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INTERNATIONAL
TECHNOLOGY
CORPORATION

November 11, 1991

Project No. 301317

Mr. Marvin Taylor
CEMRO-ED-EC (Taylor)
U.S. Army Corps of Engineers
Brandeis Building, 6th Floor
210 South 16th Street
Omaha, NE 68102-4910

Draft Remedial Investigation Report
Former Air Force Airfield and
Bomarc Missile Site
Chippewa County, Michigan

Dear Mr. Taylor:

Enclosed are five copies of the Draft Remedial Investigation Report for the former Air Force Airfield and Bomarc Missile Site for Indefinite Delivery Contract Number DACW45-88-D-0008. The enclosed report was prepared in accordance with the November 29, 1989 Scope of Services and addended to accommodate Michigan Act 307 requirements. An additional ten copies of this report have been submitted to those agencies specified in the Scope of Services.

We await your review of this document and will be prepared to address your comments during the Draft RI Report Meeting.

Please contact us at (612) 481-8084 if you require additional information or have any questions.

Sincerely,

IT CORPORATION

Thomas B. Bader
Project Manager

SP/10-91/EES/301317/40

PREFACE TO DRAFT REMEDIAL INVESTIGATION REPORT
November 11, 1991

This is the Draft Remedial Investigation Report (Draft RI) for the former Raco Air Force Airfield and Bomarc Missile Site near Raco, Michigan. The report incorporates data collected during two RI field investigations (Stage 1 and Stage 2). It will be reviewed for approximately 30 days by the U.S. Army Corps of Engineers, the USDA Forest Service, the Chippewa County Health Department, and the Michigan Department of Natural Resources. Comments on the Draft RI should be forwarded to the USACE within the 30 day review period. A review meeting will be held shortly after the review period to discuss comments and answer questions concerning this Draft RI. The report will then be amended, incorporating changes as discussed during the RI review meeting, and a final report issued approximately 30 days thereafter.

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EXECUTIVE SUMMARY

The Stage 1 and 2 Remedial Investigation (RI) at the Former Air Force Airfield and Bomarc Missile site was conducted to determine whether past activities at the site had contributed to groundwater and soil contamination and if previous investigations adequately addressed this potential contamination. The field investigation consisted of two stages. Stage 1 utilized eight monitoring wells, seven soil borings and a geophysical survey to characterize seven sites and several potential landfill areas. During Stage 2, three supplemental wells were installed, eight soil borings were advanced and one additional site was investigated while four Stage 1 sites were advanced to Stage 2. A previous Contamination Evaluation Study was prepared by Envirodyne in April of 1987. During this investigation, four monitoring wells were installed. In addition to these data points, two water supply wells installed by the U.S. Air Force. One of these original wells continues to provide water to accommodate an auto tire testing firm's icy surface needs by flooding portions of the runway. Neither well supplies drinking water at this time.

Several volatile organic compounds (VOC) and semi-volatile organic compounds (SVOC) laboratory contaminants were detected in groundwater samples. Several other VOC and SVOC constituents not attributed to laboratory contamination were found in groundwater. All of these constituents were eliminated from further study using State of Michigan Act 307 type B criteria (Act 307). Groundwater analysis also detected several metal compounds. All of these metals were eliminated from further study using Act 307 a Baseline Risk Assessment (BRA) and an Endangerment Assessment (EA). Groundwater sampling conducted as a part of this investigation concluded that VOCs, SVOCs and metals identified during the investigations present no excess risk at the former facility.

Soil sample analysis from Stage 1 and 2 detected the presence of several VOC and SVOC compounds in soils at several sites. All of these compounds were eliminated using Act 307. During the U.S. Army Corps of Engineers tank removal activities at UST C4, total recoverable petroleum hydrocarbons (TRPH) were detected above state type B criteria for total petroleum hydrocarbons (TPH). Lead and chromium concentrations were detected in soils above Act 307 criteria at the sludge drying bed and chromium concentrations were detected in soils above Act 307 criteria at the wastewater treatment lagoon. Chromium was analyzed as total chromium throughout the investigation. Act 307 came into effect after most field work was completed. Act 307 has cleanup criteria for hexavalent chromium only. The total chromium levels exceeded the cleanup criteria for hexavalent chromium at both the sludge drying bed and the wastewater treatment lagoon. Additional soil analysis at both sites for hexavalent chromium and, if results exceed cleanup criteria, analysis by toxic characteristic leaching procedure (TCLP) will be necessary to determine if hexavalent chromium has potential to leach to the groundwater. Lead analysis for soils at both aforementioned sites is also suggested using TCLP to determine the same potential outcome. The need for additional soil analysis at UST C4 will remain an issue for the Michigan Department of Natural Resources (MDNR) to determine.

A potential pathway to groundwater consumers (receptors) exists for the aforementioned subsurface soil contaminants to migrate to groundwater and move in groundwater to potential downgradient water supply wells. Based on the results obtained from the groundwater samples collected downgradient of the three potential sites discussed (sludge drying bed, wastewater treatment lagoon, and UST C4) it appears that only lead has potentially migrated from the soils in the sludge drying bed to the groundwater. Lead was eliminated from further study based on the BRA and EA.

The hydrologic investigation concluded that groundwater at the former facility flows east southeast toward Sullivan Creek and the Pine River drainage basin.

Data gaps and recommendations for Stage III work include the following:

- Collect and analyze soils at the wastewater treatment lagoon and sludge drying bed for TCLP lead, hexavalent chromium, and possible TCLP hexavalent chromium.
- Sample soils at UST C4 for TPH to determine if soils are free of hydrocarbon contamination.

DRAFT REMEDIAL INVESTIGATION REPORT
FOR THE
FORMER AIR FORCE AIRFIELD
AND
BOMARC MISSILE SITE
RACO, MICHIGAN

November 11, 1991

PREPARED FOR

UNITED STATES ARMY CORPS OF ENGINEERS
OMAHA DISTRICT
215 NORTH 17TH STREET
OMAHA, NEBRASKA 68102

PREPARED BY

IT CORPORATION
4190 NORTH LEXINGTON AVENUE
ST. PAUL, MINNESOTA 55126

CONTRACT NUMBER DACW-45-88-C-0008
IT PROJECT NUMBER 301317

1.0 Introduction

In 1980, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) established a national program for responding to hazardous substances released to the environment. The Department of Defense's (DOD) CERCLA counterpart for formerly owned federal sites is known as the Defense Environmental Restoration Program for Formerly Used Defense Sites (DERP FUDS). DERP FUDS, since the passage of the Superfund Amendments and Reauthorization Act of 1986 (SARA), is equivalent to the EPA's Superfund Program and is consistent with the National Contingency Plan (NCP). DOD funding for remedial investigations and remedial actions at a DERP FUD site is provided by the Defense Environmental Restoration Account (DERA).

The U.S. Army Corps of Engineers (USACE) is responsible for administering DERP funds for the investigation, cleanup and close-out of the DERP FUD site evaluated in this report, the former Air Force Airfield and Bomarc Missile Site near Raco, Michigan. The USACE is responsible for overall project management, technical criteria development, and review and approval of design documents. The USACE's project manager for this site is Mr. Marvin Taylor of the Environmental Branch (CEMRO-ED-GC), Omaha District, Omaha, Nebraska.

In May 1990, the USACE retained IT Corporation (IT) to perform a Remedial Investigation and Feasibility Study (RI/FS) at the former Air Force Airfield and Bomarc Missile Site. This report, the Remedial Investigation Report (RI), fulfills the remedial investigation portion of the RI/FS contract. IT performed a two-stage field investigation (Stage 1 and Stage 2) in accordance with the May 3, 1990 cost proposal submitted to the USACE in response to the November 29, 1989 Scope of Services for Preparation of Remedial Investigation and Feasibility Study Report for the former Air Force Airfield and Bomarc Missile Site. Field work included geophysical surveying, soil boring installation, monitoring well installation, groundwater and soil sampling, and permeability testing. Procedures used to perform the field investigation are described in the Quality Control and Sampling Plan (QCSP, IT, August 1990) and in the letter "Revised Bomarc Recommendations for Stage 2 Activities" (IT to the USACE project manager, May 1, 1991).

Data collected during the two-stage field investigation is utilized in this report to characterize site conditions and to assess the impact of identified contaminants on human heath and the environment. Based on results of this report, a Feasibility Study (FS) will be prepared, as necessary, to address site cleanup and/or closeout procedures.

1.1 Purpose of Report

The purpose of this report is to (1) characterize the nature and extent of potential contamination at the site, (2) assess the associated impact on human health and the environment, and (3) provide information in sufficient detail to support future decisions related to site cleanup and/or closure. To achieve these goals, analytical results for the two stages of field work are presented and evaluated, the nature and extent of contamination at sites within the former installation are assessed, applicable or relevant and appropriate requirements (ARARs) are defined, contaminant fate and transport is addressed, the effect of contaminants on human health and ecology is considered, and recommendations for each site are presented. Recommendations consist of one or more of the following, in accordance with the USACE's November 1989 Scope of Services:

- recommendation to initiate long-term monitoring or to perform no further action,
- recommendation to acquire additional data,
- recommendation to initiate preparation of engineering plans and specifications for removal of contamination (quick removal), and/or
- a recommendation to prepare a feasibility study.

The remainder of this chapter acquaints the reader with site background information and describes overall report organization.

1.2 Background Information

The former Air Force Airfield and Bomarc Missile Site is located wholly within the Hiawatha National Forest approximately 4.5 miles west of Raco, Michigan and 28 miles south and west of Sault Ste. Marie, Michigan. The property, south of Michigan State Route 28 in Chippewa County (Figure 1-1), has the approximate Michigan State Plane coordinates of 2,550,000 feet west and 580,000 feet north. The former installation covers an area slightly greater than one square mile, and is divided into the Raco Airfield, of which only the

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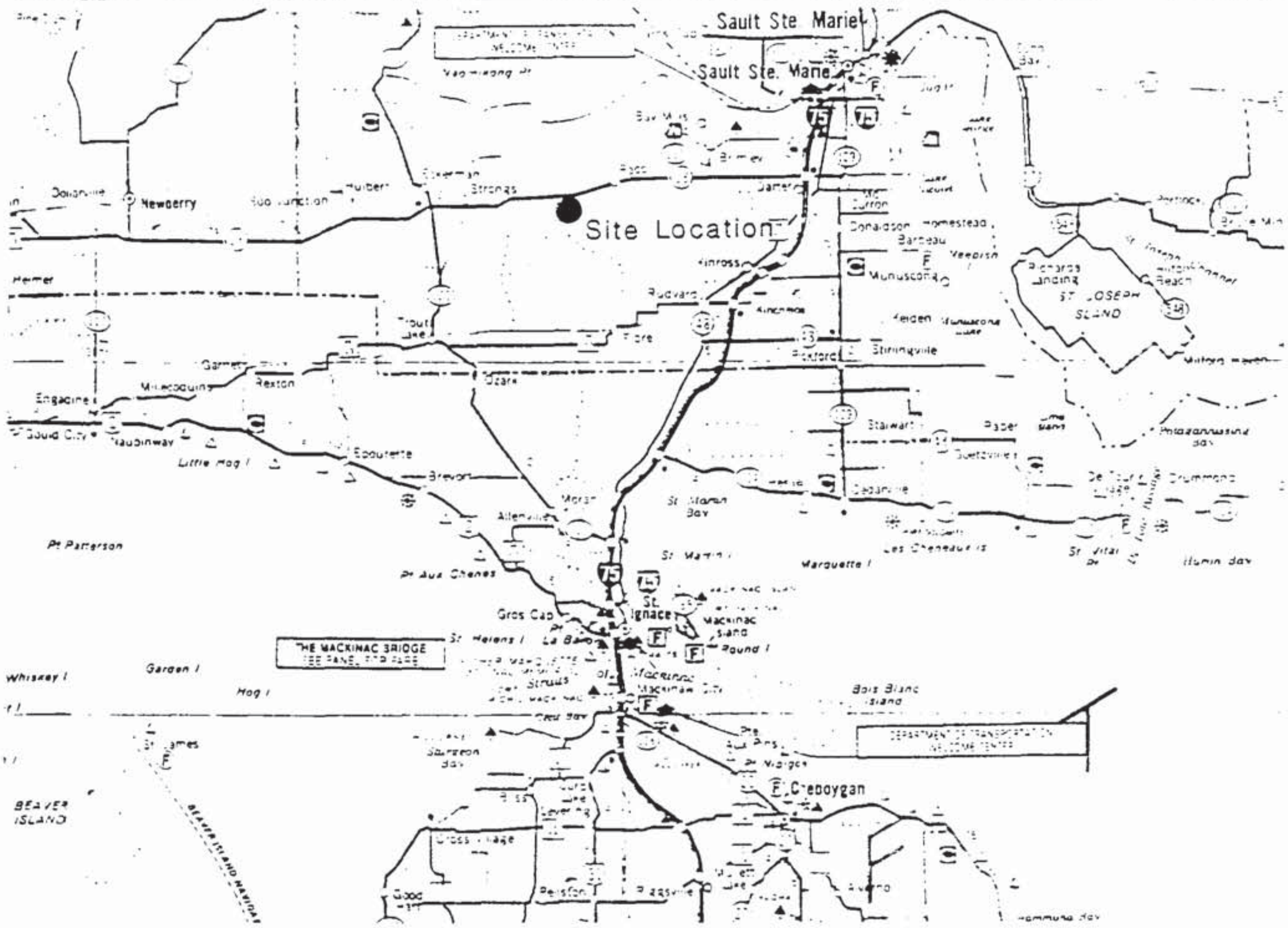

Reference Source: State Road Map of Michigan
Universal Map, Williamston, MI

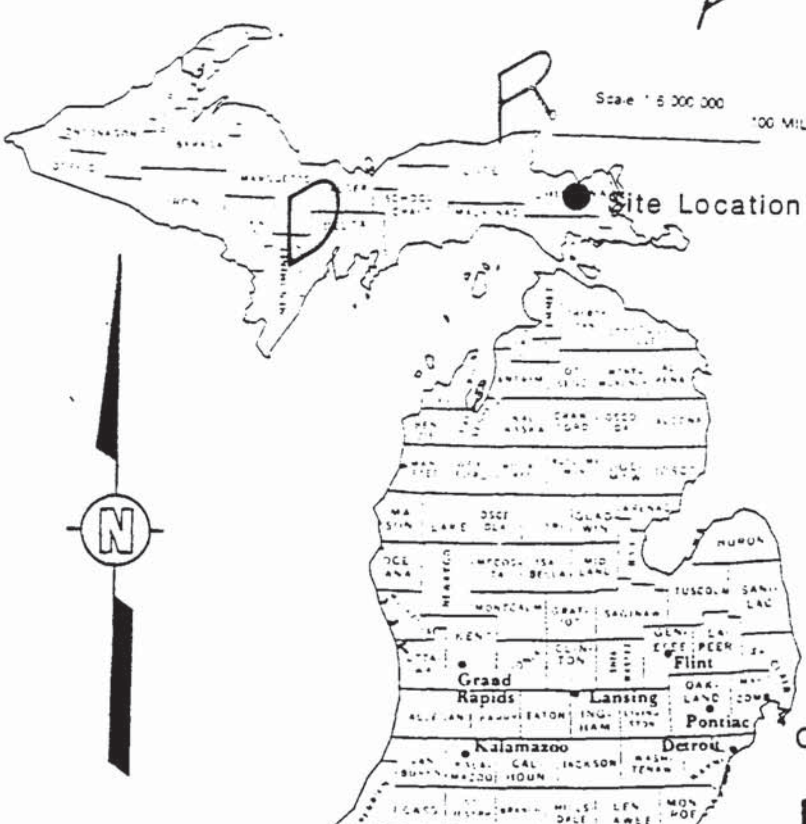

FIGURE 1-1

LOCATION MAP
FORMER AIR FORCE AIRFIELD AND BOMARC MISSILE SITE

PREPARED FOR

U.S. ARMY CORPS OF ENGINEERS
OMAHA, NEBRASKA
CONTRACT NO. DACW45-88-D-0008

INTERNATIONAL TECHNOLOGY CORPORATION

068359

"Do Not Scale This Drawing"

runways and their taxiways remain, and the Bomarc Missile Battery, which has a few roads and parking areas remaining (Figure 1-2).

1.2.1 Installation History and Description

Information contained in the Contamination Evaluation Study (Envirodyne, 1987) is summarized in this section to provide a description of historical events at the installation. As reported in the Contamination Evaluation Study (CES), the area has been intermittently controlled and used by the DOD and its predecessor agencies since 1895. In 1925, the site was given National Forest status under the jurisdiction of the United States Department of Agriculture Forest Service (USFS), subject to dominant use for defense purposes when needed by the DOD. As reported in the CES, the Secretary of Agriculture transferred 240 acres for airfield use by permit, dated August 27, 1942. Based on inspection of a USGS topographic map and a forest service map, the airfield actually covers an area of approximately one square mile, or 640 acres. The airfield was constructed between 1942 and 1943. Around 1960, the missile base was constructed on 152.54 acres of land southeast of the airfield. On January 19, 1964, the Air Force released the airfield property to the USFS, but retained the 152.54 acre missile site. On June 30, 1973, the missile site was released to the USFS.

Since June 30, 1973, the property has remained under USFS jurisdiction. The USFS has entered into several agreements with outside interests since 1973. Summaries of these are listed below:

- A special use permit was issued to a local tribe on October 16, 1973, allowing a sawmill to be operated in the composite building.
- In September 1978, the USFS sold six buildings, a water tower, and 28 missile silo shelters to a private contractor for removal.
- In November 1978, a smaller building was sold to the Michigan Technological University through the Department of Health, Education and Welfare. The building was removed from the site as an educational project.
- Between September and October 1981 and between August and October 1984, the USFS issued a special use permit to a private contractor allowing broken concrete and other construction materials to be backfilled into open missile silos at the site. According to the USACE's Scope of Services (1989a), this may have resulted in some paint wastes being disposed in one or more of the silos.

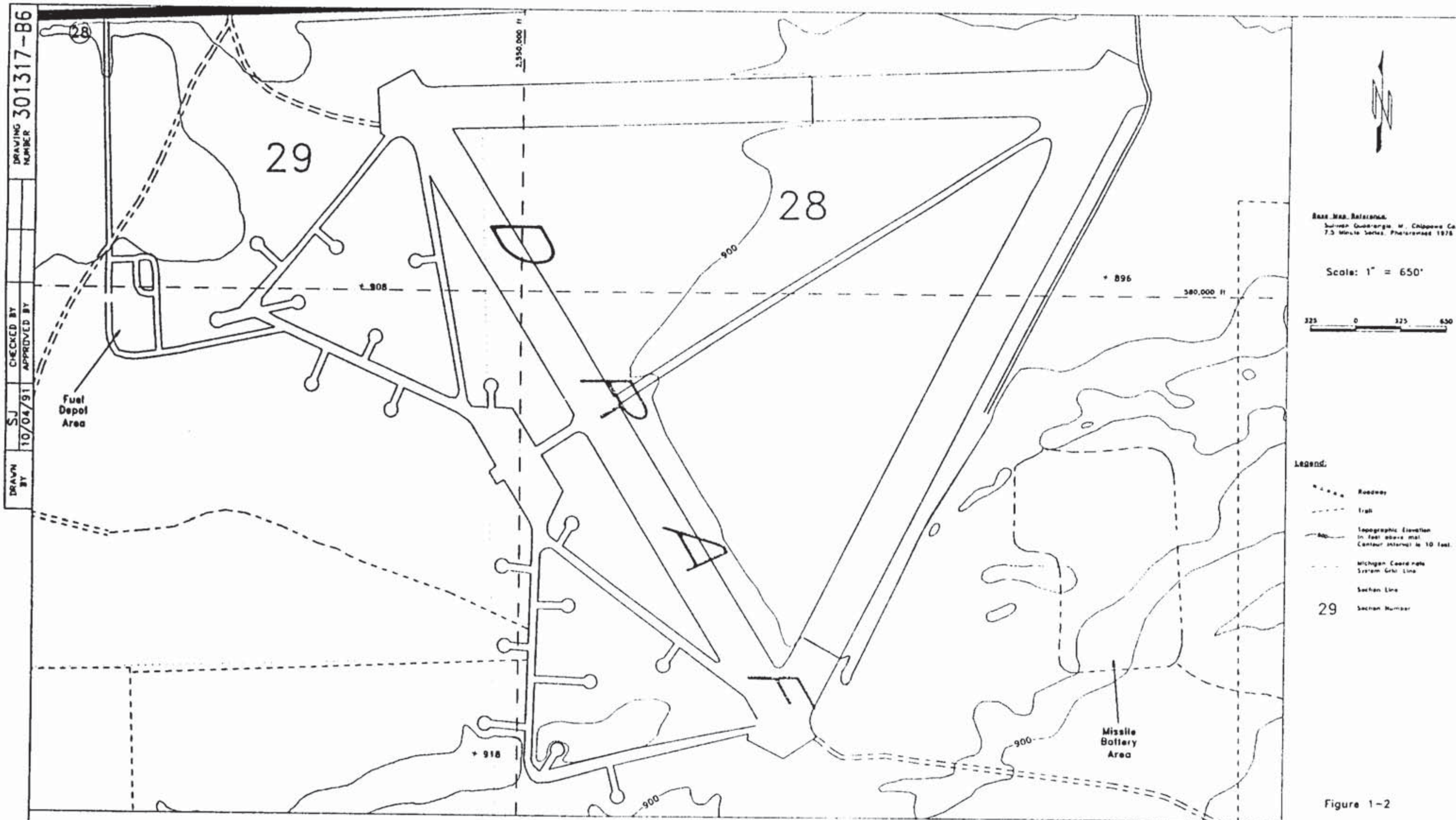

Figure 1-2

Current Site Features Map
Former Air Force Airfield
and BOMARC Missile Site

prepared for

U.S. Army Corps of Engineers
Omaha, Nebraska

Contract No. DACW45-88-D-0008

IT Creating a Safer Tomorrow

- On July 11, 1983, the USFS transferred salvage rights for the composite building and an assembly and maintenance building to Chippewa County. Demolition of the buildings, however, was not initiated by the county and removal did not occur under the agreement that terminated September 30, 1984.

In 1987, Envirodyne Engineers Incorporated (Envirodyne) completed a CES for the former installation. Findings and recommendations provided in the report are discussed in Section 1.2.2.1.

By the end of 1988, the remainder of buildings and underground fuel storage tanks (USTs) had been removed from the site under a USACE contract. All silos were tested, cleaned out (if necessary), backfilled, and covered. Soil samples were collected and analyzed during tank removal operations. Results are discussed in Section 1.2.2.2.

Currently, the airfield is periodically used to test automobile tires and brake systems.

The following sections summarize findings of previous environmental sampling efforts and describe sites investigated during the more recent Stage 1 and Stage 2 RI/FS field efforts.

1.2.2 Previous Investigations

Two studies were conducted at the former installation prior to initiation of the RI/FS investigation. The first, performed by Envirodyne, evaluated past site uses and identified potential areas of contamination. The second, performed by the USACE, entailed removal of structures and abandoned USTs, and collection of soil samples at each UST location. Each of these investigations are described in the following sections.

1.2.2.1 Contamination Evaluation Study, Envirodyne Engineers Incorporated

Envirodyne conducted a Contamination Evaluation Study (CES) at the former installation between December 1986 and April 1987. During the study, records were reviewed, a site inspection was performed, and a limited field investigation was conducted. Several areas of potential concern were identified: a transformer pad, several fuel-containing USTs, a dry wastewater treatment lagoon, a potential sludge drying bed, and 28 missile silos. The field investigation was designed to characterize contaminants at the areas of concern and included installation of four groundwater monitoring wells (RG-1, RG-2, RG-3 and RG-4), collection of groundwater and near-surface soil samples, and collection of water contained within six missile silos. Analytical results reported in the CES are summarized below and in Table 1-1:

- Total petroleum hydrocarbons (1.8 milligrams per liter), trichloroethene (3.0 micrograms per liter), 2-pentane-3,4,5-trimethyl (3.4 micrograms per liter), and 1-pentane-2,4,4-trimethyl (20.8 micrograms per liter) were detected in the groundwater sample collected from monitoring well RG-3, located adjacent to, and southeast of, the dry wastewater treatment lagoon.

- Toluene (1.9 micrograms per liter) was detected in the groundwater sample collected from monitoring well RG-4, located south of the fuel tanks at the Fuel Depot.

- Total petroleum hydrocarbons (1,810 milligrams per liter), benzene (6.0 micrograms per liter), and toluene (1.2 micrograms per liter) were detected in the water sample obtained from Missile Silo 10. Total petroleum hydrocarbons (less than or equal to 5 milligrams per liter) were detected in water samples collected from the remaining five missile silos.

- Polychlorinated biphenyl compounds (PCBs) were not detected in any soil samples.

- Total petroleum hydrocarbons were detected in soils collected near the transformer pad (>8000 micrograms per gram) and adjacent to UST C-3 (264 micrograms per gram).

The study recommended:

- resampling wells RG-3 and RG-4 to verify the presence of fuel contamination,

- additional soil sampling at the transformer pad to verify organic concentrations detected in soils, and

- removing contents of 55-gallon drums (in Silo 10) to a publicly owned treatment works (POTW).

Shortly after completion of the CES, the USACE implemented a construction removal project. This project is described in the following section.

1.2.2.2 USACE Construction Removal Project

Between 1987 and 1988, the remainder of buildings and USTs were removed from the site, and missile silos were cleaned and backfilled through a USACE contract. Fourteen USTs

Table 1-1
Summary of Contamination Evaluation Study Analytical Results
Former Air Force Airfield & Bomarc Missile Site
Raco, Michigan

Sample Number:	RB-1	RB-2	RB-3	RB-4	RB-5	RB-6	RO-1/SPLIT	RO-2	RO-3	RG-4	RS-1/SPLIT	RS-2	RS-3	RS-4	RS-5	RS-6	RS-7/RE	RS-8	RS-9
Collection Date:	12/03/86	12/03/86	12/03/86	12/03/86	12/03/86	12/03/86	01/13/87	01/15/87	01/15/87	01/13/87	01/14/87	12/02/86	12/02/86	12/02/86	12/02/86	12/02/86	12/02/86	01/14/87	12/02/86
Sample Matrix:	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Analytical Parameters:	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH	VOCs, Mets PCBs, TPH
Purgeable Aromatics & Halocarbons																			
Units: water ug/l, soil ng/g																			
Benzene	U	U	U	6.0	U	U	U / U	U	U	U	U / U	U	U	U	U	U	U / U	U	U
Ethylbenzene	1.0B	U	U	U	1.1B	U	U / U	U	U	1.5B	U / 1.1B	U	1.1B	U	U	U	8.4 / 5.8	0.6B	1.0B
Methylene Chloride	9.7B	16.7B	8.2B	20.4B	29.4B	12.1B	5.5B / 4.9B	3.5B	3.8B	4.6B	130.6B/28.3B	42.8B	36.2B	36.2B	24.7B	21.3B	50.9B / 54.5B	25.5B	19.5B
Toluene	U	U	U	1.2	U	U	U / U	U	U	1.9	9.7 / 3.6	1.1B	U	U	U	U	2.4 / 2.4	U	U
Trichloroethylene	U	U	U	U	U	U	U / U	U	3.0	U	U / U	U	U	U	U	U	U / U	U	U
Trichlorofluoromethane	U	U	U	U	U	U	U / U	U	U	U	U / U	U	U	U	U	U	U / U	U	U
Total Metals																			
Units: water mg/l, soil ug/g																			
Arsenic	U	U	U	U	U	U	U / U	U	U	U	1.48 / 1.15	1.44	U	0.80	0.56	0.47	0.64	1.06	0.71
Barium	0.008	U	0.015	U	U	0.006	0.044 / 0.062	0.029	0.078	0.019	8.4 / 8.7	7.3	U	5.9	5.8	8.1	6.3	6.1	5.0
Cadmium	U	U	U	U	U	U	U / U	U	U	U	U / U	U	U	U	U	U	U	U	U
Chromium	U	U	U	U	U	U	U / 0.006	U	U	U	4.3 / 3.1	4.9	3.1	2.1	2.3	2.8	2.4	3.0	2.9
Lead	0.010	0.011	0.019	0.018	0.014	0.012	U / 0.009	U	U	U	U / U	12.4	U	U	U	U	U	U	U
Mercury	U	U	U	U	U	U	U / U	U	U	U	U / U	U	U	U	U	U	U	U	U
Selenium	U	U	U	U	U	U	U / U	U	U	U	U / U	U	U	U	U	U	U	U	U
Silver	U	U	U	U	U	U	U / U	U	U	U	U / U	U	U	U	U	U	U	U	U
Dissolved Metals																			
Units: water mg/l																			
Arsenic	U	U	U	U	U	U	U / U	U	U	U	NR	NR	NR	NR	NR	NR	NR	NR	NR
Barium	0.008	U	0.013	U	U	0.008	0.019 / 0.019	0.026	0.071	0.012	NR	NR	NR	NR	NR	NR	NR	NR	NR
Cadmium	U	U	U	U	U	U	U / U	U	U	U	NR	NR	NR	NR	NR	NR	NR	NR	NR
Chromium	U	U	U	U	U	U	U / U	U	U	U	NR	NR	NR	NR	NR	NR	NR	NR	NR
Lead	U	0.006	0.006	0.009	0.010	0.014	U / U	U	U	U	NR	NR	NR	NR	NR	NR	NR	NR	NR
Mercury	U	U	U	U	U	0.230	U / U	U	U	U	NR	NR	NR	NR	NR	NR	NR	NR	NR
Selenium	U	U	U	U	U	U	U / U	U	U	U	NR	NR	NR	NR	NR	NR	NR	NR	NR
Silver	U	U	U	U	U	U	U / U	U	U	U	NR	NR	NR	NR	NR	NR	NR	NR	NR
PCBs																			
Units: water ug/l, soil ug/g	U	U	U	U	U	U	U / U	U	U	U	U / U	U	U	U	U	U	U	U	U
TPH																			
Units: water ug/l, soil ug/g	5.0	3.7	4.0	1810	2.4	1.7	U / U	U	1.8	U	8310 / 8530	62	36	28	40	46	264	63	24

NOTES: RB water samples collected from missile silos, RO water samples collected from monitoring wells, and RS soil samples collected from soil borings. This table does not include blank analyses results.

U - Indicates that the compound was not detected above detection limits, B - Indicates that the compound was identified in the associated laboratory blank, and NR - indicates that the analyses was not requested.

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were removed between July and August 1988. Tanks had previously stored petroleum products and ranged in diameter between 20 inches and 12 feet, however, most tanks were between 8 and 12 feet in diameter. The USTs were buried approximately 2.3 to 4 feet below surface. During removal operations, soil samples were collected immediately beneath 11 of the 14 tanks, and again 3 to 5 feet beneath the first sample interval in 13 of the 14 tank excavations. All samples were analyzed for total recoverable petroleum hydrocarbons (TRPH). Results of the soil sampling program were described in the January 17, 1989 USACE Memorandum for Record "Summary of Findings from Samples Taken During Removal of Underground Storage Tanks at the former Bomarc Missile Site at Raco, Michigan," and are presented in Table 1-2. In summary:

- Soil samples collected immediately beneath 11 of the 14 tanks contained TRPH concentrations between 140 milligrams per kilogram and 647 milligrams per kilogram.

- Samples were not collected immediately beneath three tanks (C-3, C-4 and B-1) because soils were noted to have strong petroleum hydrocarbon odors and were thus assumed contaminated. Soils were collected at deeper intervals in each of these excavations, between 3.5 and 5 feet below the bottom of each tank. Analytical results indicated the presence of TRPH between 82 milligrams per kilogram in the sample from C-3 and 2,310 milligrams per kilogram in the sample from B-1.

- Analysis of one groundwater sample collected immediately upgradient of C-4, at well RG-3, resulted in a detection of 3.0 micrograms per liter of trichloroethene.

- As described in the USACE Memorandum, the field crew stated that the soil from the C-4 excavation had strong odors resembling commonly used commercial degreasers.

- Of all samples collected below tanks, TRPH was measured at the greatest concentration in the sample collected below UST B-1. The potential for groundwater contamination was thus considered greatest at the B-1 site.

- Groundwater flow was determined to be east-northeast to northeast during reevaluation of the CES findings. Several hydraulic parameters were reported in the USACE Memorandum for Record. These are presented, as necessary, in Section 3.6.

The USACE Memorandum concluded that some groundwater contamination had resulted from past activities at the former installation and recommended that further investigations be

Table 1-2
Underground Storage Tank Removal Program
Analytical Results
Former Air Force Airfield & Bomarc Missile Site
Raco, Michigan

Tank Number	Date	Depth Below Grade (feet)	TRPH (mg/kg)	Remarks
p-1a	07/11/88	4	<50	Immediately below 20 inch dia tank
		---	---	No second sample taken
C-1	08/17/88	13	587	Immediately below 10.5 ft dia tank
		16	650	3 ft below tank base
C-2	08/17/88	13	647	Immediately below 10.5 ft dia tank
		16	---	Sample bottle broken upon arrival at lab
C-3	08/02/88	13	---	Strong fuel oil odor below tank base
		16.5	82	Tank dia 10.5 ft
C-4	08/02/88	9	---	Strong stanisol odor below tank
		14	210	Tank dia 6 ft
B-1	08/02/88	13.5	---	Strong fuel oil odor
		18	2310	Tank dia 5.3 ft
1S	08/16/88	14	385	Immediately below 10.5 ft dia tank
		17	260	3 ft below tank base
2S	08/16/88	14	486	Immediately below 10.5 ft dia tank
		17	---	Sample bottle broken upon arrival at lab
1N	08/16/88	14	555	Immediately below 10.5 ft dia tank
		17	330	3 ft below tank base
2N	08/16/88	14	412	Immediately below 10.5 ft dia tank
		17	170	3 ft below tank base
3N	08/04/88	16	200	Immediately below 12 ft dia tank
		19	410	3 ft below tank base
4N	08/04/88	16	150	Immediately below 12 ft dia tank
		19	380	3 ft below tank base
5N	08/04/88	12	140	Immediately below 8 ft dia tank
		15	---	Sample bottle broken upon arrival at lab
6N	08/04/88	14	270	Immediately below 10 ft dia tank
		17	590	3 ft below tank base

SOURCE: Memorandum for Record, 17 January 1989, CENCB-ED-HQ, Summary of Findings from Samples Taken During Removal of Underground Storage Tanks at the Former Bomarc Missile Site at Raco, Michigan

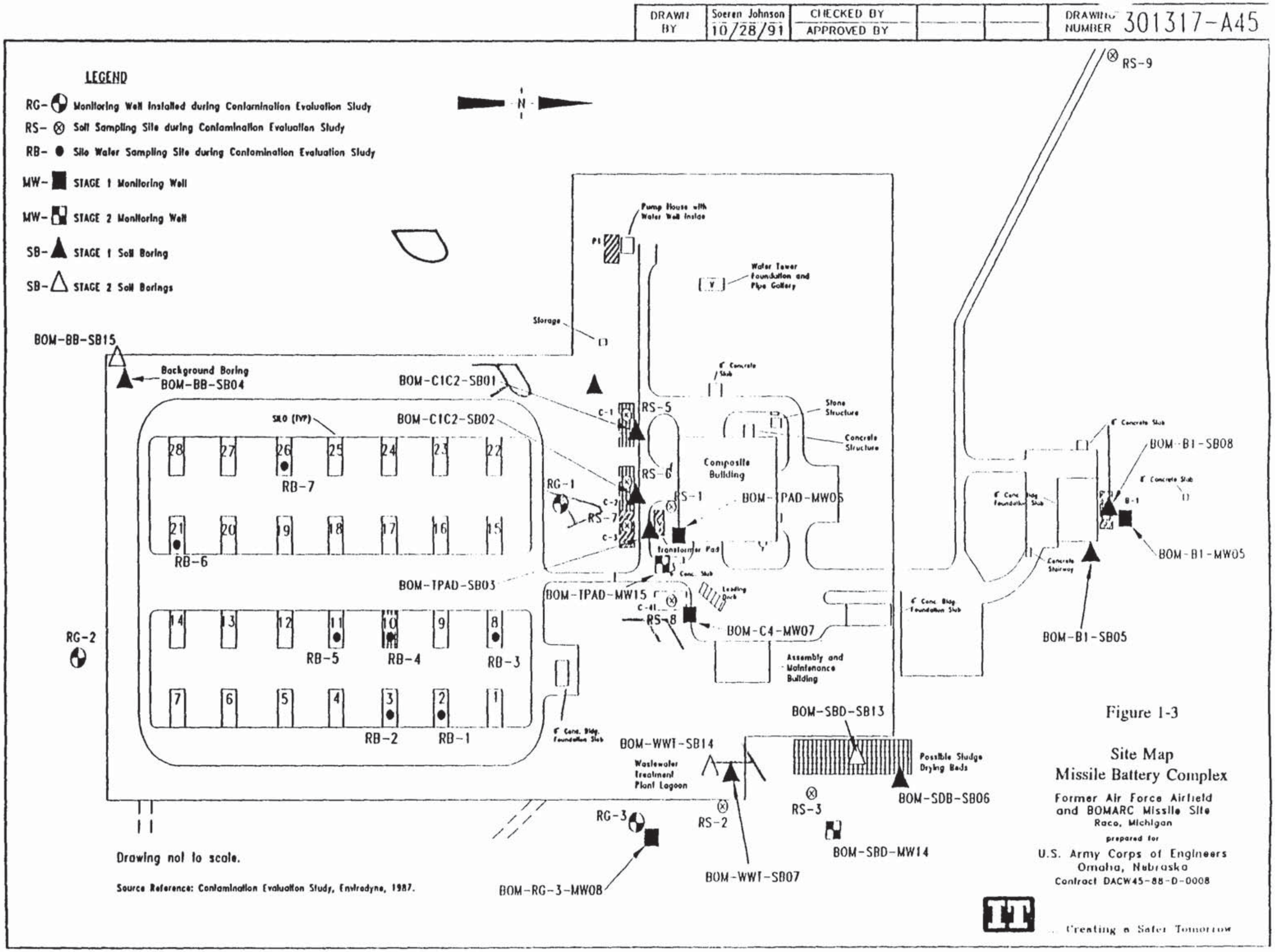

Figure 1-3

Site Map
Missile Battery Complex

Former Air Force Airfield and BOMARC Missile Site
Raco, Michigan
prepared for
U.S. Army Corps of Engineers
Omaha, Nebraska
Contract DACW45-88-D-0008

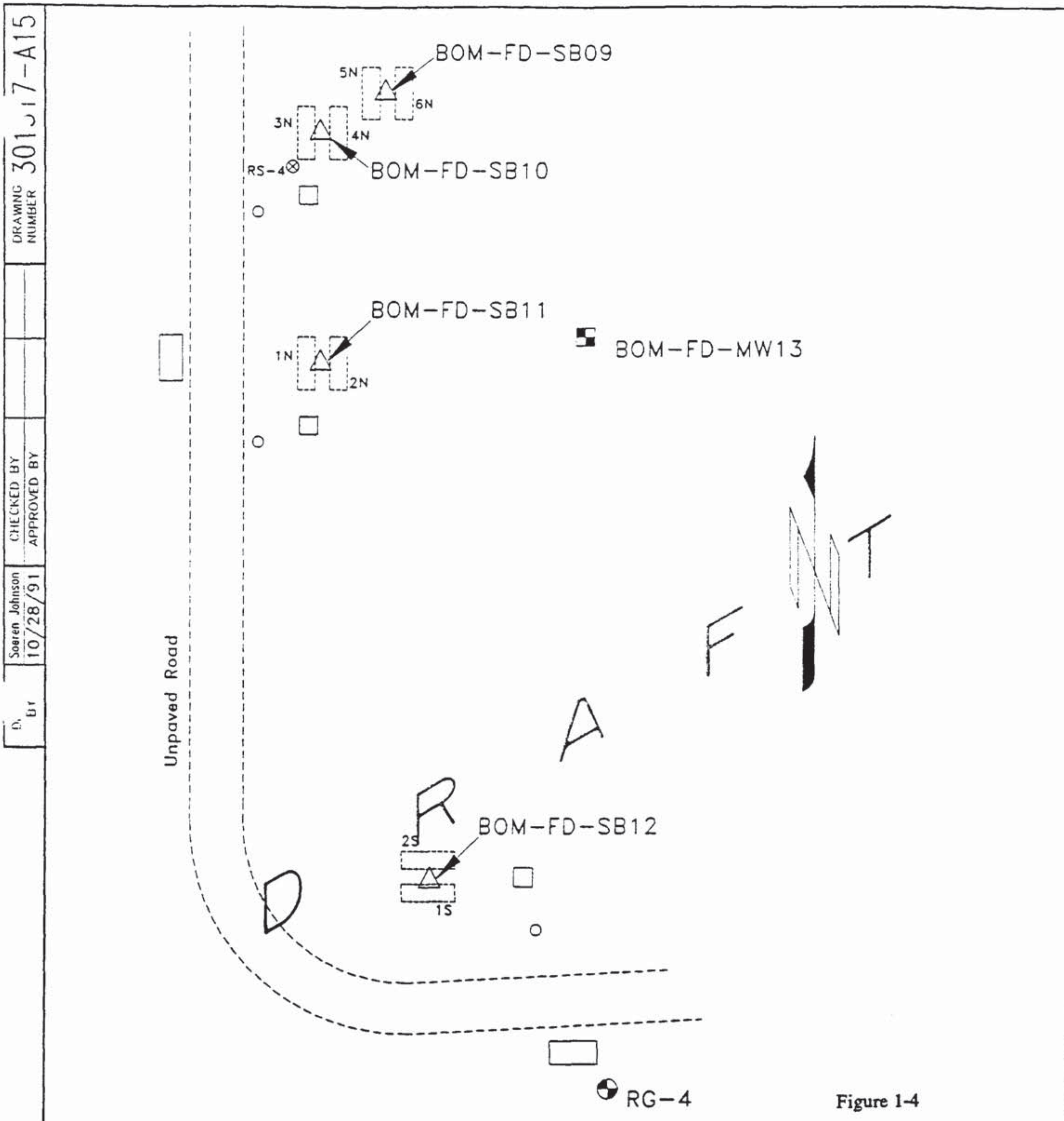

Figure 1-4

Site Map
Fuel Depot
Former Air Force Airfield
and BOMARC Missile Site
Raco, Michigan
prepared for
U.S. Army Corps of Engineers
Omaha, Nebraska
Contract DACW45-88-D-0008

LEGEND

- Former Tank Location
- RG– Monitoring Well Installed during Contamination Evaluation Study
- RS– Soil Sampling Site during Contamination Evaluation Study
- MW– STAGE 2 Monitoring Well
- SB– STAGE 2 Soil Borings

Drawing not to scale.
Reference Source: Contamination Evaluation Study, Envirodyne, 1987.

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implemented to fully delineate the extent of petroleum hydrocarbons in groundwater, and to establish whether contamination at the site was related to that at the Raco USFS Filling Station.

Based on recommendations provided in the CES and in the USACE's Memorandum, additional field work was conducted at the former installation during the Stage 1 and Stage 2 RI/FS field investigations. Following is a summary of the RI/FS tasks and a description of the sites investigated.

1.2.3 Site Descriptions

The USACE's 1989 Scope of Services, written based on conclusions and recommendations of previous investigations, requested that the following tasks be completed at the former Air Force Airfield and Bomarc Missile Site:

- Assess soil and groundwater quality at the former location of UST B-1
- Assess groundwater quality downgradient of the former location of UST C-4.
- Assess soil quality at the former locations of UST C-1 and C-2.
- Assess soil quality at the former transformer pad.
- Determine the location of a possible landfill site at the former installation.
- Evaluate overall groundwater quality at the former installation.
- Assess background soil concentrations.
- Assess soil quality at the wastewater treatment lagoon and sludge drying bed.

Based on these tasks, seven separate sites were investigated at the former installation during Stage 1. An eighth site, the fuel depot, was added to the investigation during Stage 2 as discussed below. Figures 1-3 and 1-4 show site locations and the following provides site descriptions:

- <u>Underground Storage Tanks C-1 and C-2</u>: Tanks C-1 and C-2 were located just south of the former composite building and were removed during demolition activities. Subsurface concrete support pads were left in place. Analytical results for soil samples collected during removal of these tanks indicated the presence of TRPH at concentrations ranging between 587 and 650 milligrams per kilogram.

- Underground Storage Tank C-4: This tank was located southeast of the former composite building. Trichloroethene was detected at 3.0 micrograms per liter in a groundwater sample collected downgradient of the site at RG-3. TRPH was detected at 210 milligrams per kilogram in soil collected 5 feet below the bottom of the tank during tank removal. Field crew members and the project manager noted a strong degreaser-like odor emanating from soils at this site during tank removal.

- Underground Storage Tank B-1: This UST was removed and the subsurface concrete tank pad was left in place during demolition activities. The tank had contained #2 diesel fuel and TRPH was measured at 2,310 milligrams per kilogram in soils collected from beneath the tank. No soils were excavated during tank removal.

- Transformer Pad: During previous investigations, this site contained the highest levels of petroleum hydrocarbons detected at the former installation. However, no PCBs were identified in the samples collected. The pad was located outside the southeast corner of the former composite building. During demolition activities, soils were removed from this area.

- Background Boring Location: The background boring location was selected in an area upstream of potential surface water/runoff and in an area expected to have had low historical activity. Soils in this area were expected to be relatively undisturbed and unaffected by past activities at the former installation.

- Sludge Drying Bed: A sparsely vegetated, sandy area located just north of the wastewater treatment lagoon was assumed to be a sludge drying bed during the RI investigation. This site covers an area approximately 200 feet by 100 feet. No visible surface staining was observed during RI/FS field activities.

- Wastewater Treatment Lagoon: The wastewater treatment lagoon received domestic and industrial wastewater from the former composite building and assembly and maintenance building. The lagoon is approximately 50 feet by 20 feet in area.

- Fuel Depot Underground Storage Tanks: The fuel depot is located northwest of the runways and historically consisted of eight tanks: two tanks in the southern part of the site (1S and 2S) and six tanks in the northern part of the site (1N through 6N). The fuel depot site was added to the RI/FS investigation based on previous detections of TRPH in soils. TRPH was detected between 140 milligrams per kilogram and 555 milligrams per kilogram in soils collected at the site during USACE tank removal operations.

Field activities conducted at these sites are discussed in Section 2.0.

1.3 Report Organization

The organization of this RI report was developed in accordance with the October 1988 EPA Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Slight adjustments in the suggested RI report outline have been implemented to better reflect the scope of this project, as encouraged by the guidance document. The primary goal in formulating the report structure was to present information for each of the eight sites in a consistent and organized manner.

The main body of the report, Sections 1.0 through 7.0, conforms to the suggested EPA RI report outline and describes general information pertaining to all sites such as site sampling procedures, demographics, and regional geology. In addition, Sections 1.0 through 7.0 present the primary findings and conclusions for each site. Analytical data, interpretations and conclusions specific to each site are discussed in detail in separate sections of Appendix A. Where necessary, Appendix A refers to the main body of the report to avoid duplication of information.

The main body of the report contains an introduction in Section 1.0, a description of field investigation activities in Section 2.0, a description of physical characteristics in Section 3.0, findings of the field investigations in Sections 4.0 and 5.0, a Baseline Risk Assessment and Ecological Assessment in Section 6.0, and a summary of findings and recommendations in Section 7.0. Supporting data, such as USACE Quality Assurance results, certificates of analysis, boring logs and piezometer installation sheets, calculations, results of the geophysical survey, and comments on the Draft RI, are contained in appendices B through G, respectively. The Scope of Services indicates that the Scope is to be provided in only the Draft RI Report as Appendix A. Instead, the Scope of Services is provided in the last appendix of this report, Appendix H, to facilitate its deletion prior to submittal of the Final RI Report.

2.0 Field Investigation Activities

Table 2-1 summarizes field activities conducted at the former Air Force Airfield and Bomarc Missile Site during the CES, the Stage 1 RI investigation, and the Stage 2 RI investigation. During Stage 1 and Stage 2 field investigations, soil and groundwater samples were collected and analyzed in accordance with the 1989 Scope of Services. In addition, a search for a potential on-site landfill was performed during the Stage 1 investigation. Sections 2.1 and 2.2 summarize field activities completed during Stage 1 and Stage 2, respectively. Sections 2.3 and 2.4 describe sample collection techniques and the analytical testing program. Finally, Section 2.5 presents results of the landfill search.

2.1 Summary of Stage 1 Field Investigation Activities

Stage 1 activities were performed between September and November 1990 and included drilling eight soil borings, drilling and installing eight monitoring wells, testing aquifer properties, and searching for a potential on-site landfill.

Borings were installed near the former location of USTs C-1 and C-2, in the transformer pad area, at a background location, near the former location of UST B-1, at the sludge drying bed, and at the wastewater treatment lagoon. Soil samples collected in each boring were submitted to IT's Analytical Services (ITAS) laboratory in Cincinnati, Ohio for chemical analysis, to IT's laboratory in Oak Ridge, Tennessee for grain size analysis and to IT's Technology and Development laboratory in Knoxville, Tennessee for treatability test analyses. Samples were analyzed for one or more of the following chemical parameters depending on previous site use and previous chemical detections: target compound list volatile organic compounds (VOCs), target compound list semi-volatile organic compounds (SVOCs), total petroleum hydrocarbons as high boilers (TPH), total recoverable petroleum hydrocarbons (TRPH), and/or target analyte list metals (metals). Quality control (QC) and quality assurance (QA) samples were collected in conjunction with sampling at the former installation. Results for QA samples, submitted to the USACE's Missouri River Division (MRD) Laboratory in Omaha, Nebraska for chemical analysis, are provided in Appendix B. Table 2-2 summarizes analytical methods for Stage 1 and Stage 2 analytical programs.

Table 2-1
Summary of Field Activities
Former Air Force Airfield & Bomarc Missile Site
Raco, Michigan

Activity	Contamination Evaluation Study (Envirodyne, 1986 & 1987)	Phase II Stage 1 RI (IT, 1990)	Phase II Stage 2 RI (IT, 1991)	Total
Monitoring Wells Installed	4	8	3	15
Monitoring Wells Sampled (1)	4	12	6	22
Wells in which Aquifer Tests Were Performed	4	8	3	15
Silo Samples (Water) Collected	7 (2)	0	0	7
Soil Borings Drilled	0	8	7	15
Soil Samples Collected (1)	9 (3)	51	44	104
Geotechnical Samples Collected	0	16	19	35
Geophysical Survey Conducted	No	Yes	No	---

(1) Does not include QA/QC sampling.
(2) Only six samples were analyzed because the seventh sample bottle was broken upon arrival at the laboratory.
(3) Collected by hand auger sampling at depths of approximately 2 feet.

Table 2-2
Summary of EPA Analytical Methods
Former Air Force Airfield and Bomarc Missile Site
Raco, Michigan

Analytical Parameter	Stage 1 Methods		Stage 2 Methods	
	Soil	Groundwater	Soil	Groundwater
Target Compound List Volatile Organic Compounds	CLP 8240	CLP 8240	CLP 8240	CLP 8240
Target Compound List Semi-Volatile Organic Compounds	CLP 8270	CLP 8270	CLP 8270	CLP 8270
Total Petroleum Hydrocarbons	Modified 8015	Modified 8015	Modified 8015	Modified 8015
Total Recoverable Petroleum Hydrocarbons	418.1	418.1	418.1	418.1
Target Compound List PCB/Pesticides	CLP 8080	CLP 8080	CLP 8080	CLP 8080
Target Analyte List Metals	CLP 6010/ 7000 Series	CLP 6010/ 7000 Series	CLP 6010/ 7000 Series	CLP 6010/ 7000 Series

Eight monitoring wells (MW05 through MW12) were installed during Stage 1 in selected locations based on previous analytical results and data collected during the soil boring investigation. Wells were installed at the former location of UST B-1, in the transformer pad area, at the former location of UST C-4, near existing well RG-3, in the airfield, in the sludge drying bed area, and at the fuel depot. Groundwater samples were collected from each of the eight new wells and the four existing wells (RG-1, RG-2, RG-3 and RG-4). Samples were analyzed for one or more of the following parameters depending on past site use and previous chemical detections: VOCs, SVOCs, TPH, and/or polychlorinated biphenyls and pesticides (PCB/PEST). Groundwater samples were submitted to the ITAS laboratory in Cincinnati for analysis while associated QA samples were submitted to the USACE MRD laboratory in Omaha. Results of the QA sampling effort are presented in Appendix B.

Slug tests were performed at each new well to assess the hydraulic conductivity of water bearing materials. Results are discussed in Section 3.6.

The Stage 1 field investigation also included a search for a possible base landfill. Aerial photographs were reviewed, interviews with individuals familiar with the installation were conducted, a field inspection was performed, and a geophysical survey was executed in an effort to locate the potential historical landfill. Results are discussed in Section 2.5.

2.2 Summary of Stage 2 Field Investigation Activities

Results from the Stage 1 sampling effort were reviewed to determine subsequent Stage 2 activities. Stage 2 Activities included:

- No further investigation at the former location of USTs C-1 and C-2.
- No further investigation at the former location of UST C-4.
- No further investigation at the former location of UST B-1.
- Installation of one monitoring well at the former transformer pad with soils collected for analysis. This investigation was implemented to verify TRPH concentrations detected during Stage 1.

- Installation of a second background boring near the first background boring with soils analyzed for metals and VOCs. Analytical results for this boring provided background data for metals in site soils and a means for verifying the detection of trichloroethane in site soils during Stage 1.

- Installation of a water table monitoring well downgradient of the sludge drying bed (SDB) and advancement of one soil boring through the center of the SDB. Soils and ground water were analyzed for metals and VOCs to verify Stage 1 detections of metals and toluene in soils at the site.

- Installation of one boring through the center of the wastewater treatment lagoon to obtain metals and VOC concentrations for the site.

- Advancement of four soil borings and installation of one downgradient monitoring well at the fuel depot. Soil samples were analyzed for benzene, toluene, ethylbenze and xylenes (BTEX) and TPH. Groundwater samples were analyzed for VOCs, SVOCs, and TPH. This investigation was conducted to define potential soil and/or ground water contamination in the area since it had not been thoroughly investigated in previous studies.

The Stage 2 field investigation was performed between June and August 1991. Slug tests were performed at each of three new wells installed during Stage 2 (MW13, MW14, and MW15), water samples were collected from wells RG-1, RG-3, MW08 and the three newly installed wells, and water levels were measured in all wells to provide information on hydraulic gradient and the direction of ground water flow at the site.

Soil and ground water samples for chemical analysis were submitted to the ITAS laboratory in Cincinnati and corresponding QA samples were submitted to the USACE MRD laboratory in Omaha. Soil samples collected for grain size analysis were submitted to the ITAS laboratory in Knoxville. Table 2-2 summarizes analytical methods for Stage 1 and Stage 2 analytical programs.

Sections 2.3, 2.4 and 2.5 describe the field procedures implemented during Stage 1 and Stage 2 investigations.

2.3 Soil Investigation

Borings advanced during Stage 1 and Stage 2 are identified by a BOM prefix followed by a two to four digit site identifier and the boring or well number. Site identifiers are:

- C1C2 Indicates the former location of USTs C-1 and C-2.
- B1 Indicates the former location of UST B-1.
- TPAD Indicates the former location of the transformer pad.
- BB Indicates background boring.
- SDB Indicates the sludge drying bed.
- WWT Indicates the wastewater treatment lagoon.
- FD Indicates the fuel depot USTs.
- NER Indicates northeast runway.
- CTE Indicates center taxiway, east side.

All borings were advanced to depths between 25 and 55 feet with a truck-mounted CME 75 drill rig using a 6 1/4-inch inside diameter hollow stem auger (HSA). Soil samples were collected using a 140-pound hammer falling 30 inches, to drive a two-inch outside diameter stainless steel split barrel sampler a total of 24 inches into the soil. Samples were collected at specified intervals beginning with a 5-foot interval and increasing to a 10-foot interval in some of the deeper soil borings. Blow counts were recorded for every six inches of penetration. Soil samples were classified by the IT field geologist using the Unified Soil Classification System (USCS).

Borings advanced during Stage 1 were BOM-C1C2-SB01, BOM-C1C2-SB02, BOM-TPAD-SB03, BOM-BB-SB04, BOM-B1-SB05, BOM-SDB-SB06, BOM-WWT-SB07, and BOM-B1-SB08. During Stage 2, borings BOM-FD-SB09, BOM-FD-SB10, BOM-FD-SB11, BOM-FD-SB12, BOM-SDB-SB13, BOM-WWT-SB14, BOM-BB-SB15, and BOM-TPAD-SB16 (BOM-TPAD-MW15 was completed in SB16) were advanced. Boring locations are shown in Figure 2-1.

Geotechnical samples were collected from several borings to verify field classification of grain size. Grain size analyses were performed by the ITAS laboratory in Oak Ridge, Tennessee during Stage 1 and Stage 2. Samples collected from BOM-B1-MW05, BOM-

TPAD-MW06, BOM-C4-MW07, BOM-RG3-MW08, BOM-NER-MW09, BOM-CTE-MW10, BOM-FD1-MW11, BOM-FD2-MW12, BOM-FD-MW13, BOM-SDB-MW14, BOM-TPAD-MW15 (completed in BOM-TPAD-SB16), BOM-FD-SB09, BOM-FD-SB10, BOM-FD-SB11, BON-FD-SB12, BOM-SDB-SB13, BOM-WWT-SB14, and BOM-BB-SB15 were submitted for grain size analysis, moisture content analysis, Unified Soil Classification System (USCS) characterization, and Atterberg Limits tests (only if soils had enough fine grained material). Results are summarized in Table 2-3 and Certificates of Analysis are provided in Appendix C. As indicated, the majority of samples were characterized as poorly graded sand or poorly graded sand with trace silt (USCS symbol SP). Moisture contents ranged between 2.7 and 21.2 percent depending on sample location and depth.

Three soil samples were collected during Stage 1 for treatability testing. Information obtained from treatability testing could be used if treatment of soils becomes necessary. Soil samples from BOM-B1-MW05, BOM-NER-MW09 and BOM-SDB-SB06 were submitted to the IT Technology and Development Laboratory in Knoxville, Tennessee.

Boring logs, provided to IT by the USACE, were used to document pertinent information for each soil boring and are presented in Appendix D. Total boring depths, sample collection intervals, penetration test results, descriptions of the materials encountered, and other requested information, such as the drilling date, geologist's name and driller's name, are provided on the boring logs.

All soil samples collected were screened using headspace analysis for volatile organic compounds with an HNu Systems Incorporated or Photovac TIP1 photoionization detector (PID). Soil from the split spoon sampler was placed into a quart size plastic bag and then into a glass jar. The top, open end of the plastic bag, was folded over the lip of the jar. The top of the jar was immediately sealed with one or two sheets of aluminum foil. A cap was screwed onto the jar to hold the aluminum foil in place. Each sample was shaken and allowed to sit for at least 10 minutes. Samples were again shaken prior to removing the screw cap, puncturing the aluminum foil with the PID probe, and measuring the soil headspace volatile organic concentration. Soil headspace results are summarized in Table 2-4. As indicated, PID readings generally decreased with depth and ranged between 0 and 82 parts per million.

Table 2-3
Summary of Geotechnical Results
Former Air Force Airfield & Bomarc Missile Site
Raco, Michigan

Well or Soil Boring	Screened Interval (feet)	Sample Depth (feet)	Particle Size Description	Moisture Content (percent)	USCS Symbol
MW05	50.2 - 60.2	35	Silty, Clayey Sand	12.3	SC-SM
		55	Poorly Graded Sand	17.4	SP
MW06	45.2 - 55.2	40	Poorly Graded Sand	2.7	SP
		55	Poorly Graded Sand	19.6	SP
MW07	45 - 55	15	Sandy Silt	17.0	ML
		50	Poorly Graded Sand	19.3	SP
MW08	64.6 - 74.6	35	Poorly Graded Sand	19.3	SP
		40	Poorly Graded Sand w/ Silty Clay	9.3	SP-SC
MW09	36 - 46	35	Poorly Graded Sand	8.3	SP
		40	Poorly Graded Sand	19.0	SP
MW10	35 - 45	35	Poorly Graded Sand w/ Silty Clay	8.7	SP-SC
		40	Poorly Graded Sand w/ Silty Clay	21.2	SP-SC
MW11	33 - 43	35	Poorly Graded Sand	5.3	SP
		40	Poorly Graded Sand	19.1	SP
MW12	31 - 41	35	Poorly Graded Sand	17.9	SP
		40	Poorly Graded Sand	20.4	SP
MW13	32.2 - 42.6	5	Poorly Graded Sand w/ Trace Silt	3.8	SP
		35	Poorly Graded Sand w/ Trace Silt	4.5	SP
MW14	47 - 57.4	10	Poorly Graded Sand w/ Trace Silt	4.2	SP
		50	Poorly Graded Sand w/ Trace Silt	20.8	SP
MW15	42.2 - 52.6	10	Poorly Graded Sand w/ Gravel & Trace Silt	6.0	SP
		45	Poorly Graded Sand w/ Trace Silt	12.0	SP
SB09	NA	10	Poorly Graded Sand w/ Trace Silt	4.9	SP
		35	Poorly Graded Sand w/ Trace Silt	14.7	SP
SB10	NA	15	Poorly Graded Sand w/ Trace Silt	4.1	SP
		25	Poorly Graded Sand w/ Trace Silt	8.4	SP
SB11	NA	10	Poorly Graded Sand w/ Trace Silt	4.2	SP
		25	Poorly Graded Sand w/ Trace Silt	6.8	SP
SB12	NA	25	Poorly Graded Sand w/ Trace Silt	6.7	SP
SB13	NA	15	Poorly Graded Sand w/ Trace Silt	4.9	SP
		40	Poorly Graded Sand w/ Trace Silt	5.2	SP
SB14	NA	20	Poorly Graded Sand w/ Trace Silt	5.9	SP
		40	Poorly Graded Sand w/ Trace Silt	5.4	SP
SB15	NA	10	Poorly Graded Sand w/ Trace Silt	4.8	SP
		30	Poorly Graded Sand w/ Trace Silt	5.3	SP

USCS - indicates Unified Soil Classification System

NA - indicates not applicable since a well was not installed into the soil boring

Table 2-4
Summary of Soil Headspace Analyses Results
Former Air Force Airfield & Bomarc Missile Site
Raco, Michigan

	Headspace Analyses Results in Parts Per Million (1)										
Approximate Sample Depth	5 Feet	10 Feet	15 Feet	20 Feet	25 Feet	30 Feet	35 Feet	40 Feet	45 Feet	50 Feet	55 Feet
BOM-C1C2-SB01	7	9	10	0.4	0.2	---	---	---	---	---	---
BOM-C1C2-SB02	8	8.2	8.4	9	ND(2)	---	---	---	---	---	---
BOM-TPAD-SB03	9.2	6	5.6	2.2	5.4	---	---	---	---	---	---
BOM-BB-SB04	ND	ND	ND	---	ND	---	---	---	---	---	---
BOM-B1-SB05	ND	ND	ND	ND	ND	ND	ND	---	ND	---	---
BOM-SDB-SB06	0.09	0.2	ND	ND	0.5	0.1	---	---	---	---	---
BOM-WWT-SB07	0.8	ND	---	---	ND	---	ND	---	ND	---	---
BOM-B1-SB08	82	66	58	28	5.8	4.8	8.5	3	1.8	---	---
BOM-FD-SB09	ND	---	ND	ND	ND(3)	ND(4)	---	ND(5)	---	---	---
BOM-FD-SB10	ND	ND	10	ND	30	ND	---	---	---	---	---
BOM-FD-SB11	20	15	ND	50	34	---	---	---	---	---	---
BOM-FD-SB12	15	10	15.2	---	ND	ND	ND	---	---	---	---
BOM-SDB-SB13	---	---	---	---	---	---	---	---	---	---	---
BOM-WWT-SB14	---	---	---	---	---	---	---	---	---	---	---
BOM-BB-SB15	---	---	---	---	---	---	---	---	---	---	---
BOM-C4-MW07	0.2	ND	0.2	0.3	0.1	0.2	0.2	0.7	0.1	0.7	7
BOM-RG3-MW08	3.2	0.3	0.2	0.2	0.5	0.2	0.2	0.1	0.1	0.2	0.1
BOM-FD-MW13	120	ND	3	3	3	0.5	ND	---	---	---	---
BOM-SDB-MW14	3	---	50	ND	ND	ND	ND	ND	ND	ND	---
BOM-TPAD-MW15	---	---	---	---	---	---	---	---	---	---	---

(1) Headspace analysis was performed in the field using a PID. Results presented can only be used to identify trends.
(2) ND – indicates not detected.
(3) Possible 0.5 part per million response.
(4) Questionable response of 100 parts per million.
(5) Questionable response of 70 parts per million.

--- Indicates that the sample was not collected or not tested.

While waiting for headspace development, analytical soil samples were retrieved from the split spoon sampler, placed into the appropriate sample containers, packaged, and shipped overnight in iced coolers to the laboratory. Samples were stored in iced coolers on-site prior to shipment. Chain-of-custody and request-for-analysis forms were maintained to document sample possession.

Soil borings were backfilled with neat cement grout upon completion. Information for each boring pertaining to depth, location and chemical analysis is presented in the site specific reports contained in Appendix A.

2.4 Ground Water Investigation

A total of eleven monitoring wells were installed at the former Air Force Airfield and Bomarc Missile Site during Stage 1 and Stage 2 field activities. These wells are designated as BOM-B1-MW05, BOM-TPAD-MW06, BOM-C4-MW07, BOM-RG3-MW08, BOM-NER-MW09, BOM-CTE-MW10, BOM-FD1-MW11, BOM-FD2-MW12, BOM-FD-MW13, BOM-SDB-MW14, and BOM-TPAD-MW15. Monitoring wells BOM-B1-MW05, BOM-TPAD-MW06, BOM-C4-MW07, BOM-RG3-MW08, BOM-SDB-MW14 and BOM-TPAD-MW15 were installed within the missile battery complex. Two wells, BOM-NER-MW09 and BOM-CTE-MW10, were installed at the airfield and BOM-FD1-MW11, BOM-FD2-MW12, and BOM-FD-MW13 were installed at the fuel depot. Monitoring well locations are shown in Figure 2-2.

Water levels were measured in existing wells RG-1, RG-2, RG-3 and RG-4 to determine Stage 1 well placement. Based on water level data, the groundwater flow direction was determined to be toward the northeast. This direction was supported by the groundwater level data contained in the Envirodyne Engineers Report (April 1987) and a memo written by John R. Adams of the USACE dated January 17, 1989. Subsequent water level measurements, obtained after installation of Stage 1 and Stage 2 wells, indicate that the overall groundwater flow direction is east-southeast.

Wells were surveyed to establish Michigan State Plane Coordinates and National Geodetic Vertical Datum elevations for each location. Elevations and coordinates for each well are provided in Appendix D.

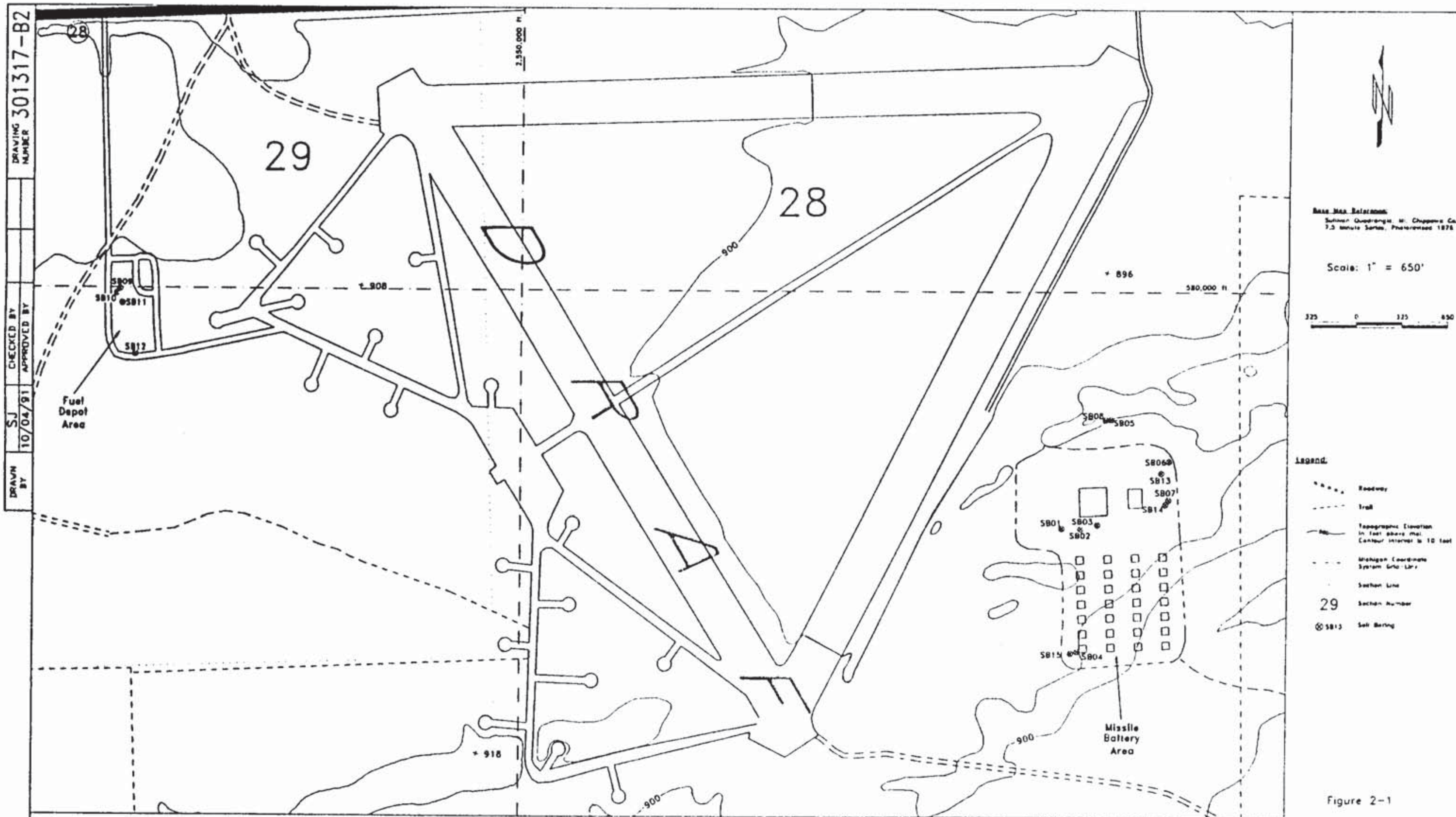

Figure 2-1

Soil Boring Locations
Former Air Force Airfield
and BOMARC Missile Site

prepared for

U.S. Army Corps of Engineers
Omaha, Nebraska

Contract No. DACW45-88-D-0008

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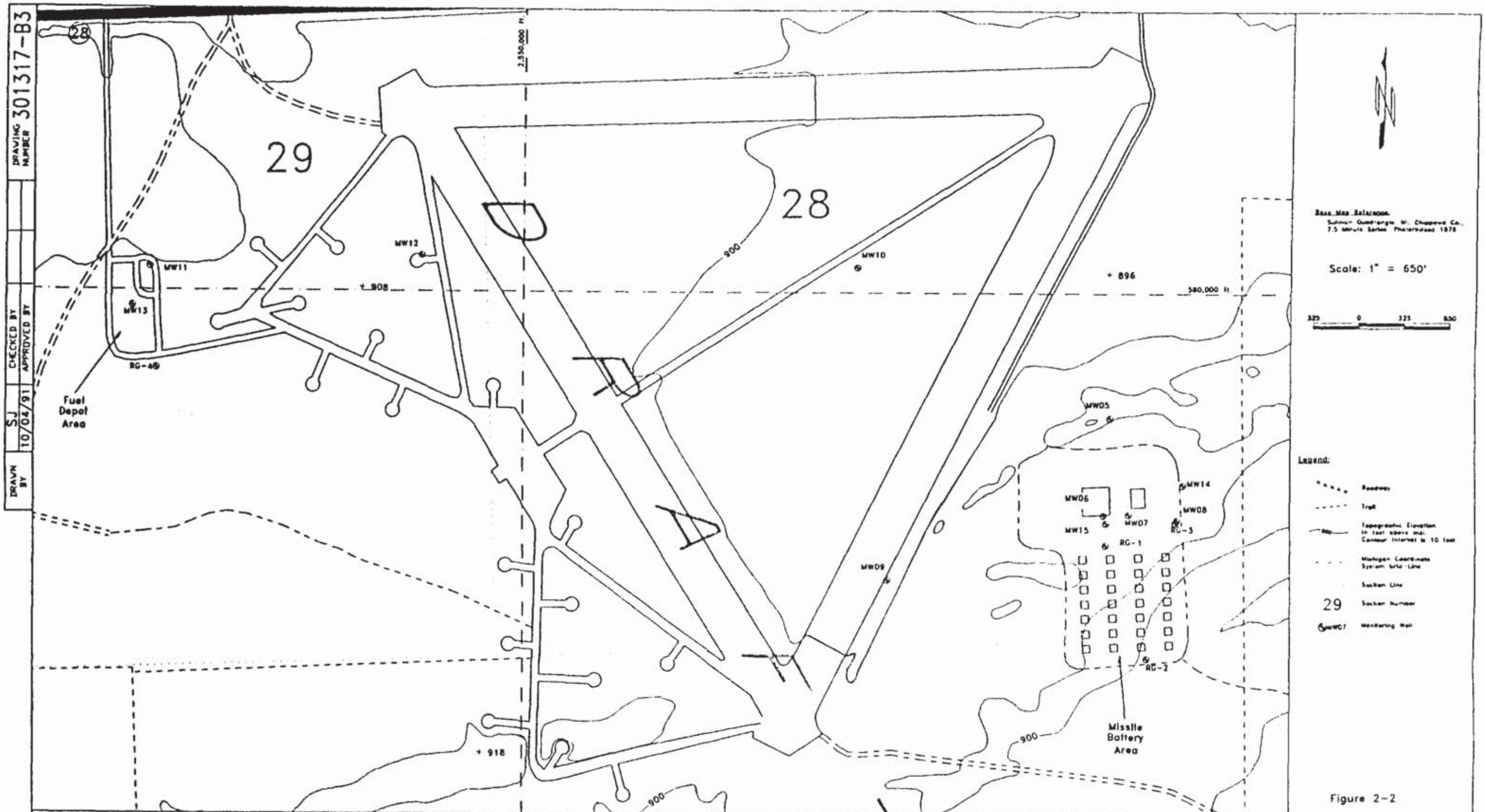

Figure 2-2

Monitoring Well Locations
Former Air Force Airfield
and BOMARC Missile Site

prepared for

U.S. Army Corps of Engineers
Omaha, Nebraska

Contract No. DACW45-88-D-0008

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2.4.1 Well Construction

Ten of the 11 new monitoring wells were installed straddling the water table, with total depths ranging between 41 and 60.2 feet. The eleventh well, BOM-RG3-MW08, was installed to a total depth of 74.6 feet. Monitoring well riser material consists of two-inch inside diameter, schedule 40, flush-threaded PVC or type 304, corrosion-resistant stainless steel. Monitoring well screens consist of two-inch inside diameter, flush-threaded, type 304, corrosion-resistant, continuous-wrap stainless steel. The PVC riser material conforms to the requirements of ASTM F 480-81 SDR 13.5. The screen length for each well is 10 feet. All monitoring well borings, except BOM-RG3-MW08, were overdrilled an average of three feet prior to setting the screen to compensate for heaving sands. Sand did not enter the hollow stem augers during installation of MW08.

Screens and risers for all wells were installed through the hollow stem auger. Augers were raised at five-foot intervals while clean-washed silica sand was packed around the screen to a minimum of two feet above the top of the screen. A two-foot bentonite seal was installed above the sand pack. Cement grout was placed above the bentonite seal and extended to the surface. To complete well installation, a protective casing was set in a three-foot-by-four-inch-thick concrete pad surrounded by three guard posts set in a triangular pattern. Well construction diagrams are provided in Appendix D.

2.4.2 Water Level Measurements

Groundwater levels were recorded for all new and existing wells during various water level measurement rounds. Table 2-5 presents groundwater level measurements, top of casing elevations, and groundwater elevations for all wells at the former installation. As shown, several groundwater level measurements were obtained during Stage 1 and Stage 2 field efforts. Minimum and maximum water level measurements obtained during Stage 1 and Stage 2 varied between 856.1 and 874.60 feet above mean sea level (msl) in MW03 and MW13, respectively. The direction and gradient of groundwater flow are discussed in Section 3.6.

2.4.3 Well Development

All wells were developed by pumping with a Brainard Kilman 1.7 inch PVC hand pump. During Stage 1, three of the four existing wells, RG-1, RG-2 and RG-4, were flushed to remove sediments with filtered compressed air or the Brainard Kilman pump. Table 2-6

Table 2-5
Water Level Measurements
Former Air Force Airfield & Bomarc Missile Site
Raco, Michigan

Well	Date Well Installed	Measurement Date	Top of Casing Elevation (feet msl)	Depth to Water (feet)	Water Level Elevation (feet msl)
RG-1	06-Dec-86	07-Sep-90	907.08	48.85	858.23
		19-Sep-90		48.83	858.25
		25-Sep-90		48.94	858.14
		26-Sep-90		49.21	857.87
		12-Nov-90		48.92	858.16
		17-Nov-90		49.15	857.93
		17-Apr-91		49.00	858.08
		16-Jul-91		47.84	859.24
		18-Jul-91		47.84	859.24
		20-Aug-91		47.91	859.17
RG-2	07-Dec-86	07-Sep-90	905.96	46.10	859.86
		19-Sep-90		46.06	859.90
		25-Sep-90		46.10	859.86
		26-Sep-90		48.40	857.56
		13-Nov-90		48.27	857.69
		17-Nov-90		48.36	857.60
		17-Apr-91		48.50	857.46
		16-Jul-91		46.80	859.16
		18-Jul-91		46.79	859.17
		20-Aug-91		46.70	859.26
RG-3	09-Dec-86	07-Sep-90	906.56	48.88	857.68
		19-Sep-90		48.88	857.68
		24-Sep-90		49.84	856.72
		26-Sep-90		49.92	856.64
		13-Nov-90		49.95	856.61
		17-Nov-90		49.90	856.66
		17-Apr-91		49.91	856.65
		16-Jul-91		48.54	858.02
		18-Jul-91		48.53	858.03
		20-Aug-91		48.63	857.93
RG-4	04-Dec-86	07-Sep-90	910.04	35.90	874.14
		19-Sep-90		35.83	874.21
		25-Sep-90		37.15	872.89
		26-Sep-90		37.30	872.74
		13-Nov-90		37.15	872.89
		17-Nov-90		37.17	872.87
		17-Apr-91		37.35	872.69
		16-Jul-91		35.74	874.30
		18-Jul-91		35.74	874.30
		20-Aug-91		35.92	874.12

Table 2-5
Water Level Measurements
Former Air Force Airfield & Bomarc Missile Site
Raco, Michigan

Well	Date Well Installed	Measurement Date	Top of Casing Elevation (feet msl)	Depth to Water (feet)	Water Level Elevation (feet msl)
MW05	09-Sep-90	19-Sep-90	915.09	57.05	858.04
		24-Sep-90		57.10	857.99
		26-Sep-90		57.06	858.03
		13-Nov-90		52.20	862.89
		17-Nov-90		57.11	857.98
		17-Apr-91		57.00	858.09
		16-Jul-91		55.76	859.33
		18-Jul-91		55.74	859.35
		20-Aug-91		55.79	859.30
MW06	10-Sep-90	18-Sep-90	908.96	51.37	857.59
		25-Sep-90		51.35	857.61
		26-Sep-90		51.30	857.66
		17-Nov-90		51.28	857.68
		17-Apr-91		51.40	857.56
		16-Jul-91		49.97	858.99
		18-Jul-91		49.74	859.22
		20-Aug-91		49.97	858.99
MW07	11-Sep-90	18-Sep-90	906.83	49.64	857.19
		25-Sep-90		49.58	857.25
		26-Sep-90		49.60	857.23
		12-Nov-90		49.56	857.27
		17-Nov-90		49.61	857.22
		17-Apr-91		49.53	857.30
		16-Jul-91		48.25	858.58
		18-Jul-91		48.24	858.59
		20-Aug-91		48.34	858.49
MW08	22-Sep-90	23-Sep-90	905.59	48.90	856.69
		25-Sep-90		48.90	856.69
		26-Sep-90		48.95	856.64
		13-Nov-90		48.94	856.65
		17-Nov-90		48.93	856.66
		17-Apr-91		48.96	856.63
		16-Jul-91		47.59	858.00
		18-Jul-91		47.58	858.01
		20-Aug-91		47.58	858.01
MW09	18-Sep-90	23-Sep-90	903.15	41.26	861.89
		25-Sep-90		41.26	861.89
		26-Sep-90		41.27	861.88
		13-Nov-90		38.10	865.05
		17-Apr-91		41.18	861.97
		16-Jul-91		40.04	863.11
		18-Jul-91		40.02	863.13
		20-Aug-91		40.00	863.15

Table 2-5
Water Level Measurements
Former Air Force Airfield & Bomarc Missile Site
Raco, Michigan

Well	Date Well Installed	Measurement Date	Top of Casing Elevation (feet msl)	Depth to Water (feet)	Water Level Elevation (feet msl)
MW10	19-Sep-90	23-Sep-90	903.87	40.60	863.27
		25-Sep-90		40.61	863.26
		26-Sep-90		40.60	863.27
		13-Nov-90		37.61	866.26
		17-Nov-90		40.49	863.38
		17-Apr-91		40.70	863.17
		16-Jul-91		39.22	864.65
		18-Jul-91		39.20	864.67
		20-Aug-91		39.33	864.54
MW11	20-Sep-90	23-Sep-90	911.79	38.90	872.89
		25-Sep-90		38.80	872.99
		26-Sep-90		38.95	872.84
		13-Nov-90		35.60	876.19
		17-Nov-90		38.99	872.80
		17-Apr-91		39.27	872.52
		16-Jul-91		37.49	874.30
		18-Jul-91		37.49	874.30
		20-Aug-91		37.73	874.06
MW12	20-Sep-90	23-Sep-90	906.60	36.90	869.70
		25-Sep-90		37.20	869.40
		26-Sep-90		37.25	869.35
		13-Nov-90		33.50	873.10
		17-Nov-90		37.30	869.30
		17-Apr-91		37.43	869.17
		16-Jul-91		36.13	870.47
		18-Jul-91		36.12	870.48
		20-Aug-91		36.18	870.42
MW13	29-Jun-91	16-Jul-91	911.66	37.06	874.60
		18-Jul-91		37.06	874.60
		20-Aug-91		37.30	874.36
MW14	30-Jun-91	16-Jul-91	909.54	51.80	857.74
		18-Jul-91		51.77	857.77
		20-Aug-91		51.75	857.79
MW15	02-Jul-91	16-Jul-91	906.86	47.90	858.96
		18-Jul-91		47.88	858.98
		20-Aug-91		47.85	859.01
Average Across the Site			908	45	863

Table 2-6
Well Development Data
Former Air Force Airfield & Bomarc Missile Site
Raco, Michigan

Monitoring Well	Date Developed (1)	Gallons Removed	Final pH	Final Conductivity	Final Groundwater Temperature (Fahrenheit)	Water Clarity
RG-1	09/21/90	70	6.70	1700	43.5	Clear
RG-2	09/22/90	110	7.28	1400	43	Clear
RG-4	09/23/90	45	6.72	1200	42	Clear
MW05	09/20/90	65	7.08	1600	43.5	Clear
MW06	09/20/90	110	6.60	1710	44	Clear
MW07	09/21/90	140	6.18	1820	44	Clear
MW08	09/23/90	270	7.31	1570	43	Clear
MW09	09/23/90	240	6.55	1120	43.5	Clear
MW10	09/23/90	280	7.27	1310	43	Clear
MW11	09/23/90	185	8.02	1190	42	Clear
MW12	09/23/90	140	7.66	1350	42	Clear
MW13	07/09/91	275	5.66	67	52.6	Clear
MW14	07/09/91	300	8.68	45	52.9	Clear
MW15	07/10/91	300	5.65	169	53.0	Clear

(1) RG-1, RG-2, RG-3, and RG-4 were initially developed in 1986. RG-1, RG-2, and RG-4 were re-developed to improve water clarity, prior to sample collection. RG-3 was not re-developed since the well yielded water suitable for sample collection.

presents pH, temperature, conductivity, and turbidity results measured at the completion of well development. As indicated, all wells had excellent recharge with 45 to 300 gallons of water removed from each well. Water clarity was good for all the wells at the end of the development period. No free product, or non-aqueous phase liquid (NAPL) was observed in any of the new or previously installed wells during development or sampling. Wells were allowed to stabilize for a minimum of 48 hours prior to sample collection.

2.4.4 Groundwater Sample Collection

Prior to collecting analytical samples, each well was purged a minimum of three well volumes or until conductivity, pH and temperature readings had stabilized. Field test results are presented in Table 2-7. Temperatures ranged between 41°F and 52.5°F, conductivities ranged between 20 umohs and 1830 umohs, and pH values ranged from 5.4 to 8.7 standard units prior to sample collection.

During Stage 1, groundwater samples were collected from the four existing wells and the eight newly installed wells. During Stage 2, groundwater samples were collected from RG-1, RG-3, BOM-RG3-MW08, and the three wells installed during Stage 2 (BOM-FD-MW13, BOM-SDB-MW14 and BOM-TPAD-MW15). Samples were obtained by pouring groundwater from a bottom emptying decontaminated teflon bailer into the appropriate sample containers. Dedicated bailers were not used at the site, instead, bailers were decontaminated between each well per the Scope of Services. Samples were packaged and stored in iced coolers prior to overnight shipment to the ITAS laboratory in Cincinnati.

QA and QC duplicate and rinsate water samples were collected from monitoring wells BOM-RG-3-MW03 and BOM-FD2-MW12. QC samples were shipped to the ITAS laboratory in Cincinnati and QA samples were shipped to the USACE MRD laboratory in Omaha for analysis.

Analytical parameters and results specific to each site are discussed in Appendix A.

2.4.5 Hydraulic Conductivity Testing

A total of 42 hydraulic conductivity tests (slug tests) were performed on the 11 newly installed monitoring wells. Slug tests were conducted after groundwater samples had been

Table 2-7
Sample Collection Field Test Data
Former Air Force Airfield & Bomarc Missile Site
Raco, Michigan

Monitoring Well	Date Sampled	Well Volume (gallons)	Amount Purged (gallons)	pH	Conductivity (umhos)	Temperature (fahrenheit)
RG-1	09/25/90	1.0	15	6.7	1710	44
	11/12/90	0.9	4	6.2	180	42
	07/11/91	1.0	10	5.6	465	52
RG-2	09/25/90	1.4	11	6.4	1430	43.5
	11/13/90	1.0	4	6.5	95	43
RG-3	09/24/90	0.6	23	6.7	1190	43
	11/13/90	0.9	4	5.9	89	43
	07/11/91	1.1	7	5.7	560	52
RG-4	09/25/90	1.3	25	7.2	1090	43
	11/13/90	1.6	7	5.9	30	41
MW05	09/24/90	0.7	21	6.7	1190	43
	11/13/90	1.7	14	6.3	34	42
MW06	09/25/90	1.0	20	5.4	1780	44
	11/12/90	0.8	4	5.5	92	43
MW07	09/25/90	1.3	15	6.4	1830	44
	11/12/90	1.3	3	5.9	160	43
MW08	09/25/90	4.0	22	7.3	1760	43
	11/13/90	3.9	12	7.1	140	43
	07/11/91	4.2	18	5.8	680	52
MW09	09/25/90	1.0	20	7.2	1190	43.5
	11/13/90	1.3	4	7.0	100	45
MW10	09/25/90	0.8	12	7.1	1120	44
	11/13/90	1.1	4	6.7	110	43
MW11	09/25/90	1.1	12	7.8	1210	43
	11/13/90	1.6	5	6.5	20	41
MW12	09/25/90	1.0	NR	NR	NR	NR
	11/13/90	1.6	5	6.2	42	44
MW13	07/11/91	1.3	8	5.7	65	52
MW14	07/11/91	1.3	7	8.7	220	51
MW15	07/12/91	1.2	9	5.7	172	52.5

NR - Indicates that data was not reported for MW12 on 09/25/90.

collected to ensure sample integrity. Four tests were conducted per well; two rising head and two falling head tests.

Data was reduced using the Bower and Rice (1976) method for unconfined aquifers. Semi-logarithmic plots of residual head versus time were used to determine the hydraulic conductivity and are presented in Appendix E. Results are discussed in Section 3.6.

2.5 Landfill Investigation

The existence of a possible base landfill was investigated during Stage 1 and consisted of reviewing available records, examining aerial photographs, interviewing individuals familiar with the former installation, conducting a field inspection, and performing a geophysical survey.

The records review consisted of examining documents provided to IT by the USACE. According to the USACE's Scope of Services, a base landfill was thought to exist southeast of the former missile battery area. The CES indicates that a borrow area several acres in size and a possible dump site were inspected during that investigation. The site, located southeast of the missile battery area, was obviously used as a borrow area, but no direct evidence of dumping was found. In addition, the CES indicated that a smaller mound in the wooded area southeast of the missile battery area was excavated and concrete rubble was piled in its center. No further information on the existence of a sanitary landfill was found.

Aerial photographs for the year 1972 were examined at the USFS's district ranger station in Sault Ste. Marie, Michigan. Aerial photographs for the years 1939 and 1953 were examined at the USFS's ranger station in Raco, Michigan. Five potential landfill locations were identified during a review of the 1972 aerial photographs. Locations were shown on a copy of the 1972 aerial photograph and attached to an IT memorandum dated July 13, 1990 (Appendix F).

Roger Jewell, the district ranger for the USFS in Sault Ste. Marie, Michigan, and Wayne Dagy, a telephone service representative for the Chippewa County Telephone Company in Brimley, Michigan reviewed the IT memorandum and the aerial photograph. Mr. Dagy provided telephone service to the missile battery area between 1963 and 1972. He was familiar with historical site operations and provided information regarding waste disposal practices at the former installation. The following observations were made during review of the aerial photograph:

- Area 1 may be a natural depression.
- Area 2 is a race track made for snowmobiles or go-carts.
- Area 3 is a soil stockpile evident in stereo view.
- Area 4 is a borrow area. Soil was removed from the southwest half of this area and used for fill in the missile launch pad area.
- Area 5 is a rifle target range.
- Mr. Dagy believed that burning and some surface disposal may have occurred east of the southern end of the runways along the road. This area was examined by IT personnel and no surface debris was observed. He also indicated that refuse may have been placed in dumpsters and subsequently disposed at a nearby landfill in Kinross, Michigan.

As a result of the interviews, Area 5, the rifle target range, was not further considered. The remaining four areas were examined in the field and selected for investigation using geophysical techniques.

The geophysical survey was conducted between September 8 and September 10, 1990 at the four remaining sites using magnetic (MAG) gradient and electromagnetic (EM) conductivity methods. Results of the geophysical investigation are presented in a letter report in Appendix F. None of the four areas surveyed revealed the presence of geophysical anomalies typically associated with landfill operations. Results of the MAG and EM surveys are summarized below:

- The survey of Area 1 did not reveal anomalous ground conductivity readings or significant magnetic gradient anomalies. Based on these surveys, there is no indication that Area 1 was used as a landfill.
- The southeastern portion of survey area 2 is littered with metallic debris. Magnetic gradient data indicate the presence of a significant amount of near-surface ferrometallic debris beyond this portion of the area.

- Survey results for Area 3 produced slightly elevated terrain conductivity, probably related to areas of moist ground and some isolated, relatively small magnitude magnetic anomalies.

- In Area 4, slight deviations in ground conductivity are most likely attributable to changes in terrain composition and/or moisture content. Low magnitude, magnetic anomalies are most likely associated with isolated pieces of near-surface ferrometallic debris. This shows evidence of soil excavation (borrow areas).

The investigation, therefore, did not produce any conclusive evidence supporting the existence of a base landfill.

3.0 Physical Characteristics of the Facility

This section describes physical characteristics of the facility in accordance with the outline presented in Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988a). Data on the physical characteristics of the former installation and surrounding areas were collected to the extent necessary to define potential transport pathways, identify potential receptor populations, and to provide sufficient engineering data for developing and screening remedial action alternatives should remediation become necessary. Surface features, human populations, climatology, surface water hydrology, geology, and hydrogeology are discussed in the following sections.

3.1 Surface Features

Surface features are described to acquaint the reader with site orientation and provide information for use in developing remedial alternatives should remediation become necessary at the former installation. Topographic surveys, aerial photographs, and drawings of the site were reviewed to determine site topography and the location of past and present buildings, roadways, railways, and other surface features.

Historically, the installation consisted of three runways, a fuel depot west of the runway area, and a missile battery area southeast of the runways. Runways are aligned in a triangular formation with a central taxiway. A parking apron, consisting of approximately 18 pads, was historically used for jet maintenance and storage. The parking apron exists along the western side of the runways. An unpaved road extends westward from the parking apron to the fuel depot. The fuel depot consisted of eight underground fuel storage tanks, two in the southern part of the area and six in the northern section of the fuel depot (Envirodyne, 1987). Three or four pumps near the underground storage tanks supplied fuel to the surface. During UST removal operations, tanks were removed and pump pits were backfilled.

The missile battery area, situated southeast of the runways, historically consisted of 28 silos each having dimensions of 23-feet-wide-by-25-feet-long-by-8-feet deep (Envirodyne, 1987). The silos housed Nike missiles for an undetermined amount of time between 1960 and June 1973. The silos were oriented in four north-south rows consisting of seven silos each. Each silo was cleaned out and backfilled during the construction removal project conducted under a USACE contract in 1987 and 1988 (USACE, 1989a).

The primary operations area, north of the missile battery area, historically consisted of two large buildings and several smaller buildings, as shown in Figure 3-1. Today, only the asphalt driveways and a loading dock and a few concrete pads remain in place.

Decontamination water at the site was provided by a USFS well located at the Raco Forest Station three miles northeast the former installation. During operation of the former installation, water was supplied by on site groundwater supply wells.

An east-west railroad, named Duluth South Shore on the demolition of structures map provided by the USACE and Soo Line on the USGS topographic map, exists north of the airstrip and County Road 28.

Regionally, topography trends from the northwest to the southeast toward the Pine River drainage basin. At the site, however, topography is relatively flat in most areas, especially at the airstrip. Slight topographic relief exists in the southeast portion of the former installation, near the former missile battery area. In this area, topography ranges from just below 900 feet above msl to 915 feet msl.

The wastewater treatment lagoon is located northeast of the missile battery area, east of the former buildings. The lagoon is relatively flat with a ridge along its eastern side.

Other significant surface features observed at the site during recent field investigations included a service road from Highway 28 that bends south around the fuel depot, across the southern end of the runway, and southeast to Sullivan Creek Road. This service road has some daily traffic as it provides a "short cut" from Highway 28 to Sullivan Creek Road.

3.2 Human Populations

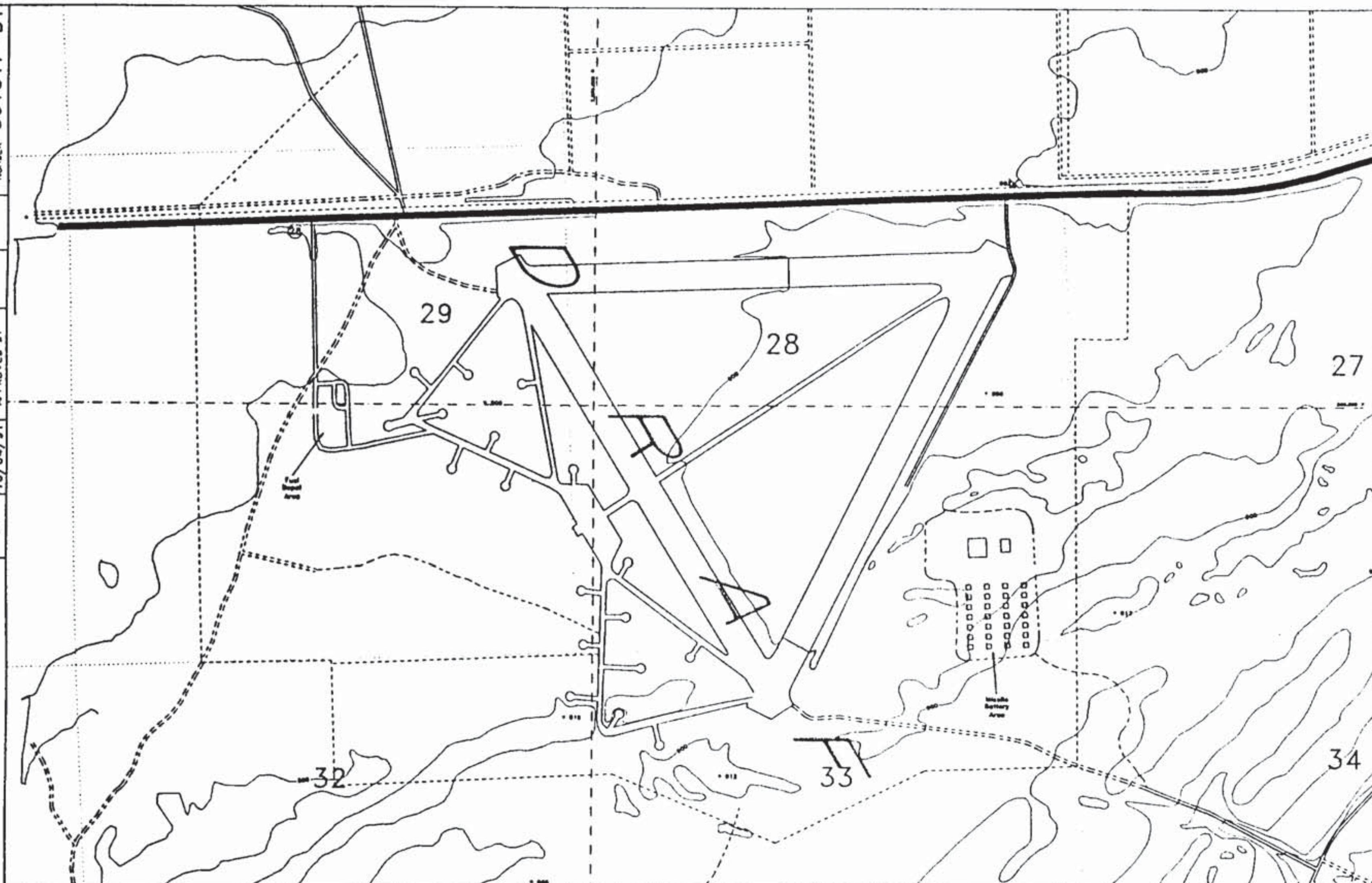
A review of the DERP Inventory Report and Hazardous Ranking System Evaluation completed by Envirodyne during the CES was performed to determine the human population near the former Air Force Airfield and Bomarc Missile Site. In addition, information obtained by IT during the recent field investigation is included as supporting data. This information can be used in the Baseline Risk Assessment (BRA), if necessary, to assess potential risks to human populations in the vicinity of the site.

DRAWING NUMBER 301317-B1

DRAWN BY SJ 10/04/91

CHECKED BY

APPROVED BY



Base Map Reference:
Sullivan Quadrangle, Mi. Chippewa Co., 7.5 Minute Series, Photorevised 1978.

Scale: 1" = 1000'

500 0 500 1000

Legend:

- Roadway
- Trail
- Topographic Elevation in feet above msl. Contour interval is 10 feet.
- Michigan Coordinate System Grid-Line
- Section Line
- 29 Section Number

Figure 3-1

Historical Site Features Map
Former Air Force Airfield
and BOMARC Missile Site

prepared for

U.S. Army Corps of Engineers
Omaha, Nebraska

Contract No. DACW45-88-D-0008

IT Creating a Safer Tomorrow

The CES determined that a population of approximately 65 people were being served by groundwater from the surficial aquifer within three miles of the former installation. Houses were counted on a topographic map and 3.8 persons per household was assumed in order to calculate the population. The nearest downgradient well was assumed to be a drinking water and irrigation well located approximately 4,600 feet southeast of the facility (Envirodyne, 1987).

The former installation is located within the Hiawatha National Forest near Raco, Michigan. While there are no permanent residents at the former installation, it is used periodically as an automobile tire and brake testing facility. According to a Sales and Marketing Management 1990 Survey, an estimated 75 people reside in Raco, approximately 4.5 miles east of the former installation.

3.3 Climatology

Climatological data can be used to define recharge, evaporation, and the effect of weather patterns on the timing and selection of potential remedial actions. For purposes of this report, precipitation and pan evaporation data were used to estimate the net precipitation available for infiltration at the site. Used in conjunction with soil data, migration of potential contaminants through vadose zone materials can be assessed. Temperature data provide general site characterization information and may be used if remedial alternatives analysis is performed.

Climatological data for three nearby weather stations was obtained from the National Climatological Data Center since weather data was not available for the former installation itself. Temperature and precipitation data recorded at the Sault Ste. Marie Municipal Airport, Rudyard and Trout Lake meteorological stations were reviewed with pertinent information reported in Table 3-1. The Sault Ste. Marie Municipal Airport is approximately 23 miles northeast of the site and is within two miles of the St. Marys River channel. The Rudyard meteorological weather station is closest to the former installation and is situated approximately 13.5 miles to the southeast. The Trout Lake weather station is approximately 15 miles southwest of the former Air Force Airfield and Bomarc Missile Site. Periods of record varied between 11 years at the Rudyard and Trout Lake stations to 29 years at the Sault Ste. Marie station.

Table 3-1
Summary of Climatological Data
for Surrounding Meteorological Stations
Former Air Force Airfield & Bomarc Missile Site
Raco, Michigan

	Temperature (Fahrenheit)			Precipitation (inches)	
Month	Mean Maximum	Mean Minimum	Mean Temperature	Total Precipitation	Mean Snow, Sleet
Rudyard (1): Station Number 20 7190 02, Latitude 46 deg 17 min N, Longitude 84 deg 37 min W, Elevation 750 ft above msl					
Jan	24.6	5.7	14.7	1.54	23.6
Feb	27.4	6.6	17.1	1.15	14.3
Mar	36.9	15.3	26.2	1.61	11.0
Apr	51.3	28.1	39.7	2.38	4.3
May	65.2	37.8	51.5	2.01	0.0
Jun	72.0	44.8	58.4	3.62	0.0
Jul	79.8	51.2	65.5	2.43	0.0
Aug	75.4	51.1	63.3	3.71	0.0
Sep	65.8	42.6	54.6	3.92	0.0
Oct	52.9	32.5	42.7	3.67	0.8
Nov	40.3	24.7	32.5	2.85	9.7
Dec	27.8	10.8	19.3	2.62	30.2
Average:	51.6	29.3	40.5	2.63	7.8
Trout Lake (2): Station Number 20 8293 02, Latitude 46 deg 12 min N, Longitude 85 deg 01 min W, Elevation 840 ft above msl					
Jan	25.2	2.2	13.7	2.34	34.2
Feb	27.1	2.7	14.9	1.16	19.9
Mar	35.7	12.3	24.0	1.85	18.0
Apr	49.0	25.9	37.5	2.34	5.2
May	62.5	35.7	49.1	2.40	0.0
Jun	70.3	44.6	57.5	4.08	0.0
Jul	78.7	50.2	64.5	2.13	0.0
Aug	75.1	50.8	63.0	3.91	0.0
Sep	65.1	42.3	53.8	2.80	0.0
Oct	52.4	32.3	42.4	3.30	1.0
Nov	40.9	24.8	32.9	3.42	5.8
Dec	28.4	10.1	19.3	2.09	26.3
Average:	50.9	27.8	39.4	2.65	9.2
Sault Ste Marie (3): Latitude 46 deg 28 min N, Longitude 84 deg 22 min W, Elevation 718 ft above msl					
Jan	22.0	6.1	14.1	2.10	28.6
Feb	22.7	4.9	13.8	1.52	19.3
Mar	32.1	14.8	23.4	1.91	15.2
Apr	46.7	29.0	37.9	2.21	5.5
May	60.1	38.8	49.5	2.73	0.5
Jun	69.8	47.1	58.5	3.01	0.0
Jul	75.0	52.7	63.9	2.68	0.0
Aug	72.9	52.9	62.9	3.05	0.0
Sep	64.6	46.5	55.5	3.61	0.1
Oct	52.9	37.3	45.1	3.04	2.3
Nov	38.5	26.6	32.5	3.17	15.3
Dec	26.9	13.7	20.3	2.42	30.0
Average:	48.7	30.9	39.8	2.62	9.7

(1) Source: National Oceanic and Atmospheric Administration, 1979 through 1990.
(2) Source: National Oceanic and Atmospheric Administration, 1979 through 1990.
(3) Source: National Oceanic and Atmospheric Administration, 1961 through 1990.

Temperature and precipitation do not vary significantly among the three meteorological weather stations. Warmest months are between June and August with average daily temperatures between 57.5 and 65.5°F. Coldest months are between December and February with average temperatures between 13.8 and 20.3°F. Precipitation is rather constant throughout the year with normal levels ranging between 1.05 and 4.08 inches per month. The mean annual precipitation is 31.51 inches at the Rudyard station, 31.82 inches at the Trout Lake station, and 31.45 inches at the Sault Ste. Marie station. An average value of 31.59 inches is assumed to be the net precipitation at the former installation.

Pan evaporation data was not available for the former Air Force Airfield and Bomarc Missile Site. Three sites in Michigan have reported pan evaporation data to the National Climatic Data Center. Data collected at these stations in 1990 is summarized in Table 3-2. The annual evaporation for these stations is about 26 inches. This value was used to calculate a net precipitation value for the former installation. If a more accurate assessment of net precipitation influx is required, pan evaporation data over a longer period of time should be obtained. However, for purposes of this investigation, an estimate of net precipitation is adequate.

Using pan evaporation data and disregarding transpiration, net precipitation at the former installation is estimated to be 5.59 inches per year (31.59 inches precipitation per year minus 26 inches evaporation per year).

3.4 Surface Water Hydrology

Surface water features can include erosion patterns and surface water bodies such as ditches, streams, ponds and lakes. Surface water features within two miles of the site were evaluated to assess the potential for off-site contaminant transport. Aerial photographs, topographic maps and observations from recent field investigations were used to locate nearby water bodies.

Boring logs indicate that soils at the former installation typically consist of unconsolidated, fine to medium grained sand with minor gravel and silt. Since clay and silt content is minimal, infiltration is readily permitted through the permeable sands. As a result, surface water features at the site are essentially non-existent. During periods of high rainfall, surface water runoff is likely controlled by surface topography resulting in southeasterly flow.

Table 3-2
Summary of Pan Evaporation Data
For Stations in Michigan
Former Air Force Airfield & Bomarc Missile Site
Raco, Michigan

Month	Pan Evaporation Data for 1990 (inches)		
	Dearborn, MI	E. Lansing, MI	Lake City, MI
January			
February			
March			
April			1.87
May	2.22	5.20	4.31
June	4.74	5.75	5.16
July	5.48	7.00	6.25
August	4.24	4.83	4.29
September	3.31	4.62	3.32
October	2.27	3.25	1.65
November			
December			
TOTAL	22.26	30.65	26.85

Source: National Oceanic and Atmospheric Administration, Asheville, North Carolina (1990).

In the vicinity of the former installation, surface water features include East Soldier Lake, located approximately 1.6 miles west of the air strip, and Sullivan Creek, located approximately 1 mile south of the air strip. Sullivan Creek is within the Pine River Basin Drainage Basin and flows to Pine River which discharges into Lake Huron. Prey Creek is approximately 1.5 miles southeast of the site air strip and is also part of the Pine River Basin. Numerous wetlands are contained within the Pine River Basin, attesting to soils of lower permeability in the area. Surrounding surface water bodies are shown in Figure 3-2.

3.5 Geology

Geologic units existing at the site are described in the following paragraphs to identify properties affecting the depth, location, and/or extent of water bearing units or aquifers, to evaluate potential routes of migration, and to consider engineering aspects of geologic units at the site should remediation become necessary. Geologic characteristics were determined by reviewing the Geological Survey Division Report of Investigation 19 "Stratigraphic Cross-Sections of the Michigan Basin" (1978), the U.S. Geological Survey Report 17 "Reconnaissance of Groundwater Resources of Chippewa County" (1958), the Bedrock Geologic Map of the Upper Peninsula (DNR, 1987), the Quaternary Geology of Northern Michigan Map (University of Michigan, 1982) and other references addressing Michigan glacial deposits. In addition, boring logs recorded at each drilling location were inspected and are summarized below.

Bedrock formations in the upper peninsula of Michigan are shown in Figure 3-3. At the former installation, bedrock consists of Middle Ordovician rocks of the Trenton and Black River Groups. These rocks occur in an arcuate belt along the mid section of the upper peninsula and consist primarily of argillaceous limestone and dolomite. Important oil and gas producing zones occur in these groups throughout Michigan (MGSD, 1978). Bedrock formations were not encountered during recent drilling activities. As shown in Figure 3-3, a preglacial river channel exists in bedrock approximately 10 miles east of the site. The channel appears to have historically drained Lake Huron into Whitefish Bay (Leverett, 1929).

Unconsolidated glacial drift, lake, beach, and dune deposits overlie bedrock formations as shown in Figure 3-4. In many areas, the glacial deposits are covered with lake sediments derived from Lake Algonquin and in some areas by beach deposits derived from Lakes Nipissing and Lake Algoma.

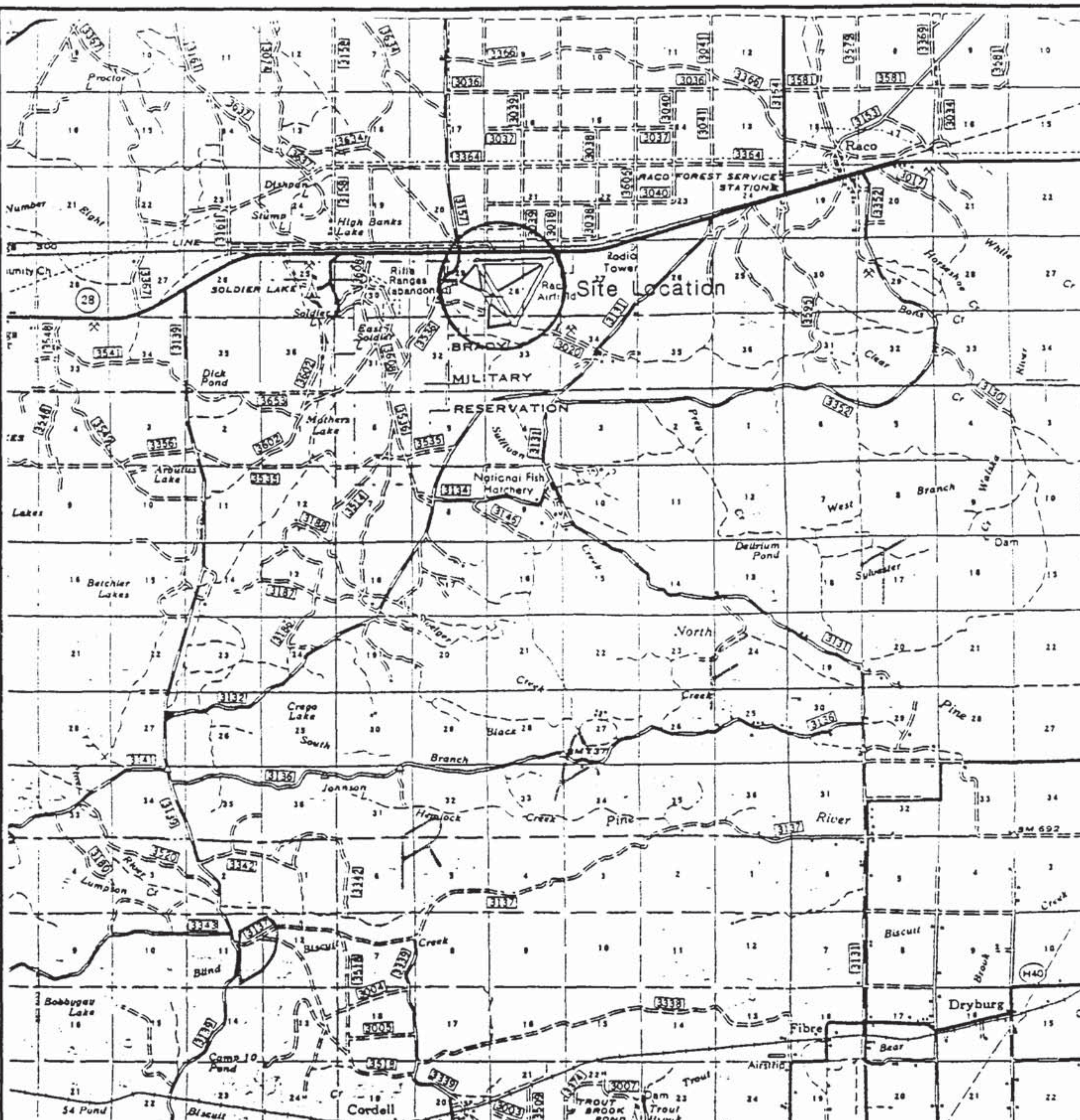


FIGURE 3-2

RACO AREA

SURFACE WATER FEATURE MAP

PREPARED FOR

U.S. ARMY CORPS OF ENGINEERS
OMAHA, NEBRASKA
CONTRACT NO. DACW45-88-D-0008

INTERNATIONAL TECHNOLOGY CORPORATION

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Scale ½" = 1 Mile

1 ½ 0 1 2 3 4 Miles

Reference Source: USDA Forest Service, Hiawatha National Forest, Michigan, 1976.

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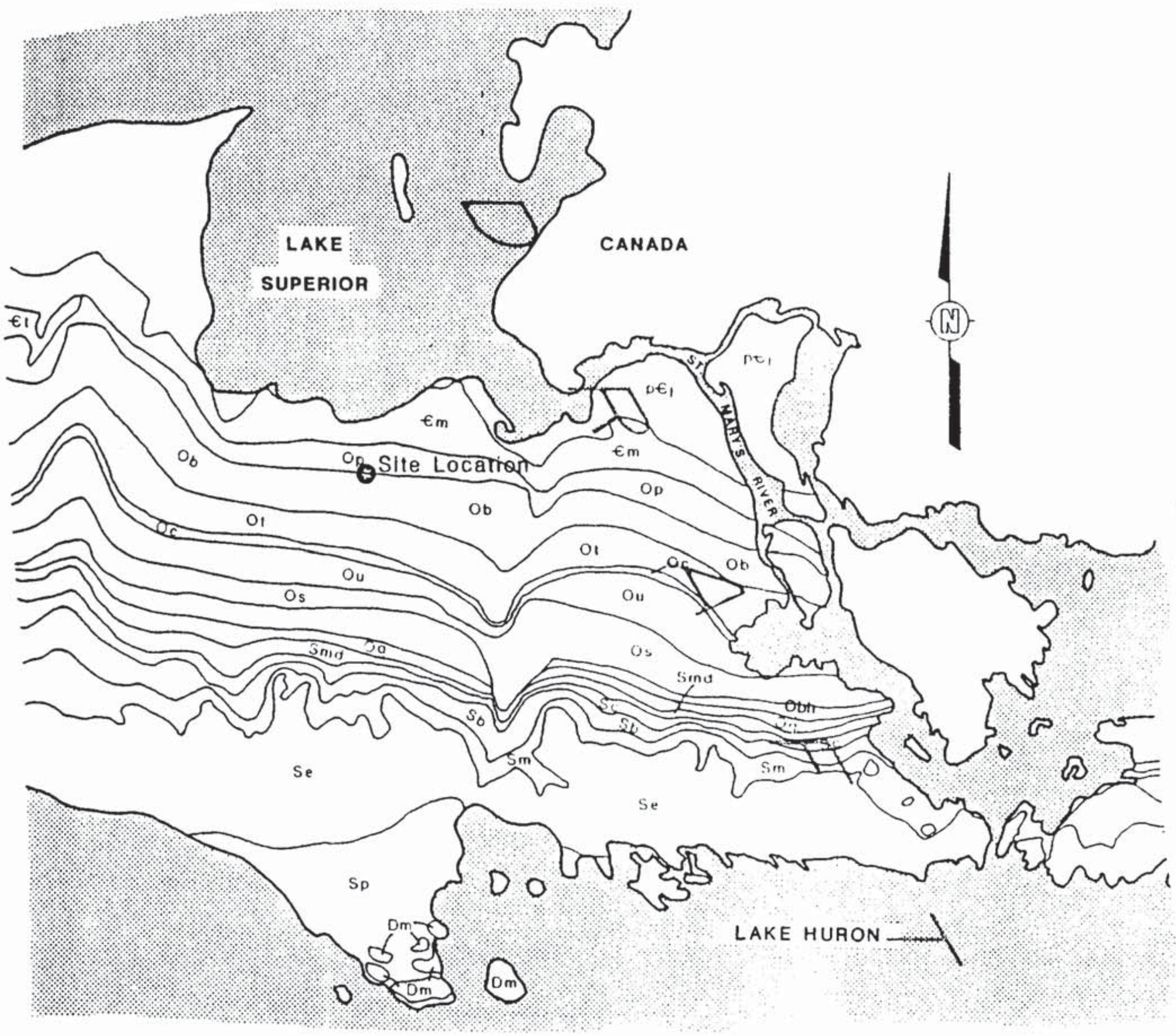

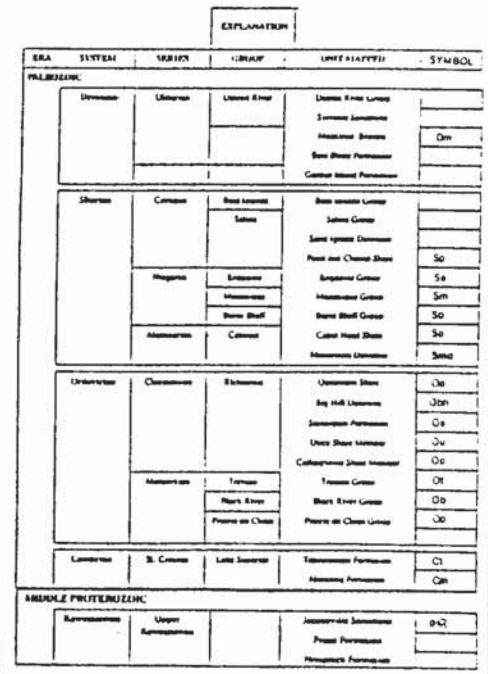

Figure 3-3

Bedrock Geology of Northern Michigan

Former Air Force Airfield and BOMARC Missile Site
Raco, Michigan

prepared for

U.S. Army Corps of Engineers
Omaha, Nebraska
Contract DACW45-88-C-0002

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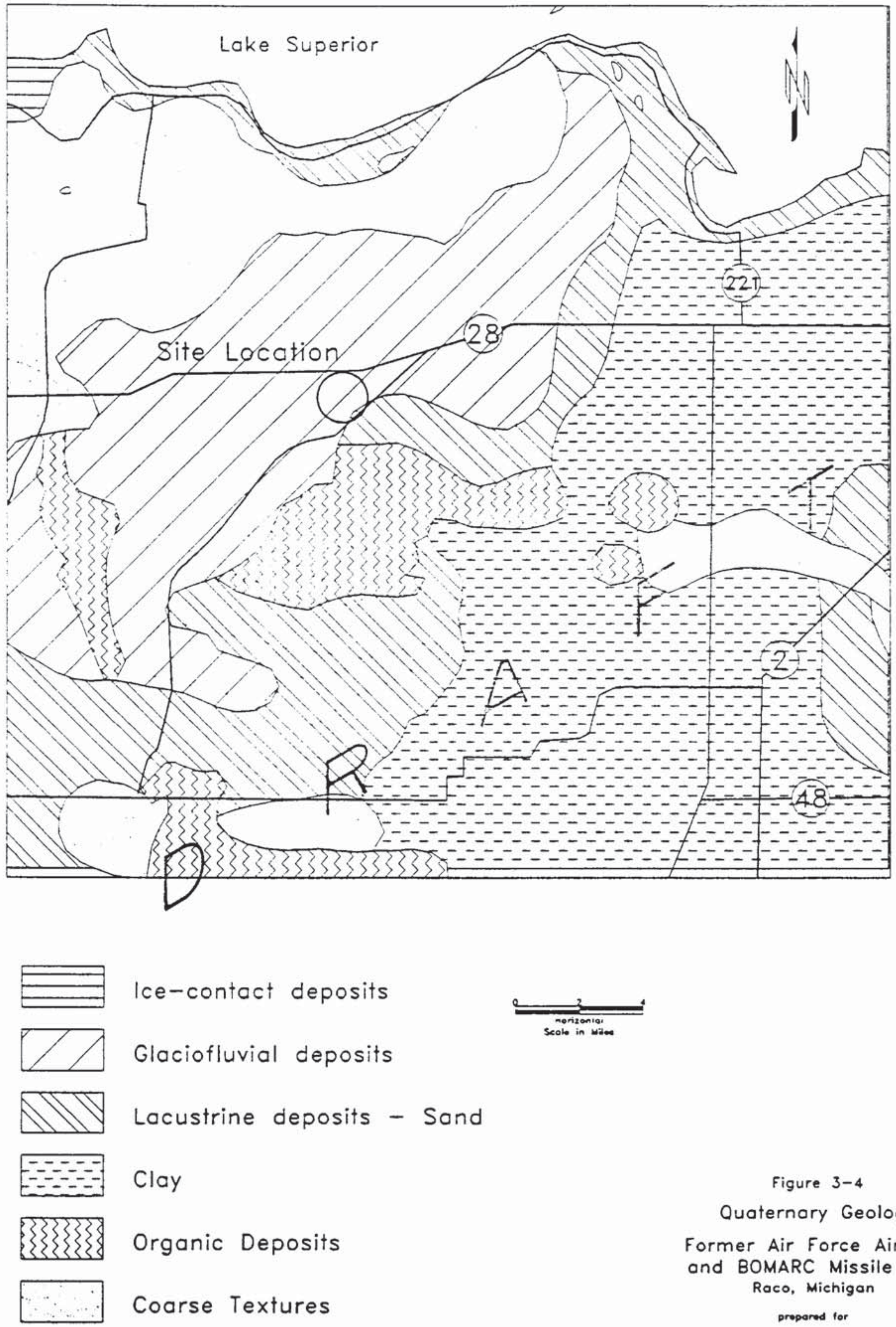

Figure 3-4

Quaternary Geology

Former Air Force Airfield and BOMARC Missile Site

Raco, Michigan

prepared for

U.S. Army Corps of Engineers

Omaha, Nebraska

Contract DACW45-88-D-0008

Reference Source: MI DNR GSD Quaternary Geology of Northern Michigan, 1982.

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In the vicinity of the site, outwash plain deposits consist of pale brown to pale reddish brown, fine to coarse sand alternating with layers of small gravel to cobbles. According to boring logs, unconsolidated deposits consist of brown, fine to medium grained, poorly graded sand with minor silt and gravel. Figure 3-5 presents north-south and east-west cross sections for the site based on boring log descriptions. As shown, unconsolidated deposits are over 75 feet thick at the site, the maximum depth drilled. According to a boring log for a water supply well installed approximately 2.5 miles south of the site at the National Fish Hatchery, glacial deposits were encountered throughout the boring length to a total depth of 260 feet.

3.6 Hydrogeology

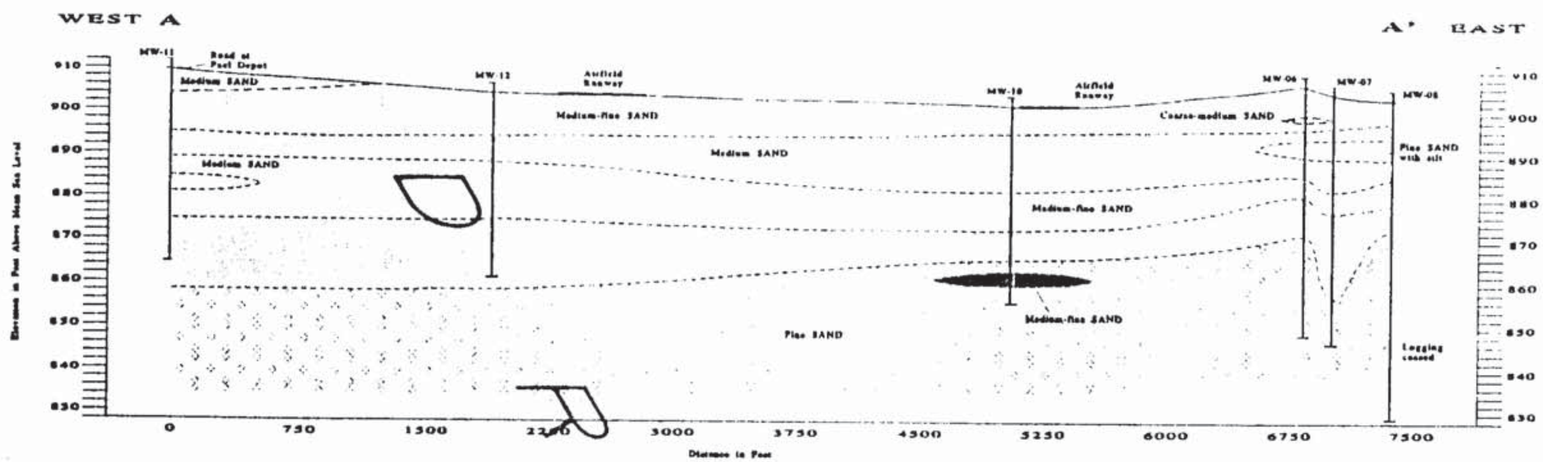
A groundwater investigation was conducted at the site to assess existing and potential impacts of contaminants on usable aquifers to determine the need for remedial action, and to provide data necessary for the design of corrective measures, where such action is required. The hydrogeologic study presented in the following paragraphs discusses groundwater bearing zones, vertical and lateral geometry of the groundwater bearing zone encountered, potentiometric surface of the water table aquifer, direction of groundwater migration, and the rate of groundwater movement.

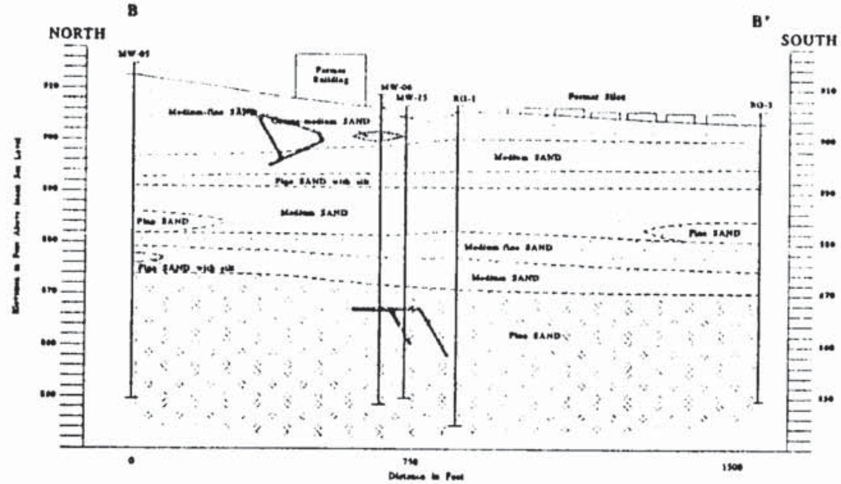
Water quality data is presented in Chapter 4.0 of this report and in the site specific reports in Appendix A.

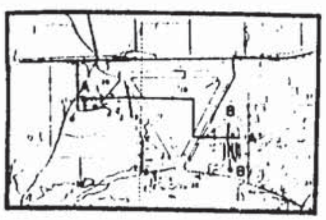
3.6.1 Groundwater Bearing Zones

"Reconnaissance of the Groundwater Resources of Chippewa County, Michigan" by Vanlier and Deutsch for the USGS (1958) was reviewed to identify regional groundwater bearing zones. According to the report, fractures and bedding planes in the Middle Ordovician limestones and dolomites of the Black River and Trenton Groups may be enlarged in places by solution. Where wells intersect these openings, small to moderate supplies of water are produced. Drillers interviewed in the report indicated that some openings had been filled locally with unconsolidated deposits, and where the sediments were permeable, groundwater was available in producible quantities.

Bedrock units were not encountered during drilling activities at the site and the water bearing zone investigated was limited to the surficial aquifer. The surficial aquifer consists of unconsolidated, fine to coarse grained sand, and is unconfined. Groundwater in the surficial







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Base Map

Figure 3-5

Cross Sections A-A' and B-B'
Former Air Force Airfield
and BOMARC Missile Site

prepared for

U.S. Army Corps of Engineers
Omaha, Nebraska
Contract No. DACW45-88-D-0008

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aquifer may or may not be connected to groundwater in the bedrock depending upon the occurrence of solution cavities in the bedrock formation and confining layers in the unconsolidated deposits.

3.6.2 Geometry of Groundwater Bearing Zones

The geometry of a water bearing zone is defined by the vertical and lateral extent of that groundwater bearing zone. Vertical and lateral geometries are best described by the aquifer thickness and identification of hydraulic barriers.

An attempt to estimate the aquifer thickness at the site was performed by assessing groundwater levels measured in 15 onsite wells, inspecting onsite and offsite boring logs, and inspecting a bedrock contour map presented in the "Reconnaissance of Groundwater Resources of Chippewa County, Michigan" (1958) report.

The Chippewa County Health Department was contacted on August 21, 1991 to obtain offsite boring logs. The representative indicated that the saturated thickness for the area of interest was not well defined because wells in the area are installed in the surficial aquifer. One of the deeper wells drilled in the area, to 260 feet below surface, is at the National Fish Hatchery located approximately 2.5 miles south of the former installation. The hatchery is at a surface elevation of approximately 800 feet msl. The log for this well indicates that bedrock was not encountered and that sand existed throughout the total depth of the well.

The former Air Force Airfield and Bomarc Missile Site is at an approximate elevation of 900 feet. Assuming sand to be continuous across the area, there could be as much as 360 feet of glacial material at the former installation. However, due to the lack of deep borings in this area, the vertical extent of the surficial aquifer could not be determined.

Boring logs recorded at the former installation indicate that the water bearing glacial deposits are continuous across the site. Hydraulic barriers, such as surface water bodies or discontinuous water bearing materials, do not appear to be present at the site or within a one mile radius of the site. Sullivan Creek and the Pine River Drainage Basin are situated south and southeast of the former installation, and groundwater appears to flow toward these areas.

3.6.3 Potentiometric Surface

The potentiometric surface of the groundwater body encountered at the former installation was contoured using water levels measured on September 26, 1990 and August 20, 1991. Resulting contours are shown in Figures 3-6 and 3-7. Hydrographs for each well are presented in Figure 3-8. As shown, groundwater levels were lowest during the fall of 1990 and highest during the summer of 1991, varying by approximately one foot. Overall, groundwater is approximately 45 feet below surface at the site or 863 feet above msl.

3.6.4 Direction of Groundwater Migration

A groundwater contour map for Chippewa County, Figure 3-9, was presented in the "Reconnaissance of Groundwater Resources of Chippewa County, Michigan" (USGS, 1958) report and indicates that the direction of groundwater flow at that time was southeast in the vicinity of the former installation. The direction of groundwater flow at the former installation was determined during this investigation by drawing flow lines perpendicular to to potentiometric contour lines as shown in Figures 3-6 and 3-7. Groundwater flows east to southeast across the site. This direction is consistent with the regional easterly-southeasterly sloping topography as well as the Chippewa County Groundwater Contour Map (USGS, 1958).

3.6.5 Rate of Groundwater Movement

The rate or velocity of groundwater movement can be determined by combining Darcy's equation with the standard continuity equation of hydraulics. In working terms, it means that the product of the sediments permeability (hydraulic conductivity) and the groundwater gradient divided by the porosity of the sediments equals a value for the rate of groundwater movement. The formula is described as:

$$V = \frac{K\,i}{n} \qquad \text{Equation 3.1}$$

Where:

V	= hydraulic velocity (feet per second)
K	= hydraulic conductivity (feet per second)
i	= hydraulic gradient or dh/dl (feet per foot)
dh	= change in water level (feet)
dl	= distance between points of water level measurement (feet)
n	= effective porosity of aquifer sediments (dimensionless)

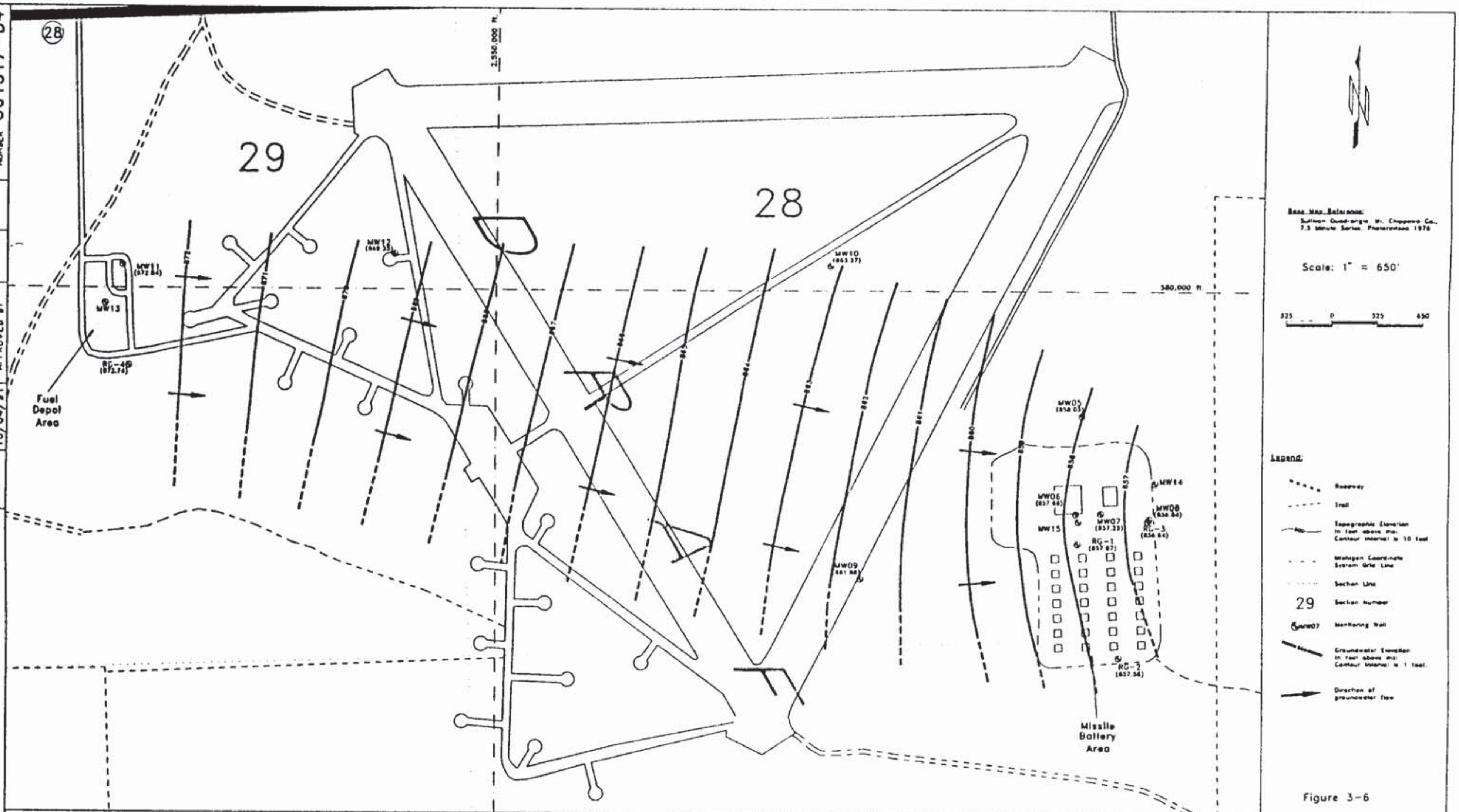

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Figure 3-6

Groundwater Contour Map
for September 26, 1990
Former Air Force Airfield
and BOMARC Missile Site

prepared for

U.S. Army Corps of Engineers
Omaha, Nebraska

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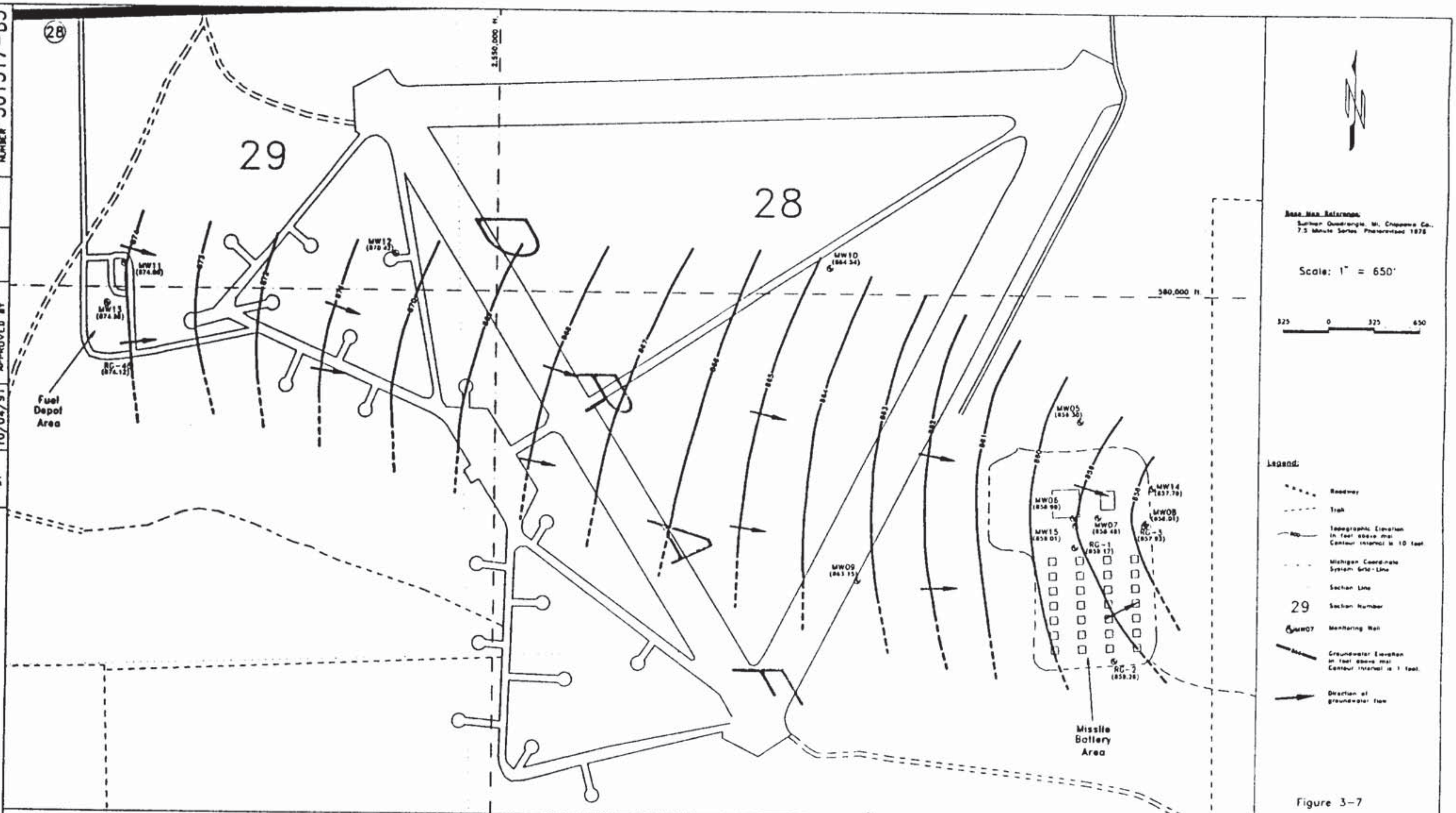

Figure 3-7

Groundwater Contour Map
for August 20, 1991
Former Air Force Airfield
and BOMARC Missile Site

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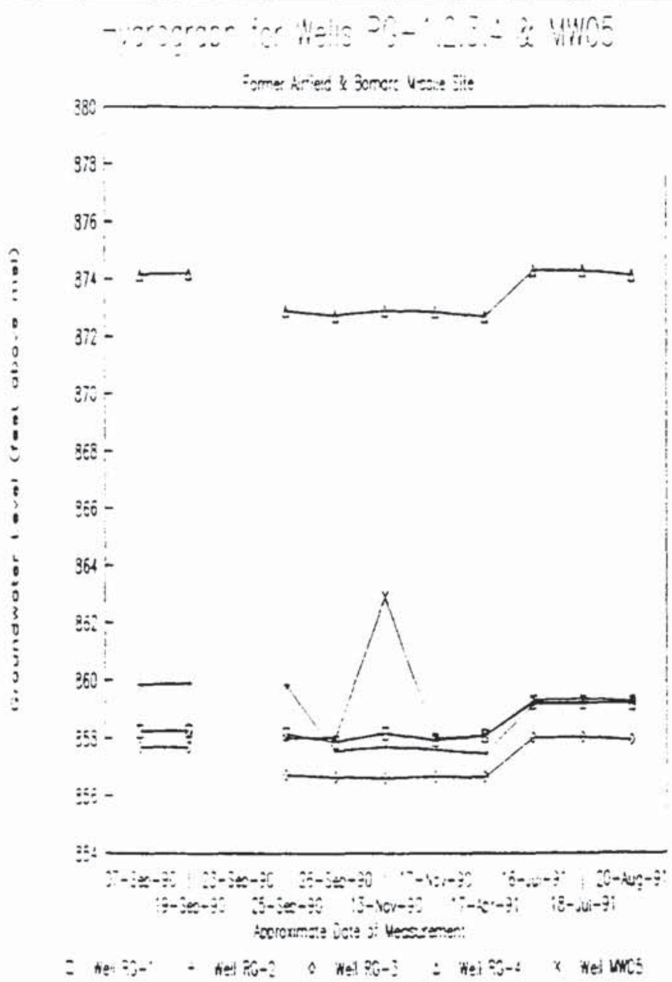

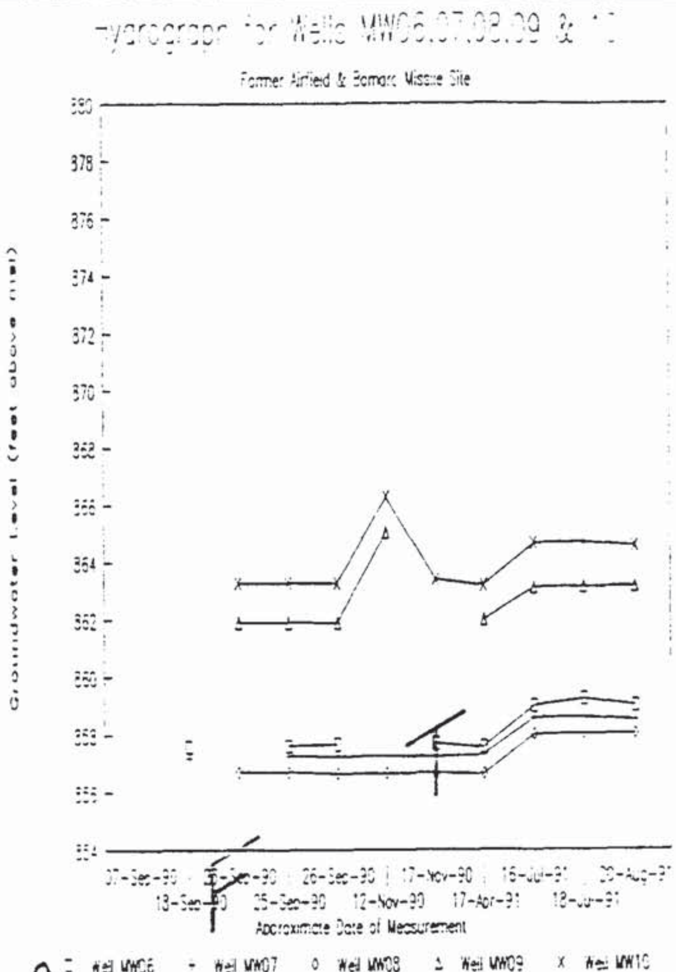

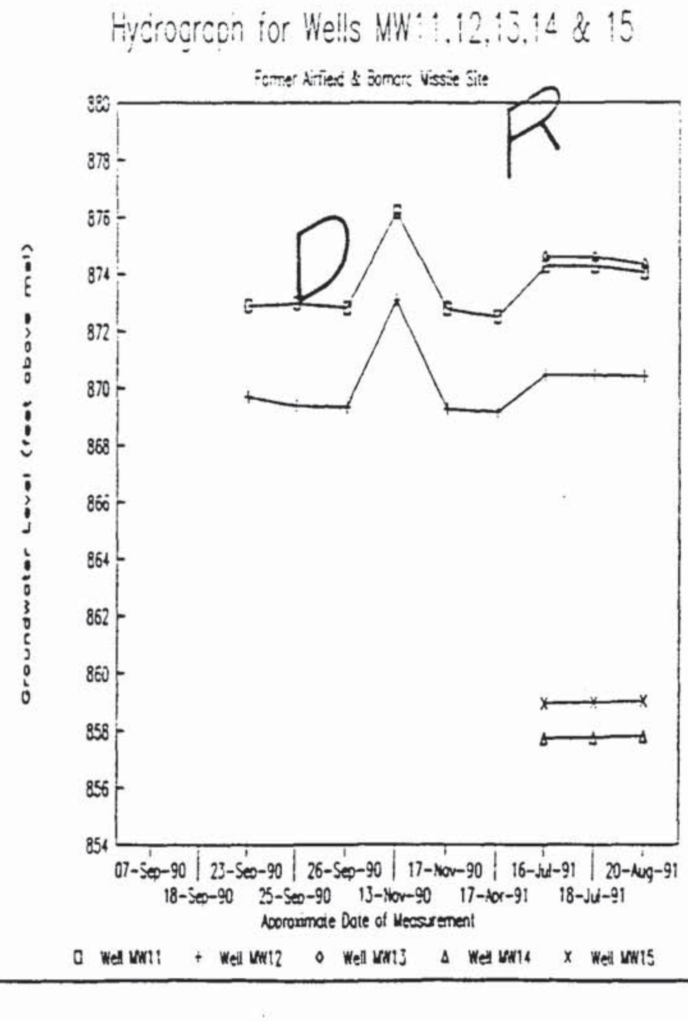

Figure 3-8

Hydrographs

Former Air Force Airfield and BOMARC Missile Site

prepared for

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Omaha, Nebraska

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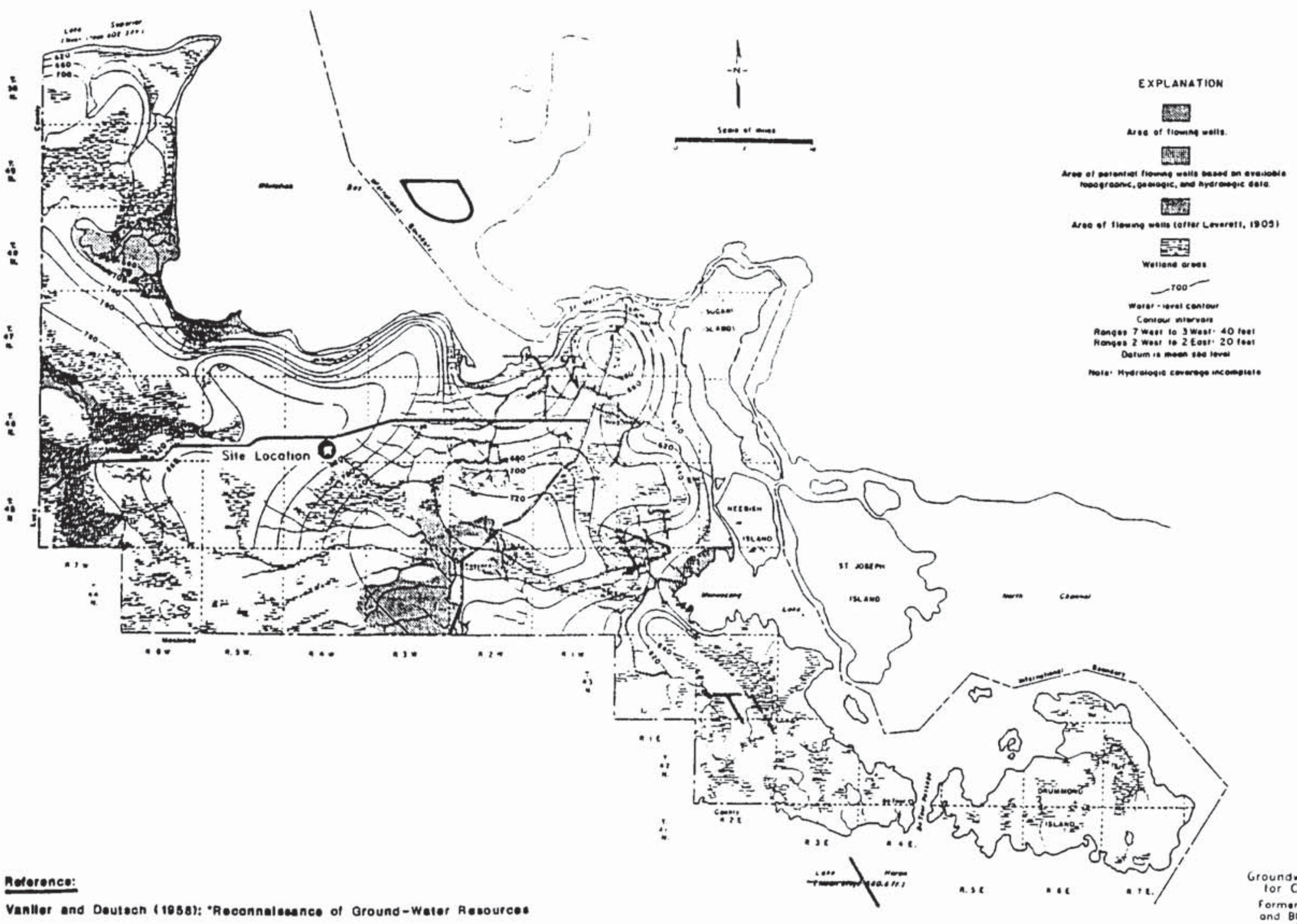

Reference:

Vanlier and Deutsch (1958): "Reconnaissance of Ground-Water Resources of Chippewa County, Michigan," USGS Progress Report No. 17.

Figure 3-9

Groundwater Contour Map for Chippewa County

Former Air Force Airfield and BOMARC Missile Site
Raco, Michigan

prepared for

U.S. Army Corps of Engineers
Omaha, Nebraska
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Hydraulic Conductivity. Calculated velocities are most sensitive to the hydraulic conductivity, which is also the most difficult parameter to determine reliably. The hydraulic conductivity at the site was estimated by performing slug tests in each of the Stage 1 and Stage 2 wells. Initially, a cylindrical slug was dropped into groundwater and water levels were recorded as they returned to static levels (falling head test). Once the water level had stabilized, the slug was removed and water levels were again recorded as groundwater returned to static conditions (rising head test). Water levels were measured during each test using a pressure transducer connected to a Hermit Data Logger. From the data logger, measurements were downloaded to a computer for subsequent data reduction.

Several methods are available for reducing slug test data; for this site, "A Slug Test for Determining the Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells," by Bouwer and Rice, 1976, was used to calculate hydraulic conductivities. Calculations are provided in Appendix E.

The change in water level is plotted versus time for each of the tests. Curves resulting from slug tests conducted in MW08 are of particularly high quality since groundwater was rising or falling within the cased portion of the well, rather than within the screened interval. Data from all tests are included in Appendix E for reference purposes.

As described previously, the vertical extent of the surficial aquifer could not be accurately determined. As a result, various aquifer thicknesses were assumed to determine the hydraulic conductivity. In MW08, the hydraulic conductivity varied between 1.52E-03 and 1.36E-03 centimeters per second for aquifer thicknesses of 29 and 455 feet, respectively. As shown, the hydraulic conductivity is within the same order of magnitude irregardless of the aquifer thickness chosen. For this reason, a value of 100 feet was used to describe the aquifer thickness at the site. As indicated in Table 3-3, the average hydraulic conductivity, K, at the site is 7.18E-02 centimeters per second (or 2.36E-03 feet per second). This value was used to calculate the rate of groundwater movement at the former installation.

Hydraulic Gradient. Inspection of the potentiometric contour map indicates a relatively flat but constant gradient of 0.002 feet per foot toward the east and southeast. The gradient, i, was determined using the two available potentiometric contour maps and dividing the change in water level across the site by the measured distance across the site.

Table 3-3
Summary of Aquifer Test Results
Former Raco Airfield & Bomarc Missile Site
Raco, Michigan

Monitoring Well Number	Hydraulic Conductivity (cm/s)				Average Hydraulic Conductivity (cm/s)
	Falling Head Test 1	Falling Head Test 2	Rising Head Test 1	Rising Head Test 2	
MW05	3.29E-02	1.60E-01	3.03E-02	2.36E-01	1.15E-01
MW06	8.47E-02	1.72E-01	3.83E-02	3.74E-02	8.31E-02
MW07	5.38E-01	7.03E-02	5.64E-02	4.92E-02	1.78E-01
MW08	1.81E-03	7.53E-04	1.38E-03	1.11E-03	1.26E-03
MW09	NR	7.92E-02	4.26E-02	5.76E-02	5.98E-02
MW10	NR	NR	7.73E-02	5.36E-02	6.55E-02
MW11	NR	NR	3.63E-02	9.71E-02	6.67E-02
MW12	NR	2.49E-01	4.81E-02	7.32E-02	1.23E-01
MW13	5.82E-02	2.27E-02	4.07E-02	2.42E-02	3.65E-02
MW14	1.23E-02	4.82E-02	3.03E-02	2.43E-02	2.88E-02
MW15	3.08E-02	NP	3.22E-02	NP	3.15E-02
AVERAGE					7.18E-02

NR - data not usable, no data regression performed
NP - test not performed

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Effective Porosity. Aquifers under unconfined conditions will possess an effective porosity roughly equivalent to the specific yield of the aquifer. According to Fetter, 1980, the specific yield for unconsolidated sediments ranging in size from fine grained sand to gravel is 25%. This corresponds relatively well with the EPA default porosity of 20% for poorly graded sands. An effective porosity, n, of 25% was thus selected for deposits at the site.

Hydraulic Velocity. Returning to Equation 3.1, values were substituted into the formula to estimate the hydraulic velocity at the site. Using K = 2.36E-03 feet per second, i = 0.002 feet per foot, and n = 0.25, V = 1.89E-05 feet per second.

Based on this estimate, groundwater travel time between up and downgradient points can be approximated. For example, it would take approximately 9 years for groundwater to migrate one mile across the site.

4.0 Nature and Extent of Contamination

The objective of this chapter is to determine the nature and extent of contamination at the sites investigated so that the level of risk presented by constituents in environmental media can be assessed, and the necessity of remediation can be determined. This chapter presents a summary of source areas and a summary of chemical detections in soils and groundwater at the sites investigated. Discussions specific to each of the sites are presented in Appendix A. Applicable, relevant, and/or appropriate regulations (ARARs) are discussed and compared to analytical detections in the final sections of this chapter.

4.1 Potential Sources

Based on recommendations of the CES (Envirodyne, 1987) and findings of the USACE's tank removal program (USACE, 1989b), the following sites were investigated as potential contaminant source areas:

- USTs C-1 and C-2: USTs C-1 and C-2 were located south of the composite building and were used to store petroleum products (USACE, 1989b). During tank removal operations, TRPH was detected in soil samples collected below each tank. During Stage 1, one boring was drilled at each of the former tank locations to assess the extent of petroleum hydrocarbon contamination.

- Transformer Pad: The transformer pad was located at the southeast corner of the composite building. Soils were found to be contaminated with TPH during the CES and were removed during the USACE's construction removal project (USACE, 1989a). Two borings and two monitoring wells were installed at the site during Stage 1 and Stage 2, to determine whether soil removal operations were successful and to determine whether groundwater at the site had been impacted.

- Background Boring: One background soil boring was drilled southwest of the missile battery area during Stage 1 to assess background concentrations. An additional boring was installed at the same location during Stage 2 to confirm Stage 1 analytical detections.

- UST B-1: UST B-1 was located north of the composite building and formerly contained #2 diesel fuel (USACE, 1989a). Soil below the tank was noted to be heavily contaminated with petroleum product during tank removal operations. Soils were not excavated (USACE, 1989a). During Stage 1, two soil borings and one monitoring well were installed at UST B-1 to assess soil and groundwater quality.

- Sludge Drying Bed: A sandy, sparse area north of the wastewater treatment lagoon was assumed to be a sludge drying bed during the RI investigation. During the CES, TPH was detected in a near-surface soil sample collected at the site. During Stage 1 and Stage 2, two soil borings and one groundwater monitoring well were installed at the site to assess soil and groundwater quality.

- Wastewater Treatment Lagoon: The wastewater treatment lagoon received domestic and industrial wastewater from the former composite building and assembly and maintenance building (Envirodyne, 1987). During the CES, TPH was detected in soil at the site and low levels of trichloroethene and TPH were detected in groundwater at the site. During Stage 1 and Stage 2, two soil borings and one deep groundwater monitoring well were installed to assess soil and groundwater quality.

- Fuel Depot: The fuel depot is located northwest of the runways and historically consisted of eight underground fuel storage tanks and two or three pump areas. During the CES, TPH was detected in soil collected at the site. Each tank was removed during the USACE's construction removal project. TRPH was detected in soils below some of the tanks removed. During Stage 1 and Stage 2, four soil borings and three groundwater monitoring wells were installed at the site to assess the nature and extent of contamination at the fuel depot.

- UST C-4: UST C-4 was located southeast of the former composite building. TPH was detected in the near-surface soil sample collected above the tank during the CES. In addition, trichloroethene was detected in the groundwater sample collected from a well downgradient of UST C-4 (the well is also downgradient of the wastewater treatment lagoon). During tank removal operations, TRPH was detected in the soil sample collected below the tank. A degreaser-like odor was noted to be emanating from the tank excavation during removal operations. During Stage 1, one monitoring well was installed at the former tank location to assess groundwater quality at the water table and one deeper groundwater monitoring well was installed adjacent to the well in which trichloroethene was detected.

- Groundwater monitoring wells MW09 and MW10 were installed between the fuel depot area and missile battery area to provide information on the direction and gradient of groundwater migration across the former installation. Samples were collected from these wells to obtain groundwater quality information. One well installed during the CES (RG-1 or MW01) was not installed in an area directly downgradient of a potential source area. However, groundwater levels and groundwater samples were obtained from the well during the RI field investigation to gain groundwater migration and groundwater quality information.

Sections 4.2 and 4.3 summarize analytical results for soil and groundwater samples collected during Stage 1 and Stage 2.

4.2 Summary of Analytical Detections in Soil

This section summarizes analytical results for soil samples collected at each of the sites investigated during Stage 1 and Stage 2. During the RI field investigation, several compounds associated with laboratory and/or field contamination were detected in soil samples analyzed. These constituents are discussed at length in the site-specific reports in Appendix A. In summary, the following compounds were generally found to be the result of laboratory and/or field contamination: methylene chloride, acetone, carbon disulfide, 2-butanone, styrene, chloroform, toluene, and phthalate esters.

The following paragraphs summarize soil analytical results for each of the sites investigated, excluding suspected field and/or laboratory contaminants.

4.2.1 Summary of Analytical Results for Soil Collected at USTs C-1 and C-2

Soils collected at USTs C-1 and C-2 were analyzed for VOCs, SVOCs, and TPH. Pentachlorophenol (PCP) was detected below the quantitation limit in soil samples collected from 5 and 25 feet below surface in the UST C-1 boring. The maximum concentration of PCP detected was 78 micrograms per kilogram. No other constituents were detected at UST C-1. Chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, and phenanthrene were detected below the quantitation limit in soil samples collected from 20 and 25 feet below surface in the UST C-2 boring. No other constituents were detected at UST C-2.

PCP is used as a wood preservative, and in manufacturing insecticides, algicides, herbicides, and fungicides. It can be found in air, water, and soil as the result of agricultural runoff or as a contaminant from wood preservation. Chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, and phenanthrene are associated with diesel fuel, jet fuel, heating oil and other heavier petroleum fractions. As a result, these compounds may exist in soils at UST C-2 as a result of previous tank leaks.

The vertical extent of these constituents is not known but is estimated to be approximately 25 feet since constituent concentrations were relatively low in the samples collected at 25 feet. In addition, these compounds were not detected in the groundwater samples collected from downgradient monitoring wells (see Section 4.3.1). The ARARs analysis in Sections 4.4 and 4.5 evaluates the compounds detected to determine whether remediation of soil will be necessary.

4.2.2 Summary of Analytical Results for Soil Collected at the Transformer Pad

Soils collected at the former transformer pad were analyzed for TRPH during Stage 1. TRPH was detected between 33 and 79 milligrams per kilogram in soil samples collected from the Stage 1 boring at 5, 10, 15, 20, and 25 feet below surface. In order to determine the nature of the TRPH constituents detected, Stage 2 samples were analyzed for VOCs, PCBs, and pesticides. No PCBs or pesticides were detected. 1,1,1-Trichloroethane (TCA) was detected in all soil samples collected from the Stage 2 boring. The maximum concentration detected was 6 micrograms per kilogram in the sample collected from 10 feet below surface and the minimum concentration detected was below the quantitation limit at 4 micrograms per kilogram in the samples collected from 20, 35 and 45 feet below surface. The Stage 2 boring was drilled and sampled to a total depth of 45 feet.

Based on these analytical results, it is apparent that residual contamination exists at the former transformer pad even though soils were excavated during the USACE construction removal project. Concentrations detected in soil are relatively low, however, and no constituents were detected in the groundwater sample collected downgradient of the site (see Section 4.3.2). Detections of TRPH and TCA are considered in the ARARs analysis in Sections 4.4 and 4.5 to determine whether remediation of soil will be necessary based on the presence of these constituents at the former transformer pad.

4.2.3 Summary of Analytical Results for Soil Collected at the Background Boring Location

Soil samples collected during Stage 1 were analyzed for VOCs, SVOCs, and TPH. Samples collected during Stage 2 were analyzed for VOCs and TAL metals. TCA was detected in the soil samples collected from 5 and 25 feet below surface at concentrations of 10 and 14 micrograms per kilogram, respectively. Tetrachloroethene (PCE) was detected below the quantitation limit in the sample collected from 25 feet below surface at a concentration of 4 micrograms per kilogram. Samples collected from the Stage 2 boring were analyzed for

VOCs to confirm the presence of TCA and PCE in soils at the background boring location. TCA was detected below the quantitation limit in Stage 2 soil samples collected at depths of 10 and 25 feet at concentrations of 2 and 4 micrograms per kilogram, respectively. PCE was not detected in the Stage 2 samples collected. As a result, PCE is not expected to occur at significant concentrations at the background boring location, if at all.

The vertical extent of TCA and PCE appears to be approximately 25 feet at the background boring location since these compounds were not detected in soil samples collected from 30 feet during Stage 1 and Stage 2 sampling rounds. TCA and PCE are evaluated in the ARARs analysis to determine whether remediation is necessary.

In the Stage 1 boring, phenanthrene, pyrene and chrysene were detected below the quantitation limit at 22, 26, and 27 micrograms per kilogram, respectively, in the duplicate sample collected 15 feet below surface. These compounds were not measured in any other samples, including the corresponding environmental sample. Phenanthrene, pyrene and chrysene are constituents that are associated with heavier fractions of petroleum hydrocarbons such as diesel fuel, jet fuel, kerosene, and heating oil. These compounds are assessed further in the ARARs analysis in Sections 4.4 and 4.5 to determine whether remediation is necessary.

Soil samples collected at the background boring during Stage 2 were analyzed for TAL metals to establish background metals concentrations at the former installation. The concentration of the metals detected in soils at the background boring location are summarized in Table 4-1. Soil samples collected from the wastewater treatment lagoon and the sludge drying bed were also analyzed for metals.

The Geotechnical Sampling and Support Unit of the Waste Management Division of the Michigan Department of Natural Resources has prepared a "Michigan Background Soil Survey" report which identifies background metals concentrations in soils throughout Michigan (DNR, 1991). Data in the report can be used for comparative purposes but cannot be used to establish cleanup levels (DNR, 1991).

Metals concentrations detected in the background boring were compared with levels reported by the Department of Natural Resources for metals in sand in the Michigan Glacial Lobe

Table 4-1
Metals Concentrations in Background Boring and DNR Mean

Metals	Michigan Glacial Lobe Mean Concentrations (mg/kg)	BOM-BB-SB15 Range of Detections in the Background Boring (mg/kg)
Aluminum	1317	450 - 1000
Antimony		<20
Arsenic	0.8	ND - 0.3
Barium	10.5	3.6 - 7.9
Beryllium		ND
Cadmium	0.6	ND
Calcium		150 - 220
Chromium	5.5	ND - 1.5
Cobalt	2.5	ND
Copper	8.1	ND - 1.3
Iron	1630	880 - 1500
Lead	16.3	0.36 - 0.78
Magnesium		130 - 290
Manganese	199.3	18 -23
Mercury	0.04	<0.05
Nickel	7.2	<4
Potassium		<200
Selenium	0.23	<0.20
Silver	0.20	ND
Sodium		37 - 58
Thallium		<50
Vanadium		ND - 3.0
Zinc	15.8	1.8 - 4.5

ND - indicates that the compound was not detected above the detection limit.
Source: Waste Management Division Michigan Department of Natural Resources.

(Table 4-1). As indicated in the table, maximum metals concentrations detected in the background boring were less than the mean metals concentrations reported by the DNR. As a result, metals concentrations detected at the background boring location are considered to be a good, but potentially low, estimation of background metals concentrations at the former installation. Since only one location was used for determining background metals concentrations, it is reasonable to assume that metals concentrations will vary to some degree, either higher or lower, from one location to another across the former installation.

To determine whether metals concentrations detected at the sludge drying bed and the wastewater treatment lagoon were above background metals concentrations measured at the background boring location, the following screening technique was applied:

- When the concentration of a metal was within the same order of magnitude as the background concentration, the metal was considered to be present at background levels.
- When the concentration of a metal was at least one order of magnitude or greater than the background concentration, the metal was identified as being above background concentrations.

Although this process is not a documented screening procedure, it is considered to be a reasonable method of screening metals concentrations for the following reasons:

- The potential for incorrectly identifying metals as being above background concentrations is reduced;
- The order of magnitude difference acts to reduce potential inaccuracies associated with using one location as being representative of background conditions; and
- The order of magnitude criteria acts to reduce potential inaccuracies often associated with laboratory analysis of soils.

Results of this screening process are discussed in Section 4.2.5 for the sludge drying bed and Section 4.2.6 for the wastewater treatment lagoon.

4.2.4 Summary of Analytical Results for Soil Collected at UST B-1

Soils collected east of UST B-1 were analyzed for SVOCs while soils collected from the boring drilled through the former tank location were analyzed for SVOCs and TPH.

Benzo(b)fluoranthene and benzo(a)pyrene were detected below the quantitation limit at 45 and 31 micrograms per kilogram in the 40 foot sample collected east of the former tank location.

Acenapthene, fluoranthene, pyrene and TPH were detected in samples collected from the boring installed through the former tank location. Acenapthene was detected at a maximum concentration of 1,500 micrograms per kilogram, fluoranthene was detected below the quantitation limit at a maximum concentration of 100 micrograms per kilogram, pyrene was detected below the quantitation limit at a maximum concentration of 300 micrograms per kilogram, and TPH was detected at a maximum concentration of 65 milligrams per kilogram. The vertical extent of these constituents appears to be approximately 20 feet since no compounds were detected in the samples collected below 20 feet.

Benzo(b)fluoranthene, benzo(a)pyrene, acenapthene, fluoranthene, and pyrene are associated with heavier petroleum fractions such as diesel fuel, kerosene, jet fuel, and heating oil and are likely present in soils at the site as the result of past tank leaks. The ARARs analysis in Sections 4.4 and 4.5 evaluates these compounds to determine whether remediation of soil will be necessary.

4.2.5 Summary of Analytical Results for Soil Collected at the Sludge Drying Bed

Soils collected at the sludge drying bed were analyzed for VOCs, SVOCs and TAL metals during Stage 1 and VOCs and TAL metals during Stage 2. Toluene and xylene were detected at 5 and 4 micrograms per kilogram, respectively, in the sample collected from 5 feet below surface in the Stage 1 boring. Toluene and xylene were not detected in soil samples collected beyond 5 feet nor in any Stage 2 soil samples. Chloroform was detected below the quantitation limit at 2 micrograms per kilogram in soil samples collected from the Stage 1 boring at depths of 35 and 45 feet. Chloroform was also detected at 7 and 6 micrograms per kilogram in soil samples collected from SB13 at depths of 15 and 20 feet, respectively. Toluene, xylene, and chloroform concentrations are evaluated in the ARARs analysis in Sections 4.4 and 4.5 to determine whether remediation will be necessary based on the presence of these constituents in soil at the sludge drying bed.

Metals concentrations detected in sludge drying bed samples were compared to background concentrations measured in soil samples collected at the background boring location. As described in Appendix A, chromium, lead and mercury were identified as exceeding background concentrations at the former installation.

Chromium was detected at a maximum concentration of 21.1 milligrams per kilogram in the 15 foot sample collected from the Stage 2 boring. Chromium was also detected above background levels at 15.6 and 10.9 milligrams per kilogram in samples collected from 35 and 40 feet in the same boring.

Lead was detected at a maximum concentration of 19 milligrams per kilogram in the 25 foot Lead was detected above background levels in only one other sample at the sludge drying bed at a concentration of 1.7 milligrams per kilogram. The sample was collected from 15 feet below surface in the Stage 1 boring.

Mercury was detected at 0.20 milligrams per kilogram in the 15 foot sample collected from the Stage 1 boring. Mercury was not detected in any other soil samples collected at the sludge drying bed site. As a result, mercury is not expected to pose a threat to human health or the environment.

Chromium and lead are considered in the ARARs analysis in Sections 4.4 and 4.5 and in the BRA and EA in Section 6.0 to determine whether remediation of soil will be necessary based on the presence of chromium and lead in soils at the sludge drying bed.

4.2.6 Summary of Analytical Results for Soil at the Wastewater Treatment Lagoon

Soil samples collected at the wastewater treatment lagoon were analyzed for VOCs, SVOCs, and metals during Stage 1 and VOCs and metals during Stage 2. Pentachlorophenol was detected below the quantitation limit at 300 micrograms per kilogram in the Stage 1 soil sample collected from 25 feet below surface. Pentachlorophenol was not detected in other soil samples collected at the wastewater treatment lagoon. However, pentachlorophenol could not be established as a laboratory or field contaminant, and, as a result, pentachlorophenol is considered in the ARARs analysis in Sections 4.4 and 4.5 and in the BRA and EA in Section 6.0 to determine whether remediation of soils at the site will be necessary based on the detection of pentachlorophenol.

Chromium was detected at a maximum concentration of 27.3 milligrams per kilogram in the 20 foot sample collected from the Stage 2 boring. Chromium was also detected above the background level at 24.5 milligrams per kilogram in the 15 foot sample collected from the same boring. Chromium is considered in the ARARs analysis in Sections 4.4 and 4.5 and in the BRA and EA in Section 6.0 to determine whether remediation will be necessary based on the detection of chromium above background levels in soils at the site.

4.2.7 Summary of Analytical Results for Soil Collected at the Fuel Depot

Soil samples collected at the fuel depot during Stage 2 were analyzed for BTEX and TPH. TPH was detected at 1.9 milligrams per kilogram in samples collected from 30 feet below surface in borings SB09 and SB10. TPH was not detected in any other soil samples collected at the site. BTEX was not detected in any of the soil samples collected at the fuel depot. TPH concentrations are evaluated in the ARARs analysis in Sections 4.4 and 4.5 to determine whether soil remediation will be necessary at the fuel depot.

4.2.8 Summary of Analytical Results for Soil Collected at UST C-4

No soil samples were collected at this site in accordance with the USACE's 1989 Scope of Services. TRPH was detected at 210 milligrams per kilogram in the soil sample collected below the tank during USACE tank removal operations. As a result, further investigation of soils at the C-4 site may be necessary. The TRPH concentration measured during tank removal operations is evaluated in the ARARs analysis to determine whether further sampling should be performed.

4.3 Summary of Analytical Detections in Groundwater

This section summarizes analytical results for groundwater samples collected at each of the sites investigated during Stage 1 and Stage 2. During the RI field investigation, several compounds associated with laboratory and/or field contamination were detected in the groundwater samples analyzed. These constituents are discussed at length in the site-specific reports in Appendix A. In summary, the following compounds were generally found to be the result of laboratory and/or field contamination: methylene chloride, acetone, carbon disulfide, toluene, and phthalate esters.

The following paragraphs summarize analytical results for each of the sites investigated, excluding suspected field and/or laboratory contaminants.

4.3.1 Summary of Analytical Results for Groundwater at USTs C-1 and C-2

The groundwater sample collected from MW06 downgradient of the site was analyzed for VOCs, SVOCs, and TPH. No constituents were detected in this sample. The groundwater sample collected from MW15 downgradient of the site was analyzed for VOCs and PCB/pesticides. No constituents were detected in the sample. As a result, groundwater does not appear to have been impacted at the UST C-1/C-2 site.

4.3.2 Summary of Analytical Results for Groundwater at the Transformer Pad

Monitoring wells MW06 and MW15 were installed at the transformer pad site. Groundwater samples collected from MW06 were analyzed for VOCs, SVOCs and TPH. Groundwater samples collected from MW15 were analyzed for VOCs and PCBs. As described above, no constituents were detected in the groundwater samples collected from these wells. MW06 is not located directly downgradient of the transformer pad, but MW15 was successfully installed downgradient of the former pad location. As a result, groundwater at the transformer pad does not appear to have been impacted by past site activities.

4.3.3 Summary of Analytical Results for Groundwater at the Background Boring

No groundwater monitoring wells were installed at the background boring location. RG-2 (or MW02) is the nearest downgradient well. Samples collected from this well during Stage 1 were analyzed for VOCs, SVOCs, and TPH. No compounds were identified in the groundwater sample.

4.3.4 Summary of Analytical Results for Groundwater at UST B-1

Monitoring well MW05 was installed at the former location of UST B-1. The groundwater sample collected from this well was analyzed for VOCs, SVOCs, and TPH during Stage 1. No constituents were detected in the groundwater sample. As a result, groundwater at the site does not appear to have been impacted by past tank leaks.

4.3.5 Summary of Analytical Results for Groundwater at the Sludge Drying Bed

Monitoring well MW14 was installed downgradient of the sludge drying bed during Stage 2. The groundwater sample collected from this well was analyzed for VOCs and TAL metals. Lead was detected above background concentrations at a maximum concentration of 11 micrograms per liter in the groundwater sample collected from MW14. This concentration is evaluated in the ARARs analysis in Sections 4.4 and 4.5 and in the BRA and EA in Section

6.0 to determine whether groundwater remediation at the sludge drying bed is necessary to protect human health and the environment.

4.3.6 Summary of Analytical Results for Groundwater at the Wastewater Treatment Lagoon

Monitoring wells RG-3 and MW08 are located downgradient (east) of the wastewater treatment lagoon. MW08 was installed to approximately 75 feet to monitoring groundwater at a deeper interval. Samples collected from these wells during Stage 1 were analyzed for VOCs, SVOCs, and TPH. In addition, the groundwater sample collected from MW03 was analyzed for PCBs and pesticides. During Stage 2, groundwater samples collected from these wells were analyzed for VOCs and TPH. Trichloroethene (TCE) was detected below the quantitation limit at 3 micrograms per liter in the groundwater samples collected from MW08 during Stage 1 and Stage 2 sampling rounds. Although TCE was detected in the groundwater sample collected from RG-3 during the CES, TCE was not detected in the groundwater samples collected from this well during Stage 1 and Stage 2 sampling rounds. TCE was not detected in soil samples collected at the wastewater treatment lagoon. As a result, the origin of TCE in groundwater downgradient of the wastewater treatment lagoon is not known. No other compounds were detected in the groundwater samples collected at the wastewater treatment lagoon. The low detections of trichloroethene are assessed further in the ARARs analysis in Sections 4.4 and 4.5.

4.3.7 Summary of Analytical Results for Groundwater at the Fuel Depot

Four wells have been installed in the vicinity of the fuel depot, RG-4 (MW04), MW11, MW12, and MW13. Groundwater samples collected from RG-4, MW11, and MW12 were analyzed for VOCs, SVOCs, and TPH. The groundwater sample collected from MW13 was analyzed for BTEX and TPH. As shown in Figures 3-6 and 3-7, MW13 is installed directly downgradient of tanks at the fuel depot while RG-4 is installed south of the fuel depot, MW11 is installed northeast of the fuel depot tanks, and MW12 is installed over one quarter mile east of the fuel depot. No constituents were detected in the groundwater samples collected from these wells. Based on this information, groundwater at the fuel depot site does not appear to have been impacted by past tank leaks.

4.3.8 Summary of Analytical Results for Groundwater at UST C-4

Monitoring well MW07 was installed downgradient of the former location of UST C-4 during Stage 1 RI activities. Groundwater collected from this well was analyzed for VOCs, SVOCs, and TPH. No constituents were detected in the groundwater sample. Trichloroethene was detected in RG-3 during the contamination evaluation study and UST C-4 was identified as a potential source. Based on analytical detections for the groundwater sample collected from MW07, UST C-4 does not appear to be the source of TCE contamination.

4.4 ARARs Analysis

This applicable or relevant and appropriate requirements (ARARs) analysis is written in accordance with guidance from the CERCLA Compliance with Other Laws Manual: Interim Final (1988b). It is intended to assist in the selection of remedial actions that meet applicable, or relevant and appropriate requirements of the Resource Conservation and Recovery Act (RCRA), Safe Drinking Water Act (SDWA), Clean Water Act (CWA), Clean Air Act (CAA), and other federal, state, county and local environmental laws. This ARARs analysis is initiated in the Remedial Investigation/Feasibility Study (RI/FS) process to ensure timely identification of pertinent ARARs and assure compliance with all ARARs.

Although the former Air Force Airfield and Bomarc Missile Site is not on the National Priorities List, it was a federal facility and may require federally funded remedial action. Therefore, this ARARs analysis is based on CERCLA guidance documents. The legal basis for applying both federal and state requirements or standards to remedial actions at federal facilities reside in Section 121(d) of the CERCLA of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. The ARARs provision under CERCLA only applies to on-site actions; off-site actions must comply fully with any laws that legally apply to that action. In addition, on-site actions must only comply with the substantive portions of a given requirement, or those that pertain directly to actions or conditions in the environment; on-site activities need not comply with administrative requirements, such as obtaining a permit or record-keeping and reporting as outlined in CERCLA 121(e). Off-site actions must comply with both substantive and administrative requirements.

Identification of ARARs involves a two-part analysis: first, a determination whether a given requirement is applicable; then, if it is not applicable, a determination whether it is nevertheless both relevant and appropriate (EPA, 1988b).

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site (EPA, 1988b).

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal and state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site (EPA, 1988b).

Previous work at the former Air Force Airfield and Bomarc Missile site identified areas where the potential for the release of a regulated substance may have occurred potentially resulting in a threat to the environment and/or human health and safety. The sites investigated are listed below:

- Underground Storage Tanks C-1 and C-2
- Underground Fuel Tank B-1
- Fuel Depot
- Wastewater Treatment Lagoon
- Sludge Drying Bed
- Transformer Pad
- Background Boring
- Underground Storage Tank C-4

This ARARs analysis addresses chemical and location-specific ARARs. Action specific ARARs should be addressed during the feasibility study process, as necessary.

A summary of compounds identified during the Stage 1 and 2 remedial investigations is presented in Table 4-2. This table identifies the compounds detected at the former installation, lists the maximum concentration and media in which the compound was identified, and lists the requisite Michigan state cleanup criteria and maximum contaminant levels.

Table 4-2
Act 307 Type B Draft Cleanup Criteria
Former Air Force Airfield & Bomarc Missile Site
Raco, Michigan

	Groundwater Criteria				Surface Water	Soil Criteria	
	Maximum Concentration Detected	SDWA MCL	SDWA MCLG	Michigan Type B Cleanup Criteria	Criteria Act 245 Rule 57	Maximum Concentration Detected	Michigan Type B Cleanup Criteria
Analytical Parameters	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/kg)	(ug/kg)
Volatile Organic Compounds							
Acetone	30B			700	500	160	14,000
2-Butanone	< 10			350		180	7,000
Carbon Disulfide	48					70B	
Chloroform	< 5	100		6	43	27	120
Methylene Chloride	2JB			5	59	160	100
Styrene	< 5	100p	100		19	47	
Tetrachloroethene	< 5	5p	0	0.7	16	4J	14
Toluene	2J	1000p	1000	800	100	5	20,000
1,1,1-Trichloroethane	< 5	200	200	200	117	14	4,000
Trichloroethene	3J	5	0	3	94	< 5	60
Xylene	< 5	10,000p	10,000	300	59	4J	6,000
Semivolatile Organic Compounds							
Acenapthene	< 10			400		1,500	8,000
Benzo(a)pyrene	< 10			0.003		31J	100
Benzo(b)fluoranthene	< 10			0.003		45J	100
Benzo(k)fluoranthene	< 10			0.003		43J	100
Bis(2-ethylhexyl)phthalate	16			2		71,000B	40
Butylbenzyl Phthalate	< 10			1,400		61J	28,000
Chrysene	< 10			0.003		29J	100
Diethyl Phthalate	79					< 670	
Di-n-butyl Phthalate	< 10			700		71J	14,000
Fluoranthene	< 10			300		100J	6,000
Pentachlorophenol	< 50	1p	0		7.4 (1)	300J	
Phenanthrene	< 10			1		22J	250
Pyrene	< 10			200		300J	4,000
Polychlorinated Biphenyls	< 1	0.5p	0	0.02	0.00002	< 320	1,000
Total Petroleum Hydrocarbons	< 50			3,000 - 5,000		79,000 (2)	100,000
Metals							
Aluminum	3,400	50-200s		Background		1,100,000	Background
Antimony	< 80			Background		410B	Background
Arsenic	1.4	50		0.02 or Background	184	300	0.4 or Background
Barium	59	1,000/2000p	2,000	5,000		10,000	100,000 or Background
Beryllium	< 1			Background		< 300	Background
Cadmium	< 2	10/5p	5	4 or Background	F	< 560	80 or Background
Calcium	[illegible]200			Background		395,000BE	Background
Chromium	39	50/100p	100	100 (3)	3 (3)	27,300	2,000 (3)
Cobalt	< 10			Background		< 4,000	Background
Copper	20	1,000s	1,300	1,000	F	2,500B	20,000
Iron	12,000	300s		Background		2,960,000	Background
Lead	11	50	0	5.0 or Background	F	19,000	Background
Magnesium	1,300			Background		290,000	Background
Manganese	350	50s		Background		30,700	Background
Mercury	3	2/2p	2	2		200	Background
Nickel	32			Background	F	8,800	Background
Potassium	1,800			Background		162,000B	Background
Selenium	< 1	10/50p	50	Background	20	60	Background
Silver	< 5	100s		Background	0.1	< 1,000	Background
Sodium	1,700			150,000		58,000	Background
Thallium	< 300			Background		100	Background
Vanadium	< 8			Background		5,500	Background
Zinc	27	5,000s		1,000	F	9,100	20,000

Source: Michigan Department of Natural Resources (Amended Draft 6/22/90) and John Tatum and Company (September 10, 1991).

Notes: SDWA - Safe Drinking Water Act; MCL - Maximum Contaminant Level; MCLG - Maximum Contaminant Level Goal; s - secondary MCL; p - proposed with effective date of July 30, 1992; and F - formula requires hardness value. For organics: B - identified in associated lab blank; J - estimated below quantitation limit. For inorganics: B - estimated below quantitation limit; E - estimated due to interference. (1) Assumed pH = 7.0 to calculate value for pentachlorophenol. (2) TRPH was detected at a maximum of 79 mg/kg. TPH was detected at a maximum of 65 mg/kg. (3) Values are for Chromium VI.

This ARARs search considered the following federal and State laws and regulations:

- Resource Conservation and Recovery Act (RCRA)
  40 CFR Parts 260-279
- Toxic Substance Control Act (TSCA)
  40 CFR Parts 702-799
- Clean Water Act (CWA)
  40 CFR Parts 104-140
- Safe Drinking Water Act (SDWA)
  40 CFR Parts 141-149
- Underground Storage Tank Regulations (UST)
  40 CFR Part 280
- Superfund Amendments and Reauthorization Act (SARA)
  40 CFR Parts 300-370
- Endangered Species Act
- Wilderness Act
- Michigan Water Resources Commission Act 245
- Michigan Safe Drinking Water Act 399
- Michigan Hazardous Waste Management Act 64
- Michigan Underground Storage Tank Act 423
- Michigan Environmental Responses Act 307
- Michigan Wetland Protection Act 203

4.4.1 Chemical-Specific ARARs

Chemical-specific ARARs address federal and state cleanup standards as they pertain to the compounds and media in which they have been identified in the remedial investigation at the former installation. Chemical-specific ARARs may also be addressed if remedial activities involve the storage, treatment and disposal of hazardous compounds.

RCRA has established criteria by which solid wastes are classified as hazardous. Although RCRA is not an ARAR at this time, it may become applicable if solid waste is removed from the former installation. In such a case, waste would need to be characterized for ignitability, corrosivity, reactivity and toxicity characteristic leaching procedure (TCLP) compounds. If wastes exceed criteria established by RCRA for any of these characteristics, the waste would be classified as a RCRA hazardous waste. Criteria are established in 40 CFR Chapter 261 Subpart C. TCLP criteria are presented in Table 4-3 for reference use during solid waste removal, should such action become necessary.

TSCA establishes limitations on concentrations of polychlorinated biphenyls (PCBs) in soil. Current EPA regulations stipulate that if soil beneath the spill site, in an unrestricted area, contains more that 10 parts per million (ppm) of PCBs, excavation is necessary. PCB analysis was completed during the Stage 1 or 2 investigations but no detections were recorded.

Under the SDWA the EPA has established primary drinking water standards. These regulations establish health-based standards for public water systems and specify maximum contaminant levels (MCLs) and MCL goals (MCLGs) for organic and inorganic compounds. A list of current MCLs and MCLGs is presented in Table 4-2.

The Michigan Water Resource Commission Act (Act 245) which establishes nondegradation of groundwater in usable aquifers rules the following, "the quality of groundwater in all usable aquifers shall not be degraded from local background groundwater quality as a result of a discharge".

The Michigan Environmental Response Act (307) includes cleanup standards that are more restrictive in some cases than the SDWA. Michigan Type B draft cleanup standards are presented in Table 4-2. Michigan Type B cleanup standards for Total Petroleum Hydrocarbons (TPH) in respective media are presented in Table 4-2.

4.4.2 Location-specific ARARs

Location-specific ARARs apply to the storage, treatment and disposal facilities and to the environmental impact of permitted releases. Location-specific ARARs may be pertinent if known endangered species are in contact with contaminated soils at the site. Several bird

Table 4-3
Summary of Toxicity Characteristic Contaminants and Regulatory Levels
Former Air Force Airfield and Bomarc Missile Site
Raco, Michigan

Contaminant	Regulatory Level (mg/L)[+]
Arsenic	5.0
Barium	100
Benzene	0.5
Cadmium	1.0
Carbon tetrachloride	0.5
Chlordane	0.03
Chlorobenzene	100.0
Chloroform	6.0
Chromium	5.0
o-Cresol	200.0[a]
m-Cresol	200.0[a]
p-Cresol	200.0[a]
Cresol	200.0[a]
2,4-D	10.0
1,4-Dichlorobenzene	7.5
1,2-Dichloroethane	0.5
1,1-Dichloroethylene	0.7
2,4-Dinitrotoluene	0.13[b]
Endrin	0.02
Heptachlor (and its hydroxide)	0.008
Hexachlorobenzene	0.13[b]
Hexachloro-1,3-butadiene	0.5
Hexachloroethane	3.0
Lead	5.0
Lindane	0.4
Mercury	0.2
Methoxychlor	10.0
Mehtyl ethyl ketone	200.0
Nitrobenzene	2.0
Pentachlorophenol	100.0
Pyridine	5.0[b]
Selenium	1.0
Silver	5.0
Tetrachloroethylene	0.7
Toxaphene	0.5
Trichloroethylene	0.5
2,4,5-Trichlorophenol	400.0
2,4,6-Trichlorophenol	2.0
2,4,5-TP (Silvex)	1.0
Vinyl chloride	0.2

[+]The regulatory level equals the chronic toxicity reference level times a dilution/attenuation factor (DAF) of 100, unless otherwise noted.
[a]If o-, m-, and p-cresol concentrations cannot be differentiated, the total cresol (D026) concentration is used. Note that D026 was added to the final rule for this purpose, but is not a new constituent.
[b]The quantitation limit (i.e., five times the detection limit) is greater than the calculated regulatory level; thus, the quantitation limit becomes the regulatory level.
Source: 55 FR 11804 and 11815-11816.

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species are known to nest in areas at the site. An endangered species search will be conducted to identify siting at the former installation. Human health may be impacted if downgradient water wells are affected as a result of site conditions.

Other location-specific ARARs may become valid during the feasibility study phase of the investigation if wastes or contaminated material are removed from the site, or if wastes are treated and/or disposed at the site. Potential ARARs at the site may include wetland or flood plain status under the Michigan Wetland Protection Act.

4.4.3 Governing ARARs for Determining Whether Remediation is Necessary at a Site

After reviewing potential ARARs and discussing applicable laws for determining cleanup levels in Michigan, it became clear that the ARAR most directly affecting cleanup levels at the former installation was Michigan Act 307. Administrative Rules for the Michigan Environmental Response Act (1982 PA 307, as amended) are the final result of a process which began in February 1989. Public hearings were first held in May 1989, and on a revised version of the proposed rules in October 1989. The final version was approved by the Joint Committee on Administrative Rules on May 24, 1990. Act 307 rules became effective on July 11, 1990. The rules establish procedures which will guide the cleanup of contaminated sites in Michigan. The rules address the following:

- Part 1 - general provisions; definitions; applicability
- Part 2 - site identification; listing and de-listing
- Part 3 - funding
- Part 4 - alternate water supplies use
- Part 5 - response activities
- Part 6 - selection of the remedial action
- Part 7 - cleanup criteria
- Part 8 - site assessment scoring system

Part 7 of the rules was used in this investigation to determine whether site remediation would be necessary. In Part 7 of Act 307, three types of cleanup criteria are established: type A, B and C. A combination of types may be used at a single site to determine acceptable remedial action as given in Rule 299.5705 (3). Type A, B and C criteria are evaluated in this report to determine whether compliance is attained when a remedial alternative of "no action" is selected.

Type A criteria are attained when constituents detected are below background concentrations or when constituents detected are below method detection limits (Rule 299.5707). The majority of analytes were below method detection limits. As a result, compliance with type A criteria was attained for those analytes not detected above method detection limits. For those constituents that were detected above method detection limits, type B criteria were applied.

Type B criteria are attained when the degree of cleanup provides hazardous substance concentrations that do not pose an unacceptable risk on the basis of standardized exposure assumptions and acceptable risk levels (Rules 299.5709 and 299.5715). Type B criteria are specified for surface water, air, soils, and groundwater in an aquifer. These criteria are discussed below.

Type B criteria for surface water are attained when hazardous substance concentrations in groundwater do not naturally discharge to surface water at levels exceeding limits established by Michigan Act 245. Constituent concentrations detected in groundwater are compared to Act 245 surface water protection limits in Table 4-2. As indicated, all constituents detected in groundwater are below Act 245 criteria. As a result, compliance with type B criteria for surface water is considered attained.

Type B criteria for air quality are attained when hazardous substances emitted from a site are below concentrations established by Michigan Act 348. Air quality criteria are not evaluated quantitatively in this report because air quality data was not collected at the sites investigated. However, emissions of hazardous substances at levels exceeding air quality criteria is not likely at the former installation because concentrations detected in subsurface soils were relatively low. In addition, future plans for the former installation allow for its use as a recreational and training facility only. As a result, compliance with type B criteria for air quality is considered attained.

Type B criteria for soil are attained when concentrations in soil do not exceed the following:

- levels required to protect surface water;
- levels required to protect against unacceptable risk through inhalation of contaminants in, or released from, soil;

- levels required to protect aquifers from the effects of contaminants in soil;
- levels required to protect against unacceptable risk through direct contact with contaminants in soil; and
- levels required to protect uses of soil as a resource.

No surface water bodies are situated within one mile of the former installation and surface water runoff is expected to be minimal due to the permeable nature of surface soils at the site. In addition, compounds detected at the former installation were at relatively low concentrations. As a result, levels to protect surface water from constituents in soils are considered attained.

As described above and in the BRA, constituents detected in subsurface soils at the site are not expected to exceed Act 348 air quality criteria and are not likely to pose an unacceptable risk under current or future use scenarios. As result, levels required to protect against unacceptable risk through inhalation of contaminants in, or released from, soil are considered attained.

To assure that constituents in soil do not pose a threat of aquifer contamination, the concentration of the hazardous substance in soil is to be below that which produces a concentration in leachate that is equal to the highest of the groundwater criteria. Leachate testing is not required to demonstrate compliance if the total concentration of a hazardous substance in soil does not exceed 20 times the criteria specified for groundwater in an aquifer (see below). Maximum concentrations of the constituents detected in soil at the former installation are presented in Table 4-2. Concentrations are compared to criteria that is 20 times the groundwater criteria. If criteria for dermal or resource protection are lower than the 20 times the groundwater criteria, these values are substituted as the soil type B cleanup criteria. If compliance with type B criteria for soils was not attained, type C criteria was applied.

Type B criteria for groundwater in an aquifer are attained when:

- the concentration of the hazardous substance in an aquifer does not exceed the *lowest* of the following:

- for a carcinogen acting by a threshold or a nonthreshold mechanism, the concentration which represents an increased cancer risk of 1 in 1,000,000 calculated according to procedures given in Rule 299.5723. These concentrations have been calculated for many constituents by the Michigan DNR and are provided in Table 4-2 as type B cleanup criteria for groundwater.

- for a hazardous substance which is not a carcinogen, a genotoxic teratogen, or a germ-line mutagen, the concentration which represents the human life cycle safe concentration calculated according to the procedures in Rule 299.5725, except as given in the two following requirements. These concentrations have been calculated for many constituents by the Michigan DNR and are provided in Table 4-2 as type B cleanup criteria for groundwater.

- for a hazardous substance which has a secondary maximum contaminant level, that level. Secondary maximum contaminant levels are provided in Table 4-2.

- for a hazardous substance which imparts adverse aesthetic characteristics to groundwater, the concentration which is documented as the taste or odor threshold or the concentration below which appearance or other aesthetic characteristics are not adversely affected. When these levels are less than the criteria listed above, they become the type B groundwater cleanup criteria listed in Table 4-2.

- The point of exposure is considered at any point in the aquifer. In this report, the point of exposure for constituents in groundwater was assumed to be at the location where the constituent was detected.

- For groundwater not in an aquifer, type B soil cleanup criteria shall be applied. Groundwater at the site is considered to be in an aquifer because the groundwater bearing zone is a geological formation capable of yielding a significant amount of groundwater to wells in the vicinity of the site. This is verified by the use of groundwater in the glacial deposits as a domestic and agricultural water supply in the vicinity of the former installation. As a result, this groundwater criteria is not considered applicable at the former installation.

Maximum concentrations of the constituents detected in groundwater are summarized in Table 4-2. If concentrations exceeded type B cleanup criteria for groundwater, type C criteria were applied.

Type C cleanup criteria are attained when the degree of cleanup provides hazardous substance concentrations that do not pose an unacceptable risk on the basis of a site-specific risk assessment (Rule 299.5717). In general, type C criteria are attained when an RI report, BRA, and EA show no adverse consequences of constituents detected in affected media in the event no further remedial action is implemented.

By applying type B criteria first, the majority of constituents detected were removed from further study in the RI, BRA, and EA. A focused evaluation of contaminant fate and transport and risk assessment can be performed for those constituents not in compliance with type B criteria to determine whether compliance with type C criteria is attained. As expected, non-compliance with type B criteria generally results in non-compliance with type C criteria. However, in some cases, compliance with type C criteria is possible even though compliance with type B criteria cannot be attained. This is primarily the result of the highly protective nature of type B criteria.

4.5 Comparison of Detections with ARARs

The site-specific reports in Appendix A compare each of the constituents detected in soil and groundwater at a given site with type B cleanup criteria. The following paragraphs summarize findings of these comparisons.

4.5.1 Underground Storage Tanks C-1 and C-2

Chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, and phenanthrene were well below type B cleanup criteria for soil. As a result, cleanup of soils at the site will not be necessary for these constituents. Type B criteria for pentachlorophenol have not been established by Michigan. As a result, this compound is assessed further in Sections 5.0 and 6.0 to evaluate potential risks associated with PCP in soils at the site. No constituents were detected in downgradient water samples.

4.5.2 Transformer Pad

TCA was detected in soil well below type B cleanup criteria. Type B cleanup criteria have not been established for TRPH. However, the type B cleanup level for TPH has been established at 100 milligrams per kilogram in soil. TRPH was detected at the site. TRPH concentrations can be compared to TPH criteria because TRPH is a measure of total petroleum hydrocarbons and includes those compounds that would be detected during TPH analysis. As a result, TRPH concentrations are expected to be higher than TPH concentrations. Since TRPH concentrations in soils collected at the transformer pad were below the TPH cleanup criteria, compliance with type B criteria is considered attained for TRPH at the site. No constituents were detected in downgradient monitoring wells. Based on these results, further remediation at the transformer pad does not appear necessary.

4.5.3 Background Boring

PCE, TCA, phenanthrene, pyrene and chrysene concentrations detected in soil samples collected at the site were well below type B cleanup criteria for soils. No constituents were detected in the groundwater sample collected downgradient of the background boring location. Based on this information, remediation at the background boring is not considered necessary.

4.5.4 Underground Storage Tank B-1

Acenapthene, fluoranthene, pyrene, benzo(b)fluoranthene, benzo(a)pyrene, and TPH concentrations detected in soil samples collected from the site were well below type B cleanup criteria for soils. No constituents were detected in the groundwater sample collected at the site. As a result, further remediation at the site is not considered necessary.

4.5.5 Sludge Drying Bed

Toluene, xylene and chloroform concentrations detected in soil samples collected at the site were well below type B cleanup criteria for soil. Chromium and lead were detected above background concentrations in soil samples collected at the site and above type B criteria. Chromium and lead are assessed further in Sections 5.0 and 6.0 to determine the risk posed by the presence of these constituents in soil at the site. Lead was detected above type B cleanup criteria for groundwater. This constituent is also assessed in Sections 5.0 and 6.0.

4.5.6 Wastewater Treatment Lagoon

Pentachlorophenol was detected in soil at the wastewater treatment lagoon. As described in Section 4.5.1, a type B cleanup level has not been established for this compound. Pentachlorophenol is assessed further in Sections 5.0 and 6.0 to evaluate potential risks associated with its presence in soils at the site. TCE was detected in the groundwater samples collected from the deep well downgradient of the wastewater treatment lagoon. Concentrations do not exceed type B cleanup criteria.

4.5.7 Fuel Depot

TPH was detected in soils at the site well below type B cleanup criteria. In addition, no constituents, excluding potential laboratory or field contaminants, were detected in groundwater samples collected at the site. Based on this information, further remediation of the site is not considered necessary.

4.5.8 Underground Storage Tank C-4

Soil samples were not collected at the site during Stage 1 and Stage 2 investigations. TRPH was detected in soil at the site above the type B cleanup criteria for TPH during tank removal. No constituents were detected in the groundwater sample collected downgradient of the site. As a result, groundwater remediation is not necessary. Further investigation of soils at the site may be warranted, but the Michigan Department of Natural Resources should be consulted for the final determination.

5.0 Contaminant Fate and Transport

Results of the site physical characteristics, source characteristics, and extent of contamination analyses are typically combined in the analyses of contaminant fate and transport. A contaminant fate and transport analysis can include an evaluation of the potential routes of migration, contaminant persistence, and contaminant migration. Information resulting from the contaminant fate and transport analysis is used in the BRA and EA to characterize the risk associated with constituents detected in environmental media at a site. As discussed in Section 4.0, many of the constituents detected at the former Air Force Airfield and Bomarc Missile Site are below Michigan Act 307 type B cleanup criteria. These constituents are not assessed in this contaminant fate and transport analysis.

Constituents that exceed type B cleanup criteria or constituents that could not be evaluated under type B criteria due to the absence of cleanup levels are evaluated in the following section and in the BRA and EA in Section 6.0. In addition, Appendix A provides site-specific information.

5.1 Constituents Considered in the Contaminant Fate and Transport Analysis

Section 4.0 describes the comparison of constituents detected at sites at the former Air Force Airfield and Bomarc Missile Site with Michigan Act 307 cleanup criteria. The following constituents were identified above type B cleanup criteria and are considered in the contaminant fate and transport analysis and in the BRA and EA:

- Pentachlorophenol (PCP)
- Chromium
- Lead

5.2 Contaminant Fate and Transport Analysis for Selected Compounds

PCP was detected below the quantitation limit at 69 and 78 micrograms per kilogram in samples collected from 5 and 25 feet below surface at UST C-1. PCP was not detected in other samples collected at the UST C-1/C-2 site. PCP was also detected in one soil sample collected at the wastewater treatment lagoon. The sample was collected from a depth of 25 feet and had a PCP concentration of 300 micrograms per kilogram. PCP was not detected in any of the groundwater samples collected at the former installation.

PCP is used in manufacturing insecticides, algicides, herbicides, and fungicides. It is also used as a wood preservative and can be found in air, water, and soil as the result of agricultural runoff or its use in wood preservation.

PCP is relatively soluble and may be expected to migrate to groundwater over a period of time. However the concentration would be decreased by degradation, attenuation, and dilution during transport through vadose zone soils to groundwater. Concentrations at the water table would thus be lower than the concentration detected in soil at 25 feet. PCP was detected at relatively low concentrations in soil, below the quantitation limit, and if or when it reaches groundwater it is not expected to do so in significant concentrations.

Chromium was detected above type B criteria for hexavalent chromium in soil samples collected at the wastewater treatment lagoon and at the sludge drying bed. Hexavalent chromium was not analyzed because Act 307 criteria had not been promulgated at the time of proposal acceptance for this project. Chromium was detected at a maximum concentration of 21.1 milligrams per kilogram in a sample collected from the sludge drying bed and at a maximum concentration of 27.3 milligrams per kilogram in a sample collected from the wastewater treatment lagoon. The background concentration of chromium in soil at the former installation is estimated to be approximately 1.5 milligrams per kilogram. The mean concentration for chromium in sand in the Michigan Glacial Lobe which includes the former installation is 5.5 milligrams per kilogram and the 95% confidence level concentration is estimated to be 16.1 milligrams per kilogram (DNR, 1991). From this information, it is evident that chromium concentrations at the wastewater treatment lagoon exceed background levels. However, under normal conditions, chromium is relatively immobile in soils and would not be easily leached to groundwater. Chromium was not detected above type B criteria in any of the groundwater samples analyzed for inorganic constituents. As a result, chromium concentrations detected at the site may be within acceptable levels.

Lead was detected at a maximum concentration of 19 milligrams per kilogram in a 25 foot soil sample collected from the sludge drying bed and at a maximum concentration of 11 micrograms per liter in the groundwater sample collected downgradient of the sludge drying bed.

The background concentration of lead measured at the former installation was 0.78 milligrams per kilogram for soil and less than 5 micrograms per liter for groundwater. The mean concentration for lead in sand in the Michigan Glacial Lobe is 16.3 milligrams per kilogram and the 95% confidence level concentration is estimated to be 37.1 milligrams per kilogram (DNR, 1991). As indicated, lead in soil at the sludge drying bed may be within acceptable limits even though lead exceeds background concentrations at the former installation. Under normal conditions, lead is relatively immobile in soils and would not be easily leached to groundwater.

The detection of lead in groundwater may be the result of past site uses since lead was detected above background concentrations in soil at the sludge drying bed.

Section 6.0 evaluates the risk associated with the presence of pentachlorophenol, chromium and lead in soil, and the presence of lead in groundwater to determine whether remediation is necessary at the site.

Further testing may be necessary to determine whether lead and chromium in soil will leach to groundwater at unacceptable levels. The Michigan Department of Natural Resources should be contacted to determine whether concentrations of lead and chromium in soil are present at unacceptable levels. If additional soil sampling is required, samples should first be analyzed for hexavalent chromium to determine whether type B cleanup levels for hexavalent chromium in soils are attained. If type B criteria are attained for hexavalent chromium, no further assessment of chromium will be necessary. Otherwise, soil samples should be analyzed for the lead and chromium using the toxicity characteristic leaching procedure (TCLP). See Appendix A5.0 and A6.0 for site specfic information at teh sludge drying bed and wastewater treatment lagoon, respectively.

6.0 Baseline Risk Assessment

Goals. This section comprises the Baseline Risk Assessment (BRA) and Environmental Assessment (EA) for the former Air Force Airfield and Bomarc Missile site. The primary goal of this section is to use selected data to conduct a quantitative risk assessment for human health exposure. Chemical data to be included in this section is based on the ARARs analysis provided in section 4.0.

This section presents the rationale and methodology used to estimate whether the suspect contaminants at the identified sites present excess risk to human or environmental receptors. Excess risk will be assessed for current and potential future use of facility land assuming "no further action" is carried out. Existing information on the location of rare, threatened and endangered species is used to conduct a qualitative environmental assessment.

To carry out the BRA and EA this section will proceed as follows:

- identify exposure pathways,
- characterize potential receptors,
- develop a conceptual model which incorporates source, release, pathway and receptor analysis,
- evaluate pathways for viability (i.e., is a path to the receptor complete and representative of "real world" conditions).
- evaluate data provided for use in the BRA and EA, and
- conduct exposure assessments on viable pathways.

A review of source areas, contaminants of concern, and release mechanisms is provided in Sections 4.0 and 5.0. Information contained in these sections is used in this BRA and EA.

6.1 Identification of Exposure Pathways

The identification of exposure pathways is accomplished by characterizing mechanisms that may transport chemical constituents to various environmental media. Exposure pathways are typically evaluated in the following order: air, surface soil, surface water and groundwater. Once the constituent is in an environmental media, it can be evaluated for its potential to expose humans or environmental receptors. The conventional routes of human exposure to contaminants in environmental media at the exposure point are inhalation, ingestion and direct contact (dermal exposure). Routes of human exposure at the former facility correspond to the following pathways:

- Inhalation of airborne contaminants (particulate or vapors).
- Ingestion of food and water or incidental ingestion of soil.
- Direct contact (dermal exposure) with soil, sediment or water.

Exposure pathways for ecological receptors are considered when contaminants reach surface water or sediment. Surface water and sediment are primarily responsible for food chain contamination due to impact on macro and microinvertebrates. It is not within the scope of this section to evaluate the impact for ecological receptors. This is not practical due to the low levels of contaminants at the site and the lack of specific data on kind, numbers and species of local fauna. The EA is limited to a discussion of potential impact and therefore a review of critical habitat and species of concern.

6.1.1 Current and Future Land-Use

Evaluation of pathways require the evaluation of current and future exposure scenarios that include accessibility to the site. Potential on-site occupational exposures could occur during excavation or other construction activity that disturbs soils. Currently, land at the former facility is leased by a testing company that uses runways for motor vehicle and tire testing. The property is also used recreationally for hunting and hiking. Construction of buildings is unlikely to occur. The military and National Guard occasionally conduct training exercises at the former facility. Roger Jewel of the U.S. Forest Service stated that future use within the facility is unlikely to be different than current use. Residential development will not occur except in special circumstances. For example, residential development of the national forest is only allowed within 1/4 mile of a public roadway intersection if there is existing housing.

6.1.2 Specific Pathways

Ambient Air. Exposure via release to ambient air may occur when a receptor inhales volatile emissions or particulates released from contaminated soil. Surface soils can be mobilized by wind erosion, vehicular traffic, or soil disturbance.

Contaminated groundwater can also release volatile compounds to air, especially during domestic use, when used for showers.

Surface Soil. Surface soil can be a source of exposure through volatilization of VOCs, airborne particulates or soil ingestion. Ingestion is primarily a concern for small children.

Ground Water. Ground water is used in the surrounding rural area for residential use. Exposure pathways are domestic use of ground water including ingestion, bathing and showering, irrigation of vegetable gardens, and laundering of clothing. Exposure could occur through inhalation of volatilized constituents, ingestion of vegetables and by dermal contact.

Surface Water. Surface water can be a pathway via ingestion of water, consumption of fish, dermal contact during swimming or wading, and inhalation of vapors off-gassing from the water. Ingestion is a minor route and is primarily limited to occasional swallowing of water while swimming.

6.2 Characterization of Potential Receptors

Potential receptors for contaminants at the former facility are human receptors that work at the site or live in the vicinity, and ecological receptors.

6.2.1 Human Receptors

Potentially exposed populations at the former facility can be described in terms of current land use and future land use. Current land use is primarily national forest with some use by leasees, and the military as described above. Receptors to be considered for present and future use are residents outside the boundaries of the facility, recreational users of the former facilities grounds, military personnel, and leasees of the grounds.

In order to present a conservative assessment that is protective of human health and the environment, "worst case" exposure assessments were calculated. If risk is not present under worst case conditions, it is logical to conclude that no further action is needed at the facility.

6.2.2 Ecological Receptors

Ecological receptors to be considered are local flora and fauna. The primary areas of interest are nearby streams. The EA includes the latest available information on critical habitat, local wildlife, and rare, threatened and endangered species.

6.3 Source - Pathway - Receptor Model

Constituents in soil and groundwater are a potential source for human and biotic receptors, provided a pathway and exposure route exist. As shown in Figure 6-1 and 6-2, contaminants could reach potential receptors via one or more of the following mechanisms:

- Dust and/or volatile emissions into the air. Release of VOCs from the soil surface to air is a possibility due to the presence of VOCs. Potential receptors of VOCs are primarily the leasee or recreational users.

- Infiltration or percolation of surface contaminants into ground water. There is a potential for soil contaminants to migrate through the vadose zone to ground water. Groundwater is currently used for residential use beyond the property line. The facility production well is not used for consumption by the leasee.

- Discharge of groundwater to surface water. Aquatic biota may ingest or absorb constituents carried to surface water and deposited in sediments. Predators may be exposed to biomagnified constituents.

- Direct contact with constituents in soil. The potential for direct contact with surface soils is a possibility for workers and recreational users of the property. A worst case assessment will be conducted by assuming child exposure to soil.

6.4 Evaluation of Pathways for Viability

6.4.1 Ambient Air

Ambient air can be impacted by volatile emissions or via soil particulates suspended by wind, vehicles or construction activity. The primary source of these impacts are surface soils.

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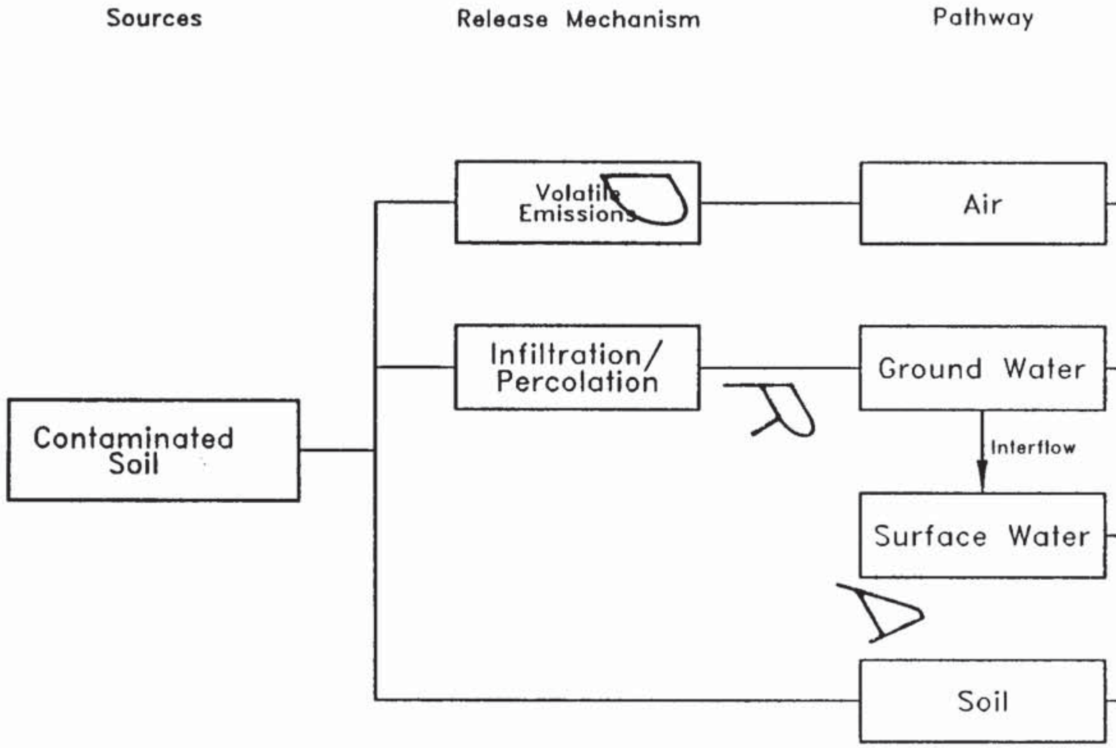

Potential Receptors

Pathway	Exposure Route	Human: Workers	Human: Local Residents	Biota: Terrestrial	Biota: Aquatic
Air	Ingestion				
	Inhalation (VOCs)	●	●		
	Dermal Contact				
Ground Water	Ingestion		●		
	Inhalation (VOCs)		●		
	Dermal Contact		●		
Surface Water	Ingestion			●	●
	Dermal Contact				●
Soil	Ingestion		●		
	Inhalation (VOCs)	●			
	Dermal Contact	●			

——— Current pathway exists.

● Current Potential Receptor

Figure 6-1

Conceptual Model for Sites with Contaminated Soil

Former Air Force Airfield and BOMARC Missile Site
Raco, Michigan

prepared for

U.S. Army Corps of Engineers
Omaha, Nebraska
Contract DACW45-88-D-0008

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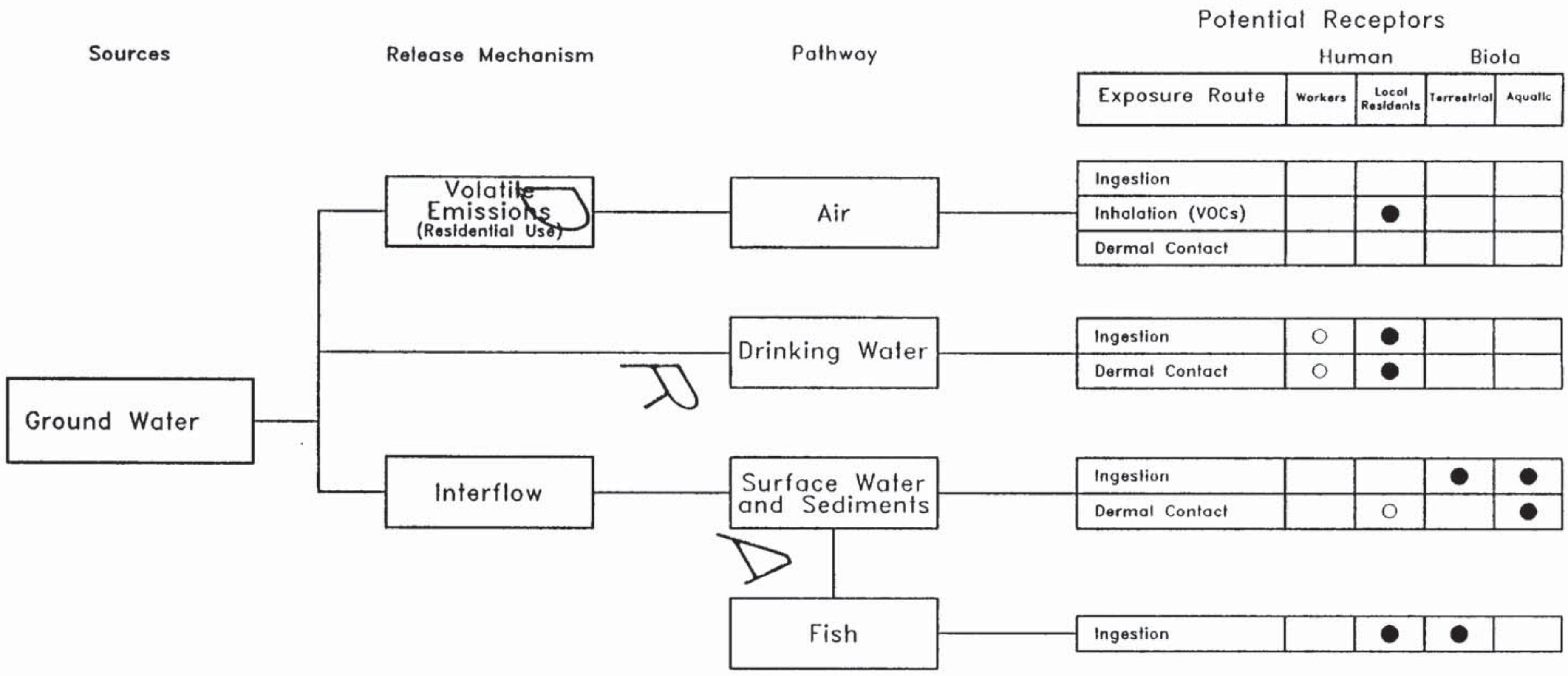

Current pathway exists.

● Current Potential Receptor

○ Future Potential Receptor

Figure 6-2

Conceptual Model for Sites with Ground Water Contamination

Former Air Force Airfield and BOMARC Missile Site
Raco, Michigan

prepared for

U.S. Army Corps of Engineers
Omaha, Nebraska
Contract DACW45-88-D-0008

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Since surface soil data was not collected during the RI, a reasonable assessment of this pathway cannot be made.

6.4.2 Surface Soil

Surface soil is a viable pathway for occupational and recreational users of the former facility. Occupational exposures via dust inhalation may occur to employees of the tire testing company that leases part of the facility. Surface soil data was not collected for the RI. However, the Contamination Evaluation Study by Envirodyne collected near-surface samples from 2-4 feet. Exposure to soil via ingestion has a much greater potential for human health impact than inhalation of particulates or volatiles. Therefore, the Envirodyne data is used by default to evaluate the soil pathway.

6.4.3 Surface Water

Because local streams are not utilized for a swimming on a routine basis, and since such use is not likely in the future, the assessment does not consider humans as potential receptors via sediments or surface water. However, an assessment of the potential for impact to wildlife is logical. Fish can bioconcentrate semi-volatile compounds such as pentachlorophenol.

Surface water does not exist within the property. In order for surface water to be a viable pathway, a mechanism must exist for soil or groundwater contaminants to reach surface water. There is a lack of well-defined site drainage patterns, and the nearest stream is Sullivan Creek, which is 3/4 mile from the south end of the airfield. Samples were not collected from surface water for this investigation. Chemicals detected in groundwater were compared to MDNR Surface Water Criteria in Section 4.0, above. Most of the chemicals detected were present at levels lower than the criteria. The status of some chemicals is in doubt because the sample detection limits were higher than the criteria. This is true for pentachlorophenol, PCBs and silver. The maximum level of chromium detected in a monitoring well, 39 ug/L, exceeds the surface water criterion of 3 ug/L for chromium (VI). Unfortunately, the scope of work for the RI included only one water sample for metals. But it should be noted that chromium was detected in only one of ten samples analyzed in the Contamination Evaluation Study, and that detect was in one part of a split sample.

Due to the degradation and dispersion of contaminants which can occur over time and distance, impacts to surface water are judged to be unlikely. Due to the lack of data, the surface water pathway was not selected for inclusion in the risk assessment. However, it appears that potential for impact is slight.

6.4.4 Groundwater

Future use within the property will not include residential development, camp grounds or other uses involving placement of wells for potable water. However, residential use of groundwater occurs at private homes beyond the property line. Therefore groundwater is a viable pathway.

6.5 Data Evaluation (General)

The purpose of this section is to review the analytical database and evaluate data for its applicability and representativeness for the purposes of quantitative risk assessment. This section supplements the discussion of ARARs and selection of constituents of concern found in Section 4.0.

6.5.1 Soil Samples

Contaminants that are relatively water soluble were detected at some depths but not at others in soil samples. Water soluble contaminants would be expected to leach downward with percolating water. Therefore, these constituents were evaluated as potential artifacts of sampling and analysis.

According to the Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (EPA 1989a), non-detects should be considered together with positive detections if a chemical is likely to be present based on site history. A review of chemicals relevant to site history is found in Section 4.0. If a chemical is not detected above the detection limit in any environmental media at a site area (i.e., fuel depot or missile site complex) the chemical was eliminated from the assessment.

6.5.2 Groundwater Samples

Except for common laboratory contaminants (discussed below) there were few monitoring well samples which contained contaminants. Only one well installed for Stage 2, MW14, was sampled for metals. Groundwater samples from the Contamination Evaluation Study contained few detects.

6.5.3 Selection of Chemical of Concern

6.5.3.1 Evaluation of Qualified Data

The IT Analytical Services (ITAS) Laboratory assigned data qualifier codes to sample results as follows:

- J - The compound is present below the detection limit, and the value is estimated
- E - For inorganic chemicals, indicates the value is estimated due to matrix interference.
- U - Compound was analyzed for but not detected.
- B - For organic compounds, the analyte was found in the laboratory blank, as well as in the sample. For inorganic constituents, the concentrations was less than the contract required detection limit.

The EPA recognizes acetone, 2-butanone (methyl ethyl ketone), methylene chloride, toluene and the phthalate esters as common laboratory contaminants. For "B" qualified organic data, the analytical results for these contaminants were validated by multiplying the amount of chemical in any blank by a factor of ten. If the concentration in the sample is not greater than this value, it is eliminated from further consideration. Other B qualified data was validated by multiplying the level in the blank by 5. Data validation is presented in Table 6-1.

6.5.3.2 Frequency of Detection

In some instances, it is appropriate to eliminate a chemical from the assessment based on frequency of detection. A chemical can be eliminated if it is detected infrequently in one or two environmental media and if there is no reason to believe the chemical may be present. For example, bis(2-ethylhexl)phthalate (BEHP) was detected in soil sample BI-SB05-109 at 71,000 ug/kg. The compound is a common laboratory contaminant but this single sample result was not eliminated by data validation at this concentration. The chemical is associated with plastics and landfills and is unlikely to be present in or around a fuel tank. It is likely a result of sample handling or collection and is therefore not included in the risk assessment.

Table 6-1
Validation of Analytical Data
Former Air Force Airfield and Bomarc Missile Site
Raco, Michigan

Volatile Organic Compounds (ug/g)	Max. Concent.	Validation Level (a)	Validation Level (b)
Acetone	11	110	--
2-butanone	6 J	60	--
2-hexanone	8 J	--	40
Methylene Chloride	3 J	30	--
4-methyl-2-pentanone	6 J	--	30
Semivolatile Organic Compounds (ug/L)			
bis(2-ethylhexyl)phthalate	430 J	4300	--
Chrysene	26 J	--	130
Phenanathrene	65 J	--	325
Benzo(a)anthracene	30 J	--	150
2-methylnaphthalane	450	--	2250
Naphthalene	140 J	--	700

Note: J = Below Method Detection Limit, Estimated Value

a Validation level for common laboratory contaminants is 10 times the maximum level in any blank.

b Validation level for other compounds is 5 times the maximum level in any blank.

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6.5.3.3 Laboratory Contamination

Field samples were contaminated with styrene due to a chemical spill at the ITAS laboratory in Cincinnati. It is evident that styrene vapor permeated sample bottle septums. Based on site history there is no reason to believe that styrene would be found at the former facility. Therefore, styrene detections are excluded from the data set for this assessment. A common laboratory contaminant, 2-butanone, was also detected in samples that were contaminated with styrene. The former is also considered an artifact and is excluded from further consideration.

Another potential laboratory contaminant is carbon disulfide. Carbon disulfide was found in a sample, in a sample duplicate and in a field rinsate at RG-3-MW03 for Stage 2. Levels were comparable in all three analyses (46, 48, and 48 ug/l, respectively). In IT's judgement, it is highly unlikely that this level would be found in a field rinsate. In addition, IT project managers have noted that this compound has shown up in other samples analyzed by the ITAS Cincinnati laboratory where the compound's presence could not be explained by site history. For example, carbon disulfide was detected in surface soil at 14 ppm during the investigation of a light house facility on an island in Lake Huron. Although carbon disulfide is not recognized by EPA as a common laboratory contaminant, it is used as an extractant during industrial hygiene analyses. The ITAS Cincinnati does include industrial hygiene analyses in its services. Based on our professional judgement, carbon disulfide is a contaminant that was present in the sample jars or was introduced during sample handling and is not present in environmental media at the former facility. Therefore, the compound is eliminated from further consideration.

Chloroform is also a constituent that is unlikely to be present as detected at the facility. For example chloroform was detected in a soil sample collected from a depth of 5 feet. Chloroform has a vapor pressure of 160 millimeters of mercury at 68 degrees Fahrenheit and would have escaped to the atmosphere over time. Chloroform, like carbon disulfide, has appeared as an anomaly in field samples from other projects analyzed by ITAS Cincinnati. Based on these considerations, chloroform is eliminated from the quantitative risk assessment.

6.5.3.4 Contaminants of Concern

According to EPA guidance, once data is validated and compared with background, a list of chemicals of potential concern is developed for use in the quantitative risk assessment. The number of chemicals to be included was reduced by ARARs analysis in Section 4.0. The contaminants of concern for soil exposure are pentachlorophenol, mercury and lead. The contaminants for groundwater are lead and mercury.

6.6 Exposure Assessment

6.6.1 Exposure Assessment - Soil

Estimated Chemical Intake. Pathway analysis indicates that the identified sites are not a restricted area for local residents. For noncarcinogens, an exposure scenario was selected that is used to evaluate risk at industrial sites (EPA 1989b). This scenario was chosen because it presents a relatively extreme exposure and is therefore an upper-bound estimate of health risk:

> A child with an average body weight of 16 kg visits the site 50 times a year over a 5 year period, and ingests 200 mg of soil per visit. Absorption of chemical in the intestines is assumed to be 100 percent.

The dose ingested over the exposure period is estimated by the following equation:

$$CDI_i = \frac{C_s \times IR \times K \times FI \times EF \times ED}{BW \times AT}$$

Where:

CDI_i = chronic daily intake in milligrams per kilogram per day (mg/kg-day),
C_s = chemical concentration in soil (mg/kg),
IR = soil Ingestion Rate (200 mg/site visit),
K = soil conversion factor (1 kg/10^6 mg),
FI = Fraction Ingested or soil ingestion absorption factor (1.0 unitless),
EF = Exposure Frequency (50 visits/year),
ED = Exposure Duration: 5 years

BW = Body weight, child, (16 kg) and
AT = Averaging time, 250 days.

Maximum contaminant levels detected were used for C_s. The result for chromium (VI) is a CDI_i of 3.06×10^{-5}. The CDI_i for the other chemicals is shown in Table 6-2.

Dermal exposure is not evaluated for two reasons: absorption factors for selected chemicals is low or negligible, and the ingestion scenario selected is sufficiently conservative to be protective of human health.

6.6.2 Exposure Assessment - Groundwater

Pathway analysis indicates that domestic use of groundwater from private wells is a valid concern. In order to conduct a worst-case assessment, maximum levels of constituents in monitoring wells were used in the exposure assessment. If the estimated risk using these concentrations is slight, it is logical to conclude that potential risk beyond the property line is not a concern. Due to degradation and dispersion of constituents in the aquifer, levels at the property line could be expected to be lower by an order of magnitude.

For groundwater ingestion, the following algorithm is used.

$$CDI_i = \frac{C_w \times IR \times EF \times ED}{BW \times AT}$$

Where:

CDI_i = Chronic Daily Intake via ingestion in mg/kg-day
C_w = Concentration in groundwater
IR = Ingestion Rate (2 liters per day)
EF = Exposure Frequency (365 days/yr)
ED = Exposure Duration (30 years)