surface geologic features will be conducted in the Salmon and Saranac River drainages, along the Lake Champlain shoreline, west of Plattsburgh AFB, and on the base itself. The data collection will follow procedures outlined in *Geology in the Field* (Compton 1985).

URS will develop piezometric surface maps for the overburden (unconfined) and bedrock (confined) aquifers using groundwater elevation data gathered from all available monitoring wells on and offbase. Spring and summer conditions will both be mapped. Discharge measurements will be made in streams exiting the base and in the Salmon River concurrently with the groundwater elevation measurements. This data will be collected according to the procedures outlined in Section 5.0 of the *Final Monitoring Well Installation Plan* (Malcolm Pirnie 1992d).

7.7 Equipment Decontamination

Equipment decontamination procedures will follow those outlined in Section 4.1.1 of the *CDAP* (Malcolm Pirnie 1992b) except that hexane will not be used as a rinse agent.

7.8 Waste Handling

Potentially hazardous materials generated during field activities shall be placed in properly labeled drums that are USDOT-approved for transport of hazardous materials. "Potentially hazardous materials" will be interpreted to mean materials with PID or FID readings exceeding 5 ppm above background levels. All potentially hazardous materials and segregated materials will be placed in separate drums (i.e., soil, water, tyvek, etc.)and secured at a designated staging area on wooden pallets, pending receipt of analytical results. All drums will be properly labeled prior to being moved to the staging area. At a minimum, the drums will be labeled as to type of materials contained, area of concern number, the Contracting Officer, and AFCEE and AFBCA points of contact. Drums containing fluid/liquids must be staged on site using an approved USDOT overpack to provide double containment. Staged drums will be tested and disposed according to the results of testing.

7.9 Groundwater Sampling

All newly installed wells and piezometers will be developed prior to sampling according to the procedures outlined in Section 6.0 of the *Final Monitoring Well Installation Plan* (Malcolm Pirnie 1992d), except that surge blocks may not be used during development. The primary means of well development will be a hydrolift pump equipped with dedicated and disposable HDPE tubing and check valves. Groundwater sampling will follow the procedures outlined in Section 4.3.5 of the *CDAP* (Malcolm Pirnie 1992b) except that dedicated and disposable, pre-cleaned Teflon bailers will be used for sampling.

7.10 Soil Sampling

Soil samples will be collected from split-spoon samplers during drilling activities according to the procedures outlined in Section 4.3.13 of the *CDAP* (Malcolm Pirnie 1992b).

7.11 Quality Control Samples

Soil and groundwater quality control samples will be collected at the frequency indicated in Table 6-2 and according to the procedures detailed in Sections 7.9 and 7.10 of this FSP.

PART III

COMMUNITY RELATIONS PLAN

8.0 OBJECTIVES OF THE PLAN

The Community Relations Plan describes the framework for contacting offbase property owners for information concerning drinking water wells and for obtaining easements for sampling and installing groundwater monitoring wells. This plan will be re-evaluated and revised if necessary as the technical program progresses.

9.0 COMMUNITY WELL SURVEY

Primarily three types of community contact will occur: (1) a potable well survey; (2) follow up information and questions concerning the survey; and (3) newsletters and press releases.

9.1 Potable Well Survey

URS will conduct a house-to-house survey of offbase property owners downgradient of the FT-002 groundwater plume to obtain information regarding potable water well use. The location of the proposed survey is presented on Figure 9-1. Fifty private well owners were tentatively identified for the water survey by the Town of Plattsburgh Water and Sewer Department. Figure 9-2 shows a preliminary survey form to be used for the survey. The form will be completed by the property owner at the time of the survey. Also included is a fact sheet (Figure 9-3) that briefly describes the program and gives a base contact for further information. This fact sheet will be left with the property owner. In the event that a property owner is unavailable at the time of the survey, a copy of the survey will be mailed to their place of residence with a stamped envelope addressed to:

URS Consultants, Inc.
282 Delaware Avenue
Buffalo, NY 14202-1805

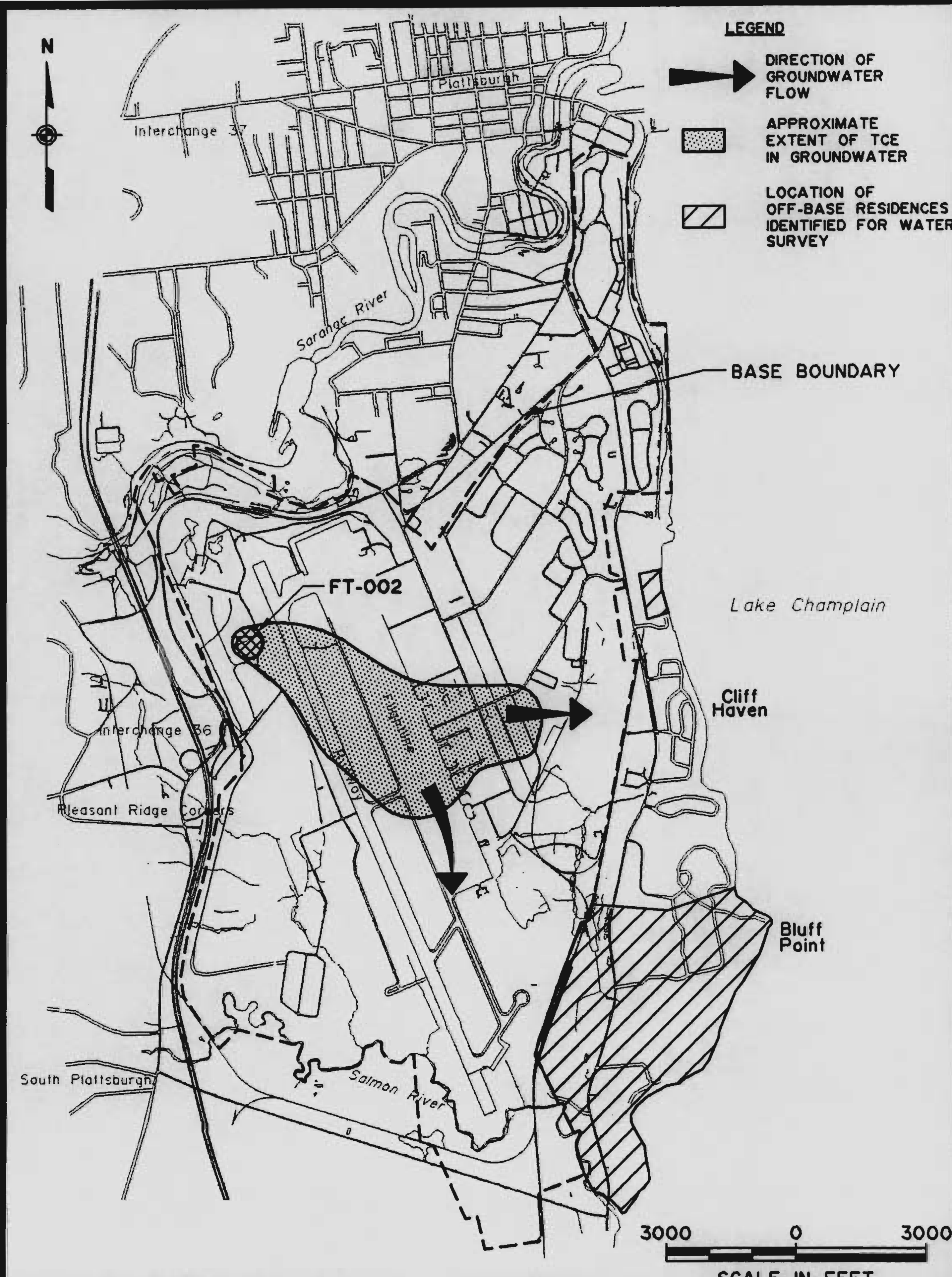
The survey is tentatively planned for February 1996. Prior to beginning the house-to-house survey, URS will prepare a press release for the local newspapers describing the proposed survey. Actual publication of the press release will be handled by the AFBCA's community relations subcontractor, WPI, Inc. Prior to performing the survey, URS will notify the Town of Plattsburgh, the Clinton County Health Department, and the New York State Department of Health. In addition, each property owner will be individually notified about the upcoming survey by mail. URS described the program in a presentation to the public at the Remedial Action Board meeting on December 7, 1995.

9.2 Additional Questions and Information for the Survey

All tasks involving public notification, including follow up information and questions concerning the water survey, will be directed to Mr. Joseph Szot at the following address:

Air Force Center for Environmental Excellence
AFCEE/OL-3A
Attn: Mr. Joseph Szot
324 U.S. Oval
Building 426
Plattsburgh AFB, NY 12903-3316
(518)563-2871

When necessary, Mr. Szot will forward technical questions to Mr. Brady Baker, AFBCA/OL-3A project director, or to Don Hunt, project manager at URS Consultants, Inc. in Buffalo, New York.



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URS CONSULTANTS, INC.

LOCATION OF OFF-BASE PROPERTIES IDENTIFIED FOR THE POTABLE WELL SURVEY

FIGURE 9-1

FIGURE 9-2
COMMUNITY WELL SURVEY
PLATTSBURGH AIR FORCE BASE

DATE:____________ SURVEYOR:____________________________

GENERAL INFORMATION

NAME:____

ADDRESS:____

TELEPHONE (optional):________________________________

No. of persons residing at Location:

Adults (18 and Over)_______________

Teenagers (13 to 18)_______________

Children (12 and under)_____________

No. of Years at Present Address:_______

POTABLE WATER SOURCE INFORMATION

1) From where do you obtain your drinking water?
   Municipal Supply?_____
   Surface Water?_______
   Well Water?_________

2) If you have a water well, please answer the following questions:

   a) List uses for this well water (if any). For example, drinking, agriculture, livestock.
      i) ________________________________
      ii) ________________________________
      iii) ________________________________
      iv) ________________________________

   b) Is the well completed in: bedrock _____
      overburden (sand or gravel) _____

   c) When was the well installed? 19____

   d) What is the well depth?________________________________

   e) What is the well type?_________________________________

   f) What is the well diameter?______________________________

g) What was the well installation method?

dug _____ drilled _____ unknown _____

h) Do you have a well construction diagram or boring log available for the well?

____

i) Does the residence have a basement?_______________________________

3) Do you have an abandoned well?_____

If yes, is it:

Capped	______	Open	_______
Plugged with cement	______	Unknown	_______

FIGURE 9-3

FACT SHEET

POTABLE WELL SURVEY

FOR

PLATTSBURGH AIR FORCE BASE

GROUNDWATER STUDY

The U.S. Air Force is conducting a house-to-house survey of property owners along Route 9 from the southern-most end of the Town waterline to the southern Plattsburgh Town line. The purpose of the survey is to determine the location, usage, and construction details of off-Base potable water wells between the Base and Lake Champlain. The geologic and demographic information gathered will be used to support a study of groundwater flow and future groundwater quality at the Base and the adjacent community. Personnel from the U.S. Air Force and URS Consultants, Inc. are conducting the survey.

Thank you for your cooperation. If you have any questions regarding the survey or the groundwater study, please contact the person listed below:

Air Force Center for Environmental Excellence
AFCEE/OL-3A
Attn: Mr. Joseph Szot
324 U.S. Oval
Building 426
Plattsburgh AFB, New York 12903
(518) 563-2871

9.3 Press Releases and Newsletters

WPI, Inc. will serve as the liaison between Plattsburgh AFB and the community for this project and will be responsible for coordinating press releases and newsletters throughout the course of the project.

10.0 EASEMENTS FOR OFFBASE ACTIVITIES

URS will identify the proposed locations for offbase monitoring wells and will provide the survey support for their installation. Where practical, off-base monitoring wells will be located on utility easements and road rights-of-way to facilitate the process of obtaining drilling easements. Contact with the property owners to notify them of the proposed installation and to negotiate permanent easements for installing and sampling the wells will be managed by the USAF. Wells will be located in remote areas and will be unobtrusive to the surrounding environment, when possible.

PART IV
SITE HEALTH AND SAFETY PLAN ADDENDUM

11.0 INTRODUCTION

This Health and Safety Plan Addendum includes appropriate health and safety procedures to be followed during environmental field activities in support of the FT-002 Groundwater Impact Study. It is to be used in conjunction with the approved *Final Site Safety and Health Plan (SSHP) for Environmental Investigations at Plattsburgh Air Force Base, Plattsburgh, New York (Malcolm Pirnie 1992c).*

The Fire Training Area (IRP Site FT-002) is an approximately 15-acre area located between landfills LF-022 and LF-023 on the west side of the base. From mid-to-late 1950s through 1989, fire training activities took place in four pits on the site. The pits were saturated with water and flammable liquids (including jet fuel, waste oil, solvents, and other chemicals) and ignited. Before 1980 the pits were unlined and some uncombusted fuel soaked into the ground forming a groundwater contaminant plume. The objective of the FT-002 Groundwater Impact Study is to determine the most appropriate action or actions necessary to protect human and ecological receptors downgradient of the plume.

12.0 ORGANIZATION

Personnel responsible for implementation of this Health and Safety Plan Addendum are:

- Donald Hunt, P.E. — **Project Manager** (716 856-5636)
- Mark Litzinger, CIH — **Corporate Health and Safety Manager** (206 623-1800)
- Richard Fudeman — **Project Health and Safety Officer** (716 856-5636)
- Steven Moeller — **Site Health and Safety Officer** (Field Office - Number not yet available)

13.0 HAZARD ASSESSMENT

13.1 Description of Field Activities

Field activities that will be conducted to collect data for the Groundwater Impact Study include ecological and geophysical surveys, soil borings, monitoring well installation, aquifer pumping tests groundwater sampling, surveying, and geologic mapping. Much of the work will be located outside the known area of contamination.

13.2 Summary of Projected Risks

Anticipated health hazards associated with field activities include the potential for exposure to hazardous chemicals and physical injury due to the environment in which the work will take place. These hazards are discussed in the following subsections.

13.2.1 Chemical Hazards

While conducting site investigations, a potential exists for exposure to chemical contaminants through ingestion/inhalation and skin contact. General chemical, physical, and toxicological data for the contaminants of concern at the site which are regulated by the Occupational Safety and Health Administration (OSHA) is given in Table 13-1. Additional information about each contaminant can be found in Appendix A (Toxicological Summary) of the *SSHP*. The majority of the field investigative activities will take place on or beyond the periphery of the FT-002 groundwater contaminant plume. However, groundwater samples may be collected from wells now located within the plume.

Dermal contact and inhalation of these contaminants can be avoided through use of proper personal protective equipment as described in Section 15.0, Personal Protective Equipment, and by implementation of real-time air monitoring, as described in Section 17.0, Monitoring.

13.2.2 Physical Hazards

The primary physical hazard which may be encountered during subsurface investigations is injury due to working with sampling equipment. To address this hazard, the following protective clothing shall be used at all times:

- Hard hats
- Steel toed work boots
- Durable work gloves
- Eye protection
- Hearing protection (as necessary)

In addition to the protective clothing listed above, blaze orange safety vests will be worn by personnel conducting investigative activities near roadways or in wooded areas and flotation vests will be worn while conducting activities near or in streams and rivers.

TABLE 13-1

TOXICOLOGY SUMMARY
FT-002

Compound	Vapor Press. (mm Hg)	Ionization Potential (eV)	PEL/ STEL (mg/m³)	Target Organs	Route of Entry	Symptoms, Toxicological Effects	First Aid
Benzene	75	9.24	3/15	Blood, CNS, skin, bone marrow, eyes, respiratory system	Inhalation, Skin Absorption, Ingestion, Skin/Eye Contact	Eye, nose, & throat irritation; dizziness, headache, nausea, staggered gait, fatigue, anorexia, lassitude, dermatitis, bone marrow depression, [carcinogen]	Eyes: Irrigate immediately Skin: Soap wash immediately Breathe: Respiratory support Swallow: Immediate medical attention
2-Butanone	78	9.54	590/885	Eyes, skin, respiratory system, CNS	Inhalation, Ingestion, Skin/Eye Contact	Eyes, skin, & nose irritation; dizziness, vomiting, dermatitis	Eyes: Irrigate immediately Skin: Water wash immediately Breathe: Fresh Air Swallow: Immediate medical attention
Carbon Disulfide	297	10.08	12/36	CNS, ANS, CVS, eyes, kidneys, liver, skin, reproductive system	Inhalation, Skin Absorption, Ingestion, Skin/Eye Contact	Dizziness, headache, poorsleep, fatigue, nervousness, anorexia, psychosis, Parkinson-like syndrome, ocular changes, coronary disease, gastritis, kidney & liver injury, eye & skin burns, dermatitis reproductive effects	Eyes: Irrigate immediately Skin: Soap wash immediately Breathe: Respiratory support Swallow: Immediate medical attention
1,2-Dichlorobenzene	1	9.06	C300	Eyes, skin, respiratory system, liver, kidneys	Inhalation, Skin Absorption, Ingestion, Skin/Eye Contact	Eye & nose irritation, liver & kidney damage, skin blisters	Eyes: Irrigate immediately Skin: Soap wash immediately Breathe: Respiratory support Swallow: Immediate medical attention

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TABLE 13-1 (Con't)

Compound	Vapor Press. (mm Hg)	Ionization Potential (eV)	PEL/ STEL (mg/m³)	Target Organs	Route of Entry	Symptoms, Toxicological Effects	First Aid
1,2 Dichloroethene	180-265	9.65	790	Respiratory system, eyes, CNS	Inhalation, Ingestion, Skin/Eye Contact	Irritated eyes, mucous membranes, headache, dermatitis, narcosis, coma	Eyes: Irrigate immediately Skin: Soap Wash immediately Breathe: Respiratory support Swallow: Immediate medical attention
Ethylbenzene	7	8.76	435/545	Eyes, upper respiratory system, skin, CNS	Inhalation, Ingestion, Skin/Eye Contact	Irritated eyes, mucous membranes, headache, dermatitis, narcosis, coma	Eyes: Irrigate immediately Skin: Water flush promptly Breathe: Respiratory support Swallow: Immediate medical attention
4-Nitroaniline	0.00002	8.85	3	Respiratory system, blood, heart, liver	Inhalation, Skin Absorption, Ingestion, Skin/Eye Contact	Irritated nose & throat, ataxia, irritatability, vomiting, diarrhea, convulsions, respiratory arrest, anemia, jaundice	Eyes: Irrigate immediately Skin: Water flush immediately Breathe: Respiratory support Swallow: Immediate medical attention
Phenol	0.4	8.50	19	Eyes, skin, respiratory system, liver, kidneys	Inhalation, Skin Absorption, Ingestion, Skin/Eye Contact	Irritated eyes, nose, & throat; anorexia, weakness, muscle ache, dark urine, liver & kidney damage, skin burns, dermatitis, ochronosis, tremors, convulsions	Eyes: Irrigate immediately Skin: Soap wash immediately Breathe: Respiratory support Swallow: Immediate medical attention
Tetrachloroethene	14	9.32	170/C20 0	Eyes, skin, respiratory system, liver, kidneys, CNS	Inhalation, Skin Absorption, Ingestion, Skin/Eye Contact	Eye, nose & throat irritation; nausea, flush face, vertigo, dizziness, liver damage	Eyes: Irrigate immediately Skin: Soap Wash immediately Breathe: Respiratory support Swallow: Immediate medical attention

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TABLE 13-1 (Con't)

Compound	Vapor Press. (mm Hg)	Ionization Potential (eV)	PEL/ STEL (mg/m^3)	Target Organs	Route of Entry	Symptoms, Toxicological Effects	First Aid
Toluene	21	8.82	375/560	Eyes, skin, respiratory system, CNS, liver, kidneys	Inhalation, Skin Absorption, Ingestion, Skin/Eye Contact	Irritated eyes & nose, fatigue, weakness, confusion, euphoria, dizziness, headache, dilated pupils, lassitude, nervousness, muscle fatigue, insomnia, paresthesia, dermatitis, liver and kidney damage	Eyes: Irrigate immediately Skin: Wash with soap and water Breathe: Respiratory support Swallow: Immediate medial attention
Trichloroethene	58	9.45	270/1080 C200	Eyes, skin, respiratory system, heart, liver, kidneys, CNS	Inhalation, Ingestion, Skin/Eye Contact	Headache, vertigo, visual disturbance, tremors, nausea, irritated eyes, dermatitis, cardiac arrhythmia, paresthesia, [carcinogen]	Eyes: Irrigate immediately Skin: Wash with soap and water Breathe: Respiratory support Swallow: Immediate medial attention
Vinyl Chloride	3.3 atm	9.99	C5 ppm	Respiratory system, skin, eyes, mucous membranes, CNS	Inhalation, Ingestion, Skin/Eye Contact	Irritated eyes, respiratory system, skin & mucous membranes, headache, vertigo, nausea, [carcinogen]	Eyes: Irrigate immediately Skin: Wash with soap and water Breath: Respiratory support Swallow: Immediate medial attention
Xylene (meta)	9	8.56	435/655	CNS, eyes, GI tract, blood, liver, kidneys, skin	Inhalation, Skin Absorption, Ingestion, Skin/Eye Contact	Dizziness, excitement, drowsiness, incoordination, staggering gait, irritated eyes, nose, or throat, corneal vacuolization, anorexia, nausea, vomiting, abdominal pain, dermatitis	Eyes: Irrigate immediately Skin: Wash with soap and water Breathe: Respiratory support Swallow: Immediate medical attention
Coal tar pitch volatiles[(1)]	Varies	Varies	0.2	Respiratory system, bladder, kidneys, skin	Inhalation, Skin/Eye Contact	Dermatitis, bronchitis, [carcinogen]	Eyes: Irrigate immediately Skin: Wash with soap and water Breathe: Respiratory support Swallow: Immediate medical attention

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TABLE 13-1 (Con't)

Compound	Vapor Press. (mm Hg)	Ionization Potential (eV)	PEL/ STEL (mg/m^3)	Target Organs	Route of Entry	Symptoms, Toxicological Effects	First Aid
PAHs	Varies	Varies	0.2	Respiratory system, bladder, kidneys, skin	Inhalation, Skin/Eye Contact	Dermatitis, bronchitis, [carcinogen]	Eyes: Irrigate immediately Skin: Wash with soap and water Breathe: Respiratory support Swallow: Immediate medical attention
Phthalates	Varies	Varies	5	Eyes, respiratory system, GI tract	Inhalation, Ingestion, Skin/Eye Contact	Irritated eyes, upper respiratory system, stomach pain	Eyes: Irrigate immediately Skin: Wash regularly Breathe: Respiratory Support Swallow: Immediate medical attention

CNS = Central nervous system
GI = Gastrointestinal
PEL = OSHA Permissible Exposure Limit
STEL = OSHA Short Term Exposure Limit
PAHs = Polynuclear Aromatic Hydrocarbons
c = OSHA ceiling
(1) = Coal tar pitch volatiles as regulated by OSHA include benzo(a)pyrene, chrysene, anthracene, pyrene, and acridine.

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- 'NIOSH Pocket Guide to Chemical Hazards." National Institute for Occupational Safety and Health, Publication No. 94-116, Cincinnati, Ohio, June 1994.
- Hawley, Gessner G. The Condensed Chemical Dictionary, Tenth Edition, New York, Van Nostrand Reinhold, 1981.
- Sax, R. Irving. Dangerous Properties of Industrial Materials, Sixth Edition, New York, Van Nostrand Reinhold, 1984.

This protective clothing shall be utilized in conjunction with the personal protective equipment requirements specified in Section 15.0 for protection from chemical hazards.

14.0 SITE CONTROL

The following site control work zones for on base intrusive activities such as monitoring well installation, soil borings, sampling, and aquifer pump tests will be established and communicated to all employees by the Site Safety and Health Officer:

- Exclusion Zone: The Exclusion Zone is the area around each active intrusive boring or sampling location. The exact size of this active Exclusion Zone will be determined by the optimal size of the work area and by local obstructions. All personnel leaving the active Exclusion Zone will be required to do so via the Contamination Reduction Zone (CRZ) and perform proper decontamination procedures.

- Contamination Reduction Zone (CRZ): The CRZ is the designated area where personnel and equipment decontamination will take place. The CRZ will be located between the Exclusion Zone and the Support Zone. The CRZ will be of sufficient size to permit decontamination activities to be conducted efficiently.

- Support Zone: The Support Zone is the area where support facilities such as the command office and the equipment storage trailer are located. It serves as the point of entry to or exit from the site for URS and subcontractor personnel.

Specific boundary locations will be determined by the Site Safety and Health Officer based on the actual boring and/or sample locations.

Prior to the initiation of sampling activities, the work zones shall be clearly marked using traffic cones and safety tape. If operations at the base or proximity to roads conflict with zone requirements, zones will be established at the discretion of the Site Safety and Health Officer.

15.0 PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE) usage will be in accordance with Section 9 of the *SSHP* (Malcolm Pirnie 1992c).

Intrusive activities will be conducted in Level D PPE. To provide protection against dermal contact with the site soils and groundwater, the following additional equipment will be required:

- Disposable protective coveralls
- Latex inner gloves
- Nitrile outer gloves
- Latex overboots

Upgrading to higher levels of PPE will be based upon criteria outlined in Section 9 of the *SSHP* (Malcolm Pirnie 1992c).

16.0 DECONTAMINATION

16.1 Personnel Decontamination

Personnel decontamination will be conducted in accordance with Section 11 of the *SSHP* (Malcolm Pirnie 1992c). The Contamination Reduction Zone (CRZ) shall be equipped with wash/rinse/disposal stations in accordance with the SSHP. Stations shall be set up and equipped as appropriate for the required level of PPE being employed.

16.2 Equipment Decontamination

The *CDAP* (Malcolm Pirnie, 1992b) specifies the sequential decontamination procedures to be followed for preparing sampling equipment (with the exception that hexane will not be used as a rinsing agent during this investigation). If photoionization detector (PID) readings above 5 ppm are encountered during sampling activities, excess soil cuttings and water will be collected and stored in 55-gallon drums for future testing and disposal. If PID readings are less than 5 ppm during sampling activities, soil cuttings will be spread on site.

17.0 MONITORING

During intrusive activities and during sampling, the breathing zone will be monitored for organic vapors with a PID calibrated to a benzene surrogate and for combustibles, oxygen, and hydrogen sulfide with a combustible gas indicator. Action levels and appropriate responses, including appropriate levels of protection, are given in Table 17-1.

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TABLE 17-1
ACTION LEVELS DURING INTRUSIVE ACTIVITIES[1]

Organic Vapors (PID)	Combustibles	Oxygen	Hydrogen Sulfide	Responses
0-1 ppm Above Background, Sustained Reading	--	--	--	• Continue intrusive activities. • Level D protection. • Continue monitoring every 10 minutes/every sample retrieved.
1-5 ppm Above Background, Sustained Reading	0-10% LEL	19.5-23.5%	0-5 ppm	• Continue intrusive activities. • Level D protection. • Continue monitoring every 10 minutes/every sample retrieved.
5-25 ppm Above Background, Sustained Reading	0-10% LEL	19.5-23.5%	5-10 ppm	• Continue intrusive activities. • Level C protection. • Continuous monitoring for organic vapors and particulates at the Exclusion Zone perimeter. • Continuous monitoring for LEL, 0_2, and H_2S.
>25 ppm Above Background, Sustained Reading	>10% LEL	<19.5% or >23.5%	>10 ppm	• Temporarily suspend intrusive activities. • Withdraw from area. • Consult with Project HSO and USAF personnel.

Notes: 1. Air monitoring for action levels will occur in the breathing zone. If action levels for any one of the monitoring parameters is exceeded, the appropriate responses listed in the right hand column should be taken.

18.0 EMERGENCY INFORMATION/RESPONSE

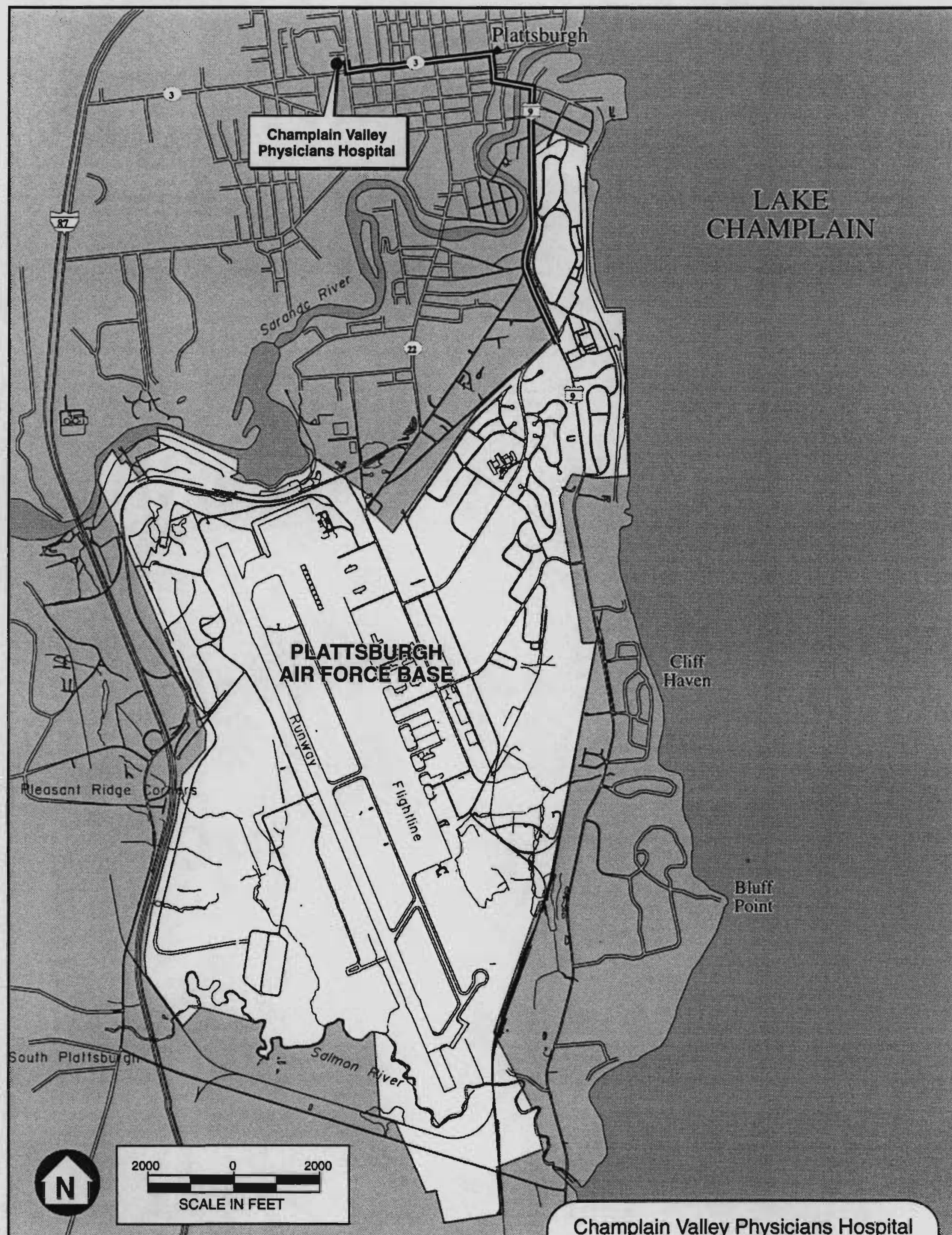
Consequent to the base closing, police and fire response will be provided by the City of Plattsburgh in the area of the old base and by the Town of Plattsburgh in the area of the new base. These agencies can be contacted in an emergency by dialing 911. Updated emergency contacts are given on Table 18-1.

The closest hospital to the base, since the closing of the base hospital, is Champlain Valley Physicians Hospital. The route to this facility is indicated on Figure 18-1.

Unarmed base security is being provided by Burns Security Services. It is important for Burns to be kept informed regarding the general location of the work areas and the personnel and companies that are authorized to work on base.

TABLE 18-1
EMERGENCY TELEPHONE NUMBERS

Police	911
Fire	911
Champlain Valley Physicians Hospital 75 Beekman Street Plattsburgh, NY 12901	(518) 561-2000 (General) (518) 562-7370 (Emergency)
Poison Control Information (Poison Control Center)	1-800-962-1253
Hazardous Material Emergency (USEPA National Response Center)	1-800-424-8802
Below Ground Utilities (Buried Cable)	1-800-272-1000
Burns Security (Main Gate)	1-518-562-4097



Champlain Valley Physicians Hospital
75 Beekman Street
Plattsburgh, New York 12901

General: (518) 561-2000
Emergency: (518) 562-7370

From Plattsburgh Air Force Base head north on US Route 9 and make a left on State Route 3 (Cornelia Street). Head west on State Route 3 and make a right on Beekman Street. The hospital will be on your left, right before University Place, as you turn onto Beekman Street.

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URS CONSULTANTS, INC.	PLATTSBURGH AIR FORCE BASE ROUTE TO THE HOSPITAL	FIGURE 18-1

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U.S. Army Corps of Engineering. 1989. Chemical Data Quality Management for Hazardous Waste Remedial Activities, ER 1100-1-263.

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