Final

Monitoring Report
for the
Deep Bedrock Well Installation in the Basal Sharon Conglomerate

Ravenna Army Ammunition Plant
Ravenna, Ohio

Contract No. W912QR-04-D-0028
Delivery Order No. 0001

Prepared for:

United States Army Corps of Engineers
Louisville District

Prepared by:

SAIC Engineering of Ohio, Inc.
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May 21, 2010

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14. ABSTRACT

This monitoring report documents the completion of installation and monitoring of six deep bedrock wells on the Basal Sharon Conglomerate. This report summarizes field activities performed and presents analytical monitoring results.

15. SUBJECT TERMS

monitoring report, groundwater sampling, monitoring wells, groundwater, bedrock, Sharon Conglomerate

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CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Science Applications International Corporation (SAIC) has completed the Final Monitoring Report for the Deep Bedrock Well Installation in the Basal Sharon Conglomerate at the Ravenna Army Ammunition Plant, Ravenna, Ohio. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of data quality objectives; technical assumptions; methods, procedures, and materials to be used; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing USACE policy.

Amanda Trenton — Date: 05/20/10

Amanda Trenton
Study/Design Team Leader

Jed Thomas — Date: 5/20/10

Jed Thomas, P.E.
Independent Technical Review Team Leader

Significant concerns and the explanation of the resolution are as follows:

Internal SAIC Independent Technical Review comments are recorded on a Document Review Record per SAIC quality assurance procedure QAAP 3.1. This Document Review Record is maintained in the project file. Changes to the report addressing the comments have been verified by the Study/Design Team Leader. As noted above, all concerns resulting from independent technical review of the project have been considered.

Tad Fox — Date: 5/20/10

Tad Fox
Principal w/ A-E firm

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NGB = National Guard Bureau
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REIMS = Ravenna Environmental Information Management System
RVAAP = Ravenna Army Ammunition Plant
SAIC = Science Applications International Corporation
USACE = United States Army Corps of Engineers
USAEC = United States Army Environmental Command

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ACRONYMS AND ABBREVIATIONS

AOC	Area of Concern
BEHP	Bis(2-ethylhexyl)phthlate
BGS	Below Ground Surface
Camp Ravenna	Camp Ravenna Joint Military Training Center
CUG	Cleanup Goal
DFFO	Director's Final Findings and Orders
DOD	Department of Defense
DQO	Data Quality Objective
FCR	Field Change Request
FWGWMP	Facility-wide Groundwater Monitoring Program
HMX	1,3,5,7-tetranitro-1,3,5,7-tetrazocane
HTRW	Hazardous, Toxic, and Radioactive Waste
ID	Inner Diameter
IDW	Investigation-Derived Waste
IRP	Installation Restoration Program
MEC	Munitions and Explosives of Concern
MT&E	Materials Testing and Evaluation
NELAC	National Environmental Laboratory Accreditation Conference
NGB	National Guard Bureau
NO_3/NO_2	Nitrate-Nitrite
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
PBA	Performance-Based Acquisition
PCB	Polychlorinated biphenyl
PETN	Pentaerythritol tetranitrate
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
ORP	Oxidation Reduction Potential
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QSM	Quality System Manual
RDX	1.3.5-trinitroperhydro-1,3,5-triazine
RFA	Resident Farmer Adult
RFC	Resident Farmer Child
RL	Reporting Limit
RSL	Regional Screening Level
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan

ACRONYMS AND ABBREVIATIONS (continued)

SVOC	Semi-Volatile Organic Compound
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
TNT	2,4,6-trinitrotoluene
UXO	Unexploded Ordnance
USACE	United States Army Corps of Engineers
USATHMA	United States Army Toxic and Hazardous Materials Agency
USGS	United States Geological Survey
VOC	Volatile Organic Compound

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1.0 INTRODUCTION

This Monitoring Report provides a summary of activities and results associated with installation of six bedrock groundwater monitoring wells in the basal Sharon Conglomerate underlying Ravenna Army Ammunition Plant (RVAAP) in Ravenna, Ohio (Figure 1-1 and 1-2). This report details monitoring well installation and groundwater sampling activities, sampling results, and field change requests executed in accordance with the *Sampling and Analysis Plan Addendum No. 1 for the Deep Bedrock Well Installation in the Basal Sharon Conglomerate* (USACE 2008), herein referred to as the Sampling and Analysis (SAP) Addendum No. 1. The SAP Addendum No.1 was issued on December 19, 2008, and approved by the Ohio Environmental Protection Agency (Ohio EPA) on January 26, 2009.

Science Applications International Corporation (SAIC) conducted monitoring well installation and groundwater sampling as part of the 2008 Performance-Based Acquisition (PBA) under contract W912QR-04-D-0028, Delivery Order 0001, Task 3 with the United States Army Corps of Engineers (USACE), Louisville District. The submission and subsequent approval of this Monitoring Report will result in the completion of Task 3 for the PBA. In addition, planning and performance of all work elements were conducted in accordance with the requirements of the Ohio EPA *Director's Final Findings and Orders* (DFFO) *for RVAAP*, dated June 10, 2004 (Ohio EPA 2004), the *Facility-wide Sampling and Analysis Plan* (USACE 2001) herein referred to as Facility-wide SAP, and the *Facility-wide Groundwater Monitoring Program* (FWGWMP) (USACE 2004), as appropriate.

1.1 FACILITY DESCRIPTION

When the RVAAP Installation Restoration Program (IRP) began in 1989, RVAAP was identified as a 21,419-acre installation. The property boundary was resurveyed by the Ohio Army National Guard (OHARNG) over a 2-year period (2002 and 2003) and the total acreage of the property was found to be 21,683.289 acres. As of February 2006, a total of 20,403 acres of the former 21,683-acre RVAAP has been transferred to the National Guard Bureau (NGB) and subsequently licensed to OHARNG for use as a military training site.

The current RVAAP consists of 1,280 acres scattered throughout the OHARNG Camp Ravenna Joint Military Training Center, herein referred to as Camp Ravenna. Camp Ravenna is in northeastern Ohio within Portage and Trumbull Counties, approximately 4.8 km (3 miles) east-northeast of the City of Ravenna. The RVAAP portions of the property are solely located within Portage County. Camp Ravenna/RVAAP is a parcel of property approximately 17.7 km (11 miles) long and 5.6 km (3.5 miles) wide bounded by State Route 5, the Michael J. Kirwan Reservoir, and the CSX System Railroad on the south; Garret, McCormick, and Berry roads on the west; the Norfolk Southern Railroad on the north; and State Route 534 on the east (Figures 1-1 and 1-2). Camp Ravenna is surrounded by several communities: Windham on the north; Garrettsville 9.6 km (6 miles) to the northwest; Newton Falls 1.6 km (1 mile) to the southeast; Charlestown to the southwest; and Wayland 4.8 km (3 miles) to the south.

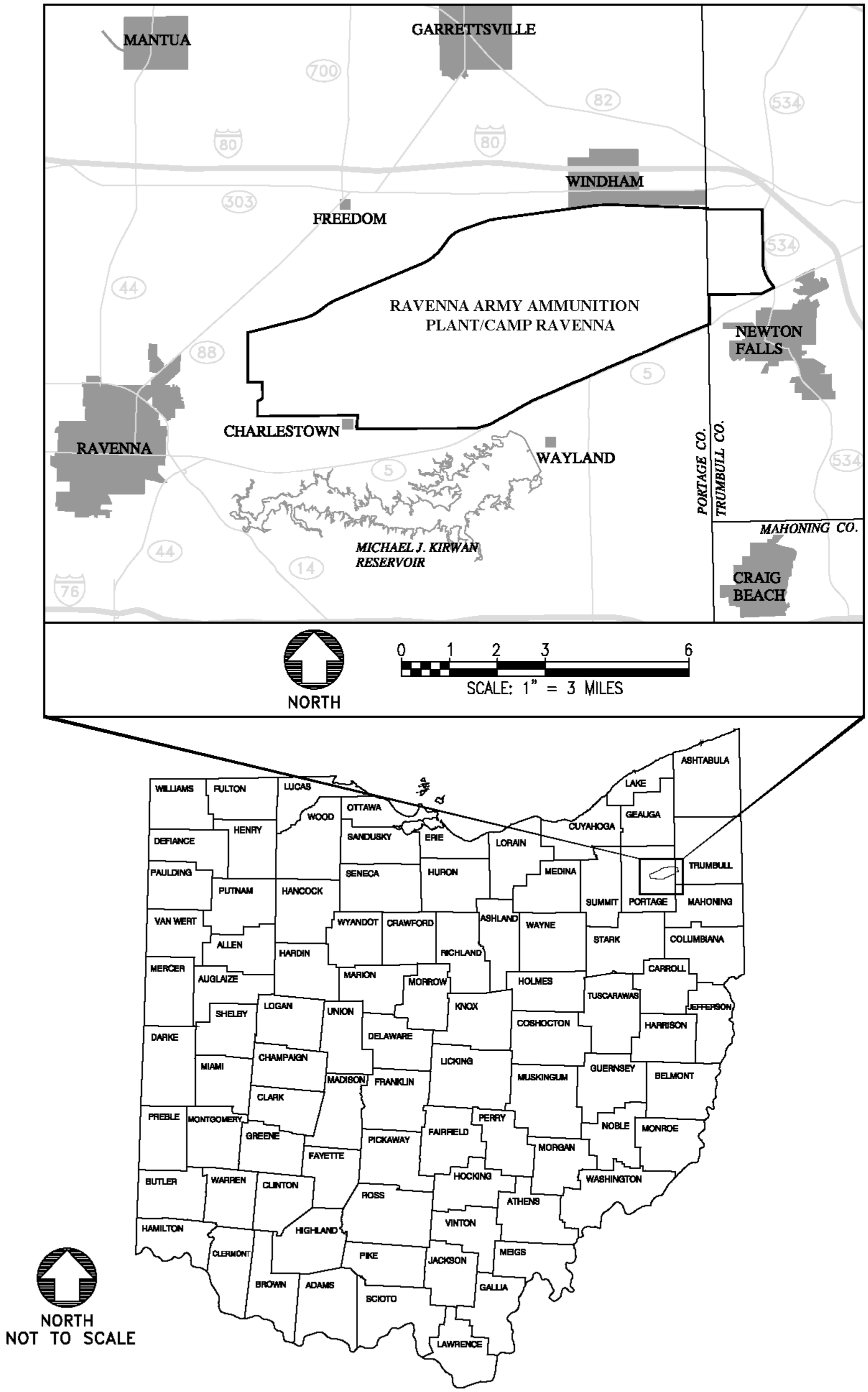
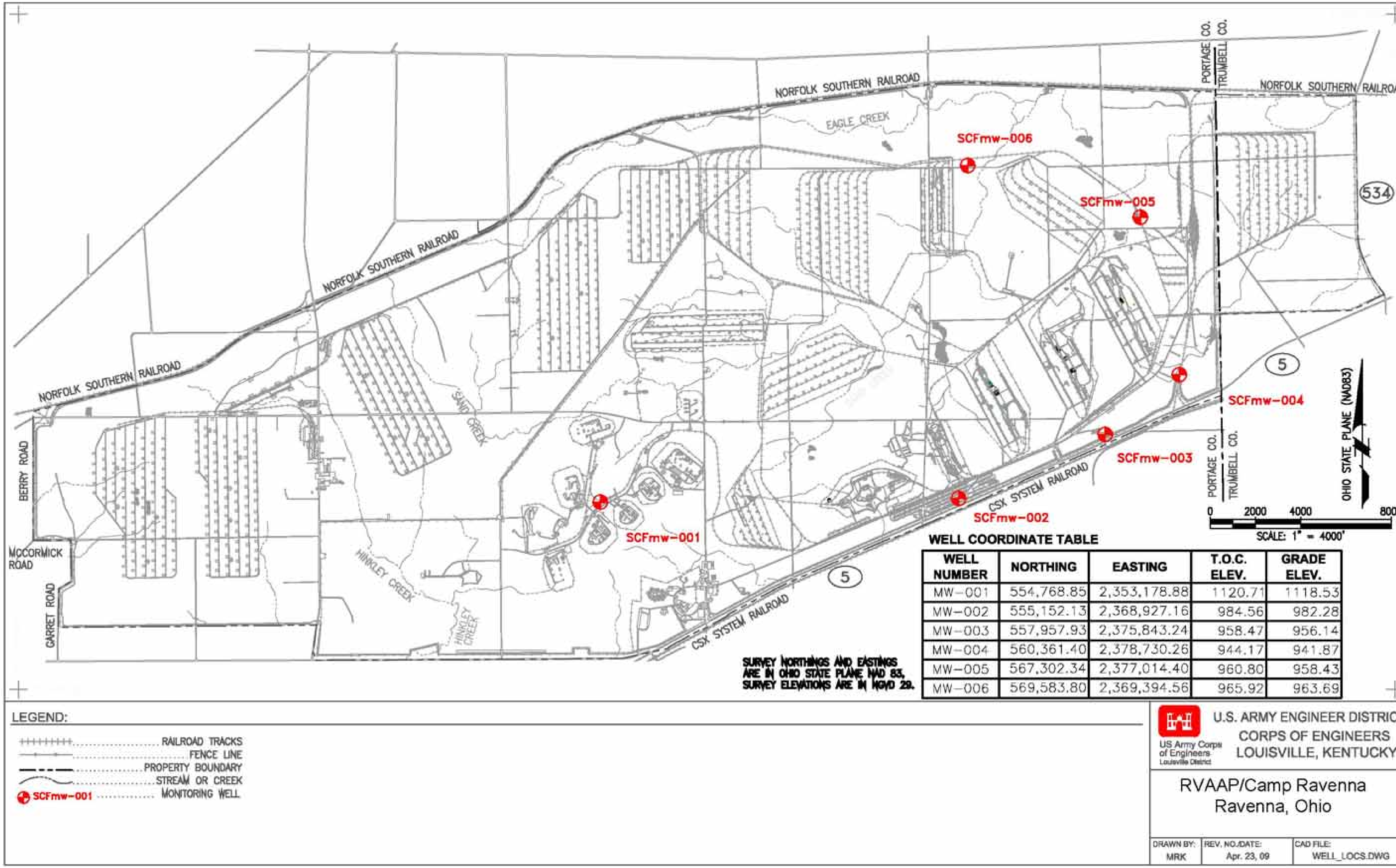


Figure 1-1. General Location and Orientation of the RVAAP/Camp Ravenna



WELL COORDINATE TABLE

WELL NUMBER	NORTHING	EASTING	T.O.C. ELEV.	GRADE ELEV.
MW-001	554,768.85	2,353,178.88	1120.71	1118.53
MW-002	555,152.13	2,368,927.16	984.56	982.28
MW-003	557,957.93	2,375,843.24	958.47	956.14
MW-004	560,361.40	2,378,730.26	944.17	941.87
MW-005	567,302.34	2,377,014.40	960.80	958.43
MW-006	569,583.80	2,369,394.56	965.92	963.69

Figure 1-3. Basal Sharon Conglomerate Monitoring Well Locations

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When RVAAP was operational, Camp Ravenna did not exist and the entire 21,683-acre parcel was a government-owned, contractor-operated industrial facility. The RVAAP IRP encompasses investigation and cleanup of past activities over the entire 21,683 acres of the former RVAAP. References to RVAAP in this document are considered to be inclusive of the historical extent of RVAAP, which is inclusive of the combined acreages of the current Camp Ravenna and RVAAP, unless otherwise specifically stated.

Industrial operations at the former RVAAP consisted of 12 munitions-assembly facilities referred to as “load lines.” Load Lines 1 through 4 were used to melt and load 2,4,6-trinitrotoluene (TNT) and Composition B into large-caliber shells and bombs. The operations on the load lines produced explosive dust, spills, and vapors that collected on the floors and walls of each building. Periodically, the floors and walls were cleaned with water and steam. Following cleaning, the wastewater, containing TNT and Composition B, known as “pink water” for its characteristic color, was collected in concrete holding tanks, filtered, and pumped into unlined ditches for transport to earthen settling ponds. Load Lines 5 through 11 were used to manufacture fuzes, primers, and boosters. Potential contaminants in these load lines include lead compounds, mercury compounds, and explosives. From 1946 to 1949, Load Line 12 was used to produce ammonium nitrate for explosives and fertilizers prior to use as a weapons demilitarization facility.

In 1950, the facility was placed on standby status and operations were limited to renovation, demilitarization, and normal maintenance of equipment, along with storage of munitions. Production activities were resumed from July 1954 to October 1957 and again from May 1968 to August 1972. In addition to production missions, various demilitarization activities were conducted at facilities constructed at Load Lines 1, 2, 3, and 12. Demilitarization activities included disassembly of munitions and explosives melt-out and recovery operations using hot water and steam processes. Periodic demilitarization of various munitions continued through 1992.

In addition to production and demilitarization activities at the load lines, other facilities at RVAAP include areas of concern (AOCs) that were used for the burning, demolition, and testing of munitions. These burning and demolition grounds consist of large parcels of open space or abandoned quarries. Potential contaminants at these AOCs include explosives, propellants, metals, and waste oils. Other types of AOCs present at RVAAP include landfills, an aircraft fuel tank testing facility, and various general industrial support and maintenance facilities.

During the period of RVAAP operations, approximately 89 exploration and production wells were drilled for potable and industrial uses throughout the facility. The majority of these wells provided water for Water Works 1 at Load Line 1, Water Works 2 at Load Line 12, Water Works 3 at Fuze and Booster Area, and the Depot Area. The sandstone facies of the Sharon Member, and in particular the Sharon Conglomerate, were the primary sources of potable groundwater during RVAAP’s active phase, although some wells were completed in the Sharon Shale. The U.S. Army Toxic and Hazardous Materials Agency (USATHMA) *Installation Assessment of Ravenna Army Ammunition Plan* (1978) indicates that only 15 production wells were considered adequate producers for potable or industrial usage, and as of 1978, only five wells were used continuously (1 to 2 days per week).

By 1992, all on-site production wells had been abandoned and sealed, with the exception of two wells. The two wells that remain in operation are located in the central portion of the facility in the administration area and provide sanitary water to personnel on-site.

Operation of the historic production wells installed in the Sharon Conglomerate may have provided a potential vertical conduit for specific area contamination associated with described historic activities at AOCs to permeate the deeper stratigraphy and groundwater units.

1.1.1 RVAAP Physiographic Setting

RVAAP is located within the Southern New York Section of the Appalachian Plateau physiographic province [U.S. Geologic Survey (USGS) 1968]. This province is characterized by elevated uplands underlain primarily by Mississippian- and Pennsylvanian-age bedrock units that are horizontal or gently dipping. The province is characterized by its rolling topography with incised streams having dendritic drainage patterns. The Southern New York Section has been modified by glaciations, which rounded ridges, filled major valleys and blanketed many areas with glacially derived unconsolidated deposits (i.e., sand, gravel, and finer-grained outwash deposits). As a result of glacial activity in this section, old stream drainage patterns were disrupted in many locales, and extensive wetland areas developed.

1.1.2 RVAAP Geologic Setting

The regional geology at RVAAP consists of horizontal to gently dipping sedimentary bedrock strata of Mississippian and Pennsylvanian age overlain by varying thicknesses of unconsolidated glacial deposits.

Bedrock at RVAAP is overlain by deposits of the Wisconsin-aged Lavery Till in the western portion of the facility and the younger Hiram Till and associated outwash deposits in the eastern two-thirds of the facility. Unconsolidated glacial deposits vary considerably in their character and thickness across RVAAP, from zero in some of the eastern portion of the facility to an estimated 46 m (150 ft) in the south-central portion. These tills consist of laterally discontinuous assemblages of yellow-brown, brown, and gray silty clays to clayey silts, with sand and rock fragments.

The bedrock encountered in studies of RVAAP includes formations of Mississippian and Pennsylvanian age, which dip to the south at a rate of approximately 5 to 10 ft/mile. A generalized stratigraphic section with description of the bedrock stratigraphy is presented as Figure 1-3 and a geologic bedrock map of RVAAP is presented as Figure 1-4.

The Mississippian Cuyahoga Group is present at depths of approximately 200 ft below ground surface (BGS) throughout the majority of the site. However, the Meadville Shale Member of the Cuyahoga Group is present at or near the surface in the very northeastern corner of RVAAP. The Meadville Shale is a blue-gray silty shale characterized by alternating thin beds of sandstone and siltstone. The Sharon Member of the Pennsylvanian Pottsville Formation unconformably overlies the

Meadville Shale Member of the Mississippian Cuyahoga Group. The unconformity has a relief of as much as 200 ft in Portage County, and this is reflected in the variation of thickness of the Sharon Member. The Sharon Member consists of two units: a shale and a conglomerate. The conglomerate unit of the Sharon Member (informally referred to as the Sharon Conglomerate) is a highly porous, loosely cemented, permeable, cross-bedded, frequently fractured and weathered orthoquartzite sandstone, which is locally conglomeratic and exhibits an average thickness of 100 ft. The Sharon Conglomerate exhibits locally occurring thin shale lenses in the upper portion of the unit. The Sharon Conglomerate outcrops in many locations in the eastern half of RVAAP.

The shale unit of the Sharon Member (informally referred to as the Sharon Shale) is a light to dark-gray fissile shale that overlies the conglomerate in some locations, but has been eroded in most areas of RVAAP. In the western half of RVAAP, the remaining members of the Pottsville Formation found in the local area overlie the Sharon Member. These remaining members of the Pottsville Formation are not found in the eastern half of the site because either the land surface was above the level of deposition, or these members were eroded. The Connoquenessing Sandstone Member, which unconformably overlies the Sharon Member, is a sporadic, relatively thin channel sandstone comprised of gray to white, coarse-grained quartz with a higher percentage of feldspar and clay than the Sharon Conglomerate. The Mercer Member is found above the Connoquenessing Sandstone and consists of silty to carbonaceous shale with many thin and discontinuous lenses of sandstone in its upper part. The Homewood Sandstone Member unconformably overlies the Mercer and is the uppermost unit of the Pottsville Formation. The Homewood occurs as a caprock on bedrock highs in the subsurface and ranges from a well-sorted, coarse-grained, white quartz sandstone to a tan, poorly sorted, clay-bonded, micaceous, medium- to fine-grained sandstone.

1.1.3 RVAAP Hydrologic Setting

Groundwater utilized during historic RVAAP operations included both overlying unconsolidated glacial deposits and bedrock sources. Groundwater from both unconsolidated and bedrock aquifers predominantly flows in an eastward direction. Groundwater flow in unconsolidated deposits on-site is influenced by topography and site drainage patterns. The most important bedrock source of groundwater at RVAAP is the Pennsylvanian Sharon Conglomerate member of the Pottsville Formation. The Sharon Conglomerate aquifer is the principle water-bearing unit at RVAAP. USATHMA (1978) reports water yields from wells completed in the Sharon Conglomerate range from 30 to 400 gallons per minute. The other local bedrock units including the Connoquenssing Sandstone and Homewood Sandstone provide important groundwater yields, though lower than the Sharon Conglomerate. The Sharon and Mercer member shales have low hydraulic conductivities and result in insignificant groundwater yields on-site.

Outside the facility boundaries, unconsolidated deposits are an important source of groundwater, as many residential and public water supplies located near the facility obtain water from wells completed in unconsolidated deposits (USACE 2004).

AGE	SYSTEM	SERIES	GROUP	FORMATION	SIGNIFICANT MEMBERS OR BEDS	DESCRIPTION
325 to 280 million years	PENNSYLVANIAN		POTTSVILLE	Homewood Sandstone		Medium- to fine- grained sandstones. Sandy shale lenses are common.
				Mercer Shale	Bedford Coal Mercer Coal (at base)	Silty to carbonaceous shales interbedded with thin sand-stones, coal seams, clays, and siltstones.
				Massillon Sandstone		Coarse- to medium-grained, sandstone. May contain minor shale and conglomerate lenses.
				Sharon Shale	Sharon Coal (at base)	Gray black, sandy to silty shale with minor siltstones and coal seams.
				Sharon Sandstone	Sharon Conglomerate	Coarse- to medium-grained, light colored sandstone. May contain conglomeratic zones.
345 to 325 million years	MISSISSIPPIAN			Cuyahoga Formation	Meadville Shale Sharpsville Sandstone Orangeville Shale	Alternating, thin bedded, gray silty shales, sandy shales, siltstones and fine-grained sandstones. Shaley facies is generally predominant in Portage County.
				Berea Sandstone		Massive, crossbedded fine-grained sandstone.
				Bedford Shale	Cussewago Sandstone	Light gray to red, fissile silty shale, with zones of fine-grained sandstone.

Figure 1-3. Generalized Stratigraphic Section of Bedrock Deposits at RVAAP (modified from ODNR 1990)

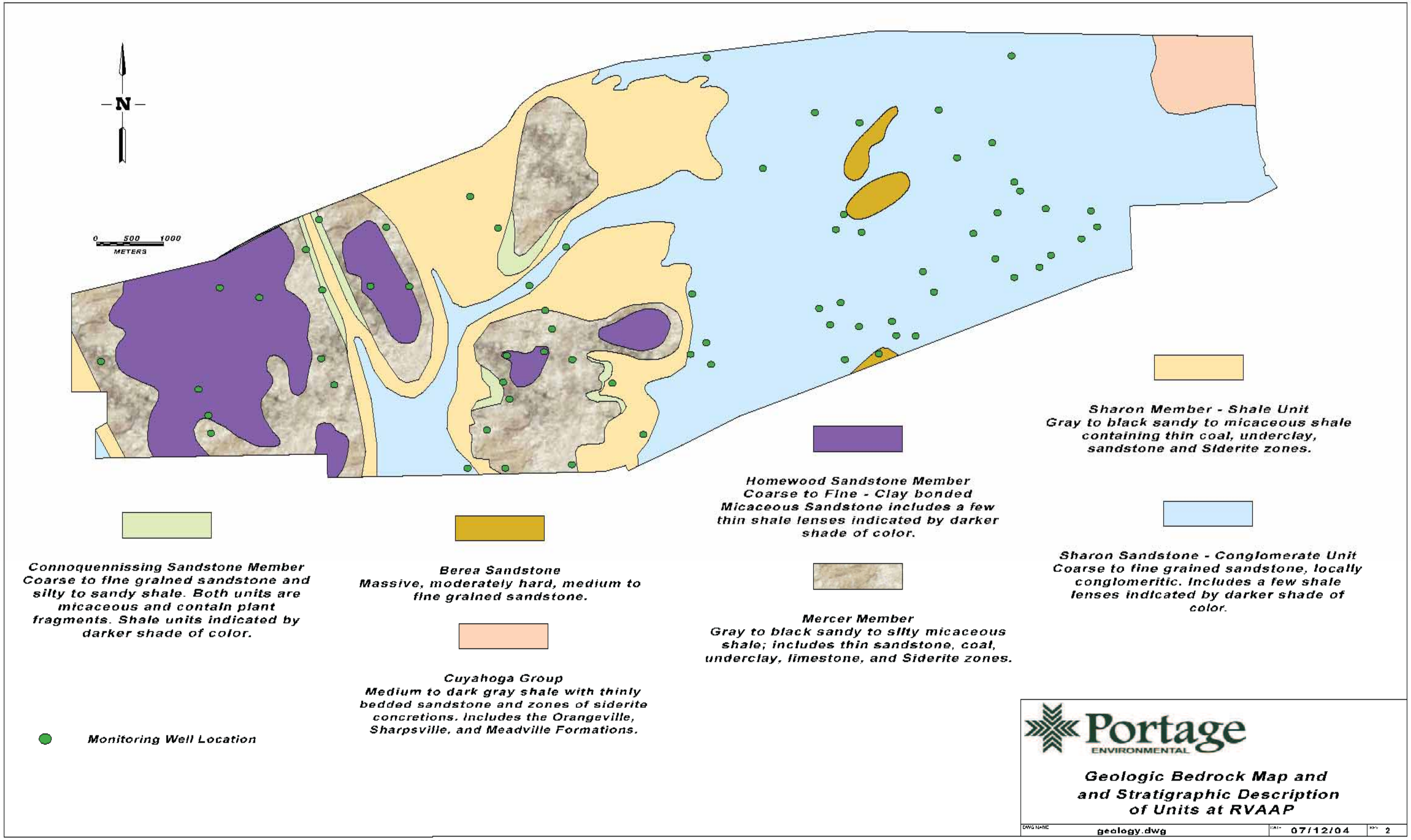

Figure 1-4. Bedrock Map of RVAAP
(USACE 2004)

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1.2 PROJECT DESCRIPTION

The primary objective of the basal Sharon Conglomerate investigation was to install and monitor six monitoring wells to evaluate the impact, if any, that historic RVAAP operations had on groundwater quality in the basal portions of the Sharon Conglomerate. Monitoring wells were installed from 86 ft BGS to 211 ft BGS in the basal Sharon Conglomerate at locations presented in the SAP Addendum No. 1 as specified by USACE with the concurrence of the Ohio EPA and the OHARNG. Monitoring well locations are illustrated in Figure 1-2.

Borehole drilling, monitoring well installation, and quarterly groundwater sampling of the six monitoring wells were completed in compliance with the requirements, guidance, and methods presented in the SAP Addendum No. 1, FWGWMP, the Facility-wide SAP, and approved field change requests.

1.3 PROJECT SCOPE AND SCHEDULE

The scope of this investigation was to install six deep bedrock wells at the base of the Sharon Conglomerate and subsequently perform four consecutive quarters of groundwater sampling to evaluate the impact, if any, that RVAAP operations had on groundwater quality in the deeper portions of the Sharon Conglomerate

The schedule for this project is shown in Figure 1-5.

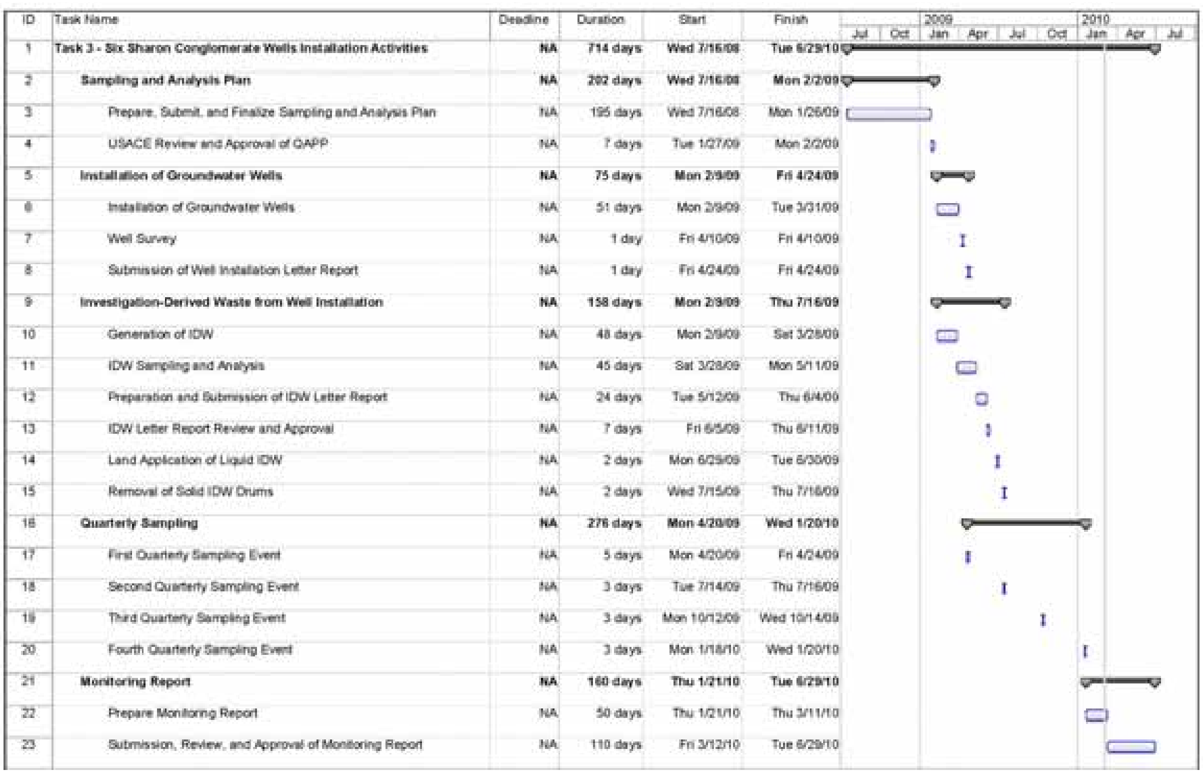

Figure 1-5. Project Schedule

1.4 REPORT ORGANIZATION

In accordance with the SAP Addendum No. 1, SAIC is issuing this monitoring report to provide details of the installation of six bedrock wells, results of groundwater sampling activities, and an assessment of water quality with future recommendations. Well construction data was previously summarized in the *Letter Report for the Deep Bedrock Well Installation in the Basal Sharon Conglomerate* (SAIC 2009).

This report is organized as follows:

- Section 1.0 – Introduction and Project Scope;
- Section 2.0 – Field Activities Associated with Well Installation and Monitoring;
- Section 3.0 – Results of Quarterly Monitoring;
- Section 4.0 – Conclusions and Recommendations; and
- Section 5.0 – References.
- Appendices:
  - Appendix A: Field Logbooks
  - Appendix B: Boring Logs
  - Appendix C: Photographs from Field Activities
  - Appendix D: Professional Survey Report
  - Appendix E: Field Change Requests
  - Appendix F: Letter Report for Well Cuttings, Drilling Decontamination Water and Recovered Drilling Water and Ohio EPA Approval Form
  - Appendix G: Well Purge Forms
  - Appendix H: Chain-of-Custody Records
  - Appendix I: Calibration Logs
  - Appendix J: Validated Quarterly Groundwater Data
  - Appendix K: Laboratory Data Packages

2.0 FIELD ACTIVITIES

The following sections describe the well installation, well development, and quarterly sampling activities performed for the six wells installed in the basal Sharon Conglomerate. These activities were conducted in accordance with the Facility-wide SAP (USACE 2001), the SAP Addendum No. 1 (USACE 2008), or approved and signed field change requests.

2.1 DRILLING AND MONITORING WELL INSTALLATION ACTIVITIES

The following subsections discuss the field assessment and survey, drilling, well installation, well development, and surface completion activities including the installation of well pads and bumper posts. All field logbooks and forms documenting drilling and monitoring well installation activities are presented as Appendix A.

2.1.1 Field Assessment and Survey

SAIC mobilized to RVAAP on February 9, 2009 to commence fieldwork for the installation of the six bedrock wells. Prior to drilling activities, SAIC performed a site survey to assess field conditions and verify the proposed locations were clear of overhead and subsurface utilities. Additionally, an unexploded ordnance (UXO) subcontractor (PIKA International, Inc.) completed a visual and instrument-assisted ground surface survey of the proposed drilling locations to ensure that the areas were free of munitions and explosives of concern (MEC). A UXO technician cleared the boreholes to a depth of 10 ft or bedrock refusal using a Schonstedt® Magnetic Locator and hand auger. This clearance confirmed that no ferrous bearing metals or utilities were within the immediate vicinity of the boring.

Some locations were relocated a nominal distance during the field assessment based on field access issues. For instance, SCFmw-006 was moved slightly closer to Smalley Rd. as its original location was set back in a heavily wooded area. SCFmw-004 was later relocated during the installation effort, as saturated soils at the original location were not sufficiently stable to support the weight of the drilling rig and outriggers. With approval from OHARNG and USACE, the location was moved to more stable soils north of the railroad tracks on February 25, 2009. Following relocation, the approved boring location was cleared by a UXO technician prior to initiating drilling activities.

2.1.2 Drilling Activities

SAIC contracted Frontz Drilling, Inc. to complete well installation activities. Drilling activities began on February 10, 2009. Prior to commencement of drilling activities, all materials to be used during field activities including granular filter pack, bentonite, grout, and potable water were approved for use by USACE. Upon mobilization to the site on February 10, 2009, drilling and support equipment were visually inspected to ensure all equipment were in operable condition and free of leaks. This visual inspection and test of functioning safety switches was documented on the Drill Rig Operational

Checklist for RVAAP AOC-Specific Investigations as provided in Figure 4-1 in the Facility-wide SAP. This full checklist was completed on a weekly basis and is included in Appendix A. Safety "kill" switches were tested every day prior to commencement of drilling activities. All drill rig safety checks were documented in the daily activity logs.

A CME-75 drilling rig and hollow stem auger equipment was used to 1) drill and obtain continuous soil samples for geologic logging from the unconsolidated zone to the overburden-bedrock interface and 2) set the outer casings for each well. Equipment used to drill a pilot boring in the overburden interval and collect continuous overburden soil samples included 4¼-inch inner diameter (ID) hollow stem augers and 2-inch diameter by 2-ft split spoons (Photograph 2-1). Soil samples were continuously collected from the surface to the bedrock interface (Photograph 2-2). Split spoons were decontaminated between intervals with a liquinox wash and a potable water rinse. All overburden soil samples were archived in core boxes for retention by USACE. Core boxes were stored in Building 1036 and transferred to USACE at the completion of drilling activities.

Photograph 2-1. Drilling using 4 ¼ inch ID Hollow Stem Augers

Photograph 2-2. Collection and Description of Soil Samples Obtained with Split Spoons

Following collection of overburden soil samples, hollow stem augers with an ID of 12 ¼ inches were used for installation of the outer steel casing for each well. An 8-inch diameter steel casing was installed through the 12 ¼-inch ID hollow stem augers to seal the unconsolidated surficial overburden material from bedrock and allow for subsequent rock coring and monitoring well installation. The set point for outer casings ranged from 3 ft to 10 ft below the overburden/bedrock interface. The variation in the depth the outer casing was set into the bedrock was dependant upon auger refusal. In all cases the outer casing was set as far as practical based on drilling conditions into the bedrock interface. Bottom outer casing depths ranged from 10 ft to 60 ft BGS. Following placement of the surface casing in the borehole, the casing was grouted into place using a tremie pipe inserted to the bottom of the borehole. Grout was allowed to set a minimum of 48 hours prior to beginning air rotary drilling. All overburden drilling activities and installation of outer casings at the six well locations occurred from February 10, 2009 to February 26, 2009.

Photograph 2-3. Drilling using 12 ¼ inch ID Hollow Stem Augers

Photograph 2-4. Installation of Outer Casing through 12 ¼ inch ID Hollow Stem Augers

Between borehole locations, all downhole equipment was decontaminated using a pressurized hot water wash at a localized decontamination pad located at Building 1036. During drilling activities, all decontamination fluids and liquid returns from the Sharon Conglomerate aquifer were placed in either a 350 or 700-gallon poly tank as a temporary container, and transferred to one of three FRAC tanks situated across the installation. During drilling activities all solid material from drilling returns (soil and rock materials) were containerized in 55-gallon drums situated at each well location. Investigation-Derived Waste (IDW) is described further in Section 2.3.

Following completion of overburden drilling and outer casing installation, an Ingersoll-Rand TH-60 air rotary drill rig was mobilized to RVAAP on March 2, 2009. Air-rotary drilling commenced at SCFmw-006. Prior to well installation, rock was cored in 10 foot sections until the Cuyahoga Formation was encountered (Photographs 2-5, 2-6, 2-7, and 2-8). Rock cores from each borehole were logged on USACE hazardous, toxic, and radioactive waste (HTRW) drilling logs, pictures were taken of each recovered section of core, and rock cores were archived in 10 ft sections in core boxes. Borehole logs with well construction diagrams are presented as Appendix B and photos of overburden and rock cores are submitted as electronic files in Appendix C.

Photograph 2-5. Setup of Air Rotary Rig and IDW Polytanks on SCFmw-001

Photograph 2-6. Recovered Section of Rock Core at SCFmw-006

Photograph 2-7. Air Rotary Drilling

Photograph 2-8. Sharon Conglomerate and Cuyahoga Formation Unconformity

Upon completion of rock coring, bentonite chips were used to backfill the borehole to the interface of the Meadville Shale Member and Sharon Conglomerate. Once the bentonite chips were sufficiently hydrated, a 2-inch monitoring well screen with one-ft well sump and inner riser casing was installed. All wells, except for SCFmw-001, were constructed with clean, new two-inch schedule 40 polyvinyl chloride (PVC) screen and casing. As described in Section 2.2.5, Schedule 80 PVC materials were used at SCFmw-001 due to its deep installation depth. Stainless steel centralizers were equally placed along the riser casing to ensure the inner casing remained centered in the boring. Silica sand filter packs, bentonite seals, and annular grout seals were installed per guidelines in Section 4.3.2.3 of the Facility-wide SAP, except for the approved field change request for well installation at SCFmw-005.

This field change request was initiated due to initial failure of the bentonite seal and reinstallation of the monitoring well as detailed in Sections 2.2.3 and 2.2.4. Table 2-1 contains well construction specifics for monitoring well construction.

Following installation of the monitoring well, an above-grade well protection assembly consisting of a 6 inch by 8 ft steel protective casing was installed around the PVC well casing. The protective casing was set approximately 5 ft below grade and extended approximately 3 ft above grade per the Facility-wide SAP. The protective casing was equipped with a locking cover and stamped with its well designation number. The final monitoring well, SCFmw-001, was installed on March 24, 2009.

Table 2-1. Sharon Conglomerate Bedrock Monitoring Well Construction Information

RVAAP Well ID	Ohio State Plane Easting[a]	Ohio State Plane Northing[a]	Surface Elevation[b]	TOC Elevation[b]	Depth to Bedrock (ft BGS)	Bottom of 8" Outer Casing (ft BGS)	Total Drilled Depth (ft BGS)	Top of Screen (ft BGS)	Bottom of Screen (ft BGS)	Bottom of Filter Pack Sand (ft BGS)	Top of Filter Pack Sand (ft BGS)	Top of Bentonite Seal (ft BGS)	Average Centralizer Spacing (ft)
SCFmw-001	2353178.98	554768.62	1118.53	1120.71	32.5	35	230	201	211	212	198	188	49
SCFmw-002	2368927.36	555152.38	982.28	984.56	24.75	30	153	137	147	148	134	118.5	41
SCFmw-003	2375843.20	557957.67	956.14	958.47	10.0	15	140	125.5	135.5	136	123	115.5	38
SCFmw-004	2378730.23	560361.03	941.87	944.17	50.0	55	120	100	110	111	95	77	30
SCFmw-005	2377014.05	567302.35	958.43	960.8	4.75	10	160	139	154	155	136	126	41
SCFmw-006	2369394.54	569583.41	963.69	965.92	53.7	60	90	76	86	87	73	70	20

[a] Horizontal control in Ohio State Plane (OSP) Coordinate System North American Datum (NAD) 1983.
[b] Elevations are in feet above mean sea level (amsl), National Geodetic Vertical Datum (NGVD) 1929.
BGS = below ground surface
All Wells were installed with an above grade completion

2.1.3 Well Development

The monitoring wells were developed in accordance with the Facility-wide SAP, with one field change request approved by USACE extending the timeframe for development from a maximum of 7 days beyond mortar collar placement to a maximum of 14 days. More details on this field change request are provided in Section 2.2.2.

Well development activities occurred on March 16, 2009 (SCFmw-005 and SCFmw-006), March 17, 2009 (SCFmw-003 and SCFmw-004), March 23, 2009 (SCFmw-002) and concluded on March 27, 2009 with the development of SCFmw-001. A submersible whaler pump was used for development. The pump was raised and lowered throughout the screened interval during development activities to ensure the complete screened interval was thoroughly developed. Per the Facility-wide SAP, the pump was turned on and off frequently to create a surging action within the well. In addition, the interior of the well casing was washed with water from the well. As SCFmw-004 is an artesian well, water flowing from the top of the casing was containerized by using a Y-shaped PVC extension that allowed the water to flow directly into a container. Well development parameters were recorded on SAIC Development Logs and are included as part of Appendix A.

Development activities were considered complete when the following criteria were achieved:

- A minimum of five times the standing water in the well, including the well screen and annulus, was removed;
- Sediment thickness within the well was less than 1% of the screen length or <0.1 ft;
- A turbidity reading of 5 NTU or less was achieved, or the water was clear to the unaided eye; and
- Stability parameters of pH, Specific Conductivity, and Temperature have stabilized within 0.2 S.U., 10% mS/cm, and 0.5°C, respectively for three consecutive well volumes.

Following completion of well development, a 1-pint water sample was removed, labeled, and photographed per the Facility-wide SAP. Photographs of well development water are included in Appendix C.

2.1.4 Well Completion and Demobilization

Following development activities, well pads and bumper posts were installed around each of the six monitoring wells. A 30 inch by 30 inch by 4 inch wood form was centered on the well protective casing and filled with concrete, which was gently sloped away from the well protective casing. After placement and curing of the concrete pad a drainage port measuring ¼ inch in diameter was drilled into the protective casing above the top of the concrete pad and mortar collar. Per instructions provided in Section 4.3.2.3.9 of the Facility-wide SAP, three guard posts were radially located 4 ft around each monitoring well. The guard posts were set in cement two feet below grade. Each guard post measured 6 ft in length and 6 inches in diameter. The guard posts were filled with filter pack sand and capped with cement to form a watertight seal. Following curing of the concrete, the protective casing and guard posts were painted yellow. The well designation number was stenciled and painted onto the protective casings. All paint was thoroughly dry prior to well sampling activities.

At the completion of drilling activities, any disturbed areas were given temporary cover with straw. SAIC later seeded the areas in late spring 2009 using the "Open Area" seed mixture for RVAAP/Camp Ravenna (Photograph 2-9). Well installation field activities were complete and all equipment and field staff demobilized by March 31, 2009.

2.1.5 Survey Activities

A monitoring well survey was completed on April 10, 2009 by KS Associates in accordance with Section 4.3.2.3.12 of the Facility-wide SAP and Section 4.3 of the SAP Addendum No. 1 (Photograph 2-10). Data is presented in Table 2-1 and on Figure 1-2 showing the surveyed locations of the wells and respective top-of-casing and surface elevations. The professional surveyor report is presented as Appendix D.

Photograph 2-9.   Placement of Seed and Straw at SCFmw-004

Photograph 2-10.   Professional Survey of SCFmw-005

2.2 FIELD CHANGE REQUESTS

All of the monitoring wells were installed according to the SAP Addendum No. 1 and the Facility-wide SAP with the exceptions noted in the field change requests (FCRs) discussed below. Copies of signed FCRs are included as Appendix E.

2.2.1 FCR RVAAP-SCF-001 – Use Of Welding Torch

FCR RVAAP-SCF-001 addressed the use of a welding torch to join and cut the sections of steel outer casings. This activity was not addressed in the original Site Safety and Health Plan within the SAP Addendum No. 1. The Activity Hazard Analysis was updated to include welding activities and was submitted and approved by USACE.

2.2.2 FCR RVAAP-SCF-002 – Well Development Schedule

FCR RVAAP-SCF-002 requested approval to change the schedule for well development after well installation. The Facility-wide SAP stated that well development should be initiated no more than 7 days after the mortar collar was installed inside of the steel protective casing. However, due to delays in the completion of additional wells, only one well was ready for development within that timeframe. SAIC requested that well development be initiated within 14 days after mortar collar installation. USACE granted the request and all wells were developed within 13 days of the mortar collar installation.

2.2.3 FCR RVAAP-SCF-003 – Use of a Thicker Bentonite Seal in SCFmw-005

FCRs RVAAP-SCF-003 and RVAAP-SCF-004 were initiated when the bentonite seal failed during the installation of the grout at monitoring well SCFmw-005 in an area of fractured bedrock above the screened interval. The failure of the bentonite seal required that the borehole be re-drilled using a larger diameter drill bit to ensure that all of the grout and well materials were removed from the boring. *FCR RVAAP-SCF-003* addressed the use of a larger bentonite seal to prevent the failure of the seal during grout placement. The Facility-wide SAP calls for the installation of a 0.9 to 1.5 meter (3.0 to 5.0 ft) bentonite seal. SAIC requested that a bentonite seal of up to 6.0 meters (20.0 ft) thick be placed to help prevent seal failure due to fractured zones within the bedrock. A 10 ft thick bentonite seal was placed during the installation of SCFmw-005.

2.2.4 FCR RVAAP-SCF-004 – Use of a Longer Screen in SCFmw-005

FCR RVAAP-SCF-004 addressed the use of a 4.5 m (15.0 ft) screen to cover the fractured zone in the bedrock at SCFmw-005. The use of the longer screen and thicker bentonite seal prevented a reoccurrence of the bentonite seal failure. The pH was monitored during well development activities and a groundwater sample was collected for metals analysis to ensure that the well had not been compromised by the grout. Field pH readings during well development did not indicate the well was compromised by the grout, and the analytical results for metals analysis confirmed this indication.

2.2.5 FCR RVAAP-SCF-005 – Use of Schedule 80 Well Screen in SCFmw-001

FCR RVAAP-SCF-005 requested the use of Schedule 80 PVC well screen and well casing in monitoring well SCFmw-001 due to the depth the well was installed. The well was installed at 211 ft BGS. The SAP Addendum No. 1 stated that Schedule 40 or 80 PVC well screen or well casing may be used based on field conditions.

2.2.6 FCR RVAAP-SCF-006 – Use of Isopropanol for Decontamination Solvent Rinse

FCR RVAAP-SCF-006 requested the use of isopropanol in lieu of methanol during the decontamination process for non-dedicated sampling equipment. This FCR was requested as isopropanol would accomplish the same chemical decontamination step without the use of a listed hazardous material.

2.2.7 FCR RVAAP-SCF-007 – Update to Perchlorate Sampling Schedule

FCR RVAAP-SCF-007 was submitted to document a change in schedule for perchlorate sampling. Per the SAP Addendum No. 1 Quality Assurance Project Plan (QAPP), perchlorate samples were to be collected during the third quarter sampling event. This FCR documented moving the sample collection to the second quarter event to occur concurrent with other perchlorate samples collected as part of the FWGWMP.

2.3 IDW GENERATION AND DISPOSAL

All solid and liquid IDW was containerized for proper characterization disposal. Sanitary waste, including used personal protective equipment (PPE), was disposed of as sanitary trash. All soil and rock cuttings were containerized in ninety-seven (97) 55-gallon drums. Approximately 51,000 gallons of liquid IDW was generated as part of well installation and development activities and was containerized in three FRAC Tanks. During field activities, one 10,000 gallon FRAC Tank was staged near Building 1036, one 21,000 gallon FRAC Tank was staged near Building 28-808, and one 21,000 gallon FRAC Tank was staged in the Atlas Scrap Yard.

SAIC collected samples of the liquid and solid IDW on March 28, 2009. Samples were collected for RVAAP full-suite analysis which includes Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), polychlorinated biphenyl (PCBs), Pesticides, Explosives, Propellants, Cyanide, Nitrate-Nitrite(NO_3/NO_2), and Target Analyte List (TAL) Metals analysis, Toxicity Characteristic Leaching Procedure (TCLP) analysis for VOCs, SVOCs, Pesticides, Herbicides, and Metals analysis, sulfide, ignitability, and corrosivity.

An IDW letter report was submitted by SAIC on June 4, 2009 summarizing the analytical characterization and recommended disposition and disposal for IDW. The IDW letter report is included as Appendix F. Concurrence with the recommended disposal option was provided by Ohio EPA, USACE, and the RVAAP Facility Manager. The Ohio EPA approval letter is also included in Appendix F.

Liquid IDW was disposed on-site by discharging to the ground. The water was filtered with a 100-micron and 10-micron filter series prior to land application. Discharge was performed to avoid ponding and surface runoff of water. SAIC completed discharge of the liquid IDW on June 29, 2009 and June 30, 2009. All FRAC tanks were removed from RVAAP by July 1, 2009. Secondary containment materials, which included liquid tight poly sheeting material secured around each tank using metal L-shaped brackets, were removed from the site on July 7, 2009.

All soil IDW was disposed off-site as non-hazardous waste by a waste disposal contractor. The last drums were removed from RVAAP on July 17, 2009.

2.4 GROUNDWATER SAMPLING ACTIVITIES

Following well installation and development, four quarterly events of groundwater sampling were completed. All groundwater sampling was conducted in accordance with the procedures provided in Section 4.3.4 of the Facility-wide SAP, FWGWMP, and SAP Addendum No. 1. These sampling events were conducted at the same time as the FWGWMP sampling. The four quarterly events were conducted April 21, 2009 through April 24, 2009, July 14, 2009 through July 16, 2009, October 12, 2009 through October 14, 2009, and January 18, 2010 through January 20, 2010. Details of groundwater sampling methods and activities are presented in following subsections.

2.4.1 Field Sampling Methods

Prior to purging and sampling, the condition of each well was evaluated and noted on well purge forms. Depth-to-water measurements were collected using a decontaminated electronic water level indicator referenced to the north side of the top of the inner well casing. Each monitoring well was purged using a decontaminated bladder pump and micropurge techniques specified in the *Technical Guidance Manual for Hydrogeologic Investigation and Groundwater Monitoring* (Ohio EPA 1995), the Facility-wide SAP, and SAP Addendum No. 1.

Wells were purged at a rate less than the maximum micropurge flow rate of 500mL/min. Each well was purged for a minimum of two pump and tubing volumes, thirty minutes, and until water quality indicators were stabilized for three consecutive measurements to the following specifications:

- pH had stabilized to +/- 0.2 of previous two readings;
- Conductivity had stabilized within 10% of previous two readings;
- Temperature had stabilized to +/- 0.5°C of previous two readings; and
- Dissolved oxygen had stabilized within 10% of previous two readings.

All water quality measurements were recorded on well purge forms (Photograph 2-11) provided in Appendix G. While Turbidity and Oxidation Reduction Potential (ORP) readings were recorded, these parameters were not used to determine stabilization, as they are not specified as stabilization parameters in the Facility-wide SAP. All purge water was temporarily containerized in labeled five-gallon plastic carboy containers prior to disposal and subsequently added to a purge water IDW drum located inside Building 1036.

Photograph 2-11. Collection of Water Quality Parameters during Monitoring Well Purging

Photograph 2-12. Micropurge Sample Collection

After completion of pre-sample purging, each of the monitoring wells were sampled using micropurge techniques. Samples were transferred from the pump and tubing directly into pre-cleaned, laboratory-supplied containers (Photograph 2-12). All groundwater samples were analyzed for VOCs, SVOCs, PCBs, Pesticides, Explosives, Propellants, Cyanide, NO_3/NO_2, and TAL metals as outlined in Section 4.3 of the FWGWMP. Samples analyzed for TAL metals were filtered using a pre-cleaned 0.45-micron in-line filter in accordance with Section 4.1.5.2 of SAP Addendum No. 1 and Section 4.3.5 of the Facility-wide SAP.

Additional samples and analyses collected during the sampling events were as follows:

1) All wells had samples collected and analyzed for perchlorate during the second quarterly sampling event. These samples were field-filtered using a pre-cleaned 0.2-micron in-line filter.
2) All wells had unfiltered samples collected and analyzed for TAL metals during the third quarterly event.

2.4.2 Quality Control

Quality control (QC) samples for monitoring well groundwater sampling activities included the following:

1) Trip blanks were included in each cooler containing VOC samples shipped to the analytical laboratory.
2) One duplicate groundwater sample was collected per quarter.
3) One split groundwater sample was collected per quarter.
4) One equipment rinsate sample was collected per quarter.

Equipment rinsate samples were used to assess the adequacy of equipment decontamination processes. Prior to sample collection, the bladder was decontaminated according to procedures outlined in the Facility-wide SAP and SAP Addendum No. 1. The equipment rinsate samples were obtained by pouring laboratory grade, de-ionized water through the bladder into sample containers. The equipment rinsates were analyzed for VOCs, SVOCs, PCBs, Pesticides, Explosives, Propellants, Cyanide, NO_3/NO_2, TAL metals, and Perchlorate (only in second quarter). Equipment rinsate samples for TAL metals and perchlorate analyses were unfiltered.

Following collection, all samples were recorded on an appropriate chain-of-custody form and maintained at 4°C (+/- 2°C). Groundwater samples, equipment rinse blanks, trip blanks, and duplicate samples were submitted to TestAmerica Laboratories in North Canton, OH. All split samples were submitted to the USACE-contracted laboratory, RTI Laboratory, for independent analysis. Sample collection activities were documented per procedures outlined in Chapter 5.0 of the Facility-wide SAP in the project field logbook and on appropriate chain-of-custody forms. Copies of the field logbook and chains-of-custody can be found in Appendices A and H, respectively.

2.4.2.1 Field Instrument Calibration

Calibration and field measurements were completed according to procedures outlined in Section 4.3.3 of the Facility-wide SAP and SAP Addendum No. 1. All equipment used were recorded on SAIC Materials Testing and Evaluation (MT&E) Equipment Logs and on well purge forms. Water quality parameters were measured using a Horiba U-22 water quality meter, which was calibrated daily. Groundwater Equipment Inventory and Calibration logs are included as Appendix I. During first quarter monitoring activities, an issue with the Horiba U-22 water quality meter was encountered. During the completion of low-flow purging at SCFmw-004 on 04/22/09, the Horiba U-22 provided pH readings of 12.47-12.64 S.U. The Horiba was properly calibrated in the morning and to not disrupt low flow purging as sampling parameters were stable, field personnel assessed the Horiba U-22 water quality instrument following well purging. Following field assessment and testing, the Horiba did not properly calibrate. The instrument was removed from service and replaced. Complete details of activities are presented in Appendix A, Logbook SCF-007, pages 6-7. No other water quality instrument issues occurred during the four quarters of monitoring.

2.4.2.2 Groundwater Flow Conditions

Groundwater levels at the Sharon Conglomerate monitoring wells were measured prior to well purging and sampling each quarter. The water level data collected are presented as Table 2-2.

Groundwater elevation data was used to generate the potentiometric surface map in Figure 2-1. Average potentiometric levels were used to generate the surface map to provide an overall assessment of groundwater direction in the basal Sharon Conglomerate at the installation scale. Groundwater flow directions were consistent among the four quarters. The groundwater potentiometric data suggests a general north-south divide running along the center RVAAP with an east-northeast groundwater flow from the topographic and groundwater high at SCFmw-001. Minor seasonal variation was observed for groundwater levels collected over the four quarters of sampling, as presented in Table 2-2. Well SCFmw-004 in the southeastern portion of RVAAP exhibited artesian characteristics, which indicates the basal Sharon Conglomerate may be partially confined in this part of the installation.

Table 2-2. Quarterly Groundwater Levels

Well ID	TOC Elevation (NGVD 1929)	Total Depth (ft btoc)	First Quarter 04/21/2009 - 04/24/2009		Second Quarter 07/14/09 - 07/16/09		Third Quarter 10/12/09 - 10/14/09		Fourth Quarter 01/18/10 - 01/20/10	
			Depth to Water (ft btoc)	Water Level Elevation (ft msl)	Depth to Water (ft btoc)	Water Level Elevation (ft msl)	Depth to Water (ft btoc)	Water Level Elevation (ft msl)	Depth to Water (ft btoc)	Water Level Elevation (ft msl)
SCFmw-001	1120.71	213.61	88.18	1032.53	89.55	1031.16	93.70	1027.01	89.77	1030.94
SCFmw-002	984.56	149.65	17.97	966.59	19.16	965.40	21.18	963.38	20.39	964.17
SCFmw-003	958.47	139.65	7.49	950.98	8.53	949.94	10.05	948.42	9.49	948.98
SCFmw-004	944.17	112.47	0.00	944.17	0.21	943.96	1.70	942.47	0.70	943.47
SCFmw-005	960.80	156.41	9.49	951.31	11.72	949.08	13.25	947.55	12.95	947.85
SCFmw-006	965.92	88.32	17.51	948.41	18.28	947.64	18.94	946.98	18.49	947.43

Measuring point elevations surveyed by KS Associates
Total depth measurements presented were collected during development activities
NGVD = National Geodetic Vertical Datum
TOC = top of casing
ft btoc = feet below top of casing
msl = mean sea level

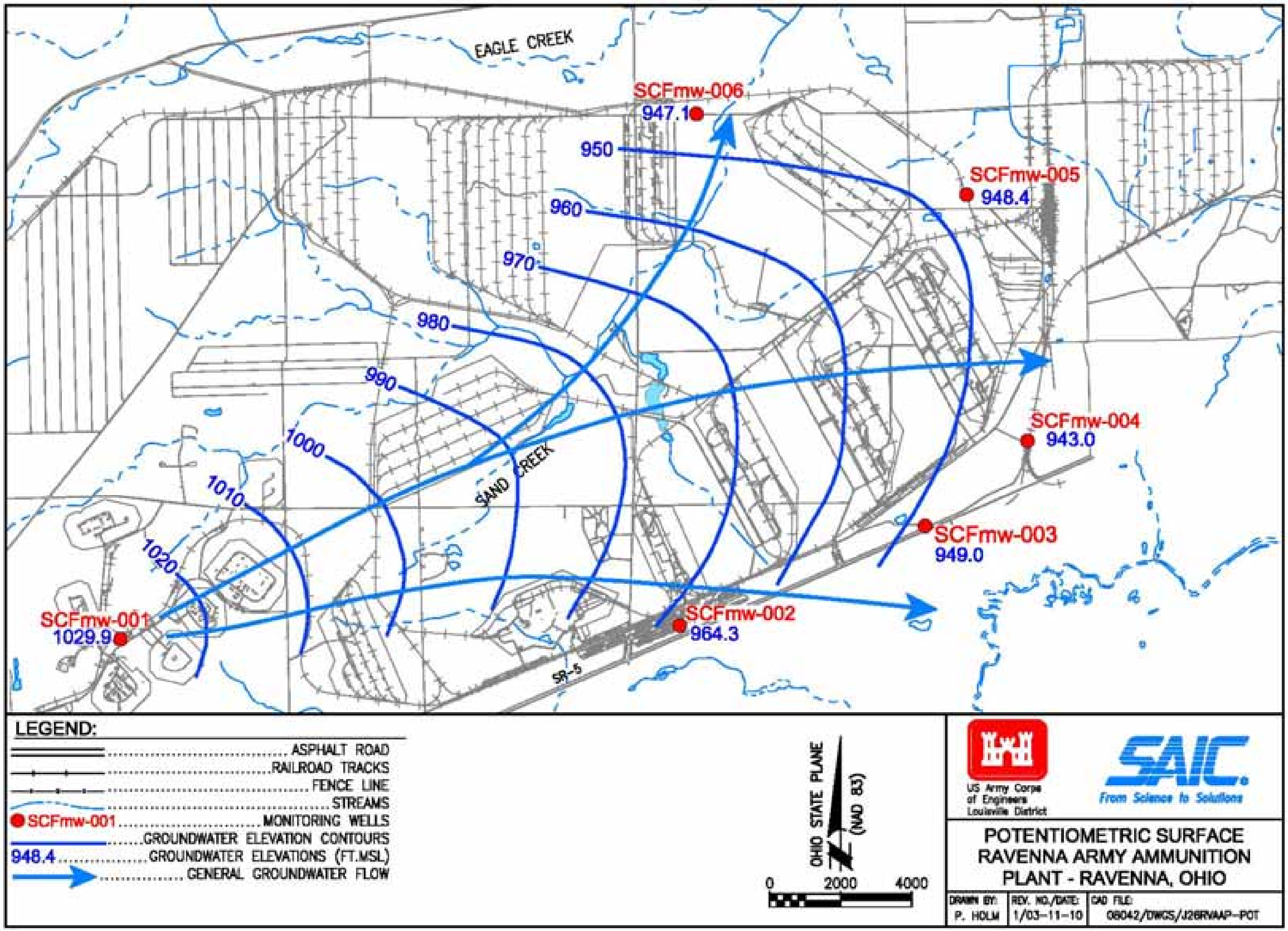

Figure 2-1. Potentiometric Map

2.5 LABORATORY ANALYSIS

Samples collected during the investigation were analyzed by TestAmerica, Inc. of North Canton, OH a National Environmental Laboratory Accreditation Conference (NELAC), Department of Defense (DOD) Quality Systems Manual (QSM), and USACE-certified laboratory. Quality Assurance (QA) split samples were prepared, packaged, and submitted to USACE's contracted laboratory, RTI Laboratory of Livonia, MI.

Analytical parameters, analytical methods, and project required reporting limits are those identified in the Facility-wide QAPP Tables 3-3 through 3-9 (excluding Table 3-6). Table 3-6 presents project quanitation levels for Polyaromatic Hydrocarbons in Soil and Water, which are incorporated into the SVOC analysis presented in Table 3-4. Strict adherence to these requirements set forth in the Facility-wide SAP was required of the analytical laboratory to ensure quality data were provided. Analytical laboratory procedures were completed in accordance with applicable professional standards, USEPA requirements, government regulations and guidelines, and specific project goals and requirements. Laboratories were required to comply with all methods as written, and recommendations were considered requirements. The laboratory provided the analyses in compliance with current versions of the referenced EPA SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Analytical Protocols* (USEPA 1990) procedures, and the referenced USACE documents. The laboratory performed all analyses with SW-846 chemical analytical procedures for the analyses of VOCs, SVOCs, pesticides, PCBs, explosives, propellants (except nitrocellulose and nitroguanidine), TAL metals, and cyanide. Analytical procedures for nitrocellulose and nitroguanidine are proprietary laboratory methods. Analytical results were reported by the laboratory in electronic format and loaded into the RVAAP Environmental Information Management System database.

The laboratory was required to perform QC analyses consistent with those defined in the referenced EPA SW-846 analytical methods, the USACE Shell for Analytical Chemistry Requirements, the DOD QSM, and the DOD QSM Louisville Supplement. QA/QC samples for this project included trip blanks, QA field duplicates, QC split samples, laboratory method blanks, laboratory control samples, laboratory duplicates, and matrix spike/matrix spike duplicate samples. Equipment rinsate blanks and trip blanks were submitted for analysis, along with field duplicate samples, to provide a means to assess the quality of the data resulting from the field sampling program.

2.5.1 Data Quality Objectives

Prepared in accordance with USACE and USEPA guidance, the Facility-wide SAP and SAP Addendum No. 1 outlined the organization, objectives, intended data uses, and QA/QC activities to achieve the desired data quality objectives (DQOs) and maintain the defensibility of the data. Project DQOs were established in accordance with EPA Region 5 guidance. DQOs for this project included analytical precision, accuracy, representativeness, completeness, comparability, and sensitivity for the measurement data. All analytical procedures were completed in accordance with applicable professional standards, USEPA requirements, government regulations and guidelines, USACE–Louisville District analytical QA guidelines, and specific project goals and requirements.

2.5.1.1 <u>Accuracy, Precision And Sensitivity of Analysis</u>

Accuracy, precision, and sensitivity goals were followed in accordance to Section 3.3 and Tables 3-1 through 3-9 of the Facility-wide QAPP and SAP Addendum No. 1.

2.5.1.2 <u>Completeness, Representativeness And Comparability</u>

Completeness, representativeness, and comparability goals were followed in accordance to Section 3.3 and Tables 3-1 through 3-9 of the Facility-wide QAPP and SAP Addendum No. 1.

2.5.2 Data Validation And Verification

Once analytical results were reported by the laboratory, verification of data was performed to ensure all requested data were received and complete. Data use qualifiers were assigned to each result based on the laboratory QA review and verification criteria. Results were qualified as follows:

- "U" not detected, concentration reported is reporting limit (RL);
- "UJ" not detected, reporting limit estimated;
- "J" analyte present but at an estimated concentration less than the reporting limit; and
- "R" result not usable.

In addition to assigning qualifiers, the verification process also selected the appropriate result to use when re-analyses or dilutions were performed. Where laboratory surrogate recovery data or laboratory QC samples were outside of analytical method specifications, a determination was made whether laboratory re-analysis should be used in place of an original reported result. If results were reported for both diluted and undiluted samples, results from the diluted sample were used only for those analytes that exceeded the calibration range of the undiluted sample.

3.0 MONITORING RESULTS

3.1 SUMMARY OF ANALYTICAL RESULTS

Validated analytical results for the quarterly sampling events from the wells installed into the basal Sharon Conglomerate are presented in Appendix J. Laboratory Data Packages for these quarterly monitoring events are included electronically in Appendix K.

A statistical evaluation is presented to identify compounds exhibiting the greatest frequency of detection, maximum concentrations, and minimum concentrations. The analytical results were compared to facility-wide background concentrations for bedrock groundwater and the USEPA *2009 Edition of the Water Standards and Health Advisories* (USEPA 2009). Subsequently, screening against the lower of the RVAAP Draft Facility-wide cleanup goals (CUGs) for a Resident Farmer Adult or Child at HI=0.1/ILCR=10-6 was performed to provide an initial indication of the presence and magnitude of any chemical contamination in groundwater within the basal Sharon Conglomerate aquifer. This screening is presented in Table 3-1.

The sample(s) that contain results between the Method Detection Limit and the RL were flagged with a "J" qualifier for estimated concentration as there is a possibility of false positive or mis-identification at these quantitation levels. In some instances estimated concentrations detected exceed facility-wide background criteria and regional screening levels (RSLs).

The following subsections discuss the concentrations of each chemical group.

3.2 VOLATILE ORGANIC COMPOUNDS

Only one VOC, carbon disulfide, was detected during the four quarters of monitoring. Carbon disulfide was detected in nine of twenty-four samples collected. The lowest detection of carbon disulfide was 0.00028J mg/L with a maximum detection of 0.0019 mg/L, which is below the RSL of 0.1 mg/L. There is no established background criterion for carbon disulfide in bedrock groundwater at RVAAP, as all VOCs are assumed to be anthropogenic and have background concentrations of zero in groundwater.

3.3 SEMIVOLATILE ORGANIC COMPOUNDS

Only one SVOC, Bis(2-ethylhexyl)phthalate (BEHP), was detected during the quarterly sampling events. BEHP was detected once during the third quarter sampling event in SCFmw-001 (concentration of 0.0014 mg/L). BEHP was detected once during the fourth quarter when SCFmw-004 had a concentration of 0.00084J mg/L. Only one of these results was above the established reporting limit (RL) for BEHP of 0.001 mg/L; therefore, the other concentration was estimated. The concentration of BEHP did not exceed the USEPA 2009 Water Standards of 0.006 mg/L.

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Table 3-1. Summary of Analytical Data and Comparison to Draft Facility-wide CUGs

Analysis Type	Analyte	CAS Number	Units	Results >Detection Limit	Minimum Detect	Maximum Detect	Background Criteria - Bedrock	Max. > Bkg.?	Screening Level (HQ=0.1/R=1E-6)?	Screening Level Type	Exceeds Screening Level (HQ=0.1/R=1E-6)?	Reason
Anions	Nitrate/Nitrite (NO3/NO2-N)	N599	mg/L	1/ 24	0.1	0.1		Yes	None	None	None	<5% detects
Metals-Dissolved	Antimony	7440360	mg/L	19/ 24	0.00013	0.0038	0	Yes	0.00039	RFC	Yes	Exceeds SL
Metals-Dissolved	Arsenic	7440382	mg/L	16/ 24	0.0033	0.0206	0	Yes	0.000056	RFA	Yes	Exceeds SL
Metals-Dissolved	Barium	7440393	mg/L	24/ 24	0.0377	0.261	0.256	Yes	0.2	RFC	Yes	Exceeds SL
Metals-Dissolved	Calcium	7440702	mg/L	24/ 24	58.5	153	53.1	Yes	None	None	None	Nutrient
Metals-Dissolved	Cobalt	7440484	mg/L	5/ 24	0.0018	0.0097	0	Yes	0.021	RFC	No	Max<SL
Metals-Dissolved	Iron	7439896	mg/L	17/ 24	0.0708	6.85	1.43	Yes	0.31	RFC	Yes	Exceeds SL
Metals-Dissolved	Magnesium	7439954	mg/L	24/ 24	16.5	61.8	15	Yes	None	None	None	Nutrient
Metals-Dissolved	Manganese	7439965	mg/L	24/ 24	0.0821	1.66	1.34	Yes	0.046	RFC	Yes	Exceeds SL
Metals-Dissolved	Nickel	7440020	mg/L	5/ 24	0.0029	0.0065	0.0834	No	0.021	RFC	No	Max<SL
Metals-Dissolved	Potassium	7440097	mg/L	24/ 24	1.18	4.79	5.77	No	None	None	None	Nutrient
Metals-Dissolved	Sodium	7440235	mg/L	24/ 24	6.76	27.1	51.4	No	None	None	None	Nutrient
Metals-Dissolved	Thallium	7440280	mg/L	4/ 24	0.00015	0.00044	0	Yes	0.000083	RFC	Yes	Exceeds SL
Metals-Dissolved	Zinc	7440666	mg/L	12/ 24	0.0114	0.333	0.0523	Yes	0.31	RFC	Yes	Exceeds SL
Metals-Total	Aluminum	7429905	mg/L	6/ 6	0.0213	1.72	9.41	No	1	RFC	Yes	Exceeds SL
Metals-Total	Antimony	7440360	mg/L	2/ 6	0.00024	0.00053	0	Yes	0.00039	RFC	Yes	Exceeds SL
Metals-Total	Arsenic	7440382	mg/L	4/ 6	0.0113	0.0186	0.0191	No	0.000056	RFA	Yes	Exceeds SL
Metals-Total	Barium	7440393	mg/L	6/ 6	0.0421	0.117	0.241	No	0.2	RFC	No	Max<SL
Metals-Total	Calcium	7440702	mg/L	6/ 6	61.5	144	48.2	Yes	None	None	None	Nutrient
Metals-Total	Chromium	7440473	mg/L	1/ 6	0.0021	0.0021	0.0195	No	0.0027	RFC	No	Max<SL
Metals-Total	Cobalt	7440484	mg/L	1/ 6	0.0018	0.0018	0	Yes	0.021	RFC	No	Max<SL
Metals-Total	Iron	7439896	mg/L	6/ 6	0.316	4.76	21.5	No	0.31	RFC	Yes	Exceeds SL
Metals-Total	Magnesium	7439954	mg/L	6/ 6	15.7	57.8	13.7	Yes	None	None	None	Nutrient
Metals-Total	Manganese	7439965	mg/L	6/ 6	0.0905	1.36	1.26	Yes	0.046	RFC	Yes	Exceeds SL
Metals-Total	Nickel	7440020	mg/L	2/ 6	0.0045	0.0089	0.0853	No	0.021	RFC	No	Max<SL
Metals-Total	Potassium	7440097	mg/L	6/ 6	1.39	2.47	6.06	No	None	None	None	Nutrient
Metals-Total	Sodium	7440235	mg/L	6/ 6	6.99	21.8	49.7	No	None	None	None	Nutrient
Metals-Total	Thallium	7440280	mg/L	2/ 6	0.00046	0.0006	0	Yes	0.000083	RFC	Yes	Exceeds SL
Metals-Total	Zinc	7440666	mg/L	5/ 6	0.0206	0.173	0.193	No	0.31	RFC	No	Max<SL
Miscellaneous	Cyanide	57125	mg/L	1/ 24	0.0076	0.0076	None	Yes	0.073	RSL	No	Max<SL
Miscellaneous	Perchlorate	7601903	mg/L	4/ 6	0.000019	0.000042	None	Yes	0.0026	RSL	No	Max<SL
Organics-Explosives	1,3,5-Trinitrobenzene	99354	mg/L	5/ 24	0.000047	0.000085	None	Yes	0.11	RSL	No	Max<SL
Organics-Explosives	4-Amino-2,6-Dinitrotoluene	19406510	mg/L	1/ 24	0.000083	0.000083	None	Yes	0.00021	RFC	No	Max<SL
Organics-Explosives	HMX	2691410	mg/L	1/ 24	0.000058	0.000058	None	Yes	0.18	RSL	No	Max<SL
Organics-Explosives	PETN	78115	mg/L	1/ 24	0.00042	0.00042	None	Yes	None	None	None	No SL
Organics-Explosives	RDX	121824	mg/L	1/ 24	0.000091	0.000091	None	Yes	0.00077	RFA	No	Max<SL
Organics-Explosives	Tetryl	479458	mg/L	1/ 24	0.00007	0.00007	None	Yes	0.015	RSL	No	Max<SL
Organics-Semivolatile	Bis(2-ethylhexyl)phthalate	117817	mg/L	2/ 24	0.00084	0.0014	None	Yes	0.0009	RFA	Yes	Exceeds SL
Organics-Volatile	Carbon disulfide	75150	mg/L	9/ 24	0.00028	0.0019	None	Yes	0.1	RSL	No	Max<SL

HMX = 1,3,5,7-tetranitro-1,3,5,7-tetrazocane
RDX = 1,3,5-trinitroperhydro-1,3,5-triazine
RFA = Resident Farmer Adult
PETN = Pentaerythritol tetranitrate
RFC = Resident Farmer Child
RSL = Regional Screening Level

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3.4 POLYCHLORINATED BIPHENYLS

No PCBs were detected during the four quarters of groundwater monitoring.

3.5 PESTICIDES

No pesticides were detected during the four quarters of groundwater monitoring.

3.6 EXPLOSIVES AND PROPELLANTS

Six explosive analytes were detected during the quarterly sampling events. These detections occurred in the first quarter and fourth quarter groundwater monitoring events. No detections of explosives occurred during second and third quarter monitoring. No propellants were detected during the four quarters of monitoring.

All detections of explosives were estimated values, as the concentrations were below laboratory reporting limits. The six analytes detected, along with concentrations and locations, are presented in Table 3-2. All detections for explosives were below screening levels based on facility-wide cleanup goals at HI=0.1/ILCR=10-6, except for Pentaerythritol tetranitrate (PETN), which has no established screening level.

While these results are estimated, additional sampling is recommended to determine if there are potential impacts to the aquifer.

Table 3-2. Summary of Detected Explosive Concentrations

Well	Sampling Quarter	Chemical	Results (mg/L)	Laboratory and Data Qualifier
SCFmw-001	First Quarter	1,3,5-Trinitrobenzene	0.000085	J
SCFmw-001	Fourth Quarter	RDX	0.000091	J
SCFmw-002	First Quarter	4-Amino-2,6-Dinitrotoluene	0.000083	J
SCFmw-002	First Quarter	Tetryl	0.00007	J
SCFmw-003	First Quarter	1,3,5-Trinitrobenzene	0.000056	J
SCFmw-004	First Quarter	1,3,5-Trinitrobenzene	0.000057	J
SCFmw-005	First Quarter	HMX	0.000058	J
SCFmw-005	First Quarter	1,3,5-Trinitrobenzene	0.000056	J
SCFmw-005	Fourth Quarter	PETN	0.00042	J
SCFmw-006	First Quarter	1,3,5-Trinitrobenzene	0.000047	J

HMX = 1,3,5,7-tetranitro-1,3,5,7-tetrazocane
PETN = Pentaerythritol tetranitrate
RDX = 1,3,5-trinitroperhydro-1,3,5-triazine
J = Concentration was detected but below laboratory reporting limits. Reported concentration is an estimated value.

3.7 PERCHLORATE

Groundwater in each well was analyzed for perchlorate during the second quarter sampling event. Perchlorate was detected in four of the six monitoring wells; however, each concentration was below the laboratory reporting limit of 0.00005 mg/L. Therefore, the analytical concentrations are estimated values. The minimum concentration of detected perchlorate was 0.000019J mg/L. The maximum concentration of detected perchlorate was 0.000042J mg/L. There is no established facility-wide background concentration for perchlorate in bedrock groundwater; however, all detections of perchlorate were below the U.S. EPA RSL of 0.0026 mg/L.

3.8 NITRATE-NITRITE

NO_3/NO_2 was detected by USEPA Method 353.2 during the second quarter sampling at SCFmw-001 at a concentration of 0.1 mg/L. No other detections of NO_3/NO_2 occurred during the four quarters of monitoring. There are no established facility-wide background criteria for bedrock groundwater or RSL for NO_3/NO_2. The concentration of NO_3/NO_2 detected is less than the established USEPA 2009 Water Standards of 10 mg/L for NO_3 and 1.0 mg/L for NO_2.

3.9 CYANIDE

Cyanide was detected at SCFmw-001 during the fourth quarter sampling event. No other detections of cyanide occurred during the four quarters of monitoring. There is no established facility-wide criterion for bedrock water for cyanide. The detected concentration was estimated at 0.0076J mg/L, as the concentration was below the RL (0.01 mg/L). This concentration was below the RSL of 0.073 mg/L.

3.10 METALS

Analysis of the filtered groundwater samples indicated the presence of thirteen dissolved metals over the four quarters of groundwater sampling. In addition to filtered metals collected on a quarterly basis, total metals were collected for analysis during the third quarter event. The collection of unfiltered metals during this one quarterly event was to support a USACE groundwater geochemical evaluation. Fifteen metals were detected during that sampling event. Analytical results are presented below in Table 3-3. Four of these metals (calcium, magnesium, potassium, and sodium) are considered essential nutrients.

Table 3-3. Comparison of Detected Unfiltered and Filtered Metals Results

Analyte	Unfiltered Metals		Filtered Metals	
	Min Detect (mg/L)	Max Detect (mg/L)	Min Detect (mg/L)	Max Detect (mg/L)
Aluminum	0.0213	1.72	ND	ND
Antimony	0.00024	0.00053	0.00013	0.0038
Arsenic	0.0113	0.0186	0.0033	0.0206
Barium	0.0421	0.117	0.0377	0.261
Calcium*	61.5	144	58.5	153
Chromium	0.0021	0.0021	ND	ND
Cobalt	0.0018	0.0018	0.0018	0.0097
Iron	0.316	4.76	0.0708	6.85
Magnesium*	15.7	57.8	16.5	61.8
Manganese	0.0905	1.36	0.0821	1.66
Nickel	0.0045	0.0089	0.0029	0.0065
Potassium*	1.39	2.47	1.18	4.79
Sodium*	6.99	21.8	6.76	27.1
Thallium	0.00046	0.0006	0.00015	0.00044
Zinc	0.0206	0.173	0.0114	0.333

* Essential nutrient.
ND = non-detect

Most dissolved metals except for zinc, nickel, and cobalt were detected in all four quarters of monitoring. Zinc was not detected during first quarter and cobalt was not detected during the third quarter event. Nickel was detected only during the second monitoring event.

As illustrated in Table 3-3, aluminum and chromium were detected as part of total metal analysis below background criteria, but were not detected in solution (i.e., filtered samples). Based on comparison of unfiltered and filtered results, metal samples collected from the monitoring wells are primarily in solution. The dissolved metals (excluding essential nutrients) antimony, arsenic, barium, cobalt, iron, manganese, thallium, and zinc are present in the Sharon Conglomerate monitoring wells at concentrations above the established facility-wide background criteria for filtered bedrock groundwater. In addition, six of these dissolved metals (antimony, arsenic, barium, iron, manganese, thallium, and zinc) were present above screening levels.

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4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The purpose of this investigation was to install six groundwater monitoring wells into the basal Sharon Conglomerate to evaluate impacts, if any, to groundwater in this formation from historical operations. The six wells were installed in the basal Sharon Conglomerate at locations selected by USACE, Ohio EPA, and OHARNG based on estimated groundwater flow directions, former operational areas of RVAAP, and the RVAAP boundary.

In addition to the well installation activities, four quarters of groundwater samples were collected from each of the six wells. Using the results of the groundwater sampling events, a screening was implemented to provide an indication of whether contamination is an issue within this aquifer. Seven inorganic metal analytes, nitrate/nitrite, PETN, and BEHP completed the screening with 1) a frequency of detection and 2) a maximum concentration exceeding facility-wide background concentrations for bedrock groundwater and the lower of the RVAAP Draft Facility-wide CUGs for a Resident Farmer Adult or Child at HI=0.1/ILCR=10-6. However, nitrate/nitrite and PETN passed the screening with concentrations below laboratory reporting levels and do not have RSLs for comparison. Trace estimated concentrations of explosives within the aquifer indicate a hydraulic communication between the shallower overburden and bedrock wells and the Sharon Conglomerate Aquifer may exist. Additional sampling will be recommended to verify this communication exists.

4.2 RECOMMENDATIONS

It is recommended that the six wells be incorporated into the FWGWMP and sampled for RVAAP full-suite analytes on a quarterly basis for at least one year to determine potential contamination and hydraulic communication between the shallower overburden and bedrock wells at the facility and the Sharon Conglomerate aquifer. At the completion of one additional year of sampling, the groundwater data will be used to determine if additional monitoring and sampling is necessary.

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5.0 REFERENCES

Ohio Department of Natural Resources (ODNR) 1990. Ground Water Pollution Potential of Portage County Ohio. Ground Water Pollution Potential Report No. 22.

Ohio Environmental Protection Agency (Ohio EPA) 1995. Technical Guidance Manual for Hydrogeologic Investigation and Groundwater Monitoring.

Ohio EPA 2004. Director’s Final Findings and Orders for RVAAP. June, 2004.

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United States Army Corps of Engineers (USACE) 2001. Facility-wide Sampling and Analysis Plan for Environmental Investigations at the Ravenna Army Ammunition Plant, Ravenna, Ohio, DACA 62-00-D-0001, D.O. CY02, Final.

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USACE 2008. Final Sampling and Analysis Plan Addendum No. 1 for the Deep Bedrock Well Installation in the Sharon Conglomerate. W912QR-04-D-0028. December 2008.

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United States Geological Survey (USGS) 1968. “Mineral Resources of the Appalachian Region,” U.S. Geological Survey Professional Paper No. 580. 1968.

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PRELIMINARY DRAFT MONITORING REPORT FOR THE DEEP BEDROCK WELL INSTALLATION IN THE BASAL SHARON CONGLOMERATE AT THE RAVENNA ARMY AMMUNITION PLANT, RAVENNA OHIO
COMMENT RESPONSE TABLE
MAY 19, 2010

Comment Number	**Page or Sheet**	**New Page or Sheet**	**Comment**	**Recommendation**	**Response**
Ohio EPA (Vicki Deppisch, DERR and Conni Mc Cambridge, DDAGW)					
O-1	Page 2-17, Section 2.5.2, Section 3.1		Section 2.5.2 text indicates ground water results were qualified as “U,” “UJ,” “J,” “R,” and “=” based on laboratory review. However, Section 3.1 further defines that organic estimated results were flagged with a “J” qualifier, while inorganic estimated results were flagged with “B.” This has been discussed many times and appears to be still unresolved. It is confusing to have two different qualifiers (“B” and “J”) representing estimated results. In addition, future sampling will be incorporated into the FWGWMP, which currently uses the “J” value for both inorganics and organics. There are also many different people utilizing the data, which can add to inaccuracies.	Please discuss and change.	Agree. To remain consistent with FWGWMP terminology the use of the “J” qualifier will be used to denote estimated result for both inorganic and organic analytes. No changes will be made to the text in Section 2.5.2. Modified text for Section 3.1 Line 17-19: “The sample(s) that contain results between the Method Detection Limit and the RL were flagged with a “J” qualifier ~~for organic analytes or a “B” qualifier for inorganic analytes~~ for estimated concentration…” Additionally, the document will globally replace the use of a “B” qualifier with the “J” qualifier where referencing an inorganic estimated result.

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
O-2	Page 3-5, Table 3-2, Section 3.6		The text indicates that six explosives were detected below the laboratory reporting limits during quarterly sampling events. While these results were flagged with a "J" (estimated) qualifier, it should be noted that "J" values may be indicative of potential impacts to the aquifer.	It is unclear whether these "J" values reported in the six new wells indicate the presence of explosives from previous facility activities in ground water. Ohio EPA concurs with the recommendation to continue quarterly ground water sampling during 2011. Ohio EPA also recommends that both filtered and unfiltered samples be collected for metal analyses during these 2011 sampling events.	05/07/10 Original Response: Agree. The following will be added as a standalone paragraph after line 20 on Page 3-5. "While these results are estimated, additional sampling is recommended to determine if there are potential impacts to the aquifer." Additionally, Section 4.2 Line 26 will be revised as follows: "…and sampled for RVAAP full-suite analytes, including filtered and unfiltered metals, on a quarterly basis…" 05/19/10 Response per Resolution Meeting: Agree. The following will be added as a standalone paragraph after line 20 on Page 3-5. "While these results are estimated, additional sampling is recommended to determine if there are potential impacts to the aquifer." The sampling for unfiltered metals during October 2009 was a one time event for USACE to support the RVAAP groundwater geochemical evaluation. Further sampling for unfiltered metals is not proposed and the text in Section 4.2, Line 26 will not be revised as originally recommended. However, the text on page 3-6; Line 31 will be revised as follows: "…total metals were collected for analysis during the third quarter event. The collection of unfiltered metals during this one quarterly event was to support a USACE groundwater geochemical evaluation. Fifteen metals…"

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
O-3	Appendix G		The April 2009 (Ist Quarter) well purge log for SCFmw-004 reports pH values between 11.45 and 12.64. These values were attributed to problems with the pH meter.	Please provide a brief discussion of this pH field issue in Sections 2.4.1 and 2.4.2.1 of the text.	Agree. The following text is proposed for insertion on pg 2-13 Line 23: "…Appendix I. During monitoring activities an issue with the Horiba U-22 water quality meter was encountered. During the completion of low-flow purging at SCFmw-004 on 04/22/09, the Horiba U-22 provided pH readings of 12.47-12.64 S.U. The Horiba was properly calibrated in the morning and to not disrupt low flow purging as sampling parameters were stable, field personnel assessed the Horiba U-22 water quality instrument following well purging. Following field assessment and testing, the Horiba did not properly calibrate. The instrument was removed from service and replaced. Complete details of activities are presented in Appendix A, Logbook SCF-007, pages 6-7. No other water quality instrument issues occurred during the four quarters of monitoring."

PRELIMINARY DRAFT MONITORING REPORT FOR THE DEEP BEDROCK WELL INSTALLATION IN THE BASAL SHARON CONGLOMERATE AT THE RAVENNA ARMY AMMUNITION PLANT, RAVENNA OHIO
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Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
O-4	Appendix G		Well purge logs reported high turbidity values (i.e., 366 NTUs in SCFmw-001 on 7/14/2009; 999 NTUs in SCFmw-001 on 10/12/2009) in several wells that utilized low-flow purging and sampling techniques. The report did not include any reasoning for the observed elevated turbidity values or address whether the newly installed wells were adequately developed. Thus, it is unclear whether these observed turbidity values are related to inadequate well development and/or well design issues.	The reason for elevated turbidity value needs to be addressed. Please provide an explanation as to how the issue of high turbidity values will be resolved to provide representative ground water samples.	Clarification. Monitoring wells were installed per the Facility Wide SAP, SAP Addendum No. 1 and approved field change requests. All wells were developed per procedures outlined in the Facility-wide SAP. As development procedures were followed, it is believed all wells were adequately developed. The results of the well development are presented in Section 2.1.3 and field documentation is included in Attachment A. The following text is proposed for insertion in Section 2.4.1 Line 20: "Wells were purged at a rate less than the maximum micropurge flow rate of 500mL/min. Each well was purged…" Additionally, as procedures were followed and representative groundwater samples were collected, line 30 will be revised as follows: "…Appendix G. While Turbidity and ORP readings were recorded, these parameters were not used to determine stabilization, as they are not specified as stabilization parameters in the Facility Wide SAP." Concerning well design: In most boreholes, small shale lenses and various fractures were observed throughout the entirety of the Sharon Conglomerate. This is common for this stratigraphic unit. Specifically in SCFmw-001, there is a small shale seam from 203-204 ft bgs. This shale seam is most likely the source for increased fines/turbidity in this well. As the 10 ft screen well construction would include a shale seam regardless of construction, this installation depth was selected as the most representative interval to characterize the basal Sharon Conglomerate.

PRELIMINARY DRAFT MONITORING REPORT FOR THE DEEP BEDROCK WELL INSTALLATION IN THE BASAL SHARON CONGLOMERATE AT THE RAVENNA ARMY AMMUNITION PLANT, RAVENNA OHIO
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Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
O-5	Appendix H		Several Chain of Custodies do not have laboratory receipt sign-off signatures (i.e., April 2009: RVAAP-SCF-004; July 2009: RVAAP-SCF-006; October 2009: RVAAP-SCF-010; January 2010: RVAAP-SCF-013).	The submittal needs to provide a brief discussion of the procedure used by the laboratory to sign off on containers containing ground water samples. Also, during future sampling events, please take adequate measures to assure that Chain of Custody forms contain the appropriate signatures.	Clarification. All COCs listed (RVAAP-SCF-004, RVAAP-SCF-006, RVAAP-SCF-010, and RVAAP-SCF-013) are COCs recording samples sent to the USACE split laboratory. Per procedures outlined in Chapter 5.0 of the Facility Wide SAP, the original COC was secured in the cooler with the samples that were submitted to the split lab via FedEx. However, as SAIC does not receive final data packages, SAIC did not receive the final COC. All samples submitted to Test America were also completed per procedures outlined in the Facility Wide SAP showing a complete chain of custody. These procedures are discussed on page 2-13, lines 9-15. SAIC proposes the following clarification/insertion: Line 13…Sample collection activities were documented per procedures outlined in Chapter 5.0 of the Facility Wide SAP in the project…
Army (Corey White, Mark Nichter)					
A-1	Table of Contents		The Table of Contents shows that the "List of Appendices" is located on page *ii*. The appendices are not listed anywhere.	Please add a list of appendices for the table of contents.	Agreed. Appendices will be added to the Table of Contents.

PRELIMINARY DRAFT MONITORING REPORT FOR THE DEEP BEDROCK WELL INSTALLATION IN THE BASAL SHARON CONGLOMERATE AT THE RAVENNA ARMY AMMUNITION PLANT, RAVENNA OHIO
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Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
A-2	4-1 / 18-20		SAIC states......"there is no indication of a direct hydraulic communication between the shallower overburden and bedrock wells at the facility, and the Sharon Conglomerate aquifer." The USACE anticipates that this statement is not well founded and may be incorrect. The presence of trace concentrations of explosives in the basal portion of the Sharon Conglomerate suggests that communication does exist or did occur at some time in the past between the shallow aquifers and the basal portion of the Sharon Conglomerate.	If SAIC believes that direct hydraulic communication does not exist between the subject aquifers, then please provide additional information supporting (and in defense of) this statement. If SAIC agrees that direct communication may exist or previously existed between the subject aquifers, then revise the statement accordingly. Provide discussion supporting the statement.	Agreed. As addressed in comment O-2- These trace results are infrequent and estimated. Additional sampling is recommended to determine if there are explosive impacts to the aquifer and communication between the overburden and shallow aquifers to the deeper Sharon Conglomerate aquifer. Text will be revised as follows: Section 4.1 Line 18: "…comparison. Trace estimated concentrations of explosives within the aquifer indicate a hydraulic communication between the shallower overburden and bedrock wells and the Sharon Conglomerate Aquifer may exist. Additional sampling will be recommended to verify if this communication exists. ~~Consequently, it is determined that there is no indication of a direct hydraulic communication between the shallower overburden and bedrock wells at the facility, and the Sharon Conglomerate aquifer.~~"

Comment Number	Page or Sheet	New Page or Sheet	Comment	Recommendation	Response
A-3	4-1 / 24-25		SAIC states……"Analytical data from these wells suggests that historical operations at RVAAP did not contribute contamination into the basal Sharon Conglomerate." Since trace concentrations of explosives have been detected in groundwater samples from the basal Sharon Conglomerate, the USACE anticipates that this statement may be difficult to defend.	Please revise this sentence (as applicable).	05/07/10 Original Response: Agreed. Text in Section 4.2 Line 24 will be revised as follows: ~~Analytical data from these wells suggests that historical operations at RVAAP did not contribute contamination into the basal Sharon Conglomerate.~~ It is recommended that the six wells be incorporated into the FWGWMP and sampled for RVAAP full-suite analytes, including filtered and unfiltered metals, on a quarterly basis for at least one year to determine potential contamination and hydraulic communication between the shallower overburden and bedrock wells at the facility, and the Sharon Conglomerate aquifer. At the completion of one additional year of sampling…" 05/19/10 Response per Resolution Meeting: Agreed. Text in Section 4.2 Line 24 will be revised as follows: ~~Analytical data from these wells suggests that historical operations at RVAAP did not contribute contamination into the basal Sharon Conglomerate.~~ It is recommended that the six wells be incorporated into the FWGWMP and sampled for RVAAP full-suite analytes on a quarterly basis for at least one year to determine potential contamination and hydraulic communication between the shallower overburden and bedrock wells at the facility, and the Sharon Conglomerate aquifer. At the completion of one additional year of sampling…"
A-4	4-1 / 26		The word "suite" is misspelled.	Correct spelling error.	Agreed. Spelling will be corrected from "sute" to "suite"

A comment resolution meeting was held between the Ohio EPA, USACE, and SAIC on May 19, 2010 at 11:15am. Attendees were Mark Nichter (USACE), Vicki Deppisch (Ohio EPA), Conni McCambridge (Ohio EPA), Amanda Trenton (SAIC), and Jed Thomas (SAIC).

The following items were clarified during this meeting:

- All parties agreed that groundwater samples will not be analyzed for unfiltered metals in future sampling events for the Sharon Conglomerate Wells. This change affects responses to Comments O-2 and A-3.
- Further description of why samples were analyzed for unfiltered metals in October 2009 will be added to the text (Comment O-2).
- SAIC does not have signed copies of Chain-of-Custody records from the USACE split laboratory in the final document. Signed copies of these COCs will not be included in the Final Monitoring Report (Comment O-5).