FIELD SAMPLING PLAN
FOR PART 2 OF THE SUPPLEMENTAL GROUNDWATER REMEDIAL INVESTIGATION

Former York Naval Ordnance Plant
1425 Eden Road, Springettsbury Township
York, Pennsylvania

Prepared for:

Harley-Davidson Motor Company Operations, Inc.

1425 Eden Road

York, Pennsylvania

April 2012

Prepared by:

Groundwater Sciences Corporation

2601 Market Place Street, Suite 310
Harrisburg, PA 17110-9340

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LIST OF ACRONYMS AND ABBREVIATIONS

AMF	American Machine & Foundry Company
AMO	AMO Environmental Decisions, Inc.
bgs	below ground surface
COC	chemicals of concern
CLP	contract laboratory program
CPA	Central Plant Area
CPS	counts-per-second
CVOC	chlorinated volatile organic compounds
DGPS	digital global positioning system
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DQOs	Data Quality Objectives
ECD	electron capture detectors
EI	electrical imaging
FCOs	field change orders
FCR	field change request
FID	flame-ionization detectors
foc	fraction of organic carbon
FS	feasibility study
FSP	field sampling plan
fYNOP	former York Naval Ordnance Plant
GC	gas chromotography
gpd	gallons per day
gpm	gallons per minute
GPR	Ground Penetrating Radar

GPS	global positioning system
GSC	Groundwater Sciences Corporation
GSSI	Geophysical Survey System
GWTS	groundwater extraction and treatment system
HASP	Health and Safety Plan
IDW	investigation-derived waste
Langan	Langan Engineering and Environmental Services, Inc.
MCLs	maximum contaminant levels
MIP	Membrane Interface Probe
mg/L	milligrams per liter
mm	millimeter
MNA	monitored natural attenuation
mS/cm	milliSeimen per centimeter
MSCs	medium specific concentrations
MSL	mean sea level
MTBE	methyl tertiary-butyl ether
NBldg4	North Building 4
NCRs	Nonconformance Reports
NPBA	Northern Property Boundary Area
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity units
PADEP	Pennsylvania Department of Environmental Protection
PaGWIS	Pennsylvania Groundwater Information System
PCE	tetrachloroethene
PID	photo-ionization detectors
PPE	personal protection equipment

PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
REWAI	R.E. Wright and Associates, Inc.
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RPM	Remedial Project Manager
RSL	Regional Screening Level
SAIC	Science Applications International Corporation
SGWRI	Part 2 of the Supplemental Groundwater Remedial Investigation
SMCLs	Secondary Maximum Contaminant Levels
SP	spontaneous potential
SPBA	Southern Property Boundary Area
SRI Report	Supplemental Remedial Investigation Soils Report (SAIC, December 2009)
SW-WPL	Southwest corner of the West Parking Lot
TCA	111trichloroethane
TCE	trichloroethene
TDS	total dissolved solids
TOC	top of casing
TSD	treatment, storage and disposal
USACE	United States Army Corps Engineers
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
VADCR	Virginia Department of Conservation and Recreation
VOCs	volatile organic compounds

WBldg2	West Building 2
WBS	Work Breakdown Schedule
WPL	West Parking Lot
YCIDA	York County Industrial Development Authority
YNOP	York Naval Ordnance Plant

1 PROJECT DESCRIPTION

Groundwater Sciences Corporation (GSC) has prepared this Field Sampling Plan (FSP) to provide details of the field activities that will be performed during Part 2 of the Supplemental Groundwater Remedial Investigation (SGWRI) at the former York Naval Ordnance Plant in York, Pennsylvania (fYNOP or Site). The Part 2 SGWRI focuses on groundwater and is being done to investigate data gaps regarding site characterization that were identified during the Part 1 SGWRI and to ultimately facilitate the eventual path forward for closure of the fYNOP site under the Pennsylvania Department of Environmental Protection (PADEP) / United States Environmental Protection Agency (USEPA) One Cleanup program.

A Site-wide remedial investigation/feasibility study (RI/FS) was initiated in 1998 to evaluate potential sources of soil and groundwater impacts, determine the fate and transport characteristics of known chemicals of concern (COCs), and evaluate risk to human health and the environment. Investigations of both soil and groundwater were completed in 2007 and 2008 as part of the Supplemental Site-Wide Remedial Investigation (RI). The RI was divided into soils and groundwater for presentation purposes and to assist in completion and review of the documents. The “Draft Supplemental Remedial Investigations Soils Report – Former York Naval Ordnance Plant”, dated December 2009 (SAIC), was approved by the USEPA Region III and PADEP in a letter to Ms. Sharon Fisher on March 17, 2010.

The Part 1 SGWRI Report was submitted to regulators on September 23, 2011 and was approved by USEPA on February 2, 2012, and by PADEP on February 3, 2012. General conclusions identified in the Part 1 SGWRI Report described that 1) the interim groundwater extraction system appears to effectively prevent off-Site migration of shallow and intermediate depth groundwater from all areas of the Site except the South Property Boundary Area (SPBA) where studies indicated no human receptors are impacted; 2) large reductions in concentrations of COCs have occurred in groundwater, with over 38,000 pounds of volatile COCs removed by the extraction system, reducing the trichloroethene concentrations by 90 to 99 percent in most wells. Data gaps were also identified in the Part 1 SGWRI Report, specifically with respect to identifying the vertical extent of COCs in the aquifer, the depth and effect of karst solution features, the interaction of storm water and surface water with the karst aquifer, and further delineation of two suspected source areas. Additional studies to evaluate these data gaps were recommended in subsection 8.7 of Part 1

SGWRI. The USEPA and PADEP concurred with the recommendations for additional investigation activities. Those investigation activities are described in detail in this FSP.

This FSP has been developed in accordance with applicable guidance (United States Army Corps of Engineers [USACE], 2001; and USEPA, November 1999). The FSP describes and defines the sampling and data gathering procedures and methods to be used on the project including preliminary reconnaissance activities; field measurements; drilling procedures; sample collection, transportation, and analysis procedures; data reporting; and field activity deliverables. Additional guidance is included in the Quality Assurance Project Plan (QAPP) for Remedial Investigation by GSC (2012). As the project proceeds, addendums to the FSP will be prepared. The addendums will provide details of testing procedures for sampling, well testing and monitoring programs.

1.1 Site Setting and History

The fYNOP is located in Springettsbury Township in York County, Pennsylvania, situated on approximately 230 acres. As shown on **Figure 1.0-1**, the facility is bordered on the south by Route 30; on the west by Eden Road, a railroad line and northward flowing Codorus Creek; and on the east and north by residential properties. Site features are illustrated on **Figure 1.0-2** which calls out the West Parking Lot (WPL), former Central Plant Area (CPA), and numerous other areas of the Site. The eastern third of the site is undeveloped woodlands. The central and northern areas are occupied by new former buildings supporting manufacturing activities. The southern and western portions of the property are parking areas.

The Site was initially developed in 1941 by the York Safe and Lock Company, a United States Navy contractor, for the manufacture, assembly, and testing of 40 millimeter (mm) twin and quadruple gun mounts, complete with guns. In 1944, the Navy took possession of the York Safe and Lock Company facility. The Navy owned and operated the facility as the York Naval Ordnance Plant (YNOP) until 1964, switching operations after World War II to overhaul war service weapons and to manufacture rocket launchers, 3-inch/50-caliber guns, 20-mm aircraft guns, and power drive units for 5-inch/54-caliber guns. In 1964, the Navy sold the YNOP to American Machine and Foundry Company (AMF), who continued similar manufacturing. In 1969, AMF merged with Harley-Davidson. In 1973, Harley-Davidson moved its motorcycle assembly operations to the

AMF York facility. In 1981, AMF sold the York facility to Harley-Davidson. Harley-Davidson has continued motorcycle assembly operations at the York facility since 1981.

Currently, Harley-Davidson is in the process of transferring ownership of the western portion of the Site to the York County Industrial Development Authority (YCIDA). The Site has been divided into the 58 acre West Campus, the portion being transferred, and the 172 acre East Campus, the portion which remains as the Harley-Davidson York, PA motorcycle manufacturing facility.

The surface of the Site is immediately underlain by either fill (associated with site industrial and roadway construction), residual soil produced from the weathering of the underlying bedrock, or alluvium. From R.E. Wright Associates, Inc. (REWAI, September 1986) natural residual soils are comprised of sandy silt, clayey silts, and silt loam deposits from four primary soil series (Duffield, Glenelg, Elk, and Chester). These soil series are derived primarily from parent bedrock formations consisting of quartzitic sandstone and limestone.

Two geologic rock types underlie the Site. Solution-prone (karst) gray carbonate bedrock (limestone and dolostone) underlies the flat lowland (western) portion of the Site. Quartzitic sandstone underlies the more steeply sloping hills and upland area on the eastern part of the Site. The limestone is a karstic carbonate aquifer with groundwater migrating through solution-enhanced discontinuities and overlying unconsolidated materials. The quartzitic sandstone is a much less permeable aquifer; with minimal primary porosity, groundwater flows through tight bedding plane partings, joints and fractures, which are not solution-enhanced as they are in the carbonate bedrock. Groundwater flow is generally westward, from the upland area at the eastern part of the Site toward Codorus Creek; however, localized groundwater flow is also controlled by an active groundwater extraction and treatment system on-Site, that otherwise intercepts groundwater flow to Codorus Creek.

Groundwater investigations beginning in 1986 revealed the presence of volatile organic compounds (VOCs) in groundwater directly under the Site. The interim remedy for addressing the VOCs in groundwater included groundwater capture via extraction wells and treatment of the groundwater using air stripping in association with thermal treatment or carbon adsorption to control off-gasses, followed by on-Site discharge of the treated groundwater back into an unnamed tributary of Codorus Creek, locally called Johnsons Run. The groundwater extraction and treatment system

(GWTS) was constructed in 1990 and has continued operations to date. The status and effectiveness of the GWTS is reported to the PADEP and USEPA via annual reports. The discharge point for treated groundwater was moved from Johnsons Run to the Codorus Creek after National Pollutant Discharge Elimination System (NPDES) renewal permitting in 2007. The location of the discharge point is shown on **Figure 1.0-2**.

1.2 Summary of Supplemental Remedial Investigation Progress

In 2007, an SRI was initiated by SAIC. The results of that study were reported in the "Draft Supplemental Remedial Investigations Soils Report" dated December 2009 by SAIC, and in the "Supplemental Remedial Investigation Groundwater Report (Part 1)" dated September 2011, by GSC. Results of the soils SRI indicated that all the shallow soils with COC concentrations exceeding the Medium Specific Concentrations (MSCs) are covered with impermeable membranes, buildings, or paved parking areas. In March of 2012, a human health risk assessment for the two campuses was completed by GSC and submitted for regulatory review.

The indoor air pathway along with vapor migration to the surface at the site was investigated and evaluated by Langan Engineering and Environmental Services, Inc. (Langan) under a separate work plan (Langan, 2003). The results of the indoor air and vapor migration investigation were presented in a draft Supplemental RI Report prepared by Langan titled "Indoor Vapor Pathway Screening Assessment" (Langan, 2005). In 2007 an off-site soil vapor intrusion investigation was performed north of the NPBA. All results were below PADEP soil gas screening criteria. The scope of any additional investigations of indoor air or vapor migration determined to be necessary will be discussed outside of this FSP.

In September of 2005, USEPA completed a letter called Documentation of Environmental Indicator Determination. The findings of that letter indicated the following:

"Based on a review of the formation contained in this EI Determination, 'Current Human Exposures' are expected to be 'Under Control' at the Harley-Davidson Motor Company facility, USEPA ID # PAD 001 643 619, located at 1425 Eden Road, York, Pennsylvania under current and reasonably expected conditions. This determination will be re-evaluated when the Agency/State becomes aware of significant changes at the facility."

1.3 Hydrogeology

Groundwater generally migrates from east to west, from the high topographic areas underlain by quartzitic sandstone to the carbonate aquifer that underlies the western half of the site. Aquifer transmissivity, the property of the aquifer that describes the ease with which groundwater moves through the saturated subsurface materials, is very different between these two geologic materials. The quartzitic sandstone transmissivity is lower due to the groundwater migrating through minor partings associated with bedding planes, joints and fractures with relative higher resistance compared to the carbonate aquifer because the openings are not solution-enhanced. Because the materials of the carbonate aquifer are prone to dissolution by migrating groundwater, transmissivity in this aquifer is greatly enhanced, and groundwater moves with relative ease through the aquifer. In fact, the dimensions of the conduits identified in boreholes are such that flow in these features may be turbulent rather than laminar, resulting in non-Darcian flow in individual conduits.

Figure 1.0-3 shows groundwater elevation contours for the water table at the Site developed from groundwater level measurements from June 2009. This contour map is from the Groundwater Extraction and Treatment System Annual Operations Report for 2009 (SAIC, 2010).

As shown on **Figure 1.0-3**, the groundwater gradient beneath the Site slopes from the upland area in the eastern portion of the Site westward toward Codorus Creek. Based on the groundwater elevation contours shown on the figure, the operation of groundwater extraction wells appears to prevent groundwater flow from the WPL to Codorus Creek. In the Northern Property Boundary Area (NPBA), flow directions are locally modified by active groundwater extraction wells to prevent northward off-Site migration; however, groundwater appears to flow off the Site to the west of MW-18. In the southeastern corner of the Site, groundwater flows off-Site to the south.

Water table gradients are steep (6 to 10%) in the upland regions underlain by quartzitic sandstone and diminish to a relatively flat gradient (1% or less) once the groundwater flows into the area underlain by carbonate rocks.

The regional groundwater flow through the property follows a general west-southwesterly direction. Locally, the groundwater flow through the karst bedrock may be widely variable, following the pathways of solutionally enlarged conduits. However, responses to pumping tests and migration pathways traced by groundwater chemistry indicate a well-connected aquifer as a result of numerous highly interconnected conduits.

Groundwater flow is redirected locally by the system of capture wells in the WPL. The combination of pumping from the extraction wells and the discharge of Site storm water to a wetland area between the western property line and the Codorus Creek have created a divide between the creek and the Site. Groundwater on the east side of the divide migrates toward the Site, and groundwater on the west side of the divide migrates westward toward the Codorus Creek. Recent changes to Harley-Davidson's operations have resulted in the discontinuation of the discharge of non-contact cooling water to the stormwater system in this this area. This operational change may result in changes to the groundwater table configuration and the position of the divide in this area.

1.4 Groundwater Chemicals of Concern

Remedial investigations and activities at the Site have indicated that the primary COCs, based on concentration, detection frequency, and potential for off-Site migration are chlorinated solvents, that include tetrachloroethene (PCE), trichloroethene (TCE), and 111trichloroethane (TCA), and degradation products of these VOCs. Less frequent detections of hexavalent chromium, lead, benzene, ethylbenzene, methyl tertiary-butyl ether (MTBE), 1,4-dioxane, and cyanide have also been detected in groundwater samples from Site monitoring wells. The distribution of these constituents in groundwater suggests that they have originated from multiple sources.

1.5 Site-Specific Sampling and Analysis Problems

Site-specific problems can result from the karst nature of the subsurface with regard to installation of wells. Appropriate drilling methods (described in Section 4) have been chosen based on experience drilling at locations where solutioned areas are typically encountered in karst conditions. No other Site-specific sampling or analysis problems are known to exist. The most difficult groundwater sampling parameter historically has been hexavalent chromium, due to the short holding times associated with the analyte. Care must be utilized when working on-Site to avoid underground utilities during all intrusive activities. The quantitation limits of the proposed sampling and the type of analyses anticipated do not present analysis completion problems.

1.6 FSP Organization

The FSP is divided into nine sections including Project Organization and Responsibility (Section 2), Scope and Objectives (Section 3), Field Activities/Sampling Procedures (Section 4), Field Instruments, Sampling Equipment and Supplies (Section 5), Sample Handling and Documentation (Section 6), Assessments and Corrective Actions (Section 7), Project Schedule (Section 8), and References (Section 9).

Section 4 of this FSP is broken into four phases:

- **Phase 1 Pre-Drilling Tasks –** There are a number of general regional and off-Site studies which do not involve drilling that will be performed first. The results of this information will be used to determine the need for off-Site drilling and to plan subsequent investigations.

- **Phase 2 Drilling Tasks –** Drilling will start with on-Site well installation in suspected deep source areas, and may be ongoing while some of the off-Site regional studies are being conducted. Off-Site drilling would follow the completion of on-Site drilling in most cases. Multiple rig types will be used.

- **Phase 3 Testing and Monitoring –** Stream studies, weir installation, rounds of surface and groundwater sampling for chemical analysis, borehole testing, and tracer testing will be conducted after the installation of wells. A long term monitoring program (on the order of six months) in which wells and streams will be instrumented will be conducted. Groundwater extraction wells will be turned off and back on while responses are recorded in the deepest wells.

- **Phase 4 Data Analysis and Report –** Findings and conclusions will be compiled using text, tables, graphs and maps.

2 PROJECT ORGANIZATION AND RESPONSIBILITY

Harley-Davidson will conduct the Part 2 SGWRI, under the PADEP/USEPA One Clean-up Program in accordance with letters dated July 15, 2005 and September 28, 2005 from James J. Burke and Eugene A. DePasquale of USEPA and PADEP, respectively, to Sharon R. Fisher of Harley-Davidson. The acknowledgement of Notice of Intent to Remediate the Site under Act 2 of 1995 was published in the Pennsylvania Bulletin on March 19, 2005. Recent approval of the Part 1 SGWRI, which included a general discussion of identified data gaps was provided in letters to Ms. Fisher dated February 2, 2012 from Griff Miller of USEPA, and February 3, 2012 from Kathleen Horvath of PADEP. The work will be subject to review by the USEPA and PADEP. Project coordination will be performed by AMO Environmental Decisions, Inc. (AMO). The contractor responsible for conducting these investigations is Groundwater Sciences Corporation (GSC) of Harrisburg, Pennsylvania.

The organizational chart shown on **Figure 2.0-1** outlines the management structure that will be used to implement the FSP. The key personnel and their functional responsibilities are described in the following sections.

2.1 Summary of Key Personnel

There are several key personnel assigned to the SGWRI of the Harley-Davidson facility.

- Sharon Fisher is the Site Environmental Manager for Harley-Davidson.
- Hamid Rafiee will provide input for the United States Army Corps of Engineers (USACE).
- Ralph Golia of AMO will serve as the Project Coordinator.
- Griff Miller is the Remedial Project Manager (RPM) for USEPA.
- Pamela S. Trowbridge is the Act 2 Program Coordinator.
- Stephen M. Snyder is the Project Director responsible for conducting the FSP for GSC.

2.2 Points of Contact

The primary project contacts are presented below:

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Harley-Davidson Motor Company Operations, Inc.
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2.3 Personnel Responsibilities

The functional responsibilities of key personnel are described in the following parts of this section.

The Harley-Davidson Site Environmental Manager (Sharon Fisher) ensures the overall management and quality of all activities performed under this FSP. Sharon Fisher will ensure that all project goals and objectives are met in a high-quality and timely manner.

The Project Coordinator (Ralph Golia, AMO) is the liaison for shared cleanup responsibility between Harley-Davidson and the federal government. Project Coordinator activities involve interfacing with Harley-Davidson, USACE, USEPA, PADEP and Contractor personnel, and tracking related budgets and schedules.

The contractor Project Director (Stephen M. Snyder, GSC) has direct responsibility for implementing the FSP, including all phases of work plan development, field activities, data management, and report preparation. This individual will also provide the overall management of the project, and serve as the technical lead and point of contact with the Harley-Davidson Site Environmental Manager and the Project Coordinator. These activities will involve coordinating all personnel working on the project, interfacing with USACE, PADEP and USEPA personnel, and tracking project budgets and schedules. GSC's Project Director will also develop, monitor, and fill project staffing needs, delegate specific responsibilities to project team members, and coordinate with administrative staff to maintain a coordinated and timely flow of all project activities.

The Project Manager (Jennifer Reese, GSC) is responsible for implementing all day to day activities in accordance with the FSP and the QAPP. This individual is responsible for: ensuring proper technical performance of field operations and sampling activities; adherence to required sample custody and other related Quality Assurance/Quality Control (QA/QC) field procedures; coordination of field personnel activities; management of investigative-derived wastes; checks of all field documentation; and preparation of Field Change Orders (FCOs), if required. The Project Manager reports directly to the Project Director except in regard to QA/QC matters that are reported directly to the QA/QC Officer.

The QA/QC Officer (Charles Rine, GSC) is responsible for the project QA/QC in accordance with the requirements of the project QAPP, other work plan documentation, and appropriate management guidance. This individual, will be responsible for approving variances during field activities before work continues; approving, evaluating, and documenting the disposition of Nonconformance Reports (NCRs); overseeing and approving any required project training; and designing audit/surveillance plans followed by supervision of these activities. The QA/QC Officer reports directly to the contractor Project Manager and to the Harley-Davidson Site Environmental Manager.

The Health and Safety Officer (Charles Rine, GSC) is responsible for ensuring that health and safety procedures designed to protect personnel are maintained throughout the field activities. This will be accomplished by strict adherence to the project Health and Safety Plan (HASP), which has been prepared as a separate document for this project. This individual will have the authority to halt fieldwork if health or safety issues arise that are not immediately resolvable in accordance with the project HASP. The Health and Safety Officer reports directly to the contractor Project Manager and the Harley-Davidson Site Environmental Manager.

The Laboratory Coordinator (Jennifer Reese, GSC) is responsible for coordination of sample shipment to the laboratory(ies), and subsequent chemical analysis and reporting performed by the subcontract laboratories, in accordance with the requirement defined in the QAPP. This individual will be responsible for obtaining required sample containers from the laboratories for use during field sample collection, resolving questions the laboratory may have regarding QAPP requirements and deliverables, and coordination of data reduction, review, and documentation activities related to sample data package deliverables received from the laboratories. The Laboratory Coordinator reports directly to the Project Director.

In addition, other field personnel participating in the implementation of field activities are anticipated to be site geologists, scientists, excavation personnel, and sampling technicians. These individuals, in coordination with field subcontractor personnel, will be responsible for performance of drilling operations, sample collection of soil, groundwater, surface water, etc. and preparation of field logbooks and other required documentation. These individuals will be responsible for performing all field activities in accordance with the FSP and QAPP, and will report directly to the Project Manager. Subcontracted field personnel, under the supervision of the Project Manager, will be responsible for performing their specific scopes of work that have been derived from the FSP. These individuals will be required to review applicable sections of the FSP, QAPP, and the entire HASP, prior to field mobilization. All subcontractor field personnel report directly to the Project Manager, who will be responsible for ensuring that all subcontractor activities comply with project requirements.

The subcontract laboratory for this project is TestAmerica Laboratories, Inc. (TestAmerica). The phone number at their Pittsburgh, Pennsylvania location is (412) 963-7058, fax (412) 963-2468. The laboratory shall report directly to the Project Laboratory Coordinator or her designee. The shipping address is:

TestAmerica Pittsburgh
301 Alpha Drive
Pittsburgh, PA 15238

The responsibilities of key personnel for the laboratory are described in the TestAmerica Pittsburgh Laboratory QA Plan in Appendix B of the QAPP.

3 SCOPE AND OBJECTIVES

The objective of the Part 2 SGWRI is to provide additional characterization data to define the extent of contamination at the facility, hydraulic characteristics of the karst aquifer, fate and transport of the COCs, source area locations, and to evaluate potential modifications to the interim groundwater extraction system. Environmental data will be obtained through the collection of representative samples which will be subjected to both on-Site and off-Site analysis per the methods described in the project QAPP and in Section 4 of this document. Much of the scope of the Part 2 SGWRI was discussed in a meeting with the USEPA and PADEP at Harley-Davidson on November 10, 2011.

Procedures for field sampling, chain-of-custody, laboratory analysis, and reporting of data are described in a separate QAPP (GSC, 2012). Specific analytical method objectives and sample quality control criteria are provided in the QAPP. General objectives provided by the QAPP include the following:

- Provide data of sufficient quality and quantity to support ongoing supplemental remedial investigation efforts.
- Provide data of sufficient quality and quantity to support area-specific remediation goals (when applicable).
- Provide data of sufficient quality to meet applicable Commonwealth of Pennsylvania and Federal (USEPA, Region III) concerns.
- Utilize QA/QC procedures for both field and laboratory methods that meet the USEPA, PADEP and other applicable guidance document requirements.

This FSP details the field activities and QA/QC measures that will be used during monitoring and sampling associated with the SGWRI at the Site. Data Quality Objectives (DQOs) and the standards of comparison for each of the sampling media are presented in the remainder of this section.

3.1 Soil Sampling

Soil sampling and analysis are planned for investigation of two suspected source areas of dense non-aqueous phase liquids (DNAPL) in the subsurface as specified in Section 4 of this FSP. The data obtained from the analysis of soil samples must be defensible, and therefore will require contract laboratory program- (CLP) like data packages. Soil data will be compared with applicable PADEP Act 2 MSCs as well as with USEPA Regional Screening Levels (RSLs). The specific PADEP Act 2 MSCs of comparison for site-wide soils will be the direct contact pathway (for surface and subsurface soils), and the soil-to-groundwater pathway. The RSLs of comparison will be for ingestion of industrial soils only.

3.2 Surface Water

The sampling and analysis of surface water across the site is discussed within Section 4 of this FSP. Surface water data will be compared with the PADEP Water Quality Criteria for toxic substances (PA Code, Chapter 16), and with the USEPA National Recommended Water Quality Criteria (Section 304a of the Clean Water Act). The PADEP Water Quality Criteria will include the fish and aquatic life continuous criteria as well as the human health criteria. The USEPA Water Quality Criteria include the freshwater continuous criteria as well as the human health criteria for the consumption of water plus the organism.

3.3 Site-wide Groundwater

The sampling and analysis of site-wide groundwater is described within Section 4 of this FSP. The data obtained from the analysis of groundwater samples must be defensible, and therefore will require CLP-like data packages. Groundwater data will be compared to the PADEP Act 2 MSCs and the USEPA maximum contaminant levels (MCLs). The specific PADEP Act 2 MSCs will be for used aquifers with total dissolved solids (TDS) values less than 2,500 milligrams per liter (mg/L), under the residential scenario. The most recently promulgated USEPA MCLs or secondary MCLs (SMCLs) and RSLs will also be used for comparison to site-wide groundwater results.

3.4 Off-Site Groundwater

The sampling and analysis of off-Site groundwater is described within Section 4 of this FSP. The data obtained from the analysis of groundwater samples must be defensible, and therefore will require CLP-like data packages. Groundwater data will be compared to the PADEP Act 2 MSCs and the USEPA MCLs. The specific PADEP Act 2 MSCs will be for used aquifers with TDS values less than 2,500 mg/L, under the residential scenario. The most recently promulgated USEPA MCLs or SMCLs and RSLs will also be used for comparison to off-Site groundwater results.

4 FIELD ACTIVITIES/SAMPLING PROCEDURES

Field activities, investigations, and sampling procedures planned for the Part 2 SGWRI are provided in the following subsections. The tasks detailed in Section 4 have been grouped into phases, to be accomplished in an order that will allow the information learned from prior phases to be used to refine the scope of the tasks in subsequent phases. Not all proposed tasks may be completed. As an example, two rounds of deep wells are scheduled to define the vertical extent of high concentrations of chlorinated solvents in each of six areas. It may not be necessary to drill a second well in each area to define the vertical extent. Unique conditions exist at the Site related to the karst setting and some of the decisions about completion of and methods of completion for various tasks may be referred to the project team for consideration.

Four phases of work are listed below and will be conducted sequentially with some minor exceptions.

- Phase 1 Pre-Drilling Tasks
- Phase 2 Drilling Tasks
- Phase 3 Testing and Monitoring
- Phase 4 Data Analysis and Report

Each of these phases of work is described further in the following subsections.

4.1 Phase 1 Pre-Drilling Tasks

There are a number of general regional and off-Site studies which do not involve drilling which will be performed first. Acquisition of off-Site property access agreements is necessary to proceed with many subsequent tasks. The results of regional and off-Site studies will be used to determine the need for and extent of off-Site drilling and to plan subsequent investigations. The regional and off-Site studies are described further in the following subsections.

4.1.1 Acquisition of Off-Site Property Access Agreements

Access to off-Site properties will be needed to perform drilling and sampling activities associated with the Part 2 SGWRI. Properties and property owners have been identified based on York County mapping information. A summary of investigative activities for individual off-Site properties will be written and legal agreements for access will be prepared and delivered for signatures from the property owners and/or companies leasing the off-Site properties.

4.1.2 Investigate Westward Migration Across Codorus Creek

There is considerable evidence that off-Site migration of groundwater to the west is being prevented by operation of the groundwater extraction system. However, due to the karst nature of the aquifer, and the limited depth of the investigation to date, further effort is planned to explore the potential of groundwater migrating from the Site westward past Codorus Creek. Some of this investigation is done in Phase 1, and then follow-up investigations will be conducted during Phases 2 and 3.

4.1.2.1 Verify Kinzers Shale and Local Geology

The Kinzers Formation existing to the west, north, and south of the Site previously was mapped in 1939 (Stose and Jonas, 1939) and shows a shale member that may act as a barrier to groundwater flow in those directions. An investigation will be conducted using a staged approach which will begin with a field reconnaissance to identify the shale member of the Kinzers Formation. The Kinzers Shale has been mapped as underlying the I-83/Arsenal Road interchange. PennDOT will be contacted to determine if borings were completed for the design of the interstate highway. Based on the findings of the field reconnaissance and PennDOT information, the regional geologic mapping will be updated.

4.1.2.2 Investigate Groundwater Pumping at the Roosevelt Quarry

The Roosevelt Quarry is located in carbonate rocks approximately 12,000 feet west of the Site as shown on **Figure 4.1-1** and **Figure 4.1-2**. The quarry pumps groundwater to depress the water table below the quarrying operation to mine the limestone rock. Personnel at the Roosevelt Quarry will be contacted to request pumping records and NPDES discharge records from the quarry. NPDES discharge records may also be pursued through PADEP file records. The groundwater elevation at the quarry will be compared to groundwater elevations at the fYNOP and in any other accessible wells located west of Codorus Creek. Additional historical information about the Roosevelt Quarry will be investigated through the use of historical aerial photographs and historical pumping/discharge records. This information will be used to determine the likelihood that dewatering at the quarry may cause groundwater to flow westward from the Site.

4.1.2.3 Monitor Existing Wells West of Site

An online search has been made of the PaGWIS database to identify existing wells west of Codorus Creek. The wells are shown on **Figure 4.1-1.** Applicability and use of these wells for groundwater level monitoring will be explored by examining well records and the reason the wells were installed. If sufficient suitable wells appear to be available, applicable wells will be targeted, identified in the field, and groundwater level monitoring will be completed on accessible wells.

A groundwater table contour map will be constructed if sufficient water levels are available. The contours may indicate whether the shale serves as a barrier to groundwater flow. Water levels may also be recorded during recharge events to determine if groundwater level changes in wells west of the Kinzers Shale occur independent of the changes observed at the Site and east of the Kinzers Shale unit. Groundwater levels at wells on either side of the Kinzers Shale may confirm that the shale acts as a barrier to groundwater flow.

Groundwater level responses in these wells will be compared with dewatering activities at the Roosevelt Quarry to assess the impact of dewatering on the groundwater flow patterns in the area.

4.1.2.4 Perform Seepage Run Surveys

Seepage run surveys will be completed to investigate the relationship between groundwater and surface water by measuring stream flows along the course of the stream. The surveys will identify stream sections that are losing or gaining flow, indicating leakage to the groundwater from the stream or discharge of groundwater to the stream. If it is determined that the stream is losing flow along its course, this is an indication that the water table is separated from the stream, and may indicate a permeable karst aquifer underlying this stream valley that could conceivably carry groundwater flow counter to the direction of stream flow.

The surveys are weather and season dependent and must be done when surface water runoff (from recent rains) is not occurring. The surveys will be run twice, once during the spring, when groundwater levels are high, and once during late summer/early fall, when groundwater levels are generally at the lowest for the year. The seepage run surveys will be conducted on a small stream west of Codorus Creek, on Johnsons Run north of the Site, and on the small stream in the wetlands area west of the Site (a tributary to Johnsons Run).

The surveys will be completed by profiling the stream flow using an in-stream velocity flow meter at several locations along each stream. Measurement locations will be chosen based on stream reaches where flow may be increasing or decreasing, such as at the confluence of tributaries, and where accurate measurements can be obtained, such as in a straight section of the stream with a smooth bottom where turbulent flow is minimized. The standard Velocity-Area procedure will be used to perform the seepage run surveys. However, if water is too shallow in the streams, then the Timed Filling procedure or the Neutrally-Buoyant Object procedure may be used. These procedures are described in the USEPA "Wadeable Streams Assessment Field Operations Manual", July 2004**.**

A small stream and valley underlain by Vintage Formation extends westward from the Codorus Creek in the vicinity of the Springettsbury Township municipal wastewater treatment plant. The northern side of this valley is coincident with the geologic fault contact between the Antietam/Harpers Formation and the Vintage Formation, while the southern side is coincident with the Kinzers Shale. The stream valley appears to have formed over faulted sections of Vintage Formation. This stream valley will be examined, and a seepage run survey will be conducted to evaluate whether this is a gaining or losing stream.

Johnsons Run and the wetlands stream are located on the east side of Codorus Creek. The wetlands stream is a tributary to Johnsons Run. Information from the seepage run surveys on Johnsons Run and the wetlands stream will be used to locate weirs on the streams and shallow wells at the wetlands area and along the streams. Most likely, one weir will be located where the wetlands stream feeds into Johnsons Run, and upstream and downstream weirs will be placed in Johnsons Run. Continuous water level recording devices will be installed at the weirs to calculate flow. Shallow wells or piezometers will be installed to observe shallow groundwater levels to determine the interaction between groundwater and surface water.

The wetlands water levels and stream flows will be observed during the long term monitoring program described in subsection 4.3**.** In addition to evaluating karst loss (see following subsection 4.3.8), this information and other groundwater elevation data from nearby wells will define the location of the groundwater flow divide and further evaluate groundwater capture effectiveness at the WPL area, especially important since the discontinuation of discharge of non-contact cooling water to the wetlands area reduced flow through the wetlands by 100,000 gallons per day (gpd) beginning in June 2011.

4.1.3 Investigate Water Quality and Hydrogeology

During past drilling of borings and monitoring wells in the carbonate bedrock at the Site, 16 percent of the total footage drilled in carbonate bedrock penetrated solution channels, indicating a very high degree of karst development in the carbonate aquifer (**Figure 4.1-3**). It is reasonable to infer that many of these solution channels are part of an active system of conduits beneath the Site that provide pathways for rapid migration of groundwater flow, while other solution channels may be plugged or poorly connected. The interconnectivity of the conduits will be investigated to characterize preferential flow paths for groundwater containing dissolved chlorinated volatile organic compounds (CVOCs) and possibly DNAPL. The work will be done in a staged approach.

4.1.3.1 Analyze Existing Geochemical Data

Temperature, pH, turbidity, conductivity, dissolved oxygen, and salinity data have been collected during each sampling event since at least 2008. These data will be analyzed for similarities between wells suspected of intercepting active conduit pathways and compared to data from wells that appear not to intercept active solution channels.

Results of these analyses may be added to the 3-D geologic model of the site. The data will be assessed by examining whether carbonate mineral undersaturation occurs in solution channels as evidence of active karstic conduit flow pathways.

4.1.3.2 Evaluate Storm Sewer System

Storm water runoff will be monitored during Phase 3 activities; however, the methods and procedures for the monitoring will be developed as part of the Phase 1 work. The configuration of the existing storm sewer and storm sewer discharge information provided by Harley-Davidson will be reviewed to design a method for monitoring storm events that will occur during the Hydrodynamic Testing phase of the investigation. A portion of the hydrodynamic testing and monitoring will involve field measurement of the runoff during storm events. The system will be inspected in the field to develop a plan for monitoring storm water flows. This information will be used in the karst loss calculations for groundwater flow through the Site.

4.1.4 Investigate Southward Off-Site Groundwater Migration

A plume of CVOCs in the groundwater originating from the southeast corner of the Site migrates southward across US Route 30 (Arsenal Road) and westward, as shown on **Figure 4.1-4**. An investigation of the off-Site horizontal and vertical extent of CVOCs migrating from the southeast corner of the Site near well couplet MW-64S&D will be performed by GSC using a staged approach. Stages of the investigation will include the following work items:

- Review well logs and construction information for existing wells on the former the Cole Steel property (currently owned by K.G. Whiteford, Ltd. Partnership), North Sherman property, and the Rutters wells south of Rt. 30 (property owned by the Argento Family Partnership), and request permission to access the wells. Measure groundwater levels at the southeast corner of the Site and off-Site.

- Perform groundwater sampling for CVOCs in selected wells.

- Fracture trace analyses and an electrical imaging survey will be performed to locate the wells along preferential flow paths.

Each of these work items is described further in the following sections.

4.1.4.1 Investigate Existing Wells and Quarry

Groundwater monitoring wells already exist south of the Site at the former Cole Steel property, shown on **Figure 4.1-4**. Well logs and construction information have been obtained for these wells from the USEPA. USEPA also provided a report of recent groundwater sampling activities at the former Cole Steel facility performed by Michael Baker, Jr., Inc. in June 2011. An internet search of the Pennsylvania Groundwater Information System (PAGWIS) database of wells conducted for this area indicates wells may exist west of the Cole Steel wells. The notoriously inaccurate locations of these wells as recorded by the PAGWIS database are shown on **Figure 4.1-1**. In addition to the internet search, GSC will contact the Pennsylvania Geological Survey to search their database for well information not available through the internet search. Wells located as a result of the database searches will be accessed and water levels measured. Also, the previous well search report conducted by Langan will be reviewed.

The location of a water supply well on Roosevelt Street southeast of the site will be considered for inclusion in this investigation.

GSC personnel will measure groundwater levels in all the accessible wells on the properties to the south of the Site, and at wells MW-92, MW-22, MW-64S&D, MW-108S&D, MW-109S&D, MW-110, MW-1, MW-40S&D, MW-85 and RW-5. If not previously established, elevations at the top of the well casings will be surveyed so that groundwater levels beneath the former Cole Steel property and the Rutters wells can be compared to those beneath the fYNOP.

Access will be obtained to the abandoned quarry south of Mill Creek. A bench mark will be established to measure the water level in this groundwater-flooded quarry. The orientation of bedding, joints and fractures and the occurrence of solution features visible in the un-submerged walls of the quarry will be measured and recorded.

The groundwater elevations will be used to generate a groundwater elevation contour map for use in evaluating groundwater flow from the Site.

4.1.4.2 Sample Selected Existing Wells

To delineate the horizontal limits of CVOCs, groundwater samples will be collected and analyzed from selected wells based on the groundwater elevation contours prepared from water level measurements described in the previous subsection. Sampled wells will most likely include MW-64S&D, MW-22, MW-108S&D, MW-109S&D, MW-110 Cole D, Cole F or Cole ES&D, MW-4 (Cole), MW-2 (Cole), and MW-11 (Cole) or MW-12 (Cole), Ru-MW-5 and Ru-MW-6. In addition to the analyses for CVOCs, samples will be analyzed for tracer dyes. D&C Red#28 dye was injected as a tracer into Well MW-64D in June 2000 and if it is detected in the groundwater from the wells south and west of the Site at concentrations believed to be above background, its presence will confirm that groundwater migrated from the fYNOP. This information may also provide a groundwater migration rate.

If it appears that few or no additional wells are available for sampling, and/or that drilling of additional off-Site wells is necessary, this sampling could be reduced to include the previously unsampled wells only. After installation of the new wells (discussed in subsection 4.2.1.5), a more robust round of wells may be sampled, to include the new wells and a limited number of existing wells.

4.1.4.3 Fracture Trace Analysis and Electrical Imaging Survey

A fracture trace analysis will be performed using historical aerial photographs of the off-Site property area south of the Site. Fracture traces will be mapped using the method developed by Lattman (1958). Traces will be verified in the field, geo-referenced, and plotted on a map.

Potential locations for installation of the off-Site wells are shown on **Figures 4.1-4 and 4.1-5**, but actual locations will consider potential preferential flow paths identified through the fracture trace analysis and electrical imaging (EI) survey. EI procedures are described in subsection 4.2.4.12.

The EI survey will be conducted along two profile lines south of the Site. One survey profile line will be run immediately south of and parallel to U.S. Route 30 / Arsenal Road for approximately 1,800 feet. The other profile line will be located north of Interstate 83 and Mill Creek for approximately 2,900 feet.

Additional EI surveying referenced in this FSP is described in subsection 4.2.1.4.

4.1.5 Research Source Area Records

Two areas are slated for source area investigations. High concentrations of CVOCs in groundwater near Bldg 58 and WBldg2 Corridor (**Figure 4.1-5**) have not been linked to an originating source area. If the location could be found, and it contains a significant mass of CVOCs, remediation of the source above and in the shallow water table may be beneficial. In addition, accurate characterization of the area of high groundwater CVOC concentration will provide design information for enhancing the groundwater extraction system and for monitoring extraction system performance.

Pre-drilling tasks will be performed in these two suspected source areas. The information learned from the tasks will be used to refine the design of the array of soil testing planned for the areas.

In 1991, interviews were conducted with 17 former or current at the time, employees of AMF and Harley-Davidson. GSC will review the results of the interviews to gain insight into past operational practices. The individuals interviewed were familiar with various activities that occurred in the plant throughout the previous 30 years. Results have been summarized into a GIS database, but handwritten notes taken during the interviews are available for review. In addition, GSC will review the information gained from a recent interview with former long term AMF and Harley-Davidson employee Chris Bongart which specifically indicated the locations of activities in both proposed investigation areas.

GSC will review historical building drawings and plans on file at the Site. A review of historical aerial photographs will be made to match up visual features with reported activities and facilities (from interviews) and with drawings.

GSC will also review information and compile sample locations from all historical soil sampling in the two suspected source areas, including the Langan soil gas and soil sampling data, and the more recent Soils SRI report.

4.2 Phase 2 – Drilling Program

This section which describes the Phase 2 Drilling Tasks includes a breakdown of areas targeted for drilling, and descriptions of drilling and sampling procedures, fracture trace analyses, electrical imaging surveys, ground penetrating radar surveys, and borehole geophysics. **Figure 4.1-5** shows the proposed general locations of all wells currently proposed.

Drilling is planned to start in the suspected undiscovered source areas (WBldg2 Corridor and Bldg 58). The wells to be constructed in the suspected source areas are the first step in defining the point of product loss. Because knowing the location of the sources would benefit the positioning of the deep wells to determine vertical extent in these suspected source areas, shallow drilling in these areas is proposed to precede drilling to determine vertical extent (subsection 4.2.1.2). Drilling will then move to other areas including the suspected deep Source/DNAPL areas on-Site, east and west of Codorus Creek, the MW-18 area at the NPBA, and off-Site to the southeast. A schedule is provided in Section 8 which describes the proposed order and anticipated schedule for completing the drilling and tasks associated with the Part 2 SGWRI.

As work progresses on-Site, decisions for well placement and depth will be dependent on observations and results of prior work done at the Site, including groundwater sampling of the newly installed wells and borehole point dilution testing. Therefore, groundwater sampling procedures and borehole point dilution testing procedures are included as part of Phase 2 – Drilling Program and are described in subsections 4.2.4.7 and 4.2.4.8. In addition, an interim report will be completed at the end of Phase 2.

4.2.1 Drilling Tasks

The following sections describe six drilling tasks that are planned for the Phase 2 work. Wells will be drilled to investigate potential source areas of CVOCs, to delineate the vertical extent of contamination and karst bedrock features, to identify groundwater flow paths and possible contaminant migration to the west and south of the Site and in the NPBA near Well MW-18, and to identify bedrock lithology and stratigraphic features at depth beneath the Site.

4.2.1.1 Source Area Investigations

High concentrations of CVOCs in groundwater near Bldg 58 and WBldg2 Corridor are not linked to an originating source area. If the location of the source could be found, and it contains a significant mass of CVOCs, remediation of the source above and in the shallow water table may be beneficial. In addition, accurate characterization of the area of high groundwater CVOC concentrations will provide design information for enhancing the groundwater extraction system and for monitoring possible future extraction system performance.

Shallow wells will be drilled at these areas using air rotary techniques. Four wells are planned at the Bldg 58 area (see **Figure 4.2-1**) and six wells are planned for the WBldg2 Corridor (see **Figure 4.2-2**). Wells will be drilled into the shallow bedrock at each area, with the expected total depth of each well being 75 feet below ground surface (bgs). Prior to drilling the shallow wells in the Bldg 58 area, ground penetrating radar will be used to attempt to define the configuration of the reported former press pits in Bldg 58.

Groundwater from the new shallow wells in these areas will be sampled and the chemistry results will be used to designate locations for approximately 40 to 80 Membrane Interface Probe (MIP) borings in each of the two areas (see subsection 4.2.4.10).

4.2.1.2 Vertical Extent in Suspected Source/DNAPL Areas

A better understanding of the nature and extent of the fYNOP COCs is required in several areas to close potential pathways for human and ecological exposure. In accordance with CERCLA guidance (October 1988), "the nature and extent of ground-water contamination should be evaluated both horizontally and vertically." The vertical extent of high concentrations of chlorinated solvents in the groundwater currently is undetermined at six areas at the Site: Southwest corner of the West Parking Lot (SW-WPL), TCA Tank/Building 2 Degreaser area, Building 58 (Bldg58) area, the North Building 4 (NBldg4) area, the West Building 2 (WBldg2) Corridor, and the Southeast Corner of the Site. These areas are shown on **Figure 4.1-5**.

Figure 4.2-3 shows a cross-sectional view of the wells planned for the SW-WPL, the TCA Tank/Building 2 Degreaser area, and the Bldg58 area. Vertical extent characterization wells planned for the NBldg4 area and the WBldg2 Corridor are shown on the cross section on **Figure 4.2-4.**

Well installation at the six areas will include the drilling, construction, development, and surveying of new deep wells or well clusters. The targeted drilling depths are summarized in **Table 4.2-1.** A well will be drilled and cased 50 feet beyond the deepest existing well in the particular vertical extent study area. If solution features (identified by rapid increase in water yield, drilling tool drops, or other changes in drilling) are encountered within this 50-foot zone to be cased, monitoring of basic water quality parameters, such as temperature, pH, and conductivity, may be performed prior to installation of the casing. The casing will be grouted to preclude the potential for dragging shallow CVOCs deeper into portions of the aquifer that have previously not been penetrated by drilling activities. Drilling will continue 50 feet more, at a minimum, until the next water bearing zone is intercepted. A water bearing zone is defined as a bedrock interval that yields one gallon per minute (gpm) or more of water and is identified as a solution feature or a fracture/discontinuity by observing drill rig performance. The well will then be constructed as either an open rock well or with screen if the subsurface material is unstable and will be developed to establish proper hydraulic connection with the surrounding aquifer. Approximately two weeks after well construction, groundwater will be sampled and analyzed for CVOCs.

Drilling will proceed to the next study area while the groundwater sample from the first well is being analyzed by a laboratory. If the laboratory results indicate that CVOC concentrations have not decreased to concentrations approaching the MSCs for residential groundwater, then another well may be drilled adjacent to the previous well resulting in a multi-level well cluster within that particular study area. The second well in the cluster would be drilled and cased 50 feet deeper than the first well, then drilling will continue 50 feet more, at a minimum, until the next water bearing zone is intercepted. The second well in the cluster will be constructed as either an open rock well or with screen if the subsurface material is unstable. If laboratory results indicate that CVOC concentrations in the second well of the cluster still have not decreased approaching the MSCs, a third well may be installed at the cluster using the same protocol.

The secondary objective for installing these deep wells is to determine the depth of circulation and active flow paths of groundwater at the Site. Therefore, determination of the total well depth for each area will depend on solution features encountered and the vertical extent of CVOC concentrations. Total depth of the well cluster in each area will be determined by drilling until 50 feet of intact rock is observed below the depth of groundwater contamination (chemical concentrations approaching or below the residential groundwater MSCs) and the depth of the borehole is below the expected karst solution features in the area as determined by inspection of surrounding deep borehole logs.

Air-rotary drilling and/or coring methods may be used for the installation of the wells. A continuous casing advancement system and spin casing drilling techniques will also provide alternatives when unstable conditions are anticipated or encountered, or to minimize the volume of water produced by drilling. Based on previous well installations at the Site, the initial borehole diameter will be oversized to accommodate the placement of surface and temporary casings to stabilize the subsurface for well construction and borehole advancement activities to occur.

A number of sections of open rock hole from these wells will be selected for down-hole geophysical logging. The sections to be selected for logging will depend on borehole stability, the logistics of borehole construction, and the availability of the logging equipment. Wells that penetrate sedimentfilled solution channels are not good candidates for geophysical logging because the hole may not stay open. The holes and sections to be logged will ideally be well distributed across the Site and in areas where information to be gained from the logging will be most useful to the groundwater and aquifer characterization.

Depending on the distribution of water bearing zones and solution channels and information from the geologic and geophysical logging, monitoring wells will be designed with or without well screens. The placement of well screens and the potential for multiple well screens in each interval will be determined as part of the drilling and well construction process.

Borehole point dilution testing to assess groundwater flow velocity, described in subsection 4.2.4.8, and water quality profiling will be done at selected well locations following the installation of the wells. This may require the placement of temporary well screen and pipe. Wells showing high groundwater flow velocity may subsequently be targeted for tracer testing. Groundwater tracer testing, described in subsection 4.2.4.9 may be performed by injecting a brine solution into the borings/wells at suspected source areas, at wells located immediately east and west of Codorus Creek, intermediate depth wells located south of the Site, and at the deep stratigraphic borings.

4.2.1.3 MW-18D Area West of NPBA

Well installation west of the NPBA, as shown on **Figure 4.1-5**, is planned to characterize the groundwater flow direction and migration of CVOCs in that area of the Site. The concern at the NPBA is that the location of the source of CVOCs detected in well MW-18 is currently undetermined and COCs may be migrating off-Site. Although groundwater flow directions are locally modified by the active extraction wells, groundwater may be flowing off-Site west of MW-18, resulting in the need for further delineation of the lateral extent of CVOCs in the area. Lateral delineation will be especially important as consideration is given to modifying the operation of the groundwater extraction wells at the NPBA.

The wells will be drilled using air rotary techniques. Two multi-level well sets will be installed as a nest in a single 8-inch bore hole at the Site boundary west of MW-18 or on the adjacent property across Eden Road. The shallow well in each well set will be screened to approximately 50 feet bgs and the deep well in each set will be screened to approximately 150 feet bgs. These depths are similar to those of MW-18S&D. Geophysical logging of a portion of two wells in the NPBA is included for delineating the orientation of bedrock, including bedding plane partings and solution features. This information will help to characterize groundwater flow direction in both the deeper and shallower zones in the area and provide an indication of vertical flows.

Groundwater from these new wells and MW-18S&D will be sampled and analyzed for CVOCs. Water levels will be measured. In the event that surface water is flowing in the streambed west of MW-18 at the time of sampling, a surface water sample also will be collected and analyzed for CVOCs to explore the possibility that shallow groundwater containing CVOCs is discharging to the stream.

4.2.1.4 Install Wells West of Site

To explore the potential of groundwater migrating from the Site westward past Codorus Creek, wells will be drilled adjacent to the Levee Area along the east side of the creek and the west side of the creek.

Two shallow wells will be installed in the residuum at the Levee Area east of Codorus Creek to investigate the role of the creek as a discharge boundary. The wells will be drilled using the hollow stem auger method through the residuum to the top of bedrock and will be constructed using 2-inch diameter PVC screen and casing. One well will be installed between the MW-98 and MW-99 well clusters, and the other well will be installed near the MW-100 well cluster (see **Figures 4.1-5 and 4.2-5**). Shallow groundwater from these wells will be sampled and analyzed for CVOCs to more fully characterize the vertical extent of CVOCs at the Levee Area and to quantify the concentration of CVOCs in groundwater discharging to the creek. During the long term monitoring program, groundwater levels in the shallow residuum wells will be compared to creek levels and to water levels in the bedrock to confirm that shallow water table discharges to the creek.

Using the existing results from EI and thermal imaging of the creek performed as part of the Part 1 SGWRI, two deep wells will be located east of Codorus Creek at the Levee Area. The wells will be drilled using air rotary and/or coring techniques. The purpose of these deep wells is to investigate the existence of deep conduit features in the carbonate bedrock and the potential for migration of groundwater in deep bedrock zones toward the west or north. The deep wells will be located where deep conduits are suspected. The depths of these wells will extend to approximately 200 feet or deeper to target carbonate solution channel areas.

Two to three wells are planned for installation on the west side of Codorus Creek. Depending on results of shallow and deep well installations on the east side of the creek, the wells to the west will be drilled using air rotary and/or coring techniques or other suitable methods such as continuous casing advancement. It may be necessary to install multilevel clusters at each location, comparable in depth to wells east of the creek.

To target well placement on the west side of Codorus Creek to intersect solution features in the bedrock, an EI survey will be conducted on the west side of Codorus Creek at the location shown on **Figure 4.1-5.** The EI profile will be performed on approximately 2,650 feet of traverse line. The EI survey will be performed and then repeated using a tracer of sodium chloride injected into the deep wells on the east side of the creek which will amplify EI signals in connected conduits. This information will be used in conjunction with the previous EI results from the east side of Codorus Creek, the previously performed fracture trace analyses, and the previously conducted thermal imaging of the creek, to best determine well placement.

Two shallow monitoring wells (piezometers) also will be installed using hollow stem drilling methods at the wetlands area west of the Site and east of the Codorus Creek to monitor shallow groundwater levels for determining the upward or downward direction of groundwater flow and the interaction between groundwater and surface water. A groundwater table mound has been postulated to exist beneath the wetlands and will be characterized by monitoring these piezometers during the testing and monitoring phase of this work.

4.2.1.5 Install Wells South of Site

Up to three nested well pairs will be installed using air rotary or other appropriate techniques south of Route 30. The wells will be positioned to intersect suspected karst conduits using fracture trace analysis, and the EI survey data that will be collected as part of the Phase 1 pre-drilling tasks outlined in subsection 4.1.3.3. Approximate well locations are shown on **Figure 4.1-5**; however, exact locations will be determined based on investigation results. General areas in which well construction will be considered (avoiding road ways and buildings) are shown on **Figure 4.2-6.**

Each well pair will be screened at depths of approximately 50 feet and 150 feet, depending on the subsurface conditions encountered. If possible, the well pairs will be constructed in the same borehole using 2-inch diameter pipe and screen. If unstable conditions do not make that possible, the wells may be constructed as cluster wells.

4.2.1.6 Install Stratigraphic Borings

Stratigraphic boring(s) will only be installed if the subsurface lithology and structure has not been adequately characterized through the installation of the deep wells at the suspected source/DNAPL areas described in subsection 4.2.1.2. To characterize the geology and the deep karst beneath the Site that impacts DNAPL penetration in the aquifer and the migration of dissolved CVOCs in groundwater, one or more stratigraphic borings will be drilled to a depth of approximately 500 feet and converted into deep groundwater monitoring well(s). The borings will be located where high concentrations of CVOCs historically have not been detected to avoid the potential for contaminating the lower portions of the aquifer. The preliminary proposed locations as shown on **Figure 4.1-5** are:

- In the WPL in the general vicinity of MW-8,
- North of former Bldg4,
- North of the northeast corner of Former Bldg2.

The air rotary and/or coring drilling method will be used to install the stratigraphic borings. Continuous casing advancement may be used in conjunction with an air-rotary drilling rig. A geologist will collect lithologic samples and record the descriptions on a standard log form.

The hydrogeologic objectives for investigating the deep karst are to understand the depth of karst beneath selected areas of the Site where contaminant migration is known to occur, and to characterize the deep karstic groundwater flow and contaminant transport through those areas. The borehole logs will be examined for interpretation of karstic features; the 3-D Site geologic model will be revised, extending it to the base of the karst; borehole water quality logging will be performed for evidence of conduit flow behavior to depth.

Well screens may be installed in the stratigraphic borings following the procedures outlined in subsection 4.2.4.4. This decision will be made during or after the borehole has reached its final depth. The decision will be made by the project director or designee, however the objectives and final disposition of the stratigraphic wells will be discussed with the fYNOP team prior to commencement of drilling.

4.2.2 Groundwater Sampling Program

After the completion of the drilling program, the groundwater from the new wells and from existing Key Wells, will be sampled. Sampling procedures are described in subsection 4.2.4.7. Key Well sampling, regularly scheduled for June, will be postponed to coincide with sampling of the newly drilled wells. Field monitoring parameters such as pH, temperature, conductivity, turbidity, oxidation-reduction potential, and dissolved oxygen will be recorded. Groundwater samples will be submitted to the laboratory (TestAmerica Pittsburgh) for analysis of CVOCs, while some wells will be selected for metals and other parameters. The list of parameters anticipated for analysis also includes 1,4-dioxane, cyanide, hexavalent chromium, PCBs, benzene, various metals, and selected semivolatile organic compounds (SVOCs). A FSP addendum with a complete list of wells to be sampled and the parameters to be tested in each well will be developed and reviewed by the fYNOP team near the end of the drilling program and prior to sampling.

4.2.2.1 Analyze Groundwater for MNA Parameters

CVOC molecules are broken down by a process called anaerobic dechlorination (see subsection 5.1.4.3 of the Part 1 SGWRI Report). Naturally occurring bacteria in the aquifer can metabolize chlorinated compounds dissolved in groundwater under appropriate conditions. Understanding the degree to which CVOCs are being metabolized and where in the aquifer it is occurring will be useful during remedy selection. The analysis will assist in the evaluation of monitored natural attenuation (MNA) as a possible final step in the cleanup process and the consideration of enhanced bioremediation in source or secondary source areas.

As part of the sampling program above, approximately 30 wells will be selected for sampling to measure the concentrations of indicator parameters listed in **Table 4.2-2**. This table includes a description of the sample volume, container type, and sample preservative required for samples that will be submitted to TestAmerica Pittsburgh for laboratory analyses. Wells will be selected for MNA parameter sampling from the quartzitic sandstone aquifer in the NPBA and South Property Boundary Area (SPBA) and from the carbonate aquifer within some of the suspected NAPL source areas, plus up gradient and down gradient of those source areas

The results of these analyses will be used to screen for anaerobic biodegradation parameters after Wiedermeier, et. al., 1999. This will allow areas within the Site to be screened for evidence of anaerobic degradation and deduce the efficiency of natural attenuation within the aquifer.

Geochemical conditions, particularly dissolved oxygen, may be influenced in the carbonate aquifer by recharge from rainfall events that would result in oxygenated water flowing through solution channels for hours or days after the rainfall event. For that reason, sampling for indicator parameters will not be conducted within a couple days after a rainfall event.

Based on the results of sampling, the value of conducting a second round will be considered. Also the value of continuous monitoring of parameters such as dissolved oxygen and temperature to evaluate the effect of recharge events on geochemistry will be considered. After deeper wells in the source areas are installed, natural attenuation parameter testing may be important to understanding fate and transport of CVOCs at those greater depths.

4.2.3 Interim Data Report of Drilling and Testing

After the new wells have been installed, an interim report will be prepared by GSC to summarize the progress and findings of drilling, initial sampling, and the groundwater velocity and tracing (point dilution testing) efforts. Well logs, sampling results, and results from the EI surveys will be included in the report. Preliminary findings regarding the presence of solution channels, the vertical extent of CVOCs, and groundwater flow paths will be reported.

4.2.4 Field Methods and Procedures

Methods and procedures that will be used throughout the drilling program are described in the following subsections.

4.2.4.1 Air Rotary Drilling

The air-rotary drilling method will be used for the installation of the monitoring wells installed into bedrock. If unstable conditions are anticipated below the bedrock surface, a continuous casing advancement system may be used in conjunction with an air-rotary drilling rig. A 6-inch minimum diameter borehole will be advanced using either a percussive down-hole hammer or a roller cone bit. In areas where unstable overburden and/or fractured or voided bedrock materials exist, the initial borehole diameter may be several sizes larger to accommodate the placement of surface and temporary casings to stabilize the subsurface for well construction and borehole advancement activities. Lithologic samples will be collected from the surface to the total depth of the borehole for visual lithologic description of the encountered subsurface materials and will be recorded on a standard log form by the geological scientist. The standard log form is included in Appendix A.

If subsurface bedrock conditions are stable as observed in the field, an open rock well completion may be selected, depending on the purpose of the boring. Open rock well completions allow for larger completed well diameters and can be more readily used for additional investigations, such as borehole geophysics. Open rock well completion will consist of installing permanent 6-inch diameter steel casing that extends from the ground surface into competent bedrock. The permanent casing may be advanced further into the bedrock if determined to be required to stabilize unstable portions of the borehole or if it is determined that it is desirable to exclude specific water-bearing features or intervals, such as in the case of nested wells where deeper wells are completed to discretely monitor successively deeper intervals of the aquifer. The steel casing will be installed inside a minimum 9-inch nominal diameter borehole and then sealed with bentonite and tremie grouted in place, as described in subsection 4.2.4.4 and below.

The bentonite seal, consisting of compressed, powdered bentonite pellets or chips, generally measuring 0.25 to 0.38 inches in size, will be placed around the bottom of the steel casing. The bentonite seal will consist of a 3 to 5 foot dry thickness, measured immediately after placement. A weighted tape will be used to measure the placement of the seal. Following placement, the bentonite seal will be allowed to hydrate a minimum of 1 hour. If the seal is above the water table, clean, potable water will be poured down the borehole several times, allowing for hydration of the seal. The remainder of the borehole above the bentonite seal will be grouted to within approximately 3 feet of the surface. The grout will consist of type I or II Portland cement; approximately 5 to 8 pounds (lbs.) dry weight of powdered bentonite per 94 lb. sack of dry cement, and a maximum of 6 to 7 gallons of approved water per sack of cement. The grout will be combined in an aboveground rigid container and mechanically blended to produce a thick, lump free mixture. The grout will be placed into the borehole through a rigid tremie pipe, initially installed to immediately above the bentonite seal. The tremie pipe will have a side discharge or 90 degree elbow on the end so that the seal is not disturbed.

If subsurface conditions are not stable or if a discrete zone or zones in the borehole are to be sampled, well construction will follow, as described in subsection 4.2.4.4.

4.2.4.2 Hollow Stem Auger Drilling

Hollow-stem auger drilling methods will generally be used to install non-bedrock monitoring wells. This type of drilling method uses hollow auger flights with a bit and plug inserted into the hollow center of the cutter head to advance the auger into the subsurface material. The augers are used as temporary casing to prevent caving and sloughing of the borehole walls. Screens and filter packs as described below in subsection 4.2.4.4 will be installed through the hollow augers. Lithologic samples will be collected from the surface to the total depth of the borehole for visual lithologic description of the encountered materials and will be recorded on a standard log form by the geological scientist. The standard log form is in Appendix A.

When unstable drilling conditions are encountered and water quality profiling is to be performed, HW spin casing drilling techniques may be considered as a drilling alternative. HW spin casing uses an auger drilling rig to go back into a borehole previously drilled using air-rotary techniques and install a temporary 4.5-inch diameter casing to hold the well open. Then the well is cleaned out using a roller bit. The spin casing is pulled back to allow for water quality profiling to be done.

4.2.4.3 PQ Wireline Core Drilling

Wells selected for water quality profiling may be drilled using PQ wireline coring techniques. The coring assembly consists of a bit containing tungsten carbide or diamond chips which is attached to a core barrel. Both an inner barrel and an outer barrel make up the core barrel, which is rotated at high speed to core through the bedrock. The drill rod acts as a casing for the borehole to preclude caving of loose rocks and sediments typically encountered in karst solutioning features. The core produced using this technique is approximately 3.4 inches in diameter, while the hole constructed is 4.8-inches in diameter.

Specifically, wells located along the east and west side of Codorus Creek and several of the wells that are planned to characterize the vertical extent of CVOCs on-Site may be drilled with PQ wireline coring. The borings will be cored into and through a solution channel zone in the bedrock and into competent bedrock below. Temporary polyvinyl chloride (PVC) screen wrapped with a geo-fabric filter will be inserted through the core rods into the solution channel zone. The core bit then will be pulled up above the solution zone to case off the screen from the upper zones. Groundwater in the solution channel zone subsequently will be tested for temperature, pH, conductivity and dissolved oxygen parameters, and point dilution testing (see subsection 4.2.4.8) of the borehole will be performed.

After the testing is complete, the temporary PVC screen will be removed. If the well is located in one of the six suspected DNAPL source areas, then the bore hole will be reamed using air rotary techniques and a steel casing will be set, sealed with bentonite, and grouted in place (see subsections 4.2.4.1 and 4.2.4.4) to preclude introducing shallower contaminated groundwater into the deeper zones. Then PQ wire line coring will continue to the next bedrock solution zone of interest. A temporary PVC screen wrapped with geo-fabric filter material will be inserted as described above and the solution zone will be tested. The temporary PVC screen will then be removed and coring will continue to the total well depth. When the total well depth is reached, a two-inch-diameter PVC well with pre-packed sand filter will be constructed through the core drilling rods. The screened groundwater zone will be sealed off from the shallower groundwater above by using a "bentonite doughnut" seal and then cement grout to the ground surface.

If the well is not located in one of the six suspected DNAPL source areas, then the above procedures will be followed, except the borehole may or may not be reamed using air rotary techniques and a steel casing may not need to be installed.

4.2.4.4 Well Construction

Drilling and well construction will be recorded on a "Daily Drilling and Monitoring Well Contruction Report", as noted in Appendix A. Well screens and casing will be new, pre-cleaned schedule 40, 2-inch diameter PVC. Screen sections will be commercially fabricated and slotted with openings equal to 0.010 inches (10 slot). Screen and casing sections will be flush joint threaded. Thermal or solvent welded couplings will not be used. Pre-packed or U-pack screen sections will be used for intervals that cannot be filter packed conventionally due to subsurface conditions such as unstable boreholes or the presence of voids. Screen lengths will vary based on the intended use of the monitoring well. When the well is to be used primarily for monitoring a discrete interval or water-bearing zone the screen length will be normally limited to 10 feet or less.

Wells that are intended for more general monitoring of the aquifer will have longer screen lengths when determined to be appropriate. Wells constructed in unconsolidated materials will generally be screened from the bedrock surface to above the water table. The tops of all well casings will be fixed with an expandable plug.

Granular filter pack will be graded similar to Morie No. 0 or Morie No 1 based on the screen slot size of 0.010 inches. The filter pack material will be visually clean, free of material that would pass through a No. 200 mesh sieve, inert, siliceous, and composed of rounded grains. The filter material will be packed in bags or buckets and will be delivered therein to the site. The filter pack will be placed to 2 to 5 feet above the top of the PVC well screen. Filter pack materials will be placed in a manner to ensure that the filter pack is continuous and has no bridging. The final depth of the filter pack will be measured with a weighted tape and recorded. Conventionally filter packed wells will be surged with a surge block following initial filter pack placement. Following the surging of the well, the filter pack level will be sounded to check for settling and additional filter pack will be added if settling has occurred.

Following filter pack placement, a bentonite seal will be placed above the filter pack. Bentonite seal materials will consist of compressed, powdered bentonite pellets or chips, generally measuring 0.25 to 0.38 inches in size. The bentonite seal will consist of a 3 to 5 foot dry thickness, measured immediately after placement. A weighted tape will be used to measure the placement of the seal. Following placement, the bentonite seal will be allowed to hydrate a minimum of 1 hour. If the seal is above the water table, clean, potable water will be poured down the borehole several times, allowing for hydration of the seal.

The remainder of the borehole above the bentonite seal will be grouted to within approximately 3 feet of the surface. The grout will consist of type I or II Portland cement; approximately 5 to 8 pounds (lbs.) dry weight of powdered bentonite per 94 lb. sack of dry cement, and a maximum of 6 to 7 gallons of approved water per sack of cement. The grout will be combined in an aboveground rigid container and mechanically blended to produce a thick, lump free mixture. The grout will be placed into the borehole through a rigid tremie pipe, initially installed to immediately above the seal. The tremie pipe will have a side discharge or 90 degree elbow on the end so that the seal is not disturbed. If temporary casings or augers are being used to maintain the integrity of the borehole, the placement of the grout will be completed incrementally. The grout will be placed and then the casing or augers will be incrementally removed with incremental additions of grout as needed.

Well development will occur to remove drilling debris, mud, silt, fine sand, and sediment from the well to provide greater hydraulic communication between the well and surrounding formation. Well development activities will not commence until the grout has cured at least 24 hours. A properly sized surge block, attached to a clean discharge pipe and air line, will be carefully lowered into the well to ensure that damage does not occur to the well. The air line will be attached to an air compressor or compressed gas cylinders. The surge block will be raised and lowered over the entire length of the well screen to loosen the fine sediments. The assembly will be lowered to the bottom and allowed to air lift until the discharge becomes free from sediment and fines. This process will be repeated several times making sure that all portions of the screen are adequately surged. The wells will be developed for a minimum of 1 hour. If open rock well construction is used, the development of those wells will be completed using the air-rotary drill rig or a j-tube assembly. The drill rods or j-tube will be lowered into the borehole to the total depth of the well and then the air compressor will be used to force the water in the borehole out of the top of the well. The air will be turned on and off, effectively surging the well and the drill rods or j-tube will be moved up and down the water column.

The development of the open rock holes may be completed with the drill rig before or after the permanent steel casing is installed and grouted in place. If a well does not have sufficient water column or yield, then the well will be developed with a bottom-filling bailer. The bailer will be used to surge the water column and to remove water and sediment. Field parameters (pH, conductivity, dissolved oxygen, and temperature) will be taken before, during, and after the development process. Well development procedures will be logged and recorded for each well.

Monitoring wells will be completed at the surface with a 2.5 to 3 foot steel, above-grade, 6-inch diameter stick-up. The stick-up will be concreted in place and will have a locking cap. If the well is located in a high traffic area, the well may be completed with an at-grade drive-over which is to be concreted in place. Wells completed with a drive-over will have a locking expandable plug placed on the top of the PVC well casing. Typical drive over covers are included in Appendix B.

At the completion of monitoring well construction activities, each new well will be surveyed by a Pennsylvania-licensed surveyor for horizontal and vertical control. The elevation of the inner and outer well casings (at designated marked points on the rims) and the ground surface at each new location will be surveyed. Some survey control checks will be made at several existing wells. The horizontal well location will be established relative to NAD 83 Pennsylvania State Plane South (feet). Vertical measurements will be made to the nearest 0.01 foot above mean sea level (MSL) (NAVD 88), and horizontal measurements will be taken to the nearest 1 foot. The identifiers, coordinates, and elevations of the new wells will be plotted on maps to show their location with references to existing wells and other site features.

4.2.4.5 Soil Sampling

Soil samples will be recovered using steam-cleaned standard split-spoon samplers assembled without lubricated threads. After each sample has been brought to the surface by the drilling contractor, it will be opened in the presence of the geological scientist. The geologist will then screen the sample using an organic vapor analyzer by holding the detector over each split-spoon as it is opened but prior to being otherwise physically disturbed. Readings from the vapor analyzer will be recorded on the field log. Soil samples to be submitted for laboratory analyses will be placed into appropriate, laboratory supplied containers and cooled to approximately 4 degrees celsius.

The length of recovery of the soil sample will be measured and recorded on the log, and the sample will be cut in half longitudinally using a clean stainless steel knife or single-use plactic spatula, the sample will then be logged for lithology, texture, weathering, color, density, moisture, sample depth interval, penetration (blow counts), and recovery, with descriptions following the Unified Soil Classification System (USCS) or Burmeister Sytstem.

As an alternative to collecting soil samples using hollow stem auger drilling and split-spoon sampling, a Geoprobe® or similar boring rig may be used to complete the soil sampling using direct-push technology. The Geoprobe® system will be used to advance a stainless-steel, 4 foot macro-core or 5 foot dual-wall tubing system sampler to the desired sample depth. The stainless-steel sample tube is fitted with a disposable, internal acetate liner and the tube is then equipped with a cutting shoe which is pushed into the ground. The sampler will be advanced 4 or 5 feet at a time, depending on sampler type, and then retrieved to extract the soil core. This will be repeated until the desired sample depth has been collected inside the sampler. Once the sampler is retrieved to the surface, the cutting shoe is removed, and the internal acetate liner is removed from the stainless-steel tube. The acetate liner is then cut lengthwise with a pre-cleaned stainless-steel knife, exposing the soil core for sampling.

4.2.4.6 Water Quality Profiling

As part of the drilling program and investigation, all or some of the wells will be selected for water quality profiling for the purpose of determining the presence of active interconnected solution channels in the carbonate bedrock. Wells planned for this profiling include the deep wells along the levee and some or all of the vertical extent wells in the suspected DNAPL source areas. Water quality profiling will be done during the drilling process (see subsection 4.2.4.3) using multi-electrode water quality sensors in the well for temperature, pH, conductivity, and dissolved oxygen.

The more rapid migration of stormwater or surface water recharge through the intermediate and deep karst conduit features of an aquifer can result in anomalous groundwater quality conditions. These anomalies include lower electrical conductivity, elevated or depressed temperature, and elevated dissolved oxygen concentrations, all of which are associated with the source of the recharge. The boreholes that are planned for the karst aquifer will be examined using borehole profiling methods for water quality to identify any anomalies. The location(s) of anomalies will be used to guide the selection of locations in the boreholes for the groundwater velocity testing, which is described in subsections 4.2.4.8 and 4.2.4.9.

Water quality profiling will be completed inside of the boreholes before steel casing is grouted in place. The boreholes may require a temporary geotextile-wrapped PVC well screen to be installed where caving conditions are encountered, to provide access for the logging tool and to protect the tool from damage. Well screen with 10-slot openings is suitable for the water quality profiling. The drilling contractor will have available the necessary drilling techniques for cleanout of the borehole prior to logging, or for temporary installation of the well screen.

The water quality profiling equipment will consist of a programmable, multi-electrode water quality sensor assembly and pressure transducer. The assembly will automatically take and store measurements at pre-set intervals. The assembly is connected to a field-grade computer at the well head for viewing of the data in real time, and for data backup. The sensors will be placed in the borehole either using a winch assembly or manually, whichever is most appropriate.

4.2.4.7 Groundwater Sampling

The groundwater sampling will be collected from new and existing wells. Water level measurements will be collected from the wells prior to purging and sampling activities. The depth from a pre-surveyed location (preferably a mark located on the inner casing) to the static groundwater elevation will be measured with an electronic water level indicator at all well locations. All readings will be reported on an appropriate field monitoring form. All attempts will be made to collect water level measurements from all the wells on a single day prior to any site groundwater purging and sampling activities. The measurement will be made to the nearest 0.01 foot from the marked top of the riser pipe of the well.

Wells will be purged using modified low-flow techniques prior to the collection of groundwater samples. A well yield matched purge sampling technique will be applied to sample groundwater monitoring wells. The well yield matched purge technique incorporates some of the aspects of low flow or micro purge sampling techniques in an attempt to acquire samples that are representative of the actual conditions within the aquifer and to collect reproducible sampling results. Several benefits of the described sampling methods are as follows: reduction of “stress” in the aquifer by pumping at a rate equal to or less than well yield, reduction of well bore mixing after completion of purge by sampling directly from purging equipment, reduction of turbidity of samples by not stirring up or “stressing” the well, purging from the water-bearing zones and not causing the filter pack or water-bearing zone to be exposed to air or aerated. Two classifications of wells will be considered during the sampling and consist of wells that have sustainable yields above the minimal pumping capabilities of the pump and low yielding wells. Monitoring wells that are determined to have yields lower than what can be reasonably matched with the limitations of the available pumps will be discussed in subsection 4.2.4.7.2 Low Yield Well Sampling.

4.2.4.7.1 Well Yield Matched Purge

The collection of groundwater samples from monitoring wells using the well yield matched purge sampling technique will be accomplished in four general steps:

1. Set the purge flow rate;
2. Control drawdown in the well;
3. Obtain stabilized water quality indicator parameters; and
4. Collect groundwater samples.

Monitoring wells should be purged and sampled in an order so that the well having the lowest suspected contaminant concentration is sampled first, and the well having the highest suspected concentration of contamination is sampled last. Decontamination of some field monitoring equipment will be required after sample collection at each well. New disposable polyethylene tubing will be used on all non-dedicated submersible, positive-displacement sampling pumps. Other approved comparable well purging and sampling equipment and methodologies may be used, as described below. The polyethylene tubing from the non-dedicated pumps will be discarded after sampling each well. The pump will be set generally at the depth of the suspected water bearing zones within each well. When sampling water table wells, the pump will be set in the middle of the screened interval. If the depths of the water-bearing zones are unknown, the pump will be set approximately 2 feet from the bottom of the screened interval. In all instances the pump will not be placed closer than 2 feet from the bottom.

Other well purging and sampling equipment which may be used includes:

1. A 2-inch diameter bladder pump, consisting of a flexible Teflon bladder enclosed in a rigid stainless steel housing. A screen is attached to the pump to filter any material which could clog either of the check valves located above or below the bladder.

2. A self-priming variable-speed low-volume peristaltic pump equipped with Teflon/silicone tubing. The tubing will be dedicated to a well.

3. A bailer constructed of PVC, Teflon, or stainless steel.

4. A Waterra pump operated with dedicated, low-sorption tubing.

The field parameters, pH, conductivity, temperature, dissolved oxygen (DO), and turbidity at a minimum will be monitored during purging. Tubing should be checked before adjusting flow rates or taking field measurements to ensure that no air is trapped in the line. The purge rate should be adjusted, as necessary, until a stabilized flow rate is achieved that results in a stabilized water level. After the water level has stabilized, field water quality parameters will be measured and recorded a minimum of every 5 minutes or each well volume, whichever is more frequent. Purging will be considered complete when the field parameters stabilize after a minimum of three readings at 5-minute intervals according to the following criteria:

- dissolved oxygen (DO): ± 0.2 milligrams/liter (mg/L)
- conductivity: ± 25 micro-mhos/centimeter (µmhos/cm)
- temperature: ± 0.5 degrees Celsius (°C)
- pH: ± 0.1 Standard units (S.U.)
- turbidity: < 50 nephelometric turbidity units (NTU)

In wells where the depths of the water bearing zones are unknown, after the pump is placed at the appropriate depth, at least one standing screen plus the borehole or open interval water column volume will be purged and the above field parameter stabilization criteria be met to consider the purging of these wells complete. The collection of groundwater samples from a monitoring well will begin immediately after stabilization of field parameters is obtained. The flow-through cell for collecting the stabilization parameters will be removed from the discharge tubing prior to starting the sampling activities. The pump tubing should be checked to ensure that no air is trapped in the lines prior to sample collection. If needed to avoid aeration, the discharge rate of the pump will be reduced to control the flow into the sample bottles and to collect bubble-free VOC samples. Samples will be transferred directly into pre-preserved laboratory sample containers from the pump tubing. Metals samples will be field filtered by attaching an in-line filter to the discharge tubing and filtering directly into the preserved sample bottles.

Immediately after the collection of samples and completion of sample container label information, each sample container will be placed into an ice-filled cooler to ensure preservation. Samples will be submitted to the selected laboratory for analyses using proper handling, shipping, and chain-of-custody procedures.

Water generated from well purging activities and decontamination water from groundwater sampling activities will be containerized and transferred to the Site groundwater treatment plant for treatment.

4.2.4.7.2 Low Yield Well Sampling

Low yield wells with respect to sampling are defined as wells that do not have a sufficient yield that enables purging with stabilization of the water level. The low yielding wells will be purged at the lowest rate available with the submersible positive-displacement pump or other approved methods, as described above in subsection 4.2.4.7.1. The pump intake will be placed at the known water-bearing zone, or if the water-bearing zone is unknown, then no closer than 2 feet from the bottom of the well. An attempt will be made to purge at least one open interval or screen plus borehole volume without exposing the entire filter pack or water-bearing zones at which point the sample will be collected from the discharge tubing. Water quality field parameters will be collected every 5 minutes during the purge. If the well cavitates before the desired purge volume is removed, the well will be allowed to recharge and the sample will be collected as soon as sufficient volume is present.

Shallow low-yielding wells may also be sampled using disposable Teflon or stainless steel bailers equipped with double check valves and valved bottom emptying devices. The bailers will be lowered slowly into the water column so as to minimize agitation of the water column. After the sample is brought to the surface, it will be emptied into the sample container using the bottom emptying device.

4.2.4.8 Borehole Point Dilution Testing

Of the many different technologies for measuring horizontal groundwater flow velocity through boreholes, the point-dilution tracer testing method is appropriate for use in rapid flow conditions of a karst aquifer. The point dilution testing method is described in Freeze and Cherry (1979) and Halevy et al. (1967), for use in aquifers with horizontal and sub-horizontal groundwater flow directions.

With the aid of a down-the-hole testing apparatus, a small quantity of tracer is injected into a borehole that penetrates a karstic conduit and the tracer is swept into the aquifer by the flowing groundwater. The groundwater flow rate is calculated using the measurements of the dissipation of the tracer concentration over time. The calculated flow rate will be used at the Site to differentiate the active conduit flow pathways in the karst aquifer from the slowly flowing or stagnant karstic zones. Karstic zones showing nearly stagnant or very slowly flowing groundwater would be eliminated from consideration for the cross-hole tracer testing. The cross-hole testing is intended to show the groundwater flow rate and direction on a larger scale.

The point-dilution tracer testing method is applied in a conduit flow feature, which is identified by examination of the borehole geologic log and the water quality profile. The conduit feature is isolated from the rest of the borehole using inflatable packers with a spacing of 5 to 15 feet, and connected by perforated steel pipe (see inset figure). The packers will eliminate the flow of water up or down the borehole which may occur between the test interval and overlying of underlying conduit zones, which have been interconnected by the borehole. For core-drill holes, which may be too narrow for packer insertion, or where the borehole wall is suspected of being too rough for packer inflation, a PVC piezometer with a 100-slot screen and geotextile filter wrap can be inserted through the test zone. Well screen that is 10-slot is not recommended for this application. A shale-trap is connected to the piezometer just above the screen, and a grout seal is constructed above the shale-trap. The borehole testing equipment is installed inside the screen and adjacent to the conduit feature. At the ground surface, the equipment setup consists of a field computer, small injection pump and hose, reservoir with tracer, and a small generator. The packer assembly is positioned in place using a boom truck. A compressed air tank, regulator, and high pressure inflation line are required to inflate the packers.

Prior to testing, the down-hole sensor assembly collects groundwater quality data for a period of time prior to tracer injection, to establish background. Once background water quality has been established to the satisfaction of the hydrogeologist, a small tracer slug is pumped into the test interval and engulfs the sensor assembly. The sensors measure the initial concentration, and the dissipation of the tracer is measured. The velocity of the groundwater is determined from the rate of dissipation of the tracer into the aquifer, using straight-forward mathematical methods. If stagnant or near-stagnant flow conditions are encountered, the hydrogeologist will make a determination and end the period of monitoring.

4.2.4.9 Groundwater Tracer Testing

Groundwater tracer testing may be performed on the Site to investigate intermediate and deep karstic flow pathways, which may be located in the following areas: 1) in suspected contaminant source areas; 2) beneath Codorus Creek and continuing westward; 3) southeast of, and due south of the Site; and 4) at the locations of the deep stratigraphic borings. The tracer testing described below would be conducted between two or more boreholes, using direct and real-time detection and quantitative interpretation methods. The interconnections between selected boreholes at the Site may be investigated by injecting either a salt brine solution, or a Rhodamine WT dye solution, into selected borings/wells at the Site.

The site-wide tracer test (see subsection 4.3.10) which has been recommended by the USACE through Dr. Wanfang Zhou, is a separate undertaking which will be conducted in Phase 3 using qualitative tracing methods which require passive detectors in groundwater springs and wells.

PADEP, USEPA, USACE, and other local entities may require notification and approval to conduct this groundwater tracing study. Off-site migration of the tracer is possible.

Pairs or groups of wells will be selected for quantitative tracer testing at each of the four general areas described above. To be selected for testing, wells would need to exhibit strong evidence of large-scale karst conditions and conduit flow, such as large open or partially-open voids as noted in the borehole log, anomalous groundwater quality, and significant karstic flow velocity from point dilution testing. Other evidence may be used including compressed air or water interconnection with adjacent boreholes during air-rotary drilling, and substantial local anisotropic (directional) drawdown in the water table, as determined using the monitoring well network. Wells that are planned for tracer injection may be tested for their recharge capacity using a freshwater flush testing method to verify their injection capacity. Discrete vertical zones to be monitored within a well bore will be determined from well logs and point dilution testing. Each borehole may contain up to four sets of sensors at selected depths in the saturated portion of the borehole, or in the screened portion of the piezometer.

A variety of borehole multi-parameter water quality sensors could be used for the brine tracer detection, including In-Situ Aqua-Trolls or multi-parameter Trolls; YSI multi-parameter sensors; and Solinst sensors. Sensors will be selected based upon availability at the time of testing. The background water quality consisting of temperature, conductivity, dissolved oxygen, and turbidity, and pressure would be collected at each of the monitored locations for one-week prior to the release of the tracer. For Rhodamine-WT tracer detection, several borehole sensors are available on the market including YSI 6130, Turner Designs Cyclops, and Hydrolab.

If a salt brine tracer is chosen for the testing, a warm, saturated "10-pound" salt brine solution will be prepared. On-Site preparation of the brine solution will utilize non-iodized sodium-chloride, which can be purchased in large quantities from agricultural feed suppliers. Alternatively, a local brine supplier can supply large brine batches, which could be stored temporarily on-site in a tank. A saturated salt solution weighs roughly 10 pounds per gallon of solution. Several thousand gallons in total of salt brine solution would be required to complete all of the testing at the various locations. The volume of tracer for each test location will vary depending on the injection capacity of the well/borehole, with larger capacity wells receiving more tracer to create a concentrated slug inside of the karstic pathway.

For dye-testing, the tracer solution should be sufficiently concentrated so that the sensor can detect the tracer after several times dilution. Each of the sensor manufacturers claim different detection limits to their equipment, and the tracer should be prepared with the sensors' detection capabilities, and potential interferences, in-mind. Substantial turbidity is one such interference, and the turbidity will be monitored during the background period of monitoring. More than one dye tracer injection may be required into a well if the concentration at the receptor well is close to the detection limit, a condition that can occur if substantial mixing and dilution occurs within the flow pathway. In such a case, a more concentrated batch of tracer would be prepared for the second injection test.

Injection of the tracer will be accomplished within a short time interval and at substantial rates, given the expected large injection capacity of the wells/boreholes. Immediately after the tracer injection, a quantity of potable water will be injected into the well to flush the tracer that remains in the well into the aquifer. Monitoring of the tracer arrival would continue until breakthrough is obtained, or until sufficient time has passed to state with confidence that arrival is unlikely for that location. For longer term tracer tests, where brine tracer is used, an automated remote monitoring system may be assembled at the well head to enable remote real-time observation of the test results, and to make a determination as to when the test is over, thus eliminating the need to schedule manpower for this task.

4.2.4.10 MIP Sampling Procedures

MIP is a semi-quantitative field screening device that can detect volatile organic compounds in soil and sediment and provide vertical profiling information of total CVOCs. It is used in conjunction with direct push drilling equipment such as the Geoprobe which pushes the MIP into the subsurface at a typical rate of foot per minute. MIP sampling procedures use heat to volatilize and mobilize contaminants for sampling. Heating the soil and/or groundwater adjacent to the MIP's semi-permeable membrane volatilizes the volatile organic compounds, which then pass through the probe's membrane and into a carrier gas for transport to a detection device located at the ground surface (www.clu-in.org/characterization/technologies/mip.cfm).

The MIP technology that will be used to characterize subsurface CVOCs utilizes gas chromatography (GC)-grade photo-ionization detectors (PID), flame-ionization detectors (FID), and electron capture detectors (ECD) to analyze total CVOC vapor concentrations. Individual compounds will not be quantified with the standard MIP technology.

Areas to be sampled using MIP technology will be marked on the ground surface or staked. Data collected from earlier MIP sampling will be used to guide the placement of later MIP sampling locations. The top approximately four feet will be soft dug to avoid contacting and damaging any subsurface utilities, and concrete overlying MIP sampling locations will be cut prior to using the Geoprobe to advance the MIP. MIP sampling will be conducted to the depth of Geoprobe refusal (assumed to be bedrock), approximately 35 feet bgs. Confirmatory soil borings and samples will be collected at 10 to 15 percent of the MIP boring locations after the completion of the MIP sampling to verify the results. Soil samples will be collected using a Geoprobe, similar direct-push drilling technology, or by collecting split-spoon samples using hollow stem auger drilling. Soil sampling techniques are described in subsection 4.2.4.5.

4.2.4.11 Ground Penetrating Radar (GPR) Procedures

GPR uses high-frequency electromagnetic pulses generated by a transmitter to investigate the subsurface. The pulse frequency (typically 80 to 1,500 megahertz [MHz]) is chosen based upon the size and depth of the target being investigated, and the expected soil type and properties. Transmitted radar pulses are reflected from various interfaces within the ground, and sensed by a receiving radar antenna at the ground surface. The reflecting surfaces may be soil horizons, the groundwater surface, soil/bedrock interface, man-made objects or other interface possessing a significant contrast in dielectric properties. The dielectric properties of materials correlate with many of the mechanical and geologic parameters of materials.

The transmission antenna may be the same as the receiving antenna (monostatic) or they may be different (bistatic). An antenna is normally pulled along the ground surface, however towing by vehicle is used in some instances. When survey data is collected using a survey-wheel, the operator can set the frequency of measurement. This frequently ranges from 24 times per foot for a very high-resolution rebar survey, to a measurement every 6-inches for a reconnaissance geological survey. Under some circumstances, positions can be integrated with a global positioning system (GPS), or other automated position locating system.

The GPR survey, designed for this project by Quality Geosciences Company of Grantville, Pennsylvania, includes inline measurements 4 times per foot (every 3 inches), with 5 foot between survey lines. Preparing for the GPR survey, push flags, or spray-paint marks will be used to mark the start and end of each traverse. These may be supplemented with temporary push flags, spray paint, chalk or other markings placed along each traverse as necessary.

The survey will be conducted using a Geophysical Survey System (GSSI) Model SIR-3000 GPR unit manufactured by Geophysical Survey Systems Inc. of New Hampshire. The geophysics contractor will use a 270 or 400 MHz antenna to survey this site. All data will be digitally recorded, and monitored for data quality in the field. An experienced GPR operator (minimum 5 years' experience) is required to ensure appropriate data is collected.

The radar depth of penetration is primarily dependent upon the electrical properties of the site soils. Therefore, the depth of radar signal penetration is site specific. The penetration measured relative to the survey objectives will be evaluated early during the survey to determine the value of continuing the survey. If poor radar penetration is identified due to site-specific conditions, an early termination of the GPR survey may be recommended.

Inline distance will be measured using a survey wheel integrated into the survey cart that carries the GPR antenna. A GPS will be used to identify the end location of each traverse. The GPS shall be integrated with the GPR system, so GPS coordinates are placed in the file header at the start of each line, and a location file is prepared showing the GPS position of all electronic reference markers that the operator places into the data during the survey.

The data will be examined while in the field. Features of interest will be marked on the ground surface using spray paint. No detailed data processing for enhancement will be performed.

Because field markings were performed, no report will be prepared for this project.

4.2.4.12 Electrical Imaging Procedures

The objective of using this geophysical method is to aid in successfully positioning wells that will penetrate conduits, fractures, or voids in the karst aquifer.

The traverse locations have been selected for west of Codorus Creek and south of the Site on the south side of Route 30. Available information regarding underground utilities will be reviewed to minimize the potential for interference. Final staking of the traverse lines will be conducted, with the assistance of personnel knowledgeable of site conditions.

The areas will be prepared for the geophysical survey. Preparation will include removing, brush-hogging, clearing and/or bull dozing vegetation and obstructions in the areas of the geophysical survey, if necessary. Arrangements will be made for any permits or approvals required for removal, brush-hogging, and clearing activities.

Electrical imaging is a geophysical technique which measures the electrical properties of the subsurface. Electrical imaging involves measuring the resistivity of the earth along a series of profiles. Electrodes are planted in the earth with their separation being increased with successive measurements. Increasing electrode separation enables measurements of greater depth. Length of profile, depth of penetration, and resolution determine the electrode spacing, which can be anywhere from 1 meter to 50 meters or more. Resistivity measurements are made by placing a known current (measured in milli-amps) into the ground using two electrodes. The resulting potential (measured in milli-volts) is measured between two other electrodes. By changing relative spacing or locations between the potential and current electrodes, different resistivity measurements can be made using different electrode array configurations. Common arrays include Wenner, Schlumberger, and dipole-dipole.

A digital global positioning system (DGPS) unit will be used to identify the location of each traverse. The DGPS unit will provide sub-meter accuracy in locating the position of the traverses. The DGPS will be used to identify prominent site features to present a reasonable and accurate base map of the geophysical survey. Survey coordinates will be collected every fourth electrode of the electrical imaging traverse using GPS equipment to an accuracy of 1 meter.

Interpretation of the raw apparent resistivity data without modeling or inversion will result in a qualitative product that is affected by a large volume of subsurface area. Inversion or modeling of the data discrete subsurface segments, called model blocks, will provide modeled resistivity values that are more discrete. This discrete modeled resistivity leads to a more-quantitative interpretation of the data. The inversion of the data will also correct for effects of topography changes, which can cause misleading interpretations of the raw apparent resistivity data from the dipole-dipole data set. The resistivity inversion program, RES2DINV, will be used to produce true resistivity models based on the apparent resistivity data.

During data analysis, the apparent resistivity data will be examined for spurious values, and invalid data caused by noise, cultural interference, or poor ground contact by the electrode will be removed. The model block sensitivity will be examined to evaluate an appropriate depth of investigation based upon the electrical signal to noise ratio and model sensitivity to modeled variations in resistivity.

The modeled data may be imported into Surfer© for contouring, interpretation annotation, and presentation. Surfer© provides a robust data contouring management tool that permits presentation of the modeled resistivities. This approach allows subsurface features in the data to be emphasized while residual information from the physical measurements or from the modeling process is de-emphasized.

Following data collection and inversion modeling, the electrical imaging electrostratigraphy information will be used to interpret the gross stratigraphy along the survey traverses. Dry materials have higher resistivity than similar wet materials because moisture increases the ability to conduct electricity. The resistivity difference between dry and wet material, if indicated in the observed electrostratigraphy, can represent water table depths. Beneath the water table and below the average bedrock depth, higher conductivity zones are indicative of karst solution channels.

At the conclusion of the field investigation and geophysics data processing, locations for test conduit wells will be selected. The locations will be field checked and ranked by the strength of the data.

4.2.4.13 Borehole Geophysical Logging

Geophysical logging of the boring may be completed using a suite of tools, including an optical or acoustic televiewer at selected intervals in the borehole. Scheduling and access conditions will be evaluated in the field to select the borings to be logged and specific equipment to be used. These logs can provide continuous and oriented 360 degree views of the borehole wall and can be used to determine strike and dip of fractures and bedding planes. Caliper, Spontaneous Potential (SP), resistivity/conductivity, natural gamma logging, and temperature and heat-pulse flow meter may also be used in the borehole to identify water bearing zones and flow conduits. Each of the individual sondes used for the logging activities will be briefly described below. All depths will be measured from the top of casing (TOC).

4.2.4.13.1 Temperature/Fluid Resistivity/Conductivity Sonde

The temperature/fluid conductivity sonde or equivalent equipment provides fluid temperature in degrees Celsius and fluid conductivity in milliSeimen per centimeter (mS/cm). The purpose of this log in the current investigation is to aid in determining zones in which water is entering or leaving the borehole in response to vertical gradients. The sonde will be calibrated by the manufacture prior to its arrival on site. Data will be acquired by logging in a downward direction after the well is allowed to equilibrate overnight. Logging downward assures that the measurements are completed before the fluid column is disturbed by the introduction of the sonde. Once the bottom of the well is reached, the well will be logged again, this time in the upward direction to verify data repeatability.

4.2.4.13.2 3-Arm Caliper/Natural Gamma Sonde

The 3-arm caliper measures the diameter of the borehole which can vary because of bedrock fractures and lithologic changes. The natural gamma portion of the sonde measures the natural radioactivity in counts-per-second (CPS). The gamma response can indicate changes in lithology within the borehole. Strong gamma responses can indicate the increased presence of some feldspars, micas and clays. The borehole will be logged in the upward direction with this sonde.

4.2.4.13.3 Heat Pulse Flowmeter

A heat pulse flowmeter can detect low vertical flow velocities within the borehole under ambient and pumped conditions. The heat pulse flowmeter can detect the direction and rate of borehole water movement. The heat pulse flowmeter operates by heating a small sheet of water between two sensitive heat sensors (thermistors) located the same distance from the heat source. The time it takes for the heated water to move upward or downward past one of the thermistors is recorded. Because the thermistors are located in a channel of fixed diameter, the flow rate can be determined form the time it takes for the peak of the heat pulse to pass one of the thermistors. A flexible diverter is used to block the annular space around the tool to channel all the flow through the measurement channel. The range of flow measurement is about 0.01-1.2 gallons per minute (gpm) in a 2- to 10-inch diameter borehole (personal communication from Randall Conger, USGS).

4.2.4.13.4 Acoustic Borehole Televiewer

The acoustic televiewer log provides a record of amplitude of high-frequency acoustic pulses reflected by the borehole wall. The televiewer is a sonic imaging tool that scans the borehole with an acoustic beam. The reflected acoustic waves are recorded digitally on a portable computer, and images of transit time and amplitude of the waves are produced. The logs are corrected for magnetic orientation, magnetic declination (true north), and borehole deviation from vertical by the logging software. Fractures and solution features are detected by longer transit times and decreased signal amplitudes. Because the returned data are oriented to true north and corrected for borehole deviation from vertical, strike and dip for each fracture or bedding plane can be determined. An acoustic televiewer may produce images of these features even where the water is cloudy or the borehole walls are coated or dark in color. The acoustic televiewer can be used underwater in 6- to 8-inch diameter boreholes, but not within six feet of the bottom of steel casing.

4.2.4.13.5 Optical Televiewer

Like the acoustic televiewer, the optical televiewer data provides both location and orientation information about features such as fractures and lithologic foliations. An optical televiewer uses a ring of lights and a camera to allow direct viewing of bedrock lithology and structures such as fractures, bedding planes, and voids. To collect optical televiewer data, the fluid within the borehole must be clear. The resulting log provides an image of the borehole wall similar to that which could be acquired by a standard video log. Unlike a standard video log, the acquired image is digitized and properly oriented with respect to borehole deviation and tool rotation, thereby allowing post processing of the data to provide the feature strike and dip information. Unlike the BHTV images, the OPTV provides the optical view of the borehole wall making it possible to visibly see lithologic changes, mineral veins, and fracture and solution channel characteristics.

4.2.5 Management of Wastes

All investigation-derived waste (IDW) generated during remedial investigation work will be managed, characterized and handled in accordance with the PADEP approved 'Contained-In' Waste Determination for Environmental Media (SAIC 2011a, 2011b, and 2011c). This determination permits non-hazardous disposal of investigation and remediation-related media contaminated with listed hazardous waste constituents when: (1) the media does not exhibit a characteristic of hazardous waste when generated, or (2) the media contaminated with a listed hazardous waste constituents has concentrations of hazardous constituents that are below health-based levels, and (3) the IDW is managed by a qualified environmental inspector. Harley-Davidson received approval of this determination from PADEP in 2011, which also includes decision and handling guidelines for screening, sampling/testing, and selecting appropriate on-site or off-site disposal options for solids, liquids and debris wastes generated during remedial actions.

In general, suspect soil, drill cuttings, drilling fluids and associated wastes will be placed on protected stockpiles, roll-offs, tanks, drums or other appropriate containers, and staged at appropriate locations, as directed by Harley-Davidson. Waste materials placed into containers will be immediately labeled, noting generator name, contents, and date of generation. As soon as laboratory results are received and a waste determination has been made, the appropriate hazardous or residual waste labeling will be applied to the containers, including generator name, address, USEPA identification number, start date of accumulation, contents and USEPA waste number(s).

The handling options will generally include on-site use, on-site treatment, or off-site transportation and disposal. Off-site disposal options may include non-hazardous landfill or wastewater treatment; or treatment/disposal at an approved Resource Conservation and Recovery Act (RCRA) treatment, storage and disposal (TSD) facility.

During various field activities, personal protection equipment (PPE) and disposable sample equipment will be generated consisting of gloves, disposable over-boots, Tyvek® coveralls and sample scoops. This IDW waste stream will be managed by including it with the materials being sampled, characterized, and disposed. IDW generated during groundwater sampling will include sample gloves, plastic sheathing, disposable sample tubing, and non-contaminated solids and miscellaneous trash such as cardboard and plastic wrappers. These types of IDW may be disposed of into an existing trash receptacle, as directed by Harley-Davidson. Efforts will be made throughout the field program to minimize the volume of waste derived from sampling and decontamination procedures.

Purge water generated during groundwater sampling and all decontamination fluids will be containerized and transported to the GWTP for proper disposal. If groundwater or fluids are generated that are determined to be hazardous or cannot be disposed of at the GWTP, the waste will be containerized and managed for off-site disposal.

4.3 Phase 3 – Testing and Monitoring

Stream studies, weir installation, stormwater monitoring, hydrodynamic testing of the Central Plant/WPL groundwater extraction system will be conducted after the installation of wells. Karst loss will be monitored on-Site and the data will be used to refine karst loss calculations.

The interaction of storm water runoff, wetlands and streams with the groundwater will be examined and characterized by measuring and monitoring water flows and levels. In addition, qualitative dye tracer testing will be conducted at the Site (refer to subsection 4.3.10). These studies will improve the understanding of the performance of the groundwater extraction system, and address the questions regarding the potential for Site groundwater escaping beneath the groundwater extraction system pumping wells, and whether Site groundwater may be passing beneath Codorus Creek.

In addition, two studies are proposed that will examine proposed changes to the groundwater extraction system.

- Depending on the outcome of the MW-18 investigation in the NPBA, the groundwater extraction wells in the NPBA will be shut down and carefully monitored.

- Also proposed is the shut down of the Building 3 Footer Drain Lift Station. Monitoring of the shut down of the Building 3 Footer Drain Lift station will continue through seasonally wet periods. The lift station not be permanently disabled until sufficient wet season monitoring is experienced.

This phase of work will culminate in a full round of sampling of approximately 115 wells for laboratory analysis of COCs.

4.3.1 Second Round of Seepage Run Surveys

Subsection 4.1.1.4 describes the seepage run survey process, and describes that seepage runs will be conducted twice, once in the spring time when water levels are generally high, and once in the late summer/fall, when water levels are typically low. This task is added here to include it in the Phase 3 program.

4.3.2 Installation of Weirs in Streams

Surface water flow, including runoff from the Site, will be monitored for a number of months prior to and during the Hydrodynamic Testing and Monitoring subsection 4.3.9. Two weirs are planned for Johnsons Run and two weirs are planned for the stream through the wetlands, a tributary to Johnsons Run. The seepage run survey, described in subsection 4.1.1.4 describes how the weir locations will be selected.

The selection of the type of weir to be used will be based on the range of flows to be measured and the geometry of the given stream. The most commonly used weirs are the sharp-crested V-notch and rectangular weirs. Weirs are used to produce a conduit for flow and mathematical calculations are used to determine the rate of flow over the structure (www.ecy.wa.gov). A pressure transducer housed in a standpipe open to the pool of water backed up behind the weir will be used to measure and record water levels, which are used to calculate flow over the weir.

4.3.3 Sampling of Codorus Creek Groundwater Discharges

The thermal/water quality survey conducted in August of 2007 indicated that groundwater was discharging to Codorus Creek from the bank and bed of the creek. After installation of shallow wells (subsection 4.2.1.4), and during the sampling of those wells, springs/groundwater discharges will be re-located using GPS and thermal probes. Samples will be collected at locations that indicate a temperature difference compared with the surrounding surface water. The samples will be collected in a manner that minimizes dilution from the surface water by placing the sample tube or sample device inches from the bottom of the stream or stream bank. A peristaltic pump or discrete sampler will be used, with placement guided by the thermistor. Samples will be analyzed for VOCs, anions and cations, and Priority Pollutant metals.

4.3.4 NPBA Extraction System Monitored Shut Down

Site-related COCs detected in off-Site residential groundwater wells to the north of the NPBA were most likely drawn to the off-Site wells by pumping of those wells for domestic water supply. Pumping of domestic wells ceased many years ago in most wells to the north, and a few years ago in the last active well (RW-4). The groundwater quality in the off-Site wells has improved dramatically. Whether groundwater would naturally migrate northward from the NPBA to off-Site properties or concentrations of COCs would rebound if the groundwater extraction system were deactivated has not been determined. Therefore, a monitored shutdown of the NPBA groundwater extraction system is proposed to evaluate the need for continued operation of this extraction system. This shutdown test will be monitored to determine the groundwater gradients under non-pumping conditions. During this same shutdown period, monitoring of water quality is planned in selected wells to observe potential chemical concentration rebound in the NPBA and off-Site to the north. Modifications to the monitored shut down plans will be described in an addendum to this FSP.

This activity will be initiated after completion of the MW-18D investigation. It is possible that the results of the MW-18D investigation will modify these proposed plans.

1. Access will be gained to measure water levels in residential wells RW-1, RW-2 and RW-4, if possible. Continuous water recorders will be installed in these wells. If feasible, methods of monitoring the fluctuations in flow from springs S-5 (if it still exists), S-6 and S-7 located north of the Site will be implemented. Continuous water level recorders will also be installed in six to eight wells on the Site and on the Herman property (well[s] to be installed as part of the MW-18D investigation).

2. The recorders will be activated, and rounds of manual water levels will be collected weekly for two to four weeks while the extraction system continues to operate normally. Approximately fifteen wells will be sampled for Site COCs.

3. The pumping wells will be deactivated. Manual rounds of water levels will be completed immediately before deactivation, 24 hours after deactivation, 72 hours after deactivation, then weekly after deactivation for six weeks. Water levels will be recorded eight weeks after deactivation and the fifteen wells will be sampled for Site COCs. The automatic water level recorders will be removed.

4. An interim analysis of data collected at eight weeks will be compiled, and adjustments to the program will be recommended, if necessary.

5. Monthly water levels will be manually collected. The fifteen wells will be sampled for Site COCs at six month intervals for two years.

6. If it is determined that the extraction system should be reactivated, a monitored start-up program would be developed to collect drawdown data.

It is possible that the NPBA groundwater extraction system will not need to be re-activated after the initial testing period. If water quality data and groundwater level data show that COCs are not migrating off-Site to the north, then a plan will be developed for monitoring in this area to continue for two years, after which time a long-term monitoring plan would be developed and implemented.

4.3.5 Building 3 Footer Drain Monitored Shut Down

Due to the low concentrations of CVOCs in the groundwater and the potential that water levels may not rise sufficiently to negatively impact Building 3 or equipment if the pumping station were deactivated, operation of the interceptor trench may no longer be necessary. The plan consists of the following four tasks to monitor water table/recharge conditions during shut down of the Building 3 footer drain pumping station. Updates to the planned activities will be provided in an addendum to this FSP.

1. Prior to implementation of the monitored shut down, the proportion of flow from the toe drain and the footer drain would be established over a period of a few months, during which time a number of precipitation events are expected to occur. Samples of footer drain discharge will be analyzed for VOCs. The purpose of this testing is to determine if footer drain water could be safely discharged to a storm sewer during high runoff conditions.

2. Monitoring points will be established. All clean outs for the footer drain will be used to monitor water levels in the trench. CW-19 will be monitored. Consideration will be given to installing monitoring points in locations of concern inside Building 3. Locations of concern will be identified by review of construction drawings and inspection of the building. Primary concerns are lowest elevation vaults, tanks or other structures in the eastern half of Building 3, with most concern in the northeastern quadrant of the building.

3. Ideally, the footer drain pipe in the Lift Station will be plugged with an inflatable packer through which the water elevation (pressure) behind the packer can be monitored. Alternately, the lift station pump will be deactivated and the water level in the station monitored. Depending on the results of observation and testing of the toe drain in task #1, above, and whether it is practical to plug the footer drain, the Lift Station may remain active through the monitored shut down of the footer drain.

4. Water levels in all established stations will be measured daily for one week (five days), then weekly for the duration of the shutdown monitoring, estimated to be eight weeks. In addition, areas of concern in Building 3, where rising water may reach low elevation pits or basement areas will be visually inspected. Inspection of seepage around the lift station, toe drain, and other likely areas will be conducted, as well.

5. A summary assessment report will be completed after sufficient monitoring has been completed.

4.3.6 Installation of Water Level and Quality Recorders

Thirty to fifty wells and observation points will be instrumented with continuous recorders for monitoring water levels and other parameters, such as temperature and conductivity. These monitoring devices will be installed in a timeframe after the new wells are constructed so that monitoring will occur over a period of approximately one year to assess groundwater conditions and aquifer responses to variations in seasonal precipitation. During the monitoring period, some recorders and sensors will be moved to different locations to accomplish the various tests that will be conducted. The selection of equipment and the wells/locations to be monitored will be described in an addendum to this work plan.

4.3.7 Installation of Weather Station

A weather station will be installed at the Site at a location acceptable to Harley-Davidson. Air temperature, precipitation, humidity, and wind speed and direction will be measured by the weather station. This data will be correlated to groundwater level measurements, surface water flow measurements, groundwater temperature, conductivity, and other parameters to assess groundwater flow patterns and karst loss. The selection of the weather station equipment will be described in an addendum to this FSP.

4.3.8 Storm Water Runoff Monitoring and Karst Loss Inventory

From Virginia Department of Conservation and Recreation (VADCR) (1999), karst loss is the term given to the enhanced recharge of overland flow into the epikarstic conduits which underlie karst terrain. Following an assessment for karst infiltration behavior, a karst loss factor is determined for a site, and the karst loss factor can be used for the calculation of the rate of enhanced recharge that enters into karst features such as swallets, sinkholes, exposed karst openings in bedrock, epikarstic openings in the bedrock surface beneath the overburden, and through stream and creek losses and leaking stormwater ponds.

Aron and Kibler (1981) describe karst loss enhancement of recharge to karst aquifers, and they offer the PSU-IV modeling technique by which karst loss factors can be estimated for a site. The land area on which epikarst recharge occurs compared to the total recharge area of the site is required for modeling. The storm frequency for the site for which karst loss is being calculated is required;

NPDES permit calculations typically require an assessment of 2-year storm frequency. Sites that receive normal or abundant high frequency storms experience more abundant karst loss. A field assessment of a site, which involves measurements of storm flow recharge onto a site and discharge leaving a site, is accomplished to determine adjustments for the karst loss factor. Using these site characteristics, the PSU-IV model is applied to calculate the karst loss modification value from which the enhanced recharge of stormwater to the site is determined. Special considerations are needed for the application of the technique to post-development sites, which applies to the fYNOP.

A plan for monitoring the storm water runoff will be prepared as part of the Phase 1 activities (subsection 4.1.2.2) and will be implemented during the Phase 3 – Testing and Monitoring activities, resulting in an addendum to this FSP. Monitoring of storm events will be conducted, and the actual volume of runoff will be measured and will be used in the karst loss calculations. Calculations of groundwater flow through the Site will be adjusted accordingly.

4.3.9 Hydrodynamic Testing and Monitoring

After the installation of wells, piezometers, wetland and surface water monitoring points, weirs and water level/water quality recorders described in the previous sections, a long term monitoring program will be initiated.

Precipitation, temperature, and storm water run-off will be recorded throughout the period. During the monitoring period, some recorders and sensors will be moved to different locations to accomplish the various tests that will be conducted. In addition to the continuous recordings, confirmatory manual measurements and manual measurements in numerous other locations (additional wells and water levels) will be maintained on an established schedule. During this program the following studies will be conducted or continued:

Surface water runoff monitoring – this involves monitoring flow in storm sewers (see subsection 4.3.8), weirs (see subsection 4.3.2) and shallow piezometers or wells in the wetlands or along Johnsons Run.

MW-50&51 water level monitoring – during storm events and manipulation of the groundwater extraction system, the water level and temperature will be monitored automatically and manually. Unusual responses to pumping and recharge events in well couplets MW-50S&D and MW-51S&D

may indicate important anomalies in the aquifer, or may be an indication of leakage from storm sewers and compromised well integrity. The close proximity to the high CVOC concentrations at NBldg4 Area makes these wells potentially important to the remedial options assessment in this area. Storm drain configurations and construction in the area will be investigated. If storm drain integrity problems are suspected, testing may be considered. Manual and continuous monitoring of temperature and water level responses to recharge events in these wells during the hydrodynamic testing and monitoring program may be conducted. The integrity of the wells will be checked and any necessary repairs will be made if possible, or the wells will be replaced, if needed.

A long term monitoring program (on the order of six months) in which wells and streams will be instrumented will be conducted. Groundwater extraction wells in the WPL, NBldg4 and TCA Tank Areas will be shut down for a period of two to three weeks while water levels and other parameters are monitored. This test will be similar to the shutdown test conducted in October and November of 2008 (see GSC, September 2011). Following the recovery of water levels to apparent static non-pumping conditions, the pumping wells will be restarted. Parameters will continue to be monitored. Of primary interest will be the influence of pumping on potentiometric levels in the deep source area wells that will be installed as part of this planned investigation (subsection 4.2.1.2) and deep wells that will be installed east and west of Codorus Creek (subsection 4.2.1.4). The projected timeframe of the monitoring is four to six months, however monitoring of all parameters will be maximized by installing recorders as early in the program as possible.

Also scheduled in this phase is the collection of a second round of water levels from all wells, followed by collection and analysis of groundwater quality samples from new wells and on-Site Key Wells. This is the second "snap shot" to include the new wells, and in most cases, the third sample to be analyzed from the newly installed wells.

4.3.10 Qualitative Dye Tracer Testing

Qualitative dye tracing tests will be performed as part of the hydrodynamic testing and monitoring of the groundwater extractions systems. Various types of dyes will be injected into monitoring wells. Collection devices will be placed into other monitoring wells, surface water bodies, and recovery wells to monitor the effectiveness of the groundwater recovery systems on-Site. The objectives, scope and methods of this study will be provided as an addendum to this FSP.

4.4 Phase 4 Data Analysis and Report

After data collection is complete, a report will be prepared, focusing on the identified data gaps from the Part 1 SGWRI report. Report preparation is shown on the schedule (see Section 8) to begin in November 2013 and is currently projected to be completed in April 2014.

5 FIELD INSTRUMENTS, SAMPLING EQUIPMENT AND SUPPLIES

Instruments and equipment used to gather, generate, or measure environmental data will be carefully acquired, handled, and used in such a manner that accuracy and reproducibility of results are maintained and documented.

5.1 Field Instruments

Field instruments may include (as appropriate to the specific investigation) a pH meter, temperature probe, specific conductivity meter, portable gas chromatograph, PIDs or FIDs for organic vapor detection, aerosol or air particulate meter, combustible gas meter, and geophysical equipment. All field instruments for this purpose will have unique identifiers, and each instrument requiring calibration will be logged in a logbook before use in the field. A designated site representative will be responsible for performing or documenting daily calibration/checkout records for instruments used in the field. If an internally calibrated field instrument fails to meet calibration/checkout procedures, it should be returned to the manufacturer for service and a backup instrument may be calibrated and used in its place. Procedures for field instrument use should follow the manufacturer's recommendations. Field instruments should be used or supervised by experienced operators. Field instrument uses, detection levels, and calibration requirements are summarized in the QAPP (GSC, 2012).

5.2 Equipment and Supplies

Equipment to be used during field sampling may include various sampling tools and rental equipment. All equipment will be examined to certify that it is clean and in good operating condition. This will include checking the manufacturer's operating manual and instructions to ensure that all maintenance requirements are being observed. Field notes from previous sampling trips will be reviewed so that the notation on any prior equipment problems will not be overlooked, and all necessary repairs to equipment will be carried out. Spare parts or duplication of equipment should be readily available for critical sampling efforts.

Supplies needed to perform required field activities may include health and safety supplies, logbooks, sampling containers, and other consumables. Materials and supplies needed for each investigation task should be identified and reviewed with the project manager and then checked and examined by the field staff to confirm conformity with the project requirements and to confirm that all supplies are of good quality.

6 SAMPLE HANDLING AND DOCUMENTATION

Sample handling and documentation for this FSP are included in GSC's "Quality Assurance Project Plan for Part 2 of the Supplemental Groundwater Remedial Investigation, Former York Naval Ordnance Plant".

7 ASSESSMENTS AND CORRECTIVE ACTIONS

7.1 Assessments

Procedures cannot fully encompass all conditions encountered during field activities. Variances from the operating procedures, field sampling plan, and/or safety and health plan may occur. All variances that occur during field activities will be documented on a field change request (FCR) form or a nonconformance report (NCR). If a variance is anticipated (i.e., because of a change in the field instrumentation), the applicable procedure will be modified.

Inspections or assessments are not planned as part of this project, but may be conducted at the discretion of the QA/QC Officer or Health and Safety Officer. Information collected during an assessment will be documented in a field logbook. Work conducted in the field will be compared to the Health and Safety Plan (HASP), work plan or instructions for compliance. The results of any site assessments will be documented in a written report, which will be forwarded to Harley-Davidson, and a copy placed in the project files.

7.2 Corrective Actions

Corrective actions will be implemented when a discrepancy is discovered by field or laboratory personnel or during field audits. GSC's QA/QC Officer will coordinate and facilitate corrective actions. If the problem is determined to be minor, the corrective action will be recorded in the field notes, with verbal notifications to other field teams or subcontractors about the deficiency and the corrective action. If the deficiency is severe and may affect the quality assurance (QA) objectives of the project, a formal written review and corrective action will be initiated. This review, called an NCR, will identify the deficiency, identify how the deficiency might affect the work product QA, propose corrective action, and document that the corrective action has been implemented. This process will be supervised by the contractor QA/QC Officer. In addition, the QA/QC Officer will maintain a log of all NCRs for the project and ensure that the NCRs and corrective actions are maintained with final project files. Details regarding field and laboratory corrective actions and the use of an NCR is provided in the QAPP (GSC, 2012).

Technical staff and project personnel will be responsible for reporting all suspected technical and QA non-conformances or suspected deficiencies of any activity or issued document by reporting the situation to the QA/QC Officer or his designee. The QA/QC Officer will be responsible for assessing the suspected problems in consultation with the Project Manager, or designee, to make a decision based on the potential for the situation to impact the quality of the data. When it is determined that the situation warrants a reportable non-conformance and corrective action, then an NCR will be initiated by the QA/QC Officer.

8 PROJECT SCHEDULE

The tasks detailed in Section 4 have been grouped into phases, to be accomplished in an order that will allow the information learned from prior phases to be used to refine the scope of the tasks in subsequent phases. **Figure 8.0-1** delineates four phases that will be conducted sequentially with some minor exceptions. This Gantt chart (time line) has been compiled to show the major subtasks to provide an overview of the proposed components of the Part 2 SGWRI. An expanded version of the Gantt chart will be used to manage the project. As progress is made or as changes to the schedule or work scope are made or considered this tool will be used to evaluate the impacts on the efforts, especially the seasonally dependent work. In addition to the Gantt chart, a Project Milestone Chart will be developed, maintained, and distributed regularly to the project team. Weekly progress reports will be issued to the project team.

The investigation is proposed to begin in May 2012, with the Data Analysis and Report to be completed in April 2014, a period of two years. The schedule, as planned, was compiled to complete the report of investigations in two years, a goal discussed by the Harley-Davidson led fYNOP Team. To accomplish this time line, substantial review time of interim reports was not included. Review of the FSP by USACE and regulators is planned be accomplished while initial tasks are carried out to accomplish the desired schedule. The biggest restraint regarding the schedule is the need to start early in 2012 to keep seasonally dependent tasks in line with the appropriate season. If there is slippage in the schedule, or if a normal pace of review and concurrence were desired by the fYNOP team, it will most likely result in adding one additional year to the project due to the link to seasons.

Not all of the planned tasks may be completed. For instance, two rounds of deep wells are scheduled to define the vertical extent of high concentrations of chlorinated solvents in each of six areas. It may not be necessary to identify the vertical extent in all six areas, and it may not require two borings in each location. Another example of a planned task that may not be completed is the installation of stratigraphic borings. By drilling the deep wells to define the vertical extent of high concentrations of chlorinated solvents, enough information might be learned about the vertical extent of karst solutioning that the deep stratigraphic borings will not be needed.

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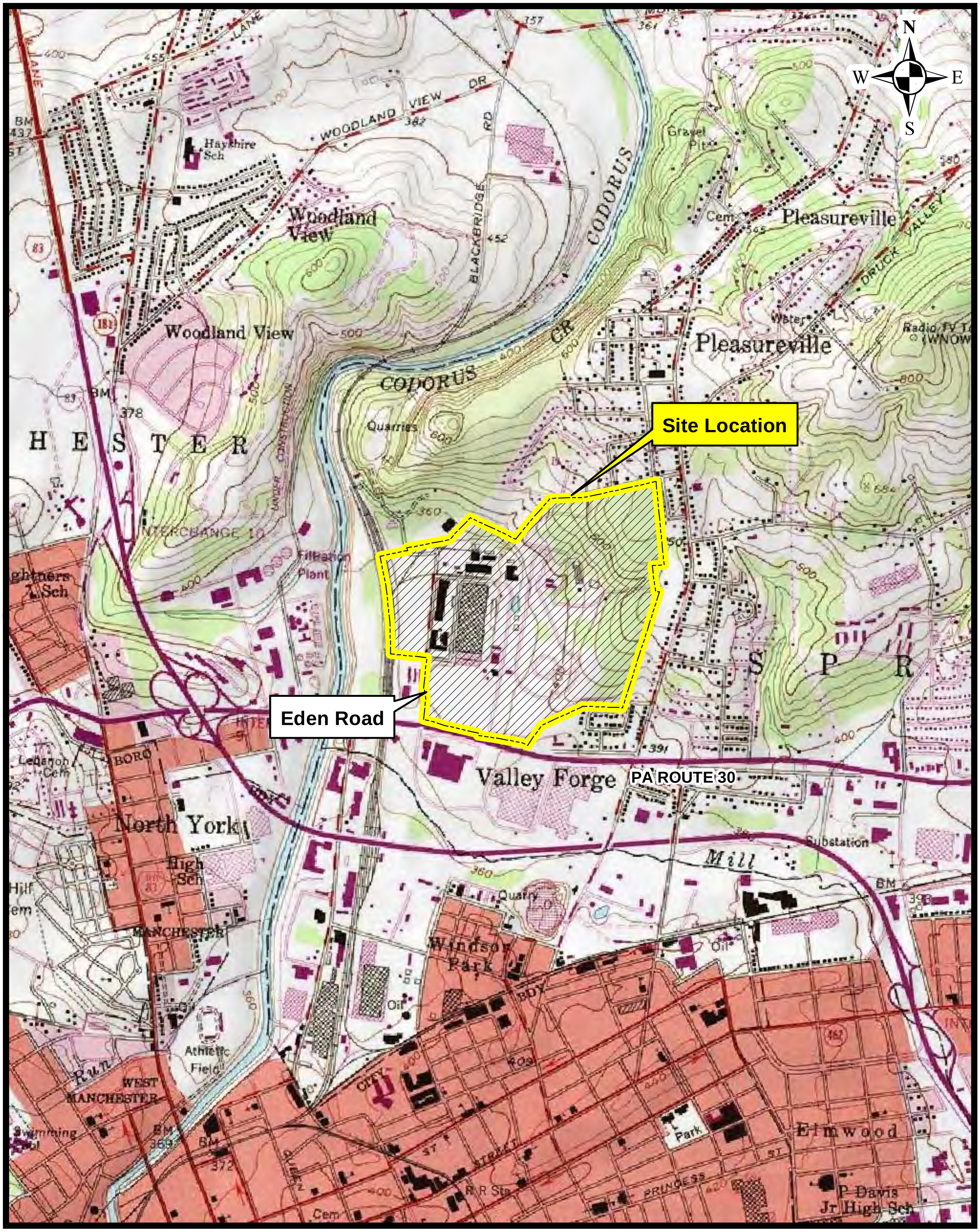
Table 4.2-1
Summary of Planned Drilling
Remedial Investigation Part 2
Former York Naval Ordnance Plant

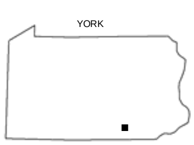
Well ID	FSP Section	Area Designation	Existing Deepest Adjacent Well / Depth (ft bgs)	Targeted Screen / Open Interval or Depth (ft bgs)	Casing Installation & Drilling Method	Open Interval Construction	Aquifer Classification	Bedrock Type
		Source Area Investigations						
MW-126		Bldg 58 - drill 1 shallow well north	MW-113 / 151	55 - 75	Air Rotary, Steel Casing installed	Open Rock or PVC Screen	Shallow	Limestone
MW-127		Bldg 58 - drill 1 shallow well south	MW-113 / 151	55 - 75	Air Rotary, Steel Casing installed	Open Rock or PVC Screen	Shallow	Limestone
MW-128		Bldg 58 - drill 1 shallow well east	MW-113 / 151	55 - 75	Air Rotary, Steel Casing installed	Open Rock or PVC Screen	Shallow	Limestone
MW-129		Bldg 58 - drill 1 shallow well west	MW-113 / 151	55 - 75	Air Rotary, Steel Casing installed	Open Rock or PVC Screen	Shallow	Limestone
MW-130		W Bldg 2 Corridor - drill 1 shallow well south	MW-114 / 143.7	55 - 75	Air Rotary, Steel Casing installed	Open Rock or PVC Screen	Shallow	Limestone
MW-131		W Bldg 2 Corridor - drill 1 shallow well northeast	MW-114 / 143.7	55 - 75	Air Rotary, Steel Casing installed	Open Rock or PVC Screen	Shallow	Limestone
MW-132		W Bldg 2 Corridor - drill 1 shallow well east	MW-114 / 143.7	55 - 75	Air Rotary, Steel Casing installed	Open Rock or PVC Screen	Shallow	Limestone
MW-133		W Bldg 2 Corridor - drill 1 shallow well southeast	MW-114 / 143.7	55 - 75	Air Rotary, Steel Casing installed	Open Rock or PVC Screen	Shallow	Limestone
MW-134		W Bldg 2 Corridor - drill 1 shallow well northwest	MW-114 / 143.7	55 - 75	Air Rotary, Steel Casing installed	Open Rock or PVC Screen	Shallow	Limestone
MW-135		W Bldg 2 Corridor - drill 1 shallow well west	MW-114 / 143.7	55 - 75	Air Rotary, Steel Casing installed	Open Rock or PVC Screen	Shallow	Limestone
		Vertical Extent/DNAPL Investigations - drill 1 or more well clusters in each area (2 per area are listed)						
MW-136A		SW-WPL	MW-75D / 217	267 - 317	To Be Determined	Open Rock or 2" PVC Screen	Deep	Limestone
MW-136B		SW-WPL	MW-75D / 217	367 - 417	To Be Determined	Open Rock or 2" PVC Screen	Deep	Limestone
MW-137A		TCA Tank/Bldg 2 Degreaser	MW-32D / 220	270 - 320	To Be Determined	Open Rock or 2" PVC Screen	Deep	Limestone
MW-137B		TCA Tank/Bldg 2 Degreaser	MW-32D / 220	370 - 420	To Be Determined	Open Rock or 2" PVC Screen	Deep	Limestone
MW-138A		Bldg 58	MW-32D / 220	270 - 320	To Be Determined	Open Rock or 2" PVC Screen	Deep	Limestone
MW-138B		Bldg 58	MW-32D / 220	370 - 420	To Be Determined	Open Rock or 2" PVC Screen	Deep	Limestone
MW-139A		N Bldg 4	MW-49D / 220	270 - 320	To Be Determined	Open Rock or 2" PVC Screen	Deep	Limestone
MW-139B		N Bldg 4	MW-49D / 220	370 - 420	To Be Determined	Open Rock or 2" PVC Screen	Deep	Limestone
MW-140A		W Bldg 2 Corridor	MW-114 / 143.7	194 - 244	To Be Determined	Open Rock or 2" PVC Screen	Deep	Limestone
MW-140B		W Bldg 2 Corridor	MW-114 / 143.7	294 - 344	To Be Determined	Open Rock or 2" PVC Screen	Deep	Limestone
MW-141A		SE Corner of Site	MW-64D / 77	127 - 177	To Be Determined	Open Rock or 2" PVC Screen	Deep	Sandstone/Limestone
MW-141B		SE Corner of Site	MW-64D / 77	227 - 277	To Be Determined	Open rock or 2" PVC Screen	Deep	Sandstone/Limestone
		North Property Boundary Area						
MW-142S		W of NPBA (MW-18 Area) - drill 1 nested well pair north	MW-18D / 140	30 - 50	Air Rotary, Steel Casing installed, Nested	2" PVC Screen	Shallow	Sandstone
MW-142D		W of NPBA (MW-18 Area) - drill 1 nested well pair north	MW-18D / 140	130 - 150	Air Rotary, Steel Casing installed, Nested	2" PVC Screen	Deep	Sandstone
MW-143S		W of NPBA (MW-18 Area) - drill 1 nested well pair south	MW-18D / 140	30 - 50	Air Rotary, Steel Casing installed, Nested	2" PVC Screen	Shallow	Sandstone
MW-143D		W of NPBA (MW-18 Area) - drill 1 nested well pair south	MW-18D / 140	130 - 150	Air Rotary, Steel Casing installed, Nested	2" PVC Screen	Deep	Sandstone
		West of Site						
MW-144		East of Codorus Creek - drill 1 overburden well near MW-98	MW-98D / 171	20 - 30	Hollow Stem Auger	2" PVC Screen	Overburden	Limestone
MW-145A		East of Codorus Creek - drill 1 deep well near MW-98	MW-98D / 171	150 - 200	To Be Determined	2" PVC Screen	Deep	Limestone
MW-146		East of Codorus Creek - drill 1 overburden well near MW-100	MW-100D / 114	20 - 30	Hollow Stem Auger	2" PVC Screen	Overburden	Limestone
MW-147A		East of Codorus Creek - drill 1 deep well near MW-100	MW-100D / 114	150 - 200	To Be Determined	2" PVC Screen	Deep	Limestone
MW-148A		West of Codorus Creek - drill 1 deep well across from MW-98	MW-98D / 171	150 - 200	To Be Determined	2" PVC Screen	Deep	Limestone
MW-149A		West of Codorus Creek - drill 1 deep well across from MW-100	MW-100D / 114	150 - 200	To Be Determined	2" PVC Screen	Deep	Limestone
		South of Site						
MW-150S		Drill 1 nested well pair east	MW-64D / 77	30 - 50	Air Rotary, Steel Casing installed, Nested	2" PVC Screen	Shallow	Limestone
MW-150D		Drill 1 nested well pair east	MW-64D / 77	130 -150	Air Rotary, Steel Casing installed, Nested	2" PVC Screen	Deep	Limestone
MW-151S		Drill 1 nested well pair west	MW-64D / 77	30 - 50	Air Rotary, Steel Casing installed, Nested	2" PVC Screen	Shallow	Limestone
MW-151D		Drill 1 nested well pair west	MW-64D / 77	130 -150	Air Rotary, Steel Casing installed, Nested	2" PVC Screen	Deep	Limestone
MW-152S		Drill 1 nested well pair south	MW-64D / 77	30 - 50	Air Rotary, Steel Casing installed, Nested	2" PVC Screen	Shallow	Limestone
MW-152D		Drill 1 nested well pair south	MW-64D / 77	130 -150	Air Rotary, Steel Casing installed, Nested	2" PVC Screen	Deep	Limestone
		Shallow Wells Along Streams/Wetlands						
MW-153		East Johnsons Run - install 1 well		20 - 30	Hollow Stem Auger	2" PVC Screen	Overburden	Limestone
MW-154		West Johnsons Run - install 1 well		20 - 30	Hollow Stem Auger	2" PVC Screen	Overburden	Limestone
MW-155		North Wetlands - install 1 well		20 - 30	Hollow Stem Auger	2" PVC Screen	Overburden	Limestone
MW-156		South Wetlands - install 1 well		20 - 30	Hollow Stem Auger	2" PVC Screen	Overburden	Limestone
		Stratigraphic Borings						
MW-157		WPL	CW-9 / 70	500	To Be Determined	To Be Determined	Deep	Limestone
MW-158		North Plant Area (N of Bldg 4)	MW-51D / 120	500	To Be Determined	To Be Determined	Deep	Limestone
MW-159		North Plant Area (NE of Bldg 2)	MW-115 / 124.5	500	To Be Determined	To Be Determined	Deep	Limestone

TABLE 4.2-2
NATURAL ATTENUATION ANALYTICAL AND FIELD SCREENING PARAMETERS

Parameter	Method/Reference	Rationale	Sample Volume, Container, and Preservation	Field or Fixed-Base Laboatory
Organics				
Volatile Organic Compounds	SW-846 8260B	CVOCs are primary target analytes for monitoring natural attenuation.	40 mL, glass, HCl, cool, 4^oC	Fixed-base
Inorganics				
Alkalinity, Total	SM20 2320B	General water quality parameter, assess buffering capacity of groundwater.	200 mL plastic or glass, cool, 4^oC	Fixed-base
Chloride	EPA 300.0	General water quality parameter to assist in assessing potential contributions from road deicing salts. Final product of chlorinated solvent reduction.	50 mL plastic or glass, cool, 4^oC	Fixed-base
Iron, Ferric	SW-846 6010B mod. (calculated)	Assess potential for vinyl chloride oxidation under ferric iron reducing conditions.	500 mL - 1 L plastic or glass, cool, 4^oC, HNO_3 to pH<2, field filter	Fixed-base
Iron, Ferrous	SM20 3500 Fe B mod.	May serve as an indicator of anaerobic degradation of vinyl chloride and fuel compounds.	250 mL amber glass, cool, 4^oC, HCl to pH<2, analyze immediately	Fixed-base
Iron, Dissolved	SW-846 6010B	Assess if anaerobic biological activity is solubilizing iron from aquifer soils.	500 mL - 1 L plastic or glass, cool, 4^oC, HNO_3 to pH<2, field filter	Fixed-base
Manganese, Dissolved	SW-846 6010B	Assess if anaerobic biological activity is solubilizing manganese for aquifer soils.	500 mL - 1 L plastic or glass, cool, 4^oC, HNO_3 to pH<2, field filter	Fixed-base
Nitrate	EPA 300.0	Substrate for microbial respiration if oxygen is depleted. Potential marker for contributions from sewers.	50 mL plastic or glass, cool, 4^oC (48 hour max hold)	Fixed-base
Dissolved Organic Carbon	EPA 415.1 mod.	Assess availability of carbon to drive reductive dechlorination.	125 mL glass, cool, 4^oC	Fixed-base
Sodium, Dissolved	SW-846 6010B	General water quality parameter to assist in assessing potential contributions from road deicing salts.	500 mL - 1 L plastic or glass, cool, 4^oC, HNO_3 to pH<2	Fixed-base
Sulfate	EPA 300.0	Substrate for anaerobic microbial respiration.	50 mL plastic or glass, cool, 4^oC	Fixed-base
Sulfide	SM20 4500 S_2 F/D or EPA 376.1/376.2	Assess anaerobic conditions supporting reductive dechlorination.	500 mL, glass, cool, 4^oC, NaOH, ZnAc (no headspace)	Fixed-base
Dissolved Gases				
Ethene and Ethane	AM20GAX	Monitor daughter products of reductive dechlorination.	2 x 40 mL, glass, Na_3PO_4, cool, 4^oC	Fixed-base
Methane and Carbon Dioxide	AM20GAX	Monitor respiration products associated with biodegradation.	2 x 40 mL, glass, Na_3PO_4, cool, 4^oC	Fixed-base
Field Screening Parameters				
pH	QED MP-20 Multimeter and flow cell, or equivalent	Stabilization parameter for low-flow sampling, aerobic and anaerobic biological processes are pH sensitive	Not applicable	Field
Temperature		Stabilization parameter for low-flow sampling, assist in monitoring influence of thermal treatment.	Not applicable	Field
Specific Conductance		Stabilization parameter for low-flow sampling, general water quality parameter.	Not applicable	Field
Oxidation-Reduction Potential		Stabilization parameter for low-flow sampling, assess aerobic and anaerobic nature of biodegradation of CVOCs.	Not applicable	Field
Dissolved Oxygen		Stabilization parameter for low-flow sampling, assess aerobic and anaerobic nature of biodegradation of CVOCs.	Not applicable	Field
Turbidity		Stabilization parameter for low-flow sampling.	Not applicable	Field



Portion of the York, PA
7.5-minute USGS Quadrangle
(2001)



Scale (feet)
0 500 1,000 2,000

Figure 1.0-1

Former York Naval Ordnance Plant

1425 Eden Road, York, PA 17402

Site Location Map

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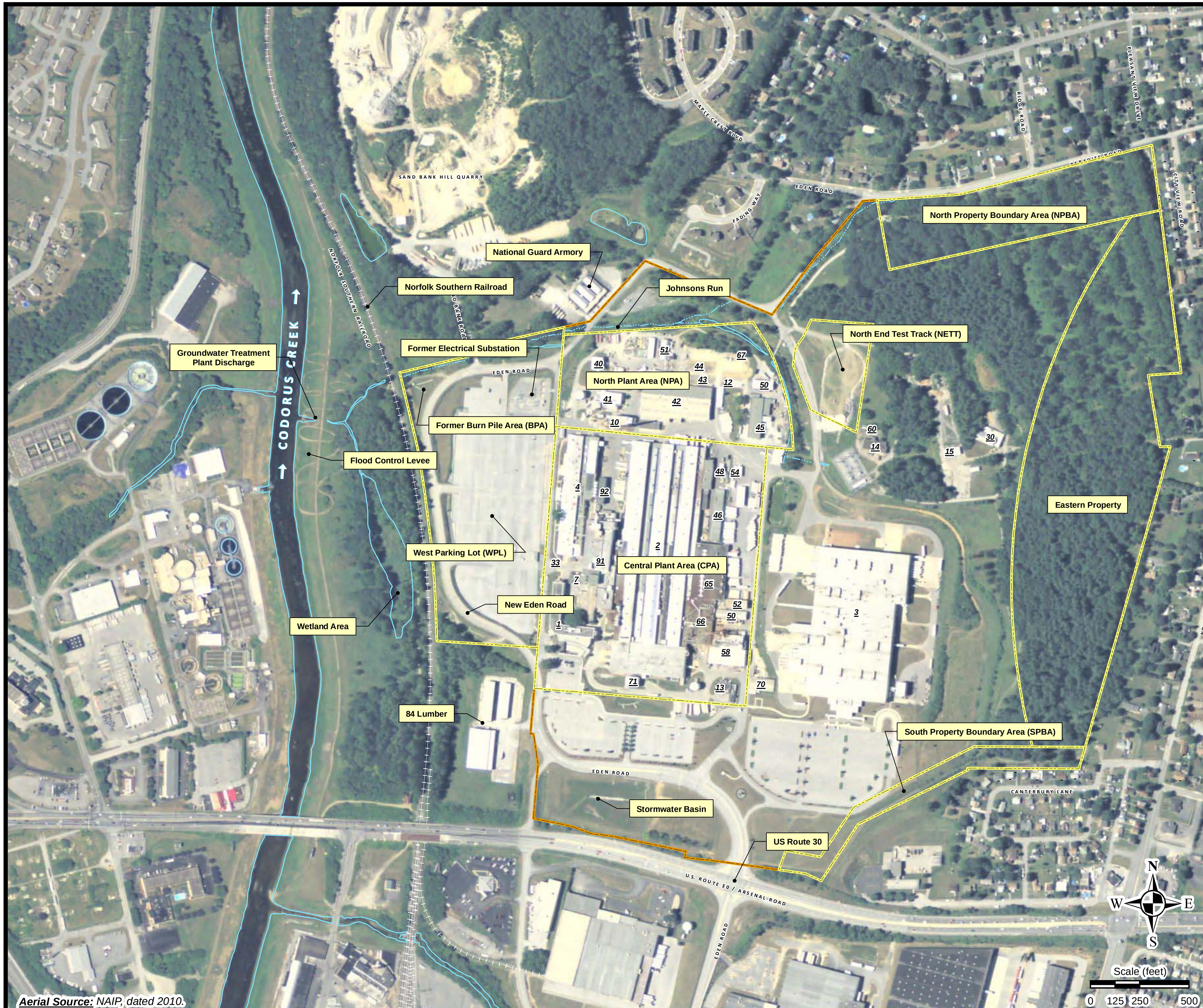

Figure 1.0-2

Former York Naval Ordnance Plant

1425 Eden Road, York, PA 17402

Site Map

DRAWN BY: JPB	CHECKED AND APPROVED BY: SMS	DATE: 3/27/2012

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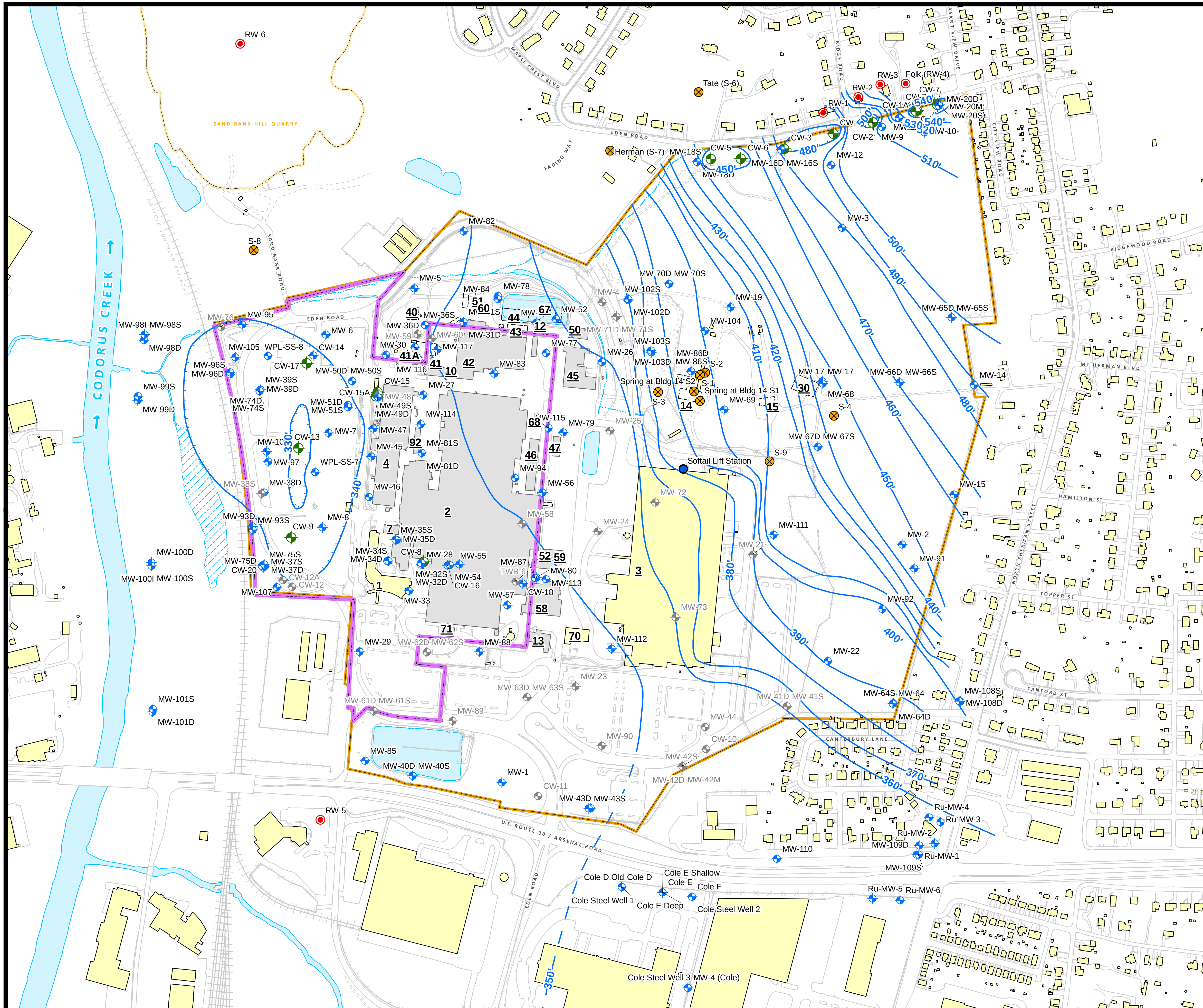

N
W E
S

LEGEND

- Collection Well
- Monitoring Well
- Abandoned Monitoring Well
- Residential Well
- Lift Station
- Spring
- June 2009 Groundwater Contour (Feet)
- June 2009 Inferred Groundwater Contour (Feet)
- June 2009 Groundwater Contour Sink (Feet)
- West Campus Property Line
- Existing Building to Remain
- Demolished
- Demolished/Slab Removed
- Harley-Davidson Property Boundary
- Railroad
- Road (Paved)
- Road Curb
- Road (Unpaved)
- Walkway
- Fenceline
- Existing Water Feature
- Existing Stream
- Wetland Boundary (2006)

Scale (feet)

0 125 250 500

Figure 1.0-3

Former York Naval Ordnance Plant

1425 Eden Road, York, PA 17402

Groundwater Elevation Contour Map
June 2009

DRAWN BY: JPB	CHECKED AND APPROVED BY: SMS	DATE: 4/30/2012

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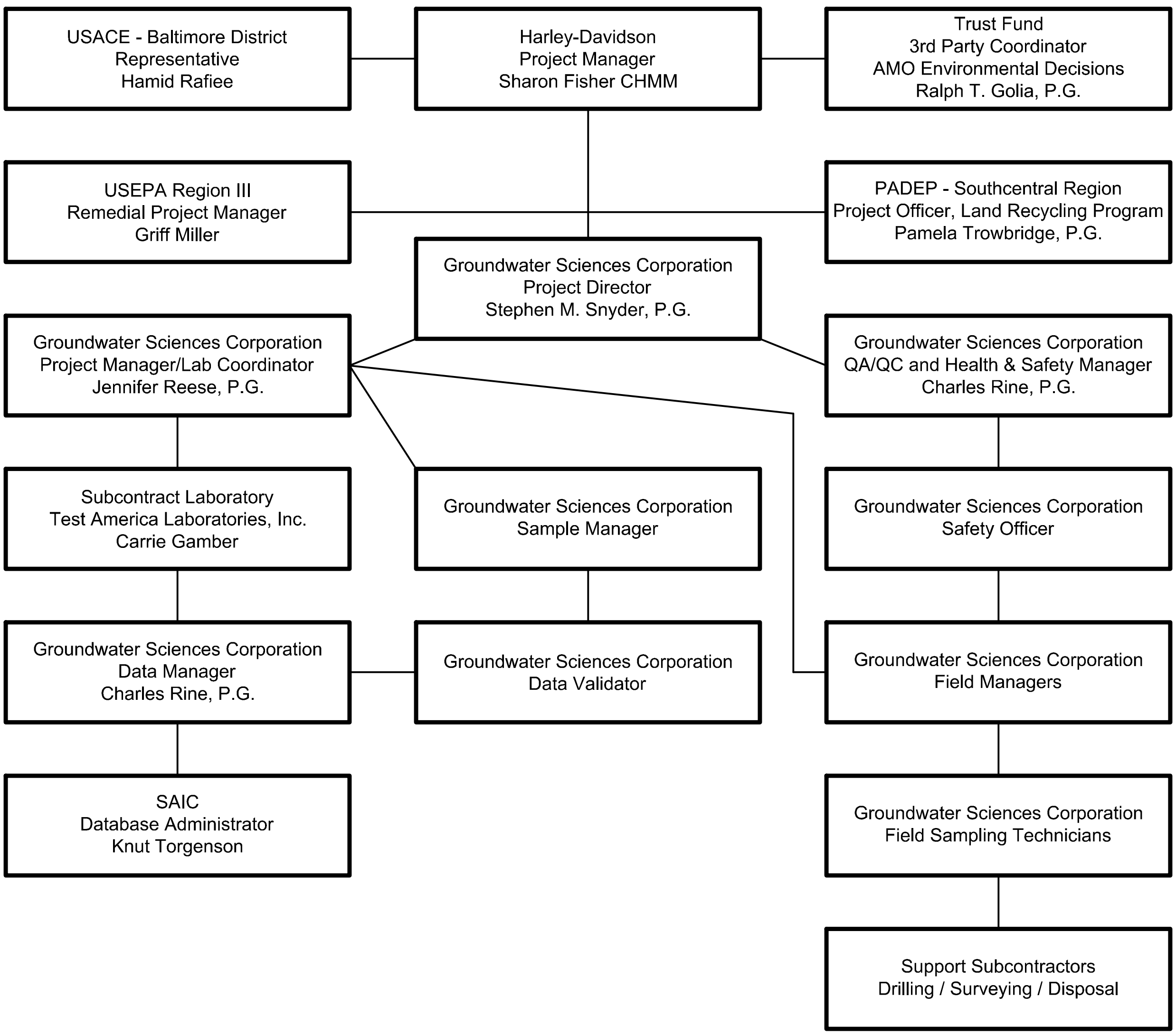
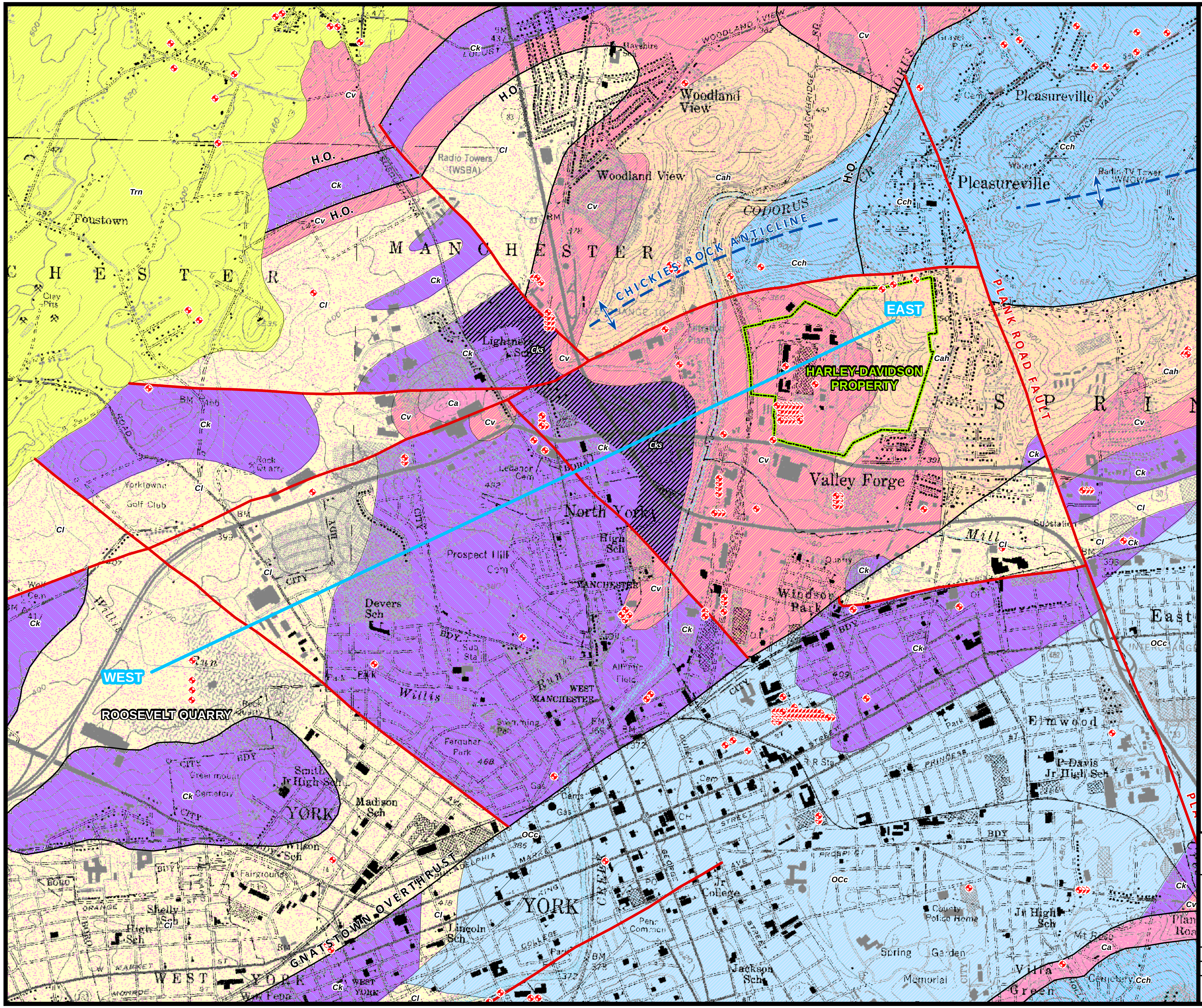
Figure 2.0-1

Project Organization Chart

Field Sampling Plan

Former York Naval Ordnance Plant





N
W E
S

LEGEND

- Wells Located from PaGWIS Database
- Cross Section Cut
- Contact
- Block Fault
- Thrust Fault
- Syncline or Anticline
- Harley-Davidson Property Boundary

GEOLOGIC FORMATION

Trnc	New Oxford Conglomerate
Trn	New Oxford Formation
OCc	Conestoga Formation
Cl	Ledger Formation
Ck	Kinzers Formation
Cks	Kinzers Shale*
Cv	Vintage Formation
Ca	Antietam Formation
Cah	Antietam & Harpers Formation, undiv.
Ch	Harpers Formation
Cch	Chickies Formation
mb	Metabasalt
vs	Greenstone Schist

Kinzers Shale member mapping was taken from Plate 1, Bulletin C67 (Stose and Jonas, 1939)

Base Map Sources:
USGS topographical quadrangles (various years)
Pennsylvania DCNR geologic map (1980)

Scale (feet)
0 500 1,000 2,000

Figure 4.1-1

Former York Naval Ordnance Plant

1425 Eden Road, York, PA 17402

Regional Map Showing Geology and PAGWIS Wells

DRAWN BY: JPB	CHECKED AND APPROVED BY: SMS	DATE: 3/27/2012

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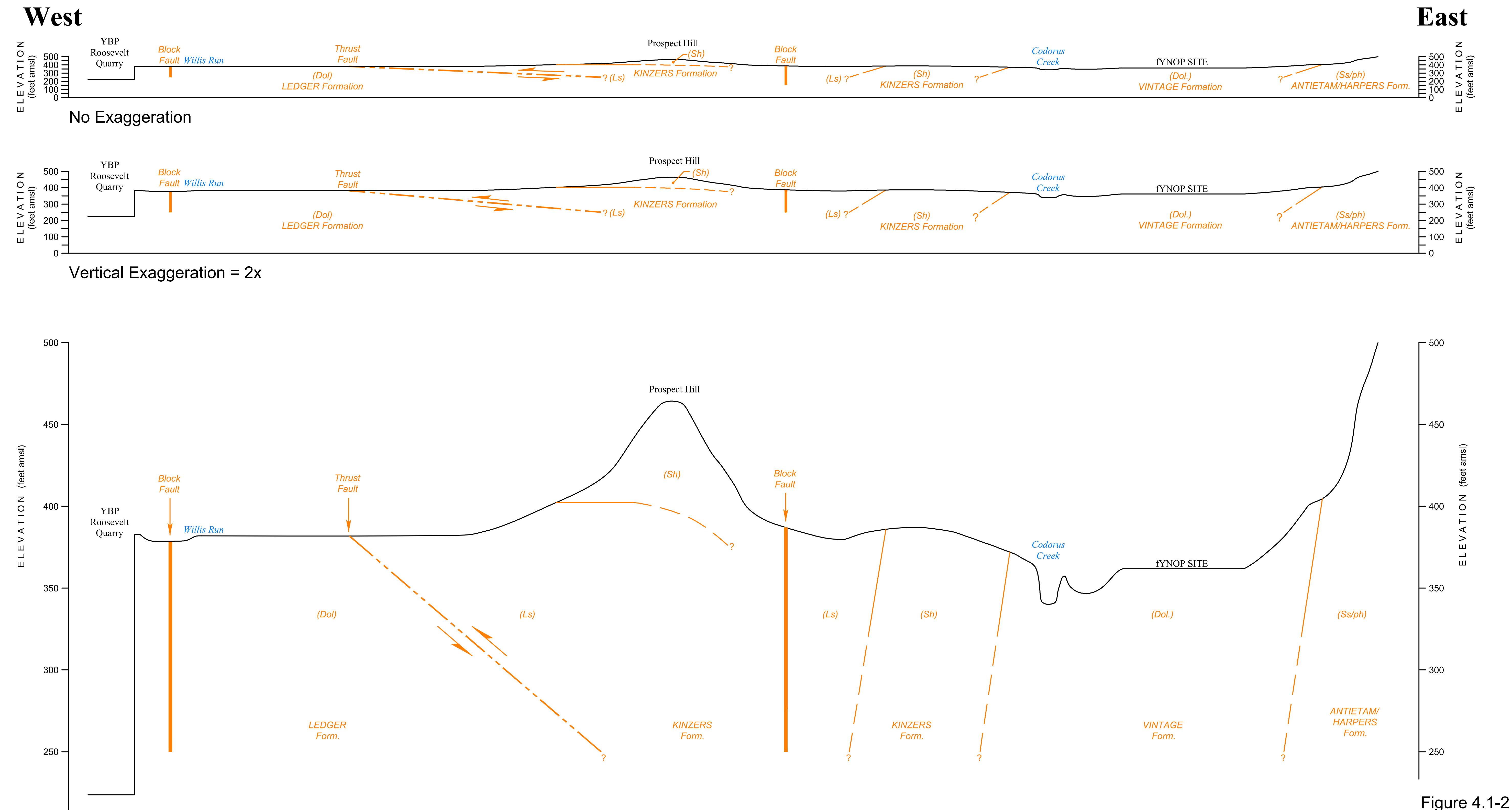

Source Information:

1. Geologic structural measurements used to construct this cross section were taken from *Geology of the Hanover-York District Pennsylvania*, by Anna Jonas Stose and George W. Stose, United States Department of the Interior, Geological Survey Professional Paper 204, 1944.

   Formation contacts east of the block fault located immediately east of Prospect Hill were drawn with a dip of 20 degrees west and obtained from Figure 4 of the referenced report. The contact between the limestone member and the shale member of the Kinzers Formation located between the thrust fault and Prospect Hill was drawn from dip measurements of 10 degrees south (projecting out of the cross section) and resulted in an apparent horizontal orientation. The dip measurements west of Prospect Hill were obtained from Figure 9 of the referenced report. Fault types were determined from Plate 1, entitled Geologic Map and Sections, of the referenced report.

2. Geologic contacts were taken from digital geologic mapping provided by the Pennsylvania Topographic and Geologic Survey, Harrisburg, PA. The Kinzers Formation was divided into members (shale and limestone) using the referenced Stose report.

Former York Naval Ordnance Plant

1425 Eden Road, York, PA 17402

York Area Geologic Cross Section
fYNOP Site to Roosevelt Quarry

DRAWN BY: MM/JB	CHECKED & APPROVED BY: SMS	DATE: 3/27/2012

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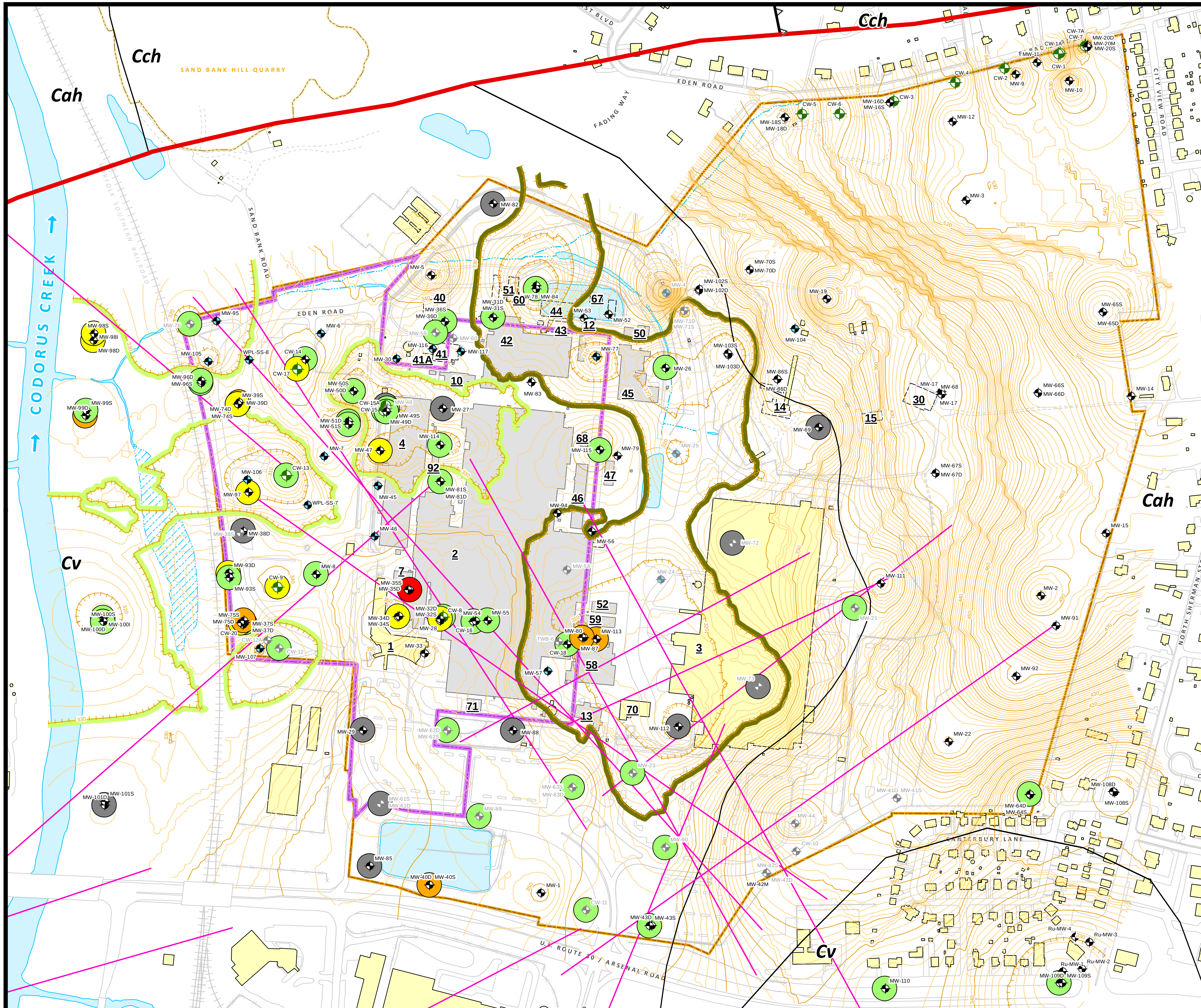

LEGEND

Total Void Footage

- Less Than 1'
- 1' - 20'
- 21' - 40'
- 41' - 60'
- Over 60'
- Collection Well
- Monitoring Well
- Abandoned Monitoring Well
- Monitoring Well (< 25' of Rock Penetrated)
- Abandoned Monitoring Well (< 25' of Rock Penetrated)
- Fracture Trace
- Contact
- Block Fault
- Thrust Fault
- Cch Chickies Formation
- Cah Antietam & Harpers Formation, undiv.
- Cv Vintage Formation
- Ck Kinzers Formation
- Cl Ledger Formation
- Major Bedrock Contour Closed Depression
- Major Bedrock Contour
- Minor Bedrock Contour
- Bedrock Surface Depression Following Bedrock Contact
- Bedrock Surface Depression - 330 Contours
- West Campus Property Line
- Existing Building to Remain
- Demolished
- Demolished/Slab Removed
- Harley-Davidson Property Boundary
- Railroad
- Road (Paved)
- Road Curb
- Road (Unpaved)
- Walkway
- Fenceline
- Wetland Boundary (2006)

N E S W

Scale (feet)
0 100 200 400

Figure 4.1-3

Former York Naval Ordnance Plant

1425 Eden Road, York, PA 17402

Epikarst Surface (Top of Bedrock) Showing Total Void Footage

DRAWN BY: JPB	CHECKED AND APPROVED BY: SMS	DATE: 3/27/2012

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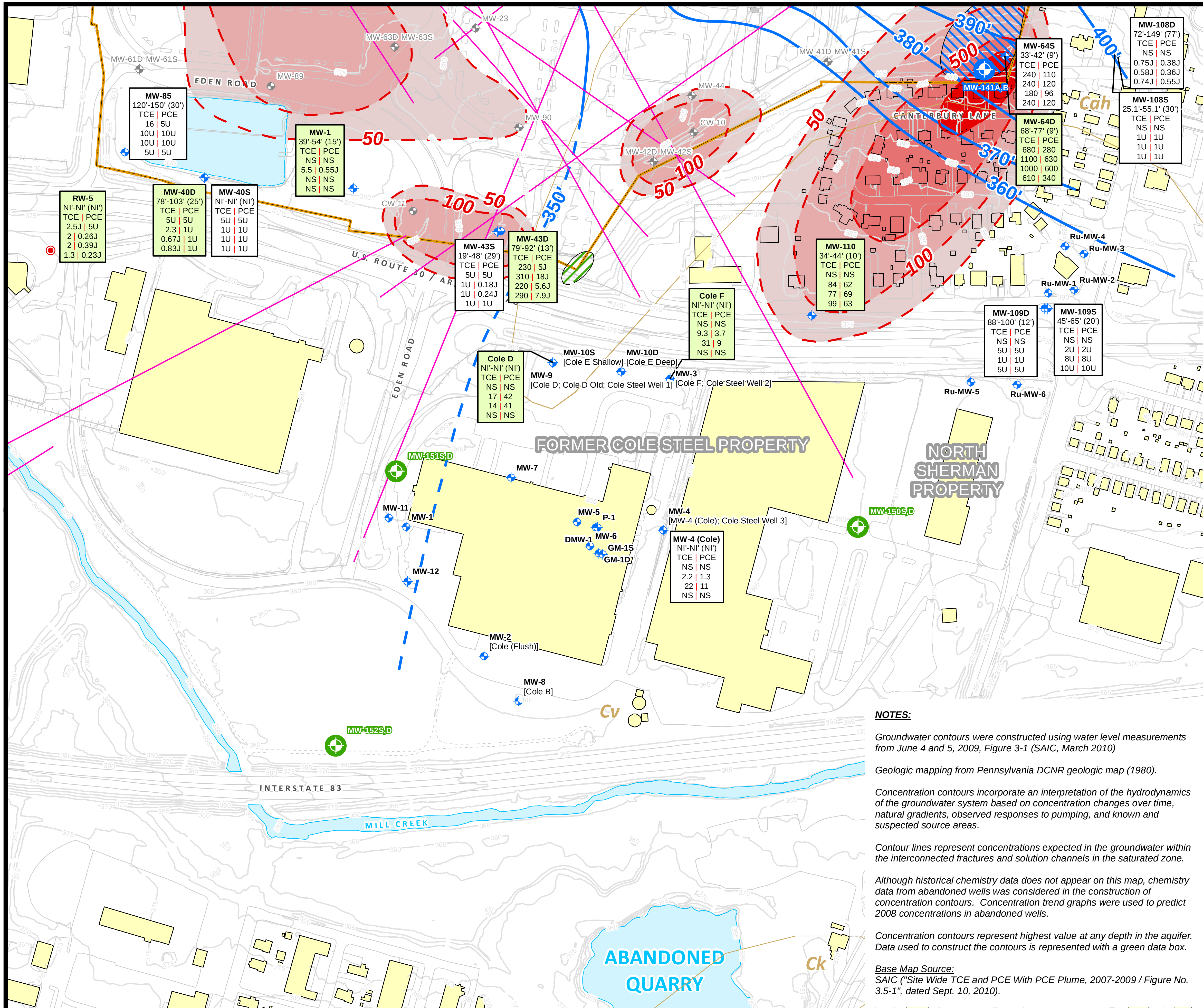

LEGEND

N S E W

- Proposed Vertical Extent Wells
- Proposed Shallow & Deep Pairs
- Residential Well,
- Monitoring Well
- Abandoned Well
- Inferred TCE Concentration Contour (ppb)
- TCE Concentration 50 ppb
- TCE Concentration 100 ppb
- TCE Concentration 500 ppb
- TCE Concentration 1000 ppb
- PCE, Known Source Area
- PCE, Suspected Source Area
- June 2009 Groundwater Contour (Feet)
- June 2009 Inferred Groundwater Contour (Feet)
- Fracture Trace
- Contact
- Cah Antietam & Harpers Formation, undiv.
- Cv Vintage Formation
- Ck Kinzers Formation
- Cl Ledger Formation
- Site Property Boundary
- Existing Building to Remain
- Demolished
- Demolished/Slab Removed
- Railroad
- Road (Paved)
- Road Curb
- Road (Unpaved)
- Walkway
- Fenceline
- Topography

Location ID
Top of Open Interval FtBGS - Bottom of Open Interval FtBGS (Open Interval Thickness)
Trichloroethene and Tetrachloroethylene
1. 2007 Key Well (May-June 2007)
2. 2008 Sup RI Rnd 1 (April-May 2008)
3. 2008 Sup RI Rnd 2 (September-October 2008)
4. 2009 Key Well (June-July 2009)

Scale (feet)
0 75 150 300

Figure 4.1-4

NOTES:

Groundwater contours were constructed using water level measurements from June 4 and 5, 2009, Figure 3-1 (SAIC, March 2010)

Geologic mapping from Pennsylvania DCNR geologic map (1980).

Concentration contours incorporate an interpretation of the hydrodynamics of the groundwater system based on concentration changes over time, natural gradients, observed responses to pumping, and known and suspected source areas.

Contour lines represent concentrations expected in the groundwater within the interconnected fractures and solution channels in the saturated zone.

Although historical chemistry data does not appear on this map, chemistry data from abandoned wells was considered in the construction of concentration contours. Concentration trend graphs were used to predict 2008 concentrations in abandoned wells.

Concentration contours represent highest value at any depth in the aquifer. Data used to construct the contours is represented with a green data box.

Base Map Source:
SAIC ("Site Wide TCE and PCE With PCE Plume, 2007-2009 / Figure No. 3.5-1", dated Sept. 10, 2010).

Former York Naval Ordnance Plant

1425 Eden Road, York, PA 17402

Study Area South of Site

DRAWN BY: JPB	CHECKED AND APPROVED BY: JR/SS	DATE: 4/3/2012

K:\10000\10012\Projects\2012 Field Sampling Plan\Fig4.1-4_TCEplumeSouth.mxd

GROUNDWATER SCIENCES CORPORATION

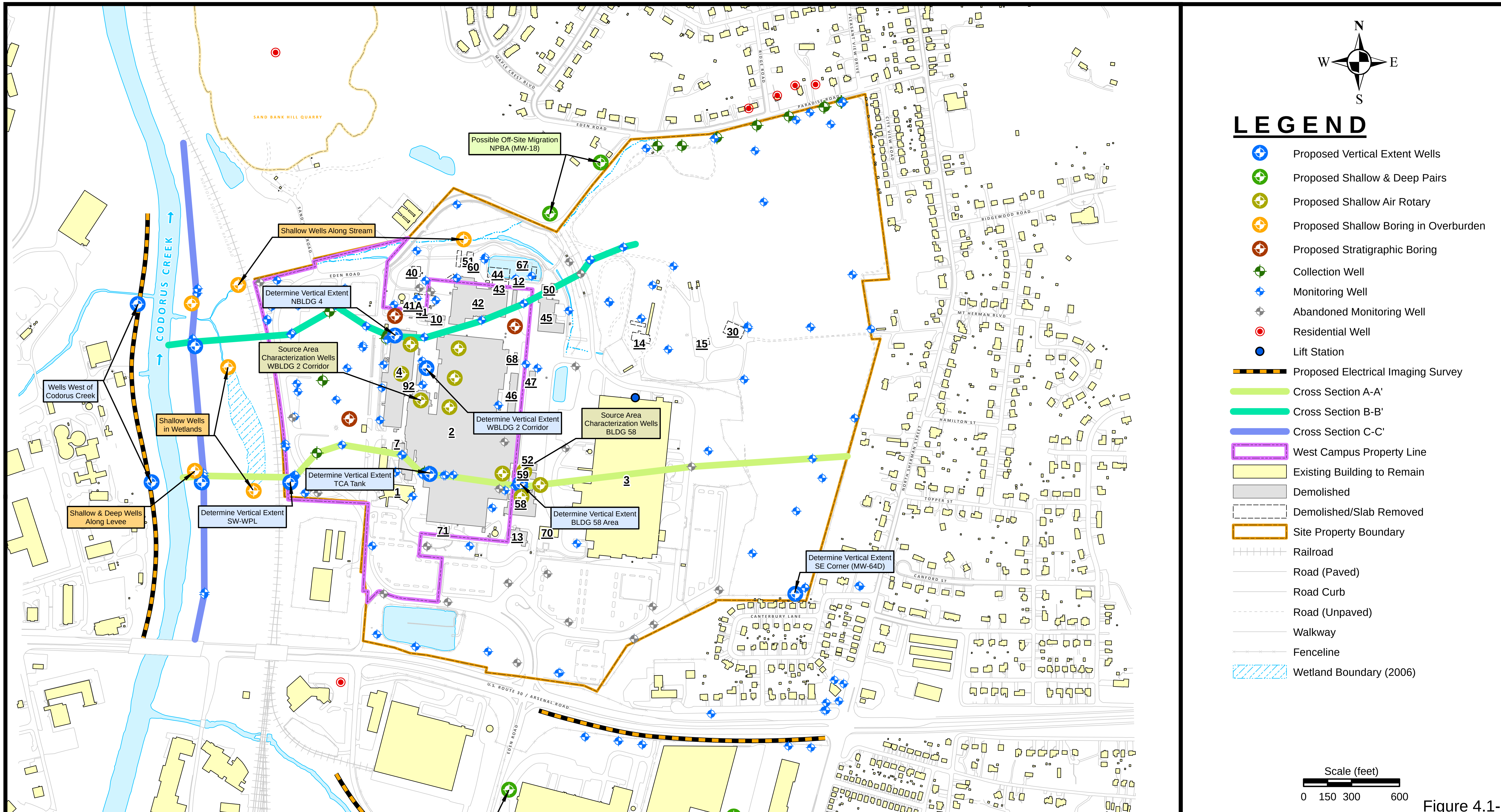

Figure 4.1-5

Former York Naval Ordnance Plant

1425 Eden Road, York, PA 17402

Proposed Drilling Program
Supplemental Remedial Investigation
Part 2

DRAWN BY: JPB	CHECKED AND APPROVED BY: SMS	DATE: 4/30/2012

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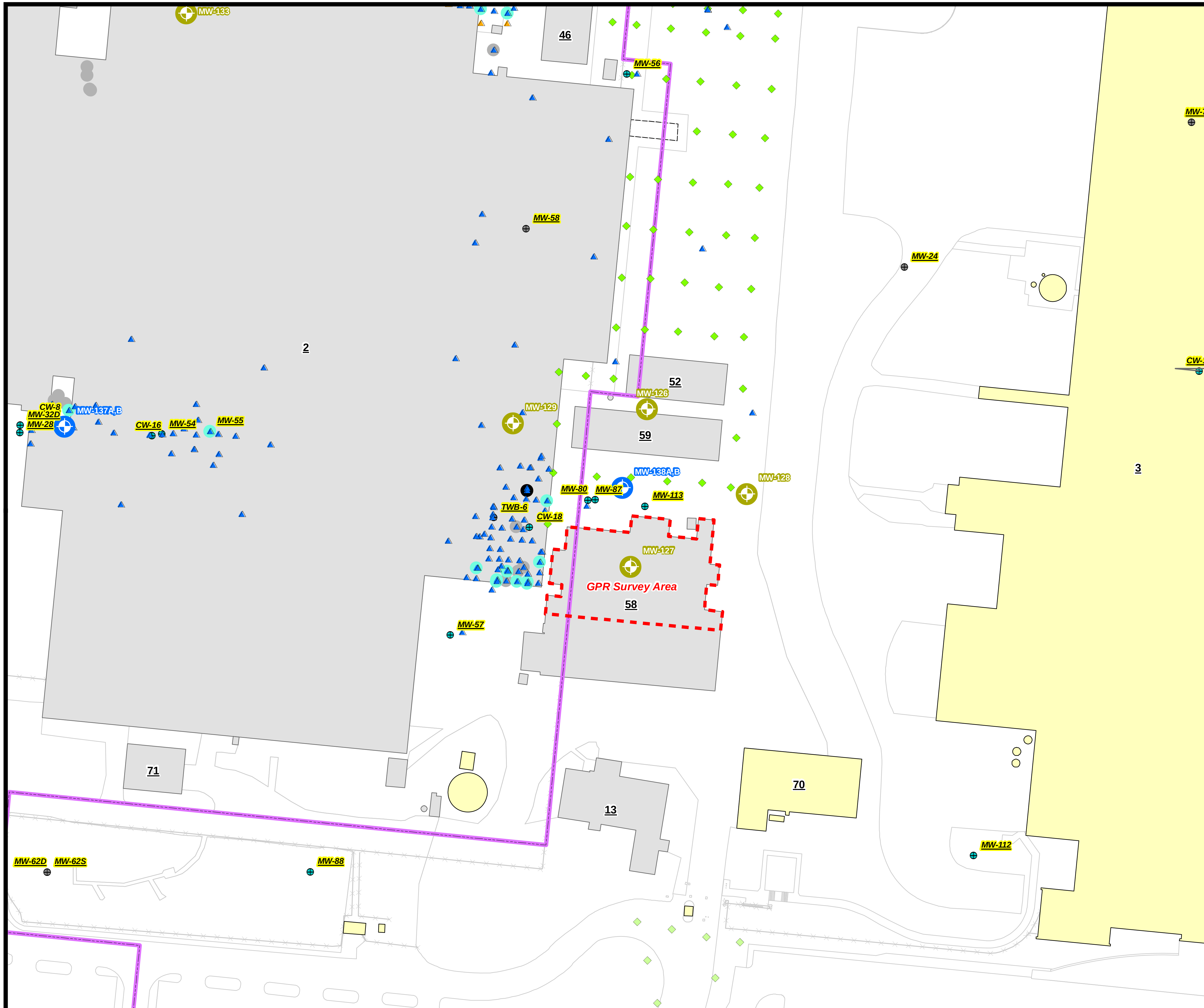
GROUNDWATER SCIENCES CORPORATION



LEGEND

N E S W

- Proposed Vertical Extent Wells
- Proposed Shallow Air Rotary
- Soil Samples Collected Prior to 1/1/2007
- Soil Samples Collected After 1/1/2007 (Current Investigation)
- Exceeds Direct Contact and Soil to Groundwater MSC
- Results > or = Direct Contact MSC (0-2' and 2'-15')
- Results > or = Soil to Groundwater MSC
- Soil to Groundwater or Direct Contact MSC Exceedance that has been excavated
- Abandoned Wells
- Active Wells
- RI Passive Soil Gas
- RI Active Soil Gas
- West Campus Property Line
- Existing Building to Remain
- Demolished
- Demolished/Slab Removed
- Railroad
- Road (Paved)
- Road Curb
- Road (Unpaved)
- Walkway
- Fenceline

NOTE:
1. All samples exceeding the Soil to Groundwater or Direct Contact 0-2' or 2-15' MSC are in place unless noted by a gray dot.
2. For more details on excavated or in-place soils, see tables 3.12-1, 3.12-1, 3.15-1, or 3.25-1 of the Soils SRI (SAIC, 2009).

Base Map Source: Figure 3.25-1 of the Soils SRI (SAIC, 2009).

Scale (feet)
0 25 50 100

Figure 4.2-1

Former York Naval Ordnance Plant

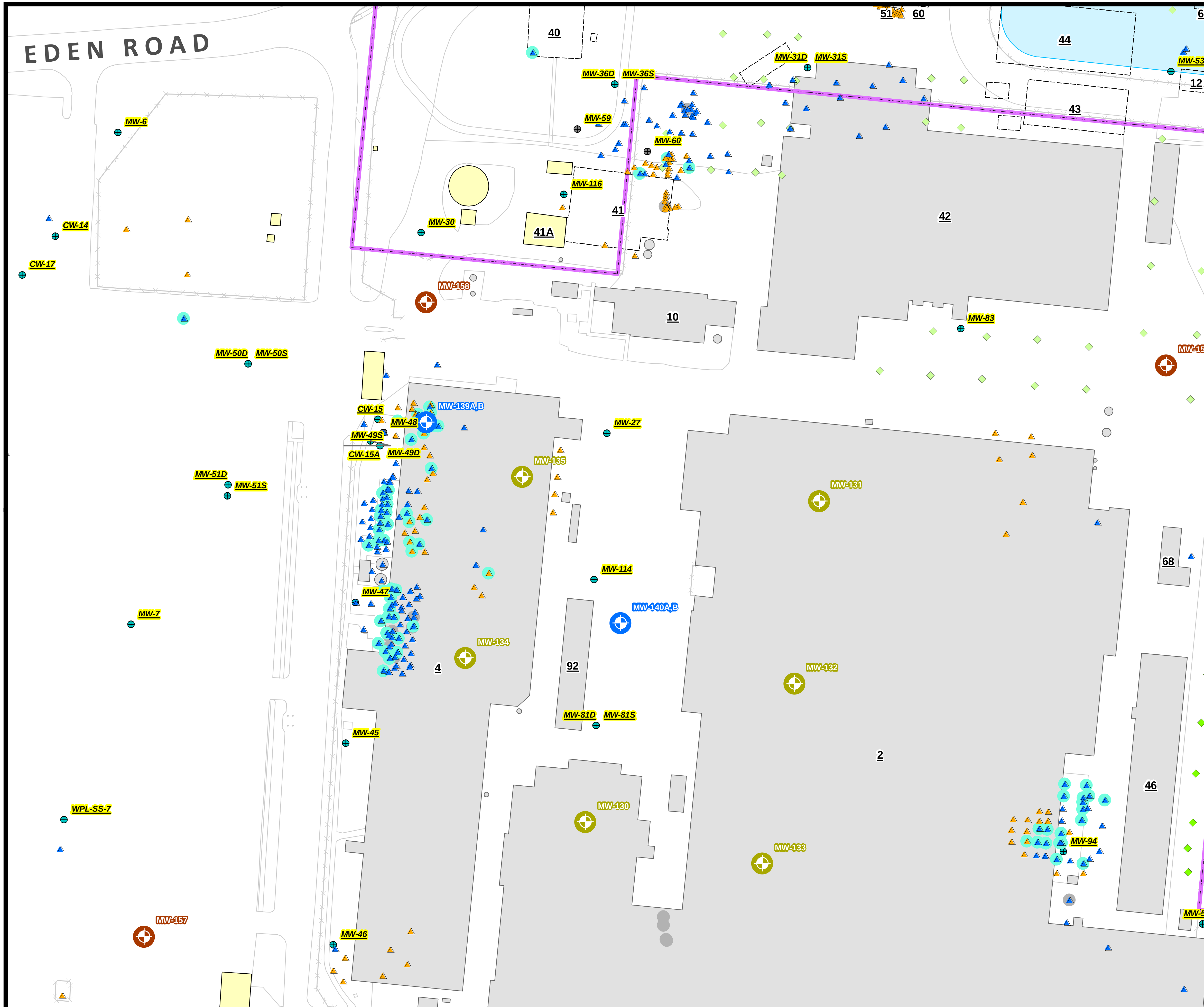
1425 Eden Road, York, PA 17402

Building 58 Source Area Investigation

DRAWN BY: JPB	CHECKED AND APPROVED BY: SMS	DATE: 4/4/2012

K:\10000\10012\Projects\2012 Field Sampling Plan\Fig4.2-1_B58Investigation.mxd

GROUNDWATER SCIENCES CORPORATION



LEGEND

- Proposed Vertical Extent Wells
- Proposed Shallow Air Rotary
- Proposed Stratigraphic Boring
- Soil Samples Collected Prior to 1/1/2007
- Soil Samples Collected After 1/1/2007 (Current Investigation)
- Exceeds Direct Contact and Soil to Groundwater MSC
- Results > or = Direct Contact MSC (0-2' and 2'-15')
- Results > or = Soil to Groundwater MSC
- Soil to Groundwater or Direct Contact MSC Exceedance that has been excavated
- Abandoned Wells
- Active Wells
- RI Passive Soil Gas
- RI Active Soil Gas
- West Campus Property Line
- Existing Building to Remain
- Demolished
- Demolished/Slab Removed
- Railroad
- Road (Paved)
- Road Curb
- Road (Unpaved)
- Walkway
- Fenceline

N
W
E
S

NOTE:
1. All samples exceeding the Soil to Groundwater or Direct Contact 0-2' or 2-15' MSC are in place unless noted by a gray dot.
2. For more details on excavated or in-place soils, see tables 3.12-1, 3.12-1, 3.15-1, or 3.25-1 of the Soils SRI (SAIC, 2009).

Base Map Source: Figure 3.25-1 of the Soils SRI (SAIC, 2009).

Scale (feet)
0 25 50 100

Figure 4.2-2

Former York Naval Ordnance Plant

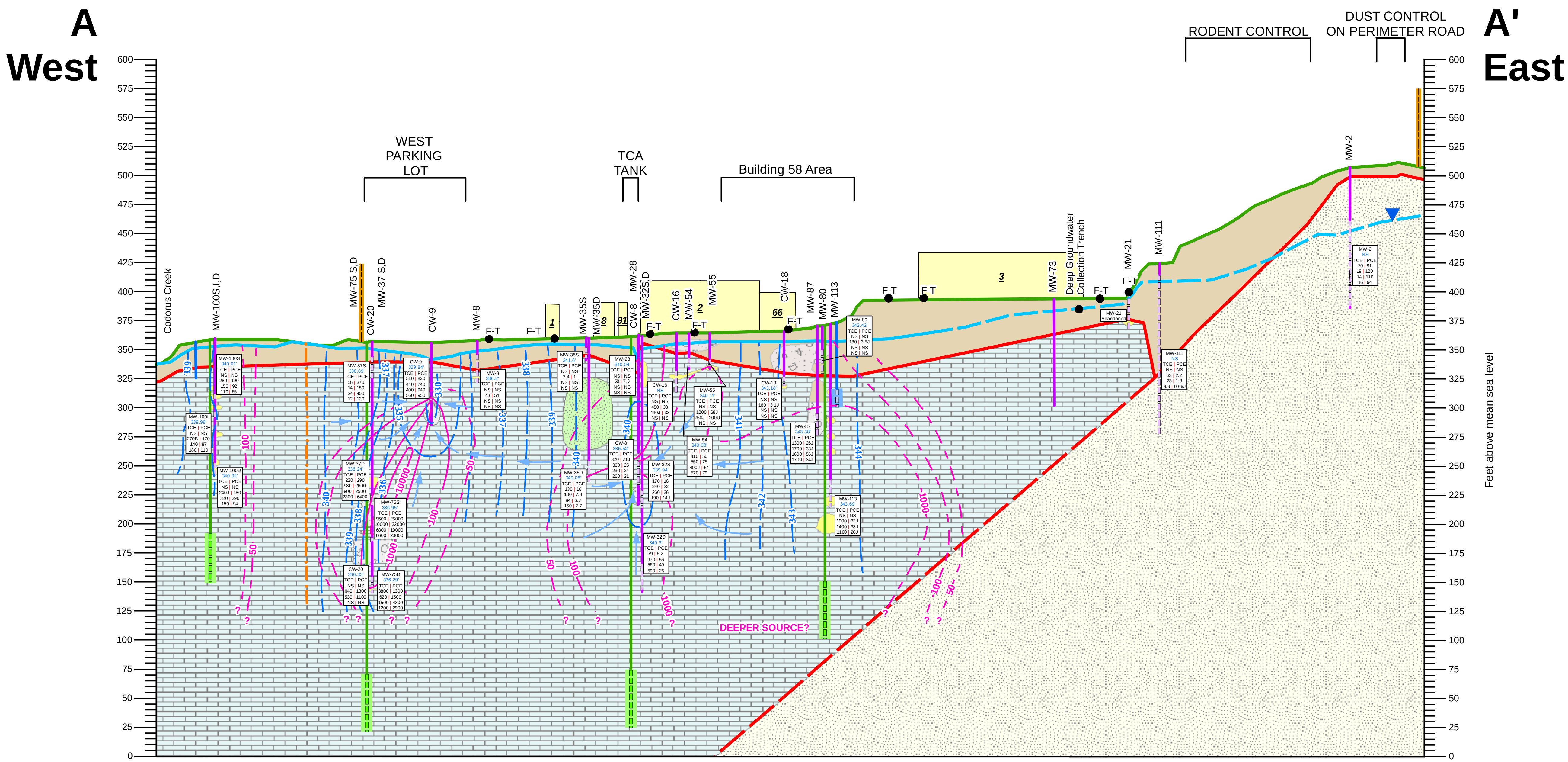
1425 Eden Road, York, PA 17402

West Building 2
Source Area Investigation

DRAWN BY: JPB	CHECKED AND APPROVED BY: SMS	DATE: 4/4/2012

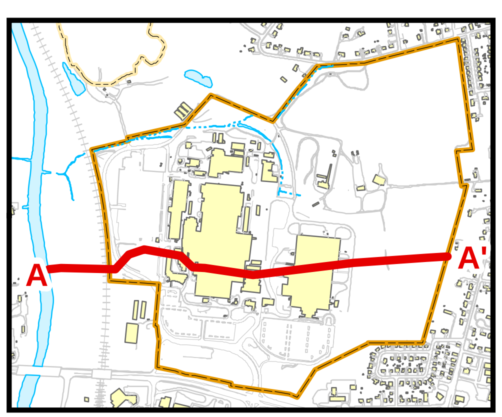
K:\10000\10012\Projects\2012 Field Sampling Plan\Fig4.2-2_B2Investigation.mxd

GROUNDWATER SCIENCES CORPORATION



NOTES:
- Colors not representative of geologic age.
- Static water levels measured October 20, 2008.
- Chemistry results in µg/L.
- CW-20, MW-37S, MW-37D, MW-75S, and MW-75D are a well cluster. CW-20 drilling log was used to represent the well cluster in cross section.
- MW-73 projected onto section from 250' south.
- The schematic piezometric isocontours, chemical concentration contours and flow arrows are intended to depict an interpretation of general trends in groundwater flow conditions.
- Base map source: "Site-Wide Cross Section A-A'" (SAIC, dated 3/22/2010).

Location ID
Groundwater Elevation from October 2008 In AMSL
(NS = Not Sampled)
TCE and PCE
1: 2007 Key Well
2: 2008 Sup RI Rnd 1
3: 2008 Sup RI Rnd 2
4: 2009 Key Well



LOCATION MAP
1:2000 SCALE

LEGEND

- Inferred Direction of Groundwater Flow
- Groundwater Divide
- 340 Inferred Piezometric Isocontour (Oct. 20, 2008)
- 100 TCE Concentration Contour (ppb)
- Inferred TCE Concentration Contour (ppb)
- Surface
- Water Table
- Extrapolated Water Tabel
- Property Boundary
- Buildings
- Existing Well
- Existing Well (Screened Interval)
- Proposed Shallow Well
- Proposed Shallow Well (Screened Interval)
- Proposed Deep Well
- Proposed Deep Well (Screened Interval)
- Bedrock
- Extrapolated Bedrock

STRATIGRAPHY

- Silt / Clay
- Open Solution Cavity
- Solution Cavity with Alluvial Gravel
- Solution Cavity with Unknown Material
- Alluvial Gravel
- Limestone / Dolostone
- Sandstone / Quartzite
- F-T Fracture Trace

Vertical Scale (feet)
0 25 50 100

Horizontal Scale (feet)
0 100 200 400

Vertical Exaggeration 4X

Figure 4.2-3

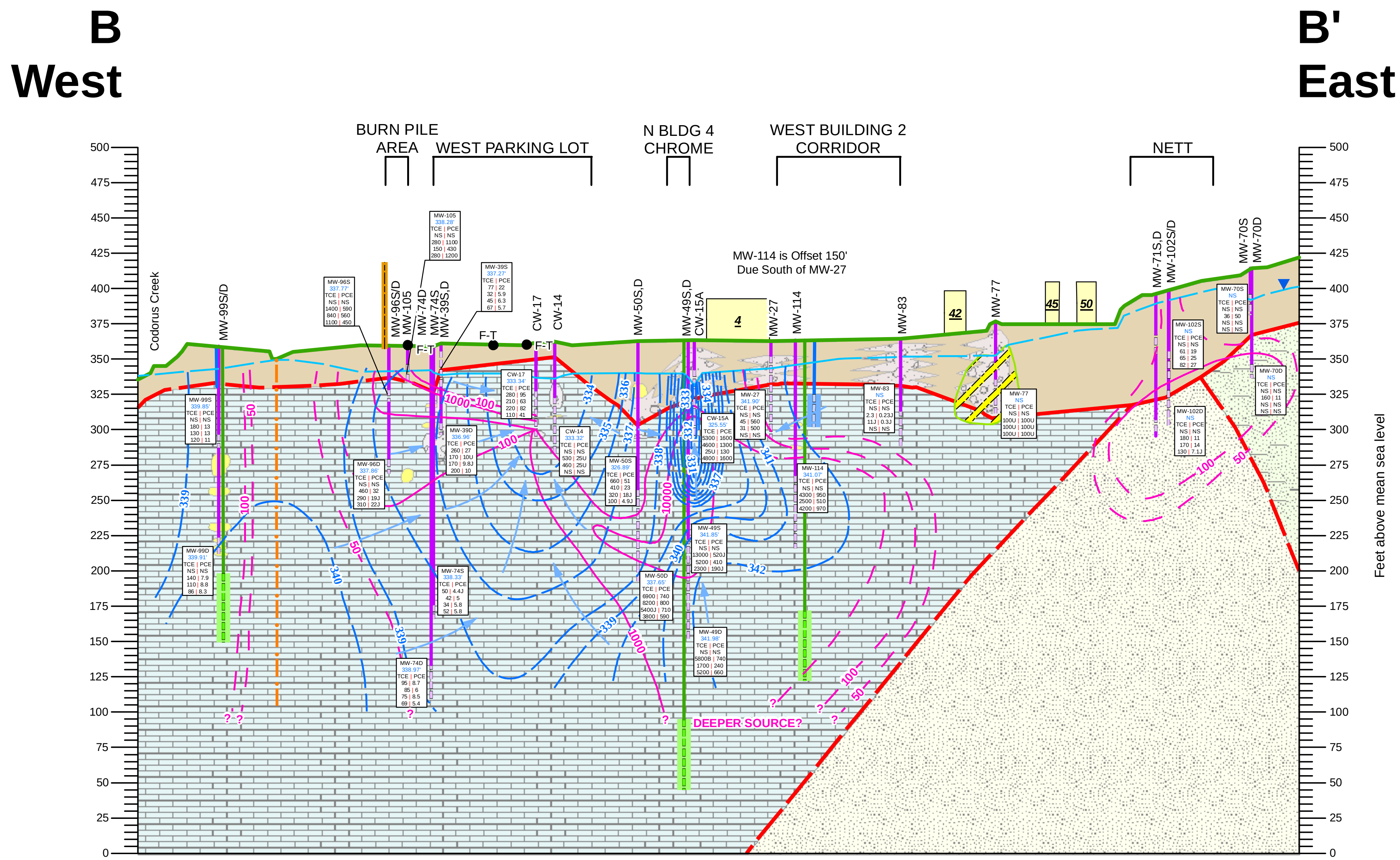
Former York Naval Ordnance Plant
1425 Eden Road, York, PA 17402

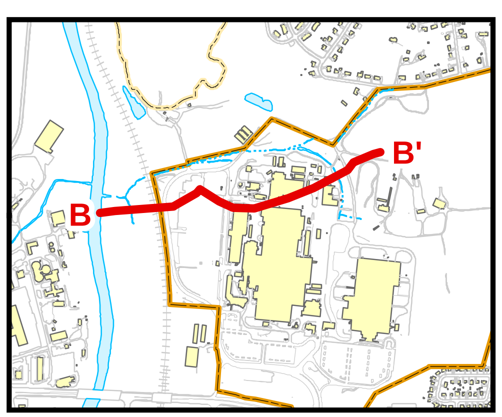
Cross Section A-A'
Proposed Deep Wells

DRAWN BY: JPB	CHECKED AND APPROVED BY: JR/SS	DATE: 4/2/2012

K:\10000\10012\Projects\2012 Field Sampling Plan\Fig4.2-3_CrossSectionAA.mxd

GROUNDWATER SCIENCES CORPORATION





LOCATION MAP
1:2000 SCALE

LEGEND

- Inferred Direction of Groundwater Flow
- 340 Inferred Piezometric Isocontour (Oct. 20, 2008)
- TCE Concentration Contour (µg/L)
- 100 Inferred TCE Concentration Contour (µg/L)
- Groundwater Divide
- Surface
- Water Table
- Extrapolated Water Table
- Property Boundary
- Buildings
- Bedrock
- Extrapolated Bedrock
- Existing Well
- Existing Well (Screened Interval)
- Proposed Shallow Well
- Proposed Shallow Well (Screened Interval)
- Proposed Deep Well
- Proposed Deep Well (Screened Interval)
- Unleaded Fuel Plume

STRATIGRAPHY

- Silt / Clay
- Open Solution Cavity
- Solution Cavity with Alluvial Gravel
- Alluvial Gravel
- Limestone / Dolostone
- Sandstone / Quartzite
- Phyllite
- F-T Fracture Trace

Location ID
Groundwater Elevation from October 2008 In AMSL
(NS = Not Sampled)
TCE and PCE
1: 2007 Key Well
2: 2008 Sup RI Rnd 1
3: 2008 Sup RI Rnd 2
4: 2009 Key Well

NOTES:
- *Colors not representative of geologic age.*
- *Static water levels measured October 20, 2008.*
- *Chemistry results in µg/L.*
- *The schematic piezometric isocontours, chemical concentration contours and flow arrows are intended to depict an interpretation of general trends in groundwater flow conditions.*
- *Base map source: "Site-Wide Cross Section C-C'" (SAIC, dated 8/13/2008).*

Vertical Scale (feet)
0 25 50 100

Horizontal Scale (feet)
0 100 200 400

Vertical Exaggeration 4X

Figure 4.2-4

Former York Naval Ordnance Plant
1425 Eden Road, York, PA 17402

Cross Section B-B'
Proposed Deep Wells

DRAWN BY: JPB	CHECKED AND APPROVED BY: JR/SS	DATE: 3/28/2012

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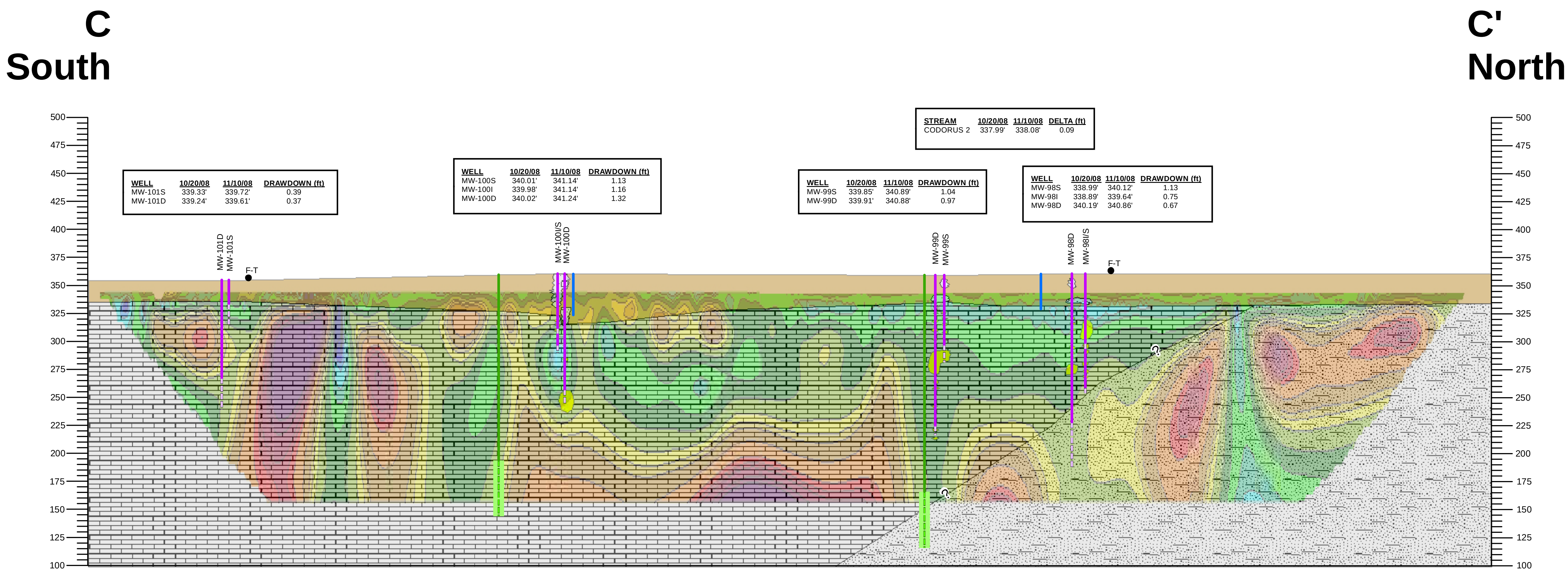
GROUNDWATER SCIENCES CORPORATION



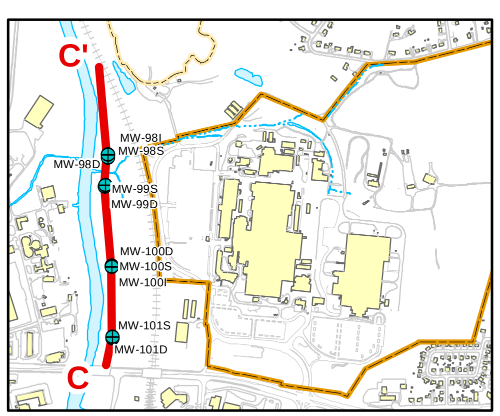
WELL	10/20/08	11/10/08	DRAWDOWN (ft)
MW-101S	339.33'	339.72'	0.39
MW-101D	339.24'	339.61'	0.37

WELL	10/20/08	11/10/08	DRAWDOWN (ft)
MW-100S	340.01'	341.14'	1.13
MW-100I	339.98'	341.14'	1.16
MW-100D	340.02'	341.24'	1.32

STREAM	10/20/08	11/10/08	DELTA (ft)
CODORUS 2	337.99'	338.08'	0.09

WELL	10/20/08	11/10/08	DRAWDOWN (ft)
MW-99S	339.85'	340.89'	1.04
MW-99D	339.91'	340.88'	0.97

WELL	10/20/08	11/10/08	DRAWDOWN (ft)
MW-98S	338.99'	340.12'	1.13
MW-98I	338.89'	339.64'	0.75
MW-98D	340.19'	340.86'	0.67



LOCATION MAP
1:2000 SCALE

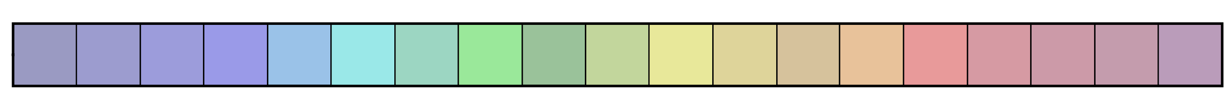
LEGEND

- Existing Well
- Existing Well (Screened Interval)
- Proposed Shallow Well
- Proposed Deep Well
- Proposed Deep Well (Screened Interval)
- F-T Fracture Trace

STRATIGRAPHY

- Open Solution Cavity
- Silt / Clay
- Alluvial Gravels
- Limestone / Dolostone
- Phyllite

Modeled Resistivity (ohm-meters)



Vertical Scale (feet)
0 50 100

Horizontal Scale (feet)
0 125 250

Vertical Exaggeration 2.5X

NOTE:
Base map source: "Site-Wide Cross Section G-G'"
(SAIC, dated 9/25/2008).

Figure 4.2-5

Former York Naval Ordnance Plant
1425 Eden Road, York, PA 17402

Cross Section C-C'
Proposed Deep and Shallow Wells

DRAWN BY: JPB	**CHECKED AND APPROVED BY:** SMS	**DATE:** 3/27/2012

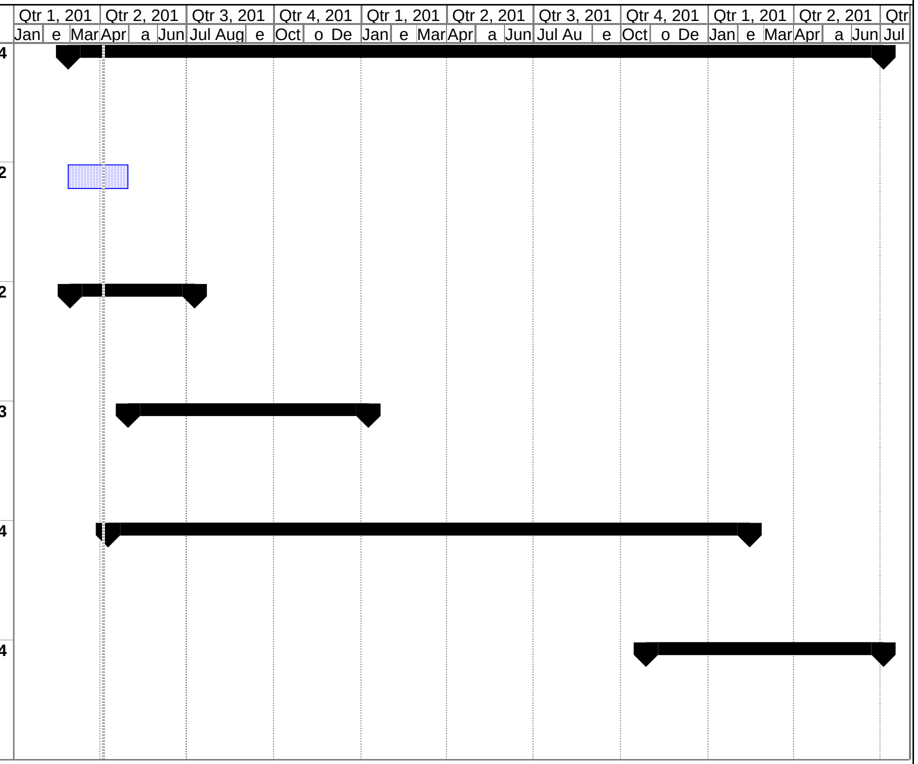
K:\10000\10012\Projects\2012 Field Sampling Plan\Fig4.2-5_CrossSectionCC.mxd

GROUNDWATER SCIENCES CORPORATION

Potential Well Locations
Shaded in Red

Figure 8.0-1
fYNOP Supplemental R (Part 2)
Schedule

ID	WBS	Task Name	Start	Finish
1	1	**fYNOP Groundwater SRI (Part 2)**	**Tue 2/28/12**	**Fri 7/4/14**
2	1.1	**Field Sampling Plan**	**Tue 2/28/12**	**Mon 4/30/12**
3	1.2	**Phase 1-Pre-Drilling Tasks**	**Thu 3/1/12**	**Mon 7/9/12**
19	1.3	**Phase 2 Drilling Tasks**	**Tue 5/1/12**	**Tue 1/8/13**
72	1.4	**Phase 3-Surface Water and Karst Studies**	**Tue 4/10/12**	**Thu 2/13/14**
99	1.5	**Phase 4-Data Analysis and Report**	**Mon 10/28/13**	**Fri 7/4/14**



Project: GWRI Part2 Schedule12_29_1
Date: Wed 4/4/12

Task	Summary	Rolled Up Progress	Project Summary
Progress	Rolled Up Task	Split	Group By Summary
Milestone	Rolled Up Milestone	External Tasks	Deadline

USE PRINTED 2-PART FORM

Groundwater Sciences Corporation

Daily Drilling and Monitoring Well Construction Report

Date ____________________ **Page** _______ **of** _________

Project Number ______________________________________

Project Name ____

Supervising Geologist(s) _______________________________

Drilling Company ______________________________________

Rig Type/Number _______________________________________

Driller ____

Driller's Helper(s) ______________________________________

Daily Drilling Log

Well/Boring Number	Location	Type (HSA/Air)	Drilling (Ft/Dia.)	Core (Ft/Dia.)	Samples (No./Dia.)	Comments

Daily Activities Log

Time	Description	Hours	Time	Description	Hours
0630			1345		
0645			1400		
0700			1415		
0715			1430		
0730			1445		
0745			1500		
0800			1515		
0815			1530		
0830			1545		
0845			1600		
0900			1615		
0915			1630		
0930			1645		
0945			1700		
1000			1715		
1015			1730		
1030			1745		
1045			1800		
1100			1815		
1115			1830		
1130			1845		
1145			1900		
1200			1915		
1215			1930		
1230			1945		
1245			2000		
1300					
1315					
1330					

Materials Used

Well/Boring	Screen (ft./dia.)	Riser (ft./dia.)	Sand	Bentonite	Steel Casing	Other Materials

____

Signature - GSC

____

Signature - Contractor

SOIL GEOLOGIC WELL LOG Project No. ___________	Total Depth ___ Depth to S.S. Refusal ___ Depth to Competent Bedrock ___ Hole Diameter ___ Notes ___ ___	Boring No. ___ Location ___ ___ ___ Driller ___ Logged By ___ Drilling Began ___ Drilling Completed ___ Well Construction Completed ___

					SAMPLE DESCRIPTION Name: GRADE, DENSITY, MOISTURE, COLOR, STRUCTURE (USCS), ETC.	Volatile Scan	Graphic		Depth
Depth	Blow Counts	R Q D ft/ft	Recv	Sample # / Run #			Lith.	Well Construction	

Groundwater Sciences Corporation

Rock Classification Sheet

Project ______________________ Job. No. ______________ Sheet ________ of ________

Site Area ____ Drill Hole No. ____________

Contractor ______________ Driller ____________ Classified By ______________ Date ____________ Coordinates N/S__________ E/W__________

	Drilling History					Geologic Characteristics	Engineering Characteristics		Groundwater
Depth	Run No.	Core Rec.	Remarks	Well Constr.	Graphic Log	Description	Description	Discont.	Static Water Level Time & Date

MORRIS
INDUSTRIES, INC.

ENVIRONMENTAL PRODUCTS

MANHOLES / VAULTS

PROTECTIVE CASINGS

Morris Watertight Manholes

Manufacturers of a quality line of manholes for use in monitor well and other applications.

Some of the standard features are:

- Hex Head Stainless Steel Bolts with nylon washers
- Neoprene Gasket
- Cast Iron Ring and Cover
- Limited Access
- Aluminum Identification Plate
- Optional heavy gauge galvanized skirt
- Optional heavy duty welded steel skirt with custom lengths available
- Customized painting features available
- Load Rated

5" Watertight Manhole Models

Item #	Skirt length	Type	Weight
305200750	7-1/2" (19.05 cm)	galvanized	8 lbs
305201200	12" (30.48 cm)	galvanized	8 lbs
305210750	7-1/2" (19.05 cm)	steel	10 lbs
305211200	12" (30.48 cm)	steel	12 lbs

8" Watertight 3-Bolt Manhole Models

Item #	Skirt length	Type	Weight
308300750	7-1/2" (19.05 cm)	galvanized	18 lbs
308301200	12" (30.48 cm)	galvanized	20 lbs
308310750	7-1/2" (19.05 cm)	steel	26 lbs
308311200	12" (30.48 cm)	steel w/tabs	32 lbs
308312400	24" (60.96 cm)	steel	47 lbs
308321200	12" (30.48 cm)	one-piece cast	38 lbs

8" Watertight 2-Bolt Manhole Models

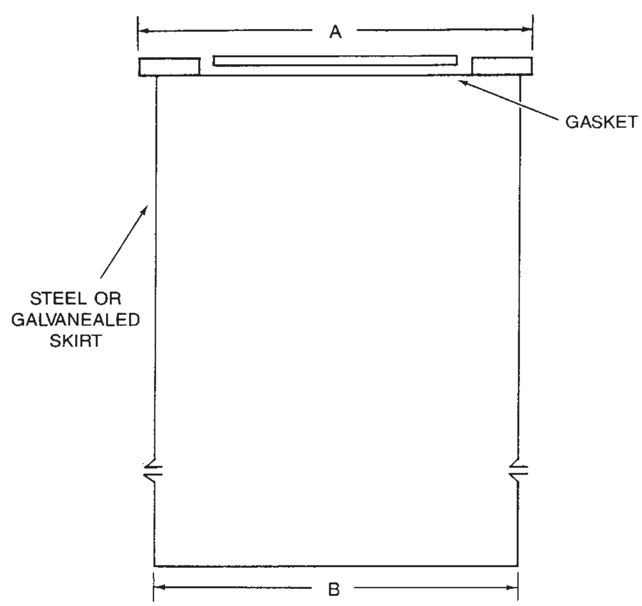
Item #	Skirt length	Type	Weight
308200750	7-1/2" (19.05 cm)	galvanized	14 lbs
308201200	12" (30.48 cm)	galvanized	15 lbs
308210750	7-1/2" (19.05 cm)	steel	25 lbs
308211200	12" (30.48 cm)	steel	29 lbs

12" Watertight Manhole Models

Item #	Skirt length	Type	Weight
312300750	7-1/2" (19.05 cm)	galvanized	30 lbs
312301200	12" (30.48 cm)	galvanized	32 lbs
312310750	7-1/2" (19.05 cm)	steel	42 lbs
312311200	12" (30.48 cm)	steel	50 lbs

Dimensions

Size	A	D
5" Manhole	6"	5-1/8"
8" Manhole	9-3/4"	8-5/8"
12" Manhole	13-1/8"	12-1/2"
8" One Piece Manhole	9-7/8"	8-1/8"



Morris Protective Casing

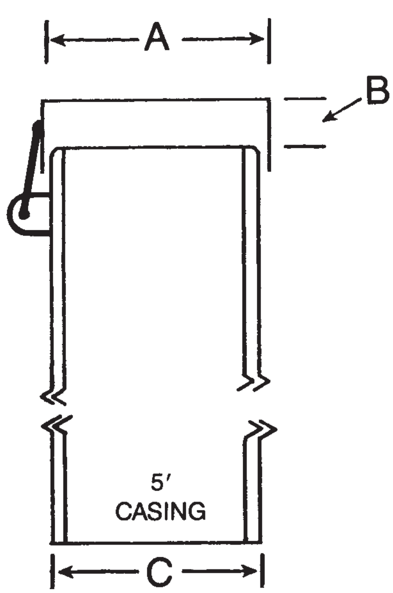
Providing security for above ground monitor wells and other applications.

Some of the standard features are:

- Made from welded steel construction
- Tamper Proof
- 4" through 12" models are stock items
- Steel tabs accept standard size padlocks
- Custom Sizes available on special order
- Custom paint colors available on special order

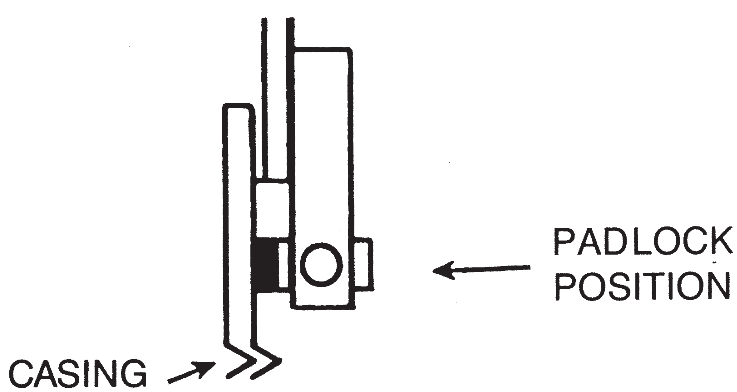
Dimensions

SIZE	A	B	C
4"	6"	1½"	4½"
6"	7 3/8"	1½"	6"
8"	10¾"	1½"	8 5/8"
10"	12½"	1½"	10¾"
12"	15"	2"	12¾"



Above Ground Hinged Pro-Casings

Item #	Size	Weight
300004100	4" Cap w/tabs	5 lbs
300004105	4"x 5' Casing	28 lbs
300006100	6" Cap w/tabs	6 lbs
300006105	6"x 5' Casing	37 lbs
300008100	8" Cap w/tabs	9 lbs
300008105	8"x 5' Casing	88 lbs
300010100	10" Cap w/tabs	12 lbs
300010105	10"x 5' Casing	110 lbs
300012100	12" Cap w/tabs	16 lbs
300012105	12"x 5' Casing	141 lbs



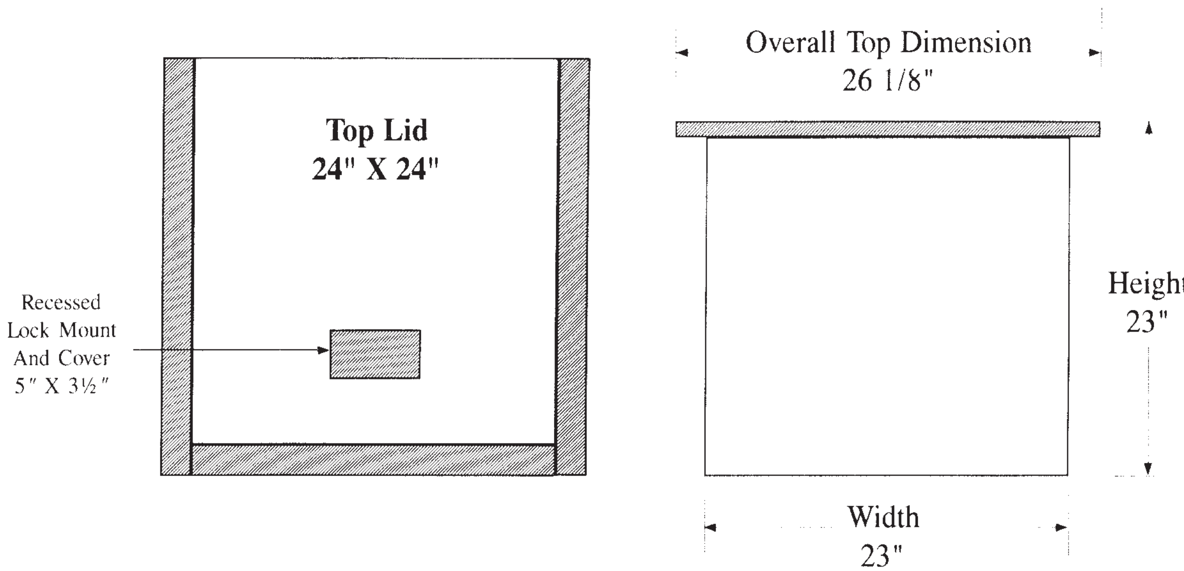
Morris Locking Vaults

24 x 24 x 24 Flush Grade Steel Locking Vaults

Some of the standard features are:

- User Friendly
- Hinged Cover with safety catch
- Heavy Duty Diamond Plate Top
- Lockable (Padlock recessed w/cover attachment)
- Flush Grade
- Heavy Gauge galvanized skirt
- Painted
- Load Rated

Item #	Skirt length	Type	Weight
319242424	23" (58.42 cm)	galvanized	135 lbs

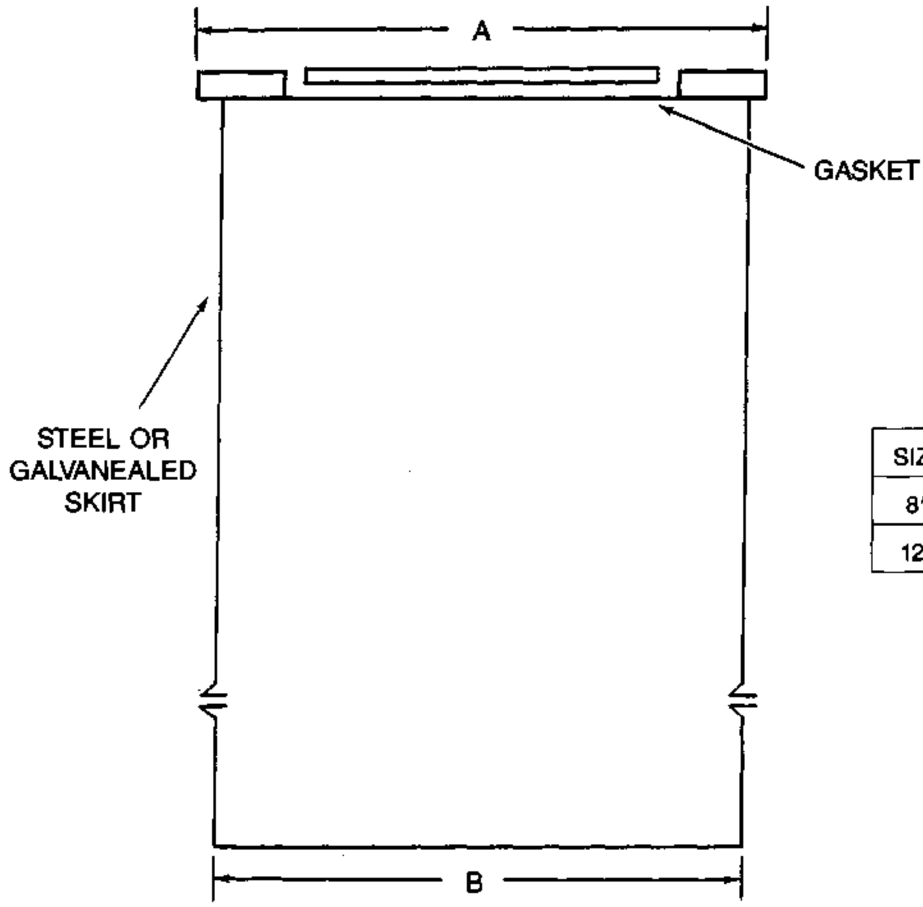


About Morris Industries, Inc.

Morris Industries was founded in 1958 and over the past 50 years has grown to be one of the largest wholesale distributors and fabricators of well casing and accessories for the water well, environmental and monitoring well markets.

Headquartered in Pompton Plains, NJ on 13 acres, Morris has become one of the largest stocking yards for steel pipe. In addition all fabrication is done at the same site with modern and automated threading machines and handling equipment for domestic sales as well as international. Manufacturing facilities for manholes, well vaults, and protective casings are also located there.

Morris has 3 additional offices and stocking yards located in Durham, Ct., Mechanicville, NY., and Dillsburg, Pa. Morris is committed to product quality and excellence in customer service and can supply your product needs anywhere in the country and beyond.



DIMENSIONS

SIZE	A	B
8"	9 3/4"	8 5/8"
12"	13 1/8"	12 1/2"

BEARING STRENGTH TEST RESULTS

TEST PERFORMED BY:

JERSEY TECHNOLOGY LABORATORIES, INC.
ENGINEERS, LABORATORY AND INSPECTION SERVICE
154-156 WRIGHT STREET at MCCARTER HIGHWAY, NEWARK, N.J. 07114
TELEPHONE (201) 242-3800

RESULTS:

We herewith submit our report of test conducted on monitor well covers delivered by the client's representative on August 20, 1991.

Procedure: On 8" diameter monitor well cover assembly a compressive load was applied with 6¼" diameter head centered on cover surface.

On 12" diameter monitor well cover assembly a compressive load was applied with 9 5/8" diameter heod centered on cover surface.

Lab. #	Diameter of Cover	Outer Diameter of the Assembly	Break Load
91-M223	8.5"	9.81"	65,000 lbs.
91-M224	12.0"	13.25"	59,000 lbs.

FULL COPIES OF TEST RESULTS ARE AVAILABLE UPON REQUEST.