REMEDIAL INVESTIGATION/ ALTERNATIVES ANALYSIS WORK PLAN

FORMER SCOTT AVIATION FACILITY AREA 1
LANCASTER, NEW YORK

Prepared for:

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AA	Alternatives Analysis
ALTA	American Land Title Association
ASP	Analytical Services Protocol
ASTM	American Society for Testing Materials
AVOX	AVOX Systems Inc.
BCP	Brownfield Cleanup Program
bgs	below ground surface
DOT	Department of Transportation
DUSR	Data Usability Summary Report
EPA	Environmental Protection Agency
ESA	Environmental Site Assessment
ESI	Environmental Site Investigation
HASP	Health and Safety Plan
IDW	Investigation-Derived Waste
IRM	Interim Remedial Measure
K	Hydraulic Conductivity
μg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
PCB	polychlorinated biphenyls
PGA	Preliminary Groundwater Assessment
PID	photoionization detector
ppm	parts per million
PVC	polyvinyl chloride
RAO	remedial action objectives
RI	Remedial Investigation
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
SCGs	Standards, Criteria, and Guidance
SVOC	Semi-Volatile Organic Compound
STL	Severn Trent Laboratories, Inc.
1,1,1-TCA	1,1,1-trichloroethane
TAGM	Technical and Administrative Guidance Memorandum
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
UFPO	Underground Facilities Protection Organization
VOC	Volatile Organic Compound

1.0 INTRODUCTION

On behalf of Scott Technologies, Inc., AECOM Technical Services, Inc. (AECOM) submitted an application on September 11, 2008 to enter the New York State Department of Environmental Conservation (NYSDEC) Brownfield Cleanup Program (BCP) per Title 6 New York State Official Compilation of Codes, Rules, and Regulations (NYCRR) Part 375-3.4 for Area 1 (Site) located at the former Scott Aviation Facility, 225 Erie Street, Village of Lancaster, Erie County, New York (Figure 1). On September 1, 2004, the former Scott Aviation Facility was sold by Scott Technologies, Inc. to the current facility owner/operator, AVOX Systems Inc. (AVOX). Scott Technologies, Inc. has applied for entry into the NYSDEC BCP as a participant.

AECOM, on behalf of Scott Technologies, Inc. has developed this Remedial Investigation (RI)/ Alternatives Analysis (AA) Work Plan for Area 1 to meet the requirements of Title 6 NYCRR Parts 375-1.6, -1.8 and 375-3.6, -3.8.

1.1 REMEDIAL INVESTIGATION/ALTERNATIVES ANALYSIS OBJECTIVE

Several Site investigations and an interim remedial measure (IRM) for soil have previously been conducted at Area 1 (refer to Section 2.0 of this Work Plan for further information). As such, the objective of this RI/AA Work Plan is to address data gaps in the existing Site investigation data collected for Area 1 in order to definitively identify the contaminant source area, define the nature and extent of contamination, assess contaminant fate and transport, and to complete a qualitative exposure assessment. The results from the RI/AA will be utilized to develop a Conceptual Site Model, determine appropriate remedial action objectives (RAOs), and identify the recommended remedial alternative for Area 1 in the subsequent AA Report.

1.2 REPORT ORGANIZATION

This RI/AA Work Plan was developed to adhere to NYSDEC Site investigation and remediation requirements (NYSDEC, December 2002). More specifically, the RI/AA Work Plan for Area 1 at the former Scott Aviation Facility is organized into nine sections and three appendices:

- Section 1.0 includes an introduction, objective, and report organization details for the RI/AA Work Plan;
- Section 2.0 contains a Site description and Site history;
- Section 3.0 presents the RI scope of work and a comprehensive description of field activities to be completed during the RI;

- Section 4.0 presents the AA approach;
- Section 5.0 describes quality assurance/quality control (QA/QC) protocols;
- Section 6.0 describes the Site-specific health and safety protocols;
- Section 7.0 contains an implementation and reporting schedule for RI activities and also presents a list of staff for the project;
- Section 8.0 includes a description of citizen participation activities; and
- Section 9.0 provides the references used in the development of the RI/AA Work Plan.

Supporting information used in the preparation of this RI/AA Work Plan is included in three appendices:

- Appendix A contains the Quality Assurance Project Plan (QAPP) referred to in Sections 3.0 and 5.0 of the RI/AA Work Plan;
- Appendix B contains the 2005 Minimum Standard Detail Requirements for American Land Title Association (ALTA) Land Title Surveys; and
- Appendix C contains the Site-specific Health and Safety Plan (HASP).

2.0 SITE DESCRIPTION AND HISTORY

Section 2.0 of the RI/AA Work Plan provides a Site description and brief chronological history of previous Site assessment and investigation activities conducted at the former Scott Aviation Facility with particular emphasis on activities completed for Area 1. Detailed information on each assessment or investigation can be found in the following documentation:

- *Phase I Environmental Site Assessment and Modified Compliance Assessment, Tyco/Scott Aviation Facility, Lancaster, New York* (Earth Tech, April 2004);
- *Phase II Environmental Site Investigation, Tyco/Scott Aviation Facility, Lancaster, New York* (Earth Tech, June 2004); and
- *Preliminary Groundwater Assessment Report, Former Scott Aviation Facility, Lancaster, New York* (Earth Tech, January 2008).

2.1 SITE DESCRIPTION

The addresses that comprise the current AVOX facility (formerly Scott Technologies, Inc.) include: 225 Erie Street, 25 Walter Winter Drive, and 27 Walter Winter Drive, in Lancaster, Erie County, New York 14086. Figure 2 shows that the facility property encompasses three separate areas: the original 6.5-acre Plant 1 Area to the south of Erie Street, an 8.4-acre Plant 2 and Plant 3 Area to the north of Erie Street with the secondary addresses of 25 and 27 Walter Winter Drive, and an undeveloped 10.1-acre Northern Area to the north of the Plant 2 and Plant 3 Area. Walter Winter Drive is located immediately to the east of the Plant 2 and Plant 3 Area. The Plant 1 Area is comprised of three adjacent parcels: a 3.8-acre central parcel (zoned light industrial) on which Plant 1 is located; a vacant 1.1-acre parcel zoned light industrial to the west of the central parcel; and a vacant 1.6-acre parcel zoned residential to the east of the central parcel. The proposed BCP boundary for Area 1 is identified on Figure 2.

2.2 PREVIOUS SITE ASSESSMENTS AND INVESTIGATIONS

A description of previous Site assessment and investigation activities is provided in the following subsections.

2.1.1 Phase I Environmental Site Assessment

In 2004, a Phase I Environmental Site Assessment (ESA) was conducted at a level of effort consistent with American Society for Testing Materials (ASTM) Standard Practice E1527-00 to evaluate the environmental status of the entire former Scott Aviation Property. A detailed study of historical aerial photographs included in Appendix E of the Phase I ESA Report indicated an area of potentially disturbed soil on the west side of Plant 1, south of the existing visitor parking area, and just outside the Plant 1 western perimeter fence line on the adjacent vacant parcel (Earth Tech, April 2004).

2.1.2 Phase II Environmental Site Investigation

A Phase II Environmental Site Investigation (ESI) was completed in 2004 for the entire Scott Aviation Facility to address environmental concerns described in the Phase I ESA Report, including the area of potentially disturbed soil on the west side of Plant 1. The Phase II ESI was conducted at a level of effort consistent with ASTM Standard Practice E1903-97, Guide for Environmental Site Assessments.

During a visual inspection of the area to the west of Plant 1, AECOM personnel noted miscellaneous debris (empty steel compressed gas cylinder, fire brick, etc.) scattered across the ground surface and partially buried. On March 29, 2004, seven test pits were excavated on the west side of the Plant 1 perimeter fence to investigate the extent of the miscellaneous debris.

In two of the test pits (TP-24A and TP-24C), what appeared to be residual paint sludge (yellow, amber, and green colors detected in the soil) of unknown origin, was observed. The paint sludge was located approximately 18 to 24 inches below ground surface (bgs), was less than one foot thick (typically six inches), and encompassed approximately 150 square feet in area (determined from a visual inspection of the test pits). Grab samples of the soil located below the observed paint sludge were collected and submitted for laboratory analysis, including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and metals plus cyanide. Subsequent laboratory analysis indicated elevated concentrations of VOCs and SVOCs within the grab soil samples. A complete summary of the Phase II ESI investigation at Area 1 is presented in the Phase II ESI Summary Report (Earth Tech, June 2004).

2.1.3 Interim Remedial Measure for Soil at Area 1

On June 28, 2005, AECOM, in accordance with the IRM/Supplemental Site Investigation Work Plan, performed an initial excavation of the buried paint sludge material located to the west of Plant 1. AECOM removed all residual paint sludge material and a minimum 1-foot buffer of soil vertically and horizontally around the visible material. The initial excavation footprint was approximately 14 feet by 18 feet, and the depth of the excavation ranged between 3.5 and 4 feet bgs. A total of 40 cubic yards of material (two roll-off boxes) were removed for subsequent off-Site disposal.

Three sidewall (sample identification numbers S-1, S-2, and S-3) and one floor (B-1) confirmation soil samples were collected and submitted for analysis of VOCs and phenols by Severn Trent Laboratories, Inc. (STL) of Amherst, New York. All sidewall sample results were below New York State Technical and Administrative Guidance Memorandum (TAGM) 4046 soil criteria, which was the appropriate screening criterion to be used for soil at the time the IRM was performed. In the excavation floor confirmation soil sample (B-1), ethylbenzene (14 parts per million [ppm]), toluene (15 ppm), trichloroethene (TCE; 1.2 ppm), xylenes (130 ppm), and phenol (54 parts per billion) were detected at levels above their respective TAGM 4046 soil criteria. The laboratory data package for the confirmation soil samples is included in Appendix A of the Preliminary Groundwater Assessment (PGA) Report (Earth Tech, January 2008). Section 2.1.4 of this Work Plan describes the PGA conducted at Area 1.

As a result of the soil concentration exceedances for confirmation soil sample number B-1, AECOM excavated an additional 2 feet of soil vertically within the existing excavation footprint on July 11, 2005, extending the total excavation depth to approximately 5.5 to 6 feet bgs. An additional 20 cubic yards of soil (one rolloff box) were removed for subsequent off-Site disposal. One confirmation soil sample (sample identification number B-1A) was collected at the bottom of the excavation and analyzed for VOCs and phenol by STL. Analytical results indicated TAGM 4046 soil criteria exceedances for toluene (17 ppm), 1,1,1-trichloroethane (1,1,1-TCA; 51 ppm), TCE (43 ppm), and xylenes (41 ppm) in the sample. The laboratory data package for the confirmation soil sample is included in Appendix A of the PGA Report (Earth Tech, January 2008). Further excavation was not completed during the IRM because groundwater was encountered at approximately 6 feet bgs, and the scope of work for the IRM only addressed vadose zone soil. In addition, no remaining visible paint sludge material was observed in the soil excavation footprint.

The 60 cubic yards of soil that was excavated to the west of Plant 1 was characterized for disposal by STL. The laboratory data package for the waste characterization sample (sample identification number W-1) is included in Appendix A of the PGA Report. The resulting analytical data indicated that the excavated soil was non-hazardous. The soil was subsequently disposed at a Waste Management landfill located in Lewiston, New York (Earth Tech, January 2008). The excavation was backfilled with soil from LaFarge North America, Inc. (Niagara Falls, New York). Analytical data for the backfill material is provided as Appendix D.

2.1.4 Preliminary Groundwater Assessment

As a result of the elevated VOC and SVOC (phenol only) soil concentrations detected in the excavation bottom at Area 1 during the 2005 IRM, a PGA was performed in 2006 and 2007. The purpose of the PGA was to assess the nature and extent of VOCs in groundwater in the vicinity of Area 1 and an additional area (Area 2) located to the northeast of AVOX Plant 2. The PGA Report was provided to NYSDEC in November 2007 with revised pages provided to the NYSDEC in January 2008 (Earth Tech, January 2008). The PGA Report was developed in accordance with the Draft DER-10 Technical

Guidance for Site Investigation and Remediation (NYSDEC, December 2002). A summary of the PGA results for Area 1 is provided below.

The PGA at Area 1 was performed using Geoprobe® sampling techniques and completed in three separate phases: 1) Phase I – February through March 2006; 2) Phase II - May 2006; and 3) Phase III - May 2007. Soil borings were completed to bedrock (or refusal) using DPT sampling techniques. Continuous soil samples were obtained at each location using 2-inch diameter Geoprobe® Macro-Core® samplers. Based on lithologic characterization activities, subsurface materials encountered in Area 1 were determined to be primarily comprised of silts and clays with sand lenses (identified as the shallow overburden unit), underlain by a thin, coarser-grained silt, sand, and gravel layer (identified as the deep overburden unit) located immediately above bedrock. Depth to bedrock (refusal) ranged from 18 to 23.5 feet bgs at Area 1. The bedrock was observed to consist of black shale in the Skaneateles Formation (Hamilton Group). In western New York, the Skaneateles Formation consists of gray limestone overlain by gray to black shale (Versar, 1993). The thickness of this formation is estimated at 60-90 feet (Versar, 1993). The contact between the Skaneateles Formation and the Marcellus Formation, which is stratigraphically below the Skaneateles Formation, crosses Erie Street (Versar, 1993).

Eighteen one-inch diameter temporary piezometers were installed and screened across the water table (shallow overburden groundwater) at each boring location following the collection of a deep overburden groundwater sample using a Geoprobe® SP-15 sampling tool. Deep overburden groundwater piezometers were not installed for the PGA at Area 1. Table 1 provides a summary of installation details for all Area 1 temporary piezometers.

Groundwater surface elevations were measured periodically at Area 1 during and following each phase of the PGA. Figure 3 shows shallow overburden groundwater surface contours based on the most recently collected groundwater elevation data at Area 1. This figure shows that on May 31, 2007, the shallow overburden groundwater flow direction beneath Area 1 was primarily inward, towards the existing on-Site storm water sewer system. Table 2 provides a summary of the groundwater elevation measurements by temporary piezometer location used to develop Figure 3.

Groundwater samples were collected from each of the temporary piezometers installed at Area 1 using low-flow sampling techniques that included a peristaltic pump and dedicated poly tubing. Groundwater samples were analyzed for Target Compound List (TCL) VOCs by Environmental Protection Agency (EPA) SW846 Method 8260B, and select groundwater samples in Area 1 were also analyzed for TCL SVOCs by EPA SW846 Method 8270C.

A total of 26 VOCs and four SVOCs were detected in groundwater at Area 1. Eighteen of the 26 VOCs were detected at concentrations exceeding their respective Title 6 NYCRR Part 703 Class GA

Groundwater Standards. TCE is present in the shallow overburden groundwater (90,000 micrograms per liter [μg/L]) and deep overburden groundwater (6,600 μg/L) at the highest concentration and largest areal extent of all chemical constituents detected in groundwater at Area 1. The lateral extent of TCE was delineated in both overburden groundwater units during the PGA and was limited in aerial extent to within the existing facility property boundary southwest of Plant 1. The location and concentration of TCE detected in shallow and deep overburden groundwater are shown on Figures 4 and 5, respectively

3.0 REMEDIAL INVESTIGATION SCOPE OF WORK

Based on a review of the existing Site investigation data for Area 1, the following activities are proposed to be completed during the RI to address existing Site data gaps:

- Completion of a soil vapor intrusion evaluation at AVOX Plant 1 (Section 3.1.1);
- Collection of two rounds of groundwater levels from the existing network of temporary piezometers and monitoring well (MW-30); and, newly installed monitoring wells (Section 3.1.2);
- Performance of a utility clearance (Section 3.1.3);
- Installation and development of nine permanent monitoring wells in shallow (three wells) and deep (six wells) overburden groundwater and two permanent monitoring wells in bedrock;
- Collection of two rounds of groundwater samples from all monitoring wells and existing piezometers (Section 3.1.4);
- Installation and development of four temporary piezometers in the storm sewer line bedding material with subsequent collection of two rounds of groundwater samples (Section 3.1.5);
- Survey of permanent monitoring wells and temporary piezometers. Completion of an ALTA survey to establish the boundaries of Area 1 for the BCP (Section 3.1.6);
- Completion of aquifer characterization testing at one shallow and one deep overburden permanent monitoring well (Section 3.1.7);
- Collection of soil samples to delineate soil contamination in the vicinity of DPT-8 boring and the IRM area;
- Collection of soil characteristic parameter samples (Section 3.1.8); and
- Collection of a soil investigation-derived waste (IDW) composite sample for disposal purposes (Section 3.1.9).

RI activities will be conducted in accordance with the Draft DER-10 Technical Guidance for Site Investigation and Remediation (NYSDEC, December 2002) and Title 6 NYCRR Parts 375-1.6 and 375-3.6.

3.1 REMEDIAL INVESTIGATION FIELD ACTIVITES

The following subsections describe RI field activities proposed for Area 1. Note that the referenced Site-specific QAPP and its associated attachments are located in Appendix A. For all fieldwork performed, a notice of at least 7 business days will be given to the NYSDEC Project Manager and AVOX prior to initiation.

3.1.1 Soil Vapor Intrusion Evaluation

Based on the results of the PGA for Area 1 and subsequent written correspondence between NYSDEC and Tyco Safety Products, corporate parent of Scott Technologies, Inc., dated January 30, 2008, a soil vapor intrusion evaluation will be conducted for AVOX Plant 1 in accordance with Section 3.4 of the Draft DER-10 Technical Guidance for Site Investigation and Remediation (NYSDEC, December 2002) and the Guidance for Evaluating Soil Vapor Intrusion in the State of New York (New York State Department of Health [NYSDOH], October 2006). If the soil vapor intrusion evaluation indicates there is a potential issue, an expanded study will be discussed with the NYSDEC. Again, based on the current delineation of the groundwater plume, no vapor sampling is currently proposed for any of the residences located along Erie Street/Walter Winter Drive. In the event that RI data indicates potential groundwater impacts within 100 feet of a residence, the soil vapor intrusion evaluation will be expanded to include the potentially impacted residence.

The soil vapor intrusion evaluation for Area 1 is described below.

AVOX Plant 1 Preliminary Site Visit

On April 22, 2008, AECOM completed a preliminary Site visit at AVOX Plant 1. In particular, the Site visit focused on facility activities currently being conducted in the southwest corner of AVOX Plant 1 to document the use and/or storage of oils and other hazardous materials that could potentially interfere with the soil vapor intrusion evaluation. During the visit, and as illustrated in Figure 4, AECOM noted that the majority of rooms in the southwest corner of Plant 1 are used for, or adjacent to, product assembly and testing, equipment degreasing and repair, and storage of used oil. The aforementioned facility activities all actively use solvents, paints, glues, and oils that emit odors on a daily basis.

During a discussion with the AVOX Safety and Environmental Coordinator at the Site visit, it was determined that the relocation of the chemicals stored in the southwest corner of Plant 1 or temporarily halting the activities associated with the use of these chemicals is impractical. Potential vapor sample locations to the north or east within Plant 1 would be too far from the Area 1 plume to be considered representative of potential vapor intrusion issues related to the plume.

Official Pre-Sampling Inspection and Inventory

An official pre-sampling inspection and inventory will be performed prior to the collection of any vapor sample at AVOX Plant 1. The inspection will evaluate the type of structure, floor layout, air flows, and physical condition of Plant 1. This information, along with information on sources of potential indoor air contamination, will be identified on a building inventory form. A product inventory will be provided for each room in the southwest portion of Plant 1 that vapor intrusion samples will be collected. The objective of the inventory will be to actively identify the occurrence and use of chemicals and products that could potentially interfere with the soil vapor intrusion evaluation. The presence and description of odors (e.g., solvents) and portable vapor monitoring equipment readings will also be noted on the building inventory form and used to evaluate potential indoor air interferences in AVOX Plant 1.

Sub-slab Vapor Sampling

Figure 4 shows the three proposed sub-slab sampling location in the southwest area of Plant 1. At these locations, the slab will be penetrated by means of a portable electric drill. A temporary probe constructed with Teflon®-lined polyethylene tubing will be inserted no more than two inches into the sub-slab material. The annular space around the probe will be sealed at the surface of the slab with melted beeswax, modeling clay, or other non-VOC-containing, non-shrinking product for each temporary probe installation. Once the probe is constructed, helium will be applied to the surface of the sampling point as a tracer gas to evaluate the seal integrity. An apparatus outfitted with barbed connections will be placed over the sub-slab sampling point. A volume of helium will be directed from a cylinder into the apparatus and the sub-slab vapor will be screened for helium gas using a helium detector. If helium is detected, the probe will be reset, resealed, and retested until no leaks are detected.

After installation of the probe and helium tracer gas application, three volumes of vapor (i.e., the volume of the sample probe and tube) will be purged using a peristaltic pump prior to collection of the actual sub-slab vapor sample in a six-liter Summa® canister. Following sub-slab sample collection, the concrete floor will be repaired with floor patching materials (e.g., Quikcrete) that are approved by the AVOX Plant 1 facility contact.

Indoor Air Sampling

Three indoor air samples that are co-located with the aforementioned sub-slab vapor samples will be collected in the southwest area of Plant 1 (**Figure 4**). Indoor air samples will be collected by connecting a dedicated length of selected tubing to a six-liter Summa® canister and affixing the opposite end of the tubing to a sampling stand that is set at a height of approximately 3 to 5 feet above the floor (i.e., the breathing zone). One indoor air field duplicate sample will also be collected.

Outdoor Ambient Air Sampling

One ambient air background sample will be collected to the west of Plant 1 to represent outdoor air quality (Figure 4). The sampling methodology for outdoor air is similar to that of indoor air, with the exception that the sampling apparatus will be secured to maintain the preferred sampling height and prevent against weather-related interference. If field observations indicated that the proposed outdoor air sample location does not represent actual upwind conditions, relocation of the sampling point will be considered.

Sample Collection and Analytical Testing

The vapor/air samples will be collected in a six-liter Summa® canister over a 24-hour period. The vapor/air samples will be submitted via overnight courier to Contest Analytical of East Longmeadow, Massachusetts (an ELAP-certified laboratory) for analysis of VOCs using EPA Method TO-15. Analysis and reporting of the full list of VOCs under EPA Method TO-15 will be performed. Table 3 includes a summary of the soil vapor intrusion evaluation sample location numbers and the laboratory analysis requested. Table 4 includes a summary of sample container, preservation, and holding time requirements. A Data Usability Summary Report (DUSR) will be prepared to meet the NYSDEC requirements for all analytical data generated during an RI. Section 2.5.1 of the Site-specific QAPP contains further information related to soil vapor intrusion sampling protocol and laboratory analytical testing methodology.

Comparison to Standards, Criteria, and Guidance (SCGs)

Vapor sample analytical results for Area 1 will be compared to NYSDOH SCGs, as represented in the Decision Matrices in Section 3.4 of the New York State Guidance for Soil Vapor Intrusion (NYSDOH, October 2006). Based on this comparison, the next step, if any, related to soil vapor intrusion at AVOX Plant 1 will be addressed.

3.1.2 Groundwater Elevation Measurement

As indicated in Section 2.1.4 of this Work Plan, the most recent groundwater elevation measurements (May 31, 2007) collected for Area 1 indicated that the shallow overburden groundwater flow direction was primarily inward, towards the existing on-Site storm water sewer system. This groundwater flow direction was consistent with previous groundwater elevation measurement events collected at Area 1.

One round of groundwater elevation measurements will be collected from the network of temporary piezometers installed at Area 1 to verify that shallow overburden groundwater flow direction continues to remain consistent with previous measurement events and also to verify the final locations for permanent monitoring wells to be installed at Area 1 during the RI. Groundwater elevation measurement protocol is described in Section 2.2 of the QAPP.

3.1.3 Utility Clearance

AECOM or its selected subcontractor(s) will contact the Underground Facilities Protection Organization (UFPO) to clear proposed well and temporary piezometer locations. Utility clearance typically requires three days advance notice to the UFPO. Because this work is being conducted at Area 1 of the former Scott Aviation Facility, an assessment of privately-owned utilities will also be conducted for the investigation area. Following utility mark-out and clearance, AECOM will mobilize field personnel, field equipment, and subcontractors to the Site.

3.1.4 Permanent Monitoring Well Installation, Development, and Sampling

Permanent monitoring wells will be installed in the shallow and deep overburden groundwater at Area 1 to ensure that the existing groundwater plume is not migrating off-Site including to the northwest towards an adjacent residence. In addition, two permanent monitoring wells will be installed in bedrock to complete vertical delineation of groundwater contamination at Area 1. In the event the plume is not adequately delineated, discussions with Scott technologies and the agency will be held to determine if additional monitoring wells may be needed.

Overburden Monitoring Well Installation

Nine new overburden monitoring wells (three upper overburden and six deep overburden) will be constructed using 2-inch diameter Schedule 40 polyvinyl chloride (PVC) well casing and well screen. Three of these wells (MW-35S, MW-36S, and MW-37S) will be screened in the shallow overburden groundwater (Figure 4), and six of these wells (MW-35D, MW-36D, MW-37D, MW-38D, MW-39D, and MW-40D) will be screened in the deep overburden groundwater (Figure 5). Screens for each of these wells will be 0.010-inch slot size. Each well will be completed in a continuous 4 ¼ - inch hollow stem auger boring which will extend to a depth determined in the field from split spoon samples. Based on data presented in the PGA Report, the anticipated screened interval for the upper overburden wells will be 5-15 feet bgs, and the anticipated screened interval for the deep overburden wells will be in the water-bearing zone (approximately 15 to 20 feet bgs) just above split spoon refusal (i.e. top of weathered bedrock). The annular space between the well screen and the borehole will be backfilled with an appropriately sized silica sand filter pack (#00) to one foot above the top of screen. A 2-foot thick bentonite seal will be placed on top of the filter pack, and the balance of the annular space will then be backfilled with grout. The well heads at MW-35S, MW-35D, and MW-38D will be completed in an 8-

inch diameter, bolt-down, traffic-rated manhole cover installed in a 2' x 2' x 6" concrete pad. The well heads at MW-36S, MW-36D, MW-37S, MW-37D, MW-39D, and MW-40D will be stick-up completions with a 4-inch steel protective casing set in a 2' x 2' x 6" concrete pad.

Bedrock Monitoring Well Installation

Two new bedrock monitoring wells (MW-41B1 and MW-41B2) will be installed using water or mud rotary drilling methods within the identified source area for the Site (Figure 5). One bedrock well will be completed below the top of competent rock and the second will be completed within the weathered bedrock zone (if present).

The deeper of the two bedrock monitoring wells will be installed by advancing a 4 ¼ - inch inner diameter auger to the top of competent bedrock. A tri-cone roller bit will then be used to install an overburden casing socket a minimum of 3 feet into the top of competent rock. A 4-inch steel casing will be cement-bentonite grouted in place to approximately 2 feet above ground surface. After allowing the grout to set a minimum of 24 hours, a nominal 4-inch diameter bedrock core hole will be advanced using wireline coring methods. A wireline HQ-size core barrel will be used to make up to a 10-foot core run to the desired well completion depth. The monitoring well will be constructed using 2-inch diameter Schedule 40 PVC well casing and well screen. The well screen will have a 0.010-inch slot size. The annular space between the well screen and the borehole will be backfilled with an appropriately sized silica sand filter pack (#00) to one foot above the top of screen. The filter pack will be followed by a 2-foot thick bentonite seal, and the balance of the annular space will then be backfilled with grout. The well head will be a stick-up completion with a 4-inch steel protective casing set in a 2' x 2' x 6" concrete pad.

The deep bedrock monitoring well will be completed in a water-bearing zone. If a water-bearing zone is not encountered within 20 feet below the bottom of the overburden casing, the NYSDEC project manager will be contacted to discuss options of continuing deeper or completing the well at the current depth. If groundwater is not encountered in the bedrock well within 48 hours, it will be interpreted that impacted deep overburden groundwater has not entered the bedrock and vertical delineation of the Area 1 groundwater plume is complete. The bedrock boring will then be abandoned. Well abandonment will be performed in accordance with NYSDEC draft Groundwater Monitoring Well Decommissioning Policy (NYSDEC, June 11, 2009) and will include the removal of casing and screen, over-drilling of the well borehole, and grouting to the surface. A record will be prepared for the abandoned well (refer to Attachment 1 in the QAPP).

The weather bedrock zone monitoring well will be installed using the same techniques as described for the deeper bedrock monitoring well. The well screen will extend from the top of split spoon refusal and extend to auger refusal. If the zone of weathered bedrock is determined to be less than two feet, the NYSDEC project manager will be contacted to discuss options for completing the well.

Construction details for the overburden groundwater well installations and the bedrock well installation will be recorded on individual well completion forms. Examples of these forms are included in Attachment 1 of the QAPP. Soil cuttings produced during monitoring well installation will be placed in properly labeled Department of Transportation (DOT)-rated 55-gallon drums for future soil IDW disposal (See Section 3.1.9 of this Work Plan and Section 2.8 of QAPP for additional information). These drums will subsequently be stored inside the existing groundwater treatment building located to the west of AVOX Plant 2 pending receipt of disposal characterization analytical results.

Continuous split spoon sampling will be conducted at each new well location. A qualified AECOM geologist or field engineer will describe soil samples by visual examination in accordance with New York State DOT soil description procedure. Soil descriptions will be recorded in the field notebook. A log of each boring will be prepared using the HTW Drill Log included in Attachment 1 of the QAPP. Soil screening using a photoionization detector (PID) will be conducted during the installation of each new monitoring well. A complete description of soil screening procedures using the PID is presented in Section 2.1 of the QAPP.

Monitoring Well Development

After installation, all new wells will be developed to remove sediment from the well screen and sand pack material. Well development will attempt to produce groundwater samples with less than 5 nephelometric turbidity units. However, because of the fine-grained composition of the subsurface soils at Area 1, this target value may not be achievable. Development will be performed using a bailer or surface pump. Groundwater withdrawal rates will be calibrated to avoid bailing or pumping the well completely dry. Development will proceed until pH, temperature, conductivity and turbidity stabilize to within 10 percent on three successive readings. The AECOM Project Manager will be contacted if stabilization of water quality parameters is not achieved after removal of five well volumes, or if the well runs dry on three successive development attempts. Data collected during well development activities will be recorded on the Monitoring Well Development Log, included in Attachment 1 of the QAPP.

Development water will be containerized in properly labeled DOT-rated 55-gallon drums for disposal at an existing groundwater remediation system, which is owned and operated by Scott Technologies, Inc. and located to the west of AVOX Plant 2 (refer to Section 2.8 in the QAPP for additional information). Any hazardous wastes generated during or as a result of monitoring well development or installation activities will be managed and disposed of in accordance with all applicable laws, and Scott Technologies, Inc. will be the generator of record for any such wastes and will utilize its own EPA ID number for all waste management and disposal activities. Monitoring well development equipment will be decontaminated between uses as described in Section 2.4 of the QAPP.

Groundwater Elevation Measurement

Prior to the start of each groundwater sampling event, measurement of one complete set of initial static groundwater levels for the monitoring well and piezometer network will be completed. Groundwater elevation measurement protocol is described in Section 2.2 of the QAPP.

Monitoring Well Sampling

Two rounds of groundwater samples will be collected from each of the newly installed permanent monitoring wells as well as the existing shallow overburden piezometers and monitoring well MW-30 using low flow sampling techniques. The aqueous samples will be submitted to Test America (an ELAP-certified laboratory) in Amherst, New York for VOC analyses. The sample collected from monitoring well MW-30 will additionally be submitted for analysis of TAL metals. The samples collected from monitoring wells MW-36S, MW-39D, and MW-41B2 will additionally be analyzed for SVOCs, polychlorinated biphenyls (PCBs), pesticides, and metals analyses. Attachment 1 in the QAPP includes an example of a sampling log, and Attachment 2 in the QAPP contains a description of low-flow sampling procedures. Table 3 includes a summary of the monitoring well groundwater sample location numbers, analyses requested, and the number of groundwater samples to be collected including QA/QC samples. Table 4 includes a summary of sample container, preservation, and holding time requirements. A DUSR will be prepared to meet the NYSDEC requirements for all analytical data generated. Section 2.5.2 of the QAPP contains further information related to groundwater sampling.

Comparison to SCGs

Groundwater sample analytical results for Area 1 will be compared to Title 6 NYCRR Part 703 Class GA Groundwater Standards.

Potential Additional Well Installation

Based on the bedrock groundwater analytical results obtained during this RI, additional monitoring well installations may be warranted. Prior to the installation of any additional bedrock monitoring wells, agreement on location and number of wells will be obtained from the NYSDEC. Additional well installations will be completed as a separate mobilization.

3.1.5 Soil Contamination Delineation

DPT-8 Area

During the Phase II Environmental Site Investigation a grab sample of foundry sand was collected from boring DPT-8 (0-1’ bgs) as part of the Plant No. 1 Foundry Area investigation. Delineation of the current Part 375 soil cleanup objective exceedances observed in the DPT-8 (0-1’) sample will be performed during this RI investigation. The delineation will be accomplished by collecting continuous split-spoon samples from ground surface to the water table at three locations in the grassy area located south of the DPT-8 location. The final location of these borings will be agreed to by the NYSDEC.

A soil sample from each boring will be collected from the 0-2’ bgs interval and the interval with the highest PID or evidence of visual impacts. If no elevated PID reading is encountered and no evidence of impacted soil is observed, the soil sample will be collected from the two foot interval immediately above the groundwater table. A total of three soil samples will be submitted to Test America (an ELAP-certified laboratory) in Amherst, New York for VOCs, SVOCs, polychlorinated biphenyls (PCBs), pesticides, and metals analyses.

IRM Area

During the installation of the new deep overburden monitoring wells, soil samples will be collected from the perimeter of the currently identified VOC plume. A soil sample will be collect within the unsaturated zone from the soil borings associated with the installation of monitoring wells MW36D, MW-37D, and MW-39D. The sample will be collected from the two foot interval with the highest PID or evidence of visual impacts. If no elevated PID readings are encountered and no evidence of impacted soil is observed, the soil sample will be collected from the two foot interval immediately above the groundwater table. The soil samples will be submitted to Test America (an ELAP-certified laboratory) in Amherst, New York for VOCs, SVOCs, PCBs, pesticides, and metals analysis.

3.1.6 Temporary Piezometer Installation, Development, and Sampling

Two temporary piezometers (TP-1 and TP-2) will be installed along the north-south orientated storm water sewer line located at Area 1 and two temporary piezometers (TP-3 and TP-4) will be installed along the east-west orientated storm water sewer line (Figure 4). The temporary piezometers will be installed using a hand auger and screened in the storm water sewer line gravel bedding to confirm the effect or lack of effect of the storm sewer gravel bedding on the offsite migration of Area 1 groundwater plume configuration. Each temporary piezometer will consist of ¾-inch diameter PVC riser pipe, a 0.010-inch slotted PVC screen (exact length to be determined in the field), and a PVC end cap. For each temporary piezometer completion, a sand pack extending one foot above the top of the screen and a bentonite seal will be used. The anticipated top of screen interval for each of the temporary piezometers will be approximately 4 to 5 feet bgs. The exact screen interval will be determined in the field depending on the actual depth of the gravel bedding. Soil cuttings generated during temporary piezometer installation will be placed in properly labeled DOT-rated 55-gallon drums for future soil IDW disposal. These drums will subsequently be stored inside the existing groundwater treatment building located to the west of AVOX Plant 2 pending receipt of disposal characterization analytical results, in accordance with all applicable laws. Scott Technologies, Inc. will be the generator of record for all wastes generated during or as a result of temporary piezometer development or installation activities and will utilize its own EPA ID number for all waste management and disposal activities, including storage. The temporary piezometers will be removed at the end of RI field activities with NYSDEC concurrence.

Each of the temporary piezometers will be developed and sampled as described in Section 3.1.4 of this Work Plan. Two rounds of groundwater samples will be submitted to TestAmerica in Amherst, New York for VOC analysis. Table 3 includes a summary of the temporary piezometer groundwater sample location numbers, analyses requested, and the number of groundwater samples to be collected. Table 4 includes a summary of sample container, preservation, and holding time requirements. A DUSR will be prepared to meet the NYSDEC requirements for the analytical data generated. Section 2.5.2 of the Site-specific QAPP contains further information related to groundwater sampling.

3.1.7 Surveying

A surveyor licensed in the State of New York will survey all newly installed permanent monitoring wells, temporary piezometers, and soil borings. The subcontractor will use the temporary benchmark developed during previous Site investigation fieldwork (fire hydrant at southern end of the existing groundwater extraction trench, on the north side of Erie Street). Location and elevation data (ground, top-of-well casing, top-of-protective casing) will be obtained at each new monitoring well. Vertical measurements will be made relative to the National Geodetic Vertical Datum. Vertical measurements will be accurate to within 0.01 foot. Horizontal measurements will be accurate to within 0.1 foot. The temporary piezometers will be surveyed for horizontal coordinates only.

Per BCP requirements, a licensed State of New York land surveyor will also be subcontracted to perform an ALTA survey to establish the final BCP boundaries for Area 1. Appendix B includes a copy of the 2005 Minimum Standard Detail Requirements for ALTA Land Title Surveys.

3.1.8 Aquifer Characterization Testing

Testing will be conducted during the RI to determine characteristic properties of the shallow and deep overburden aquifer at Area 1. A slug test will be performed at one new shallow overburden monitoring well and one new deep overburden monitoring well to determine the hydraulic conductivity of the surrounding geologic material. The slug test method involves lowering or raising the static water level in a well bore by the removal or insertion of a cylinder (slug) of known volume. The return of the water level to a pre-test static level is then measured over time. The change in water level over time is plotted to determine hydraulic conductivity (K). K is a function of the formation permeability, the fluid in the formation, and is influenced by well construction.

The monitoring wells will be tested by rising head and falling head methods. Aquifer testing data will be recorded on the slug test data log that is included in Attachment 1 of the QAPP. In the event that one form of the test cannot be conducted, the well location and the problem will be documented. For the rising head test, if possible, the slug test will be performed in such a manner as to prevent the water level in the well from dropping below the top of the screened interval when the slug is removed. Each test will be performed following the completion of groundwater sampling at the selected wells, and testing will be contingent upon the selected monitoring well containing sufficient water to allow for testing (i.e., minimum of 5 feet or as determined by the Field Geologist).

Slug tests will only be initiated after the well has recovered from groundwater sampling (or after a minimum of 12 hours has elapsed) and will be conducted in accordance with Attachment 3 in the QAPP, SOP 09, *Conducting Slug Tests*.

3.1.9 Site Soil Characteristic Parameter Sampling

As previously described in Section 3.1.4 of this Work Plan, MW-41B1 will be installed in the identified source area for Area 1. One shallow overburden soil sample and one deep overburden soil sample will be collected from MW-41B1 to characterize the soil at Area 1. An additional sample will be collected from the soil cuttings that exhibit the highest (PID) detector readings at MW-41B1 to assess future soil disposal characteristics. Table 3 includes a summary of the soil sample analyses requested. Table 4 includes a summary of sample container, preservation, and holding time requirements. A DUSR will be prepared to meet the NYSDEC requirements for the soil sample analytical data generated. Section 2.5.3 of the Site-specific QAPP contains further information related to soil sampling.

3.1.10 Investigation-Derived Waste Sampling

As described in Sections 3.1.4 and 3.1.5 of this Work Plan, soil cuttings generated during permanent monitoring well and temporary piezometer installation will be placed in properly labeled DOT-rated 55-gallon drums. One composite soil sample will be collected from the drums of soil cuttings generated and submitted to Test America for analyses. Table 3 summarizes the laboratory analytical requested, and Table 4 summarizes sample container, preservation, and holding time requirements. Section 2.8 of the QAPP contains additional information related to IDW generated during the RI. All soil drums will be temporarily stored inside the groundwater treatment building located to the west of AVOX Plant 2 pending receipt of disposal characterization analytical results, in accordance with all applicable laws.

Scott Technologies, Inc. will be the generator of record for all wastes generated during or as a result of monitoring well or temporary piezometer development or installation activities and will utilize its own EPA ID number for all waste management and disposal activities, including storage. .

4.0 ALTERNATIVES ANALYSIS APPROACH

The approach for selecting an appropriate remedial alternative for a Site consists of developing a list of potentially applicable remedial technologies, screening the list of technologies, assembling a focused list of remedial alternatives, and evaluating the remedial alternatives. This section presents the approach that will be used to both screen the potentially applicable remedial technologies and to evaluate the focused list of assembled remedial alternatives. AA activities will be conducted in accordance with the Draft DER-10 Technical Guidance for Site Investigation and Remediation (NYSDEC, December 2002) and Title 6 NYCRR Parts 375-1.8 and 375.3.8.

4.1 REMEDIAL GOALS AND REMEDIAL ACTION OBJECTIVES DEVELOPMENT

The results from the proposed RI activities in Section 3.0 of this Work Plan and previous Site investigations will be utilized to establish remedial goals and to develop RAOs for Area 1. RAOs are medium-specific objectives for the protection of public health and the environment and are developed based on contaminant-specific SCGs.

4.2 TECHNOLOGY SCREENING CRITERIA

Once the RAOs are developed, a list of potentially applicable remedial technologies for Area 1 will be developed and subsequently screened. The initial screening process will be used to develop a focused list of applicable remedial alternatives that will be more fully evaluated. Criteria used to initially screen potentially applicable remedial technologies include Site, contaminant, and technology characteristics. A description of each criterion is provided below:

- Site characteristics: All Site investigation data will be reviewed to identify conditions that may limit or preclude the use of certain technologies. Technologies whose use are clearly precluded by Site characteristics will be eliminated from further consideration;
- Contaminant characteristics: Identification of contaminant characteristics that limit the effectiveness or feasibility of technologies is an important part of the screening process. Technologies clearly limited by these contaminant characteristics will be eliminated from consideration. Contaminant characteristics particularly affect the feasibility of in situ methods, direct treatment methods, and land disposal (on/off Site); and
- Technology limitations: During the screening process, the level of technology development; the performance record; and the inherent construction, operation, and maintenance problems will be identified for each technology considered. Technologies that are unreliable, perform poorly, or are not fully demonstrated will be eliminated during the screening process.

4.3 ALTERNATIVES ANALYSIS

Technologies which pass the initial screening will be subsequently used to develop remedial alternatives. Each alternative will be evaluated according to the following standards:

- Overall protection of human health and the environment;
- Compliance with SCGs;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume with treatment;
- Short-term effectiveness;
- Implementability; and
- Cost.

Based on the results of the AA evaluation, a remedy for Area 1 will be recommended.

5.0 QUALITY ASSURANCE/QUALITY CONTROL ACTIVITIES

QA/QC activities are described in the QAPP (Appendix A).

A qualified AECOM representative will oversee all field activities conducted. QA/QC is a responsibility of the AECOM Project Manager. All analytical laboratories used for sample analysis during the RI will comply with the requirements of the NYSDEC document "Analytical Laboratory Terms, Division of Environmental Remediation" and will hold current NYSDOH ELAP certification in all categories of Contract Laboratory Protocol analysis. The 1995 NYSDEC Analytical Services Protocol (ASP) will be followed unless approved otherwise by the NYSDEC Project Manager, for example, if necessary to achieve lower detection limits for evaluation of remedial goals and standards. All laboratory analytical data generated during the RI will be reported in NYSDEC ASP Category B deliverables package.

All analytical methods, both ASP and non-ASP, are specified in the Section 3.0 of this Work Plan and the QAPP. Any deviations from these methods will be approved in advance by the NYSDEC. Accordingly, AECOM's Quality Assurance Officer will maintain close contact with both the NYSDEC and all analytical laboratories used to correct any analytical problems that may arise during analyses. A DUSR, prepared independently of the analytical laboratory, will be produced for all analytical data generated during the RI to ensure that the data are obtained in a manner to ensure sufficient quality to support subsequent decisions.

The collection of QA/QC samples such as duplicates/replicates, blanks, and Matrix Spike/Matrix Spike Duplicates and use of standard Reference Materials are summarized in Section 4.0 of the QAPP.

6.0 SITE-SPECIFIC HEALTH AND SAFETY PROTOCOLS

Activities described in the RI/AA Work Plan for Area 1 will be performed in accordance with the Site-specific HASP (Appendix C). At a minimum, all field personnel will be required to be 40-hour HAZWOPER-trained and wear the following protective equipment:

- Hard-hats;
- Steel-toed safety boots;
- Safety glasses;
- Latex gloves (as necessary); and
- Hearing protection (e.g., ear plugs when necessary).

7.0 PROJECT SCHEDULE, REPORTING, AND STAFFING

7.1 PROJECT SCHEDULE

Project activities described in this RI/AA Work Plan will begin immediately upon receipt of written approval for the Final RI/AA Work Plan by the NYSDEC. RI activities at Area 1 are anticipated to commence following review of the RI/AA Work Plan by the NYSDEC and NYSDOH, incorporation of their comments, and a 30-day public review period. Presently, RI activities are anticipated to commence after March 31, 2010, with completion of all RI activities and submittal of the Final AA by October 29, 2010. The proposed project schedule is included as Figure 6. Minor changes to the schedule may occur due to the NYSDEC review and approval process, unforeseen weather delays, and/or the coordination of RI activities with the ongoing operation of AVOX's facility so as not to unreasonably disturb AVOX's operations, particularly for any work taking place in a building interior.

The following is an approximate timeline of BCP activities for the Site prior to submittal of this document;

- BCP pre-application meeting – April 8, 2008,
- Submittal of draft BCP application, draft RI/AA, and draft CPP – May 12, 2008,
- NYSDEC complete informal review of draft BCP application, draft RI/AA, and draft CPP – July 24, 2008,
- Submittal of BCP application, draft RI/AA, and draft CPP – September 2008,
- Moratorium on the Brownfield Cleanup Program,
- Effective date of BCP Agreement between NYSDEC and Tyco – August 12, 2009,
- NYSDEC complete review of RI/AA and CPP – September 2, 2009 and September 14, 2009,
- Submittal of final RI/AA – October 13, 2009,
- Submittal of final CPP – October 29, 2009,
- NYSDEC submit additional comments on the final RI/AA and final CPP – December 14, 2009,
- Submittal of response to comments – January 6, 2010,
- NYSDEC accepts response to comments – January 21, 2010.

7.2 PROJECT REPORTING

Monthly progress reports will be provided to the NYSDEC, with a copy to AVOX, upon commencement of RI activities at Area 1. Following completion of RI activities, and consultation with AVOX, a Draft AA Report will be prepared to summarize the findings of the RI and to provide a recommended remedial alternative for Area 1. The Draft AA Report will be provided to the NYSDEC, with a copy to AVOX.

Upon incorporation of comments by the NYSDEC, a Final AA Report will be issued. A Fact Sheet summarizing the AA Report results will be issued concurrently with the Final AA Report, and copies of both will be provided to AVOX.

7.3 PROJECT STAFFING

Figure 7 is an organization chart for this project including key management and technical responsibilities, proposed personnel, and subcontractors.

8.0 CITIZEN PARTICIPATION ACTIVITIES

Citizen participation activities will be completed in accordance with the *Draft Brownfield Cleanup Program Guide* (NYSDEC, May 2004). As required, a Brownfield Site Contact List will be developed, which will include AVOX, and a local document repository will be established. A Citizen Participation Plan for the Site will be developed for Area 1 and issued under separate cover. It will provide both NYSDEC and AVOX the opportunity for review and approval of notices, fact sheets, and other public communications prior to issuance.

9.0 REFERENCES

Earth Tech. January 2008. "Preliminary Groundwater Assessment Report, Former Scott Aviation Facility, Lancaster, New York".

Earth Tech. June 2004. "Phase II Environmental Site Investigation Summary Report, Tyco/Scott Aviation Facility, Lancaster, New York".

Earth Tech. April 2004. "Phase I Environmental Site Assessment and Modified Compliance Assessment, Tyco/Scott Aviation Facility, Lancaster, New York".

Earth Tech. November 2003. "Remedial Design Work Plan, Scott Aviation, Inc., Lancaster, New York".

NYSDEC. May 2004. "Draft Brownfield Cleanup Program Guide".

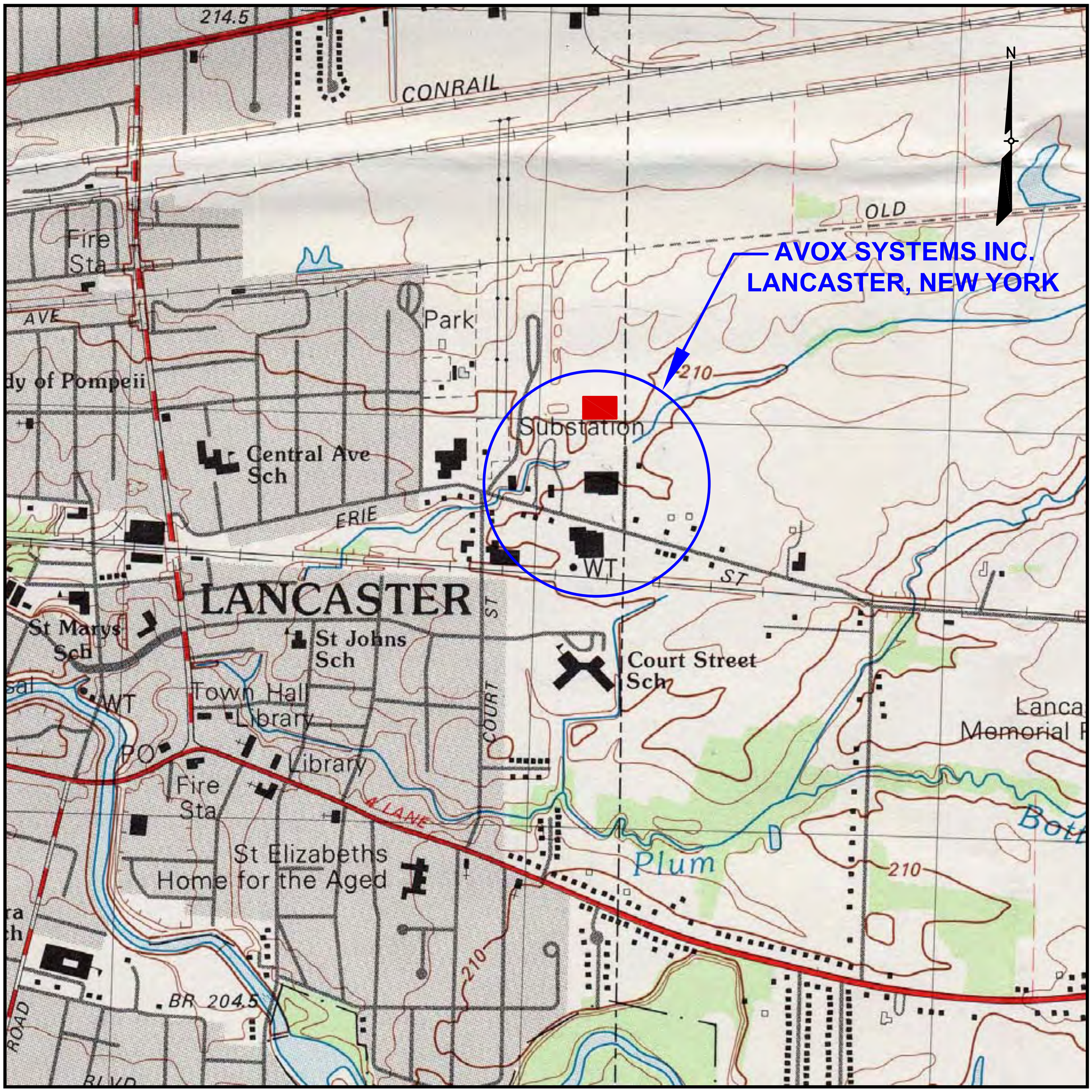
NYSDEC. April 2003. "Groundwater Monitoring Well Decommissioning Procedures".

NYSDEC. December 2002. "New York State Department of Environmental Conservation, Division of Environmental Remediation, Draft DER-10 Technical Guidance for Site Investigation and Remediation".

NYSDOH. October 2006. "Guidance for Evaluating Soil Vapor Intrusion in the State of New York".

Versar, Inc. November 1993. "Remedial Investigation Report, Scott Aviation, 225 Erie Street, Lancaster, New York".

FIGURES



SOURCE:
1982 GEOLOGIC SURVEY 7.5 X 15 MINUTE TOPOGRAPHIC QUADRANGLE
LANCASTER, NEW YORK

LEGEND

AVOX PLANT 3 ADDED AFTER PUBLICATION OF LANCASTER, NEW YORK TOPOGRAPHIC QUADRANGLE.

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AECOM

FIGURE 1
SITE LOCATION MAP

FORMER SCOTT AVIATION FACILITY AREA 1
LANCASTER, NEW YORK

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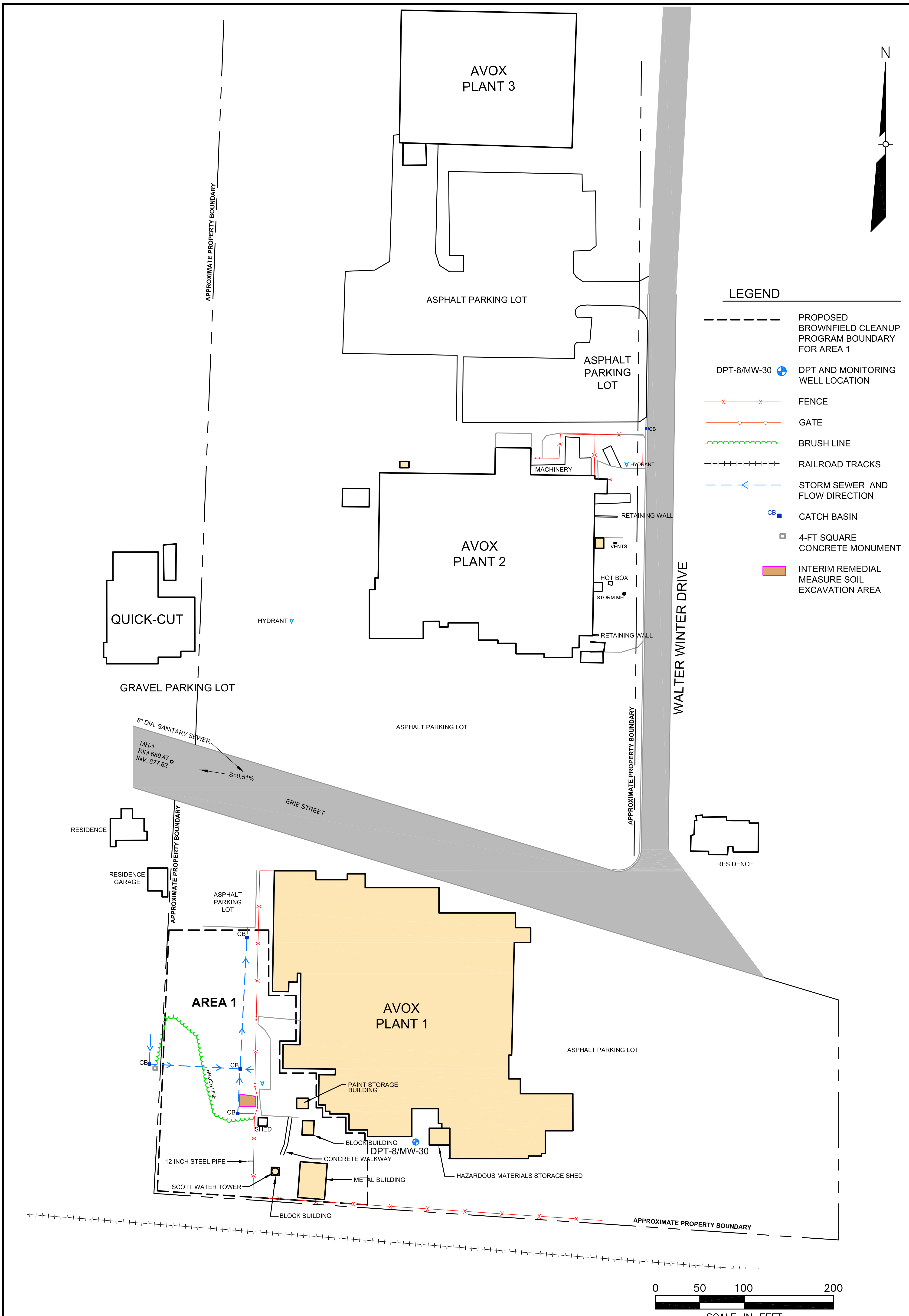

AECOM

FIGURE 2
FACILITY LAYOUT MAP

FORMER SCOTT AVIATION FACILITY AREA 1
LANCASTER, NEW YORK

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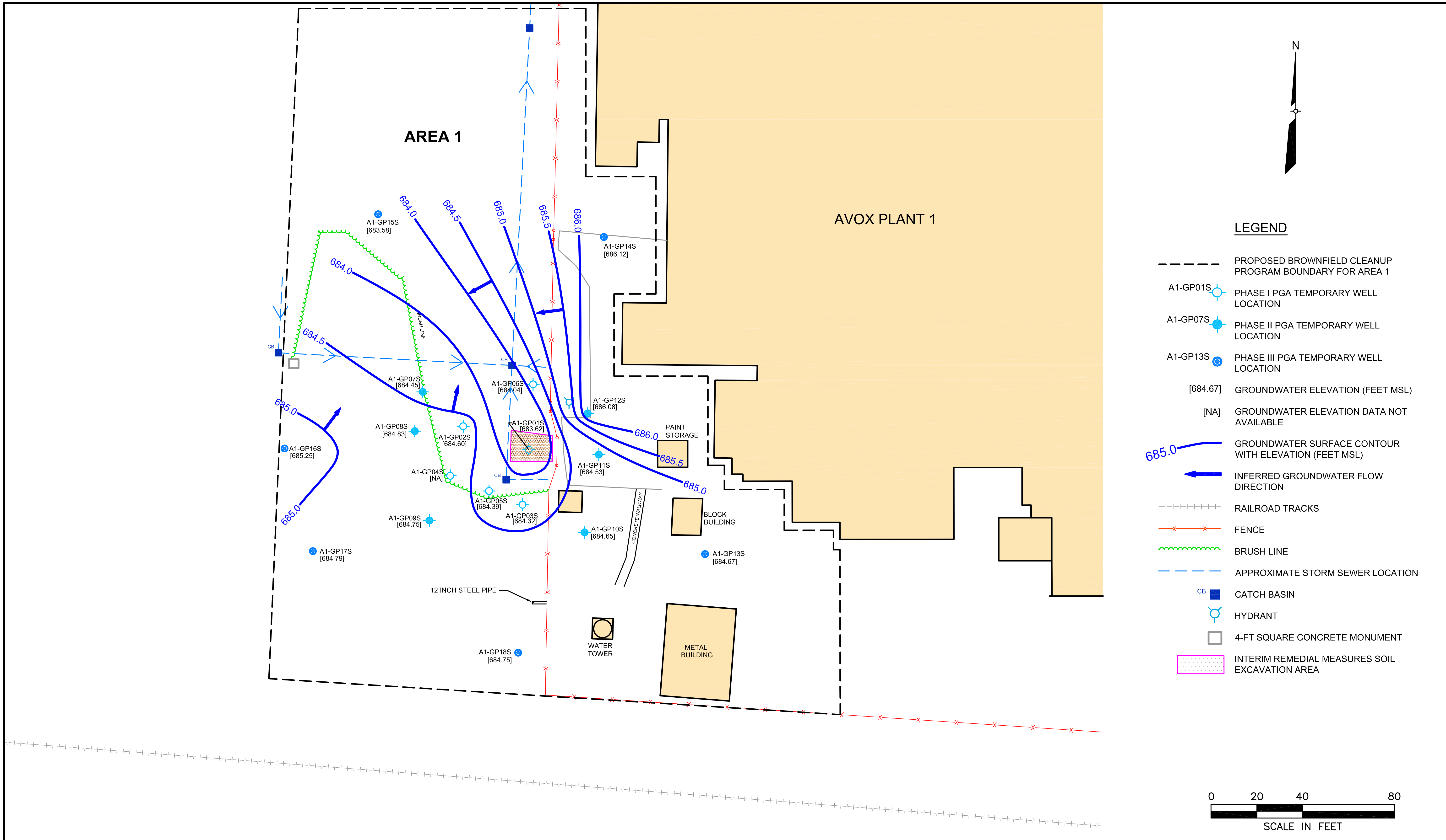
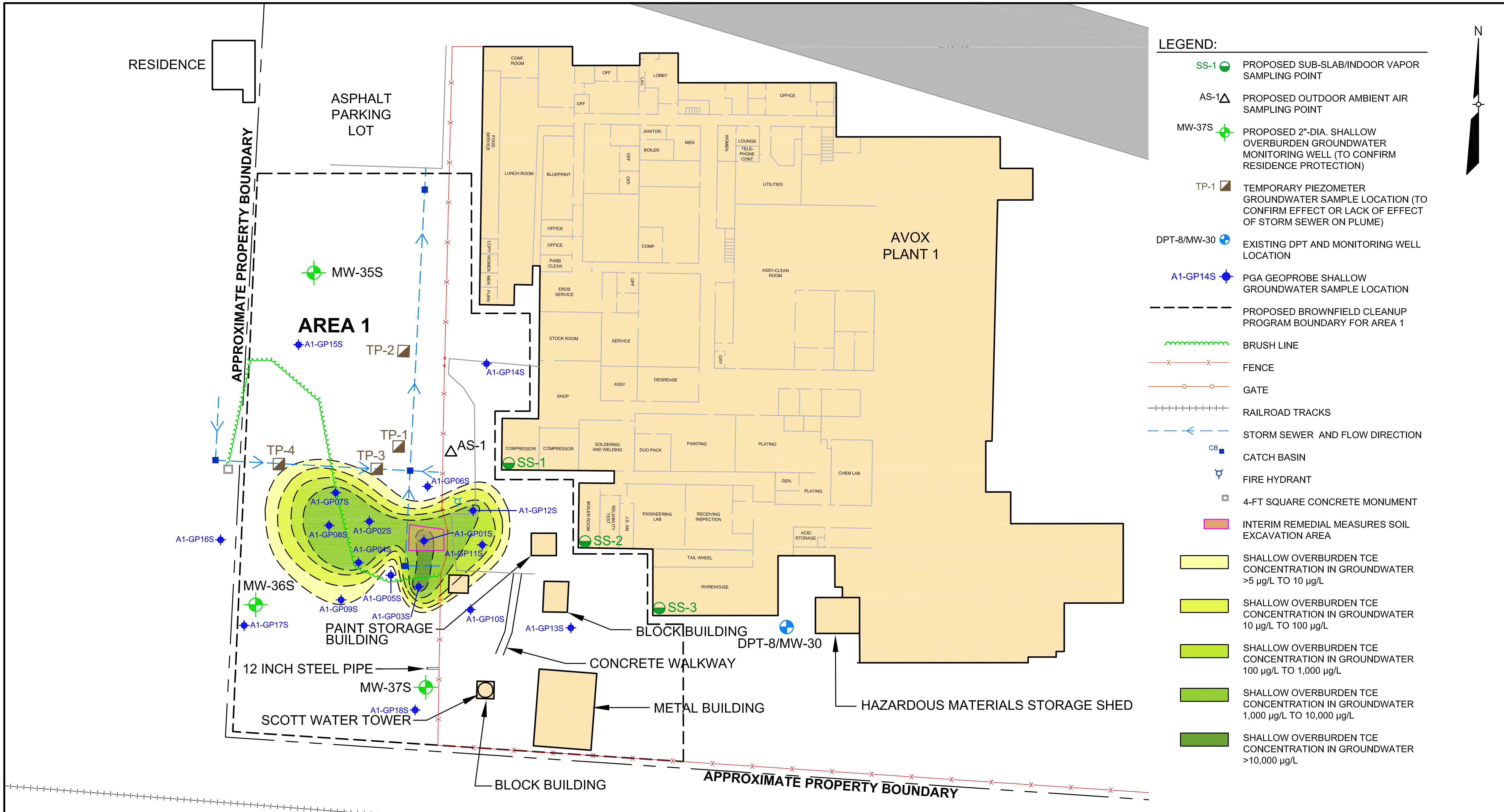


AECOM

FIGURE 3
GROUNDWATER SURFACE CONTOUR MAP
SHALLOW OVERBURDEN GROUNDWATER - AREA 1
MAY 31, 2007
FORMER SCOTT AVIATION FACILITY AREA 1
LANCASTER, NEW YORK

L:\work\82152\CADD\82152_037 Phase III PGA GW Samp Loc Map.dwg, 2/3/2010 9:48:18 AM, splawnm



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SCALE IN FEET

NOTES:

ISOCONCENTRATION CONTOURS WERE DEVELOPED FROM DATA COLLECTED DURING THE THREE PHASES OF THE PRELIMINARY GROUNDWATER ASSESSMENT. DATES SAMPLES WERE COLLECTED WERE AS FOLLOWS:

PGA PHASE	PIEZOMETERS	DATES SAMPLED
I	1S - 6S	2/28/06 - 3/2/06
II	7S - 12S	5/15/06 - 5/17/06
III	13S - 18S	5/23/07 - 5/24/07

AECOM

FIGURE 4
PROPOSED SOIL VAPOR INTRUSION AND SHALLOW OVERBURDEN MONITORING / SAMPLING LOCATIONS
FORMER SCOTT AVIATION FACILITY AREA 1
LANCASTER, NEW YORK

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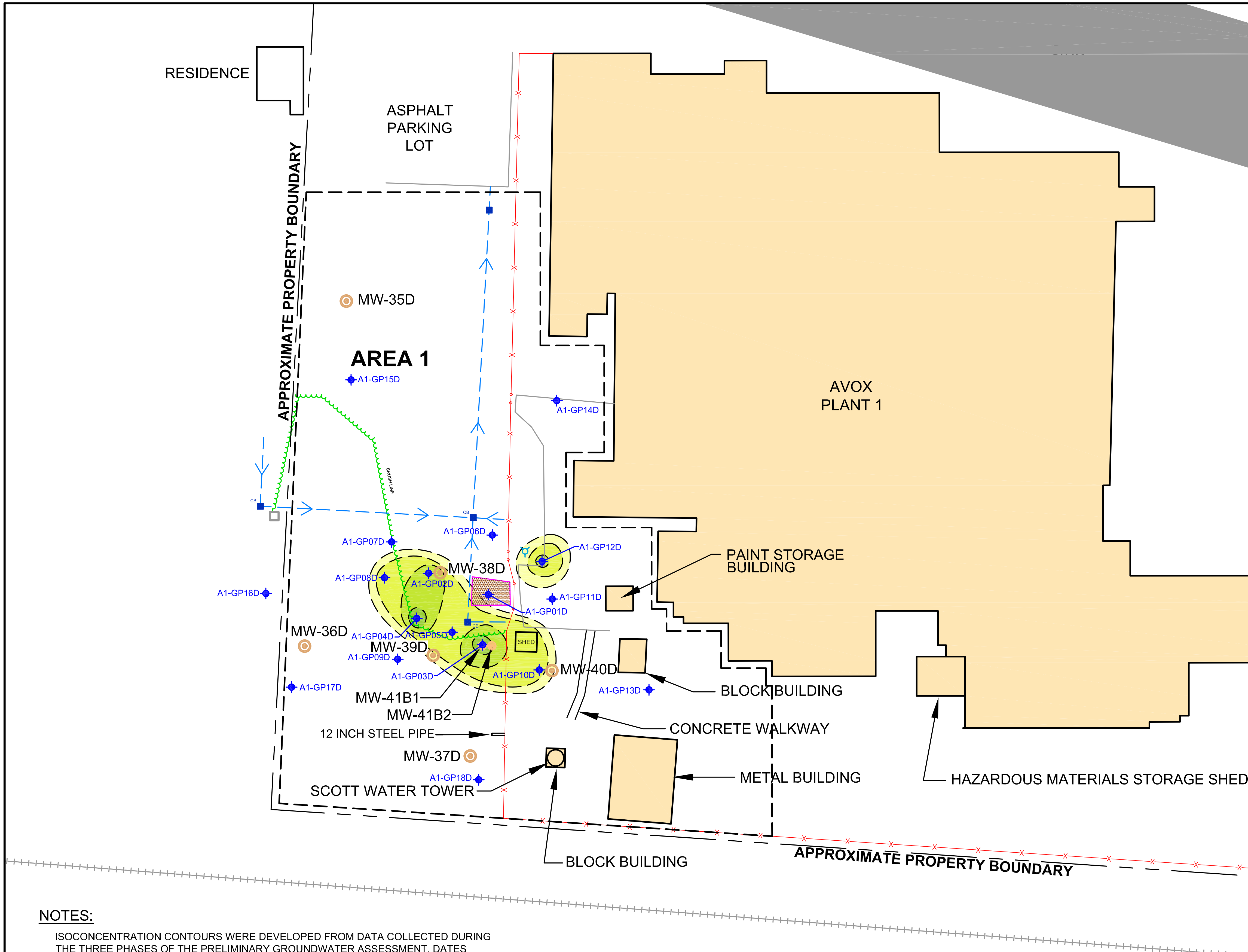


LEGEND

MW-41B	PROPOSED 2"-DIA. BEDROCK MONITORING WELL (TO CONFIRM VERTICAL DELINEATION)
MW-38D	PROPOSED 2"-DIA. DEEP OVERBURDEN GROUNDWATER MONITORING WELL (TO CONFIRM RESIDENCE PROTECTION)
A1-GP14D	PGA GEOPROBE DEEP GROUNDWATER GRAB SAMPLE LOCATION. ALL LOCATIONS HAVE BEEN ABANDONED.
	PROPOSED BROWNFIELD CLEANUP PROGRAM BOUNDARY FOR AREA 1
	RAILROAD TRACKS
	FENCE
	GATE
	BRUSH LINE
	STORM SEWER AND FLOW DIRECTION
CB	CATCH BASIN
	HYDRANT
	4-FT SQUARE CONCRETE MONUMENT
	INTERIM REMEDIAL MEASURES SOIL EXCAVATION AREA
	DEEP OVERBURDEN TCE CONCENTRATION IN GROUNDWATER >5 µg/L TO 10 µg/L
	DEEP OVERBURDEN TCE CONCENTRATION IN GROUNDWATER 10 µg/L TO 100 µg/L
	DEEP OVERBURDEN TCE CONCENTRATION IN GROUNDWATER 100 µg/L TO 1,000 µg/L
	DEEP OVERBURDEN TCE CONCENTRATION IN GROUNDWATER >1,000 µg/L

0 25 50 100

SCALE IN FEET

NOTES:

ISOCONCENTRATION CONTOURS WERE DEVELOPED FROM DATA COLLECTED DURING THE THREE PHASES OF THE PRELIMINARY GROUNDWATER ASSESSMENT. DATES SAMPLES WERE COLLECTED WERE AS FOLLOWS:

PGA PHASE	PIEZOMETERS	DATES SAMPLED
I	1D - 6D	2/28/06 - 3/3/06
II	7D - 12D	5/15/06 - 5/17/06
III	13D - 18D	5/23/07 - 5/24/07

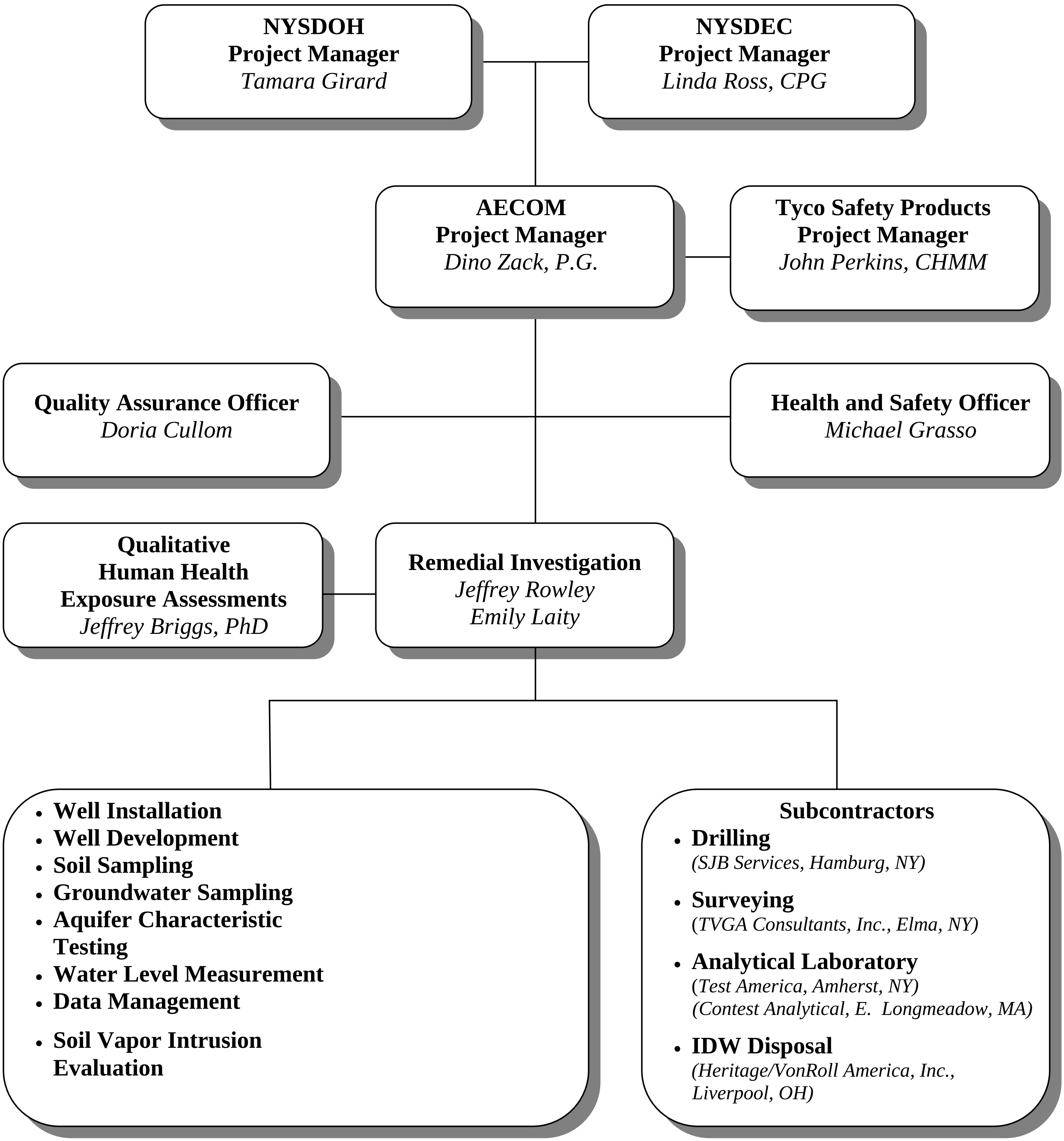
AECOM

FIGURE 5
PROPOSED DEEP OVERBURDEN AND BEDROCK MONITORING/SAMPLING LOCATIONS

FORMER SCOTT AVIATION FACILITY AREA 1
LANCASTER, NEW YORK

L:\work\82152\CADD\82152_044 Proposed Deep Overburden and Bedrock Samp Locs.dwg, 2/4/2010 5:04:56 PM, splawnm

Figure 7
Project Organization Chart
Remedial Investigation/Alternatives Analysis Work Plan
Former Scott Aviation Facility Area 1
Lancaster, New York



TABLES

Table 1
Temporary Piezometer Installation Details
Former Scott Aviation Facility Area 1
Lancaster, New York

Location ID	PGA Phase	Date Soil Boring Completed	Depth To Bottom of Geoprobe Boring (ft bgs) (1)	Piezometer Screen Interval (ft bgs)
Area 1				
A1-GP01S	Phase I	2/27/2006	18	5-15
A1-GP02S		2/27/2006	20.4	5-15
A1-GP03S		2/27/2006	21	5-15
A1-GP04S		2/27/2006	20.5	5-15
A1-GP05S		2/27/2006	21	5-15
A1-GP06S		2/27/2006	20	5-15
A1-GP07S	Phase II	5/16/2006	20.5	5-15
A1-GP08S		5/16/2006	20	5-15
A1-GP09S		5/16/2006	20.3	5-15
A1-GP10S		5/16/2006	22.5	5-15
A1-GP11S		5/15/2006	22.5	5-15
A1-GP12S		5/16/2006	22	5-15
A1-GP13S	Phase III	5/22/2007	23.2	5-15
A1-GP14S		5/22/2007	23.5	5-15
A1-GP15S		5/23/2007	23.5	5-15
A1-GP16S		5/23/2007	18.5	5-15
A1-GP17S		5/23/2007	21	5-15
A1-GP18S		5/24/2007	21	5-15

Notes:
(1) All geoprobe borings advanced to refusal.
ft bgs - feet below ground surface
S - shallow overburden groundwater

Table 2
Shallow Groundwater Elevation Measurements
May 31, 2007
Former Scott Aviation Facility Area 1
Lancaster, New York

Well Number	Well Installation Date	Measuring Point		Thursday, May 31, 2007	
		Description	Elevation (ft)	Depth to Water (ft)	Elevation of Water (ft)
A1-GP01-S	2/28/2006	Top of Casing(1)	687.60	3.98	683.62
A1-GP02-S	2/28/2006	Top of Casing(2)	689.82	5.22	684.60
A1-GP03-S	2/28/2006	Top of Casing(2)	690.70	6.38	684.32
A1-GP04-S	2/28/2006	Top of Casing(3)	690.46	NM	NM
A1-GP05-S	2/28/2006	Top of Casing(2)	690.38	5.99	684.39
A1-GP06-S	2/28/2006	Top of Casing(1)	687.71	3.67	684.04
A1-GP07-S	5/17/2006	Top of Casing(2)	690.47	6.02	684.45
A1-GP08-S	5/17/2006	Top of Casing(2)	689.68	4.85	684.83
A1-GP09-S	5/17/2006	Top of Casing(2)	689.36	4.61	684.75
A1-GP10-S	5/16/2006	Top of Casing(1)	689.10	4.45	684.65
A1-GP11-S	5/15/2006	Top of Casing	689.34	4.81	684.53
A1-GP12-S	5/15/2006	Top of Casing	689.18	3.31	685.87
A1-GP13-S	5/22/2007	Top of Casing	689.69	5.02	684.67
A1-GP14-S	5/22/2007	Top of Casing	689.43	3.31	686.12
A1-GP15-S	5/23/2007	Top of Casing	687.69	4.11	683.58
A1-GP16-S	5/23/2007	Top of Casing	689.86	4.61	685.25
A1-GP17-S	5/23/2007	Top of Casing	690.11	5.32	684.79
A1-GP18-S	5/24/2007	Top of Casing	690.37	5.62	684.75

Notes:
(1) Piezometer converted from stickup to flush mount completion in May 2007.
(2) Piezometer top of casing adjusted during the installation of protective casings in May 2007.
(3) Piezometer damaged during installation of protective casing in May 2007.
ft - feet
NM - Not measured due to piezometer damage. See Note (3).

Table 3
Analytical Sampling Program
Former Scott Aviation Facility Area 1
Lancaster, New York

Location	Matrix	VOCs[1] (Method TO-15)	Field Parameters[2] (Water Quality Meter)	VOCs (8260B)	SVOCs (8270)	Metals (6010)	PCBs (8082)	Pesticides (8081)	Bulk Density (ASTM E-868)	Specific Gravity (ASTM E-868)	Moisture Content (E160.3)	Grain Size (ASTM D422)	TOC (Walkely-Black)	TCLP VOCs (8260B)	TCLP SVOCs (8270D)	TCLP Metals (6010C/7470A)	Ignitability (1010)	Corrosivity (9045)	Reactivity (Sect. 7.3)
Soil Vapor Intrusion Evaluation Sampling																			
SS-1	Vapor	✓																	
SS-2	Vapor	✓																	
SS-3	Vapor	✓																	
SS-3-a	Vapor	✓																	
AS-1	Vapor	✓																	
Monitoring Well and Temporary Piezometer Groundwater Sampling																			
MW-30	Groundwater		✓	✓		✓													
MW-35S	Groundwater		✓	✓															
MW-35S-a	Groundwater		✓	✓															
MW-35S-c	Groundwater			✓															
MW-35D	Groundwater		✓	✓															
MW-36S	Groundwater		✓	✓															
MW-36D	Groundwater		✓	✓															
MW-37S	Groundwater		✓	✓															
MW-37D	Groundwater		✓	✓															
MW-38D	Groundwater		✓	✓															
MW-39D	Groundwater		✓	✓															
MW-40D	Groundwater		✓	✓															
MW-41B1	Groundwater		✓	✓															
MW-41B2	Groundwater		✓	✓															
A1-GP01-S	Groundwater		✓	✓															
A1-GP02-S	Groundwater		✓	✓															
A1-GP03-S	Groundwater		✓	✓															
A1-GP04-S	Groundwater		✓	✓															
A1-GP05-S	Groundwater		✓	✓															
A1-GP06-S	Groundwater		✓	✓															
A1-GP07-S	Groundwater		✓	✓															
A1-GP08-S	Groundwater		✓	✓															
A1-GP09-S	Groundwater		✓	✓															
A1-GP10-S	Groundwater		✓	✓															
A1-GP11-S	Groundwater		✓	✓															
A1-GP12-S	Groundwater		✓	✓															
A1-GP13-S	Groundwater		✓	✓															
A1-GP14-S	Groundwater		✓	✓															
A1-GP15-S	Groundwater		✓	✓															
A1-GP16-S	Groundwater		✓	✓															
A1-GP17-S	Groundwater		✓	✓															
A1-GP18-S	Groundwater		✓	✓															
TP-1	Groundwater			✓															
TP-2	Groundwater			✓															
TP-3	Groundwater			✓															
TP-4	Groundwater			✓															

Table 3
Analytical Sampling Program
Former Scott Aviation Facility Area 1
Lancaster, New York

Location	Matrix	VOCs[1] (Method TO-15)	Field Parameters[2] (Water Quality Meter)	VOCs (8260B)	SVOCs (8270)	Metals (6010)	PCBs (8082)	Pesticides (8081)	Bulk Density (ASTM E-868)	Specific Gravity (ASTM E-868)	Moisture Content (E160.3)	Grain Size (ASTM D422)	TOC (Walkely-Black)	TCLP VOCs (8260B)	TCLP SVOCs (8270D)	TCLP Metals (6010C/7470A)	Ignitability (1010)	Corrosivity (9045)	Reactivity (Sect. 7.3)
IRM Soil Delineation																			
SS-MW-36D-x	Soil			✓	✓	✓	✓	✓											
SS-MW-37D-x	Soil			✓	✓	✓	✓	✓											
SS-MW-39D-x	Soil			✓	✓	✓	✓	✓											
DPT-8 Soil Delineation																			
SS-DPT8-1A-x	Soil			✓	✓	✓	✓	✓											
SS-DPT8-1B-x	Soil			✓	✓	✓	✓	✓											
SS-DPT8-2A-x	Soil			✓	✓	✓	✓	✓											
SS-DPT8-2B-x	Soil			✓	✓	✓	✓	✓											
SS-DPT8-3A-x	Soil			✓	✓	✓	✓	✓											
SS-DPT8-3B-x	Soil			✓	✓	✓	✓	✓											
Soil Characteristic Parameter Sampling																			
MW-41B1-x[3]	Soil								✓	✓	✓	✓	✓						
MW-41B1-x[4]	Soil								✓	✓	✓	✓	✓						
MW-41B1-x[5]	Soil													✓	✓	✓	✓	✓	✓
Soil IDW Profiling																			
IDW-1[6]	Soil													✓	✓	✓	✓	✓	✓

Notes:
-a - Indicates a field duplicate sample.
ASTM - American Society for Testing Materials
-c - Indicates a trip blank sample. The trip blank sample should be the first sample collected each day (at the first sampling location).
IDW - Investigation Derived Waste
-ms - Indicates a matrix spike duplicate sample.
-msd - Indicates a matrix spike duplicate sample.
SVOC - Semivolatile Organic Compound
TCLP - Toxicity Characteristic Leaching Procedure
TOC - Total Organic Carbon
VOC - Volatile Organic Compound
SS- Soil Sample
x - Sample collection depth to be determined in the field.
[1]Reduced analyte list. Report only 1,1-Dichloroethane, 1,1-Dichloroethene, cis-1,2-Dichloroethene, Methylene chloride, 1,1,1-Trichloroethane, and Trichloroeth
[2]Field Parameters include pH, temperature, turbidity, oxidation-reduction potential (ORP), dissolved oxygen (DO), and specific conductivi
[3]Sample collected from shallow overburden
[4]Sample collected from deep overburden
[5]Sample collected from soil with highest Photoionization Detector (PID) reading
[6]Composite soil sample collected from drummed soil cutting

Table 4
Sample Container, Preservation, and Holding Time Requirements
Former Scott Aviation Facility Area 1
Lancaster, New York

Analysis	Method	Sample Containers			Preservation[2]	Holding Time		Comment
		Material	Size	Quantity[1]		Extraction	Analysis	
Soil Vapor Intrusion Evaluation Sampling								
VOCs	(Method TO-15)	Summa Canister	6 Liter	1	NA	NA	14 days	
Monitoring Well and Temporary Piezometer Groundwater Sampling								
VOCs	(8260B)	Glass	40 mL	2	HCl	NA	14 days	
Metals	(6010)	Plastic	250 mL	1	HNO3	180 days	180 days	
Soil Characteristic Parameter Sampling								
Bulk Density	(ASTM E-868)	Glass	1 Liter	1	NA	NA	NA	
Grain Size	(ASTM D422)	Glass	1 Liter	1	NA	NA	NA	
Specific Gravity	(ASTM E-868)	Glass	1 Liter	1	NA	NA	NA	
Moisture Content	(E160.3)	Glass	1 Liter	1	NA	NA	NA	
TOC	(Walkely-Black)	Glass	4 oz	1	NA	NA	28 days	
Soil IDW Profiling								
TCLP VOCs	(8260B)	Glass	4 oz	1	NA	7 days	14 days	
TCLP SVOCs	(8270D)	Glass	4 oz	1	NA	14 days	40 days	
TCLP Metals	(6010C/7470A)	Glass	4 oz	1	NA	NA	6 months	
Ignitability	(1010)	Glass	4 oz	1	NA	NA	6 months	
Corrosivity	(9045)	Glass	4 oz	1	NA	NA	7 days	
Reactivity	(Sect. 7.3)	Glass	4 oz	1	NA	NA	6 months	

Notes:
ASTM - American Society for Testing Materials
HCl - Hydrochloric Acid
IDW - Investigation Derived Waste
NA - Not Applicable
SVOC - Semivolatile Organic Compound
TCLP - Toxicity Characteristic Leaching Procedure
TOC - Total Organic Carbon
VOC - Volatile Organic Compound
[1]Quantity listed is per sample location.
[2]All samples for chemical analysis should be held at 4 °C in addition to required preservation.

APPENDICES

APPENDIX A

QUALITY ASSURANCE PROJECT PLAN

Appendix A

QUALITY ASSURANCE PROJECT PLAN

FORMER SCOTT AVIATION FACILITY AREA 1
LANCASTER, NEW YORK

Prepared for:

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February 2010

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LIST OF ATTACHMENTS

1.0 INTRODUCTION

1.1 OBJECTIVE

This Quality Assurance Project Plan (QAPP) prescribes requirements for assuring that Remedial Investigation (RI) activities for Area 1 (site) at the former Scott Aviation Facility, located in Lancaster, Erie County, New York (refer to Figures 1 and 2 in the RI/Alternative Analysis (AA) Work Plan) are planned and executed in a manner consistent with the project's quality assurance objectives. The objective of the QAPP is to ensure that the technical data generated during the RI are of sufficient quality for making informed decisions regarding site groundwater and soil quality and the characteristics of any waste identified at the site.

1.2 PROJECT MANAGEMENT AND ORGANIZATION

1.2.1 Personnel

The general responsibilities of key project personnel are listed below.

Project Manager:	Dino Zack, P.G., will have responsibility for overall project management and coordination of subcontractors.
Task Manager:	Jeffrey Rowley will have responsibility for coordination, supervision, and management of RI field activities, subcontractors, and coordination with AVOX Plant 1 personnel.
QA Officer:	Doria Cullom, will serve as Quality Assurance Officer, and will be responsible for laboratory subcontractor procurement and assignment.
H & S Officer:	Michael Grasso, CHI, District Health & Safety Manager, will be responsible for overall project health and safety.

1.2.2 Specific Tasks and Services

AECOM Technical Services, Inc. (AECOM) has obtained subcontractor specialists for services relating to laboratory/analytical, drilling, field surveying, and investigation-derived waste (IDW) disposal. The proposed subcontractors are:

Laboratory Analyses:	Contest Analytical, East Longmeadow, New York
	TestAmerica Laboratories, Amherst, New York
Drilling Services:	SJB Services, Hamburg, New York
Surveying Services:	TVGA Consultants, Inc., Elma, New York

IDW Disposal:	Heritage/Von Roll America Inc., East Liverpool, Ohio

2.0 RI FIELD ACTIVITIES AND ASSOCIATED FIELD PROCEDURES

The RI field activities for Area 1 addressed by this QAPP include:

- Performance of air surveillance and soil vapor intrusion monitoring;
- Collection of groundwater elevation measurements from the existing temporary piezometer network and the newly installed monitoring wells;
- Performance of a utility clearance prior to any intrusive field activities;
- Installation, development, and sampling of nine permanent monitoring wells in shallow (3 wells) and deep (6 wells) overburden groundwater and two permanent monitoring wells in bedrock.
- Installation and development of four temporary piezometers with subsequent collection of groundwater samples along the storm sewer piping system;
- Survey of newly installed permanent monitoring wells and temporary piezometers. Completion of an ALTA survey to establish the boundaries of Area 1 for the New York State Department of Environmental Conservation (NYSDEC) Brownfield Cleanup Program (BCP);
- Completion of aquifer characterization testing at one shallow and one deep overburden permanent monitoring well;
- Collection of soil samples in the vicinity of former soil boring DPT-8 and in the vicinity of the current VOC plume (IRM area);
- Collection of soil characteristic parameter samples; and
- Collection of a composite soil IDW sample for disposal purposes.

All environmental sampling and other RI field activities will be performed in general accordance with the RI/AA Work Plan and this QAPP.

2.1 AIR SURVEILLANCE AND MONITORING

Air monitoring for volatile organic compounds (VOCs) for health and safety concerns will be performed with a portable photoionization detector (PID) or equivalent. Monitoring will be performed during invasive activities such as drilling, monitoring well installation, well development, well sampling, and soil sampling. Additional details regarding air surveillance and monitoring are presented in the site-specific Health and Safety Plan (HASP), which is included as Appendix C in the RI/AA Work Plan for Area 1.

The PID will be calibrated daily, in accordance with manufacturer's recommendations using a standard calibration gas. Soil screening will be performed by holding the probe of the PID directly over the sample and slowly passing the probe over the length of the recovered soil core. A response of less than 1 part per million (ppm) using this method is not considered significant and will be reported as trace.

2.2 GROUNDWATER MEASUREMENT

An electronic water level indicator probe will be used for groundwater elevation monitoring. The date, time, depth to water and reference point will be noted on a field form. An example of this form is provided in Attachment 1. Well gauging equipment will be decontaminated between well locations by rinsing with an Alconox® solution (i.e., Alconox® and potable water); followed by distilled water rinse, and wiping with a clean cloth.

2.3 SUBSURFACE DRILLING ACTIVITIES

Nine overburden monitoring wells, two bedrock monitoring wells, and four temporary piezometers will be installed as described in Section 3.1.4 of the RI/AA Work Plan. In addition three soil borings will be completed in the vicinity of former DPT-8 boring as described in Section 3.1.5 of the RI/AA Work Plan. Continuous split spoon sampling will be conducted at each new monitoring well location. At locations where a well cluster is being installed (shallow overburden paired with a deep overburden), continuous split spoon sampling will be completed at the deepest boring installed. A qualified AECOM geologist or field engineer will describe soil samples by visual examination in accordance with NYSDOT soil description procedure. Soil descriptions will be recorded on a field log. Immediately upon opening each split-spoon sampler, the soil will be screened using a PID. The PID will be properly calibrated according to the manufacturer recommendations each day. A log of each boring will be prepared using the HTW Drill Log presented in Attachment 1 with appropriate stratification lines, blow counts, sample identification, sample depth interval, recovery, date, etc. Following completion of each monitoring well and temporary piezometer, a well diagram, as presented in Attachment 1, will be completed. The temporary piezometers will be abandoned upon completion of RI activities. A copy of an abandonment decision flow diagram and an abandonment field log are included in Attachment 1. The DPT-8 soil delineation soil borings will be properly abandoned upon completion of the associated soil sampling.

2.4 MONITORING WELL AND TEMPORARY PIEZOMETER DEVELOPMENT

All monitoring wells and temporary piezometers installed during the RI will be developed using a peristaltic pump. Field measurements of pH, conductivity, temperature, and turbidity will be monitored throughout the development process. An attempt will be made to develop each well until a water turbidity of 50 NTUs or less is achieved. If a monitoring well or temporary piezometer purges to dryness during development, it will be allowed to recover before development continues. Data collected during development will be recorded on the Monitoring Well Development Log, presented in Attachment 1.

2.5 SAMPLING METHODS

The subsections below describe the procedures that will be followed during the sampling of soil vapor, groundwater, and soil. Table 3 in the RI/AA Work Plan for Area 1 includes a summary of the sample matrices, sample location numbers, analyses requested, and the number of samples to be collected including QA/QC samples.

2.5.1 Soil Vapor Intrusion Evaluation Sampling

Section 3.1.1 of the RI/AA Work Plan describes soil vapor intrusion evaluation sampling activities planned for Area 1. Pertinent observations, such as spills, floor stains, odors, and readings from field instrumentation (e.g., vapors via PID) will be recorded on a field log for each sampling location. Weather conditions and building ventilation conditions (e.g., heating system active and windows closed, etc.) will also be reported on the field log sheet. In addition, the log will summarize sample identification, date and time of sample collection, sampling height, identity of sampling technicians, sampling methods and devices, vacuum of Summa® canisters before and after samples are collected, and chain-of-custody protocols and records used to track samples from sampling point to receipt by the selected analytical laboratory.

Reporting Limits/Lab Package: The samples will be submitted via UPS or FedEx Ground to Con-Test Analytical Laboratory in East Longmeadow, MA, an ELAP-certified laboratory, for analysis of VOCs using USEPA Method TO-15 (full list of VOCs). The standard turnaround time is 7 business days for results in Electronic Data Deliverable (EDD) format. Reporting limits will meet NYSDOH requirements of 1 $\mu g/m^3$ for all VOCs, 0.25 $\mu g/m^3$ for trichloroethene (TCE), and 0.25 $\mu g/m^3$ for carbon tetrachloride unless the sample is found to contain VOC concentrations above those reporting limits. The laboratory will provide an enhanced deliverable package comprising the following elements: analytical report; QA/QC summary; chain of custody; method blank; laboratory control samples – control limits; reporting limits; and surrogate recoveries for GC/MS analysis with control limits.

Flow Rates: The Teflon-lined tubing will be purged using a personal air pump calibrated to a flow of less than 0.2 L/min. Each of the samples will be collected in an individually certified-clean Summa® canister during a 24-hour period with a flow rate of less than 0.2 L/min. Canister regulators will be pre-set by the laboratory to accommodate the sample duration and flow rate.

2.5.2 Low Flow Groundwater Sampling

Section 3.1.4 of the RI/AA Work Plan describe groundwater sampling activities planned for Area 1. Low flow groundwater procedures, as presented in Attachment 2, will be used for sampling all monitoring wells and temporary piezometers installed during the RI. Refer to Attachment 1 for a copy of the groundwater purging and sampling log.

2.5.3 Soil Contamination Delineation (IRM Area and DPT-8 Area) Soil Sampling

Section 3.1.5 of the RI/AA Work Plan describes soil sampling planned for Area 1 (IRM Area and DPT-8 Area). Soil samples will be collected from the split spoon sampler. Each soil sample will be submitted for TCL VOCs, SVOCs, PCBs, pesticides, and TAL metals analyses.

VOC soil samples will not be mixed but will be placed directly from the sampling equipment into the sample container in a manner limiting headspace by compacting the soil into the container.

Analytical soil samples for SVOCs, PCBs, pesticides, and TAL metals will be transferred from the sample collection device (e.g., split spoon) to a decontaminated stainless steel bowl, homogenized using a decontaminated stainless steel spoon or spatula, and placed in the appropriate containers.

Soil on the threads of each container will be wiped off prior to placing the cap on the sample container. Samples will be labeled in accordance with Section 3.1 of the QAPP.

2.5.4 Site Soil Characterization Sampling

Section 3.1.5 of the RI/AA Work Plan describes soil characterization activities planned for Area 1 (IRM) and DPT8 area. Soil samples will be collected using standard split spoon sampling procedures from grade to the required depth as determined in the field. Samples will be logged for geologic identification using the New York State Department of Transportation soil description procedure (NYSDOT Soil Mechanics Bureau STP-2 dated May 1, 1975, as amended).

2.6 AQUIFER CHARACTERISTIC TESTING

Testing to determine characteristic properties of the site aquifer will be conducted in accordance with Attachment 3, SOP 09, *Conducting Slug Tests*. A description of this RI activity is provided in Section 3.1.8 of the RI/AA Work Plan. A copy of the slug test field form is provided in Attachment 1.

2.7 EQUIPMENT DECONTAMINATION

To limit potential cross contamination, sampling equipment (defined as any piece of equipment which may contact a sample) will be decontaminated according to the procedures outlined below.

2.7.1 Non-Dedicated Reusable Equipment

Non-dedicated, reusable equipment such as stainless steel spoons, split spoons, bailers, slugs, etc., will require field decontamination. Acids and solvents will not be used in the field decontamination of this type of equipment. Decontamination will include scrubbing/washing with a laboratory grade non-phosphate detergent (i.e. Alconox® and potable water) to remove visible contamination, followed by potable (tap) water rinse and a final analyte-free water rinse. Only tap water obtained from a treated municipal water system will be used for initial equipment rinse water. All field-decontaminated equipment will be allowed to dry prior to use. Steam cleaning or high-pressure hot water cleaning will be used as needed in the initial removal of gross, visible contamination.

2.7.2 Disposable Sampling Equipment

Disposable sampling equipment includes vapor and groundwater sample tubing, disposable bailers, disposable spoons and spatulas, etc. Such equipment will not be field-decontaminated. All disposable sampling equipment will be dedicated to a single sampling location and will be discarded following the first use.

2.7.3 Subsurface Boring

Subsurface boring equipment, such as a hollow stem augers, drill rods, etc., will be used as tools to obtain subsurface soil samples. Such equipment will be subject to high-pressure hot water or steam cleaning between uses. A member of the sampling team will visually inspect the equipment to check that visible contamination has been removed by this procedure prior to sampling. The split spoon sampler and hand auger will be cleaned between each use using laboratory grade non-phosphate detergent (i.e. Alconox® and potable water) to remove visible contamination, followed by potable (tap) water rinse and a final analyte-free water rinse. All equipment will be thoroughly decontaminated and inspected prior to leaving the site.

2.8 STORAGE AND DISPOSAL OF INVESTIGATION-DERIVED WASTE

Personal protective equipment and disposable sampling equipment will be placed in plastic garbage bags, transferred to dedicated Department of Transportation (DOT)-approved 55-gallon drum(s) and stored on site for future disposal in accordance with all applicable regulations. Liquid wastes (development water, purge water, decontamination water) will be collected in 55-gallon drums and subsequently transferred for disposal in an existing groundwater treatment system located immediately to the west of AVOX Plant 2. Soil cuttings will be placed in 55-gallon drums and temporarily stored inside the groundwater treatment building located to the west of AVOX Plant 2 pending receipt of disposal characterization analytical results. All drums will be recorded on the IDW Management Form, presented in Attachment 1.

3.0 SAMPLE HANDLING

3.1 SAMPLE IDENTIFICATION/LABELING

Samples will be assigned a unique identification using the sample location or other sample-specific identifier. Sample identification will be limited to seven alphanumeric characters to be consistent with the limitations of the laboratory tracking/reporting software. Typically this will include the boring number and depth interval for soil samples, vapor location number for vapor samples, or monitoring well number for aqueous samples.

Quality control blind duplicate samples will be submitted to the laboratory using a fictitious sample ID. The sample identifications of the original sample and its field duplicate will be marked in the field book and on the *copy* of the chain-of-custody kept by the sampler and copied to the project manager. Sample containers will be labeled in the field prior to the collection of samples. Affixed to each sampling container will be a non-removable label on which the following information will be recorded with permanent waterproof ink.

- Site name, location, and job number;
- Sample identification code;
- Sampling date and time;
- Sampler's name;
- Number and type of sample containers and preservative;
- Sample matrix (e.g., water, soil, oil, and air); and
- Requested analyses.

3.2 SAMPLE, BOTTLES, PRESERVATION, AND HOLDING TIME

Table 4 in the RI Work Plan for Area 1 specifies the analytical method, matrix, holding time, containers, and preservatives for the various laboratory analyses. Sample bottle requirements, preservation, and holding times are discussed further below.

3.2.1 Sample Containers

The selection of sample containers used to collect samples is based on the criteria of sample matrix, analytical method, potential contaminants of concern, reactivity of container material with the sample, Quality Assurance/Quality Control (QA/QC) requirements and any regulatory protocol requirements. Sample bottles will be provided by the analytical laboratory and will conform to the requirements of United States Environmental Protection Agency (USEPA) Specifications and Guidance for Contaminant-

Free Sample Containers. An adequate number of sample containers for each sampling location and analytical parameter will be provided to ensure an adequate volume of sample is delivered to the laboratory.

3.2.2 Sample Preservation

Samples will be preserved as indicated on Table 4 in the RI Work Plan for Area 1.

3.2.3 Holding Times

Holding times are judged from the verified time of sample receipt (VTSR) by the laboratory; samples will be shipped from the field to arrive at the lab no later than 48 hours from the time of sample collection. Holding time requirements will be those specified in the NYSDEC Analytical Services Protocol (ASP); it should be noted that for some analyses, these holding times are more stringent than the holding time for the corresponding USEPA method.

Although trip blanks are prepared in the analytical laboratory and shipped to the site prior to the collection of environmental samples, for the purposes of determining holding time conformance, trip blanks will be considered to have been generated on the same day as the environmental samples with which they are shipped and delivered. Procurement of bottles and blanks will be scheduled to prevent trip blanks from being stored for excessive periods prior to their return to the laboratory; the goal is that trip blanks should be held for no longer than one week prior to use.

3.3 CHAIN-OF-CUSTODY AND SHIPPING

A chain-of-custody form will track the path of sample containers from the project site to the laboratory. Sample/bottle tracking sheets or the chain-of-custody will be used to track the containers from the laboratory to the containers' destination. The project manager or QA officer will notify the laboratory of upcoming field sampling events and the subsequent transfer of samples. This notification will include information concerning the number and type of samples, and the anticipated date of arrival. Insulated sample shipping containers (typically coolers) will be provided by the laboratory for shipping samples. All sample bottles within each shipping container will be individually labeled with an adhesive identification label provided by the laboratory. Project personnel receiving the sample containers from the laboratory will check each cooler for the condition and integrity of the bottles prior to conducting any fieldwork.

Once the sample containers are filled, they will be immediately placed in a cooler with ice (in Ziploc plastic bags to prevent leaking and sample label deterioration) or synthetic ice packs to maintain the samples at 4^{o} C. The field sampler will indicate the sample designation/location number in the space provided on the chain-of-custody form for each sample. The chain-of-custody forms will be signed and placed in a sealed plastic Ziploc bag in the cooler. The completed shipping container will be closed for transport with nylon strapping, or a similar shipping tape. Following the preparation of the sample container for shipping, two paper custody seals will be affixed to the lid of the container across the opening of the container, and they will be signed and dated by the individual responsible for preparing the shipping package. These seals must be broken to open the cooler and will indicate tampering if the seals are broken before receipt at the laboratory. A label will be affixed identifying the cooler as containing "Environmental Samples”. When the laboratory receives the coolers, the custody seals will be checked and lab personnel will sign the chain-of-custody form.

All samples will be packaged and shipped by an overnight delivery service to the laboratory on the day of collection unless it is physically impossible to transfer the package(s) to the delivery service before the close of their business day. If the latter occurs, the sample packages will be iced but not sealed for shipment, and the chain-of-custody form will not be signed for release to the laboratory. The condition of the samples will be checked on the following day, the ice will be replenished if necessary, the chain-of-custody form will be signed, the package will be sealed as described above, and the package will be transferred to the delivery services for overnight delivery. No samples will be held for shipping for more than one day after collection (e.g., not over a weekend).

4.0 DATA QUALITY REQUIREMENTS

4.1 QUALITY ASSURANCE OBJECTIVES

Data quality objectives (DQOs) for measurement data in terms of sensitivity and the PARCC parameters (precision, accuracy, representativeness, comparability, and completeness) are established so that the data collected are sufficient and of adequate quality for their intended uses. Data collected and analyzed in conformance with the DQO process described in this QAPP will be used in assessing the uncertainty associated with decisions related to this site.

4.2 FIELD QUALITY ASSURANCE

Analyte free water used for preparation of trip blanks (and equipment rinsate blanks if applicable) will be supplied by the laboratory. The laboratory will conduct analysis of all analyte free water to ensure that no detectable quantities of target analytes are present in that water prior to its shipment to the field site location.

4.2.1 Field Duplicate Samples

Field duplicate samples are used to assess the variability of a matrix at a specific sampling point and to assess the reproducibility of the sampling method. Each duplicate sample will be analyzed for the same parameters as the original sample collected that day. The blind field duplicate Relative Percent Difference (RPD) objective will be ±50% percent RPD for aqueous samples. Field duplicates will be collected at a frequency of 1 per 10 aqueous samples sent to the analytical laboratory for all test parameters. One indoor air field duplicate sample will also be collected. Field duplicates will not be collected for soil samples.

4.2.2 Trip Blanks

The purpose of a volatile organic compound (VOC) trip blank (using demonstrated analyte-free water) is to place a mechanism of control on sample bottle preparation and blank water quality, and sample handling. The trip blank travels from the laboratory to the site with the empty sample bottles and back from the site with the collected samples. There will be a minimum of one trip blank per shipment containing aqueous samples for VOCs analysis. Trip blanks will be collected only when aqueous volatile organics are being sampled and shipped.

4.3 LABORATORY QUALITY ASSURANCE

4.3.1 Method Blanks

A method blank is laboratory water on which every step of the method is performed and analyzed along with the collected samples. Method blanks are used to assess the background variability of the method and to assess the introduction of contamination to the samples by the method, technique, or instruments as the sample is prepared and analyzed in the laboratory. Method blanks will be analyzed at a frequency of one for every 10 samples analyzed or as otherwise specified in the analytical protocol.

4.3.2 Laboratory Duplicates

Laboratory duplicates are sub-samples taken from a single aliquot of sample after the sample has been thoroughly mixed or homogenized (with the exception of volatile organics), to assess the precision or reproducibility of the analytical method on a sample of a particular matrix. Laboratory duplicate analysis will be performed on spiked aqueous and soil matrix samples as a Matrix Spike and a Matrix Spike Duplicate (MS/MSD) for volatile organics.

4.3.3 Spiked Samples

Two types of spiked samples will be prepared and analyzed as quality controls: MS/MSD is analyzed to evaluate instrument and method performance and performance on samples of similar matrix. MS/MSD will be analyzed at a frequency of one (pair) for every 20 samples of like matrix. MS/MSD analysis will be performed on a batch basis by the laboratory. No additional sample volume will be collected and identified for MS/MSD analysis by field staff. In addition, matrix spike blanks (MSBs) will also be run by the lab as part of the NYSDEC Contract Laboratory Program (CLP).

5.0 DATA DOCUMENTATION

A field logbook will be initiated at the start of on-site RI activities. Each subcontractor in the field will have a notebook dedicated to record pertinent activities. In addition to any forms that will be filled out summarizing fieldwork (and become part of the project file), legible photocopies of pertinent notebook pages will be submitted by the contractors with their finished written report or product. The field notebook will include the following daily information for all site activities:

- Date;
- Meteorological conditions (temperature, wind, precipitation);
- Site conditions (e.g. dry, damp, dusty, etc.);
- Identification of crew members (AECOM and subcontractor present) and other personnel (e.g., agency or site owner) present;
- Description of field activities;
- Location(s) where work is performed;
- Problems encountered and corrective actions taken;
- Records of field measurements or descriptions recorded; and,
- Notice of modifications to the scope of work.

During drilling operations, the supervising field engineer/geologist will add the following information to the field notebook:

- Drill rig type;
- Documentation of materials used;
- Downtime;
- Time work is performed at an elevated or lowered level of respiratory protection; and,
- Description of soil or rock strata.

6.0 EQUIPMENT CALIBRATION AND MAINTENANCE

6.1 STANDARD WATER AND AIR QUALITY FIELD EQUIPMENT

Field equipment used during the collection of environmental samples includes a PID and groundwater field parameter instrumentation. Equipment to be used for the field sampling will be examined to confirm that it is in good operating condition. This includes checking the manufacturer’s operating manual and the instructions for each instrument to confirm that the maintenance requirements are being observed.

A portable photoionization detector (PID) or equivalent will be used for soil screening and health and safety air monitoring. The instrument will be calibrated following the manufacturer's instructions, at the beginning of the day, whenever the instrument is shut off for more than two hours, and at the field technician's discretion.

A Horiba U-22 water quality meter (or equivalent) and the HF Scientific DRT-15 turbidity meter (or equivalent) will arrive on site fully calibrated following the manufacturer's instructions. At the beginning of each sampling day, the following equipment measurement calibrations will be performed and recorded in the field notebook:

- pH will be calibrated with three calibration standards (4, 7, 10);
- Redox potential;
- Dissolved oxygen;
- Specific conductance will be calibrated with two calibration standards; and
- Turbidity.

6.2 LABORATORY EQUIPMENT

Laboratory equipment will be calibrated according to the requirements of the 2000 Revised NYSDEC ASP, Superfund CLP for each parameter or group of similar parameters, and maintained following professional judgment and the manufacturer's specifications.

7.0 CORRECTIVE ACTIONS

If instrument performance or data fall outside acceptable limits, then corrective actions will be taken. These actions may include recalibration or standardization of instruments, acquiring new standards, replacing equipment, repairing equipment, and reanalyzing samples or redoing sections of work.

Subcontractors providing analytical services should perform their own internal laboratory audits and calibration procedures with data review conducted at a frequency so that errors and problems are detected early, thus avoiding the prospect of redoing large segments of work.

8.0 DATA REDUCTION AND REPORTING

8.1 LABORATORY DATA REPORTING AND REDUCTION

The laboratory will meet the applicable documentation, data reduction, and reporting protocols as specified in the 2000 revision of the NYSDEC ASP CLP. Laboratory data reports for non-CLP data will conform to NYSDEC Category B deliverable requirements. With full CLP documentation, deliverables will include, but not be limited to:

Organics	**Inorganics**
Chains of Custody	Chains of Custody
Blanks	Blanks
Holding Times	Holding Times
Internal Standards	Furnace AA QC
Laboratory Duplicates	CRDL Standards
Tentatively Identified Compounds	ICP Serial Dilutions
GC/MS Instrument Performance Check	Laboratory Control Samples
System Monitoring Compound Recovery	Laboratory Duplicates
Matrix Spike & Matrix Spike Duplicates	ICP Interference Check
GC/MS Tuning	Spiked Sample
Surrogate Recoveries	Recovery

Copies of the laboratory's generic Quality Assurance Plan (QAP) are on file with AECOM. The laboratory's QAP or audit will indicate the standard methods and practices for obtaining and assessing data, and how data are reduced from the analytical instruments to a finished report, indicating levels of review along the way.

In addition to the hard copy of the data report, the laboratory will be asked to provide the sample data in spreadsheet form on computer diskette. The diskette will be generated to the extent possible directly from the laboratory's electronic files or information management system to minimize possible transcription errors resulting from the manual transcription of data.

Data validation will be performed and a Data Usability Summary Report (DUSR) will be prepared to meet the NYSDEC requirements for all analytical data generated during an RI. The DUSR will be prepared by AECOM's Quality Assurance Officer.

8.2 FIELD DATA

Field data collected during air monitoring and soil screening (e.g., PID readings) will be presented in tabular form with any necessary supporting text. Unless activities resulted in significant unexpected results, field data comments can be added as footnotes to the tables.

9.0 PERFORMANCE AND SYSTEM AUDITS

The laboratories assigned to this project have been verified to be certified by the NYSDOH Environmental Laboratory Approval Program (ELAP) for the analytical protocols to be used. Therefore, no audit of the laboratory(s) will be performed unless warranted by a problem(s) that cannot be resolved by any other means, or at the discretion of AECOM.

10.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

The project manager, through task managers, will be responsible for verifying that records and files related to this project are stored appropriately and are retrievable.

The laboratory will submit any memoranda or correspondence related to quality control of this project's samples as part of its deliverables package.

ATTACHMENT 1

FIELD DATA FORMS

AECOM

WATER LEVEL DATA SUMMARY

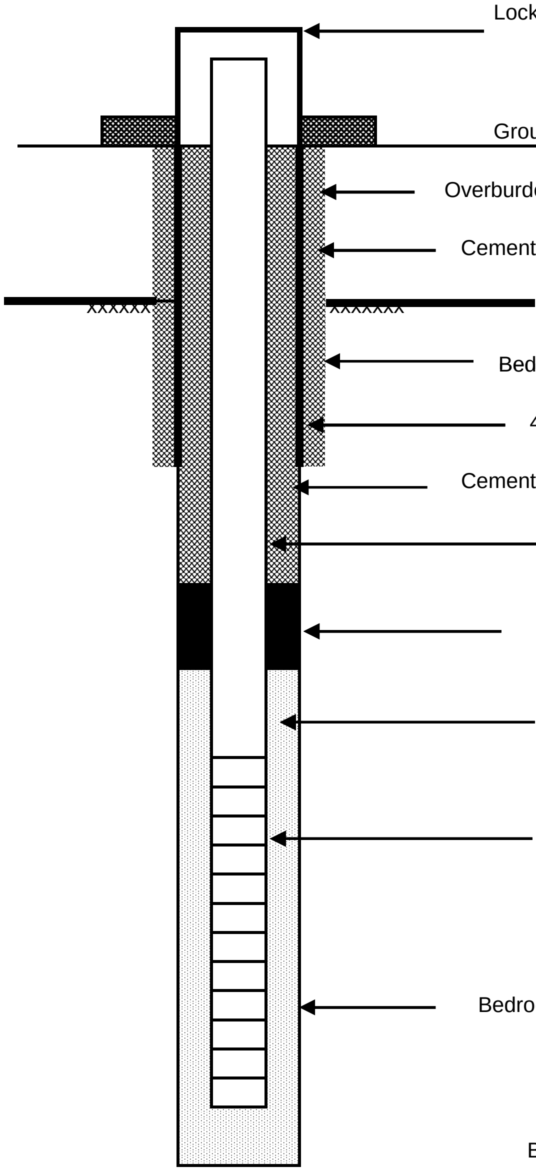
PROJECT: Former Scott Aviation Site Area 1	JOB NUMBER:
LOCATION: Lancaster, New York	DATE:
CLIENT:	MEASURED BY:
SURVEY DATUM: NAVD 88	
MEASURING DEVICE:	

WELL NUMBER	TIME (Military)	MEASURING POINT		DEPTH TO WATER (FT)	ELEVATION OF WATER (FT)	COMMENTS
		Description	Elevation (FT)			

AECOM **Bedrock Well Diagram** **Well No.**

Project: Area 1 Former Scott Aviation	Location: Lancaster, NY	Page 1 of 1
AECOM Project No.:	Subcontractor:	Water Levels
Surface Elevation: Ft	Driller:	Date / Time / Depth
Top of PVC Casing Elevation: Ft	Well Permit No.: AECOM Rep.:	
Datum: NGVD 1988	Date of Completion:	

Date	Time	Depth



Locking protective stickup with concrete pad

Inner casing stickup ________ ft to ________ ft

Ground Surface

Overburden borehole diameter ________ inches (ID)

Cement-bentonite grout from ________ ft to ________ ft

Top of Bedrock ________ ft bgs

Bedrock socket diameter ________ inches

4-inch ID steel casing ________ ft to ________ ft

Cement-bentonite grout from ________ ft to ________ ft

Riser Pipe from ________ ft to ________ ft

Bentonite seal from ________ ft to ________ ft

Filter pack from ________ ft to ________ ft

Sand Size ________

Well screen from ________ ft to ________ ft

Diameter ________ inches

Slot size ________ inches

Type ________

Bedrock borehole diameter ________ inches

Bottom Cap at ________ ft

Bottom of Borehole at ________ ft

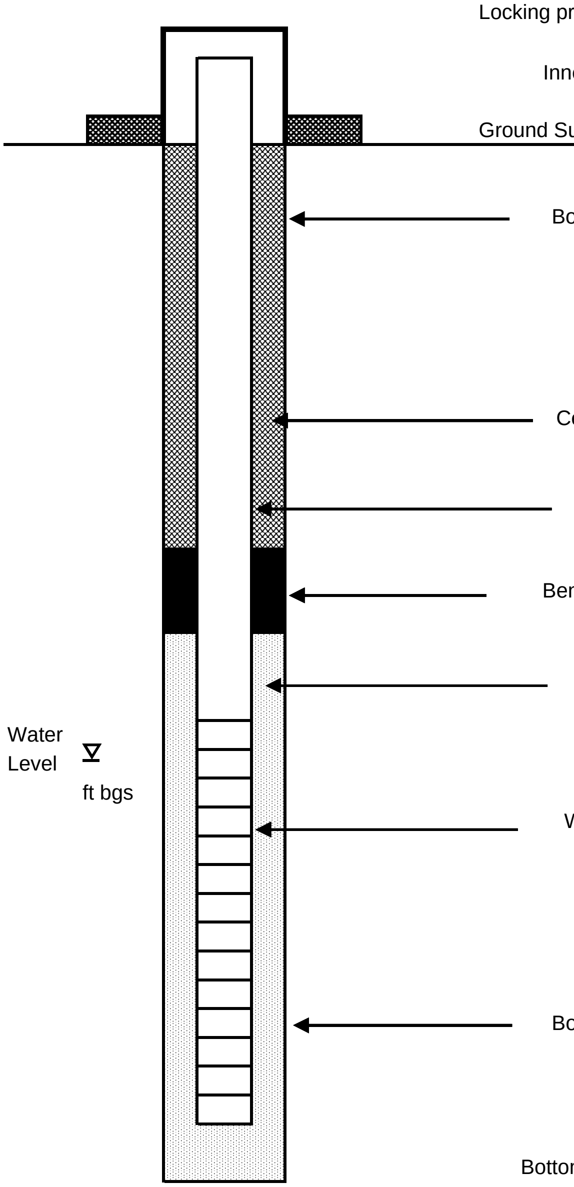
Note: All measurements based on ground surface at 0.0 feet. (+) above grade. (-) below grade.

(NOT TO SCALE)

AECOM

Overburden Well Diagram **Well No.**

Project: Area 1 Former Scott Aviation Site	Location: Lancaster, NY	Page 1 of 1
AECOM Project No.:	Subcontractor:	Water Levels
Surface Elevation: Ft	Driller:	Date / Time / Depth
Top of PVC Casing Elevation: Ft	Well Permit No.: AECOM Rep.	
Datum: NGVD 1988	Date of Completion:	



Locking protective stickup with concrete pad, three bollards

Inner casing stickup ____ ft to ____ ft

Ground Surface

Borehole diameter ____ inches

Cement-bentonite grout from ____ ft to ____ ft

Riser Pipe from ____ ft to ____ ft

Bentonite seal from ____ ft to ____ ft

Filter pack from ____ ft to ____ ft

Sand Size ____

Well screen from ____ ft to ____ ft

Diameter ____ inches
Slot size ____ inches
Type ____

Borehole diameter ____ inches

Bottom Cap at ____ ft

Bottom of Borehole at ____ ft

Note: All measurements based on ground surface at 0.0 feet. (+) above grade. (-) below grade.

(NOT TO SCALE)

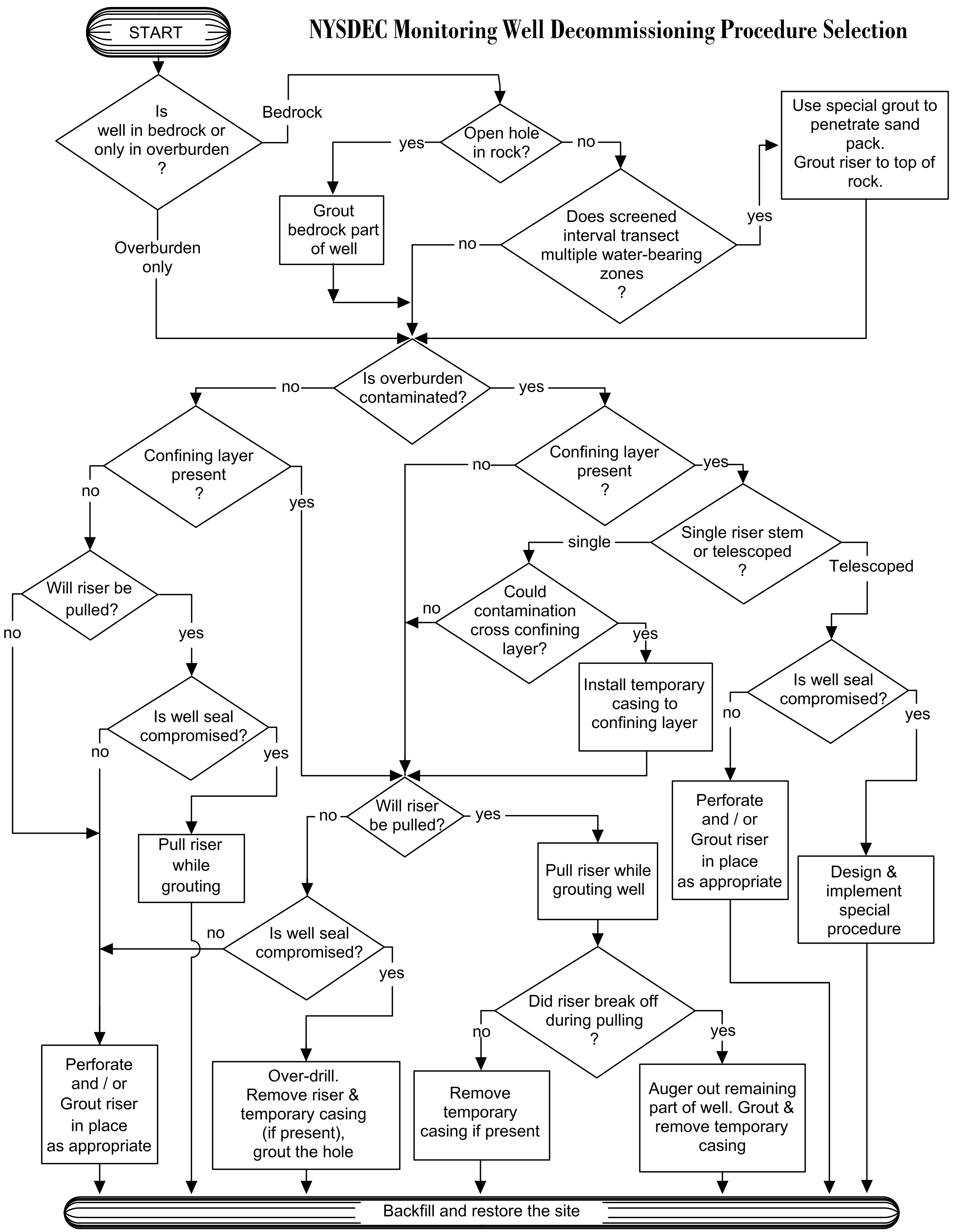

START
NYSDEC Monitoring Well Decommissioning Procedure Selection
Is well in bedrock or only in overburden ?
Bedrock
Overburden only
Open hole in rock?
yes
no
Grout bedrock part of well
Does screened interval transect multiple water-bearing zones ?
yes
no
Use special grout to penetrate sand pack. Grout riser to top of rock.
Is overburden contaminated?
no
yes
Confining layer present ?
no
yes
Confining layer present ?
no
yes
Will riser be pulled?
no
yes
Single riser stem or telescoped ?
single
Telescoped
Could contamination cross confining layer?
no
yes
Install temporary casing to confining layer
Is well seal compromised?
no
yes
Is well seal compromised?
no
yes
Will riser be pulled?
no
yes
Pull riser while grouting
Perforate and / or Grout riser in place as appropriate
Design & implement special procedure
Pull riser while grouting well
Is well seal compromised?
no
yes
Did riser break off during pulling ?
no
yes
Perforate and / or Grout riser in place as appropriate
Over-drill. Remove riser & temporary casing (if present), grout the hole
Remove temporary casing if present
Auger out remaining part of well. Grout & remove temporary casing
Backfill and restore the site

FIGURE 2

FIGURE 3
WELL DECOMMISSIONING RECORD

Site Name:	Well I.D.:
Site Location:	Driller:
Drilling Co.:	Inspector:
	Date:

DECOMMISSIONING DATA
(Fill in all that apply)

OVERDRILLING

Interval Drilled	
Drilling Method(s)	
Borehole Dia. (in.)	
Temporary Casing Installed? (y/n)	
Depth temporary casing installed	
Casing type/dia. (in.)	
Method of installing	

CASING PULLING

Method employed	
Casing retrieved (feet)	
Casing type/dia. (in)	

CASING PERFORATING

Equipment used	
Number of perforations/foot	
Size of perforations	
Interval perforated	

GROUTING

Interval grouted (FBLS)	
# of batches prepared	

For each batch record:

Quantity of water used (gal.)	
Quantity of cement used (lbs.)	
Cement type	
Quantity of bentonite used (lbs.)	
Quantity of calcium chloride used (lbs.)	
Volume of grout prepared (gal.)	
Volume of grout used (gal.)	

WELL SCHEMATIC*

Depth
(feet)

COMMENTS:

* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

Drilling Contractor

Department Representative

AECOM

Monitoring Well Development Log

Date Started (mo/day/yr) ________ Date Completed (mo/day/yr) ________

Field Personnel ________

Site Name ________

Earth Tech Job # ________

Well ID # ________

Investigative Area ________

Weather Conditions ________

Air Temperature ________ °F

Total Well Depth (TWD) = ________ 1/100 ft

Depth to Ground Water (DGW) = ________ 1/100 ft

Length of Water Column (LWC) = TWD - DGW = ________ 1/100 ft

1 Casing Volume (OCV) = LWC x ________ = ________ gallons

5 Casing Volumes = ________ gallons

Method of Well Development ________

____

Total Volume of Water Removed ________ gallons

Date/Time	Discharge Rate (gpm)	Volume Purged (gallons)	Water Temperature (°C)	DO	pH	ORP	Specific Conductivity (µmhos/cm)	Turbidity/Color	Water Level (ft BTIC)	Remarks

COMMENTS/OBSERVATIONS: ________

____

AECOM

GROUNDWATER SAMPLING LOG

Date (mo/day/yr) ____________________

Field Personnel ____________________

Site Name **Former Scott Aviation Site Aera 1 - Lancaster, NY**

Earth Tech Job # ____________________

Well ID # ____________________

________ Upgradient ________ Downgradient

Weather Conditions ____________________

Air Temperature ____________________ ° F

Total Depth (TWD) Below Top of Casing = ____________ 1/100 ft

Depth to Groundwater (DGW) Below Top of Casing = ____________ 1/100 ft

Length of Water Column (LWC) = TWD - DGW = ____________ 1/100 ft

1 Casing Volume (OCV) = LWC x 0.163 = ____________ gal

3 Casing Volumes = ____________ gal

Method of Well Evacuation ____________________

Method of Sample Collection ____________________

Total Volume of Water Removed ____________________ lit

Casing Diameter ____________________ inches

Casing Material ____________________

Measuring Point Elevation ____________________ 1/100 ft

Height of Riser (above land surface) ____________________ 1/100 ft

Land Surface Elevation ____________________ 1/100 ft

Screened Interval (below land surface) ____________________ 1/100 ft

Container	Analysis (Method)	# Bottles	Preservative	Dup - MS/MSD

FIELD ANALYSES

Flow Rate (ml/min)								
Time (Minutes)								
Depth to Groundwater Below Top of Casing (ft)								
Drawdown (ft)								
pH (S.U.)								
Sp. Cond. (mS/cm)								
Turbidity (NTUs)								
Dissolved Oxygen (mg/L)								
Water Temperature (°C)								
ORP (mV)								

Physical appearance at start Color ________ Odor ________

Sheen/Free Product ____________

Physical appearance at sampling Color ________ Odor ________

Sheen/Free Product ____________

COMMENTS/OBSERVATIONS ____________________

____

Slug Test Data

Location ________________________ Geologic Unit __________ Well Number _________ Sheet _______ of _____

Field Team Member Signature

(Print name and title, then sign)

Test Method: ___ Slug Injection or ___ Slug Withdrawal Slug Dimensions or volume _______________

Well Construction Details (attach diagram): ____

Test Started __________________ Test Stopped _______________ Test ID ____________________________

Method of Water-Level Measurement: ____

Comments: ____

____

____

Time of Measurement	**Elapsed Time (minutes)**	**Depth to Water (feet)**	**Time of Measurement**	**Elapsed Time (minutes)**	**Depth to Water (feet)**

☐ Check here if continued on the back of this sheet.

IDW MANAGEMENT FORM

COMPANY______________________________ PROJECT______________________________

SITE NAME______________________________ LOCATION______________________________

CONTAINER NUMBER	MEDIA DESCRIPTION	MEDIA ORIGIN	DATE FILLED	DATE SAMPLED	DATE DISPOSED	COMMENTS

Data/ Graphics/ Tyndall/ 202661/ idw_1of3.fh8

ATTACHMENT 2

LOW FLOW GROUNDWATER SAMPLING PROCEDURES

United States Environmental Protection Agency | Office of Research and Development | Office of Solid Waste and Emergency Response | EPA/540/S-95/504 April 1996

Ground Water Issue

LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES

by Robert W. Puls[1] and Michael J. Barcelona[2]

Background

The Regional Superfund Ground Water Forum is a group of ground-water scientists, representing EPA's Regional Superfund Offices, organized to exchange information related to ground-water remediation at Superfund sites. One of the major concerns of the Forum is the sampling of ground water to support site assessment and remedial performance monitoring objectives. This paper is intended to provide background information on the development of low-flow sampling procedures and its application under a variety of hydrogeologic settings. It is hoped that the paper will support the production of standard operating procedures for use by EPA Regional personnel and other environmental professionals engaged in ground-water sampling.

For further information contact: Robert Puls, 405-436-8543, Subsurface Remediation and Protection Division, NRMRL, Ada, Oklahoma.

I. Introduction

The methods and objectives of ground-water sampling to assess water quality have evolved over time. Initially the emphasis was on the assessment of water quality of aquifers as sources of drinking water. Large water-bearing units were identified and sampled in keeping with that objective. These were highly productive aquifers that supplied drinking water via private wells or through public water supply systems. Gradually, with the increasing awareness of subsurface pollution of these water resources, the understanding of complex hydrogeochemical processes which govern the fate and transport of contaminants in the subsurface increased. This increase in understanding was also due to advances in a number of scientific disciplines and improvements in tools used for site characterization and ground-water sampling. Ground-water quality investigations where pollution was detected initially borrowed ideas, methods, and materials for site characterization from the water supply field and water analysis from public health practices. This included the materials and manner in which monitoring wells were installed and the way in which water was brought to the surface, treated, preserved and analyzed. The prevailing conceptual ideas included convenient generalizations of ground-water resources in terms of large and relatively homogeneous hydrologic *units*. With time it became apparent that conventional water supply generalizations of *homogeneity* did not adequately represent field data regarding pollution of these subsurface resources. The important role of *heterogeneity* became increasingly clear not only in geologic terms, but also in terms of complex physical,

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Technology Innovation Office
Office of Solid Waste and Emergency Response, US EPA, Washington, DC

Walter W. Kovalick, Jr., Ph.D.
Director

chemical and biological subsurface processes. With greater appreciation of the role of heterogeneity, it became evident that subsurface pollution was ubiquitous and encompassed the unsaturated zone to the deep subsurface and included unconsolidated sediments, fractured rock, and *aquitards* or low-yielding or impermeable formations. Small-scale processes and heterogeneities were shown to be important in identifying contaminant distributions and in controlling water and contaminant flow paths.

It is beyond the scope of this paper to summarize all the advances in the field of ground-water quality investigations and remediation, but two particular issues have bearing on ground-water sampling today: aquifer heterogeneity and colloidal transport. Aquifer heterogeneities affect contaminant flow paths and include variations in geology, geochemistry, hydrology and microbiology. As methods and the tools available for subsurface investigations have become increasingly sophisticated and understanding of the subsurface environment has advanced, there is an awareness that in most cases a primary concern for site investigations is characterization of contaminant flow paths rather than entire aquifers. In fact, in many cases, plume thickness can be less than well screen lengths (e.g., 3-6 m) typically installed at hazardous waste sites to detect and monitor plume movement over time. Small-scale differences have increasingly been shown to be important and there is a general trend toward smaller diameter wells and shorter screens.

The hydrogeochemical significance of colloidal-size particles in subsurface systems has been realized during the past several years (Gschwend and Reynolds, 1987; McCarthy and Zachara, 1989; Puls, 1990; Ryan and Gschwend, 1990). This realization resulted from both field and laboratory studies that showed faster contaminant migration over greater distances and at higher concentrations than flow and transport model predictions would suggest (Buddemeier and Hunt, 1988; Enfield and Bengtsson, 1988; Penrose et al., 1990). Such models typically account for interaction between the mobile aqueous and immobile solid phases, but do not allow for a mobile, reactive solid phase. It is recognition of this third *phase* as a possible means of contaminant transport that has brought increasing attention to the manner in which samples are collected and processed for analysis (Puls et al., 1990; McCarthy and Degueldre, 1993; Backhus et al., 1993; U. S. EPA, 1995). If such a phase is present in sufficient mass, possesses high sorption reactivity, large surface area, and remains stable in suspension, it can serve as an important mechanism to facilitate contaminant transport in many types of subsurface systems.

Colloids are particles that are sufficiently small so that the surface free energy of the particle dominates the bulk free energy. Typically, in ground water, this includes particles with diameters between 1 and 1000 nm. The most commonly observed mobile particles include: secondary clay minerals; hydrous iron, aluminum, and manganese oxides; dissolved and particulate organic materials, and viruses and bacteria. These reactive particles have been shown to be mobile under a variety of conditions in both field studies and laboratory column experiments, and as such need to be included in monitoring programs where identification of the *total* mobile contaminant loading (dissolved + naturally suspended particles) at a site is an objective. To that end, sampling methodologies must be used which do not artificially bias *naturally* suspended particle concentrations.

Currently the most common ground-water purging and sampling methodology is to purge a well using bailers or high speed pumps to remove 3 to 5 casing volumes followed by sample collection. This method can cause adverse impacts on sample quality through collection of samples with high levels of turbidity. This results in the inclusion of otherwise immobile artifactual particles which produce an overestimation of certain analytes of interest (e.g., metals or hydrophobic organic compounds). Numerous documented problems associated with filtration (Danielsson, 1982; Laxen and Chandler, 1982; Horowitz et al., 1992) make this an undesirable method of rectifying the turbidity problem, and include the removal of potentially mobile (contaminant-associated) particles during filtration, thus artificially biasing contaminant concentrations low. Sampling-induced turbidity problems can often be mitigated by using low-flow purging and sampling techniques.

Current subsurface conceptual models have undergone considerable refinement due to the recent development and increased use of field screening tools. So-called hydraulic *push* technologies (e.g., cone penetrometer, Geoprobe®, QED HydroPunch®) enable relatively fast screening site characterization which can then be used to design and install a monitoring well network. Indeed, alternatives to conventional monitoring wells are now being considered for some hydrogeologic settings. The ultimate design of any monitoring system should however be based upon adequate site characterization and be consistent with established monitoring objectives.

If the sampling program objectives include accurate assessment of the magnitude and extent of subsurface contamination over time and/or accurate assessment of subsequent remedial performance, then some information regarding plume delineation in three-dimensional space is necessary prior to monitoring well network design and installation. This can be accomplished with a variety of different tools and equipment ranging from hand-operated augers to screening tools mentioned above and large drilling rigs. Detailed information on ground-water flow velocity, direction, and horizontal and vertical variability are essential baseline data requirements. Detailed soil and geologic data are required prior to and during the installation of sampling points. This includes historical as well as detailed soil and geologic logs which accumulate during the site investigation. The use of borehole geophysical techniques is also recommended. With this information (together with other site characterization data) and a clear understanding of sampling objectives, then appropriate location, screen length, well diameter, slot size, etc. for the monitoring well network can be decided. This is especially critical for new in situ remedial approaches or natural attenuation assessments at hazardous waste sites.

In general, the overall goal of any ground-water sampling program is to collect water samples with no alteration in water chemistry; analytical data thus obtained may be used for a variety of specific monitoring programs depending on the regulatory requirements. The sampling methodology described in this paper assumes that the monitoring goal is to sample monitoring wells for the presence of contaminants and it is applicable whether mobile colloids are a concern or not and whether the analytes of concern are metals (and metalloids) or organic compounds.

II. Monitoring Objectives and Design Considerations

The following issues are important to consider prior to the design and implementation of any ground-water monitoring program, including those which anticipate using low-flow purging and sampling procedures.

A. Data Quality Objectives (DQOs)

Monitoring objectives include four main types: detection, assessment, corrective-action evaluation and resource evaluation, along with *hybrid* variations such as site-assessments for property transfers and water availability investigations. Monitoring objectives may change as contamination or water quality problems are discovered. However, there are a number of common components of monitoring programs which should be recognized as important regardless of initial objectives. These components include:

1) Development of a conceptual model that incorporates elements of the regional geology to the local geologic framework. The conceptual model development also includes initial site characterization efforts to identify hydrostratigraphic units and likely flow-paths using a minimum number of borings and well completions;

2) Cost-effective and well documented collection of high quality data utilizing simple, accurate, and reproducible techniques; and

3) Refinement of the conceptual model based on supplementary data collection and analysis.

These fundamental components serve many types of monitoring programs and provide a basis for future efforts that evolve in complexity and level of spatial detail as purposes and objectives expand. High quality, reproducible data collection is a common goal regardless of program objectives.

High quality data collection implies data of sufficient accuracy, precision, and completeness (i.e., ratio of valid analytical results to the minimum sample number called for by the program design) to meet the program objectives. Accuracy depends on the correct choice of monitoring tools and procedures to minimize sample and subsurface disturbance from collection to analysis. Precision depends on the repeatability of sampling and analytical protocols. It can be assured or improved by replication of sample analyses including blanks, field/lab standards and reference standards.

B. Sample Representativeness

An important goal of any monitoring program is collection of data that is truly representative of conditions at the site. The term *representativeness* applies to chemical and hydrogeologic data collected via wells, borings, piezometers, geophysical and soil gas measurements, lysimeters, and temporary sampling points. It involves a recognition of the statistical variability of individual subsurface physical properties, and contaminant or major ion concentration levels, while explaining extreme values. Subsurface temporal and spatial variability are facts. Good professional practice seeks to maximize representativeness by using proven accurate and reproducible techniques to define limits on the distribution of measurements collected at a site. However, measures of representativeness are dynamic and are controlled by evolving site characterization and monitoring objectives. An evolutionary site characterization model, as shown in Figure 1, provides a systematic approach to the goal of consistent data collection.

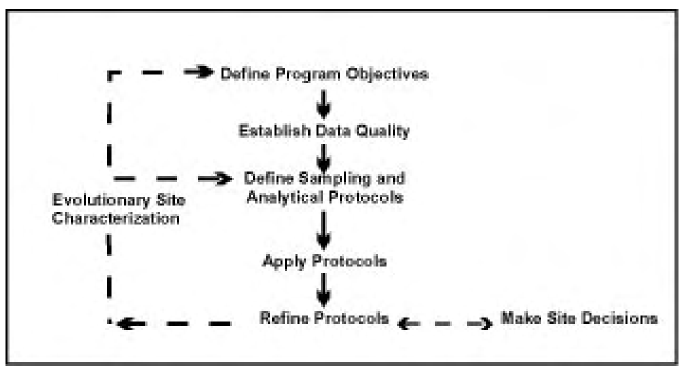

Figure 1. Evolutionary Site Characterization Model

The model emphasizes a recognition of the causes of the variability (e.g., use of inappropriate technology such as using bailers to purge wells; imprecise or operator-dependent methods) and the need to control avoidable errors.

1) Questions of Scale

A sampling plan designed to collect representative samples must take into account the potential scale of changes in site conditions through space and time as well as the chemical associations and behavior of the parameters that are targeted for investigation. In subsurface systems, physical (i.e., aquifer) and chemical properties over time or space are not statistically independent. In fact, samples taken in close proximity (i.e., within distances of a few meters) or within short time periods (i.e., more frequently than monthly) are highly auto-correlated. This means that designs employing high-sampling frequency (e.g., monthly) or dense spatial monitoring designs run the risk of redundant data collection and misleading inferences regarding trends in values that aren't statistically valid. In practice, contaminant detection and assessment monitoring programs rarely suffer these *over-sampling* concerns. In corrective-action evaluation programs, it is also possible that too little data may be collected over space or time. In these cases, false interpretation of the spatial extent of contamination or underestimation of temporal concentration variability may result.

2) Target Parameters

Parameter selection in monitoring program design is most often dictated by the regulatory status of the site. However, background water quality constituents, purging indicator parameters, and contaminants, all represent targets for data collection programs. The tools and procedures used in these programs should be equally rigorous and applicable to all categories of data, since all may be needed to determine or support regulatory action.

C. Sampling Point Design and Construction

Detailed site characterization is central to all decision-making purposes and the basis for this characterization resides in identification of the geologic framework and major hydro-stratigraphic units. Fundamental data for sample point location include: subsurface lithology, head-differences and background geochemical conditions. Each sampling point has a proper use or uses which should be documented at a level which is appropriate for the program's data quality objectives. Individual sampling points may not always be able to fulfill multiple monitoring objectives (e.g., detection, assessment, corrective action).

1) Compatibility with Monitoring Program and Data Quality Objectives

Specifics of sampling point location and design will be dictated by the complexity of subsurface lithology and variability in contaminant and/or geochemical conditions. It should be noted that, regardless of the ground-water sampling approach, few sampling points (e.g., wells, drive-points, screened augers) have zones of influence in excess of a few feet. Therefore, the spatial frequency of sampling points should be carefully selected and designed.

2) Flexibility of Sampling Point Design

In most cases *well-point* diameters in excess of 1 7/8 inches will permit the use of most types of submersible pumping devices for low-flow (minimal drawdown) sampling. It is suggested that *short* (e.g., less than 1.6 m) screens be incorporated into the monitoring design where possible so that comparable results from one device to another might be expected. *Short*, of course, is relative to the degree of vertical water quality variability expected at a site.

3) Equilibration of Sampling Point

Time should be allowed for equilibration of the well or sampling point with the formation after installation. Placement of well or sampling points in the subsurface produces some disturbance of ambient conditions. Drilling techniques (e.g., auger, rotary, etc.) are generally considered to cause more disturbance than *direct-push* technologies. In either case, there may be a period (i.e., days to months) during which water quality near the point may be distinctly different from that in the formation. Proper development of the sampling point and adjacent formation to remove fines created during emplacement will shorten this water quality *recovery* period.

III. Definition of Low-Flow Purging and Sampling

It is generally accepted that water in the well casing is non-representative of the formation water and needs to be purged prior to collection of ground-water samples. However, the water in the screened interval may indeed be representative of the formation, depending upon well construction and site hydrogeology. Wells are purged to some extent for the following reasons: the presence of the air interface at the top of the water column resulting in an oxygen concentration gradient with depth, loss of volatiles up the water column, leaching from or sorption to the casing or filter pack, chemical changes due to clay seals or backfill, and surface infiltration.

Low-flow purging, whether using portable or dedicated systems, should be done using pump-intake located in the middle or slightly above the middle of the screened interval. Placement of the pump too close to the bottom of the well will cause increased entrainment of solids which have collected in the well over time. These particles are present as a result of well development, prior purging and sampling events, and natural colloidal transport and deposition. Therefore, placement of the pump in the middle or toward the top of the screened interval is suggested. Placement of the pump at the top of the water column for sampling is only recommended in unconfined aquifers, screened across the water table, where this is the desired sampling point. Low-flow purging has the advantage of minimizing mixing between the overlying stagnant casing water and water within the screened interval.

A. Low-Flow Purging and Sampling

Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface which can be affected by flow regulators or restrictions. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical taking into account established site sampling objectives. Typically, flow rates on the order of 0.1 - 0.5 L/min are used, however this is dependent on site-specific hydrogeology. Some extremely coarse-textured formations have been successfully sampled in this manner at flow rates to 1 L/min. The effectiveness of using low-flow purging is intimately linked with proper screen location, screen length, and well construction and development techniques. The reestablishment of natural flow paths in both the vertical and horizontal directions is important for correct interpretation of the data. For high resolution sampling needs, screens less than 1 m should be used. Most of the need for purging has been found to be due to passing the sampling device through the overlying casing water which causes mixing of these stagnant waters and the dynamic waters within the screened interval. Additionally, there is disturbance to suspended sediment collected in the bottom of the casing and the displacement of water out into the formation immediately adjacent to the well screen. These disturbances and impacts can be avoided using dedicated sampling equipment, which precludes the need to insert the sampling device prior to purging and sampling.

Isolation of the screened interval water from the overlying stagnant casing water may be accomplished using low-flow minimal drawdown techniques. If the pump intake is located within the screened interval, most of the water pumped will be drawn in directly from the formation with little mixing of casing water or disturbance to the sampling zone. However, if the wells are not constructed and developed properly, zones other than those intended may be sampled. At some sites where geologic heterogeneities are sufficiently different within the screened interval, higher conductivity zones may be preferentially sampled. This is another reason to use shorter screened intervals, especially where high spatial resolution is a sampling objective.

B. Water Quality Indicator Parameters

It is recommended that water quality indicator parameters be used to determine purging needs prior to sample collection in each well. Stabilization of parameters such as pH, specific conductance, dissolved oxygen, oxidation-reduction potential, temperature and turbidity should be used to determine when formation water is accessed during purging. In general, the order of stabilization is pH, temperature, and specific conductance, followed by oxidation-reduction potential, dissolved oxygen and turbidity. Temperature and pH, while commonly used as purging indicators, are actually quite insensitive in distinguishing between formation water and stagnant casing water; nevertheless, these are important parameters for data interpretation purposes and should also be measured. Performance criteria for determination of stabilization should be based on water-level drawdown, pumping rate and equipment specifications for measuring indicator parameters. Instruments are available which utilize in-line flow cells to continuously measure the above parameters.

It is important to establish specific well stabilization criteria and then consistently follow the same methods thereafter, particularly with respect to drawdown, flow rate and sampling device. Generally, the time or purge volume required for parameter stabilization is independent of well depth or well volumes. Dependent variables are well diameter, sampling device, hydrogeochemistry, pump flow rate, and whether the devices are used in a portable or dedicated manner. If the sampling device is already in place (i.e., dedicated sampling systems), then the time and purge volume needed for stabilization is much shorter. Other advantages of dedicated equipment include less purge water for waste disposal, much less decontamination of equipment, less time spent in preparation of sampling as well as time in the field, and more consistency in the sampling approach which probably will translate into less variability in sampling results. The use of dedicated equipment is strongly recommended at wells which will undergo routine sampling over time.

If parameter stabilization criteria are too stringent, then minor oscillations in indicator parameters may cause purging operations to become unnecessarily protracted. It should also be noted that turbidity is a very conservative parameter in terms of stabilization. Turbidity is always the last parameter to stabilize. Excessive purge times are invariably related to the establishment of too stringent turbidity stabilization criteria. It should be noted that natural turbidity levels in ground water may exceed 10 nephelometric turbidity units (NTU).

C. Advantages and Disadvantages of Low-Flow (Minimum Drawdown) Purging

In general, the advantages of low-flow purging include:

- samples which are representative of the *mobile* load of contaminants present (dissolved and colloid-associated);
- minimal disturbance of the sampling point thereby minimizing sampling artifacts;
- less operator variability, greater operator control;

- reduced stress on the formation (minimal drawdown);
- less mixing of stagnant casing water with formation water;
- reduced need for filtration and, therefore, less time required for sampling;
- smaller purging volume which decreases waste disposal costs and sampling time;
- better sample consistency; reduced artificial sample variability.

Some disadvantages of low-flow purging are:

- higher initial capital costs,
- greater set-up time in the field,
- need to transport additional equipment to and from the site,
- increased training needs,
- resistance to change on the part of sampling practitioners,
- concern that new data will indicate a *change in conditions* and trigger an *action*.

IV. Low-Flow (Minimal Drawdown) Sampling Protocols

The following ground-water sampling procedure has evolved over many years of experience in ground-water sampling for organic and inorganic compound determinations and as such summarizes the authors' (and others) experiences to date (Barcelona et al., 1984, 1994; Barcelona and Helfrich, 1986; Puls and Barcelona, 1989; Puls et. al. 1990, 1992; Puls and Powell, 1992; Puls and Paul, 1995). High-quality chemical data collection is essential in ground-water monitoring and site characterization. The primary limitations to the collection of *representative* ground-water samples include: mixing of the stagnant casing and *fresh* screen waters during insertion of the sampling device or ground-water level measurement device; disturbance and resuspension of settled solids at the bottom of the well when using high pumping rates or raising and lowering a pump or bailer; introduction of atmospheric gases or degassing from the water during sample handling and transfer, or inappropriate use of vacuum sampling device, etc.

A. Sampling Recommendations

Water samples should not be taken immediately following well development. Sufficient time should be allowed for the ground-water flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well construction materials. This lag time will depend on site conditions and methods of installation but often exceeds one week.

Well purging is nearly always necessary to obtain samples of water flowing through the geologic formations in the screened interval. Rather than using a general but arbitrary guideline of purging three casing volumes prior to sampling, it is recommended that an in-line water quality measurement device (e.g., flow-through cell) be used to establish the stabilization time for several parameters (e.g. , pH, specific conductance, redox, dissolved oxygen, turbidity) on a well-specific basis. Data on pumping rate, drawdown, and volume required for parameter stabilization can be used as a guide for conducting subsequent sampling activities.

The following are recommendations to be considered before, during and after sampling:

- use low-flow rates (<0.5 L/min), during both purging and sampling to maintain minimal drawdown in the well;
- maximize tubing wall thickness, minimize tubing length;
- place the sampling device intake at the desired sampling point;
- minimize disturbances of the stagnant water column above the screened interval during water level measurement and sampling device insertion;
- make proper adjustments to stabilize the flow rate as soon as possible;
- monitor water quality indicators during purging;
- collect unfiltered samples to estimate contaminant loading and transport potential in the subsurface system.

B. Equipment Calibration

Prior to sampling, all sampling device and monitoring equipment should be calibrated according to manufacturer’s recommendations and the site Quality Assurance Project Plan (QAPP) and Field Sampling Plan (FSP). Calibration of pH should be performed with at least two buffers which bracket the expected range. Dissolved oxygen calibration must be corrected for local barometric pressure readings and elevation.

C. Water Level Measurement and Monitoring

It is recommended that a device be used which will least disturb the water surface in the casing. Well depth should be obtained from the well logs. Measuring to the bottom of the well casing will only cause resuspension of settled solids from the formation and require longer purging times for turbidity equilibration. Measure well depth after sampling is completed. The water level measurement should be taken from a permanent reference point which is surveyed relative to ground elevation.

D. Pump Type

The use of low-flow (e.g., 0.1-0.5 L/min) pumps is suggested for purging and sampling all types of analytes. All pumps have some limitation and these should be investigated with respect to application at a particular site. Bailers are inappropriate devices for low-flow sampling.

1) General Considerations

There are no unusual requirements for ground-water sampling devices when using low-flow, minimal drawdown techniques. The major concern is that the device give consistent results and minimal disturbance of the sample across a range of *low* flow rates (i.e., < 0.5 L/min). Clearly, pumping rates that cause minimal to no drawdown in one well could easily cause *significant* drawdown in another well finished in a less transmissive formation. In this sense, the pump should not cause undue pressure or temperature changes or physical disturbance on the water sample over a reasonable sampling range. Consistency in operation is critical to meet accuracy and precision goals.

2) Advantages and Disadvantages of Sampling Devices

A variety of sampling devices are available for low-flow (minimal drawdown) purging and sampling and include peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps. Devices which lend themselves to both dedication and consistent operation at definable low-flow rates are preferred. It is desirable that the pump be easily adjustable and operate reliably at these lower flow rates. The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and some volatiles loss. Gas-driven pumps should be of a type that does not allow the gas to be in direct contact with the sampled fluid.

Clearly, bailers and other *grab* type samplers are ill-suited for low-flow sampling since they will cause repeated disturbance and mixing of *stagnant* water in the casing and the *dynamic* water in the screened interval. Similarly, the use of inertial lift foot-valve type samplers may cause too much disturbance at the point of sampling. Use of these devices also tends to introduce uncontrolled and unacceptable operator variability.

Summaries of advantages and disadvantages of various sampling devices are listed in Herzog et al. (1991), U. S. EPA (1992), Parker (1994) and Thurnblad (1994).

E. Pump Installation

Dedicated sampling devices (left in the well) capable of pumping and sampling are preferred over <u>any</u> other type of device. Any portable sampling device should be slowly and carefully lowered to the middle of the screened interval or slightly above the middle (e.g., 1-1.5 m below the top of a 3 m screen). This is to minimize excessive mixing of the stagnant water in the casing above the screen with the screened interval zone water, and to minimize resuspension of solids which will have collected at the bottom of the well. These two disturbance effects have been shown to directly affect the time required for purging. There also appears to be a direct correlation between size of portable sampling devices relative to the well bore and resulting purge volumes and times. The key is to minimize disturbance of water and solids in the well casing.

F. Filtration

Decisions to filter samples should be dictated by sampling objectives rather than as a *fix* for poor sampling practices, and field-filtering of certain constituents should not be the default. Consideration should be given as to what the application of field-filtration is trying to accomplish. For assessment of truly dissolved (as opposed to operationally *dissolved* [i.e., samples filtered with 0.45 µm filters]) concentrations of major ions and trace metals, 0.1 µm filters are recommended although 0.45 µm filters are normally used for most regulatory programs. Alkalinity samples must also be filtered if significant particulate calcium carbonate is suspected, since this material is likely to impact alkalinity titration results (although filtration itself may alter the CO_2 composition of the sample and, therefore, affect the results).

Although filtration may be appropriate, filtration of a sample may cause a number of unintended changes to occur (e.g. oxidation, aeration) possibly leading to filtration-induced artifacts during sample analysis and uncertainty in the results. Some of these unintended changes may be unavoidable but the factors leading to them must be recognized. Deleterious effects can be minimized by consistent application of certain filtration guidelines. Guidelines should address selection of filter type, media, pore size, etc. in order to identify and minimize potential sources of uncertainty when filtering samples.

In-line filtration is recommended because it provides better consistency through less sample handling, and minimizes sample exposure to the atmosphere. In-line filters are available in both disposable (barrel filters) and non-disposable (in-line filter holder, flat membrane filters) formats and various filter pore sizes (0.1-5.0 µm). Disposable filter cartridges have the advantage of greater sediment handling capacity when compared to traditional membrane filters. Filters must be pre-rinsed following manufacturer's recommendations. If there are no recommendations for rinsing, pass through a minimum of 1 L of ground water following purging and prior to sampling. Once filtration has begun, a filter cake may develop as particles larger than the pore size accumulate on the filter membrane. The result is that the effective pore diameter of the membrane is reduced and particles smaller than the stated pore size are excluded from the filtrate. Possible corrective measures include prefiltering (with larger pore size filters), minimizing particle loads to begin with, and reducing sample volume.

G. Monitoring of Water Level and Water Quality Indicator Parameters

Check water level periodically to monitor drawdown in the well as a guide to flow rate adjustment. The goal is minimal drawdown (<0.1 m) during purging. This goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience. In-line water quality indicator parameters should be continuously monitored during purging. The water quality indicator parameters monitored can include pH, redox potential, conductivity, dissolved oxygen (DO) and turbidity. The last three parameters are often most sensitive. Pumping rate, drawdown, and the time or volume required to obtain stabilization of parameter readings can be used as a future guide to purge the well. Measurements should be taken every three to five minutes if the above suggested rates are used. Stabilization is achieved after all parameters have stabilized for three successive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or DO. Three successive readings should be within ± 0.1 for pH, ± 3% for conductivity, ± 10 mv for redox potential, and ± 10% for turbidity and DO. Stabilized purge indicator parameter trends are generally obvious and follow either an exponential or asymptotic change to stable values during purging. Dissolved oxygen and turbidity usually require the longest time for stabilization. The above stabilization guidelines are provided for rough estimates based on experience.

H. Sampling, Sample Containers, Preservation and Decontamination

Upon parameter stabilization, sampling can be initiated. If an in-line device is used to monitor water quality parameters, it should be disconnected or bypassed during sample collection. Sampling flow rate may remain at established purge rate or may be adjusted slightly to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. Typically, flow rates less than 0.5 L/min are appropriate. The same device should be used for sampling as was used for purging. Sampling should occur in a progression from least to most contaminated well, if this is known. Generally, volatile (e.g., solvents and fuel constituents) and gas sensitive (e.g., Fe^{2+}, CH_4, H_2S/HS^-, alkalinity) parameters should be sampled first. The sequence in which samples for most inorganic parameters are collected is immaterial unless filtered (dissolved) samples are desired. Filtering should be done last and in-line filters should be used as discussed above. During both well purging and sampling, proper protective clothing and equipment must be used based upon the type and level of contaminants present.

The appropriate sample container will be prepared in advance of actual sample collection for the analytes of interest and include sample preservative where necessary. Water samples should be collected directly into this container from the pump tubing.

Immediately after a sample bottle has been filled, it must be preserved as specified in the site (QAPP). Sample preservation requirements are based on the analyses being performed (use site QAPP, FSP, RCRA guidance document [U. S. EPA, 1992] or EPA SW-846 [U. S. EPA, 1982]). It may be advisable to add preservatives to sample bottles in a controlled setting prior to entering the field in order to reduce the chances of improperly preserving sample bottles or introducing field contaminants into a sample bottle while adding the preservatives.

The preservatives should be transferred from the chemical bottle to the sample container using a disposable polyethylene pipet and the disposable pipet should be used only once and then discarded.

After a sample container has been filled with ground water, a Teflon™ (or tin)-lined cap is screwed on tightly to prevent the container from leaking. A sample label is filled out as specified in the FSP. The samples should be stored inverted at 4^oC.

Specific decontamination protocols for sampling devices are dependent to some extent on the type of device used and the type of contaminants encountered. Refer to the site QAPP and FSP for specific requirements.

I. Blanks

The following blanks should be collected:

(1) field blank: one field blank should be collected from each source water (distilled/deionized water) used for sampling equipment decontamination or for assisting well development procedures.

(2) equipment blank: one equipment blank should be taken prior to the commencement of field work, from each set of sampling equipment to be used for that day. Refer to site QAPP or FSP for specific requirements.

(3) trip blank: a trip blank is required to accompany each volatile sample shipment. These blanks are prepared in the laboratory by filling a 40-mL volatile organic analysis (VOA) bottle with distilled/deionized water.

V. Low-Permeability Formations and Fractured Rock

The overall sampling program goals or sampling objectives will drive how the sampling points are located, installed, and choice of sampling device. Likewise, site-specific hydrogeologic factors will affect these decisions. Sites with very low permeability formations or fractures causing discrete flow channels may require a unique monitoring approach. Unlike water supply wells, wells installed for ground-water quality assessment and restoration programs are often installed in low water-yielding settings (e.g., clays, silts). Alternative types of sampling points and sampling methods are often needed in these types of environments, because low-permeability settings may require extremely low-flow purging (<0.1 L/min) and may be technology-limited. Where devices are not readily available to pump at such low flow rates, the primary consideration is to avoid dewatering of the well screen. This may require repeated recovery of the water during purging while leaving the pump in place within the well screen.

Use of low-flow techniques may be impractical in these settings, depending upon the water recharge rates. The sampler and the end-user of data collected from such wells need to understand the limitations of the data collected; i.e., a strong potential for underestimation of actual contaminant concentrations for volatile organics, potential false negatives for filtered metals and potential false positives for unfiltered metals. It is suggested that comparisons be made between samples recovered using low-flow purging techniques and samples recovered using passive sampling techniques (i.e., two sets of samples). Passive sample collection would essentially entail acquisition of the sample with no or very little purging using a dedicated sampling system installed within the screened interval or a passive sample collection device.

A. Low-Permeability Formations (<0.1 L/min recharge)

1. Low-Flow Purging and Sampling with Pumps

a. "portable or non-dedicated mode" - Lower the pump (one capable of pumping at <0.1 L/min) to mid-screen or slightly above and set in place for minimum of 48 hours (to lessen purge volume requirements). After 48 hours, use procedures listed in Part IV above regarding monitoring water quality parameters for stabilization, etc., but do not dewater the screen. If excessive drawdown and slow recovery is a problem, then alternate approaches such as those listed below may be better.

b. "dedicated mode" - Set the pump as above at least a week prior to sampling; that is, operate in a dedicated pump mode. With this approach significant reductions in purge volume should be realized. Water quality parameters should stabilize quite rapidly due to less disturbance of the sampling zone.

2. Passive Sample Collection

Passive sampling collection requires insertion of the device into the screened interval for a sufficient time period to allow flow and sample equilibration before extraction for analysis. Conceptually, the extraction of water from low yielding formations seems more akin to the collection of water from the unsaturated zone and passive sampling techniques may be more appropriate in terms of obtaining "representative" samples. Satisfying usual sample volume requirements is typically a problem with this approach and some latitude will be needed on the part of regulatory entities to achieve sampling objectives.

B. Fractured Rock

In fractured rock formations, a low-flow to zero purging approach using pumps in conjunction with packers to isolate the sampling zone in the borehole is suggested. Passive multi-layer sampling devices may also provide the most "representative" samples. It is imperative in these settings to identify flow paths or water-producing fractures prior to sampling using tools such as borehole flowmeters and/or other geophysical tools.

After identification of water-bearing fractures, install packer(s) and pump assembly for sample collection using low-flow sampling in "dedicated mode" or use a passive sampling device which can isolate the identified water-bearing fractures.

VI. Documentation

The usual practices for documenting the sampling event should be used for low-flow purging and sampling techniques. This should include, at a minimum: information on the conduct of purging operations (flow-rate, drawdown, water-quality parameter values, volumes extracted and times for measurements), field instrument calibration data, water sampling forms and chain of custody forms. See Figures 2 and 3 and "Ground Water Sampling Workshop -- A Workshop Summary" (U. S. EPA, 1995) for example forms and other documentation suggestions and information. This information coupled with laboratory analytical data and validation data are needed to judge the "useability" of the sampling data.

VII. Notice

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Figure 2. **Ground Water Sampling Log**

Project ________________ **Site** ________________ **Well No.** ______________ **Date** ___________________________

Well Depth _____________ **Screen Length** ___________ **Well Diameter** __________ **Casing Type** _____________

Sampling Device ________________ **Tubing type** _______________________ **Water Level** ___________________

Measuring Point ____________________ **Other Infor** ____

____

Sampling Personnel ____

Time	pH	Temp	Cond.	Dis.O_2	Turb.	[ ]Conc			Notes

Type of Samples Collected

____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi\ r^3$

Figure 3. **Ground Water Sampling Log** (with automatic data logging for most water quality parameters)

Project ______________ **Site** ______________ **Well No.** ____________ **Date** ______________________

Well Depth ___________ **Screen Length** _________ **Well Diameter** ________ **Casing Type** __________

Sampling Device ______________ **Tubing type** ___________________ **Water Level** _______________

Measuring Point _________________ **Other Infor** ____

____

Sampling Personnel ____

Time	Pump Rate	Turbidity	Alkalinity	[ ] Conc	Notes

Type of Samples Collected

____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi\ r^3$

ATTACHMENT 3

SOP 09, *CONDUCTING SLUG TESTS*

1. OBJECTIVE

The objective of these guidelines is to provide general reference information for estimating the hydraulic conductivity of an aquifer by in-situ tests performed in either piezometers, monitoring wells or boreholes.

2. LIMITATIONS

These guidelines are for information only and are not to take precedence over the requirements of project-specific plans for in-situ hydraulic conductivity testing.

These tests approximate the hydraulic conductivity of the formation only at the interval of the test. The disturbance to the formations caused by drilling and the potential turbulence from the well screen can influence the data. The diameter of the well is critical to the computation of the hydraulic conductivity, and the effective diameter of a well can be increased considerably by the well development process. Poor well efficiency caused by inappropriate slot size, poor condition of the well screen, or a poorly designed gravel pack could produce results not representative of the tested formation. Hydraulic conductivity tests in wells should be conducted only after the well has been fully developed. Slug test evaluation formulas assume an instantaneous initial change in water level in the tested interval. Tests performed after extended periods of pumping or water addition may yield inaccurate results. Slug tests provide only rough estimates of hydraulic conductivity, and should not be run in preference to pumping tests.

3. DEFINITIONS

Slug Test - An aquifer test made either by pouring a small instantaneous charge of water into a well or by withdrawing a slug of water from the well. A synonym for this test, when a slug of water is removed from the well, is a bail-down test.

Rising Head Test - A test performed in an individual borehole or well within the saturated zone to estimate the hydraulic conductivity of the surrounding formation by lowering the water level in the boring or well and measuring the rate of recovery of the water level. The water level may be lowered by pumping or bailing.

Falling Head Test - A test performed in an individual borehole or well to estimate the hydraulic conductivity of the surrounding formation by raising the water level in the boring or well and measuring the rate of drop in the water level.

Constant Head Test - A constant head test is a variation of the falling head test in which water is constantly added to the borehole or well to be tested, and the flow rate required to maintain a hydraulic head at a constant level above the static water level is measured.

Packer Test - A hydraulic conductivity test using inflatable packers to isolate a discrete zone within the borehole for testing purposes.

Packer - A sealing device installed in a well or borehole which isolates intervals within the boring or well for testing purposes.

4. GUIDELINES

In-situ hydraulic conductivity testing provides a relatively rapid method of estimating the hydraulic conductivity of a portion of an aquifer and the transmissivity (if the saturated thickness of the unconfined or confined aquifer is known). While the performance of a pumping test is the optimum aquifer testing method for estimation of hydraulic conductivities, transmissivities, and storage coefficients, pumping tests are relatively expensive and time consuming. Certain methods of in-situ testing, on the other hand, are much less expensive, less time intensive per test and several wells or piezometers can be tested in a single day by one technician. These guidelines present methods for conducting in-situ hydraulic conductivity tests in piezometers, monitoring wells, and boreholes.

4.1 Slug Test

Slug tests are conducted to estimate the hydraulic conductivity of the soil/rock strata within the screen interval of a piezometer or a monitoring well. A standard slug test consists of instantaneous injection or withdrawal of a known volume that causes immediate change of water levels in the well. The subsequent amounts of rise or decline of water levels with time are recorded and used to calculate hydraulic conductivities of the in-situ materials open to the well. Because the slug is small compared to the volume of water in the surrounding aquifer, the slug test is an estimate of permeability within only a few feet of the well.

A slug test is performed by quickly lowering a slug into a well to displace the water from the initial water level and measuring the rate at which the water level declines (falling-head test), then measuring the rate at which the water level rises (rising-head test) after the slug is removed. A bailer can also be used to remove a slug of water. This type of test is usually called a "bail-down test" or "bailer" test. Water level measurements should be recorded every 5 to 10 seconds for the first two minutes and every 30 seconds thereafter. Measurement can be terminated when the depth to water has stabilized for approximately 10 minutes. Water levels during the test can be recorded manually using a water level indicator, or a Hermit Model SE 100B Data logger with a pressure transducer can be used for this purpose.

Prior to slug testing, the well should be thoroughly developed and water levels allowed to stabilize in order to obtain accurate results. The following data should be obtained when performing a slug test, in addition to the static water level and all time and water level measurements:

1. Casing diameter
2. Borehole diameter
3. Well pipe and screen diameter and length
4. Screen slot size
5. Procedures used

6. Gravel pack size
7. Saturated thickness of the aquifer being tested

4.1.1 Slug Test Data Analysis

Slug test data can be analyzed by three different methods to determine in-situ hydraulic conductivity. The first method (Cooper, Bredehoeft, and Papadopulos, 1967) assumes slug test data was collected from wells in a confined aquifer with fully penetrating wells. The second method (Bouwer and Rice, 1976), while originally developed for an unconfined aquifer, can also be used for confined or stratified aquifers if the top of the screen or perforated section is some distance below the upper confining layer (Bouwer, 1989). The third method (Hvorslev, 1951) calculates permeabilities for various well geometries based on the assumption of infinite vertical extent (upward and downward) of the flow system. Detailed description of these methods can be located in the listed references. The most widely used method to reduce slug test data is that of Hvorslev. A brief description of this method is given below.

Figure 9-1 shows the geometry of a piezometer installed in an aquifer. In the case of a piezometer installed into a low permeability unit, special attention must be paid to the method of construction. In many cases, gravel pack is used to fill the open annular space between the well screen and the wall of the open hole. Under such conditions, the radius of the well screen, R, is the radius of the borehole and the length of the well screen, L, is the length of the gravel pack. The gravel pack would typically be extended one to several feet above the well screen and the remainder of the open hole backfilled with some type of grout.

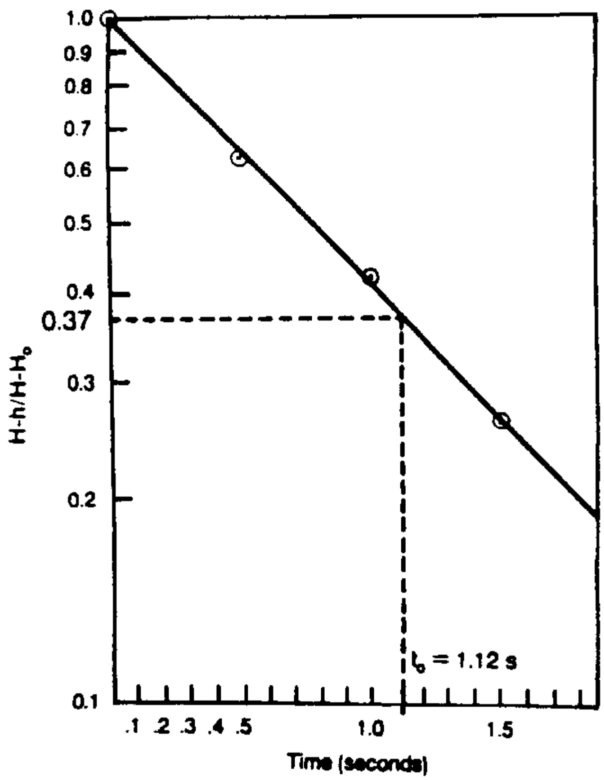

FIGURE 9-1 DIAGRAM OF HVORSLEV PIEZOMETER TEST

The data for the Hvorslev method is plotted as H-h/H-H_o versus time on semi-log paper with H-h/H-H_o on the log scale and time on the arithmetic scale. Ideally, the data will plot as a straight line.

Once the data has been plotted, a best fit line is drawn through the data points. A line is then drawn parallel to the time axis for H-h/H-H_o = 0.37. Where this line intersects the line through data points, a value for time is determined. This value is To (see Figure 9-2).

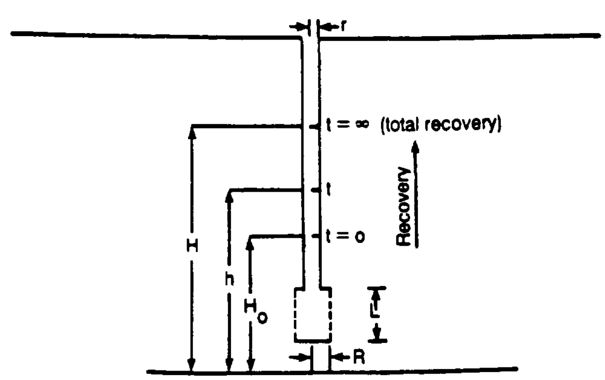

FIGURE 9-2 PLOT OF PIEZOMETER TEST DATA - HVORSLEV METHOD

The hydraulic conductivity can then be determined using the following equation:

$$K = \frac{r^2 \ln (L / R)}{2 L T_0}$$

where:

K	=	hydraulic conductivity
r	=	radius of well casing
R	=	radius of the well screen
L	=	length of the well screen
T_o	=	time required for the water level to rise or fall 37 percent of the initial change

The above equation is one of the many formulae presented by Hvorslev for different piezometer geometry and aquifer conditions. However, it is one that is quite useful and could be applied to unconfined conditions for most piezometer designs where the length is typically quite a bit greater than the radius of the well screen (L/R > 8). For other conditions, the original Hvorslev (1951) paper should be consulted.

4.2 Falling Head/Rising Head Tests

In-situ hydraulic conductivity tests can be performed in a boring while it is being advanced. This permits testing of formations at different depths throughout the drilling process. Both rising and falling head hydraulic conductivity tests can be performed in saturated formations during drilling. In general, either the rising or the falling head methods should be used if the permeability is low enough to permit accurate determination of the water level.

Borings in which permeability tests are to be performed should be designated before drilling. Therefore holes should be supported by casing, and the use of drilling mud or recirculated drill water should not be allowed.

Two different methods are described for performing variable (falling/rising) head permeability tests. In the first method, the casing is cleaned flush with the bottom of the boring; in the second method, the casing is pulled above the bottom of the cleaned borehole.

Falling Head Test: Flush Bottom

Once the desired testing depth is reached, the drilling operations should be stopped, the casing seated at the depth of the drilling bit, and the hole carefully cleaned.

After cleaning the boring to remove loose materials, the drill bit and drill rods should be withdrawn slowly to prevent loosening of the soil at the bottom of the hole.

The hole should then be maintained full of water to a level within 5 ft from the top of the casing for about 10 to 15 minutes by adding the necessary amount of water. This is essential to develop a steady seepage condition.

When the water level inside the casing has been adjusted for the last time, the depth to water should be recorded and a timer started. The depth to water should be measured with a calibrated tape equipped with a sounding device. In highly permeable soils or rock, an electric pressure transducer and recorder may be required. The level of water is then allowed to fall inside the hole from the seepage of water through the bottom of the hole.

The depth of water inside the hole should be carefully recorded at logarithmically increasing intervals of time as determined by the site geologist. The top of the casing should be used as a reference point for all measurements.

The length of the test should be determined by the site geologist.

The following data should be obtained, in addition to all time and depth measurements (when applicable):

1. Ground elevation
2. Reference elevation
3. Depth of test run
4. Casing diameter
5. Length of uncased borehole
6. Identification of equipment used

Falling Head Test: Pulling Back Casing

This method is similar to the above method except that the hole is backfilled with a clean, washed sand and the casing is bumped back a designated distance. A well screen may also be used that is fitted with threads at the top to accept pipe to pull it back out after the test is complete.

The hole should be prepared as described above. The test should be carried out in a similar manner as described previously or as determined by the site geologist, and all pertinent data should be similarly recorded.

Rising Head Test

This method is equivalent to that used for the falling head test.

The water level in the borehole is temporarily lowered as quickly as possible and readings are obtained as the water rises in the borehole. Any convenient means of rapidly lowering the water in the boring may be used, such as a bailer or pump.

All pertinent data should be similarly recorded.

4.2.1 Rising Head/Falling Head Test Data Analysis

There are many different published formulae for calculating hydraulic conductivity from in-situ borehole tests. Some of these formulae are outlined in Figure 9-2 (Hvorslev, 1951) for various geometries keeping in view the nature of subsurface materials encountered in the boreholes. Relevant formulae can be selected based on site-specific conditions for data analysis. These formulae are based on the assumptions that the effect of soil compressibility is negligible.

4.3 Constant Head Test

A constant head test is normally conducted as an inflow test in which arrangements are made for water to flow into the ground under a sensibly constant head. In this method water is added to the casing at a rate sufficient to maintain a constant water level at or near the top of the casing for a period of not less 10 minutes. The water may be added by pouring from calibrated containers or by pumping through a water meter. The intake rate is measured and the hydraulic conductivity is determined from this. It is essential to use clean water for the test. A limitation of the constant head test is that foreign water introduced into the formation must be removed from the well area before a representative groundwater sample can be obtained. This method of testing may be used in both saturated and unsaturated formations. In those cases where the permeability is so high as to preclude an accurate measurement of the rising or falling water level, the constant head test is used.

Two different setups (similar to falling/rising head tests) can be used to conduct the constant head test. In the case first case, the casing is cleaned flush with the bottom of the boring; in the second case, the casing is pulled above the bottom of the cleaned borehole. A brief description of these setups is given in Section 4.2.

4.3.1 Constant Head Test Data Analysis

Constant head test data can be analyzed by using an appropriate applicable equation from Figure 9-2, keeping in view the test setup.

4.4 Packer Test

Inflatable packers are used to isolate a test zone within the borehole to perform in-situ permeability tests. The apparatus for pressure tests usually comprises a water pump, a manually-adjusted automatic pressure relief valve, pressure gauge, a water meter, and a packer assembly. The packers, which provide a means of sealing off a limited section of borehole for testing should have a length of five times the diameter of the hole. They may be of the pneumatically or mechanically expandable type. The former are preferred since they adapt to an oversized hole, whereas the latter may not. The piping of the packer assembly is designed to permit testing of either the portion of the hole between the packers or the portion below the lower packer. Flow to the section below the lower packer is through the interior pipe; flow to the section between the packers is provided by perforations in the outer pipe which have an outlet area two or more times the cross-sectional area of the pipe. The packers are normally set 2, 5, or 10 feet apart and it is common to provide flexibility in testing by having assemblies with different packer spacings available, thereby permitting the testing of different lengths of the hole. The wider spacings are used for rock which is more uniform; the shorter spacing is used to test individual joints which may be the cause of high water loss in otherwise tight strata.

Methods of Testing

The test procedure used depends upon the condition of the rock. In rock which is not subject to cave-in, the following method is in general use. The hole is drilled to the total depth without testing. Two inflatable packers 5 to 10 feet apart are mounted near the bottom of the rod or pipe used for making the test. The bottom of the rod or pipe is sealed, and the section between the packers is perforated. The perforations should be at least one quarter of an inch in diameter, and the total area of all perforations should be greater than two times the inside cross-sectional area of he pipe or rod. Tests are made beginning at the bottom of the hole. After each test, the packers are raised the length of the test section and another test made. This procedure is followed until the entire length of the hole has been tested.

If the rock in which the hole is being drilled is subject to cave-in, the pressure test is conducted after each advance of the hole for a length equal to the maximum unsupported length of hole or the distance between the packers, whichever is less.

Cleaning Test Sections Before Testing

Before each test, the test section should be surged with clean water and bailed out to clear cuttings and drilling fluid from the face of the hole. If the test section is above the water table and will not hold water, water should be poured into the hole during the surging, then bailed out as rapidly as possible. When a completed hole is tested using two packers, the entire hole can be cleaned in one operation. Cleaning the hole is frequently omitted from testing procedures; however, this omission may result in a permeable rock appearing to be impermeable because the hole face is sealed by cuttings or drilling fluid. In such cases, the computed permeability will be lower than the true permeability.

Length of Test Section

The length of the test section is governed by the character of the rock, but generally a length of 10 feet is desirable. At times, a good seal cannot be obtained for the packer at the planned elevation because of bridging, railing, or the presence of fractures. Under these circumstances, the test section length should be increased or decreased or test sections overlapped to assure that the test is made with well-seated packers. On some tests, a 10-foot sections will take more water than the pump can deliver; hence, no back pressure can be developed. When this occurs, the length of the test sections should be shortened until back pressure can be developed, or the falling head test might be tried.

The test sections should never be shortened to where the ratio $\frac{A}{D}$ is less than 5, where D is the diameter of the hole and A is the length of the test section.

Size of Rod or Pipe to Use in Tests

Drill rods are commonly used as intake pipes to make pressure and permeability tests. NX and NW rods can be used for this purpose without seriously affecting the reliability of the test data, if the intake of the test section does not exceed 12 to 15 gallons per minute and the depth to the top of the test section does not exceed 50 feet. For tests deeper than 50 feet, head loss due to friction in pipe should be accounted for when calculating hydraulic conductivity.

Pumping Equipment

Permeability tests made in drill holes ideally should be performed using centrifugal pumps having sufficient capacity to develop back pressure. A pump with a capacity of up to 250 gallons per minute against a total head of 160 feet would be adequate for most testing. Head and discharge of such pumps are easily controlled by changing engine speed or with a control valve on the discharge.

Water Pressures, Duration of Tests, and Data to Be Recorded

A minimum of three pressures are utilized at each test section. The magnitude of the pressures should be respectively at least 10, 20, and 40 lbs/sq. in. (psi) above the natural piezometric pressure or 10, 20, and 40 psi where pressure testing above the piezometric level except that in no case should the excess pressure above natural piezometric pressure exceed one psi per foot of existing overburden. Each pressure increment should be maintained for ten or more minutes until a uniform rate of flow has been reached or until stopped by the geologist. The quantity of flow for each pressure is recorded at one, two, and five minutes, and at five minute intervals thereafter. After the rate of flow at 10, 20, and 40 psi pressures have been recorded, the water pressure should be reduced to 20 and 10 psi and the intake recorded at these pressures. Additional data to be recorded in each test are as follows:

1. Depth of hole at time of each test.
2. Depth to bottom of top packer.
3. Depth to top of lower packer.
4. Depth to water surface in boring at specified intervals.
5. Elevation of piezometer level in artesian strata.
6. Length of test section.
7. Radius of hole.
8. Length of packer.
9. Distance pressure gauge is above ground surface.

10. Description of material tested.
11. Height of water swivel above ground surface.

Packer Test Data Analysis

The following equation can be used to determine in-situ hydraulic conductivity using the packer test data:

$$K = \frac{Q}{2\pi\ LH} \log_e \frac{L}{r};\ L \geq 10r$$

$$K = \frac{Q}{2\pi\ LH} \sinh^{-1} \frac{L}{2r},\ 10r > L \geq r$$

where: K = hydraulic conductivity

Q	=	constant rate of flow into the hole
L	=	length of the portion of the hole tested
H	=	differential head of water
r	=	radius of hole tested
$\log_e$	=	natural logarithm
$\sinh^{-1}$	=	inverse hyperbolic sine

These formulas have best validity when the thickness of the stratum tested is at least 5L, and they are considered to be more accurate for tests below groundwater table than above it.

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6. REVISION HISTORY

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Revision 1.2 - August 1994 - Internal review; typographical errors and technical content corrected; references added.

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Ground Water Issue

LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES

by Robert W. Puls[1] and Michael J. Barcelona[2]

Background

The Regional Superfund Ground Water Forum is a group of ground-water scientists, representing EPA's Regional Superfund Offices, organized to exchange information related to ground-water remediation at Superfund sites. One of the major concerns of the Forum is the sampling of ground water to support site assessment and remedial performance monitoring objectives. This paper is intended to provide background information on the development of low-flow sampling procedures and its application under a variety of hydrogeologic settings. It is hoped that the paper will support the production of standard operating procedures for use by EPA Regional personnel and other environmental professionals engaged in ground-water sampling.

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I. Introduction

The methods and objectives of ground-water sampling to assess water quality have evolved over time. Initially the emphasis was on the assessment of water quality of aquifers as sources of drinking water. Large water-bearing units were identified and sampled in keeping with that objective. These were highly productive aquifers that supplied drinking water via private wells or through public water supply systems. Gradually, with the increasing awareness of subsurface pollution of these water resources, the understanding of complex hydrogeochemical processes which govern the fate and transport of contaminants in the subsurface increased. This increase in understanding was also due to advances in a number of scientific disciplines and improvements in tools used for site characterization and ground-water sampling. Ground-water quality investigations where pollution was detected initially borrowed ideas, methods, and materials for site characterization from the water supply field and water analysis from public health practices. This included the materials and manner in which monitoring wells were installed and the way in which water was brought to the surface, treated, preserved and analyzed. The prevailing conceptual ideas included convenient generalizations of ground-water resources in terms of large and relatively homogeneous hydrologic *units*. With time it became apparent that conventional water supply generalizations of *homogeneity* did not adequately represent field data regarding pollution of these subsurface resources. The important role of *heterogeneity* became increasingly clear not only in geologic terms, but also in terms of complex physical,

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chemical and biological subsurface processes. With greater appreciation of the role of heterogeneity, it became evident that subsurface pollution was ubiquitous and encompassed the unsaturated zone to the deep subsurface and included unconsolidated sediments, fractured rock, and *aquitards* or low-yielding or impermeable formations. Small-scale processes and heterogeneities were shown to be important in identifying contaminant distributions and in controlling water and contaminant flow paths.

It is beyond the scope of this paper to summarize all the advances in the field of ground-water quality investigations and remediation, but two particular issues have bearing on ground-water sampling today: aquifer heterogeneity and colloidal transport. Aquifer heterogeneities affect contaminant flow paths and include variations in geology, geochemistry, hydrology and microbiology. As methods and the tools available for subsurface investigations have become increasingly sophisticated and understanding of the subsurface environment has advanced, there is an awareness that in most cases a primary concern for site investigations is characterization of contaminant flow paths rather than entire aquifers. In fact, in many cases, plume thickness can be less than well screen lengths (e.g., 3-6 m) typically installed at hazardous waste sites to detect and monitor plume movement over time. Small-scale differences have increasingly been shown to be important and there is a general trend toward smaller diameter wells and shorter screens.

The hydrogeochemical significance of colloidal-size particles in subsurface systems has been realized during the past several years (Gschwend and Reynolds, 1987; McCarthy and Zachara, 1989; Puls, 1990; Ryan and Gschwend, 1990). This realization resulted from both field and laboratory studies that showed faster contaminant migration over greater distances and at higher concentrations than flow and transport model predictions would suggest (Buddemeier and Hunt, 1988; Enfield and Bengtsson, 1988; Penrose et al., 1990). Such models typically account for interaction between the mobile aqueous and immobile solid phases, but do not allow for a mobile, reactive solid phase. It is recognition of this third *phase* as a possible means of contaminant transport that has brought increasing attention to the manner in which samples are collected and processed for analysis (Puls et al., 1990; McCarthy and Degueldre, 1993; Backhus et al., 1993; U. S. EPA, 1995). If such a phase is present in sufficient mass, possesses high sorption reactivity, large surface area, and remains stable in suspension, it can serve as an important mechanism to facilitate contaminant transport in many types of subsurface systems.

Colloids are particles that are sufficiently small so that the surface free energy of the particle dominates the bulk free energy. Typically, in ground water, this includes particles with diameters between 1 and 1000 nm. The most commonly observed mobile particles include: secondary clay minerals; hydrous iron, aluminum, and manganese oxides; dissolved and particulate organic materials, and viruses and bacteria. These reactive particles have been shown to be mobile under a variety of conditions in both field studies and laboratory column experiments, and as such need to be included in monitoring programs where identification of the *total* mobile contaminant loading (dissolved + naturally suspended particles) at a site is an objective. To that end, sampling methodologies must be used which do not artificially bias *naturally* suspended particle concentrations.

Currently the most common ground-water purging and sampling methodology is to purge a well using bailers or high speed pumps to remove 3 to 5 casing volumes followed by sample collection. This method can cause adverse impacts on sample quality through collection of samples with high levels of turbidity. This results in the inclusion of otherwise immobile artifactual particles which produce an overestimation of certain analytes of interest (e.g., metals or hydrophobic organic compounds). Numerous documented problems associated with filtration (Danielsson, 1982; Laxen and Chandler, 1982; Horowitz et al., 1992) make this an undesirable method of rectifying the turbidity problem, and include the removal of potentially mobile (contaminant-associated) particles during filtration, thus artificially biasing contaminant concentrations low. Sampling-induced turbidity problems can often be mitigated by using low-flow purging and sampling techniques.

Current subsurface conceptual models have undergone considerable refinement due to the recent development and increased use of field screening tools. So-called hydraulic *push* technologies (e.g., cone penetrometer, Geoprobe®, QED HydroPunch®) enable relatively fast screening site characterization which can then be used to design and install a monitoring well network. Indeed, alternatives to conventional monitoring wells are now being considered for some hydrogeologic settings. The ultimate design of any monitoring system should however be based upon adequate site characterization and be consistent with established monitoring objectives.

If the sampling program objectives include accurate assessment of the magnitude and extent of subsurface contamination over time and/or accurate assessment of subsequent remedial performance, then some information regarding plume delineation in three-dimensional space is necessary prior to monitoring well network design and installation. This can be accomplished with a variety of different tools and equipment ranging from hand-operated augers to screening tools mentioned above and large drilling rigs. Detailed information on ground-water flow velocity, direction, and horizontal and vertical variability are essential baseline data requirements. Detailed soil and geologic data are required prior to and during the installation of sampling points. This includes historical as well as detailed soil and geologic logs which accumulate during the site investigation. The use of borehole geophysical techniques is also recommended. With this information (together with other site characterization data) and a clear understanding of sampling objectives, then appropriate location, screen length, well diameter, slot size, etc. for the monitoring well network can be decided. This is especially critical for new in situ remedial approaches or natural attenuation assessments at hazardous waste sites.

In general, the overall goal of any ground-water sampling program is to collect water samples with no alteration in water chemistry; analytical data thus obtained may be used for a variety of specific monitoring programs depending on the regulatory requirements. The sampling methodology described in this paper assumes that the monitoring goal is to sample monitoring wells for the presence of contaminants and it is applicable whether mobile colloids are a concern or not and whether the analytes of concern are metals (and metalloids) or organic compounds.

II. Monitoring Objectives and Design Considerations

The following issues are important to consider prior to the design and implementation of any ground-water monitoring program, including those which anticipate using low-flow purging and sampling procedures.

A. Data Quality Objectives (DQOs)

Monitoring objectives include four main types: detection, assessment, corrective-action evaluation and resource evaluation, along with *hybrid* variations such as site-assessments for property transfers and water availability investigations. Monitoring objectives may change as contamination or water quality problems are discovered. However, there are a number of common components of monitoring programs which should be recognized as important regardless of initial objectives. These components include:

1) Development of a conceptual model that incorporates elements of the regional geology to the local geologic framework. The conceptual model development also includes initial site characterization efforts to identify hydrostratigraphic units and likely flow-paths using a minimum number of borings and well completions;

2) Cost-effective and well documented collection of high quality data utilizing simple, accurate, and reproducible techniques; and

3) Refinement of the conceptual model based on supplementary data collection and analysis.

These fundamental components serve many types of monitoring programs and provide a basis for future efforts that evolve in complexity and level of spatial detail as purposes and objectives expand. High quality, reproducible data collection is a common goal regardless of program objectives.

High quality data collection implies data of sufficient accuracy, precision, and completeness (i.e., ratio of valid analytical results to the minimum sample number called for by the program design) to meet the program objectives. Accuracy depends on the correct choice of monitoring tools and procedures to minimize sample and subsurface disturbance from collection to analysis. Precision depends on the repeatability of sampling and analytical protocols. It can be assured or improved by replication of sample analyses including blanks, field/lab standards and reference standards.

B. Sample Representativeness

An important goal of any monitoring program is collection of data that is truly representative of conditions at the site. The term *representativeness* applies to chemical and hydrogeologic data collected via wells, borings, piezometers, geophysical and soil gas measurements, lysimeters, and temporary sampling points. It involves a recognition of the statistical variability of individual subsurface physical properties, and contaminant or major ion concentration levels, while explaining extreme values. Subsurface temporal and spatial variability are facts. Good professional practice seeks to maximize representativeness by using proven accurate and reproducible techniques to define limits on the distribution of measurements collected at a site. However, measures of representativeness are dynamic and are controlled by evolving site characterization and monitoring objectives. An evolutionary site characterization model, as shown in Figure 1, provides a systematic approach to the goal of consistent data collection.

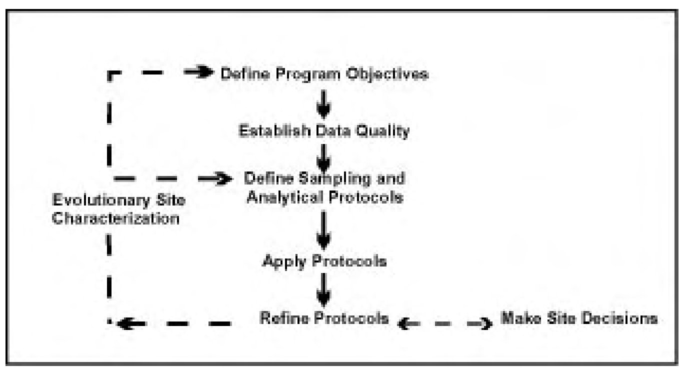

Figure 1. Evolutionary Site Characterization Model

The model emphasizes a recognition of the causes of the variability (e.g., use of inappropriate technology such as using bailers to purge wells; imprecise or operator-dependent methods) and the need to control avoidable errors.

1) Questions of Scale

A sampling plan designed to collect representative samples must take into account the potential scale of changes in site conditions through space and time as well as the chemical associations and behavior of the parameters that are targeted for investigation. In subsurface systems, physical (i.e., aquifer) and chemical properties over time or space are not statistically independent. In fact, samples taken in close proximity (i.e., within distances of a few meters) or within short time periods (i.e., more frequently than monthly) are highly auto-correlated. This means that designs employing high-sampling frequency (e.g., monthly) or dense spatial monitoring designs run the risk of redundant data collection and misleading inferences regarding trends in values that aren't statistically valid. In practice, contaminant detection and assessment monitoring programs rarely suffer these *over-sampling* concerns. In corrective-action evaluation programs, it is also possible that too little data may be collected over space or time. In these cases, false interpretation of the spatial extent of contamination or underestimation of temporal concentration variability may result.

2) Target Parameters

Parameter selection in monitoring program design is most often dictated by the regulatory status of the site. However, background water quality constituents, purging indicator parameters, and contaminants, all represent targets for data collection programs. The tools and procedures used in these programs should be equally rigorous and applicable to all categories of data, since all may be needed to determine or support regulatory action.

C. Sampling Point Design and Construction

Detailed site characterization is central to all decision-making purposes and the basis for this characterization resides in identification of the geologic framework and major hydro-stratigraphic units. Fundamental data for sample point location include: subsurface lithology, head-differences and background geochemical conditions. Each sampling point has a proper use or uses which should be documented at a level which is appropriate for the program's data quality objectives. Individual sampling points may not always be able to fulfill multiple monitoring objectives (e.g., detection, assessment, corrective action).

1) Compatibility with Monitoring Program and Data Quality Objectives

Specifics of sampling point location and design will be dictated by the complexity of subsurface lithology and variability in contaminant and/or geochemical conditions. It should be noted that, regardless of the ground-water sampling approach, few sampling points (e.g., wells, drive-points, screened augers) have zones of influence in excess of a few feet. Therefore, the spatial frequency of sampling points should be carefully selected and designed.

2) Flexibility of Sampling Point Design

In most cases *well-point* diameters in excess of 1 7/8 inches will permit the use of most types of submersible pumping devices for low-flow (minimal drawdown) sampling. It is suggested that *short* (e.g., less than 1.6 m) screens be incorporated into the monitoring design where possible so that comparable results from one device to another might be expected. *Short*, of course, is relative to the degree of vertical water quality variability expected at a site.

3) Equilibration of Sampling Point

Time should be allowed for equilibration of the well or sampling point with the formation after installation. Placement of well or sampling points in the subsurface produces some disturbance of ambient conditions. Drilling techniques (e.g., auger, rotary, etc.) are generally considered to cause more disturbance than *direct-push* technologies. In either case, there may be a period (i.e., days to months) during which water quality near the point may be distinctly different from that in the formation. Proper development of the sampling point and adjacent formation to remove fines created during emplacement will shorten this water quality *recovery* period.

III. Definition of Low-Flow Purging and Sampling

It is generally accepted that water in the well casing is non-representative of the formation water and needs to be purged prior to collection of ground-water samples. However, the water in the screened interval may indeed be representative of the formation, depending upon well construction and site hydrogeology. Wells are purged to some extent for the following reasons: the presence of the air interface at the top of the water column resulting in an oxygen concentration gradient with depth, loss of volatiles up the water column, leaching from or sorption to the casing or filter pack, chemical changes due to clay seals or backfill, and surface infiltration.

Low-flow purging, whether using portable or dedicated systems, should be done using pump-intake located in the middle or slightly above the middle of the screened interval. Placement of the pump too close to the bottom of the well will cause increased entrainment of solids which have collected in the well over time. These particles are present as a result of well development, prior purging and sampling events, and natural colloidal transport and deposition. Therefore, placement of the pump in the middle or toward the top of the screened interval is suggested. Placement of the pump at the top of the water column for sampling is only recommended in unconfined aquifers, screened across the water table, where this is the desired sampling point. Low-flow purging has the advantage of minimizing mixing between the overlying stagnant casing water and water within the screened interval.

A. Low-Flow Purging and Sampling

Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface which can be affected by flow regulators or restrictions. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical taking into account established site sampling objectives. Typically, flow rates on the order of 0.1 - 0.5 L/min are used, however this is dependent on site-specific hydrogeology. Some extremely coarse-textured formations have been successfully sampled in this manner at flow rates to 1 L/min. The effectiveness of using low-flow purging is intimately linked with proper screen location, screen length, and well construction and development techniques. The reestablishment of natural flow paths in both the vertical and horizontal directions is important for correct interpretation of the data. For high resolution sampling needs, screens less than 1 m should be used. Most of the need for purging has been found to be due to passing the sampling device through the overlying casing water which causes mixing of these stagnant waters and the dynamic waters within the screened interval. Additionally, there is disturbance to suspended sediment collected in the bottom of the casing and the displacement of water out into the formation immediately adjacent to the well screen. These disturbances and impacts can be avoided using dedicated sampling equipment, which precludes the need to insert the sampling device prior to purging and sampling.

Isolation of the screened interval water from the overlying stagnant casing water may be accomplished using low-flow minimal drawdown techniques. If the pump intake is located within the screened interval, most of the water pumped will be drawn in directly from the formation with little mixing of casing water or disturbance to the sampling zone. However, if the wells are not constructed and developed properly, zones other than those intended may be sampled. At some sites where geologic heterogeneities are sufficiently different within the screened interval, higher conductivity zones may be preferentially sampled. This is another reason to use shorter screened intervals, especially where high spatial resolution is a sampling objective.

B. Water Quality Indicator Parameters

It is recommended that water quality indicator parameters be used to determine purging needs prior to sample collection in each well. Stabilization of parameters such as pH, specific conductance, dissolved oxygen, oxidation-reduction potential, temperature and turbidity should be used to determine when formation water is accessed during purging. In general, the order of stabilization is pH, temperature, and specific conductance, followed by oxidation-reduction potential, dissolved oxygen and turbidity. Temperature and pH, while commonly used as purging indicators, are actually quite insensitive in distinguishing between formation water and stagnant casing water; nevertheless, these are important parameters for data interpretation purposes and should also be measured. Performance criteria for determination of stabilization should be based on water-level drawdown, pumping rate and equipment specifications for measuring indicator parameters. Instruments are available which utilize in-line flow cells to continuously measure the above parameters.

It is important to establish specific well stabilization criteria and then consistently follow the same methods thereafter, particularly with respect to drawdown, flow rate and sampling device. Generally, the time or purge volume required for parameter stabilization is independent of well depth or well volumes. Dependent variables are well diameter, sampling device, hydrogeochemistry, pump flow rate, and whether the devices are used in a portable or dedicated manner. If the sampling device is already in place (i.e., dedicated sampling systems), then the time and purge volume needed for stabilization is much shorter. Other advantages of dedicated equipment include less purge water for waste disposal, much less decontamination of equipment, less time spent in preparation of sampling as well as time in the field, and more consistency in the sampling approach which probably will translate into less variability in sampling results. The use of dedicated equipment is strongly recommended at wells which will undergo routine sampling over time.

If parameter stabilization criteria are too stringent, then minor oscillations in indicator parameters may cause purging operations to become unnecessarily protracted. It should also be noted that turbidity is a very conservative parameter in terms of stabilization. Turbidity is always the last parameter to stabilize. Excessive purge times are invariably related to the establishment of too stringent turbidity stabilization criteria. It should be noted that natural turbidity levels in ground water may exceed 10 nephelometric turbidity units (NTU).

C. Advantages and Disadvantages of Low-Flow (Minimum Drawdown) Purging

In general, the advantages of low-flow purging include:

- samples which are representative of the *mobile* load of contaminants present (dissolved and colloid-associated);
- minimal disturbance of the sampling point thereby minimizing sampling artifacts;
- less operator variability, greater operator control;

- reduced stress on the formation (minimal drawdown);
- less mixing of stagnant casing water with formation water;
- reduced need for filtration and, therefore, less time required for sampling;
- smaller purging volume which decreases waste disposal costs and sampling time;
- better sample consistency; reduced artificial sample variability.

Some disadvantages of low-flow purging are:

- higher initial capital costs,
- greater set-up time in the field,
- need to transport additional equipment to and from the site,
- increased training needs,
- resistance to change on the part of sampling practitioners,
- concern that new data will indicate a *change in conditions* and trigger an *action*.

IV. Low-Flow (Minimal Drawdown) Sampling Protocols

The following ground-water sampling procedure has evolved over many years of experience in ground-water sampling for organic and inorganic compound determinations and as such summarizes the authors' (and others) experiences to date (Barcelona et al., 1984, 1994; Barcelona and Helfrich, 1986; Puls and Barcelona, 1989; Puls et. al. 1990, 1992; Puls and Powell, 1992; Puls and Paul, 1995). High-quality chemical data collection is essential in ground-water monitoring and site characterization. The primary limitations to the collection of *representative* ground-water samples include: mixing of the stagnant casing and *fresh* screen waters during insertion of the sampling device or ground-water level measurement device; disturbance and resuspension of settled solids at the bottom of the well when using high pumping rates or raising and lowering a pump or bailer; introduction of atmospheric gases or degassing from the water during sample handling and transfer, or inappropriate use of vacuum sampling device, etc.

A. Sampling Recommendations

Water samples should not be taken immediately following well development. Sufficient time should be allowed for the ground-water flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well construction materials. This lag time will depend on site conditions and methods of installation but often exceeds one week.

Well purging is nearly always necessary to obtain samples of water flowing through the geologic formations in the screened interval. Rather than using a general but arbitrary guideline of purging three casing volumes prior to sampling, it is recommended that an in-line water quality measurement device (e.g., flow-through cell) be used to establish the stabilization time for several parameters (e.g. , pH, specific conductance, redox, dissolved oxygen, turbidity) on a well-specific basis. Data on pumping rate, drawdown, and volume required for parameter stabilization can be used as a guide for conducting subsequent sampling activities.

The following are recommendations to be considered before, during and after sampling:

- use low-flow rates (<0.5 L/min), during both purging and sampling to maintain minimal drawdown in the well;
- maximize tubing wall thickness, minimize tubing length;
- place the sampling device intake at the desired sampling point;
- minimize disturbances of the stagnant water column above the screened interval during water level measurement and sampling device insertion;
- make proper adjustments to stabilize the flow rate as soon as possible;
- monitor water quality indicators during purging;
- collect unfiltered samples to estimate contaminant loading and transport potential in the subsurface system.

B. Equipment Calibration

Prior to sampling, all sampling device and monitoring equipment should be calibrated according to manufacturer's recommendations and the site Quality Assurance Project Plan (QAPP) and Field Sampling Plan (FSP). Calibration of pH should be performed with at least two buffers which bracket the expected range. Dissolved oxygen calibration must be corrected for local barometric pressure readings and elevation.

C. Water Level Measurement and Monitoring

It is recommended that a device be used which will least disturb the water surface in the casing. Well depth should be obtained from the well logs. Measuring to the bottom of the well casing will only cause resuspension of settled solids from the formation and require longer purging times for turbidity equilibration. Measure well depth after sampling is completed. The water level measurement should be taken from a permanent reference point which is surveyed relative to ground elevation.

D. Pump Type

The use of low-flow (e.g., 0.1-0.5 L/min) pumps is suggested for purging and sampling all types of analytes. All pumps have some limitation and these should be investigated with respect to application at a particular site. Bailers are inappropriate devices for low-flow sampling.

1) General Considerations

There are no unusual requirements for ground-water sampling devices when using low-flow, minimal drawdown techniques. The major concern is that the device give consistent results and minimal disturbance of the sample across a range of *low* flow rates (i.e., < 0.5 L/min). Clearly, pumping rates that cause minimal to no drawdown in one well could easily cause *significant* drawdown in another well finished in a less transmissive formation. In this sense, the pump should not cause undue pressure or temperature changes or physical disturbance on the water sample over a reasonable sampling range. Consistency in operation is critical to meet accuracy and precision goals.

2) Advantages and Disadvantages of Sampling Devices

A variety of sampling devices are available for low-flow (minimal drawdown) purging and sampling and include peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps. Devices which lend themselves to both dedication and consistent operation at definable low-flow rates are preferred. It is desirable that the pump be easily adjustable and operate reliably at these lower flow rates. The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and some volatiles loss. Gas-driven pumps should be of a type that does not allow the gas to be in direct contact with the sampled fluid.

Clearly, bailers and other *grab* type samplers are ill-suited for low-flow sampling since they will cause repeated disturbance and mixing of *stagnant* water in the casing and the *dynamic* water in the screened interval. Similarly, the use of inertial lift foot-valve type samplers may cause too much disturbance at the point of sampling. Use of these devices also tends to introduce uncontrolled and unacceptable operator variability.

Summaries of advantages and disadvantages of various sampling devices are listed in Herzog et al. (1991), U. S. EPA (1992), Parker (1994) and Thurnblad (1994).

E. Pump Installation

Dedicated sampling devices (left in the well) capable of pumping and sampling are preferred over <u>any</u> other type of device. Any portable sampling device should be slowly and carefully lowered to the middle of the screened interval or slightly above the middle (e.g., 1-1.5 m below the top of a 3 m screen). This is to minimize excessive mixing of the stagnant water in the casing above the screen with the screened interval zone water, and to minimize resuspension of solids which will have collected at the bottom of the well. These two disturbance effects have been shown to directly affect the time required for purging. There also appears to be a direct correlation between size of portable sampling devices relative to the well bore and resulting purge volumes and times. The key is to minimize disturbance of water and solids in the well casing.

F. Filtration

Decisions to filter samples should be dictated by sampling objectives rather than as a *fix* for poor sampling practices, and field-filtering of certain constituents should not be the default. Consideration should be given as to what the application of field-filtration is trying to accomplish. For assessment of truly dissolved (as opposed to operationally *dissolved* [i.e., samples filtered with 0.45 µm filters]) concentrations of major ions and trace metals, 0.1 µm filters are recommended although 0.45 µm filters are normally used for most regulatory programs. Alkalinity samples must also be filtered if significant particulate calcium carbonate is suspected, since this material is likely to impact alkalinity titration results (although filtration itself may alter the CO_2 composition of the sample and, therefore, affect the results).

Although filtration may be appropriate, filtration of a sample may cause a number of unintended changes to occur (e.g. oxidation, aeration) possibly leading to filtration-induced artifacts during sample analysis and uncertainty in the results. Some of these unintended changes may be unavoidable but the factors leading to them must be recognized. Deleterious effects can be minimized by consistent application of certain filtration guidelines. Guidelines should address selection of filter type, media, pore size, etc. in order to identify and minimize potential sources of uncertainty when filtering samples.

In-line filtration is recommended because it provides better consistency through less sample handling, and minimizes sample exposure to the atmosphere. In-line filters are available in both disposable (barrel filters) and non-disposable (in-line filter holder, flat membrane filters) formats and various filter pore sizes (0.1-5.0 µm). Disposable filter cartridges have the advantage of greater sediment handling capacity when compared to traditional membrane filters. Filters must be pre-rinsed following manufacturer's recommendations. If there are no recommendations for rinsing, pass through a minimum of 1 L of ground water following purging and prior to sampling. Once filtration has begun, a filter cake may develop as particles larger than the pore size accumulate on the filter membrane. The result is that the effective pore diameter of the membrane is reduced and particles smaller than the stated pore size are excluded from the filtrate. Possible corrective measures include prefiltering (with larger pore size filters), minimizing particle loads to begin with, and reducing sample volume.

G. Monitoring of Water Level and Water Quality Indicator Parameters

Check water level periodically to monitor drawdown in the well as a guide to flow rate adjustment. The goal is minimal drawdown (<0.1 m) during purging. This goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience. In-line water quality indicator parameters should be continuously monitored during purging. The water quality indicator parameters monitored can include pH, redox potential, conductivity, dissolved oxygen (DO) and turbidity. The last three parameters are often most sensitive. Pumping rate, drawdown, and the time or volume required to obtain stabilization of parameter readings can be used as a future guide to purge the well. Measurements should be taken every three to five minutes if the above suggested rates are used. Stabilization is achieved after all parameters have stabilized for three successive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or DO. Three successive readings should be within ± 0.1 for pH, ± 3% for conductivity, ± 10 mv for redox potential, and ± 10% for turbidity and DO. Stabilized purge indicator parameter trends are generally obvious and follow either an exponential or asymptotic change to stable values during purging. Dissolved oxygen and turbidity usually require the longest time for stabilization. The above stabilization guidelines are provided for rough estimates based on experience.

H. Sampling, Sample Containers, Preservation and Decontamination

Upon parameter stabilization, sampling can be initiated. If an in-line device is used to monitor water quality parameters, it should be disconnected or bypassed during sample collection. Sampling flow rate may remain at established purge rate or may be adjusted slightly to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. Typically, flow rates less than 0.5 L/min are appropriate. The same device should be used for sampling as was used for purging. Sampling should occur in a progression from least to most contaminated well, if this is known. Generally, volatile (e.g., solvents and fuel constituents) and gas sensitive (e.g., Fe^{2+}, CH_4, H_2S/HS^-, alkalinity) parameters should be sampled first. The sequence in which samples for most inorganic parameters are collected is immaterial unless filtered (dissolved) samples are desired. Filtering should be done last and in-line filters should be used as discussed above. During both well purging and sampling, proper protective clothing and equipment must be used based upon the type and level of contaminants present.

The appropriate sample container will be prepared in advance of actual sample collection for the analytes of interest and include sample preservative where necessary. Water samples should be collected directly into this container from the pump tubing.

Immediately after a sample bottle has been filled, it must be preserved as specified in the site (QAPP). Sample preservation requirements are based on the analyses being performed (use site QAPP, FSP, RCRA guidance document [U. S. EPA, 1992] or EPA SW-846 [U. S. EPA, 1982]). It may be advisable to add preservatives to sample bottles in a controlled setting prior to entering the field in order to reduce the chances of improperly preserving sample bottles or introducing field contaminants into a sample bottle while adding the preservatives.

The preservatives should be transferred from the chemical bottle to the sample container using a disposable polyethylene pipet and the disposable pipet should be used only once and then discarded.

After a sample container has been filled with ground water, a Teflon™ (or tin)-lined cap is screwed on tightly to prevent the container from leaking. A sample label is filled out as specified in the FSP. The samples should be stored inverted at 4°C.

Specific decontamination protocols for sampling devices are dependent to some extent on the type of device used and the type of contaminants encountered. Refer to the site QAPP and FSP for specific requirements.

I. Blanks

The following blanks should be collected:

(1) field blank: one field blank should be collected from each source water (distilled/deionized water) used for sampling equipment decontamination or for assisting well development procedures.

(2) equipment blank: one equipment blank should be taken prior to the commencement of field work, from each set of sampling equipment to be used for that day. Refer to site QAPP or FSP for specific requirements.

(3) trip blank: a trip blank is required to accompany each volatile sample shipment. These blanks are prepared in the laboratory by filling a 40-mL volatile organic analysis (VOA) bottle with distilled/deionized water.

V. Low-Permeability Formations and Fractured Rock

The overall sampling program goals or sampling objectives will drive how the sampling points are located, installed, and choice of sampling device. Likewise, site-specific hydrogeologic factors will affect these decisions. Sites with very low permeability formations or fractures causing discrete flow channels may require a unique monitoring approach. Unlike water supply wells, wells installed for ground-water quality assessment and restoration programs are often installed in low water-yielding settings (e.g., clays, silts). Alternative types of sampling points and sampling methods are often needed in these types of environments, because low-permeability settings may require extremely low-flow purging (<0.1 L/min) and may be technology-limited. Where devices are not readily available to pump at such low flow rates, the primary consideration is to avoid dewatering of the well screen. This may require repeated recovery of the water during purging while leaving the pump in place within the well screen.

Use of low-flow techniques may be impractical in these settings, depending upon the water recharge rates. The sampler and the end-user of data collected from such wells need to understand the limitations of the data collected; i.e., a strong potential for underestimation of actual contaminant concentrations for volatile organics, potential false negatives for filtered metals and potential false positives for unfiltered metals. It is suggested that comparisons be made between samples recovered using low-flow purging techniques and samples recovered using passive sampling techniques (i.e., two sets of samples). Passive sample collection would essentially entail acquisition of the sample with no or very little purging using a dedicated sampling system installed within the screened interval or a passive sample collection device.

A. Low-Permeability Formations (<0.1 L/min recharge)

1. Low-Flow Purging and Sampling with Pumps

a. "portable or non-dedicated mode" - Lower the pump (one capable of pumping at <0.1 L/min) to mid-screen or slightly above and set in place for minimum of 48 hours (to lessen purge volume requirements). After 48 hours, use procedures listed in Part IV above regarding monitoring water quality parameters for stabilization, etc., but do not dewater the screen. If excessive drawdown and slow recovery is a problem, then alternate approaches such as those listed below may be better.

b. "dedicated mode" - Set the pump as above at least a week prior to sampling; that is, operate in a dedicated pump mode. With this approach significant reductions in purge volume should be realized. Water quality parameters should stabilize quite rapidly due to less disturbance of the sampling zone.

2. Passive Sample Collection

Passive sampling collection requires insertion of the device into the screened interval for a sufficient time period to allow flow and sample equilibration before extraction for analysis. Conceptually, the extraction of water from low yielding formations seems more akin to the collection of water from the unsaturated zone and passive sampling techniques may be more appropriate in terms of obtaining "representative" samples. Satisfying usual sample volume requirements is typically a problem with this approach and some latitude will be needed on the part of regulatory entities to achieve sampling objectives.

B. Fractured Rock

In fractured rock formations, a low-flow to zero purging approach using pumps in conjunction with packers to isolate the sampling zone in the borehole is suggested. Passive multi-layer sampling devices may also provide the most "representative" samples. It is imperative in these settings to identify flow paths or water-producing fractures prior to sampling using tools such as borehole flowmeters and/or other geophysical tools.

After identification of water-bearing fractures, install packer(s) and pump assembly for sample collection using low-flow sampling in "dedicated mode" or use a passive sampling device which can isolate the identified water-bearing fractures.

VI. Documentation

The usual practices for documenting the sampling event should be used for low-flow purging and sampling techniques. This should include, at a minimum: information on the conduct of purging operations (flow-rate, drawdown, water-quality parameter values, volumes extracted and times for measurements), field instrument calibration data, water sampling forms and chain of custody forms. See Figures 2 and 3 and "Ground Water Sampling Workshop -- A Workshop Summary" (U. S. EPA, 1995) for example forms and other documentation suggestions and information. This information coupled with laboratory analytical data and validation data are needed to judge the "useability" of the sampling data.

VII. Notice

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Figure 2. **Ground Water Sampling Log**

Project _______________ **Site** _______________ **Well No.** _____________ **Date** _________________________

Well Depth ____________ **Screen Length** __________ **Well Diameter** _________ **Casing Type** ____________

Sampling Device _______________ **Tubing type** _____________________ **Water Level** __________________

Measuring Point ___________________ **Other Infor** ____

____

Sampling Personnel ____

Time	pH	Temp	Cond.	Dis.O_2	Turb.	[ ]Conc			Notes

Type of Samples Collected

____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi r^3$

Figure 3. **Ground Water Sampling Log** (with automatic data logging for most water quality parameters)

Project _______________ **Site** _______________ **Well No.** _____________ **Date** _________________________

Well Depth ____________ **Screen Length** __________ **Well Diameter** _________ **Casing Type** ___________

Sampling Device _______________ **Tubing type** _____________________ **Water Level** _________________

Measuring Point ___________________ **Other Infor** ____

____

Sampling Personnel ____

Time	Pump Rate	Turbidity	Alkalinity	[ ] Conc	Notes

Type of Samples Collected

____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi r^3$

AECOM

WATER LEVEL DATA SUMMARY

PROJECT: Former Scott Aviation Site Area 1

LOCATION: Lancaster, New York

CLIENT:

SURVEY DATUM: NAVD 88

MEASURING DEVICE:

JOB NUMBER:

DATE:

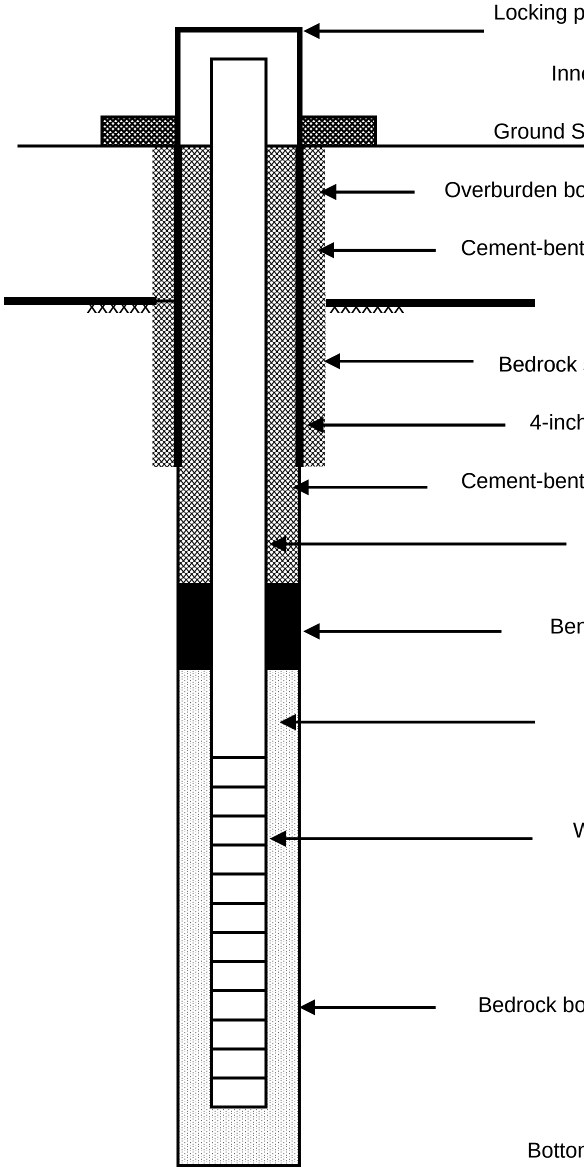
MEASURED BY:

WELL NUMBER	TIME (Military)	MEASURING POINT		DEPTH TO WATER (FT)	ELEVATION OF WATER (FT)	COMMENTS
		Description	Elevation (FT)			

AECOM

Bedrock Well Diagram **Well No.**

Project: Area 1 Former Scott Aviation	Location: Lancaster, NY	Page 1 of 1		
AECOM Project No.:	Subcontractor:	Water Levels		
Surface Elevation: Ft	Driller:	Date	Time	Depth
Top of PVC Casing Elevation: Ft	Well Permit No.:			
	AECOM Rep.:			
Datum: NGVD 1988	Date of Completion:			



Locking protective stickup with concrete pad

Inner casing stickup ________ ft to ________ ft

Ground Surface

Overburden borehole diameter ________ inches (ID)

Cement-bentonite grout from ________ ft to ________ ft

Top of Bedrock ________ ft bgs

Bedrock socket diameter ________ inches

4-inch ID steel casing ________ ft to ________ ft

Cement-bentonite grout from ________ ft to ________ ft

Riser Pipe from ________ ft to ________ ft

Bentonite seal from ________ ft to ________ ft

Filter pack from ________ ft to ________ ft

Sand Size ________

Well screen from ________ ft to ________ ft

Diameter ________ inches

Slot size ________ inches

Type ________

Bedrock borehole diameter ________ inches

Bottom Cap at ________ ft

Bottom of Borehole at ________ ft

Note: All measurements based on ground surface at 0.0 feet. (+) above grade. (-) below grade.

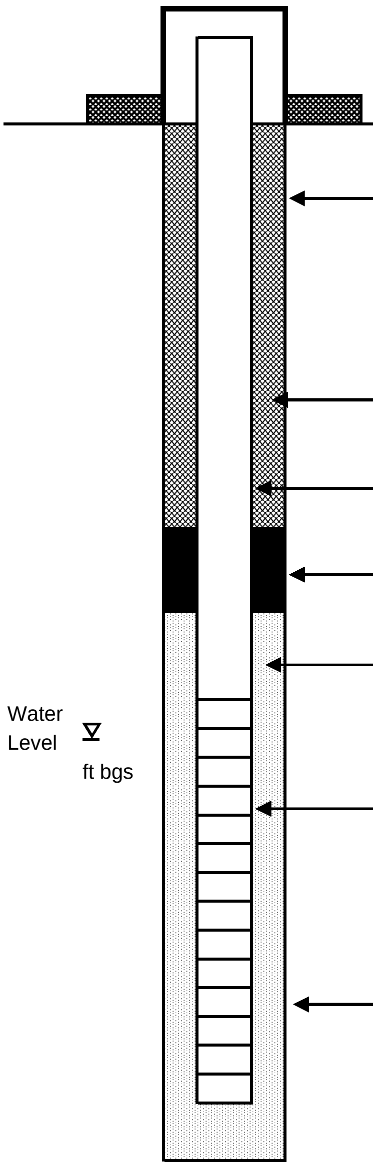
(NOT TO SCALE)

AECOM

Overburden Well Diagram **Well No.**

Project: Area 1 Former Scott Aviation Site	Location: Lancaster, NY	Page 1 of 1		
AECOM Project No.:	Subcontractor:	Water Levels		
Surface Elevation: Ft	Driller:	Date	Time	Depth
Top of PVC Casing Elevation: Ft	Well Permit No.:			
	AECOM Rep.			
Datum: NGVD 1988	Date of Completion:			

Locking protective stickup with concrete pad, three bollards



Inner casing stickup ______ ft to ______ ft

Ground Surface

Borehole diameter ______ inches

Cement-bentonite grout from ______ ft to ______ ft

Riser Pipe from ______ ft to ______ ft

Bentonite seal from ______ ft to ______ ft

Filter pack from ______ ft to ______ ft

Sand Size ______

Water Level ft bgs

Well screen from ______ ft to ______ ft

Diameter ______ inches

Slot size ______ inches

Type ______

Borehole diameter ______ inches

Bottom Cap at ______ ft

Bottom of Borehole at ______ ft

Note: All measurements based on ground surface at 0.0 feet. (+) above grade. (-) below grade.

(NOT TO SCALE)

NYSDEC Monitoring Well Decommissioning Procedure Selection

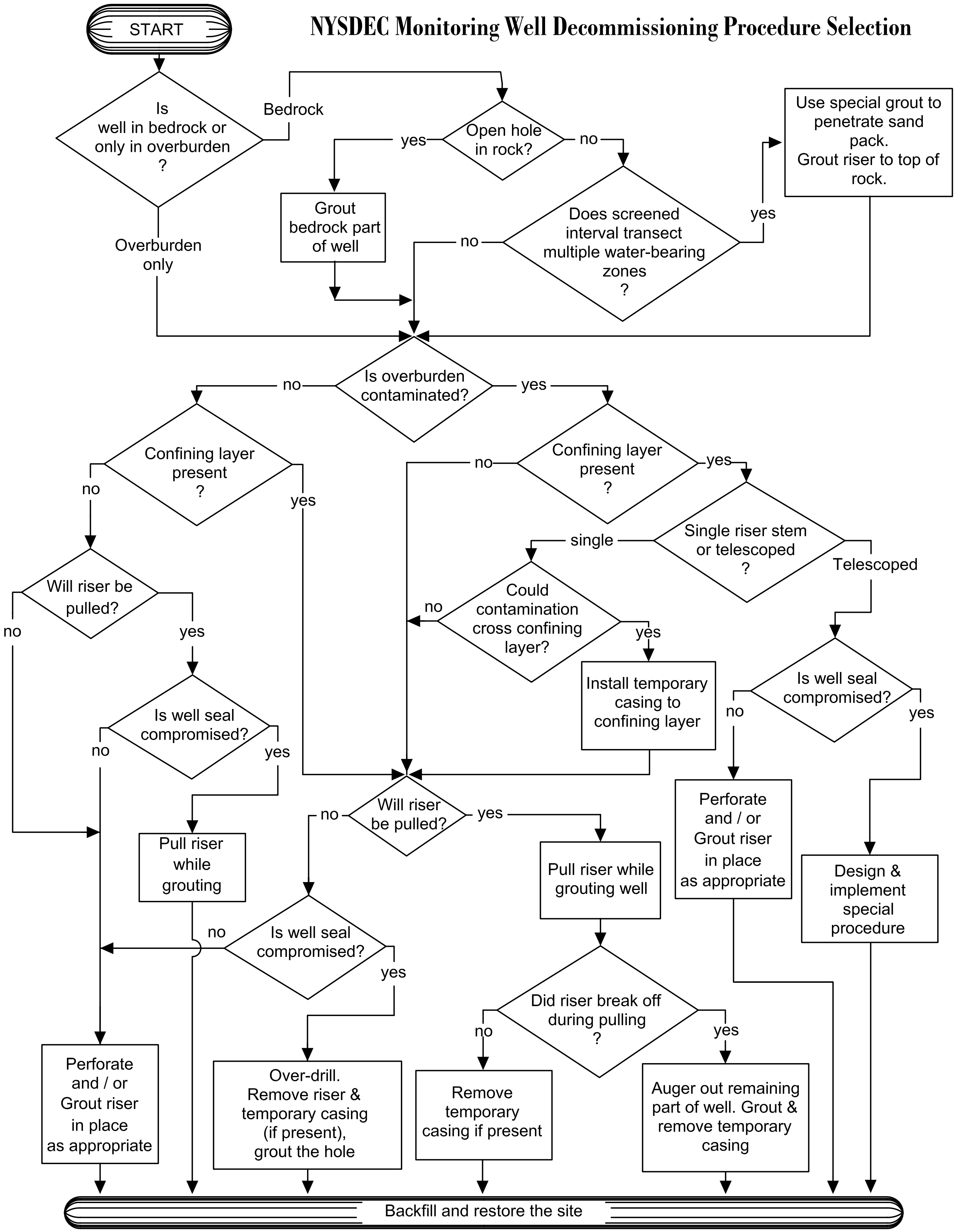


FIGURE 2

FIGURE 3

WELL DECOMMISSIONING RECORD

Site Name:	Well I.D.:
Site Location:	Driller:
Drilling Co.:	Inspector:
	Date:

DECOMMISSIONING DATA
(Fill in all that apply)

OVERDRILLING

Interval Drilled	
Drilling Method(s)	
Borehole Dia. (in.)	
Temporary Casing Installed? (y/n)	
Depth temporary casing installed	
Casing type/dia. (in.)	
Method of installing	

CASING PULLING

Method employed	
Casing retrieved (feet)	
Casing type/dia. (in)	

CASING PERFORATING

Equipment used	
Number of perforations/foot	
Size of perforations	
Interval perforated	

GROUTING

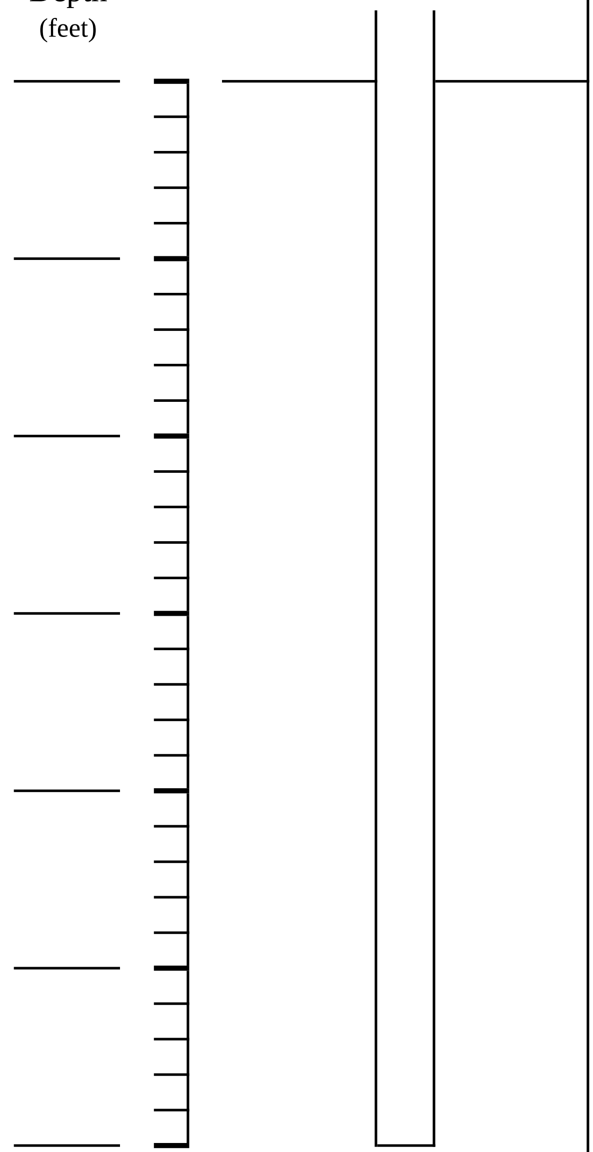
Interval grouted (FBLS)	
# of batches prepared	

For each batch record:

Quantity of water used (gal.)	
Quantity of cement used (lbs.)	
Cement type	
Quantity of bentonite used (lbs.)	
Quantity of calcium chloride used (lbs.)	
Volume of grout prepared (gal.)	
Volume of grout used (gal.)	

WELL SCHEMATIC*

Depth
(feet)



COMMENTS:

* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

Drilling Contractor

Department Representative

AECOM

Monitoring Well Development Log

Date Started (mo/day/yr) ____________ Date Completed (mo/day/yr) ____________

Field Personnel ____________

Site Name ____________

Earth Tech Job # ____________

Well ID # ____________

Investigative Area ____________

Weather Conditions ____________

Air Temperature ____________ °F

Total Well Depth (TWD) = ____________ 1/100 ft

Depth to Ground Water (DGW) = ____________ 1/100 ft

Length of Water Column (LWC) = TWD - DGW = ____________ 1/100 ft

1 Casing Volume (OCV) = LWC x ______ = ____________ gallons

5 Casing Volumes = ____________ gallons

Method of Well Development ____________

____

Total Volume of Water Removed ____________ gallons

Date/Time	Discharge Rate (gpm)	Volume Purged (gallons)	Water Temperature (°C)	DO	pH	ORP	Specific Conductivity (µmhos/cm)	Turbidity/Color	Water Level (ft BTIC)	Remarks

COMMENTS/OBSERVATIONS: ____________

____

AECOM

GROUNDWATER SAMPLING LOG

Date (mo/day/yr) ______________________

Field Personnel ______________________

Site Name **Former Scott Aviation Site Aera 1 - Lancaster, NY**

Earth Tech Job # ______________________

Well ID # ______________________

______ Upgradient ______ Downgradient

Weather Conditions ______________________

Air Temperature ______________________ ° F

Total Depth (TWD) Below Top of Casing = ____________ 1/100 ft

Depth to Groundwater (DGW) Below Top of Casing = ____________ 1/100 ft

Length of Water Column (LWC) = TWD - DGW = ____________ 1/100 ft

1 Casing Volume (OCV) = LWC x 0.163 = ____________ gal

3 Casing Volumes = ____________ gal

Method of Well Evacuation ______________________

Method of Sample Collection ______________________

Total Volume of Water Removed ____________ lit

Casing Diameter ______________________ inches

Casing Material ______________________

Measuring Point Elevation ______________________ 1/100 ft

Height of Riser (above land surface) ______________________ 1/100 ft

Land Surface Elevation ______________________ 1/100 ft

Screened Interval (below land surface) ______________________ 1/100 ft

Container	Analysis (Method)	# Bottles	Preservative	Dup - MS/MSD

FIELD ANALYSES

Flow Rate (ml/min)								
Time (Minutes)								
Depth to Groundwater Below Top of Casing (ft)								
Drawdown (ft)								
pH (S.U.)								
Sp. Cond. (mS/cm)								
Turbidity (NTUs)								
Dissolved Oxygen (mg/L)								
Water Temperature (°C)								
ORP (mV)								

Physical appearance at start Color ________ Odor ________

Sheen/Free Product ______________

Physical appearance at sampling Color ________ Odor ________

Sheen/Free Product ______________

COMMENTS/OBSERVATIONS ____

____

Slug Test Data

Location ________________________ Geologic Unit __________ Well Number _________ Sheet _______ of _____

Field Team Member Signature

(Print name and title, then sign)

Test Method: ___ Slug Injection or ___ Slug Withdrawal Slug Dimensions or volume _______________

Well Construction Details (attach diagram): ____

Test Started __________________ Test Stopped _______________ Test ID ____________________________

Method of Water-Level Measurement: ____

Comments: ____

____

____

Time of Measurement	**Elapsed Time (minutes)**	**Depth to Water (feet)**	**Time of Measurement**	**Elapsed Time (minutes)**	**Depth to Water (feet)**

□ Check here if continued on the back of this sheet.

IDW MANAGEMENT FORM

COMPANY____________________ PROJECT____________________

SITE NAME____________________ LOCATION ____________________

CONTAINER NUMBER	MEDIA DESCRIPTION	MEDIA ORIGIN	DATE FILLED	DATE SAMPLED	DATE DISPOSED	COMMENTS

1. OBJECTIVE

The objective of these guidelines is to provide general reference information for estimating the hydraulic conductivity of an aquifer by in-situ tests performed in either piezometers, monitoring wells or boreholes.

2. LIMITATIONS

These guidelines are for information only and are not to take precedence over the requirements of project-specific plans for in-situ hydraulic conductivity testing.

These tests approximate the hydraulic conductivity of the formation only at the interval of the test. The disturbance to the formations caused by drilling and the potential turbulence from the well screen can influence the data. The diameter of the well is critical to the computation of the hydraulic conductivity, and the effective diameter of a well can be increased considerably by the well development process. Poor well efficiency caused by inappropriate slot size, poor condition of the well screen, or a poorly designed gravel pack could produce results not representative of the tested formation. Hydraulic conductivity tests in wells should be conducted only after the well has been fully developed. Slug test evaluation formulas assume an instantaneous initial change in water level in the tested interval. Tests performed after extended periods of pumping or water addition may yield inaccurate results. Slug tests provide only rough estimates of hydraulic conductivity, and should not be run in preference to pumping tests.

3. DEFINITIONS

Slug Test - An aquifer test made either by pouring a small instantaneous charge of water into a well or by withdrawing a slug of water from the well. A synonym for this test, when a slug of water is removed from the well, is a bail-down test.

Rising Head Test - A test performed in an individual borehole or well within the saturated zone to estimate the hydraulic conductivity of the surrounding formation by lowering the water level in the boring or well and measuring the rate of recovery of the water level. The water level may be lowered by pumping or bailing.

Falling Head Test - A test performed in an individual borehole or well to estimate the hydraulic conductivity of the surrounding formation by raising the water level in the boring or well and measuring the rate of drop in the water level.

Constant Head Test - A constant head test is a variation of the falling head test in which water is constantly added to the borehole or well to be tested, and the flow rate required to maintain a hydraulic head at a constant level above the static water level is measured.

Packer Test - A hydraulic conductivity test using inflatable packers to isolate a discrete zone within the borehole for testing purposes.

Packer - A sealing device installed in a well or borehole which isolates intervals within the boring or well for testing purposes.

4. GUIDELINES

In-situ hydraulic conductivity testing provides a relatively rapid method of estimating the hydraulic conductivity of a portion of an aquifer and the transmissivity (if the saturated thickness of the unconfined or confined aquifer is known). While the performance of a pumping test is the optimum aquifer testing method for estimation of hydraulic conductivities, transmissivities, and storage coefficients, pumping tests are relatively expensive and time consuming. Certain methods of in-situ testing, on the other hand, are much less expensive, less time intensive per test and several wells or piezometers can be tested in a single day by one technician. These guidelines present methods for conducting in-situ hydraulic conductivity tests in piezometers, monitoring wells, and boreholes.

4.1 Slug Test

Slug tests are conducted to estimate the hydraulic conductivity of the soil/rock strata within the screen interval of a piezometer or a monitoring well. A standard slug test consists of instantaneous injection or withdrawal of a known volume that causes immediate change of water levels in the well. The subsequent amounts of rise or decline of water levels with time are recorded and used to calculate hydraulic conductivities of the in-situ materials open to the well. Because the slug is small compared to the volume of water in the surrounding aquifer, the slug test is an estimate of permeability within only a few feet of the well.

A slug test is performed by quickly lowering a slug into a well to displace the water from the initial water level and measuring the rate at which the water level declines (falling-head test), then measuring the rate at which the water level rises (rising-head test) after the slug is removed. A bailer can also be used to remove a slug of water. This type of test is usually called a "bail-down test" or "bailer" test. Water level measurements should be recorded every 5 to 10 seconds for the first two minutes and every 30 seconds thereafter. Measurement can be terminated when the depth to water has stabilized for approximately 10 minutes. Water levels during the test can be recorded manually using a water level indicator, or a Hermit Model SE 100B Data logger with a pressure transducer can be used for this purpose.

Prior to slug testing, the well should be thoroughly developed and water levels allowed to stabilize in order to obtain accurate results. The following data should be obtained when performing a slug test, in addition to the static water level and all time and water level measurements:

1. Casing diameter
2. Borehole diameter
3. Well pipe and screen diameter and length
4. Screen slot size
5. Procedures used

6. Gravel pack size
7. Saturated thickness of the aquifer being tested

4.1.1 Slug Test Data Analysis

Slug test data can be analyzed by three different methods to determine in-situ hydraulic conductivity. The first method (Cooper, Bredehoeft, and Papadopulos, 1967) assumes slug test data was collected from wells in a confined aquifer with fully penetrating wells. The second method (Bouwer and Rice, 1976), while originally developed for an unconfined aquifer, can also be used for confined or stratified aquifers if the top of the screen or perforated section is some distance below the upper confining layer (Bouwer, 1989). The third method (Hvorslev, 1951) calculates permeabilities for various well geometries based on the assumption of infinite vertical extent (upward and downward) of the flow system. Detailed description of these methods can be located in the listed references. The most widely used method to reduce slug test data is that of Hvorslev. A brief description of this method is given below.

Figure 9-1 shows the geometry of a piezometer installed in an aquifer. In the case of a piezometer installed into a low permeability unit, special attention must be paid to the method of construction. In many cases, gravel pack is used to fill the open annular space between the well screen and the wall of the open hole. Under such conditions, the radius of the well screen, R, is the radius of the borehole and the length of the well screen, L, is the length of the gravel pack. The gravel pack would typically be extended one to several feet above the well screen and the remainder of the open hole backfilled with some type of grout.

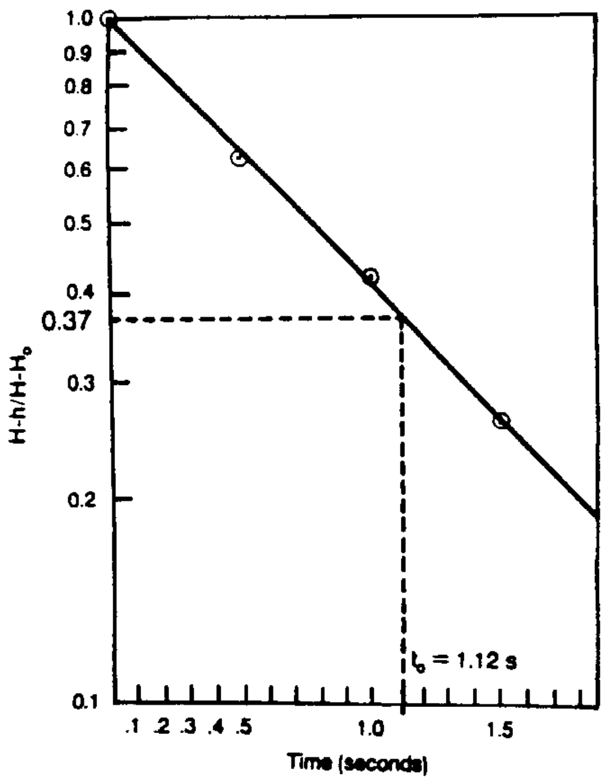


FIGURE 9-1 DIAGRAM OF HVORSLEV PIEZOMETER TEST

The data for the Hvorslev method is plotted as H-h/H-H_o versus time on semi-log paper with H-h/H-H_o on the log scale and time on the arithmetic scale. Ideally, the data will plot as a straight line.

Once the data has been plotted, a best fit line is drawn through the data points. A line is then drawn parallel to the time axis for H-h/H-H_o = 0.37. Where this line intersects the line through data points, a value for time is determined. This value is To (see Figure 9-2).

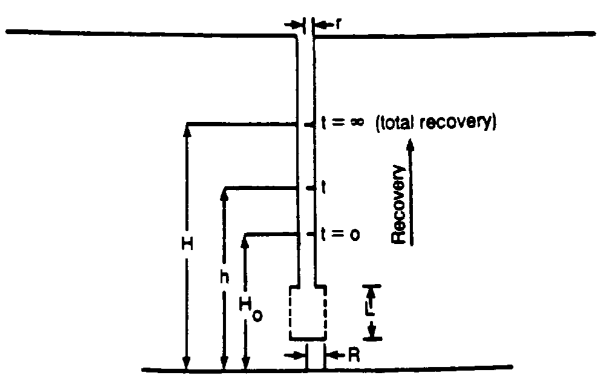


FIGURE 9-2 PLOT OF PIEZOMETER TEST DATA - HVORSLEV METHOD

The hydraulic conductivity can then be determined using the following equation:

$$K = \frac{r^2 \ln (L / R)}{2 L T_0}$$

where:

K	=	hydraulic conductivity
r	=	radius of well casing
R	=	radius of the well screen
L	=	length of the well screen
T_o	=	time required for the water level to rise or fall 37 percent of the initial change

The above equation is one of the many formulae presented by Hvorslev for different piezometer geometry and aquifer conditions. However, it is one that is quite useful and could be applied to unconfined conditions for most piezometer designs where the length is typically quite a bit greater than the radius of the well screen (L/R > 8). For other conditions, the original Hvorslev (1951) paper should be consulted.

4.2 Falling Head/Rising Head Tests

In-situ hydraulic conductivity tests can be performed in a boring while it is being advanced. This permits testing of formations at different depths throughout the drilling process. Both rising and falling head hydraulic conductivity tests can be performed in saturated formations during drilling. In general, either the rising or the falling head methods should be used if the permeability is low enough to permit accurate determination of the water level.

Borings in which permeability tests are to be performed should be designated before drilling. Therefore holes should be supported by casing, and the use of drilling mud or recirculated drill water should not be allowed.

Two different methods are described for performing variable (falling/rising) head permeability tests. In the first method, the casing is cleaned flush with the bottom of the boring; in the second method, the casing is pulled above the bottom of the cleaned borehole.

Falling Head Test: Flush Bottom

Once the desired testing depth is reached, the drilling operations should be stopped, the casing seated at the depth of the drilling bit, and the hole carefully cleaned.

After cleaning the boring to remove loose materials, the drill bit and drill rods should be withdrawn slowly to prevent loosening of the soil at the bottom of the hole.

The hole should then be maintained full of water to a level within 5 ft from the top of the casing for about 10 to 15 minutes by adding the necessary amount of water. This is essential to develop a steady seepage condition.

When the water level inside the casing has been adjusted for the last time, the depth to water should be recorded and a timer started. The depth to water should be measured with a calibrated tape equipped with a sounding device. In highly permeable soils or rock, an electric pressure transducer and recorder may be required. The level of water is then allowed to fall inside the hole from the seepage of water through the bottom of the hole.

The depth of water inside the hole should be carefully recorded at logarithmically increasing intervals of time as determined by the site geologist. The top of the casing should be used as a reference point for all measurements.

The length of the test should be determined by the site geologist.

The following data should be obtained, in addition to all time and depth measurements (when applicable):

1. Ground elevation
2. Reference elevation
3. Depth of test run
4. Casing diameter
5. Length of uncased borehole
6. Identification of equipment used

Falling Head Test: Pulling Back Casing

This method is similar to the above method except that the hole is backfilled with a clean, washed sand and the casing is bumped back a designated distance. A well screen may also be used that is fitted with threads at the top to accept pipe to pull it back out after the test is complete.

The hole should be prepared as described above. The test should be carried out in a similar manner as described previously or as determined by the site geologist, and all pertinent data should be similarly recorded.

Rising Head Test

This method is equivalent to that used for the falling head test.

The water level in the borehole is temporarily lowered as quickly as possible and readings are obtained as the water rises in the borehole. Any convenient means of rapidly lowering the water in the boring may be used, such as a bailer or pump.

All pertinent data should be similarly recorded.

4.2.1 Rising Head/Falling Head Test Data Analysis

There are many different published formulae for calculating hydraulic conductivity from in-situ borehole tests. Some of these formulae are outlined in Figure 9-2 (Hvorslev, 1951) for various geometries keeping in view the nature of subsurface materials encountered in the boreholes. Relevant formulae can be selected based on site-specific conditions for data analysis. These formulae are based on the assumptions that the effect of soil compressibility is negligible.

4.3 Constant Head Test

A constant head test is normally conducted as an inflow test in which arrangements are made for water to flow into the ground under a sensibly constant head. In this method water is added to the casing at a rate sufficient to maintain a constant water level at or near the top of the casing for a period of not less 10 minutes. The water may be added by pouring from calibrated containers or by pumping through a water meter. The intake rate is measured and the hydraulic conductivity is determined from this. It is essential to use clean water for the test. A limitation of the constant head test is that foreign water introduced into the formation must be removed from the well area before a representative groundwater sample can be obtained. This method of testing may be used in both saturated and unsaturated formations. In those cases where the permeability is so high as to preclude an accurate measurement of the rising or falling water level, the constant head test is used.

Two different setups (similar to falling/rising head tests) can be used to conduct the constant head test. In the case first case, the casing is cleaned flush with the bottom of the boring; in the second case, the casing is pulled above the bottom of the cleaned borehole. A brief description of these setups is given in Section 4.2.

4.3.1 Constant Head Test Data Analysis

Constant head test data can be analyzed by using an appropriate applicable equation from Figure 9-2, keeping in view the test setup.

4.4 Packer Test

Inflatable packers are used to isolate a test zone within the borehole to perform in-situ permeability tests. The apparatus for pressure tests usually comprises a water pump, a manually-adjusted automatic pressure relief valve, pressure gauge, a water meter, and a packer assembly. The packers, which provide a means of sealing off a limited section of borehole for testing should have a length of five times the diameter of the hole. They may be of the pneumatically or mechanically expandable type. The former are preferred since they adapt to an oversized hole, whereas the latter may not. The piping of the packer assembly is designed to permit testing of either the portion of the hole between the packers or the portion below the lower packer. Flow to the section below the lower packer is through the interior pipe; flow to the section between the packers is provided by perforations in the outer pipe which have an outlet area two or more times the cross-sectional area of the pipe. The packers are normally set 2, 5, or 10 feet apart and it is common to provide flexibility in testing by having assemblies with different packer spacings available, thereby permitting the testing of different lengths of the hole. The wider spacings are used for rock which is more uniform; the shorter spacing is used to test individual joints which may be the cause of high water loss in otherwise tight strata.

Methods of Testing

The test procedure used depends upon the condition of the rock. In rock which is not subject to cave-in, the following method is in general use. The hole is drilled to the total depth without testing. Two inflatable packers 5 to 10 feet apart are mounted near the bottom of the rod or pipe used for making the test. The bottom of the rod or pipe is sealed, and the section between the packers is perforated. The perforations should be at least one quarter of an inch in diameter, and the total area of all perforations should be greater than two times the inside cross-sectional area of he pipe or rod. Tests are made beginning at the bottom of the hole. After each test, the packers are raised the length of the test section and another test made. This procedure is followed until the entire length of the hole has been tested.

If the rock in which the hole is being drilled is subject to cave-in, the pressure test is conducted after each advance of the hole for a length equal to the maximum unsupported length of hole or the distance between the packers, whichever is less.

Cleaning Test Sections Before Testing

Before each test, the test section should be surged with clean water and bailed out to clear cuttings and drilling fluid from the face of the hole. If the test section is above the water table and will not hold water, water should be poured into the hole during the surging, then bailed out as rapidly as possible. When a completed hole is tested using two packers, the entire hole can be cleaned in one operation. Cleaning the hole is frequently omitted from testing procedures; however, this omission may result in a permeable rock appearing to be impermeable because the hole face is sealed by cuttings or drilling fluid. In such cases, the computed permeability will be lower than the true permeability.

Length of Test Section

The length of the test section is governed by the character of the rock, but generally a length of 10 feet is desirable. At times, a good seal cannot be obtained for the packer at the planned elevation because of bridging, railing, or the presence of fractures. Under these circumstances, the test section length should be increased or decreased or test sections overlapped to assure that the test is made with well-seated packers. On some tests, a 10-foot sections will take more water than the pump can deliver; hence, no back pressure can be developed. When this occurs, the length of the test sections should be shortened until back pressure can be developed, or the falling head test might be tried.

The test sections should never be shortened to where the ratio $\frac{A}{D}$ is less than 5, where *D* is the diameter of the hole and *A* is the length of the test section.

Size of Rod or Pipe to Use in Tests

Drill rods are commonly used as intake pipes to make pressure and permeability tests. NX and NW rods can be used for this purpose without seriously affecting the reliability of the test data, if the intake of the test section does not exceed 12 to 15 gallons per minute and the depth to the top of the test section does not exceed 50 feet. For tests deeper than 50 feet, head loss due to friction in pipe should be accounted for when calculating hydraulic conductivity.

Pumping Equipment

Permeability tests made in drill holes ideally should be performed using centrifugal pumps having sufficient capacity to develop back pressure. A pump with a capacity of up to 250 gallons per minute against a total head of 160 feet would be adequate for most testing. Head and discharge of such pumps are easily controlled by changing engine speed or with a control valve on the discharge.

Water Pressures, Duration of Tests, and Data to Be Recorded

A minimum of three pressures are utilized at each test section. The magnitude of the pressures should be respectively at least 10, 20, and 40 lbs/sq. in. (psi) above the natural piezometric pressure or 10, 20, and 40 psi where pressure testing above the piezometric level except that in no case should the excess pressure above natural piezometric pressure exceed one psi per foot of existing overburden. Each pressure increment should be maintained for ten or more minutes until a uniform rate of flow has been reached or until stopped by the geologist. The quantity of flow for each pressure is recorded at one, two, and five minutes, and at five minute intervals thereafter. After the rate of flow at 10, 20, and 40 psi pressures have been recorded, the water pressure should be reduced to 20 and 10 psi and the intake recorded at these pressures. Additional data to be recorded in each test are as follows:

1. Depth of hole at time of each test.
2. Depth to bottom of top packer.
3. Depth to top of lower packer.
4. Depth to water surface in boring at specified intervals.
5. Elevation of piezometer level in artesian strata.
6. Length of test section.
7. Radius of hole.
8. Length of packer.
9. Distance pressure gauge is above ground surface.

10. Description of material tested.
11. Height of water swivel above ground surface.

Packer Test Data Analysis

The following equation can be used to determine in-situ hydraulic conductivity using the packer test data:

$$K = \frac{Q}{2\pi\ LH} \log_e \frac{L}{r}; L \geq 10r$$

$$K = \frac{Q}{2\pi\ LH} \sinh^{-1} \frac{L}{2r}, 10r > L \geq r$$

where: K = hydraulic conductivity
Q = constant rate of flow into the hole
L = length of the portion of the hole tested
H = differential head of water
r = radius of hole tested
$\log_e$ = natural logarithm
$\sinh^{-1}$ = inverse hyperbolic sine

These formulas have best validity when the thickness of the stratum tested is at least 5L, and they are considered to be more accurate for tests below groundwater table than above it.

5. REFERENCES

Bouwer, H., and R. C. Rice, 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells." *Water Resources Research*, 12 (1976):423-428.
Bouwer, Herman, 1989. "The Bouwer and Rice Slug Test - An Update." *Ground-Water*, 27:3, pp 304 et seq.

Cooper, H. H. Jr., J. D. Bredehoeft, and I. S. Papadopulos, 1967. Response of a Finite Diameter Well to an Instantaneous Charge of Water." *Water Resources Research*, 3(1967):263-269.

Hvorslev, M. J., 1951. *Time Lag and Soil Permeability in Ground Water Observations*. U.S. Army Corps of Engineers Waterway Experimentation Station, Bulletin 36, 1951, 50 pp.

6. REVISION HISTORY

Original - revision 0 - April 1989

Revision 1 - June 1991 - complete rewrite, text expanded, graphics incorporated.

Revision 1.1 - May 1993 - typographical errors corrected, minor formatting changes

Revision 1.2 - August 1994 - Internal review; typographical errors and technical content corrected; references added.

APPENDIX B

REQUIREMENTS FOR AMERICAN LAND TITLE ASSOCIATION LAND TITLE SURVEYS

2005 MINIMUM STANDARD DETAIL REQUIREMENTS FOR ALTA/ACSM LAND TITLE SURVEYS
as adopted by American Land Title Association and National Society of Professional Surveyors
(a member organization of the American Congress on Surveying and Mapping)

It is recognized that members of the American Land Title Association (ALTA) have specific needs, peculiar to title insurance matters, which require particular information for acceptance by title insurance companies when said companies are asked to insure title to land without exception as to the many matters which might be discoverable from survey and inspection and not be evidenced by the public records. In the general interest of the public, the surveying profession, title insurers and abstracters, ALTA and the National Society of Professional Surveyors, Inc. (NSPS) jointly promulgate and set forth such details and criteria for standards. It is recognized and understood that local and state standards or standards of care, which surveyors in those respective jurisdictions are bound by, may augment, or even require variations to the standards outlined herein. Where conflicts between the standards outlined herein and any jurisdictional statutes or regulations occur, the more restrictive requirement shall apply. It is also recognized that title insurance companies are entitled to rely on the survey furnished to them to be of an appropriate professional quality, both as to completeness and as to accuracy. It is equally recognized that for the performance of a survey, the surveyor will be provided with appropriate data which can be relied upon in the preparation of the survey.

For a survey of real property and the plat or map of the survey to be acceptable to a title insurance company for purposes of insuring title to said real property free and clear of survey matters (except those matters disclosed by the survey and indicated on the plat or map), certain specific and pertinent information shall be presented for the distinct and clear understanding between the client (insured), the title insurance company (insurer), and the surveyor (the person professionally responsible for the survey). These requirements are:

1. The client shall request the survey or arrange for the survey to be requested and shall provide a written authorization to proceed with the survey from the person responsible for paying for the survey. Unless specifically authorized in writing by the insurer, the insurer shall not be responsible for any costs associated with the preparation of the survey. The request shall specify that an **"ALTA/ACSM LAND TITLE SURVEY"** is required and shall designate which of the optional items listed in Table A are to be incorporated. The request shall set forth the record description of the property to be surveyed or, in the case of an original survey, the record description of the parent parcel that contains the property to be surveyed. Complete copies of the record description of the property (or, in the case of an original survey, the parent parcel), any record easements benefiting the property; the record easements or servitudes and covenants burdening the property ("Record Documents"); documents of record referred to in the Record Documents; and any other documents containing desired appropriate information affecting the property being surveyed and to which the survey shall make reference shall be provided to the surveyor for notation on the plat or map of survey.

2. The plat or map of such survey shall bear the name, address, telephone number, and signature of the professional land surveyor who performed the survey, his or her official seal and registration number, the date the survey was completed, the dates of all of the surveyor's revisions and the caption "ALTA/ACSM Land Title Survey" with the certification set forth in paragraph 8.

3. An "**ALTA/ACSM LAND TITLE SURVEY**" shall be in accordance with the then-current "Accuracy Standards for Land Title Surveys" ("Accuracy Standards") as adopted, from time to time by the National Society of Professional Surveyors and the American Land Title Association and incorporated herein by reference.

4. On the plat or map of an "**ALTA/ACSM LAND TITLE SURVEY**," the survey boundary shall be drawn to a convenient scale, with that scale clearly indicated. A graphic scale, shown in feet or meters or both, shall be included. A north arrow shall be shown and when practicable, the plat or map of survey shall be oriented so that north is at the top of the drawing. Symbols or abbreviations used shall be identified on the face of the plat or map by use of a legend or other means. If necessary for clarity, supplementary or exaggerated diagrams shall be presented accurately on the plat or map. The plat or map shall be a minimum size of 8½ by 11 inches.

5. The survey shall be performed on the ground and the plat or map of an "**ALTA/ACSM LAND TITLE SURVEY**" shall contain, in addition to the required items already specified above, the following applicable information:

(a) All data necessary to indicate the mathematical dimensions and relationships of the boundary represented, with angles given directly or by bearings, and with the length and radius of each curve, together with elements necessary to mathematically define each curve. The point of beginning of the surveyor's description shall be shown as well as the remote point of beginning if different. A bearing base shall refer to some well-fixed line, so that the bearings may be easily re-established. The North arrow shall be referenced to its bearing base and should that bearing base differ from record title, that difference shall be noted.

(b) When record bearings or angles or distances differ from measured bearings, angles or distances, both the record and measured bearings, angles, and distances shall be clearly indicated. If the record description fails to form a mathematically closed figure, the surveyor shall so indicate.

(c) Measured and record distances from corners of parcels surveyed to the nearest right-of-way lines of streets in urban or suburban areas, together with recovered lot corners and evidence of lot corners, shall be noted. For streets and highways abutting the property surveyed, the name, the width and location of pavement relative to the nearest boundary line of the surveyed tract, and the width of existing rights of way, where available from the controlling jurisdiction, shall be shown. Observable evidence of access (or lack thereof) to such abutting streets or highways shall be indicated. Observable evidence of private roads shall be so indicated. Streets abutting the premises, which have been described in Record Documents, but not physically opened, shall be shown and so noted.

(d) The identifying titles of all recorded plats, filed maps, right of way maps, or similar documents which the survey represents, wholly or in part, shall be shown with their appropriate recording data, filing dates and map numbers, and the lot, block, and section numbers or letters of the surveyed premises. For non-platted adjoining land, names, and recording data identifying adjoining owners as they appear of record shall be shown. For platted adjoining land, the recording data of the subdivision plat shall be shown. The survey shall indicate platted setback or building restriction lines which have been recorded in subdivision plats or which appear in Record Documents which have been delivered to the surveyor. Contiguity, gores, and overlaps along the exterior boundaries of the surveyed premises, where ascertainable from field evidence or Record Documents, or interior to those exterior boundaries, shall be clearly indicated or noted. Where only a part of a recorded lot or parcel is included in the survey, the balance of the lot or parcel shall be indicated.

(e) All evidence of monuments shall be shown and noted to indicate which were found and which were placed. All evidence of monuments found beyond the surveyed premises on which establishment of the corners of the surveyed premises are dependent, and their application related to the survey shall be indicated.

(f) The character of any and all evidence of possession shall be stated and the location of such evidence carefully given in relation to both the measured boundary lines and those established by the record. An absence of notation on the survey shall be presumptive of no observable evidence of possession.

(g) The location of all buildings upon the plot or parcel shall be shown and their locations defined by measurements perpendicular to the nearest perimeter boundaries. The precision of these measurements shall be commensurate with the Relative Positional Accuracy of the survey as specified in the current Accuracy Standards for ALTA/ACSM Land Title Surveys. If there are no buildings erected on the property being surveyed, the plat or map shall bear the statement, "No buildings." Proper street numbers shall be shown where available.

(h) All easements evidenced by Record Documents which have been delivered to the surveyor shall be shown, both those burdening and those benefiting the property surveyed, indicating recording information. If such an easement cannot be located, a note to this effect shall be included. Observable evidence of easements and/or servitudes of all kinds, such as those created by roads; rights-of-way; water courses; drains; telephone, telegraph, or electric lines; water, sewer, oil or gas pipelines on or across the surveyed property and on adjoining properties if they appear to affect the surveyed property, shall be located and noted. If the surveyor has knowledge of any such easements and/or servitudes, not observable at the time the present survey is made, such lack of observable evidence shall be noted. Surface indications, if any, of underground easements and/or servitudes shall also be shown.

(i) The character and location of all walls, buildings, fences, and other visible improvements within five feet of each side of the boundary lines shall be noted. Without expressing a legal opinion, physical evidence of all encroaching structural appurtenances and projections, such as fire escapes, bay windows, windows and doors that open out, flue pipes, stoops, eaves, cornices, areaways, steps, trim, etc., by or on adjoining property or on abutting streets, on any easement or over setback lines shown by Record Documents shall be indicated with the extent of such encroachment or projection. If the client wishes to have additional information with regard to appurtenances such as whether or not such appurtenances are independent, division, or party walls and are plumb, the client will assume the responsibility of obtaining such permissions as are necessary for the surveyor to enter upon the properties to make such determinations.

(j) Driveways, alleys and other ways of access on or crossing the property must be shown. Where there is evidence of use by other than the occupants of the property, the surveyor must so indicate on the plat or map. Where driveways or alleys on adjoining properties encroach, in whole or in part, on the property being surveyed, the surveyor must so indicate on the plat or map with appropriate measurements.

(k) As accurately as the evidence permits, the location of cemeteries and burial grounds (i) disclosed in the Record Documents provided by client or (ii) observed in the process of performing the field work for the survey, shall be shown.

(l) Ponds, lakes, springs, or rivers bordering on or running through the premises being surveyed shall be shown.

6. As a minimum requirement, the surveyor shall furnish two sets of prints of the plat or map of survey to

the title insurance company or the client. If the plat or map of survey consists of more than one sheet, the sheets shall be numbered, the total number of sheets indicated and match lines be shown on each sheet. The prints shall be on durable and dimensionally stable material of a quality standard acceptable to the title insurance company. The record title description of the surveyed tract, or the description provided by the client, and any new description prepared by the surveyor must appear on the face of the plat or map or otherwise accompany the survey. When, in the opinion of the surveyor, the results of the survey differ significantly from the record, or if a fundamental decision related to the boundary resolution is not clearly reflected on the plat or map, the surveyor may explain this information with notes on the face of the plat or map or in accompanying attachments. If the relative positional accuracy of the survey exceeds that allowable, the surveyor shall explain the site conditions that resulted in that outcome with a note on the face of the map or plat.

7. Water boundaries necessarily are subject to change due to erosion or accretion by tidal action or the flow of rivers and streams. A realignment of water bodies may also occur due to many reasons such as deliberate cutting and filling of bordering lands or by avulsion. Recorded surveys of natural water boundaries are not relied upon by title insurers for location of title.

When a property to be surveyed for title insurance purposes contains a natural water boundary, the surveyor shall measure the location of the boundary according to appropriate surveying methods and note on the plat or map the date of the measurement and the caveat that the boundary is subject to change due to natural causes and that it may or may not represent the actual location of the limit of title. When the surveyor is aware of changes in such boundaries, the extent of those changes shall be identified.

8. When the surveyor has met all of the minimum standard detail requirements for an ALTA/ACSM Land Title Survey, the following certification shall be made on the plat:

To (name of client), (name of lender, if known), (name of title insurance company, if known), (name of others as instructed by client):

This is to certify that this map or plat and the survey on which it is based were made in accordance with the "Minimum Standard Detail Requirements for ALTA/ACSM Land Title Surveys," jointly established and adopted by ALTA and NSPS in 2005, and includes Items _____ of Table A thereof. Pursuant to the Accuracy Standards as adopted by ALTA and NSPS and in effect on the date of this certification, undersigned further certifies that in my professional opinion, as a land surveyor registered in the State of __________, the Relative Positional Accuracy of this survey does not exceed that which is specified therein.

Date: (signed) (seal)
Registration No.

NOTE: If, as otherwise allowed in the Accuracy Standards, the Relative Positional Accuracy exceeds that which is specified therein, the following certification shall be made on the plat:

To (name of client), (name of lender, if known), (name of title insurance company, if known), (name of others as instructed by client):

This is to certify that this map or plat and the survey on which it is based were made in accordance with the "Minimum Standard Detail Requirements for ALTA/ACSM Land Title Surveys," jointly established and adopted by ALTA and NSPS in 2005, and includes Items _____ of Table A thereof. Pursuant to the Accuracy Standards as adopted by ALTA and NSPS and in effect on the date of this certification, undersigned further certifies that in my professional opinion, as a land surveyor registered in the State of __________, the maximum Relative Positional Accuracy is _____feet.

Date: (signed) (seal)
Registration No.

The 2005 Minimum Standard Detail Requirements for ALTA/ACSM Land Title Surveys are effective January 1, 2006. As of that date, all previous versions of the Minimum Standard Detail Requirements for ALTA/ACSM Land Title Surveys are superseded by these 2005 standards.

Adopted by the American Land Title Association on October 5, 2005.
Adopted by the Board of Directors, National Society of Professional Surveyors on October 24, 2005.
American Land Title Association, 1828 L St., N.W., Suite 705, Washington, D.C. 20036.
National Society of Professional Surveyors, Inc., 6 Montgomery Village Avenue, Suite 403, Gaithersburg, MD 20879

TABLE A

OPTIONAL SURVEY RESPONSIBILITIES AND SPECIFICATIONS

NOTE: The items of Table A must be negotiated between the surveyor and client. It may be necessary for the surveyor to qualify or expand upon the description of these items, e.g., in reference to Item 6, there may be a need for an interpretation of a restriction. The surveyor cannot make a certification on the basis of an interpretation or opinion of another party. Items 16, 17 and 18 are only for use on projects for the U.S. Department of Housing and Urban Development (HUD).

If checked, the following optional items are to be included in the ALTA/ACSM LAND TITLE SURVEY, except as otherwise negotiated:

1. _____ *Monuments placed (or a reference monument or witness to the corner) at all major corners of the boundary of the property, unless already marked or referenced by an existing monument or witness to the corner.*

2. _____ *Vicinity map showing the property surveyed in reference to nearby highway(s) or major street intersection(s).*

3. _____ *Flood zone designation (with proper annotation based on federal Flood Insurance Rate Maps or the state or local equivalent, by scaled map location and graphic plotting only.)*

4. _____ *Gross land area (and other areas if specified by the client).*

5. _____ *Contours and the datum of the elevations.*

6. _____ *List setback, height, and floor space area restrictions disclosed by applicable zoning or building codes (beyond those required under paragraph 5d of these standards). If none, so state. The source of such information must be disclosed. See "Note" above.*

7. _____ *(a) Exterior dimensions of all buildings at ground level*

(b) Square footage of:

_____ *(1) exterior footprint of all buildings at ground level*

_____ *(2) gross floor area of all buildings; or*

_____ *(3) other areas to be defined by the client*

_____ *(c) Measured height of all buildings above grade at a defined location. If no defined location is provided, the point of measurement shall be shown.*

8. _____ *Substantial, visible improvements (in addition to buildings) such as billboards, signs, parking structures, swimming pools, etc.*

9. _____ *Parking areas and, if striped, the striping and the type (e.g. handicapped, motorcycle, regular, etc.) and number of parking spaces.*

10. _____ *Indication of access to a public way on land such as curb cuts and driveways, and to and from waters adjoining the surveyed tract, such as boat slips, launches, piers and docks..*

11. *Location of utilities (representative examples of which are shown below) existing on or serving the surveyed property as determined by:*

_____ *(a) Observed evidence*

_____ *(b) Observed evidence together with evidence from plans obtained from utility companies or provided by client, and markings by utility companies and other appropriate sources (with reference as to the source of information)*

- *railroad tracks and sidings;*
- *manholes, catch basins, valve vaults or other surface indications of subterranean uses;*
- *wires and cables (including their function, if readily identifiable) crossing the surveyed premises, all poles on or within ten feet of the surveyed premises, and the dimensions of all crossmembers or overhangs affecting the surveyed premises; and*
- *utility company installations on the surveyed premises.*

12. _____ *Governmental Agency survey-related requirements as specified by the client.*

13. _____ *Names of adjoining owners of platted lands.*

14. _____ *The distance to the nearest intersecting street as designated by the client*

15. _____ *Rectified orthophotography, photogrammetric mapping, laser scanning and other similar products, tools or technologies may be utilized as the basis for the location of certain features (excluding boundaries) where ground measurements are not otherwise necessary to locate those features to an appropriate and acceptable accuracy relative to a nearby boundary. The surveyor shall (a) discuss the ramifications of such methodologies (e.g. the potential accuracy and completeness of the data gathered thereby) with the title company, lender and client prior to the performance of the survey and, (b) place a note on the face of the survey explaining the source, date, relative accuracy and other relevant qualifications of any such data.*

16. _____ *Observable evidence of earth moving work, building construction or building additions within recent months.*

17. _____ *Any changes in street right of way lines either completed or proposed, and available from the controlling jurisdiction. Observable evidence of recent street or sidewalk construction or repairs.*

18. _____ *Observable evidence of site use as a solid waste dump, sump or sanitary landfill.*

19. ____

Accuracy Standards for ALTA/ACSM Land Title Surveys

Introduction

These Accuracy Standards address Relative Positional Accuracies for measurements that control land boundaries on ALTA/ACSM Land Title Surveys.

In order to meet these standards, the surveyor must assure and certify that the Relative Positional Accuracies resulting from the measurements made on the survey do not exceed that which is allowable.

If the size or configuration of the property to be surveyed, or the relief, vegetation or improvements on the property will result in survey measurements for which the allowable Relative Positional Accuracies will be exceeded, the surveyor must alternatively certify as to the Relative Positional Accuracy that was otherwise achieved on the survey.

Definition:

"Relative Positional Accuracy" means the value expressed in feet or meters that represents the uncertainty due to random errors in measurements in the location of any point on a survey relative to any other point on the same survey at the 95 percent confidence level.

Background

The lines and corners on any property survey have uncertainty in location which is the result of (1) availability and condition of reference monuments, (2) occupation or possession lines as they may differ from record lines, (3) clarity or ambiguity of the record descriptions or plats of the surveyed tracts and its adjoiners and (4) Relative Positional Accuracy.

The first three sources of uncertainty must be weighed as evidence in the determination of where, in the professional surveyor's opinion, the boundary lines and corners should be placed. Relative Positional Accuracy is related to how accurately the surveyor is able to monument or report those positions.

Of these four sources of uncertainty, only Relative Positional Accuracy is controllable, although due to the inherent error in any measurement, it cannot be eliminated. The first three can be estimated based on evidence; Relative Positional Accuracy can be estimated using statistical means.

The surveyor shall, to the extent necessary to achieve the standard contained herein, (1) compensate or correct for systematic errors, including those associated with instrument calibration, (2) select the appropriate equipment and methods, and use trained personnel and (3) use appropriate error propagation and other measurement design theory to select the proper instruments, field procedures, geometric layouts and computational procedures to control random errors.

If radial survey methods, GPS or other acceptable technologies or procedures are used to locate or establish points on the survey, the surveyor shall apply appropriate procedures in order to assure that the allowable Relative Positional Accuracy of such points is not exceeded.

Computation of Relative Positional Accuracy

Relative Positional Accuracy may be tested by:
(1) comparing the relative location of points in a survey as measured by an independent survey of higher accuracy or
(2) the results of a minimally constrained, correctly weighted least square adjustment of the survey.

Allowable Relative Positional Accuracy for Measurements Controlling Land Boundaries on ALTA/ACSM Land Title Surveys

0.07 feet (or 20 mm) + 50 ppm

APPENDIX C

SITE-SPECIFIC HEALTH AND SAFETY PLAN

APPENDIX C
HEALTH AND SAFETY PLAN
FOR
REMEDIAL INVESTIGATION/
ALTERNATIVES ANALYSIS

FORMER SCOTT AVIATION FACILITY AREA 1
LANCASTER, NEW YORK

Prepared for:

Scott Technologies, Inc.
6600 Congress Avenue
Boca Raton, FL 33487

Prepared by:

AECOM Technical Services, Inc.
100 Corporate Parkway, Suite 341
Amherst, New York 14226

February 2010

HEALTH AND SAFETY PLAN APPROVAL

This Health and Safety Plan (HASP) was prepared for employees performing a specific, limited scope of work. It was prepared based on the best available information regarding the physical and chemical hazards known or suspected to be present on the project site. While it is not possible to discover, evaluate, and protect in advance against all possible hazards, which may be encountered during the completion of this project, adherence to the requirements of the HASP will significantly reduce the potential for occupational injury.

By signing below, I acknowledge that I have reviewed and hereby approve the HASP for the Area 1 – Former Scott Aviation site. This HASP has been written for the exclusive use of AECOM, its employees, and subcontractors. The plan is written for specified site conditions, dates, and personnel, and must be amended if these conditions change.

Revised and Approved by:

Michael Grasso, CIH Northeast Regional District H&S Manager	09-28-09 Date
Project Manager	10-05-09 Date

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ATTACHMENTS

FIGURES

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ADDENDUM

Earth Tech is now part of AECOM Technical Services, Inc. AECOM Safety Health and Environmental Standard Operating Procedures, where applicable will be substituted for the referenced Earth Tech Health, and Environmental Standard Operating Procedures, (SH&E SOPs). AECOM SH&E SOPs can be found on the intranet at http://intranet.aecomnet.com/.

1.0 INTRODUCTION

This Health and Safety Plan (HASP) (including Attachments A-C) provides a general description of the levels of personal protection and safe operating guidelines expected of each employee or subcontractor associated with the environmental services being conducted at the Area 1 – Former Scott Aviation site, located at 225 Erie Street in Lancaster, New York. This HASP also identifies chemical and physical hazards known to be associated with the AECOM Technical Services, Inc. (AECOM)-managed activities addressed in this document.

HASP Supplements will be generated as necessary to address any additional activities or changes in site conditions which may occur during field operations. Once generated, each Supplement will be inserted in Attachment C and reviewed/acknowledged by field personnel prior to the start of applicable work activities.

1.1 GENERAL

The provisions of this HASP are mandatory for all AECOM personnel engaged in fieldwork associated with the environmental services being conducted at the subject site. A copy of this HASP, any applicable HASP Supplements and the AECOM, Health, and Environmental Standard Operating Procedures, (SH&E SOPs) shall be maintained on site and available for review at all times. Record keeping will be maintained in accordance with this HASP and the applicable SH&E SOPs. In the event of a conflict between this HASP, the SH&E SOPs and federal, state, and local regulations, workers shall follow the most stringent/protective requirements.

1.2 POLICY STATEMENT

It is the policy of AECOM to provide a safe and healthy work environment for all of its employees. AECOM considers no phase of operations or administration is of greater importance than injury and illness prevention. Safety takes precedence over expediency or shortcuts. Every accident and every injury is avoidable. At AECOM, we believe every accident and every injury is avoidable. We will take every reasonable step to reduce the possibility of injury, illness, or accident. This policy is detailed in AECOM/Earth Tech Corporate Policy SH&E 001, *Safety, Health and Environmental Policy Statement.*

The practices and procedures presented in this HASP and any supplemental documents associated with this HASP are binding on all AECOM employees while engaged in the subject work. In addition, all site visitors shall abide by these procedures as the minimum acceptable standard for the work site. Operational changes to this HASP and supplements that could affect the health or safety of personnel, the community, or the environment will not be made without prior approval of the AECOM Project Manager (PM) and the assigned AECOM Safety Professional.

1.3 REFERENCES

This HASP conforms to the regulatory requirements and guidelines established in the following documents:

- Title 29, Part 1910 of the Code of Federal Regulations (29 CFR 1910), *Occupational Safety and Health Standards* (with special attention to Section 120, *Hazardous Waste Operations and Emergency Response*).
- Title 29, Part 1926 of the Code of Federal Regulations (29 CFR 1926), *Safety and Health Regulations for Construction*.

- National Institute for Occupational Safety and Health (NIOSH)/OSHA/U.S. Coast Guard (USCG)/EPA, *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, Publication No. 85-115, 1985.

1.3.1 Safety, Health and Environmental Website

Safety Website is located on the Corporate Intranet, and is available for all AECOM employees as a resource for safety information, updates, and procedures. Project management and employees are encouraged to visit the website for key safety items and information, such as:

- The AECOM Employee Orientation,
- Contact information for Safety Department staff,
- Safety Forms,
- Safety Program Manuals,
- Safety Alerts and other communications,
- Accident, Injury, and Near-Miss Reporting Requirements,
- Links to safety and regulatory information,
- Training Resources,
- Ergonomics Information, and
- A feedback link to the Safety Director.

The website is located at the following web address:

http://intranet.aecomnet.com/.

Please note that the website can only be accessed when connected to AECOM's Wide-Area Network.

2.0 SITE INFORMATION AND SCOPE OF WORK

AECOM will conduct environmental services at the Former Scott Aviation Facility Area 1. Work will be performed in accordance with the applicable Statement of Work (SOW) and associated Work Plans developed for the Former Scott Aviation Facility Area 1. Deviations from the listed SOW will require that a Safety Professional review any changes made to this HASP, to ensure adequate protection of personnel and other property.

The following is a summary of relevant data concerning the Former Scott Aviation Facility Area 1, and the work procedures to be performed. The Remedial Investigation/Alternative Analysis (RI/AA) Work Plan prepared by AECOM as a companion document to this HASP provides significantly greater details concerning both site history and planned work operations.

2.1 SITE INFORMATION

This section provides a general description and historical information associated with the site.

2.1.1 General Description

The addresses that comprise the current AVOX Systems Inc. (AVOX) facility (formerly Scott Aviation, Inc.) include: 225 Erie Street, 25 Walter Winter Drive, and 27 Walter Winter Drive, in Lancaster, Erie County, New York 14086 (Figure 2-1). The facility property encompasses three separate areas: the original 6.5-acre Plant 1 Area to the south of Erie Street, an 8.4-acre Plant 2 and Plant 3 Area to the north of Erie Street with the secondary address of 25 Walter Winter Drive, and an undeveloped 10.1-acre Northern Area to the north of the Plant 2 and Plant 3 Area. Walter Winter Drive is located immediately to the east of the Plant 2 and Plant 3 Area. The Plant 1 Area is comprised of three adjacent parcels: a 3.8-acre central parcel (zoned light industrial) on which Plant 1 is located; a vacant 1.1-acre parcel zoned light industrial to the west of the central parcel; and a vacant 1.6-acre parcel zoned residential to the east of the central parcel. Area 1 is located to the southwest of AVOX Plant 1, primarily on the 1.1-acre parcel of land.

2.1.2 Site Background/History

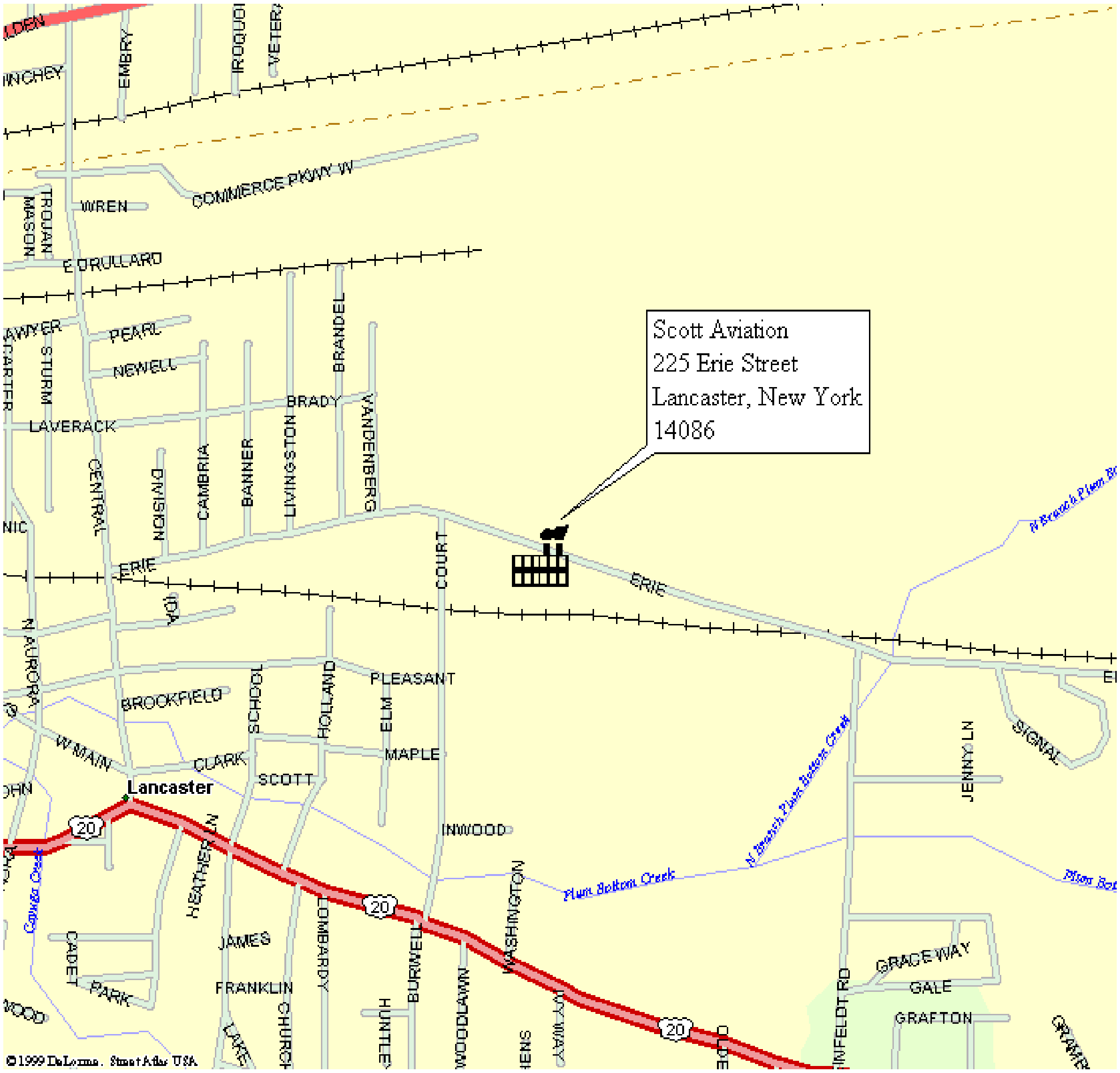
Section 2.0 of the RI/AA Work Plan provides a site description and brief chronological history of previous site assessment and investigation activities associated with the former Scott Aviation site with particular emphasis placed on activities completed for Area 1. Detailed information on each assessment or investigation can be found in the following documentation:

- *Phase I Environmental Site Assessment and Modified Compliance Assessment, Tyco/Scott Aviation Facility, Lancaster, New York* (Earth Tech, April 2004);
- *Phase II Environmental Site Investigation, Tyco/Scott Aviation Facility, Lancaster, New York* (Earth Tech, June 2004); and
- *Preliminary Groundwater Assessment Report, Former Scott Aviation Facility, Lancaster, New York* (Earth Tech, January 2008).

2.1.3 Previous Investigations

On June 28, 2005, Earth Tech (now AECOM) performed an initial excavation of buried waste material located to the west of Plant 1. Earth Tech removed all waste and a minimum 1-foot buffer of soil vertically and horizontally around the waste. The initial excavation footprint was approximately 14 feet by 18 feet, and the depth of the excavation ranged between 3.5 and 4 feet below ground surface (bgs). A total of 40 cubic yards of material (two rolloff boxes) were removed for subsequent off-Site disposal.

Figure 2-1. Site Map



North = top of page

Three sidewall (sample identification numbers S-1, S-2, and S-3) and one floor (B-1) confirmation soil samples were collected and submitted for analysis of VOCs and phenols by STL Laboratories, Inc (STL) of Amherst, New York. All sidewall sample results were below New York State Technical and Administrative Guidance Memorandum (TAGM) 4046 soil criteria In the excavation floor confirmation soil sample, ethylbenzene (14 parts per million [ppm]), toluene (15 ppm), trichloroethene (TCE; 1.2 ppm), xylenes (130 ppm), and phenol (54 parts per billion) were detected at levels above the TAGM 4046 soil criteria.

As a result of the soil concentration exceedances for confirmation soil sample B1, Earth Tech excavated an additional 2 feet of soil vertically within the existing excavation footprint on July 11, 2005, extending the total excavation depth to approximately 5.5 to 6 feet bgs. An additional 20 cubic yards of soil (one rolloff box) were removed for subsequent off-Site disposal. One confirmation soil sample (sample identification number B-1A) was collected at the bottom of the excavation and analyzed for VOCs and phenol by STL. Analytical results indicated TAGM 4046 soil criteria exceedances for toluene (17 ppm), 1,1,1-trichlorethane (1,1,1-TCA; 51 ppm), TCE (43 ppm), and xylenes (41 ppm) in the sample. VOC concentrations in soil exceeded 1 milligram per kilogram in 4 of 21 DPT borings. TCE was detected at concentrations ranging from 1.01 to 72.08 ppm. Cis-1,2-DCE was detected at concentrations ranging from 1.54 to 16.07 ppm. Vinyl chloride was detected at concentrations ranging from 1.01 to 4.43 ppm.

As a result of the elevated VOC and SVOC (phenol only) soil concentrations detected in the excavation bottom at Area 1 during the 2005 IRM, a Preliminary Groundwater Assessment (PGA) was performed in 2006 and 2007. The PGA at Area 1 was performed using Geoprobe® sampling techniques and completed in three separate phases: 1) Phase I – February through March 2006; 2) Phase II - May 2006; and 3) Phase III - May 2007. Soil borings were completed to bedrock (or refusal) using DPT sampling techniques. Continuous soil samples were obtained at each location using 2-inch diameter Geoprobe® Macro-Core® samplers.

Eighteen, one-inch diameter temporary piezometers were installed and screened across the water table (shallow overburden groundwater) at each boring location following the collection of a deep overburden groundwater sample using a Geoprobe® SP-15 sampling tool. Deep overburden groundwater piezometers were not installed for the PGA at Area 1. Groundwater samples were collected from each of the temporary piezometers installed at Area 1 using low-flow sampling techniques utilizing a peristaltic pump and dedicated poly tubing. Groundwater samples were analyzed for Target Compound List (TCL) VOCs by United States Environmental Protection Agency (EPA) SW846 Method 8260B, and select groundwater samples in Area 1 were also analyzed for TCL SVOCs by EPA SW846 Method 8270C.

A total of 26 VOCs and four SVOCs were detected in groundwater at Area 1. Eighteen of the 26 VOCs were detected at concentrations exceeding their respective Title 6 NYCRR Part 703 Class GA Groundwater Standards. TCE is present in shallow overburden and deep overburden groundwater at the highest concentration and largest aerial extent of all chemical constituents detected in groundwater at Area 1. The highest TCE concentration in groundwater is 90 ppm, while the highest concentration of 1,1,1-TCA is 130 ppm. The lateral extent of TCE was delineated in both groundwater units and was limited in aerial extent to within the existing facility property boundary southwest of Plant 1.

2.2 SCOPE OF WORK

AECOM will conduct environmental services at the site. Work will be performed in accordance with the applicable SOW and associated Work Plans developed for Area 1 – Former Scott Aviation Site.

2.2.1 Overburden and Bedrock Monitoring Well Installation

- Three (3) new shallow overburden monitoring wells; 2” diameter PVC, installed into the shallow silt and clay zone to an average depth of 18’ bgs; 5 to 10 feet of well screen.
- Six (6) new deep overburden monitoring wells, 2” diameter PVC, installed into the deeper sand and gravel zone to an average depth of 25’ bgs; 2 to 4 feet of well screen.
- Two (2) new bedrock monitoring wells; 2” diameter, PVC screen, one installed within the top 10 feet of competent bedrock (shale); 10 feet of well screen, and the other to be installed within the weather bedrock zone; screen length to be determined.
- Four (4) temporary piezometers, ¾” diameter, PVC screen, installed within the bedding gravel of the storm sewer line located to the west of Plant 1 to an average depth of 5 to 6 feet; 2 to 4 feet of well screen.
- Soils will be characterized at depth during the well installation to identify permeable zones and degree of contamination, or presence of free product.
- Analyze groundwater samples from these wells for VOCs. Field measurements for pH, dissolved oxygen (DO) and oxidation/reduction potential (ORP) will also be collected. The chemical data will be used to establish site conditions.
- Submit select soil samples from the bedrock well location for geotechnical analysis.
- Perform hydraulic testing (slug test) at two (2) overburden monitoring wells.
- AECOM will subcontract and oversee all drilling and well installation activities. Prior to conducting the drilling, a utility clearance will be conducted using the one call clearance system and consultation with site representatives to ensure subsurface facilities are not impacted by drilling activities.
- Welding/Cutting.

2.2.2 Vapor Intrusion Sampling

- Exact sampling locations will be determined in the field based on prior site reconnaissance and recorded.
- Temporary soil gas probes will be installed to the desired depth of sampling.
- After reaching the desired depth, dedicated Teflon or polyethylene tubing of laboratory or food grade will be used to collect the soil vapor samples.
- Prior to the collection of soil gas samples, the temporary soil gas probes will be purged in accordance with the New York State Department of Health (NYSDOH) guidance for evaluating soil vapor intrusion. One to three volumes (i.e., volume of the sample probe and tubing) will be purged at a flow rate which does not exceed 0.2 liters per minute).
- Helium tracer gas will be used during the soil gas investigation in accordance with the NYSDOH Soil Vapor Intrusion Guidance for Public Comment.
- The flow rate during sampling shall not exceed 0.2 liters per minute to minimize outdoor air infiltration during sampling.

2.2.3 Soil Delineation Sampling

- Collection of soil samples in the vicinity of former soil boring DPT-8 (six (6) soil samples).
- Collection of soil samples in the area of the IRM (three (3) soil samples).
- AECOM will subcontract and oversee all drilling activities. Prior to conducting the drilling, a utility clearance will be conducted using the one call clearance system and consultation with site representatives to ensure subsurface facilities are not impacted by drilling activities.

2.2.4 Additional Work Operations

The following additional tasks will also be performed as necessary in support of planned site activities:

Mobilization/Demobilization: Mobilization and demobilization represent limited pre and post-task activities. These activities include driving to and from the site; initial site preparations, such as trailer and toilet facilities setup; and post-work activities, such as removing files and office equipment and general housekeeping.

Equipment Decontamination: Earth Tech and subcontractor personnel will perform decontamination of equipment used to perform work within controlled work areas.

Investigative-Derived Waste (IDW) Management: IDW will be collected and categorized as non-hazardous or hazardous. Potentially hazardous IDW (purge water, and decontamination fluids, and soil cuttings [if any]) will be tested and disposed of within 90 calendar days of completing the field activities. Potentially hazardous IDW waste will be staged onsite, and then delivered to an IDW storage facility for processing. Non-hazardous IDW (normal trash) will be disposed of in a timely fashion during fieldwork.

3.0 PROJECT HEALTH AND SAFETY ORGANIZATION

3.1 PROJECT MANAGER [DINO ZACK]

The Project Manager (PM) has overall management authority and responsibility for all site operations, including safety. The specific safety responsibilities for the PM are listed in Section 4.0 of SH&E 001, *Safety Health & Environmental Policy Statement*. The PM will provide the site supervisor with work plans, staff and budgetary resources which are appropriate to meet the safety needs of the project operations.

3.2 SAFETY PROFESSIONAL [MICHAEL GRASSO]

The Safety Professional is the member of the AECOM Safety, Health and Environmental Department assigned to oversee health and safety requirements for the project and provide any needed technical support. The Safety Professional will be the first point-of-contact for all of the project's health and safety matters. Duties include the following:

- Approving this HASP and any required changes.
- Approving of the designated site safety officer.
- Reviewing all personal exposure monitoring results.
- Investigating any reported unsafe acts or conditions.

3.3 SITE SUPERVISOR [JEFFREY ROWLEY]

The site supervisor has the overall responsibility and authority to direct work operations at the job site according to the provided work plans. The PM may act as the site supervisor while on site.

3.3.1 Responsibilities

The site supervisor is responsible to:

- Discuss deviations from the work plan with the SSO and PM.
- Discuss safety issues with the PM, Site Safety Officer (SSO), and field personnel.
- Assist the SSO with the development and implementation of corrective actions for site safety deficiencies.
- Assist the SSO with the implementation of this HASP and ensuring compliance.
- Assist the SSO with inspections of the site for compliance with this HASP and applicable SH&E SOPs.

3.3.2 Authority

The site supervisor has authority to:

- Verify that all operations are in compliance with the requirements of this HASP, and halt any activity which poses a potential hazard to personnel, property or the environment.
- Temporarily suspend individuals from field activities for infractions against the HASP pending consideration by the SSO, the Safety Professional, and the PM.

3.3.3 Qualifications

In addition to being Hazardous Waste Operations and Emergency Response (HAZWOPER)-qualified (see Section 4.1), the Site Supervisor is required to have completed the 8-hour HAZWOPER Supervisor Training Course in accordance with 29 CFR 1910.120 (e)(4).

3.4 SITE SAFETY OFFICER [EMILY LAITY]

3.4.1 Responsibilities

The SSO is responsible to:

- Update the site-specific HASP to reflect changes in site conditions or the SOW. HASP updates must be reviewed and approved by the Safety Professional.
- Be aware of changes in AECOM Safety Policy. Changes are posted on the Safety Website (see Section 1.3 of this HASP).
- Monitor the lost time incidence rate for this project and work toward improving it.
- Inspect the site for compliance with this HASP and the SH&E SOPs using the appropriate audit inspection checklist provided by an AECOM Safety Professional.
- Work with the site supervisor and PM to develop and implement corrective action plans to correct deficiencies discovered during site inspections. Deficiencies will be discussed with project management to determine appropriate corrective action(s).
- Contact the Safety Professional for technical advice regarding safety issues.
- Provide a means for employees to communicate safety issues to management in a discreet manner (i.e., suggestion box, etc.).
- Determine emergency evacuation routes, establishing and posting local emergency telephone numbers, and arranging emergency transportation
- Ensure that all site personnel and visitors have received the proper training and medical clearance prior to entering the site
- Establish any necessary controlled work areas (as designated in this HASP or other safety documentation)
- Present tailgate safety meetings and maintain attendance logs and records
- Discuss potential health and safety hazards with the Site Supervisor, the Safety Professional, and the PM
- Select an alternate SSO by name and inform him/her of their duties, in the event that the SSO must leave or is absent from the site.

3.4.2 Authority

The SSO has authority to:

- Verify that all operations are in compliance with the requirements of this HASP.
- Issue a "Stop Work Order" under the conditions set forth in Section 4.7 of this HASP.
- Temporarily suspend individuals from field activities for infractions against the HASP pending consideration by the Safety Professional and the PM.

3.4.3 Qualifications

In addition to being HAZWOPER-qualified (see Section 4.1), the SSO is required to have completed the 8-hour HAZWOPER Supervisor Training Course in accordance with 29 CFR 1910.120 (e)(4).

3.5 EMPLOYEES

3.5.1 Employee Responsibilities

Responsibilities of employees associated with this project include, but are not limited to:

- Understanding and abiding by the policies and procedures specified in the HASP and other applicable safety policies, and clarifying those areas where understanding is incomplete.
- Providing feedback to health and safety management relating to omissions and modifications in the HASP or other safety policies.
- Notifying the SSO, in writing, of unsafe conditions and acts.

3.5.2 Employee Authority

The health and safety authority of each employee assigned to the site includes the following:

- The right to refuse to work and/or stop work authority when the employee feels that the work is unsafe (including subcontractors or team contractors), or where specified safety precautions are not adequate or fully understood.
- The right to refuse to work on any site or operation where the safety procedures specified in this HASP or other safety policies are not being followed.
- The right to contact the SSO or the Safety Professional at any time to discuss potential concerns.

3.6 SUBCONTRACTORS

The requirements for subcontractor selection and subcontractor safety responsibilities are outlined in SH&E 207, *Contractor and Subcontractor SH&E Requirements*. Each subcontractor is responsible for assigning specific work tasks to their employees. Each subcontractor's management will provide qualified employees and allocate sufficient time, materials, and equipment to safely complete assigned tasks. In particular, each subcontractor is responsible for equipping its personnel with any required personnel protective equipment (PPE).

AECOM considers each subcontractor to be an expert in all aspects of the work operations for which they are tasked to provide, and each subcontractor is responsible for compliance with the regulatory requirements that pertain to those services. Each subcontractor is expected to perform its operations in accordance with its own unique safety policies and procedures, in order to ensure that hazards associated with the performance of the work activities are properly controlled. Copies of any required safety documentation for a subcontractor's work activities will be provided to AECOM for review prior to the start of onsite activities, if required.

Hazards not listed in this HASP but known to any subcontractor, or known to be associated with a subcontractor's services, must be identified and addressed to the AECOM PM or the Site Supervisor prior to beginning work operations. The Site Supervisor or authorized representative has the authority to halt any subcontractor operations, and to remove any subcontractor or subcontractor employee from the site for failure to comply with established health and safety procedures or for operating in an unsafe manner.

3.7 VISITORS

Authorized visitors (e.g., client representatives, regulators, AECOM management staff, etc.) requiring entry to any work location on the site will be briefed by the PM on the hazards present at that location. Visitors will be escorted at all times at the work location and will be responsible for compliance with their employer's health and safety policies. In addition, this HASP specifies the minimum acceptable qualifications, training and personal protective equipment which are required for entry to any controlled work area; visitors must comply with these requirements at all times.

Unauthorized visitors, and visitors not meeting the specified qualifications, will not be permitted within established controlled work areas.

4.0 SAFETY PROGRAMS

4.1 HAZWOPER QUALIFICATIONS

Personnel performing work at the job site must be qualified as HAZWOPER workers (unless otherwise noted in specific THAs or by the SSO), and must meet the medical monitoring and training requirements specified in the following safety procedures:

- SH&E 114, *Safety Training Programs*
- SH&E 115 *Hazard Communication Program*
- SH&E 201, *General Safety Rules*
- SH&E 301, *Hazardous Waste Operations*

Personnel must have successfully completed training meeting the provisions established in 29 CFR 1910.120 (e)(2) and (e)(3) (40-hour initial training). As appropriate, personnel must also have completed annual refresher training in accordance with 29 CFR 1910.120 (e)(8); each person’s most recent training course must have been completed within the previous 365 days. Personnel must also have completed a physical exam in accordance with the requirements of 29 CFR 1910.120 (f), where the medical evaluation includes a judgment of the employee's ability to use respiratory protective equipment and to participate in hazardous waste site activities. These requirements are further discussed in SH&E 301, *Hazardous Waste Operations*.

If site monitoring procedures indicate that a possible exposure has occurred above the OSHA permissible exposure limit (PEL), employees may be required to receive supplemental medical testing to document specific to the particular materials present.

4.2 SITE-SPECIFIC SAFETY TRAINING

All personnel performing field activities at the site will be trained in accordance with SH&E 114, *Safety Training Requirements*. For this project, training will include the requirements specified in the following:

1. SH&E 101, *Injury, Illness, and Near Miss Reporting*
2. SH&E 112, *Respiratory Protection Program*
3. SH&E 115, *Hazard Communication Program*
4. SH&E 202, *Safety Meetings*
5. SH&E 210, *Walking-Working Surface Protection*
6. SH&E 301, *Hazardous Waste Operations*
7. SH&E 403, *Drilling*
8. SH&E 404, *Manual Lifting*
9. SH&E 411, *Welding, Cutting, and Other Hot Work*
10. SH&E 505, *Powered Hand Tools*
11. SH&E 506, *Manual Hand Tools*
12. SH&E 510, *High Pressure Washers*
13. SH&E 513, *Heavy Equipment*
14. SH&E 517, *Traffic Safety*
15. SH&E 604, *Decontamination*

In addition to the general health and safety training programs, personnel will be:

- Instructed on the contents of applicable portions of this HASP and any supplemental health and safety information developed for the tasks to be performed.
- Informed about the potential routes of exposure, protective clothing, precautionary measures, and symptoms or signs of chemical exposure and heat stress.
- Made aware of task-specific physical hazards and other hazards that may be encountered during site work. This includes any client-specific required training for health and safety.
- Made aware of fire prevention measures, fire extinguishing methods, and evacuation procedures.

The site-specific training will be performed prior to the worker performing the subject task or handling the impacted materials and on an as-needed basis thereafter. Training will be conducted by the SSO (or his/her designee) and will be documented on the form attached to SH&E 202, *Safety Meetings*.

4.3 HAZARD COMMUNICATION

Section 5.2 provides information concerning the materials that may be encountered as environmental contaminants during the work activities. In addition, any organization wishing to bring any hazardous material onto any AECOM-controlled work site must first provide a copy of the item's Material Safety Data Sheet (MSDS) to the SSO for approval and filing (the SSO will maintain copies of all MSDSs on site). MSDSs may not be available for locally-obtained products, in which case some alternate form of product hazard documentation will be acceptable. In accordance with the requirements of SH&E 115, *Hazard Communication Program*, all personnel shall be briefed on the hazards of any chemical product they use, and shall be aware of and have access to all MSDSs.

All containers on site shall be properly labeled to indicate their contents. Labeling on any containers not intended for single-day, individual use shall contain additional information indicating potential health and safety hazards (flammability, reactivity, etc.).

Attachment B provides copies of MSDSs for those items planned to be brought on site at the time this HASP is prepared. This information will be updated as required during site operations.

4.4 CONFINED SPACE ENTRY

The SSO/site supervisor shall identify all potential confined spaces in accordance with SH&E 118, *Confined Space Entry*. In addition, the SSO/site supervisor will inform all employees of the location of confined spaces. Confined space entry procedures and training requirements are listed in SH&E 118.

4.5 HAZARDOUS, SOLID, OR MUNICIPAL WASTE

If hazardous, solid and/or municipal wastes are generated during any phase of the project, the waste shall be accumulated, labeled, and disposed of in accordance with applicable Federal, State, and/or local regulations.

4.6 GENERAL SAFETY RULES

All site personnel shall adhere to SH&E 201, *General Safety Rules*, during site operations. In addition, the housekeeping and personal hygiene requirements listed below will also be observed.

4.6.1 Housekeeping

During site activities, work areas will be continuously policed for identification of excess trash and unnecessary debris. Excess debris and trash will be collected and stored in an appropriate container (e.g., plastic trash bags, garbage can, roll-off bin) prior to disposal. At no time will debris or trash be intermingled with waste PPE or contaminated materials.

4.6.2 Smoking, Eating, or Drinking

Smoking, eating and drinking will not be permitted inside any controlled work area at any time. Field workers will first wash hands and face immediately after leaving controlled work areas (and always prior to eating or drinking). Consumption of alcoholic beverages is prohibited at any AECOM site.

4.6.3 Personal Hygiene

The following personal hygiene requirements will be observed:

Water Supply: A water supply meeting the following requirements will be utilized:

> *Potable Water* - An adequate supply of potable water will be available for field personnel consumption. Potable water can be provided in the form of water bottles, canteens, water coolers, or drinking fountains. Where drinking fountains are not available, individual-use cups will be provided as well as adequate disposal containers. Potable water containers will be properly identified in order to distinguish them from non-potable water sources.
>
> *Non-Potable Water* - Non-potable water may be used for hand washing and cleaning activities. Non-potable water will not be used for drinking purposes. All containers of non-potable water will be marked with a label stating:

Non-Potable Water
Not Intended for Drinking Water Consumption

Toilet Facilities: A minimum of one toilet will be provided for every 20 personnel on site, with separate toilets maintained for each sex except where there are less than 5 total personnel on site. For mobile crews where work activities and locations permit transportation to nearby toilet facilities on-site facilities are not required.

Washing Facilities: Employees will be provided washing facilities (e.g., buckets with water and Alconox) at each work location. The use of water and hand soap (or similar substance) will required by all employees following exit from the Exclusion Zone, prior to breaks, and at the end of daily work activities.

4.6.4 Buddy System

All field personnel will use the buddy system when working within any controlled work area. Personnel belonging to another organization on site can serve as "buddies" for AECOM personnel. Under no circumstances will any employee be present alone in a controlled work area.

4.6.5 Heat and Cold Stress

Heat and cold stress may vary based upon work activities, PPE/clothing selection, geographical locations, and weather conditions. To reduce the potential of developing heat/cold stress, be aware of the signs and symptoms of heat/cold stress and watch fellow employees for signs of heat/cold stress. For additional requirements, refer to SH&E 124, *Heat Stress*, and SH&E 125, *Cold Stress*.

Heat stress can be a significant field site hazard, particularly for non-acclimated personnel operating in the hot, humid environments. Site personnel will be instructed in the identification of a heat stress victim, the first-aid treatment procedures for the victim and the prevention of heat stress casualties. Work-rest cycles will be determined and the appropriate measures taken to prevent heat stress as outlined in SH&E 124, *Heat Stress and Hot Weather Operations*.

4.6.5.1 Responding to Heat-Related Illness

The guidance below will be used in identifying and treating heat-related illness.

Table 4-1. Identification and Treatment of Heat-Related Illness

Type of Heat-Related Illness	Description	First Aid
Mild Heat Strain	The mildest form of heat-related illness. Victims exhibit irritability, lethargy, and significant sweating. The victim may complain of headache or nausea. This is the initial stage of overheating, and prompt action at this point may prevent more severe heat-related illness from occurring.	• Provide the victim with a work break during which he/she may relax, remove any excess protective clothing, and drink cool fluids. • If an air-conditioned spot is available, this is an ideal break location. • Once the victim shows improvement, he/she may resume working; however, the work pace should be moderated to prevent recurrence of the symptoms.
Heat Exhaustion	Usually begins with muscular weakness and cramping, dizziness, staggering gait, and nausea. The victim will have pale, clammy moist skin and may perspire profusely. The pulse is weak and fast and the victim may faint unless they lie down. The bowels may move involuntarily.	• Immediately remove the victim from the work area to a shady or cool area with good air circulation (avoid drafts or sudden chilling). • Remove all protective outerwear. • Call a physician. • Treat the victim for shock. (Make the victim lie down, raise his or her feet 6–12 inches, and keep him or her cool by loosening all clothing). • If the victim is conscious, it may be helpful to give him or her sips of water. • Transport victim to a medical facility as soon as possible.
Heat Stroke	The most serious of heat illness, heat stroke represents the collapse of the body's cooling mechanisms. As a result, body temperature may rise to 104 degrees Fahrenheit or higher. As the victim progresses toward heat stroke, symptoms such as headache, dizziness, nausea can be noted, and the skin is observed to be dry, red, and hot. Sudden collapse and loss of consciousness follows quickly and death is imminent if exposure continues. Heat stroke can occur suddenly.	• Immediately evacuate the victim to a cool and shady area. • Remove all protective outerwear and as much personal clothing as decency permits. • Lay the victim on his or her back with the feet slightly elevated. • Apply cold wet towels or ice bags to the head, armpits, and thighs. • Sponge off the bare skin with cool water or rubbing alcohol, if available. • The main objective is to cool without chilling the victim. • Give no stimulants or hot drinks. • Since heat stroke is a severe medical condition requiring professional medical attention, emergency medical help should be summoned immediately to provide onsite treatment of the victim and proper transport to a medical facility.

4.6.5.2 Solar Protection

To protect against exposure to solar radiation, workers will observe the following requirements:

1. All workers will wear sunglass-type safety glasses at all times when working outdoors during daylight hours.
2. Workers will utilize a commercial sunblock with a minimum solar protection factor (SPF) of 15.

4.6.5.3 Cold Stress

Type of Cold Stress

Cold injury is classified as either localized, as in frostbite, frostnip or chilblain; or generalized, as in hypothermia. The main factors contributing to cold injury are exposure to humidity and high winds, contact with wetness and inadequate clothing.

The likelihood of developing frostbite occurs when the face or extremities are exposed to a cold wind in addition to cold temperatures. The freezing point of the skin is about 30^{o} F. When fluids around the cells of the body tissue freeze, skin turns white. This freezing is due to exposure to extremely low temperatures. As wind velocity increases, heat loss is greater and frostbite will occur more rapidly.

Symptoms of Cold Stress

The first symptom of frostbite is usually an uncomfortable sensation of coldness, followed by numbness. There might be a tingling, stinging or aching feeling in the affected area. The most vulnerable parts of the body are the nose, cheeks, ears, fingers and toes.

Symptoms of hypothermia, a condition of abnormally low body temperature, include uncontrollable shivering and sensations of cold. The heartbeat slows and can become irregular, the pulse weakens and the blood pressure changes. Pain in the extremities and severe shivering can be the first warning of dangerous exposure to cold.

Maximum severe shivering develops when the body temperature has fallen to 95^{o} F. Productive physical and mental work is limited when severe shivering occurs. Shivering is a serious sign of danger. Immediately remove any person who is shivering from the cold.

Methods to Prevent Cold Stress

When the ambient temperature, or a wind chill equivalent, falls to below 40^{o} F (American Conference of Governmental Industrial Hygienists recommendation), site personnel who must remain outdoors should wear insulated coveralls, insulated boot liners, hard hat helmet liners and insulated hand protection. Wool mittens are more efficient insulators than gloves. Keeping the head covered is very important, since 40% of body heat can be lost when the head is exposed. If it is not necessary to wear a hard hat, a wool knit cap provides the best head protection. A facemask may also be worn.

Persons should dress in several layers rather than one single heavy outer garment. The outer piece of clothing should ideally be wind and waterproof. Clothing made of thin cotton fabric or synthetic fabrics such as polypropylene is ideal since it helps to evaporate sweat. Polypropylene is best at wicking away moisture while still retaining its insulating properties. Loosely fitting clothing also aids in sweat evaporation. Denim is not a good protective fabric. It is loosely woven which allows moisture to penetrate. Socks with high wool content are best. If two pairs of socks are worn, the inner sock should be smaller and made of cotton, polypropylene or similar types of synthetic material that wick away moisture. If clothing becomes wet, it should be taken off immediately and a dry set of clothing put on.

If wind conditions become severe, it might become necessary to shield the work area temporarily. The SSO and the PM will determine if this type of action is necessary. Heated break trailers or a designated area that is heated should be available if work is performed continuously in the cold at temperatures, or equivalent wind chill temperatures, of 20^{o} F.

Dehydration occurs in the cold environment and can increase the susceptibility of the worker to cold injury due to significant change in blood flow to the extremities. Drink plenty of fluids, but limit the intake of caffeine

Work/Rest Cycles for Cold Weather

If wind chill temperatures fall below **minus 25^o F**, breaks from the cold will occur at a rate of one every hour. If wind chill temperatures fall below **minus 45^o F,** all work will cease and persons will be required to go indoors. Also see Section 1.1.1 regarding shift duration. However, these guidelines can be modified at any time based on actual site conditions and professional judgment rendered by either the Field Manger and/or SSO. For example, the Field Manger and/or SSO will evaluate field crew fitness; the condition of their cold-weather gear, including boots; and will observe employees alertness, including fatigue and rate of cold tolerance/acclimation.

4.7 STOP WORK AUTHORITY

All employees have the right and duty to stop work when conditions are unsafe, and to assist in correcting these conditions. Whenever the SSO determines that workplace conditions present an uncontrolled risk of injury or illness to employees, immediate resolution with the appropriate supervisor shall be sought. Should the supervisor be unable or unwilling to correct the unsafe conditions, the SSO is authorized and required to stop work, which shall be immediately binding on all affected AECOM employees and subcontractors.

Upon issuing the stop work order, the SSO shall implement corrective actions so that operations may be safely resumed. Resumption of safe operations is the primary objective; however, operations shall not resume until the Safety Professional has concurred that workplace conditions meet acceptable safety standards.

4.8 CLIENT SPECIFIC SAFETY REQUIREMENTS

The client has specified no additional health and safety requirements.

5.0 HAZARD ASSESSMENT

5.1 TASK HAZARD ANALYSIS

Task hazard analysis (THA) is a technique used to identify hazards and hazard controls associated with a specific job function. THAs focus on the relationship between the workers, the task, the resources required to complete the task, and the work environment. These variables must be evaluated to identify the potential hazards associated with the task. Once identified, steps can be taken to eliminate, reduce, or control the hazards to an acceptable risk level.

Section 2.2 describes the work activities anticipated to be performed during this project. Individual THAs for the tasks associated with this work can be found in Attachment A.

5.1.1 Unanticipated Work Activities/Conditions

Operations at the site may require additional tasks not identified in Section 2.2 or addressed in Attachment A THAs. Before performing any task not covered in this HASP a THA must be prepared, and approved by the Safety Professional.

5.2 ENVIRONMENTAL CONTAMINANT EXPOSURE HAZARDS

The following is a discussion of the hazards presented to worker personnel during this project from on-site chemical and radiological hazards known or suspected to be present on site. Hazards associated with chemical products brought to the site during work operations are addressed separately, under the Hazard Communication process described in Section 4.3.

Exposure symptoms and applicable first aid information for each suspected site contaminant listed in Section 2 are located in the following subsections.

5.2.1 VOCs

The widespread use of organic solvent compounds for a variety of cleaning and surface treating industrial applications has occurred for many decades. During that time, usage patterns have changed a better compounds have been identified. Costs have changed and/or knowledge concerning the hazards associated with particular solvents has prompted replacement with less hazardous alternatives. Therefore, while it is known that solvents have been employed at some of the POIs, there is no means for identifying, which solvents may be present as environmental contaminants. In addition, many types of solvents, especially chlorinated compounds, break down in the environment into several intermediate solvent compounds (e.g., TCE can form several isomers of dichloroethylene).

<u>Trichloroethylene (TCE)</u>

Moderate exposures to TCE cause symptoms similar to those of alcohol inebriation. Higher concentrations cause narcotic effects. Ventricular fibrillation has been cited as the cause of death following heavy exposures. TCE-induced hepatocellular carcinomas have been detected in mice during tests conducted by the National Cancer Institute. Organ systems affected by overexposure to TCE are the CNS (euphoria, analgesia, anesthesia), degeneration of the liver and kidneys, the lungs (tachypnea), heart (arrhythmia) and skin (irritation, vesication, and paralysis of fingers when immersed in liquid TCE). Contact with the liquid effects the skin, causing topical dermatitis. Certain people appear to experience synergistic effects from TCE exposure concomitant with exposure to caffeine, alcohol, and other drugs. Other reported symptoms of TCE exposure include abnormal fatigue, headache, irritability, gastric disturbances, and intolerance to alcohol. The OSHA PEL is 100 ppm while the ACGIH TLV is 50 ppm. The ACGIH STEL is 100 ppm.

Dichloroethylenes (DCE) (1,1-DCE & 1,2-DCE)

1,2-Dichloroethylene is listed as a possible carcinogen, hazardous substance, hazardous waste, and priority toxic pollutant by the U.S. EPA, while 1,1-DCE has not been classified. DCE is used as a chemical intermediate, particularly as a monomer in the production of plastics, but is more likely to be encountered as an environmental contaminant as a result of the environmental breakdown of other chlorinated compounds (especially TCE).

DCE has a characteristic sweet smell that resembles carbon tetrachloride or chloroform. Most persons can detect a mild but definite odor at 1,000 ppm in air. Some can detect it at 500 ppm. Vapors containing decomposition products have a disagreeable odor and can be detected at concentrations considerably less than 500 ppm. Exposure to high concentrations results primarily in CNS depression and the associated symptoms of drunkenness that may progress to unconsciousness. Chronic exposure to low concentrations results primarily in injury to the liver and kidneys.

The ACGIH TLV for 1,1-DCE is 5 ppm, while the TLV for 1,2-DCE is 200 ppm. Where airborne concentrations of DCE exceed 5 ppm, exposure control can be accomplished through the use of air purifying respirators equipped with organic vapor cartridges. The use of skin protection (chemically-protective gloves, etc.) is required when handling 1,1-DCE-contaminated materials.

Tetrachloroethylene (Perchloroethylene – PCE). PCE affects the central nervous system, causing a lack of coordination, headache, vertigo (loss of balance), light narcosis, dizziness, and unconsciousness. In extremely high concentrations death may occur. Various types of irritable effects have been attributed to PCE exposure. Some of the symptoms involved include: eye, nose, and throat irritation, indications of nausea and intestinal gas, and possible changes to both the liver and the kidneys. Skin exposure to PCE has not been seen to produce harmful effects in cases where the PCE was allowed to evaporate immediately after contact. However, in cases where skin was exposed to PCE frequently and for prolonged periods of time without evaporating, symptoms of dermatitis by defatting of the skin was evident. PCE is listed as an anticipated human carcinogen by the NTP. The OSHA PEL and the ACGIH TLV are 25 ppm with an ACGIH STEL of 100.

Vinyl Chloride - Vinyl chloride is a colorless gas, which exhibits a high odor threshold (20 ppm). It is often used as a chemical intermediate in the production of certain types of plastics. It is also found as an environmental contaminant at sites contaminated by more complex chlorinated compounds, where it is a produced as the result of natural degradation. As a gas the primary route of exposure to vinyl chloride is via inhalation. As with many other types of chlorinated and other organic compounds, high airborne concentrations of vinyl chloride have been demonstrated to depress CNS function. Lower-level chronic exposure can produce effects to the liver, and vinyl chloride has been shown to produce liver cancer. This carcinogenic effect is of the greatest importance in the establishment of occupational exposure limits.

Both the OSHA PEL and ACGIH TLV for vinyl chloride are 1 ppm as an 8-hour time weight average. And since vinyl chloride's odor threshold greatly exceeds this limit the use of supplied-air respiratory protection is required to control exposures.

5.2.2 Assessment of Exposure Hazards

Inhalation – Due to the type of drilling being done (hollow stem auger drilling) there is a higher chance of inhaling contaminants. Using this method of drilling, the spoils of the drilling operation have to be physically handled and moved from the hole, into drums to be containerized. During the moving of contaminated soil the highest chance of inhalation will occur.

Skin Contact – Using this method of soil removal there is also a chance of absorption of the contaminants through the skin. During the moving of contaminated soil from the hole to the drums all employees need to be wearing the appropriate PPE to keep any areas that could come in contact with the soil covered, this includes Nitrile gloves.

Ingestion – There is little to no chance of an ingestion hazard. All personnel are required to follow the personal hygiene section of this HASP and must leave the exclusion zone and wash hands before they eat or drink.

5.3 PHYSICAL HAZARDS

5.3.1 Manual Lifting

Most materials associated with investigation and remedial activities are moved by hand. The human body is subject to severe damage in the forms of back injury, muscle strains, and hernia if caution is not observed in the handling process. Whenever possible, use at least two people to lift, or roll/lift with your arms as close to the body as possible. Under no circumstances should any one person lift more than 49 pounds unassisted.

5.3.2 Slips, Trips, Falls, and Protruding Objects

Hazards from protruding objects, careless movements, or placement of materials on paths or foot traffic areas present a problem with regard to slips, trips, and falls. Injuries typically resulting from such activities may involve cuts, scrapes, bruises, and/or puncture wounds. Personnel will use a reasonable amount of effort to ensure the prevention of such injuries.

5.4 BIOLOGICAL HAZARDS

Contact with animals, insects, and plants can cause injury and illness to personnel. Care must be taken to ensure that these types of injuries are avoided. Some examples of biological hazards include:

- Wild animals, such as snakes, raccoons, squirrels, and rats. These animals not only can bite and scratch, but can carry transmittable diseases (e.g., rabies). Avoid the animals whenever possible. If bitten, go to the nearest medical facility.
- Insects such as mosquitoes, ticks, bees, and wasps. Mosquitoes can potentially carry and transmit the West Nile Virus. Ticks can transmit Lyme disease or Rocky Mountain Spotted Fever. Bees and wasps can sting by injecting venom, which causes some individuals to experience anaphylactic shock (extreme allergic reaction). Whenever you will enter areas that provide a habitat for insects (e.g., grass areas, woods), wear light-colored clothing, long pants and shirt, and spray exposed skin areas with a DEET-containing repellent. Keep away from high grass wherever possible. Keep your eyes and ears open for bee and wasp nests. If bitten by insects, see a doctor if there is any question of an allergic reaction.
- Plants such as poison ivy and poison oak can cause severe rashes on exposed skin. Be careful where you walk, wear long pants, and minimize touching exposed skin with your hands after walking through thickly vegetated areas until after you have thoroughly washed your hands with soap and water.

5.5 RADIOLOGICAL HAZARDS

There are no anticipated Radiological Hazards on this site.

5.6 OTHER HAZARDS

There are no other anticipated hazards on this site.

6.0 ACTIVITY SPECIFIC REQUIREMENTS

6.1 SUPPLEMENTAL SAFETY PROCEDURES

As discussed in Section 5.0, personnel may be exposed to a variety of chemical, physical, radiological and biological hazards. The requirements for the control of many of these hazards these hazards is discussed in Standard Operating Procedures found in the 500 Series of the SH&E Manual.

Specific procedures applicable to this project include:

- SH&E 505, *Powered Hand Tools*
- SH&E 506, *Manual Hand Tools*
- SH&E 510, *High Pressure Washers*
- SH&E 513, *Heavy Equipment*
- SH&E 517, *Traffic Safety*

6.2 EXPOSURE MONITORING PROCEDURES

Monitoring procedures will be employed during site characterization activities to assess employee exposure to chemical and physical hazards. Monitoring will consist primarily of onsite determination of various parameters (e.g., airborne contaminant concentrations and heat stress effects), but may be supplemented by more sophisticated monitoring techniques, if necessary.

6.2.1 Real-Time Exposure Measurement

Monitoring shall be performed within the work area on site in order to detect the presence and relative levels of toxic substances. The data collected throughout monitoring shall be used to determine the appropriate levels of PPE. Monitoring shall be conducted as specified in each THA (Attachment A) as work is performed.

Table 6-1specifies the real-time monitoring equipment which will be used for this project.

Table 6-1. Monitoring Parameters and Equipment

INSTRUMENT	MANUFACTURER/MODEL	SUBSTANCES DETECTED
Photo Ionization Detector (PID)	RAE Systems multi-RAE	Petroleum hydrocarbons Volatile Organic Compounds
Colorimetric Detector Tubes	Draeger Tubes	Benzene 0.5–10 ppm Vinyl Chloride > 0.5 ppm

6.2.1.1 Health and Safety Action Levels

An action level is a point at which increased protection is required due to the concentration of contaminants in the work area or other environmental conditions. The concentration level (above background level) and the ability of the PPE to protect against that specific contaminant determine each action level. The action levels are based on concentrations in the breathing zone.

If ambient levels are measured which exceed the action levels in areas accessible to unprotected personnel, necessary control measures (barricades, warning signs, and mitigative actions, etc.) must be implemented prior to commencing activities at the specific work area.

Personnel should also be able to upgrade or downgrade their level of protection with the concurrence of SSO or the Safety Professional.

Reasons to upgrade:

- Known or suspected presence of dermal hazards.
- Occurrence or likely occurrence of gas, vapor, or dust emission.
- Change in work task that will increase the exposure or potential exposure to hazardous materials.

Reasons to downgrade:

- New information indicating that the situation is less hazardous than was originally suspected.
- Change in site conditions that decrease the potential hazard.
- Change in work task that will reduce exposure to hazardous materials.

6.2.1.2 Monitoring Procedures

PARAMETER	MONITORING INTERVAL	RESPONSE LEVEL (above background)	RESPONSE
VOC's (Total by PID, see "RESPONSE" for chemical-specific monitoring using detector tubes when meter units are 1-5)	Prior to initial entry in to impacted areas and then at least every 30 minutes afterwards in the worker's breathing zone or in the immediate work area. Confined spaces will require initial and continuous monitoring.	1 - 10 ppm	Continue to work in Level D and continue monitoring.
		10 - 50 ppm	Monitor for Vinyl Chloride using Drager Tubes. If Vinyl Chloride is not present, continue to work in Level D and continue monitoring.
		50 - 200 ppm (Sustained for 5 minutes)	Contact the SSO. Monitor for Vinyl Chloride using Drager Tubes If Vinyl Chloride is not present, implement mitigation measures and upgrade PPE to Level C (respirator with organic vapor cartridge) if concentrations persist for more than 5 minutes.
		> 200 ppm	Contact the SSO.
Vinyl Chloride	Using Dragger Tubes on an as needed bases in accordance with PID readings for VOCs	0 – 0.5 mg/m^3	Continue work in Modified Level D and continue monitoring.
		>0.5 mg/m^3 (Sustained for 5 minutes)	Stop Work Activities. Contact the SSO. Project management and the Health and Safety Coordinator to determine alternative work approach to reduce concentrations or shut down until concentrations decrease to below response level.

6.2.1.3 Monitoring Equipment Calibration

All instruments used will be calibrated at the beginning and end of each work shift, in accordance with the manufacturer's recommendations. If the owner's manual is not available, the personnel operating the equipment will contact the applicable office representative, rental agency or manufacturer for technical guidance for proper calibration. If equipment cannot be pre-calibrated to specifications, site operations requiring monitoring for worker exposure or off-site migration of contaminants will be postponed or temporarily ceased until this requirement is completed.

6.2.1.4 Personal Sampling

Should site activities warrant performing personal sampling to better assess chemical exposures experienced by AECOM employees, the SSO, under the direction of a Certified Industrial Hygienist (CIH), will be responsible for specifying the monitoring required. Within five working days after the receipt of monitoring results, the CIH will notify each employee, in writing, of the results that represent that employee's exposure. Copies of air sampling results will be maintained in the project files.

Should the site activities warrant, the subcontractor will ensure its employees' exposures are quantified via the use of appropriate sampling techniques. The subcontractor shall notify the employees sampled in accordance with health and safety regulations, and provide the results to the SSO for use in determining the potential for other employees' exposure.

6.2.2 Noise Exposure Monitoring

When heavy equipment is in operation, it will be necessary to ensure that each exclusion zone fully encompasses all areas where hazardous noise levels are present (85dBA or greater). Once each work day, the SSO will use a sound level meter to survey the perimeter of each exclusion zone, while all onsite heavy equipment within the zone is being operated simultaneously. If the sound pressure level exceeds 85 dBA at any location along the site perimeter, the SSO will exit the exclusion zone and use the meter to determine the 85 dBA limit. The exclusion zone boundary will then be adjusted to fully encompass this region.

7.0 PERSONAL PROTECTIVE EQUIPMENT

7.1 PERSONAL PROTECTIVE EQUIPMENT

The purpose of personal protective equipment (PPE) is to provide a barrier, which will shield or isolate individuals from the chemical and/or physical hazards that may be encountered during work activities. SH&E 113, *Personal Protective Equipment*, lists the general requirements for selection and usage of PPE. Table 7-1 lists the minimum PPE required during site operations and additional PPE that may be necessary. The specific PPE requirements for each work task are specified in the individual THAs found in Attachment A.

By signing this HASP you are agreeing that you have been properly trained in the use, limitations, care and maintenance of the protective equipment you will use at this project. If you have not received training on the proper use, care, and limitations of the PPE required for this project, please see the PM/SSO for the proper training prior to signing this HASP.

Table 7-1. Personal Protective Equipment

TYPE	MATERIAL	ADDITIONAL INFORMATION
Minimum PPE:		
Safety Vest	High-visibility	Must have reflective tape and be visible from all sides
Boots	Leather	ANSI approved safety toe
Safety Glasses		ANSI Approved
Hard Hat		ANSI Approved
Work Uniform		No shorts/cutoff jeans or sleeveless shirts
Additional PPE:		
Hearing Protection	Ear plugs and/ or muffs	In hazardous noise areas
Leather Gloves		If working with sharp objects or powered equipment.
Protective Chemical Gloves	Nitrile or equivalent	
Level C Respiratory Protection	MSA (Full Face or equivalent) equipped with Organic Vapor cartridges	
Faceshield		For welding /cutting/ hot work operations
Apron		For welding /cutting/ hot work operations
Welding Equipment		For cutting into the steel well cases

7.2 DECONTAMINATION

All requirements for performing personal and equipment decontamination may be found in AECOM Environmental Practice Standard SH&E 604, *Decontamination*.

7.3 PPE DOFFING AND DONNING INFORMATION

The following information is to provide field personnel with helpful hints that, when applied, make donning and doffing of PPE a more safe and manageable task:

- Never cut disposable booties from your feet with basic utility knives. This has resulted in workers cutting through the booty and the underlying sturdy leather work boot, resulting in significant cuts to the legs/ankles. Recommend using a pair of scissors or a package/letter opener (cut above and parallel with the work boot) to start a cut in the edge of the booty, then proceed by manually tearing the material down to the sole of the booty for easy removal.
- When applying duct tape to PPE interfaces (wrist, lower leg, around respirator, etc.) and zippers, leave approximately one inch at the end of the tape to fold over onto itself. This will make it much easier to remove the tape by providing a small handle to grab while still wearing gloves. Without this fold, trying to pull up the tape end with multiple gloves on may be difficult and result in premature tearing of the PPE.
- Have a “buddy” check your ensemble to ensure proper donning before entering controlled work areas. Without mirrors, the most obvious discrepancies can go unnoticed and may result in a potential exposure situation.
- Never perform personal decontamination with a pressure washer.

8.0 SITE CONTROL

8.1 GENERAL

The purpose of site control is to minimize potential contamination of workers, protect the public from site hazards, and prevent vandalism. The degree of site control necessary depends on the site characteristics, site size, and the surrounding community.

Controlled work areas will be established at each work location, and if required, will be established directly prior to the work being conducted. Diagrams designating specific controlled work areas will be drawn on site maps, posted in the support vehicle or trailer and discussed during the daily safety meetings. If the site layout changes, the new areas and their potential hazards will be discussed immediately after the changes are made. General examples of zone layouts have been developed for drilling and earth moving activities [(e.g., excavating, trenching, etc.) and are attached to this section.

8.2 CONTROLLED WORK AREAS

Each HAZWOPER controlled work area will consist of the following three zones:

- Exclusion Zone: Contaminated work area.
- Contamination Reduction Zone (CRZ): Decontamination area.
- Support Zone: Uncontaminated or "clean area" where personnel should not be exposed to hazardous conditions.

Each zone will be periodically monitored in accordance with the air monitoring requirements established in this HASP. The Exclusion Zone and the Contamination Reduction Zone are considered work areas. The Support Zone is accessible to the public (e.g., vendors, inspectors).

8.2.1 Exclusion Zone

The Exclusion Zone is the area where primary activities occur, such as sampling, remediation operations, installation of wells, cleanup work, etc. This area must be clearly marked with hazard tape, barricades or cones, or enclosed by fences or ropes. Only personnel involved in work activities, and meeting the requirements specified in the applicable THA and Sections 4.1 and 4.2, will be allowed in an Exclusion Zone.

The extent of each area will be sufficient to ensure that personnel located at/beyond its boundaries will not be affected in any substantial way by hazards associated with sample collection activities. To meet this requirement, the following minimum distances will be used:

- **HSA Drilling**. Determine the mast height of the drill rig. This height will be cleared, if practical, in all directions from the bore-hole location and designated as the exclusion zone. The cleared area will be sufficient to accommodate movement of necessary equipment and the stockpiling of spoils piles.

All personnel should be alert to prevent unauthorized, accidental entrance into controlled-access areas (the Exclusion Zone and CRZ). If such an entry should occur, the trespasser should be immediately escorted outside the area, or all HAZWOPER-related work must cease. All personnel, equipment, and supplies that enter controlled-access areas must be decontaminated or containerized as waste prior to leaving (through the CRZ only).

8.2.2 Contamination Reduction Zone

The CRZ is the transition area between the contaminated area and the clean area. Decontamination is the main focus in this area. The decontamination of workers and equipment limits the physical transfer of hazardous substances into the clean area. This area must also be clearly marked with hazard tape and access limited to personnel involved in decontamination. Decontamination procedures are further explained in SH&E 604.

8.2.3 Support Zone

The Support Zone is an uncontaminated zone where administrative and other support functions, such as first aid, equipment supply, emergency information, etc., are located. The Support Zone shall have minimal potential for significant exposure to contaminants (i.e., background levels).

Employees will establish a Support Zone (if necessary) at the site before the commencement of site activities. The Support Zone would also serve as the entry point for controlling site access.

8.3 SITE ACCESS DOCUMENTATION

If implemented by the PM, all personnel entering the site shall complete the "Site Entry/Exit Log" located at the site trailer or primary site support vehicle.

8.3.1 Visitor Access

Visitors to any HAZWOPER controlled-work area must comply with the health and safety requirements of this HASP, and demonstrate an acceptable need for entry into the work area. All visitors desiring to enter any controlled work area must observe the following procedures:

1. A written confirmation must be received by AECOM documenting that each of the visitors has received the proper training and medical monitoring required by this HASP. Verbal confirmation can be considered acceptable provided such confirmation is made by an officer or other authorized representative of the visitor's organization.
2. Each visitor will be briefed on the hazards associated with the site activities being performed and acknowledge receipt of this briefing by signing the appropriate tailgate safety briefing form.
3. All visitors must be escorted by an AECOM employee.

If the site visitor requires entry to any Exclusion Zone, but does not comply with the above requirements, all work activities within the Exclusion Zone must be suspended. Until these requirements have been met, entry will not be permitted.

8.4 SITE SECURITY

Site security is necessary to:

- Prevent the exposure of unauthorized, unprotected people to site hazards.
- Avoid the increased hazards from vandals or persons seeking to abandon other wastes on the site.
- Prevent theft.
- Avoid interference with safe working procedures.

To maintain site security during working hours:

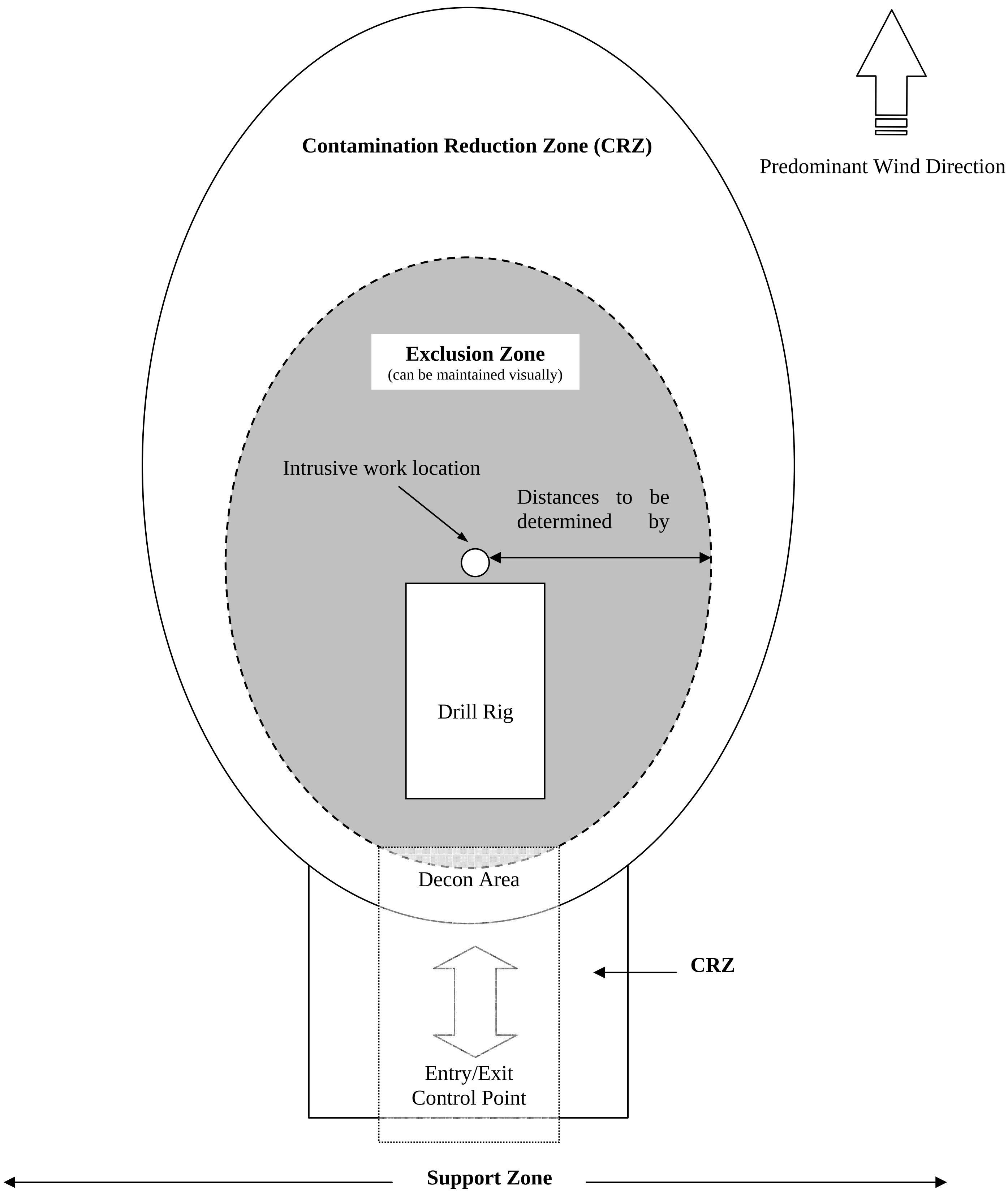
1. Maintain security in the Support Zone and at access control points.
2. Establish an identification system to identify authorized persons and limitations to their approved activities.
3. Assign responsibility for enforcing authority for entry and exit requirements.
4. When feasible, install fencing or other physical barrier around the site.

5. If the site is not fenced, post signs around the perimeter and whenever possible, use guards to patrol the perimeter. Guards must be fully apprised of the hazards involved and trained in emergency procedures.
6. Have the PM approve all visitors to the site. Make sure they have valid purpose for entering the site. Have trained site personnel accompany visitors at all times and provide them with the appropriate protective equipment.

To maintain site security during off-duty hours:

1. If possible, assign trained, in-house technicians for site surveillance. They will be familiar with the site, the nature of the work, the site's hazards, and respiratory protection techniques.
2. If necessary, use security guards to patrol the site boundary. Such personnel may be less expensive than trained technicians, but will be more difficult to train in safety procedures and will be less confident in reacting to problems around hazardous substances.
3. Enlist public enforcement agencies, such as the local police department, if the site presents a significant risk to local health and safety.
4. Secure the equipment.

Figure 8-1. Drilling Site Control Layout



9.0 EMERGENCY RESPONSE PLANNING

9.1 EMERGENCY ACTION PLAN

Although the potential for an emergency to occur is remote, an emergency action plan has been prepared for this project should such critical situations arise. The only significant type of onsite emergency that may occur is physical injury or illness to a member of the AECOM team. The emergency action plan will be reviewed by all personnel prior to the start of field activities.

Three major categories of emergencies could occur during site operations:

1. Illnesses and physical injuries (including injury-causing chemical exposure)
2. Catastrophic events (fire, explosion, earthquake, or chemical)
3. Safety equipment problems

9.1.1 Emergency Response Coordinator

Prior to beginning site activities, the PM will complete Table 9-1 by filling in the names of the Emergency Coordinator (EC) and the alternate EC. The duties of the EC and the alternate EC have been specified in SH&E 102.

9.1.2 Site-Specific Emergency Procedures

Prior to the start of site operations, the EC shall fill in the following with any site-specific information regarding evacuations, muster points, communication, and other site-specific emergency procedures:

Table 9-1. Emergency Planning

Emergency	Evacuation Route	Muster Location
Chemical Spill	• Upwind	• TBD onsite
Fire/Explosion	• TBD onsite	• TBD onsite
Lightning	• TBD onsite	• Vehicle
Additional Information		
Communication Procedures	All personnel will be in hearing range or have 2 way radio or cell phone access	
CPR/First Aid Trained Personnel	•	

9.1.3 Spill Containment Procedure

Work activities may involve the use of hazardous materials (i.e. fuels, solvents) or work involving drums or other containers. The following procedures will be used to prevent or contain spills:

- All hazardous material will be stored in appropriate containers
- Tops/lids will be placed back on containers after use.
- Containers of hazardous materials will be stored appropriately away from moving equipment.

At least one spill response kit, to include an appropriate empty container, materials to allow for booming or diking the area to minimize the size of the spill, and appropriate clean-up material (i.e. speedy dri) shall be available at each work site (more as needed).

- All hazardous commodities in use (i.e. fuels) shall be properly labeled.
- Containers shall only be lifted using equipment specifically manufactured for that purpose.
- For drums/containers, follow the procedures in SH&E 405, *Handling of Drums and Large Containers*, to minimize spillage.

9.1.4 Site-Specific Emergency Procedures

Prior to the start of site operations, the EC shall fill in the following with any site-specific information regarding evacuations, muster points, spill response, communication, and other site-specific emergency procedures.

9.1.5 Accident/Incident Reporting

All accidents and incidents that occur on-site during any field activity will be promptly reported to the SSO and the FM in accordance with AECOM Safety Procedure SH&E 101, *Injury, Illness, and Near-Miss Reporting*.

If any AECOM employee is injured and requires medical treatment, the FM will contact AECOM's **Incident Reporting Line at (800) 348-5046 immediately**. The FM will initiate a written report, using the ***Supervisor's Report of Incident*** form (see SH&E 101). The FM will complete the first two sections of this form and forward to the CTO Manager for completion of Section 3. The report will then be provided to the H&SP before the end of the following shift.

If any employee of a subcontractor is injured, documentation of the incident will be accomplished in accordance with the subcontractor's procedures; however, copies of all documentation (which at a minimum must include the OSHA Form 301 or equivalent) must be provided to the SSO within 24 hours after the accident has occurred.

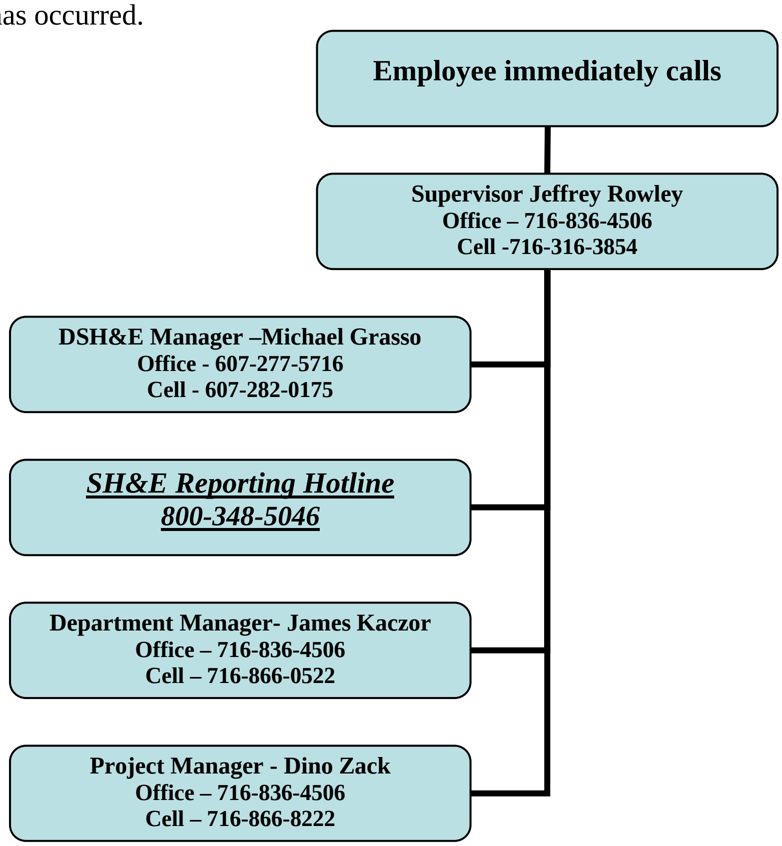


Table 9-2. Emergency Contacts

Emergency Coordinators / Key Personnel			
Name	**Title/Workstation**	**Telephone Number**	**Cellular Phone**
John Perkins	Client Contact	861-912-6197	561-289-1493
Dino Zack	Project Manager	716-836-4506	716-866-8222
Emily Laity	Site Safety Officer	716-836-4506	716-531-2889
Michael Grasso	District Safety Manager	607-277-5716	607-282-0175
Phil Platcow	NE Regional SH&E Manager	617-371-4461	617-899-5403
Incident Reporting	Corporate Safety Administrator	800-348-5046	

Organization / Agency	
Name	**Telephone Number**
Police Department	911 or 716-683-3100
Fire Department	911 or 716-891-2400
State Police	911
Ambulance Service ***(EMT will determine appropriate hospital for treatment)***	911 or 716-891-2400
Hospital ***(Use by site personnel is only for non-emergency cases) Saint Joseph's Hospital***	716-891-2400
Address: 2605 Harlem Street	
Buffalo, NY	
Hospital Route: (Hospital Route Maps on following page)	
Poison Control Center	800-222-1222
Pollution Emergency	800-292-4706
National Response Center	800-424-8802
Chem-Trec	800-424-9300
Title 3 Hotline	800-535-0202

Public Utilities	
Name	**Telephone Number**
Dig Safely New York	800-962-7962

Figure 9-1. Clinic/Hospital Route/Detail Map

OCCUPATIONAL CARE CLINIC

Once the injury has been reported, seek treatment at the identified occupational care clinic for non-critical injuries; i.e. injuries of the First Aid variety.

Western New York Immediate Care
7616 Transit Rd
Buffalo, NY 14221-6017

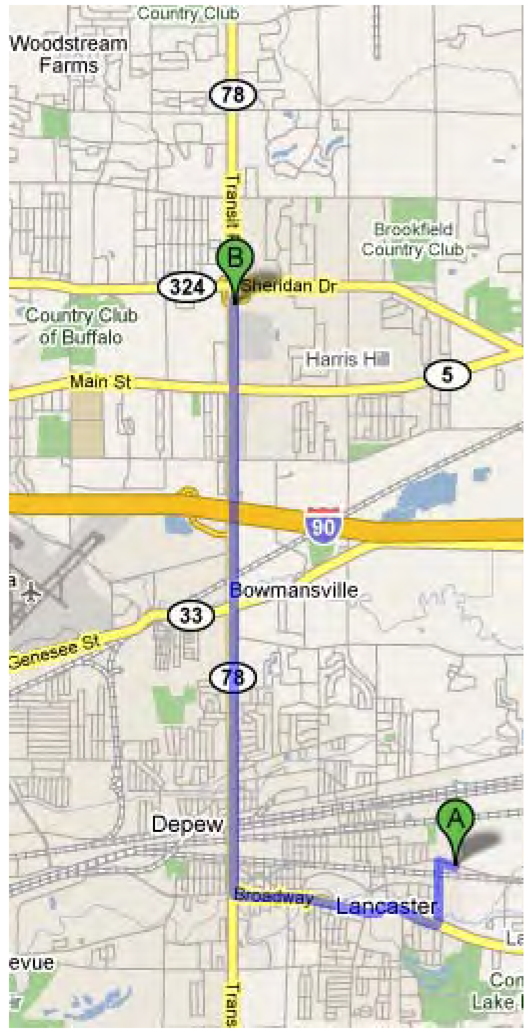
716.204.2273

Driving distance is approximately 7.8 miles; driving time is approximately 18 minutes

Start: 225 Erie St
Lancaster, NY

1. Head **west** on **Erie St** toward **Court St**	0.1 mi
2. Take the 1st **left** onto **Court St**	0.6 mi
3. Take the 3rd **right** onto **Broadway St/US-20**	1.8 mi
4. Turn **right** at **NY-78/Transit Rd**	5.2 mi
5. Sharp **left** to stay on **NY-78/Transit Rd**	381 ft

End: 7616 Transit Rd
Buffalo, NY 14221-6017



Hospital

1. Start at **225 ERIE ST, LANCASTER** going toward **WEST COURT ST** - go **0.7** mi

2. Turn **RIGHT** on **CENTRAL AVE(CR-57)** - go **0.7** mi

3. Turn **LEFT** on **WALDEN AVE** - go **5.8** mi

4. Turn **RIGHT** on **HARLEM RD(RT-240)** - go **0.5** mi

5. Arrive at **2605 HARLEM RD, BUFFALO,** on the **RIGHT**

Route Details:


HARRIS
MEADOWLAWN RD
CLAUDETTE
SANTIN
NADINE
EVANE
ENEZ
GEORGE URBAN
JOSEPH
Dick-Urban Plaza Shopping Center
BARNABAS
GILLN
CHERYL LN
DONNA
BONITA
MIDDLES
ALAGRAW
GEORGE URBAN
HARVARD
BOSTWICK
WALDEN
BUCHANAN
ZOERB
GOERING
ELLICOTT
SCHLENKER
ELLICOTT RD
OLD BROADWAY
INDIAN RD
GOULD
CHATEAU
CAYUGA
14043
ZURBRICK RD
JEFFERSO
ANDERSON
MONROE
COMO PARK
COMO PARK
LETREE
BENNETT RD
2ND
1ST
DEER TRL
OLD FARM
GARFIELD
ELY RD
FAWN
Bellevue
Stiglmeier Park
CRABAPPLE LN
CYPRESS RD
14227
STRASMER RD
JOEL
FILLMORE
PIERCE
JOHNSON
HAYES
HARDING
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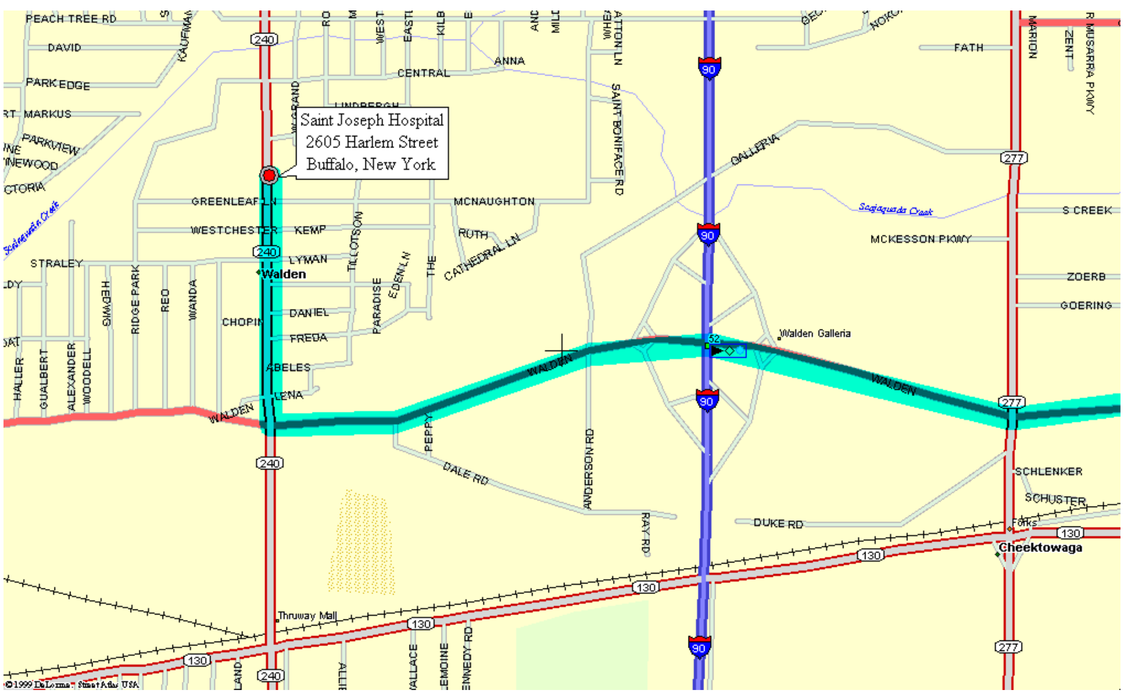
PEACH TREE RD
DAVID
PARKEDGE
MARKUS
CENTRAL
ANNA
FATH
Saint Joseph Hospital
2605 Harlem Street
Buffalo, New York
GREENLEAF LN
MCNAUGHTON
WESTCHESTER
KEMP
RUTH
LYMAN
Walden
CATHEDRAL LN
GALLERIA
MCKESSON PKWY
S CREEK
ZOERB
GOERING
DANIEL
FREDA
ABELES
LENA
WALDEN
WALDEN
WALDEN
Walden Galleria
DALE RD
SCHLENKER
SCHUSTER
DUKE RD
Cheektowaga
Thruway Mall
©1999 DeLorme, Street Atlas USA

10.0 PERSONNEL ACKNOWLEDGEMENT

By signing below, the undersigned acknowledges that he/she has read and reviewed the AECOM Health and Safety Plan for the Former Scott Aviation Facility Area 1. The undersigned also acknowledges that he/she has been instructed in the contents of this document and understands the information pertaining to the specified work, and will comply with the provisions contained therein.

PRINT NAME	SIGNATURE	ORGANIZATION	DATE

ATTACHMENT A

TASK HAZARD ANALYSES

ADMINISTRATIVE INFORMATION

Job/Task Name: Monitoring Well Development	
Project Name: Former Scott Aviation Facility – Area 1	Project Location: Lancaster, New York
Project Manager: Dino Zack	Analysis performed by: Dino Zack
Date Job/Task to be performed: November 2010	Type of Job/Task: ☒ One time ☐ Routine job/task
Responsible Organization: AECOM Technical Services, Inc.	Job Supervisor: Jeffrey Rowley

JOB EVENT SEQUENCE

LIST ONE STEP OF THE JOB FOR EACH LINE. (*ATTACH ADDITIONAL JOB EVENT SEQUENCE FORM(S) AS NECESSARY*) PAGE 1 OF 1

1. Inspect well locations for trip/slip/fall/protruding objects	6. Sound well for depth
2. Verify equipment has no safety issues	7. Install groundwater pump into well
3. Don PPE as needed	8. Purge and surge well while monitoring groundwater parameters
4. Check well with PID upon opening j-plug	9. Dispose of PPE and purge water per FOSP
5. Record water level	10. Decontaminate equipment as needed.

CHEMICAL HAZARDS

- ☐ Asbestos
- ☐ Acids
- ☐ Caustics
- ☒ Chlorinated hydrocarbons (TCE)
- ☐ Lead
- ☐ Gasoline or diesel fuel
- ☐ BTEX
- ☐ Jet fuel (JP-4, JP-5, JP-8)
- ☐ PCBs
- ☐ Cadmium
- ☐ Compressed gases/asphyxiants
- ☐ PAHs
- ☐ Welding fumes
- ☐ Hydrogen sulfide
- ☐ Other metals
- ☐ Bunker fuel/oil
- ☐ Explosives (TNT)
- ☐ Dust
- ☐ Dioxins
- ☐ Pesticides/Herbicides
- ☐ MTBE
- ☐ Methylene chloride
- ☐ Waste oil
- ☐ Hydraulic fluid
- ☐ Petroleum hydrocarbons

PHYSICAL HAZARDS

- ☐ Electricity/High voltage
- ☐ Elevated work areas (fall hazard)
- ☐ Manual materials handling/Back
- ☐ OE/UXO
- ☒ Hand tool usage
- ☐ Power tool usage
- ☐ Heavy equipment operations
- ☐ Drill rig (HSA, DP, Air Rotary)
- ☐ Excavations (engulfment/collapse)
- ☐ Confined space entry
- ☐ Ionizing radiation
- ☒ Eye hazards (impact, light, etc.)
- ☒ Slips, trips, and falls
- ☐ Hazardous noise
- ☒ Heat or cold stress
- ☐ Oxygen-deficient atmosphere
- ☐ Oxygen-enriched atmosphere
- ☐ Explosive atmosphere
- ☐ Powder-actuated tools
- ☐ Vehicular traffic

Other Chemical/Physical Hazards (*List*): Biological hazards (poisonous plants, insects).

PERSONAL PROTECTIVE EQUIPMENT (PPE) REQUIRED

Boots:
- ☐ Rubber (safety-toe)
- ☒ Leather (safety-toe)

General:
- ☐ Coveralls ____________(*type*)
- ☐ Hearing protection (plugs/muffs)
- ☐ FF APR ___(*cartridges*) if needed
- ☐ ½-face APR ______(*cartridges*)
- ☐ Safety harness & lanyard
- ☐ ANSI-approved Hard hat

Eye Protection:
- ☐ Faceshield
- ☒ Safety glasses or goggles
- ☐ Welder's helmet/goggles

Gloves:
- ☒ Chemically-protective
  N-Dex nitrile rubber (*type*)
- ☐ Leather/cloth
- ☐ Welder's
- ☐ Electrical safety _______(*volts*)

Other (*List*):

OTHER SAFETY EQUIPMENT/CONSIDERATIONS

- ☒ Fire ext. 1A:10B:C (*rating*)
- ☒ First-aid kit
- ☐ Dust control/mitigation
- ☒ Portable eyewash
- ☐ Fire watch
- ☒ Traffic control measures

Other (*List*): Traffic control measures req'd if working in/adjacent to traffic

INSPECT/PERMIT REQUIREMENTS	EQUIPMENT TO BE USED
	Water level probe
	Generator
	PID
	Groundwater purging and monitoring equipment

APPLICABLE SOPs (SEE HASP/SSHP/APP)

SH&E 124, SH&E 201, SH&E 301, SH&E 505, SH&E 605

TRAINING REQUIREMENTS

40 hr Hazwoper

ADMINISTRATIVE INFORMATION	
Job/Task Name: Monitoring Well Development	
Project Name: Former Scott Aviation Facility – Area 1	Project Location: Lancaster, New York
Project Manager: Dino Zack	Analysis performed by: Dino Zack
Date Job/Task to be performed: November 2010	Type of Job/Task: ☒ One time ☐ Routine job/task
Responsible Organization: AECOM Technical Services, Inc.	Job Supervisor: Jeffrey Rowley

JOB EVENT SEQUENCE (CONT'D) LIST ONE STEP OF THE JOB FOR EACH LINE. PAGE ____ OF ____
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MONITORING PROCEDURES

ADMINISTRATIVE INFORMATION	
Job/Task Name: Monitoring Well Development	
Project Name: Former Scott Aviation Facility – Area 1	Project Location: Lancaster, New York
Project Manager: Dino Zack	Analysis performed by: Dino Zack
Date Job/Task to be performed: November 2010	Type of Job/Task: ☒ One time ☐ Routine job/task
Responsible Organization: AECOM Technical Services, Inc.	Job Supervisor: Jeffrey Rowley

I HAVE READ OR BEEN BRIEFED ON THE HAZARDS AND PROTECTIVE MEASURES IDENTIFIED FOR THE ABOVE-LISTED JOB/TASK AND FULLY UNDERSTAND THE JOB/TASK-SPECIFIC REQUIREMENTS THAT HAVE BEEN ESTABLISHED FOR IT.

DATE	EMPLOYEE NAME	EMPLOYEE SIGNATURE	EMPLOYER NAME

ADMINISTRATIVE INFORMATION	
Job/Task Name: Monitoring Well Installation	
Project Name: Former Scott Aviation Facility – Area 1	Project Location: Lancaster, New York
Project Manager: Dino Zack	Analysis performed by: Dino Zack
Date Job/Task to be performed: November 2010	Type of Job/Task: ☒ One time ☐ Routine job/task
Responsible Organization: AECOM Technical Services, Inc.	Job Supervisor: Jeffrey Rowley

JOB EVENT SEQUENCE

LIST ONE STEP OF THE JOB FOR EACH LINE. (*ATTACH ADDITIONAL JOB EVENT SEQUENCE FORM(S) AS NECESSARY*) PAGE 1 OF 1

1. Inspect well locations for trip/slip/fall/protruding objects	6. Monitor breathing zone with PID
2. Verify utility clearances	7. Establish contaminant reduction zone and exclusion zone
3. Inspect drill rig, tools and equipment	8. Initiate well installation activities
4. Don required PPE	9. Dispose of PPE, drilling fluids, and spoils per RI/AA
5. Calibrate PID	10. Decontaminate equipment as needed.

CHEMICAL HAZARDS		PHYSICAL HAZARDS	
☐ Asbestos	☐ Bunker fuel/oil	☐ Electricity/High voltage	☐ Ionizing radiation
☐ Acids	☐ Explosives (TNT)	☐ Elevated work areas (fall hazard)	☒ Eye hazards (impact, light, etc.)
☐ Caustics	☐ Dust	☐ Manual materials handling/Back	☒ Slips, trips, and falls
☒ Chlorinated hydrocarbons (TCE)	☐ Dioxins	☐ OE/UXO	☒ Hazardous noise
☐ Lead	☐ Pesticides/Herbicides	☒ Hand tool usage	☒ Heat or cold stress
☐ Gasoline or diesel fuel	☐ MTBE	☐ Power tool usage	☐ Oxygen-deficient atmosphere
☐ BTEX	☐ Methylene chloride	☐ Heavy equipment operations	☐ Oxygen-enriched atmosphere
☐ Jet fuel (JP-4, JP-5, JP-8)	☐ Waste oil	☒ Drill rig (HSA, DP, Air Rotary)	☐ Explosive atmosphere
☐ PCBs	☐ Hydraulic fluid	☐ Excavations (engulfment/collapse)	☐ Powder-actuated tools
☐ Cadmium	☐ Petroleum hydrocarbons	☐ Confined space entry	☐ Vehicular traffic
☐ Compressed gases/asphyxiants	**Other Chemical/Physical Hazards (*List*):** Biological hazards (poisonous plants, insects).		
☐ PAHs			
☐ Welding fumes			
☐ Hydrogen sulfide			
☐ Other metals			

PERSONAL PROTECTIVE EQUIPMENT (PPE) REQUIRED

Boots:
☐ Rubber (safety-toe)
☒ Leather (safety-toe)

General:
☒ Coveralls ____________(*type*)
☐ Hearing protection (plugs/muffs)
☐ FF APR ___(*cartridges*) if needed
☐ ½-face APR ______(*cartridges*)
☐ Safety harness & lanyard
☒ ANSI-approved Hard hat

Eye Protection:
☐ Faceshield
☒ Safety glasses or goggles
☐ Welder's helmet/goggles

Gloves:
☒ Chemically-protective
N-Dex nitrile rubber ______(*type*)
☐ Leather/cloth
☐ Welder's
☐ Electrical safety _______(*volts*)

Other (*List*):

OTHER SAFETY EQUIPMENT/CONSIDERATIONS

☒ Fire ext. 1A:10B:C ____(*rating*)
☒ First-aid kit
☐ Dust control/mitigation
☒ Portable eyewash
☐ Fire watch
☒ Traffic control measures

Other (*List*): Traffic control measures req'd if working in/adjacent to traffic

INSPECT/PERMIT REQUIREMENTS	EQUIPMENT TO BE USED
	PID

APPLICABLE SOPs (SEE HASP/SSHP/APP)	TRAINING REQUIREMENTS
SH&E 124, SH&E 201, SH&E 301, SH&E 403, SH&E 513, SH&E 604	40 hr Hazwoper

ADMINISTRATIVE INFORMATION	
Job/Task Name: Monitoring Well Installation	
Project Name: Former Scott Aviation Facility – Area 1	Project Location: Lancaster, New York
Project Manager: Dino Zack	Analysis performed by: Dino Zack
Date Job/Task to be performed: November 2010	Type of Job/Task: ☒ One time ☐ Routine job/task
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MONITORING PROCEDURES

ADMINISTRATIVE INFORMATION	
Job/Task Name: Monitoring Well Installation	
Project Name: Former Scott Aviation Facility – Area 1	Project Location: Lancaster, New York
Project Manager: Dino Zack	Analysis performed by: Dino Zack
Date Job/Task to be performed: November 2010	Type of Job/Task: ☒ One time ☐ Routine job/task
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DATE	EMPLOYEE NAME	EMPLOYEE SIGNATURE	EMPLOYER NAME

ADMINISTRATIVE INFORMATION	
Job/Task Name: Groundwater sampling	
Project Name: Former Scott Aviation Facility – Area 1	Project Location: Lancaster, New York
Project Manager: Dino Zack	Analysis performed by: Dino Zack
Date Job/Task to be performed: November 2010	Type of Job/Task: ☒ One time ☐ ☐Routine job/task
Responsible Organization: AECOM Technical Services, Inc.	Job Supervisor: Jeffrey Rowley

JOB EVENT SEQUENCE LIST ONE STEP OF THE JOB FOR EACH LINE. (*ATTACH ADDITIONAL JOB EVENT SEQUENCE FORM(S) AS NECESSARY*) PAGE 1 OF 1	
1. Inspect well locations for trip/slip/fall/protruding objects	6. Purge well to stabilize groundwater parameters
2. Verify equipment has no safety issues	7. Collect groundwater samples using caution with preservatives in sample bottles
3. Don PPE as needed	8. Secure samples in cooler with proper COC seals
4. Check well with PID upon opening j-plug	9. Contact Level II shipper prior to sending samples to lab
5. Install groundwater pump into well	10. Dispose of PPE and purge water per FOSP

CHEMICAL HAZARDS

☐ Asbestos	☐ Bunker fuel/oil
☐ Acids	☐ Explosives (TNT)
☐ Caustics	☐ Dust
☒ Chlorinated hydrocarbons (TCE)	☐ Dioxins
☐ Lead	☐ Pesticides/Herbicides
☐ Gasoline or diesel fuel	☐ MTBE
☐ BTEX	☐ Methylene chloride
☐ Jet fuel (JP-4, JP-5, JP-8)	☐ Waste oil
☐ PCBs	☐ Hydraulic fluid
☐ Cadmium	☐ Petroleum hydrocarbons
☐ Compressed gases/asphyxiants	
☐ PAHs	
☐ Welding fumes	
☐ Hydrogen sulfide	
☐ Other metals	

PHYSICAL HAZARDS

☐ Electricity/High voltage	☐ Ionizing radiation
☐ Elevated work areas (fall hazard)	☒ Eye hazards (impact, light, etc.)
☐ Manual materials handling/Back	☒ Slips, trips, and falls
☐ OE/UXO	☐ Hazardous noise
☒ Hand tool usage	☒ Heat or cold stress
☐ Power tool usage	☐ Oxygen-deficient atmosphere
☐ Heavy equipment operations	☐ Oxygen-enriched atmosphere
☐ Drill rig (HSA, DP, Air Rotary)	☐ Explosive atmosphere
☐ Excavations (engulfment/collapse)	☐ Powder-actuated tools
☐ Confined space entry	☐ Vehicular traffic

Other Chemical/Physical Hazards (*List*): Biological hazards (poisonous plants, insects).

PERSONAL PROTECTIVE EQUIPMENT (PPE) REQUIRED

Boots:
☐ Rubber (safety-toe)
☒ Leather (safety-toe)

General:
☐ Coveralls ____________(*type*)
☐ Hearing protection (plugs/muffs)
☐ FF APR ___(*cartridges*) if needed
☐ ½-face APR ______(*cartridges*)
☐ Safety harness & lanyard
☐ ANSI-approved Hard hat

Eye Protection:
☐ Faceshield
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☐ Welder's helmet/goggles

Gloves:
☒ Chemically-protective
N-Dex nitrile rubber ______(*type*)
☐ Leather/cloth
☐ Welder's
☐ Electrical safety _______(*volts*)

Other (*List*):

OTHER SAFETY EQUIPMENT/CONSIDERATIONS

☒ Fire ext. 1A:10B:C _____(*rating*)	☒ Portable eyewash
☒ First-aid kit	☐ Fire watch
☐ Dust control/mitigation	☒ Traffic control measures

Other (*List*): Traffic control measures req'd if working in/adjacent to traffic

INSPECT/PERMIT REQUIREMENTS	EQUIPMENT TO BE USED
	Water level probe
	Generator
	PID
	Groundwater purging and monitoring equipment

APPLICABLE SOPS (SEE HASP/SSHP/APP)	TRAINING REQUIREMENTS
SH&E 124, SH&E 201, SH&E 301, SH&E 505, SH&E 605	40 hr Hazwoper

ADMINISTRATIVE INFORMATION	
Job/Task Name: Groundwater sampling	
Project Name: Former Scott Aviation Facility – Area 1	Project Location: Lancaster, New York
Project Manager: Dino Zack	Analysis performed by: Dino Zack
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MONITORING PROCEDURES

ADMINISTRATIVE INFORMATION	
Job/Task Name: Groundwater sampling	
Project Name: Former Scott Aviation Facility – Area 1	Project Location: Lancaster, New York
Project Manager: Dino Zack	Analysis performed by: Dino Zack
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DATE	EMPLOYEE NAME	EMPLOYEE SIGNATURE	EMPLOYER NAME

ATTACHMENT B

MATERIAL SAFETY DATA SHEETS

ATTACHMENT C

HEALTH AND SAFETY PLAN SUPPLEMENTS