EA Science and Technology

FINAL
Remedial Investigation Work Plan Oasis Fuel Point Wheeler-Sack Army Airfield, Fort Drum, New York

U.S. Army Corps of Engineers
Baltimore District

Headquarters, 10th Mountain Division (Light Infantry) and Fort Drum
Fort Drum, New York

January 2012

Remedial Investigation Work Plan
Oasis Fuel Point
Wheeler-Sack Army Airfield
Fort Drum, New York

Prepared for

U.S. Army Corps of Engineers–Baltimore District
Engineering Division–HTRW Branch
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1. INTRODUCTION AND OVERVIEW

The U.S. Army Corps of Engineers (USACE)–Baltimore District has tasked EA Engineering, P.C. and its affiliate EA Science and Technology (EA) to perform remedial investigation activities including additional site characterization and implementation of an ozone sparging pilot test at the Oasis Fuel Point (Oasis), Wheeler-Sack Army Airfield, Fort Drum, New York. The goal of the additional investigation and pilot testing is to provide information necessary to develop a groundwater remedy in accordance with the Consent Order between the State of New York and the U.S. Army.

This document serves as the Work Plan for additional investigation and pilot testing at the Oasis and satisfies the Consent Order requirement to develop a remedial investigation work plan. The investigation activities outlined in this work plan are not intended to limit the potential for expansion to include additional investigation, if required, based on the results. Project activities at this site will be conducted in accordance with New York State Department of Environmental Conservation (NYSDEC) and U.S. Environmental Protection Agency (EPA) Region 2 regulatory guidelines.

1.1 BACKGROUND

The Fort Drum Military Installation (Fort Drum), which encompasses approximately 168 mi^2, is located approximately 10 mi northeast of Watertown, 80 mi north of Syracuse, and 25 mi southeast of the United States and Canadian border (Figure 1). Fort Drum occupies a large portion of northeastern Jefferson County, a portion of western Lewis County, and abuts the southern edge of St. Lawrence County.

The Oasis site is a refueling area for helicopters that is located at Wheeler-Sack Army Airfield (Figure 2). The site contains six fuel dispensers and associated piping/equipment required to transfer JP-8 from the aboveground storage tanks (ASTs) east of the site to the dispensers. The fueling area consists of a 600-ft × 400-ft asphalt pad that is approximately 6-in. thick. The site is bounded to the south by Taxiway A, to the west by Taxiway J, and to the east by Taxiway B. A small, grassy area adjoins the area to the north. The closest structure is Building 2069 (Oasis operations building) located south of the fuel point.

1.1.1 Light Non-Aqueous Phase Liquid

In May 2006, a release of JP-8 fuel was discovered in Service Pit No. 6, which is located at the northern end of the system’s pipeline. At the time the spill was discovered, the refueling system pipeline was deactivated, fuel was removed from Service Pit No. 6, and the spill was reported to the NYSDEC and the New York State Department of Health. The cause of the fuel spill was determined to be a faulty pressure relief valve located within Service Pit No. 6.

Vadose zone (unsaturated) soil has been impacted by residual JP-8 fuel in the area immediately around and beneath the release (Service Pit No. 6) where fuel leaking from the pit entered the subsurface and migrated vertically until intercepting the water table at 40-45 ft below ground surface (bgs). Upon reaching the water table, fuel spread radially as evidenced by impacted soil at the water table interface and the presence of light non-aqueous phase liquid (LNAPL) was observed in wells installed throughout the site. Based on data available from the site, the LNAPL plume extends across more than 4 acres at the Oasis as a result of the release (Figure 3). Approximately 400,000 gal of LNAPL were estimated to be present at the water table interface; however, there remains a degree of uncertainty with the volume estimate due to variables associated with site-specific properties of the LNAPL and subsurface soil conditions.

1.1.2 Groundwater

A dissolved-phase groundwater plume (greater than 20 acres in areal extent) has formed as a result of the JP-8 spill (Figure 3). The local groundwater flow direction, observed to be to the northeast then turning to the east, has influenced migration of the dissolved-phase groundwater plume. The Oasis site is located southeast of the shallow groundwater divide and overlies a deltaic sand, silt, and gravel deposit with observed zones of varying hydraulic conductivity which may locally impact groundwater flow (and contaminant transport). Although the hydraulic gradient in the vicinity of the spill is low (0.003-0.006 ft/ft), it increases steeply (0.01 ft/ft) beyond the eastern edge of the airfield. The average groundwater velocity is approximately 200 ft/year in the source area of the LNAPL plume and increases to greater than 450 ft/year in the downgradient area.

The horizontal extent of the dissolved-phase plume extends approximately 2,800 ft eastward in the direction of groundwater flow from the upgradient boundary of the LNAPL plume. Within the LNAPL plume boundary, the dissolved-phase plume extends from the water table LNAPL interface (located at approximately 40 ft bgs) to approximately 65-70 ft bgs, with concentrations decreasing downward. The dissolved-phase plume descends away from the water table to deeper portions of the aquifer and thins downgradient from the LNAPL plume boundary. Impacted groundwater has migrated from approximately 45 ft bgs (water table) in the source area to more than 100 ft below the water table (approximately 160 ft bgs) at the downgradient extent of the dissolved-phase plume.

1.1.3 LNAPL Interim Remedial Measures

LNAPL Recovery via Skimming and Vacuum Enhanced Skimming

Following the initial site assessment, an interim remedial measure (IRM) was implemented in January 2007 to continuously recover LNAPL. LNAPL skimmer systems (each consisting of a LNAPL skimmer pump, control panel, ASTs, and associated sensors) were installed in five extraction wells/piezometers. LNAPL collected by each system at the Oasis was pumped to the surface for temporary storage in a 1,000-gal AST. The five original skimmer systems operated at the Oasis recovered a total of 32,653 gal through 5 May 2008.

An upgrade to the LNAPL skimming IRM was implemented in July 2008 using vacuum enhanced skimming (VES) to increase LNAPL recovery while a final remedial action was being evaluated. VES employs a vacuum to induce the migration of LNAPL to the recovery well where it is removed via skimmer pumps. The IRM upgrade included installation of 10 additional recovery wells and a vacuum blower to recover LNAPL from up to 15 locations.

The VES system was temporarily shut down during the surfactant enhanced aquifer remediation (SEAR) pilot test and disassembled (due to power limitations and to provide accessibility during installation of the expanded wellfield) prior to SEAR implementation in Parcel 1. However, additional LNAPL removal activities continued using a mobile vacuum truck prior to SEAR implementation in Parcel 1 and following installation of the remaining SEAR wellfield. In addition, in September 2010, skimmers were installed and temporarily operated in the last line of SEAR extraction wells (T-line).

Following completion of SEAR in Parcel 1, an interim VES system was restarted in December 2010 with six recovery wells. Nine additional recovery wells were added to the system in January 2011, and a mobile skimmer pump was used in 25 locations to assess recovery rates and recover additional LNAPL. In February to March 2011, the VES system was reconfigured as the expanded downgradient plume boundary was delineated. The VES LNAPL recovery system was operated continuously at 19 locations through May 2011. In May 2011, the system was expanded and operating at a total of 25 locations.

Surfactant Enhanced Aquifer Remediation

Prior to SEAR implementation, a treatability test and pilot study were completed to evaluate the suitability of the Oasis site for the proposed technology. The results of the treatability study were used to develop and formulate a SEAR pilot study (0.12 acres with 13 injection wells and 2 extraction wells) to assess the viability and effectiveness at the site. Based on the results of the pilot study (2,740 gal of LNAPL recovered), implementation of SEAR was selected as an IRM for LNAPL removal at the Oasis site.

The treatment zone footprint used for the first iteration of SEAR implementation was approximately 0.7 acres, and included 47 injection wells and 20 extraction wells. A total of 21,363 gal of LNAPL were recovered during SEAR implementation in Parcel 1. Based on the findings of full-scale SEAR implementation in Parcel 1, SEAR was not recommended to be applied to the remainder of the Oasis site (including treatment of residual LNAPL in Parcel 1). Further efforts to remove remaining LNAPL within Parcel 1 were recommended to be performed concurrently with site-wide LNAPL recovery; however, the recovered fluids from Parcel 1 must be processed separately to address the residual surfactant. Addition of oxygen was recommended to enhance degradation of residual surfactant and the constituents and breakdown products associated with the surfactant mixture.

Dual-Phase Extraction and Air Injection

A dual-phase extraction (DPE) IRM is being implemented plume wide during the 2011 field season (August through November 2011) to continue LNAPL recovery. Current aboveground, temporary DPE operations include a 76-well, plume-wide DPE system including the 20-well

Parcel 1 DPE system and a 56-well DPE system throughout the remainder of the LNAPL plume area (Figure 4). A temporary, aboveground air injection system is also being operated using 26 injection wells in Parcel 1 to enhance degradation of residual surfactant and related breakdown products (e.g., through the addition of oxygen).

A 10-well winterized LNAPL plume-edge DPE system is currently being constructed and is slated to begin full-time operation in mid-October 2011. This system is intended to continue to provide containment/control of the leading edge of the LNAPL plume while a final remedial action is evaluated and developed. Nine of the wells from this system (i.e., EW-01, EW-02, EW-04, EW-05, EW-06, EW-08, EW-09, EW-10, and EW-13) are currently being operated as part of the aboveground, plume-wide DPE operation. One additional extraction well (i.e., EW-03), installed in August 2011, will also be incorporated into the winterized DPE system.

LNAPL Recovery to Date

Through 26 September 2011, a total of 149,143 gal of LNAPL have been recovered from the Oasis via skimming, VES, SEAR, and DPE since IRMs began in 2007. The breakdown of volume recovered via each method is summarized below.

Method	Timeframe	Volume Recovered (gal)
Skimming	January 2007 - May 2008	32,653
Skimming/VES	May 2008 – July 2010	43,075
SEAR pilot test	September – November 2009	2,740
Skimming and vacuum truck	August – November 2010	12,024
SEAR Parcel 1	August – November 2010	21,363
VES	December 2010 – July 2011	25,091
DPE	August 2011 – September 2011	12,197
	TOTAL	149,143

1.2 REMEDIATION PATH FORWARD

The Consent Decree between Fort Drum and the State of New York identifies milestones for remediation at the Oasis site, including completion of the LNAPL removal IRM (specifically identified as SEAR) by 27 July 2011 and implementation of a groundwater remedial action by 28 January 2014. In April 2011, the SEAR IRM, which was specified in the Consent Decree, was replaced by plume-wide DPE as the source area IRM in order to provide containment/control and recovery

The temporary, aboveground DPE system which began operation in August 2011 will continue to operate through mid-November 2011, by which time a winterized LNAPL-edge DPE system will be operational. The LNAPL-edge DPE system will be supplemented throughout the winter with limited VES operation. Plume-wide DPE operation is scheduled to resume in April 2012. Pilot testing of DPE enhancements is planned for early spring, and if successful, will be implemented on a larger scale to accelerate LNAPL recovery.

Additionally, the pilot groundwater treatment system, which is intended to provide containment and treatment of the downgradient extent of the dissolved-phase groundwater plume, is also slated to be tested in Fall 2011 and implemented by Spring 2012. Due to the continued expansion of the dissolved-phase plume and the observed increases in methyl tertiary-butyl ether (MTBE) concentrations in the downgradient area, the original proposal for a biosparging system has been replaced with ozone sparging, and additional site characterization activities will be performed to refine the areal and vertical extent of the downgradient groundwater plume.

As a condition of the Consent Decree, Fort Drum is required to complete a remedial action selection (RAS) report to develop a remedial strategy to address residual petroleum impacts remaining following completion of the IRM. The results of remedial investigation activities proposed in this Work Plan will be incorporated into the RAS. In order to develop the remedial investigation and advance the RAS, a preliminary remedial alternative evaluation was performed by assessing a range of criteria for technology alternatives with the potential to address residual LNAPL/soil and groundwater cleanup.

Initially, a preliminary screening was performed whereby technologies were qualitatively scored by media (i.e., LNAPL/soil and groundwater) against criteria including effectiveness, implementability, and cost. Following the preliminary screening, retained technologies were coupled across various media to produce three remedial alternatives that would comprehensively address LNAPL/soil and groundwater remediation. Subsequent to the alternative technology development process, a preliminary preferred alternative was selected based on a relative ranking system that considered criteria including effectiveness, implementability, cost, schedule, and potential impact on the base mission.

The preliminary preferred alternative to address LNAPL/soil and groundwater remediation includes LNAPL recovery enhancements, source ozone treatment, and downgradient groundwater ozone sparging. This remediation strategy for source area and groundwater treatment will be refined/modified and formalized in the RAS report.

1.3 PROJECT OBJECTIVES AND SCOPE

The objective of the additional site characterization activities and ozone sparging pilot testing is to collect information required to develop a final remedial action. A summary of activities for this project’s objectives are as follows:

- Preparation of this Work Plan
- Additional site characterization:
    - Groundwater profiling
    - Monitoring well installation
    - Groundwater sampling
    - LNAPL-groundwater flux sampling

- Ozone sparging pilot test

- Reporting:
    - Remedial Investigation Summary Report
    - Ozone Sparging Pilot Test Report.

1.4 PROJECT ORGANIZATION AND RESPONSIBILITIES

1.4.1 Project Management

The additional groundwater investigation activities and installation/implementation of the ozone sparging pilot test at the Oasis will be managed through an organized effort of scientific and engineering personnel and technical resources. These efforts will employ pre-approved field procedures, sampling techniques, and analytical methods to accomplish the project objectives. Effective program organization will accommodate these requirements while maintaining a manageable degree of control over these activities.

The key technical management of this investigation will be accomplished by the Project Manager and assigned project team. Additional individuals will be made available if warranted.

Key members of project team include:

Project Officer/Program Manager	Brenda Herman
Project Manager	Christopher Canonica, P.E.
Quality Assurance/Quality Control Officer/Senior Technical Review	Frank Barranco, P.G.
Program Safety and Health Officer	Peter Garger, CIH
Remedial Investigation Manager	Jennifer Martin Bouchard, P.G.
Site Manager/Site Safety and Health Officer	Mike Valvo

1.4.2 Qualifications of Personnel

Project personnel will be qualified to perform the tasks to which they are assigned. Appraisal of the qualifications of field personnel will be made by the Project Manager and will include comparison of the job assignment requirements with the relevant experience and training of the proposed personnel. It will also include a determination of whether further training is required and, if required, by what method. On-site training is an acceptable method, provided such training is given by a person qualified to perform the trainee’s assignment and that this training does not otherwise impede the progress of the project.

1.4.3 Project Subcontractors

Successful implementation of the field activities proposed in this Work Plan will require several subcontractors. The subcontractors will include a drilling company for the installation of wells, on-site and off-site laboratory services, an ozone equipment supplier, and a New York State certified surveyor. To ensure compliance with the project quality assurance/quality control objectives, subcontractor activities will be directed and supervised by a member of the project implementation team.

1.4.4 USACE Support

USACE-Savannah District drillers will be responsible for groundwater profiling and installation of all of the additional groundwater monitoring wells, with the exception of the monitoring point clusters associated with the short-term ozone sparging pilot test. Specifications (i.e., number, location, and well screen design [slot size, diameter, length, etc.]) will be determined in collaboration with EA, based on the results of the groundwater profiling activities.

2. PREVIOUS SITE CHARACTERIZATION

2.1 SUBSURFACE SOIL

Soil borings were installed at the Oasis during the preliminary and site characterization investigation (EA 2007)[1] to define the areal extent of impacted soil. Additional vertical delineation of the LNAPL smear zone was performed during the SEAR Treatability Study (EA 2010a)[2], the SEAR pre-design investigation (EA 2010b)[3], during installation of the SEAR wellfield (EA 2011)[4], and during additional plume delineation activities following SEAR implementation (i.e., installation of additional extraction wells and temporary monitoring points during Winter 2010/2011 through Spring 2011).

The results of these investigations indicated that subsurface soil is impacted throughout the areal extent of the LNAPL plume (detailed in the following section). And, as expected, the area with the thickest interval of petroleum impacted soil (approximately 8-9 ft) is within the interior of the plume beneath the point of the original release (Service Pit No. 6) where the highest concentrations of constituents of concern have been detected in soils from the 40- to 45-ft (water table) interval. The thickness of petroleum impacted soil throughout the majority of the LNAPL plume appears to be between 5 and 6 ft, and decreases to approximately 2 ft at the margins.

2.2 LNAPL DISTRIBUTION AND VOLUME

A substantial LNAPL plume has formed at the water table interface beneath the site as a result of the JP-8 fuel release. Subsurface soil has been impacted by residual JP-8 fuel in the area immediately surrounding Service Pit No. 6, and between 1 and 4 ft of LNAPL has been observed in piezometers, monitoring points, and recovery wells installed throughout the site. The areal extent of the LNAPL plume is estimated to be 3.5-4 acres (Figure 3).

The volume of JP-8 released at the Oasis site was estimated using the American Petroleum Institute LNAPL Distribution Recovery Model. Data obtained from geotechnical analysis of soils from the Oasis site coupled with additional site-specific data, including LNAPL thicknesses, soil parameters, etc., were used to re-estimate the LNAPL plume volume at the Oasis site.

Running the model using three scenarios (i.e., incorporating the mean, low, and high values for the most sensitive soil parameters) resulted in varying estimates of specific LNAPL volume for each well. These estimates were interpolated and summed over the plume area to provide the following range of LNAPL volumes:

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[1] EA Engineering, P.C., and its Affiliate EA Science and Technology. 2007. Site Characterization Report, Oasis Fuel Point, Wheeler-Sack Army Airfield, Fort Drum, New York. November. Draft.

[2] EA Engineering, P.C., and its Affiliate EA Science and Technology. 2010a. Draft Surfactant Enhanced Aquifer Remediation Pilot Study Report Oasis Fuel Point, Wheeler-Sack Army Airfield, Fort Drum, New York. January.

[3] EA Engineering, P.C., and its Affiliate EA Science and Technology. 2010b. Final Work Plan for the Surfactant Enhanced Aquifer Remediation Interim Remedial Measure Oasis Fuel Point, Wheeler-Sack Army Airfield, Fort Drum, New York. July.

[4] EA Engineering, P.C., and its Affiliate EA Science and Technology. 2011. Draft Surfactant Enhanced Aquifer Remediation Parcel 1 Summary Report Oasis Fuel Point, Wheeler-Sack Army Airfield, Fort Drum, New York. April.

- Low: 150,000 gal
- Mean: 400,000 gal
- High: 650,000 gal.

2.3 DISSOLVED-PHASE GROUNDWATER PLUME

2.3.1 Subsurface Geology

Site investigation activities performed from 2006 to 2009 confirmed that the Oasis is underlain by a thick, fine to medium sand deposit, characteristic of the Pine Plains delta, which extends from the ground surface to more than 100 ft bgs (Figure 5). While the material underlying the site generally transitions from medium sand to fine sand and silt at depth, the results of the *in situ* groundwater profiling and geotechnical analysis indicate that vertical and horizontal heterogeneities across the site may be influencing the horizontal LNAPL migration and associated vertical migration of the dissolved-phase groundwater plume.

2.3.2 Groundwater Flow

Groundwater flow is generally to the east-northeast in the vicinity of the Oasis site and adjoining runway; however, based on elevations measured in the airfield sanitary landfill (ASL) located southeast of MW-16, the direction of groundwater flow turns southeast towards the Black River (Figure 6). Groundwater elevation measurements at the Oasis ranged from a low of 623.67 ft above mean sea level at ASL-MW-961 to a high of 665 ft above mean sea level at the sentinel well. The calculated hydraulic gradient in the source area between wells MW-03 and the MW-12 cluster was approximately 0.004. The gradient increases slightly to 0.005 across the taxiway to the east of the Oasis (between well clusters MW-13 and MW-16) where it increases to 0.01 between well clusters MW-16 and MW-18.

Based on groundwater elevations within shallow, intermediate, and deep wells at well cluster locations, groundwater flow at and immediately downgradient of the Oasis is primarily in the horizontal direction with little or no vertical component to flow. However, groundwater elevation differences in the shallow, intermediate, and deep wells at well clusters MW-16, MW-17, and MW-18 suggest a downward vertical component to groundwater flow in the unconsolidated Pine Plains aquifer.

2.3.3 Groundwater Quality

Site-Wide Groundwater

Groundwater sampling of the site-wide monitoring network has been conducted quarterly since March 2007 (Table 1). Samples are analyzed for volatile organic compounds (VOCs) by EPA Method 8260B. Samples have also been analyzed for total petroleum hydrocarbons as diesel range organics (TPH-DRO) by EPA Method 8015 starting in May 2009.

Within the LNAPL plume boundary, elevated concentrations of VOCs and TPH-DRO seem to be confined to the area immediately below the LNAPL plume boundary, with concentrations decreasing with depth (Figures 7a/b and 8a/b). However, as the dissolved-phase plume moves away from the source area, there appears to be both a horizontal and downward vertical migration of higher concentrations of VOCs and TPH-DRO downgradient from the LNAPL plume boundary. The vertical extent of the dissolved-phase plume increases between the MW-12 and MW-16 clusters, and the leading edge of the plume expanded from just beyond the MW-16 cluster in August 2009 to beyond the MW-18 cluster in June 2011. Based on the increase in total VOC concentrations in the MW-13 and MW-16 clusters installed within the core of the dissolved-phase plume, and the increasing MTBE concentrations at the MW-17 and MW-18 clusters at the downgradient edge of the plume, the plume appears to be migrating downgradient. In addition, based on the increase of total VOCs (particularly benzene, MTBE, and/or naphthalene) in deep wells MW-11D and MW-08D, the plume appears to be expanding and/or shifting northward.

The vertical extent of the dissolved-phase groundwater plume appears to be partially limited by a change in geologic material from fine to medium sand to very fine sand/sandy silt at depths ranging from approximately 92 to 104 ft bgs. The change in geology may function as a semi-confining unit in the area between the LNAPL plume boundary and the MW-16 cluster. Once the dissolved-phase groundwater plume reaches the very fine sand/sandy silt, it appears to move laterally along the geologic contact in the direction of lateral groundwater flow. While the change in geologic material appears to be limiting the rate of vertical migration of the dissolved-phase groundwater plume, it does not eliminate the possibility of further vertical migration. The increasing trend in benzene, naphthalene, and MTBE concentrations indicates that the dissolved-phase plume extends vertically below monitoring well MW-13D2. Additionally, detections of MTBE in the bedrock well at the MW-18 cluster (at a depth of approximately 164 ft bgs) may indicate that the very fine sand/sandy silt unit is discontinuous between the MW-16 and MW-18 clusters, and the clay unit that underlies the fine sand/sandy silt unit is also missing in the vicinity of MW-18 resulting in a vertical gradient which likely facilitated vertical migration of the dissolved-phase plume.

Since the dissolved-phase groundwater plume has expanded laterally and vertically beyond the existing monitoring well network, it was recommended that additional delineation be performed to define the lateral and vertical extents, particularly in the vicinity of the MW-11, MW-08, and MW-02 clusters (lateral extent); and MW-13 and MW-16 (vertical extent). The rationale, approach, and sampling methods for additional groundwater plume delineation are detailed in Section 3.

Parcel 1 Groundwater

Five post-SEAR groundwater sampling events were conducted in Parcel 1 (from December 2010 to June 2011) in order to monitor changes in VOC, TPH-DRO, and methylene blue active substance (MBAS) concentrations following SEAR implementation. Samples were collected from 10 wells: PZ-03, SGMP-01, SGMP-02, SGMP-03, SPMP-04, GMP-01D, GMP-02D, GMP-03D, GMP-04D, and GMP-05D (Figure 9). With the exception of PZ-03 and SPMP-04, which are screened to intercept the water table interface (i.e., 38-48 ft bgs), all of the remaining wells are screened below the smear zone, from approximately 52 to 57 ft bgs. Groundwater samples were analyzed for VOCs, TPH-DRO, and MBAS by EPA Method 425.1. Concentrations in background well PZ-03 were non-detect throughout post-SEAR groundwater sampling.

VOCs were detected in all SEAR and SEAR pilot wells immediately following completion of SEAR (November 2010 sampling event), with total VOC concentrations (excluding acetone) ranging from 497 µg/L (GMP-01D) to 19,210 µg/L (SGMP-02) (Table 2). Peak concentrations during the five post-SEAR sampling events ranged from 904 µg/L (SGMP-03; November 2010) to 26,221 µg/L (SGMP-01; December 2010) (Figure 10a). In general, the increase to peak concentrations occurred between November 2010 and January 2011, with concentrations decreasing at the majority of locations following the January 2011 sampling event. Peak concentrations at the majority of wells were elevated above background VOC concentrations within the LNAPL plume, as based on historical concentrations in MW-9I1 (ranging from 807 to 5,501 µg/L). However, by June 2011, total VOC concentrations (excluding acetone, which is addressed below) in the Parcel 1 groundwater monitoring points had decreased to background levels, with concentrations ranging from 10 µg/L (SGMP-03) to 4,374 µg/L (SGMP-02).

TPH-DRO was detected at all of the Parcel 1 monitoring points immediately following completion of SEAR, with concentrations ranging from 9 mg/L (GMP-03D) to 1,300 mg/L (SGMP-02). With the exception of GMP-01D and GMP-03D, peak concentrations were observed during the November 2010 event, with concentrations ranging from 27 mg/L (SGMP-03) to 1,300 mg/L (SGMP-02) (Figure 10b). The peak at GMP-01D was observed in December 2010, while the peak at GMP-03D was observed in March 2011. Concentrations decreased at all locations in June 2011, with concentrations ranging from 1.86 mg/L (SGMP-03) to 219 mg/L (SGMP-02), with concentrations at SGMP-03 and SPMP-04 within the historical background TPH-DRO concentration range, as observed at MW-09I1 (1.6 to 13.2 mg/L).

MBAS was included in the SEAR monitoring events to estimate the concentration of surfactant[5] in groundwater and monitor the breakdown of surfactant over time. Following completion of SEAR in Parcel 1, MBAS was detected at all of the Parcel 1 monitoring points, with concentrations ranging from 1 mg/L (GMP-03D) to 652 mg/L (SGMP-02). With the exception of SPMP-04 (water table well), peak concentrations of MBAS were reached between December 2010 and March 2011 for all wells, with concentrations ranging from 18.9 mg/L (SGMP-03, December 2010) to 1,130 mg/L (SGMP-01, December 2010) (Figure 10c). MBAS concentrations decreased at all locations (with the exception of SPMP-04) in June 2011, with concentrations ranging from 0.2 mg/L (SGMP-03) to 281 mg/L (SGMP-02). The MBAS concentration at SPMP-04 has continuously increased since December 2010, with the highest concentration (281 mg/L) observed in June 2011.

The identification of acetone in observed groundwater samples was attributed to the breakdown of isopropyl alcohol, which was an additive to the surfactant solution used during SEAR

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[5] MBAS is a colorimetric method used to detect foaming agents. Due to the nature and chemistry of the surfactants used, the MBAS method may under-estimate the concentration of residual surfactant.

implementation. Isopropyl alcohol was used as a stabilizer during storage and transport of the surfactants to guard against precipitation and breakdown. Acetone has not been detected in any of the downgradient monitoring well clusters. Following completion of SEAR in Parcel 1, acetone was detected at all SEAR and SEAR pilot wells, with concentrations ranging from 7,600 µg/L to 110,000 µg/L. Peak concentrations of acetone ranged from 7,527 µg/L (SGMP-04, January 2011) to 200,000 µg/L (SGMP-02, December 2010) (Figure 10d). Concentrations generally decreased during the March and June 2011 sampling events, with current acetone concentrations ranging from non-detect (SGMP-01, GMP-04D) to 111,000 µg/L (SGMP-02).

The final post-SEAR sampling event will coincide with the December 2011 site-wide, quarterly groundwater sampling event. By December 2011, the temporary Parcel 1 air injection operation will be shut down; therefore, the effect of short-term air injection on surfactant degradation will be evaluated.

MTBE

MTBE, a fuel oxygenate not typically found in JP-8, has been detected throughout the dissolved-phase groundwater plume, with the areal extent of MTBE extending from within the LNAPL plume (MW-09 cluster) to the currently delineated downgradient extent of the groundwater plume (6.5 µg/L; MW-18 bedrock) (Figures 11a/b). The highest concentrations during June 2011 were detected at depth within the middle portion of the dissolved-phase plume (904 µg/L; MW-13D2). MTBE concentrations have continued to increase laterally in the mid-portion of the plume with recent detections in wells MW-11D and MW-08I along the northern periphery of the dissolved-phase groundwater plume, and vertically with increasing concentrations detected in deeper monitoring wells at the MW-13 and MW-18 clusters.

Within the LNAPL plume boundary, the areal and vertical distribution of MTBE in groundwater is not well defined. No MTBE concentrations have been detected in any of the Parcel 1 groundwater monitoring points, which are screened below the smear zone. Parcel 1 is located within the upgradient portion of the LNAPL plume and is upgradient of the LNAPL source area (Service Pit No. 6).

Downgradient from Parcel 1 and the source area, MTBE concentrations (ranging from 23 µg/L to 1,600 µg/L) have been detected in the MW-09 cluster well, which is screened immediately below the smear zone (55-60 ft bgs). Estimated concentrations of MTBE have been detected at the next lower interval (65-70 ft bgs). With the exception of two low concentrations in May and September 2009 (0.83 and 3.8 µg/L, respectively) at MW-09I2 (65-70 ft bgs), MTBE has not been detected in the deeper intervals at the MW-09 cluster.

The MW-01/12 cluster is located along the southern boundary of the LNAPL plume downgradient from the MW-09 cluster. MTBE has not been detected in the shallow (water table well) or the deepest well interval (95-100 ft bgs) at this location. However, MTBE concentrations have been detected in the upper intermediate well (MW-12I1, 55-60 ft bgs) ranging from 10 to 24 µg/L; lower intermediate well (MW-12I2, 65-70 ft bgs) ranging from 95 to 340 µg/L; and upper deep well (MW-12D1, 78-83 ft bgs) ranging from 38 to 310 µg/L.

Three other monitoring wells (i.e., MW-19, MW-21, and MW-22) screened below the smear zone (55-60 ft bgs) were installed in the downgradient portion of the LNAPL plume to monitor for fugitive flow during SEAR (Figure 12). MW-19 and MW-22 were installed crossgradient of MW-09, with MW-19 located immediately outside the southern boundary of the LNAPL plume and MW-22 located within the northern edge of the LNAPL plume. MW-21 was installed within the LNAPL plume downgradient of MW-09 and upgradient of MW-01. Since SEAR implementation was limited to the Parcel 1 area, these wells were only sampled once (August 2010). MTBE was detected at MW-22 (560 µg/L), but was not detected in the other monitoring well (MW-21) where VOC and TPH-DRO concentrations were detected (Table 3). No VOCs or TPH-DRO were detected at MW-19.

Regional Groundwater

Two primary aquifer systems are present at Fort Drum: the Pine Plains surficial aquifer and the underlying bedrock aquifer system (Reynolds 1986)[6]. The bedrock aquifer system can be divided by geologic unit into two principal aquifers: the Ordovician-aged carbonate rocks of the Black River Group and the underlying Cambrian-aged Potsdam Sandstone and Theresa Formation.

Surficial Aquifer

The surficial aquifer is a shallow, unconfined aquifer in the unconsolidated deltaic deposits that ranges from less than 10 to more than 100-ft thick and extends from the village of Black River across the southern portion of Fort Drum. The aquifer is primarily recharged by precipitation and the water table is generally highest in the spring, due to precipitation and snow melt, and the absence of evapotranspiration. Recharge is generally low in summer, but increases again in the late-fall as evapotranspiration is diminished.

A regional groundwater divide is located in the vicinity of the Wheeler-Sack Army Airfield (WSAAF), approximately following the northern edge of the Black River (ARM Group Inc. 2005)[7]. In general, groundwater in the shallow aquifer to the north of the divide discharges to the Indian River, while groundwater to the south of the divide discharges to the Black River.

Bedrock Aquifer

The underlying bedrock aquifer is located between 130 and 180 ft bgs, and may be locally confined or unconfined, depending upon the presence of glaciolacustrine silt and clay deposits. A groundwater divide similar to that of the regional shallow groundwater divide is located in the vicinity of the WSAAF. Groundwater in bedrock to the north of the divide flows north and discharges to Indian River (Reynolds 1986)[6]. To the south of the divide, groundwater in bedrock flows south and discharges to the Black River. However, during periods of high river stage, the gradient can reverse and allow surface water from the Black River to recharge the bedrock aquifer.

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[6] Reynolds, R.J. 1986. *Hydrogeology of the Fort Drum Area, Jefferson, and St. Lawrence Counties, New York*. United States Department of the Interior Geological Survey. Water-Resources Investigations Report 85-4119.

[7] ARM Group Inc. 2005.

Fort Drum Well Field

The majority of Fort Drum's groundwater supply wells are located almost entirely within the footprint of the WSAAF (Figure 2). Most of the wells are located west or north of the runways, with the closest well to the Oasis site located approximately 1,500 ft to the west. Five wells (i.e., 2, 5, 9, 10, and 11) are installed in bedrock, one of which is screened in the Black River Group and four in the Theresa or Potsdam Sandstone (Fort Drum Well Inventory; Reynolds 1986[6]). The remaining five active wells (i.e., 3, 4, 6, 7, and 8) are screened in overburden sediments; with wells 4, 6, 7, and 8 in the Pine Plains delta deposits; and well 3 in sediments over bedrock. The confining layer is present at well 3, between the delta deposits and the gravel overlying bedrock (Fort Drum Well Inventory). Well 12 was permanently closed and well 1 was abandoned.

During Fall 2009, six additional production wells were installed to the northeast of the Oasis site to supplement the existing water supply network. Wells 13 through 18 are installed as open boreholes in sedimentary bedrock with depths ranging from 167.5 to 250 ft bgs.

3. ADDITIONAL SITE CHARACTERIZATION

A Safety, Health, and Emergency Response Plan (SHERP) Addendum, which is intended to supplement approved Accident Prevention Plan for the Oasis site, is provided as Appendix A. The SHERP Addendum provides site-specific information to protect the safety and health of personnel while performing field activities detailed in this Work Plan. The Fort Drum Basewide Quality Assurance Project Plan (QAPP) addresses field sampling and analytical procedures and generic quality assurance/quality control protocols applicable to Fort Drum Installation Restoration Program projects. Accordingly, these procedures and protocols are not restated in this Work Plan, but are provided in Appendix B. Specifically, the Basewide QAPP contains protocols for documentation and chain-of-custody, instrument calibration, equipment decontamination, analytical procedures, data reduction and reporting, internal quality control, performance and system audits, preventive maintenance, data assessment procedures, corrective actions, and quality assurance reporting.

3.1 GROUNDWATER INVESTIGATION

3.1.1 Lateral and Vertical Extent of the Proposed Investigation

A total of 12 additional locations have been selected to fill data gaps in the current delineation of the dissolved-phase groundwater plume (Figure 13). As detailed in Section 2.3, increasing VOC concentration trends have been observed along the approximate centerline of the plume at the MW-13 and MW-16 clusters. The vertical extent of the groundwater plume is no longer defined by the deepest existing well at these clusters. Therefore, two of the groundwater profiling points will be located at these clusters to define the vertical extent of the dissolved-phase plume at these locations and to determine where it is necessary to augment the existing monitoring well network.

Groundwater profiling will continue at these locations until VOCs are not detected in groundwater or until bedrock is encountered. If bedrock is encountered prior to achieving vertical delineation of VOC impacts, then a bedrock monitoring well will be installed at that location. If bedrock is not encountered within 20 ft of the deepest existing well at these clusters, additional monitoring well(s) will be installed, as required, to delineate the vertical extent of the dissolved-phase plume in the unconsolidated material.

The existing downgradient monitoring well network, which consists of nine well clusters located downgradient of the LNAPL plume boundary, provides limited resolution of the areal extent of the groundwater plume. In the area immediately downgradient of the LNAPL plume, VOCs have been detected at varying depths in the perimeter well clusters (i.e., MW-02, MW-11, and MW-08). Two of the downgradient clusters, MW-14 and MW-15, demarcate the lateral extent of the plume to the south and north, respectively. However, additional information on the lateral extent of the dissolved-phase plume, particularly in the vicinity of the MW-16 cluster, is needed to determine the location and extent of the proposed full-scale ozone sparging system[8]. The following profiling locations are proposed to fill downgradient data gaps:

- Northern plume extent: MW-26, MW-29, MW-31, and MW-32
- Southern plume extent: MW-23, MW-24, MW-25, MW-27, and MW-30
- Downgradient ozone pilot area: MW-27, MW-28, MW-29, MW-33, and MW-34.

Additional monitoring wells/monitoring well clusters will be installed based on the groundwater profiling data collected at each of the proposed locations.

3.1.2 Groundwater Profiling

Groundwater profiling will be conducted using the Geoprobe® screen point 22 (SP22) sampling tool deployed within a 6.25-in. diameter mud rotary borehole. The SP22 sampling tool is designed to work in unconsolidated material by advancing the tool to the bottom of a borehole and driving the protected point into the undisturbed ground. Once the tool has been advanced to the sample depth, a protective sheath is retracted to expose a screen (2-ft long), and the sampler collects groundwater. Once filled, the sampler is retrieved and advancement of the borehole will continue. The groundwater sample will then be analyzed for VOCs by EPA Method 8260B using an on-site mobile laboratory to provide quick-turnaround results (within 1 hour). Sampling will continue at each profiling location, at 10-ft intervals, until the target completion depth is reached.

Proposed sampling intervals are dependent upon the location of the profiling point (Table 4). For example, at profiling points located adjacent to existing morning well clusters, sampling will begin 10 ft below the deepest well screen interval. At new locations, the first profiling sample will be collected at approximately 60 ft bgs. The maximum proposed depth for the groundwater profiling is 160 ft bgs, which is the maximum anticipated depth for the overburden/bedrock interface.

The groundwater profiling activities will be conducted using an iterative approach, with the potential for profiling points to be added, if needed, to delineate the lateral and vertical extent of the dissolved-phase plume and to establish perimeter monitoring points. Therefore, should analytical results suggest that the initially selected profiling locations are within the dissolved-phased plume, the proposed monitoring well may be relocated. For example, if a profiling location intended to establish the lateral extent of the dissolved-phase plume shows elevated levels of VOCs, then it would be necessary to step out further from the centerline of the plume to establish a perimeter monitoring well location.

3.1.3 Unconsolidated Monitoring Well Installation

Up to four monitoring wells, including one shallow well intersecting the water table and up to three wells installed below the water table, are planned to be installed at each of the new multi-

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[8] The single well pilot test for the downgradient ozone sparging system is detailed in Section 4. The full-scale system design will be based on the successful completion of the pilot test.

port well locations (Table 5). Actual well depths and screened intervals will be determined based on the results of the groundwater profiling. Multiport well construction diagrams are provided in Appendix C.

One 10.25-in. diameter borehole will be installed at each multi-port well location using mud-rotary drilling methods. Up to four wells will be installed within a multi-port well location, with wells co-located within a 4-in. diameter polyvinyl chloride (PVC) casing installed within each 10.25-in. diameter borehole. Each well will consist of a 0.75-in. teflon tubing extending from ground surface through the PVC casing to the top of the desired screened interval. Two 0.5-in. PVC 90-degree elbows will be used to connect the polyethylene tubing to the well screen, located outside the PVC casing. Well screens will consist of 0.75-in. diameter, 0.020-in. slot, schedule 80 PVC screen. Wells intersecting the water table will be installed with a 10-ft long screen. Wells below the water table will be installed with a 5-ft long screen. Each multi-port system will be assembled above ground and lowered into the borehole.

Size #0 sand will extend from approximately 2 ft below to 2 ft above each well screen. A bentonite seal will be placed above/between each filter pack. The remaining borehole above the uppermost filter pack and bentonite seal will be filled with a bentonite/cement grout mix and the well will be completed at ground surface with a steel protective cover.

3.1.4 Bedrock Monitoring Well Installation

The two bedrock monitoring wells will be installed at the MW-13 and MW-16 clusters, respectively. The bedrock wells will be installed using mud rotary drilling to the bedrock interface, and PQ rock coring techniques to drill approximately 2-4 ft into bedrock. This will be followed by NQ rock coring through the PQ drill stem to advance the borehole approximately 20 ft into bedrock. A 2-in. diameter PVC riser with a 20-ft section of 0.01-in. slot screen will be installed to prevent collapse of bedrock, with size #0 sand foundation seal above the screen interval and the remaining casing grouted in place.

Well installation will be performed under the full-time supervision of field geologist. At a minimum, the following information will be recorded by the field geologist:

- Date/times drilling occurred
- Borehole depth information
- Rock quality density (bedrock)
- Description of fractures (bedrock)
- Lithology description
- Headspace photoionization detector (PID) readings
- Any unusual characteristics (e.g., odor, staining, etc.)
- Depth to water
- Drill rig behavior and penetration rate.

Following completion of each well, steel flush mount or stick up protective covers will be installed at the ground surface.

3.1.5 Well Development

The newly installed bedrock monitoring wells will be developed by surging and purging using a submersible pump no sooner than 48 hours after final grouting of each well is completed. The entire screened intervals of the bedrock monitoring wells will be surged prior to pumping. A minimum of 3 well volumes will be purged from each well during development, with 1 well volume consisting of the saturated volume of the annular space, plus the volume of water (if any) added during well installation to control running sands or lost to the formation during rock coring. Pumping rates for development will range between 1 and 2 gal per minute for bedrock wells. Unconsolidated multi-port wells will be developed to the extent practicable using a bladder pump.

Well development parameters, including temperature, pH, conductivity, oxygen reduction potential, and turbidity, as well as depth to water, will be monitored during development. Development and monitoring will be conducted until parameters have stabilized and turbidity is below 50 nephelometric turbidity units (NTU).

3.1.6 Well Surveying

Wells will be surveyed upon completion. Horizontal and vertical coordinates for each new location will be integrated with existing survey information for the Oasis site. The surveyor will establish elevations with respect to benchmarks currently installed at Fort Drum. The elevations for all new locations will be established both for land surface and for the top of casing at a measuring point notch. Vertical measurements will be referenced to the National Geodetic Vertical Datum of 1929 and be reported to 0.01 ft.

Horizontal control will be established by traverse runs to establish location with respect to the New York State planar horizontal coordinate grid system and be provided in New York State planar and Universal Transverse Mercator coordinates (NAD83). Horizontal traverses will be tied into established permanent benchmarks. Horizontal traverse runs will be tied back to initial control points as a check for closure and error of closure will be recorded. The horizontal location of wells will be reported to within 0.1 ft.

3.1.7 Groundwater Monitoring

The new monitoring well clusters will be integrated with the existing site-wide, quarterly groundwater monitoring program, with the first event anticipated to occur in December 2011. Groundwater samples will be collected from the monitoring wells no sooner than 2 weeks after well development is complete. Prior to sampling, all site monitoring wells will be gauged for groundwater elevation prior to sampling to generate potentiometric surface maps.

Low-flow sampling techniques will be utilized. The wells will be purged using a submersible Grundfos pump, with a flow rate of approximately 0.3 L per minute. Multiport monitoring wells will be sampled using a bladder pump (e.g., Solinst Model 408M Micro Double Valve Pump or similar, with a flow rate of 150 mL per minute). Water quality parameters, including temperature, pH, oxidation reduction potential (ORP), conductivity, salinity, dissolved oxygen (DO), and turbidity, will be monitored at 3-minute intervals using a water quality monitoring system with flow-through cell. In addition, the depth to water will be measured every 3 minutes during purging using a water level meter. Wells will be purged until the parameters have stabilized, at which time the groundwater samples will be collected.

Groundwater samples will be collected using clean nitrile gloves and placed in laboratory containers labeled with well number, date/time of sample collection, and method of analysis. Sample containers will be placed in ice-filled coolers prepared for shipment/delivery to Accutest for analysis of VOCs (including MTBE and naphthalene) by EPA Method 8260B and TPH-DRO by EPA Method 8015M.

3.2 LNAPL-GROUNDWATER FLUX STUDIES

The selection of the source area groundwater remedy will be based upon the residual concentrations of key constituents, namely MTBE, naphthalene, and benzene, as well as residual surfactant in the Parcel 1 area. As detailed in Section 2.3.3, there is variability in the spatial and temporal concentrations of the key constituents. Because these constituents will drive the selection, design, and implementation of the groundwater remedy, it is critical to understand the variability in the chemistry of the LNAPL and the resultant flux to groundwater. To assess the variability of LNAPL chemistry and flux to groundwater, samples of LNAPL will be collected from locations across the plume (except in the Parcel 1 area where groundwater can be collected directly), mixed vigorously with site groundwater, and allowed to equilibrate before the dissolved phase is decanted and sent for laboratory analysis.

3.2.1 Extent of the Proposed Investigation

The concentration of the key constituents varies spatially and temporally. Initially samples from five locations will be collected, processed, and analyzed (Figure 14). The location of the five samples will be based on the noted variations in MTBE concentrations at the MW-01S/MW-12I and the MW-09I1 locations (one sample in the vicinity of each location), with remaining three locations spread spatially across the site (one from RW-01, one from the MW-21 area, and from the MW-22 area). It should be noted that these locations are not intended provide a full assessment of the variability present, rather they are intended to shed light on the degree of previously observed variability.

Following analysis and interpretation of the initial five samples, the locations and number of samples for a larger scale investigation will be determined. A maximum of 70 total locations is estimated for the larger-scale investigation based on the radius of influence of the current DPE system and the ability to obtain representative samples of LNAPL from the sample locations.

3.2.2 Methodology for Sample Collection

LNAPL samples will be collected using a small diameter bailer. In areas where there are significant thicknesses of LNAPL present, the entire LNAPL thickness will be collected and mixed prior to decanting an aliquot for testing. Site groundwater will be obtained from the water supply well installed during SEAR implementation. The samples and site groundwater will be transported to the USACE- Baltimore District laboratory facility at Fort McHenry.

3.2.3 Laboratory Analysis

For each sample, 100 mL of LNAPL (based on the mole fraction and effective solubility of each constituent in the LNAPL) will be mixed with 1 L of site groundwater and agitated vigorously for 30 seconds, then allowed to equilibrate in a capped separatory funnel for a minimum of 7 days (based on the prior solubility study)[4]. Following the equilibration period, the dissolved phase will be decanted into laboratory glassware and submitted to Accutest Laboratories for analysis of VOCs by EPA Method 8260B.

3.3 FIELD EQUIPMENT CALIBRATION AND MAINTENANCE

Field equipment to be used during well installation, development, and sampling includes PIDs, interface probes/water level meters, water quality equipment, and submersible Grundfos pumps; and controllers, generators, and a water quality meter with a flow-through cell, which includes probes for measurement of temperature, pH, turbidity, DO, temperature, and conductivity. Prior to mobilization, equipment will be inspected for proper operation. This equipment will be calibrated and maintained at a frequency and under conditions per manufacturer’s specifications, and Sections 6 and 11 of the Basewide QAPP (Appendix B). Manufacturer’s instrumentation and equipment manuals will be available in the field.

Calibration and maintenance activities will be recorded on data quality control reports as presented in Section 14 of the Basewide QAPP. Calibration standards required for the instrumentation will be checked for expiration prior to use and the lot number recorded on the data quality control report.

After each use, equipment will be decontaminated as defined in Section 3.6. All equipment will be checked and stored in an area shielded from weather conditions.

3.4 FIELD DOCUMENTATION AND REPORTING

Field logbooks, soil boring logs, groundwater sampling logs, and chain of custody forms will be used during all on-site work. A dedicated field logbook will be maintained by the Site Manager overseeing the site activities. Field activities, including installation of soil borings/profiles and groundwater monitoring wells, will be photo documented.

Soil and groundwater samples will be handled and packaged following proper chain of custody procedures and delivered to the analytical laboratories within 24 hours to meet all holding time requirements. The chain of custody record is a document that tracks the collection, possession, and handling of samples from the time of sampling to the time the samples are analyzed.

3.5 EQUIPMENT DECONTAMINATION

Drilling equipment and sample collection equipment will be decontaminated between each drilling and sampling location. A self-contained decontamination area will be established at the site. Drilling equipment will be steam cleaned following installation of each boring/well. Disposal of decontamination fluid is discussed below.

Field equipment used during well development and sampling will be washed with Alconox detergent and water, then rinsed with deionized water between individual wells to prevent cross-contamination.

3.6 INVESTIGATIVE-DERIVED MATERIAL

Investigative-derived material generated during field investigation activities will include:

- Drill cuttings (soil) derived from soil boring/well installation activities
- Development and purging fluids
- Decontamination fluids
- Fluids from the LNAPL-groundwater flux studies
- Used personal protective equipment.

The following sections describe the procedures that will be followed for handling investigative-derived material.

3.6.1 Soil

A distiller will be used during installation of the monitoring wells in order to separate sand from rotary drilling fluids during the drilling process. Sand and rotary drilling fluid generated during the installation of the intermediate and deep monitoring wells will be staged in rolloffs pending transport to Building P-2019 for disposal by Fort Drum.

3.6.2 Water

It is anticipated that the decontamination fluid generated during steam-cleaning activities for borings/wells will be discharged to the ground surface. Decontamination and well development water, as well as fluids remaining from the LNAPL-groundwater flux study, will be processed (via a filter box and oil/water separator) and incorporated into the DPE process stream.

Purging fluids will be generated during sampling of the monitoring wells. These fluids will be processed via the oil/water separator and incorporated into the LNAPL Edge DPE system process stream.

3.6.3 Used Personal Protective Equipment

Used personal protective equipment will be double-bagged and disposed of through Fort Drum's solid waste program as general refuse.

4. OZONE PILOT TESTING

4.1 PURPOSE

The purpose of pilot testing ozone sparging is to collect data to determine its effectiveness as a remediation technology to achieve New York State Groundwater Standards[9]. If test results indicate ozone sparging is effective, then the parameters reduced from the pilot test (i.e., effective zone of treatment, ozone loading, and system flow rates) would be used in the full-scale system design.

4.2 TECHNOLOGY OVERVIEW

Ozone sparging is an *in situ* chemical oxidation process that employs injected ozone (O_3) to remove a variety of adsorbed and dissolved-phase organic contaminants in subsurface soils and groundwater including chlorinated solvents, petroleum hydrocarbons, and fuel oxygenates. Ozone gas is produced using an ozone generator unit and is mixed with ambient air at the surface. The resulting mixture is injected into the saturated zone below or within the impacted zone to accelerate organic compound oxidation. As ozone gas moves vertically through the soil column, organic compounds are oxidized and eventually mineralized.

4.3 LOCATION

The location selected for ozone pilot testing is approximately 1,000 ft east (downgradient) of the LNAPL plume edge and directly upgradient from the MW-16 well cluster (Figure 15a). This pilot location is within an open, unpaved area which is easily accessible and would be suitable for temporary installation/setup of the test equipment and aboveground piping.

The depth to water in this area generally fluctuates from 50 to 53 ft bgs, with the dissolved-phase groundwater plume extending from at least 70 to 115 ft bgs. The highest concentrations of total VOCs (565 µg/L), which primarily include benzene, MTBE, and naphthalene, in the area are present in the D2 interval (screened from 90 to 100 ft bgs) of the MW-16 cluster. At the deepest interval of the MW-16 cluster (screened from 110 to 115 ft bgs), only estimated concentrations of benzene and MTBE have been detected; however, during the June 2011 event, naphthalene was also detected in this well at 11 µg/L.

Site-specific data from the ozone pilot test area were collected during the pre-design investigation and used to finalize well construction (specifically screen depth intervals). A summary of the pre-design investigation data collection will be provided in the ozone pilot test report.

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[9] NYS Regulation 6 New York Code of Rules and Regulations Part 703 Class GA standards

4.4 APPROACH

It is anticipated that approximately 4 weeks will be required to complete the overall ozone sparging pilot, during which two different methods for delivering ozone may be tested:

Method	Flow Rate (cfm)	Ozone Loading (lbs/day)	Ozone Concentration (ppm)
Lower Flow Rate	3	3	5,200
Higher Flow Rate	6	3	2,600

NOTE: cfm = cubic feet per minute
ppm = parts per million

The pilot test will begin with an air injection rate of 3 cfm, which will deliver approximately 5,200 ppm ozone. The following key parameters will be monitored during the test: ozone concentration, DO, and ORP. Subsequent to the start of ozone injection, it is expected that ozone would be detected (background is expected to be zero), DO would be expected to increase (through the injection and breakdown of ozone), and ORP would be expected to increase (an indicator of an oxidized environment). After 2 weeks, the injection flow rate will be increased to 6 cfm (2,600 ppm ozone). Regardless of the flow rate, the test equipment will deliver 57 grams per hour of ozone to the subsurface. The concentration of ozone in the injected air stream will decrease as the air flow is increased.

4.5 BASIS FOR OZONE PILOT TESTING

This section provides an overview of preliminary calculations which were performed to provide a basis for the ozone pilot testing. The calculations included estimations of the ozone mass required to treat the VOCs in the subsurface due to both natural and contaminant reactions. Calculation sheets are provided in Appendix D. In addition, a summary of literature reviewed to support the anticipated zone of influence, as well as results of air sparging implemented at other Fort Drum sites are provided below.

4.5.1 Ozone Loading Rate Assessments

Two methods were used to assess the ozone loading rates. The first method evaluated the total stoichiometric oxidant demand from the subsurface and compared it to the oxidant mass assumed to be provided during the 30-day pilot study. This oxidant demand included the oxidant demand associated with the soil and groundwater. The second method assesses the stoichiometric demand under equilibrium conditions, which would exist when the ozone treatment zone has been established and the only remaining source of oxidant demand is the incoming VOC flux from upgradient groundwater. A summary of the calculations for each method is provided in Appendix D.

Method 1

The expected oxidant demand was calculated from the sum of the stoichiometric VOC demand, oxidizable metals demand, and soil demand[10]. The calculated total oxidant demand for the 30-day pilot test is summarized below.

Component	Oxidant Demand (grams)
Stoichiometric Demand	6,431
Soil Oxidative Demand	1,929
Ferrous Iron Demand	3,712
Total Oxidant Demand	12,072

The total quantity of ozone proposed to be delivered during the 30 day pilot test is 40,830 grams; therefore, the test ozone supply is assessed to be 3.4 times the expected oxidant demand under this method. To estimate the amount of time required to satisfy the oxidant demand, the total ozone demand (12,072 grams) can be divided by the expected ozone delivery rate (1,361 grams/day), which yields approximately 9 days.

Method 2

The results of the calculations indicate that a mass flux of 4.61 grams of VOC would enter the treatment zone each day. This flux would require an oxidant demand of approximately 14.79 grams per day or 443.6 g for the 30-day pilot test. To account for auto-decomposition of the gaseous ozone over time and distance, a gaseous ozone half-life of 20 hours was assumed (Kerfoot 2004)[11]. For a 30-day period, it was calculated that 1,373 grams of ozone would remain within the zone of treatment. This equates to approximately 3.1 times the expected oxidant demand from the incoming groundwater.

4.5.2 Anticipated Zone of Influence

A general basis for zone of influence was determined through a review of relevant literature, which included USACE engineering manual EM 1110-1-4005 (Engineering and Design: In-Situ Air Sparging); EPA 510-R-04-002 (How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites); and Conceptual Modeling of Air Sparging for Groundwater Remediation (Reddy and Adams 2008)[12]. Based on this review, zones of influence of up to 40 ft have been observed in geologic conditions similar to Oasis (i.e., fine to medium sand). In addition, the results of air sparging pilot testing at other Fort Drum sites resulted in measured zones of influence ranging from 30 to 40 ft (EA 2005)[13]. A conservative monitoring point placement of 5, 15, and 25 ft was selected to be within the expected zone of influence.

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[10] A procedure for ozone demand calculations for MTBE, as a primary constituent, was published in the *MTBE Remediation Handbook* (E.E. Moyer and P.T. Kostecki, eds., Amherst Scientific Publishers, Amherst, MA, 2003).
[11] Kerfoot 2004. National Groundwater Association. Conference of MTBE and Perchlorate.
[12] Reddy and Adams. 2008. Conceptual Modeling of Air Sparging for Groundwater Remediation
[13] EA. 2005. Work Plan for Dual Phase Extraction System Enhancements, AAFES Station, Fort Drum, New York.

Based on the Method 2 ozone loading calculation results, the ozone concentrations remaining (after auto-decomposition) at the leading edge of the ozone injection area will reach equilibrium (i.e., ozone concentrations sufficient to oxidize the influent VOCs concentrations) after approximately 9 to 10 days of travel time in the subsurface. However, it should be noted that partial treatment of the influent VOC concentrations could occur further outside of this equilibrium condition. This equates to an approximate ozone radius of treatment of 30 to 35 ft. Based on the assessed bubble travel velocity, it is anticipated that the two vertical zones of treatment will overlap and will address the vertical extent of the dissolved-phase plume.

4.6 PRE-DESIGN INVESTIGATION

Additional delineation of the dissolved-phase groundwater plume was required in the pilot test area to determine the ozone treatment intervals. Ozone sparging wells and associated monitoring point clusters were installed based on the groundwater profiling data collected during installation of the first monitoring point cluster. Groundwater profiling methods similar to those detailed in Section 3.1.2 were used in the ozone pilot test area. To assist in assessing the oxidant demand for the ozone sparging test area, groundwater (from one of the ozone monitoring points) and soil (from the ozone injection point) were collected during the pre-design investigation for laboratory analysis of total organic carbon and total inorganic carbon.

4.7 TEST LAYOUT

Two ozone sparge points (located approximately 5-ft apart), three groundwater monitoring point clusters, and one additional geophysical monitoring point will be used to determine the effective radius of treatment of the ozone sparging system. The monitoring point clusters were located at 5-ft (northeast), 15-ft (southeast), and 25-ft (east) intervals downgradient of the sparge points (Figure 15a). The additional geophysical monitoring point was located 5 ft southeast of the sparge points.

4.8 WELL DESIGN

4.8.1 Sparge Points

Two ozone sparge points were installed at 78-80 ft and 100-102 ft, with the deeper sparge point located approximately 5 ft downgradient of the shallow sparge point (Figure 15b). These depths were selected based on the groundwater profiling results from the ozone pilot study area. Two separate drilling methods were used to further evaluate the preferred drilling method for the full-scale implementation: the shallow ozone sparge point was installed using 3.25-in. hollow-stem auger drilling methods, while the deep ozone sparge point was installed using a 3.9-in. (nominal 4-in.) diameter roller bit mud rotary drilling method.

The depth of the deeper point (100-102 ft bgs) was selected in the field based on the results of the pre-design investigation (i.e., based on vertical delineation of the dissolved-phase groundwater plume and identification of lower permeability material in the soil sample collected from the 108-112 ft bgs interval). The shallow sparge point was located at the mid-point between the deep sparge point and the water table.

Each ozone sparge point was constructed with a 2.75-in. diameter, 2-ft long Spargepoint® assembly (14-in. long micro-porous PVC screen with end cap and top adapter/coupler) and an appropriate length of 0.75-in. diameter Schedule 80 PVC riser (flush-threaded with Viton o-rings) extending to the ground surface. Native sand was allowed to collapse around the sparge point to extend from the base of the boring (at least 6-in. below base of sparge point) to a minimum of 1-ft above the top of the sparge point. A 3-ft-thick bentonite pellet seal was installed via tremie-pipe above the sand pack. The remaining area of each borehole was filled via tremie-pipe with a bentonite/cement grout mix to the ground surface. Upon completion, the sparge point was filled with distilled water. Sparge point construction diagrams are provided in Appendix C.

4.8.2 Monitoring Point Clusters

Three monitoring point clusters were installed northeast, southeast, and east of the injection points at distances of 5 ft, 15 ft, and 25 ft, respectively. Four vertical intervals were installed at each monitoring point cluster, with two intervals located above each sparging point interval (Figure 15b). An additional monitoring point (consisting of a solid, transparent casing) was installed at a single depth approximately 5 ft southeast of the injection points to facilitate geophysical logging.

Two, 2-in. diameter monitoring points were co-located in each nominal 6-in. diameter borehole installed using mud rotary drilling methods. Wells were installed with appropriate lengths of 0.010-in. slot, Schedule 40 PVC well screen[14]. Size 0 filter pack was installed from the base of the boring to approximately 2-ft above the top of the deepest well screen. A bentonite seal was installed above the sand pack to approximately 1 ft below the bottom of the upper well screen. Filter pack material was installed from the top of the lower bentonite seal to approximately 2 ft above the upper well screen. A second bentonite seal was installed above the upper filter pack. The remaining area of the boreholes were filled with a bentonite/cement grout mix and completed at ground surface with a steel, flush-mount cover.

The additional monitoring point at the 5-ft distance (southeast of the injection point) was installed in the nominal 6-in. diameter mud-rotary borehole that was advanced during pre-design groundwater profiling to facilitate downhole geophysical logging. The monitoring point was constructed with transparent 2-in. diameter, Schedule 40 PVC with an end cap. No filter pack was installed. The formation material surrounding the monitoring point was allowed to collapse in place as the drilling equipment is retracted from the borehole.

---

[14] Well screen lengths will vary by vertical interval (i.e., longer for the shallow interval versus shorter for the intermediate/deep interval). Actual lengths will be based on the results of the groundwater profiling.

4.9 PILOT TEST

4.9.1 Equipment

A rented trailer-mounted ozone sparging test unit will be mobilized to the site by an equipment subcontractor (Bisco/Kerfoot Technologies) to implement the pilot test. The ozone sparging test unit, which consists of an ozone generation subsystem, compressed air subsystem, and associated controls/pressure gauges, will be operated using a rented generator. Ozone sparging equipment will be connected to the sparging points using 0.5-in. diameter tubing.

The pilot test system will utilize an air compressor capable of producing up to 14.7 cfm at 100 psi. The proposed injection rates and pressures will be substantially less than the compressor capabilities. The system will be equipped with pressure regulators between the air compressor and the injection points to control/limit the amount of pressure being applied to the subsurface. The system will also be equipped with two oxygen concentrators that feed a pair of 30 grams per hour ozone generators.

4.9.2 Ozone Delivery

Both ozone approaches deliver the same overall quantity of ozone of 3 lbs/day (1.5 lbs/injection point/day) to the subsurface, but at different concentrations in the injected air stream. It is anticipated that large-scale changes in groundwater chemistry (i.e., DO, ORP, conductivity, and pH) will be observed within 1-2 weeks of initiating the pilot test. However, it is anticipated that measureable changes in at least some of the field parameters should be evident in less than one week, especially in the monitoring points located closer to the injection points.

As described previously, the first portion of the pilot test will consist of the injection of ozone at a lower flow rate (3 standard cfm) which results in a higher ozone concentration (approximately 5,200 ppm). The second portion of the pilot test would consist of the injection of ozone in a higher flow rate (6 cfm) which results in a lower ozone concentration (approximately 2,600 ppm).

Pulsed Operation

Pulsed ozone injection is typically performed to enhance distribution and increase residence time for the ozone to react with the constituents of concern. The ozone injection wells will be pulsed by cycling the flow of air from the deep injection point to the shallow injection point on a half-hour basis. That is, air will be delivered to the deep point for the first half-hour (while the shallow point does not receive air flow), then solenoid valves divert the flow to the shallow point for the next half-hour (while the deep point does not receive air flow). This cycle will repeat itself for the duration of the test.

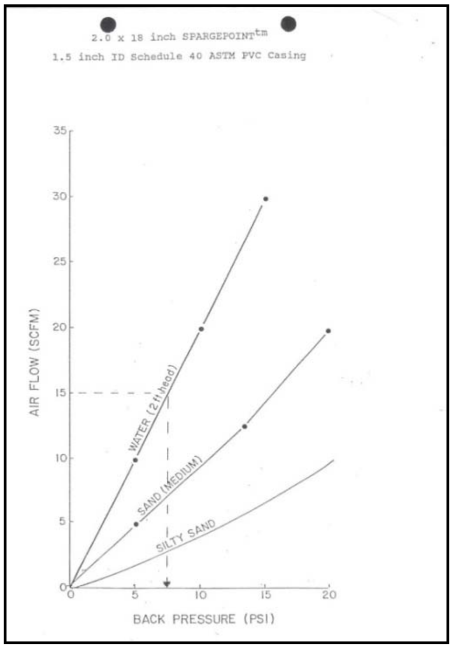
Injection Pressures

Since the Oasis pilot test will employ two different injection depths (20 ft and 40 ft below the static water table elevation) using two different flow rates (3 cfm and 6 cfm), injection pressures will vary. The injection pressure was calculated based on the following components[15] (Appendix D):

- Hydrostatic pressure (needed to displace the column of water standing in the well pipe)
- Frictional losses in pipe (head loss due to friction of fluid moving between the wellhead and well screen): these losses were assumed to be negligible due to a combination of the low air flows, injection point and piping diameters, and relatively short distance of piping (i.e., less than 100 ft).

- Spargepoint® air-entry pressure[16]: backpressure resulting from air flow through the injection point in a medium sand (see Figure). The backpressures correspond to 3 psi and 6 psi for 3 cfm and 6 cfm of air flow, respectively.

- Formation air-entry pressure: Reference value for formation air-entry pressure for the fine-medium sand (0.44 psi).



Based on the results of the calculations, the following air entry pressures were estimated:

Static Head (ft bgs)	Flow Rate (cfm)	Pressure (psi)
20	3	12.1
20	6	15.1
40	3	20.8
40	6	23.8

As a precaution, additional calculations were performed to establish the maximum air injection pressure that would be used during pilot testing, in order to prevent pneumatic fracturing of the formation. The maximum injection pressure was calculated based on the following components[13] (Appendix D):

- Overburden pressure (unsaturated and saturated soil)
- Soil characteristics (for fine to medium sand)
- Applied safety factor of 70%.

Based on the results of the calculations, the maximum injection pressures for the shallow and deep injection points are 46.8 psi and 59.9 psi, respectively.

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[15] USACE guidance manual EM 1110-1-4005 (*In-situ* Air Sparging)

[16] Used in lieu of "formation air-entry pressure" since the injection points were installed without a filter pack.

4.10 MONITORING

4.10.1 Field

System monitoring will include collection of injected air flow and ozone concentration at the system/injection well. Performance monitoring will include periodic measurements of soil gas pressure, groundwater elevation, DO concentration, ozone concentration, and ORP in the surrounding monitoring point clusters (Table 6). In addition, groundwater elevation and soil vapor VOC concentrations will be measured in the shallow monitoring points at each cluster. Performance monitoring data will be collected more frequently during the first day and week of operation during each flow rate test.

In addition to the standard performance monitoring, changes in water saturation resulting from ozone sparging will be collected from the area of the supplementary geophysical monitoring point installed 5 ft from the injection well by measuring resistivity. The development of air channels and changes in water saturation can be assessed by logging the resistivity prior to system start-up and then subsequently logging the resistivity as the test progresses over hours and days. Because the resistivity of the formation and the water chemistry do not change dramatically over this period of time, a change in resistivity (usually an increase) would reflect increased air in the formation. This method will provide two-dimensional qualitative data on the distribution of air in the formation as a result of the pilot test activities.

A suite of downhole geophysics will be run prior to start-up including resistivity via electromagnetic induction, natural gamma, spontaneous potential, and single point resistance in order to identify any anomalies which may impact the resistivity method. Resistivity via electromagnetic induction will be logged within 1 hour of startup, at 4 hours after startup, and 1 day after startup. The downhole geophysical equipment to be used includes the following Mount Sopris instruments: Matrix Winch/Logger, 2PGA-1000 probe, and 2PIA-1000 probe.

4.10.2 Analytical

In addition to the field monitoring, groundwater concentrations will be monitored during the pilot testing period to assess the reduction in VOC and TPH-DRO concentrations. Groundwater samples will be collected from the three monitoring point clusters using low-flow sampling techniques (see Section 3.1.7). Sampling events will be performed prior to initiation of the pilot test, after 2 weeks of ozone sparging, and following completion of the pilot test.

4.11 DATA EVALUATION

The data collected during the pilot test will be evaluated to estimate the ozone sparging zone/radius of influence in the saturated zone and contaminant oxidation. The final anticipated use of this technology will rely on the natural flow of groundwater to transport contaminants through the line of ozone injection wells; therefore, the success of the barrier line will eventually be measured by the amount of reduction in contaminant concentrations observed between the upgradient and downgradient monitoring wells. For the purposes of the 30-day pilot, test parameters will be monitored in the pilot study monitoring points located 5 ft, 15 ft, and 25 ft from the injection points, and will assess the distribution of ozone and the relative reduction of VOCs within this zone of treatment produced by the pilot test. A description of how these parameters will be evaluated follows.

Determination of Zone/Radius of Influence

The zone/radius of influence of the ozone sparging system will be determined by evaluating data obtained from the monitoring points during the pilot test: ozone, concentrations of VOCs, DO, ORP, differential pressures, water table elevations, and vadose zone soil VOC concentration data. Each of the data sets will be reduced and represented graphically as follows:

Direct Indicators

- Increases in ozone measurements above pre-operation levels (anticipated to be non-detect) will be evaluated. Detections of ozone will be interpreted as confirmation ozone sparging has influenced the associated monitoring point.

- Reductions in dissolved concentrations of VOCs below baseline (pre-operation) levels will be evaluated. Reductions in concentrations of constituents of concern will be interpreted as confirmation ozone sparging has influenced the associated monitoring point.

Indirect Indicators

- Increases in DO measurements above baseline/pre-operation levels will be evaluated in reference to the distance from the sparging well. Increases in DO will be interpreted as an indication that air injection has influenced the associated point. Oxygen (O_2) is a by-product of ozone (O_3) oxidation.

- Increases in ORP above baseline/pre-operation levels will be evaluated in reference to the distance from the sparging well. Increases in ORP will be interpreted as an indication that ozone/air injection has influenced the associated point.

- Increases in soil gas pressures above baseline/pre-operation levels will be evaluated in reference to the distance from the sparging well. Increases in pressure will be interpreted as an indication that air injection has influenced the associated point. Injected air would have entered the monitoring point and pressured the head space.

- Increases in the water table above baseline/pre-operation levels will be evaluated in reference to the distance from the sparging well. Increases in water table (i.e., groundwater mounding) will be interpreted as an indication that air injection has influenced the associated point.

Other Parameters

Total vapor-phase VOC measurements will be collected from shallow monitoring points (screened within the vadose zone) using a PID. Significant increases in VOCs in the vapor phase will be interpreted as an indication that VOCs have been volatized from the saturated zone and not oxidized. Soil vapor VOC detections would most likely trigger a lowering of the sparging flow rate to reduce volatilization.

4.12 FULL-SCALE DESIGN CONSIDERATIONS

The conceptual design for a full-scale pilot study ozone system will be developed based on the successful completion of the single-location pilot test. The data evaluation detailed in the previous section will be used to determine the optimum well spacing, ozone loading rates, flow rate, and injection pressure.

In addition to system design parameters, considerations for long-term operation and maintenance also need to be evaluated in order to determine whether ozone sparging would be a cost-effective long-term remedial measure for groundwater treatment at the Oasis. Iron precipitation is typically one of the primary concerns for long-term operation and maintenance of groundwater remediation systems, particularly when oxygen addition is a primary means of treatment. Since the pilot test well construction also included direct burial of microporous PVC injection wells, an evaluation of the potential long-term impacts of iron fouling was warranted. A summary of the calculations performed to evaluate the potential for iron fouling is provided in Appendix E.

Based on this assessment, formational plugging is unlikely to impact ozone injection capabilities for the anticipated duration of the downgradient ozone barrier system operation. However, reflux of water into the injection point during pulsed operation could occur. This reflux results in the potential for additional iron precipitation within the interior of the injection point. The degree of plugging would likely be manageable through routine operations, maintenance, and rehabilitation techniques; as long as correct check valve operation is ensured. If the check valves fail to operate as intended, higher levels of iron precipitation and additional plugging within the injection points may occur.

5. PROJECT SCHEDULE AND DELIVERABLES

The proposed schedule for implementation of the remedial investigation and preparation of project deliverables is summarized in the following table and detailed in Figure 16. The schedule identifies the tasks associated with the completion of the work effort and the duration of each. Commencement of field activities will be contingent upon Fort Drum, USACE, and NYSDEC approval of the Work Plan. It is anticipated that the duration of the proposed effort covered under this Work Plan, including reporting, will be approximately 5-6 months.

Description	Start	Complete
Remedial Investigation Work Plan	---	September 2011
Additional Site Characterization	October 2011	December 2011
Ozone Pilot Test	October 2011	December 2011
Ozone Pilot Test Report	December 2011	January 2012
Remedial Investigation Summary Report	January 2012	February 2012

Additional site characterization activities, including groundwater profiling and well installation, will be performed by USACE-Savannah District, with EA support, from October to December 2011. EA will install the wells and monitoring points required to perform the ozone pilot test concurrent with USACE drilling activities. Implementation of the ozone pilot test will begin following well development and sampling of the pilot monitoring points. The additional monitoring wells for the remedial investigation will be installed based on highest to lowest priority, and all additional monitoring wells installed will be incorporated into the site-wide well network and sampled during the next site-wide sampling event scheduled for December 2011.

The schedule does not account for delays due to conditions that are not possible to anticipate, including unscheduled Fort Drum functions that prohibit field activities and/or weather delays. Unexpected delays will be documented and reported to Fort Drum and USACE–Baltimore District within 48 hours. In the event that the schedule needs to be modified, EA will contact Fort Drum and USACE for approval of the updated schedule.

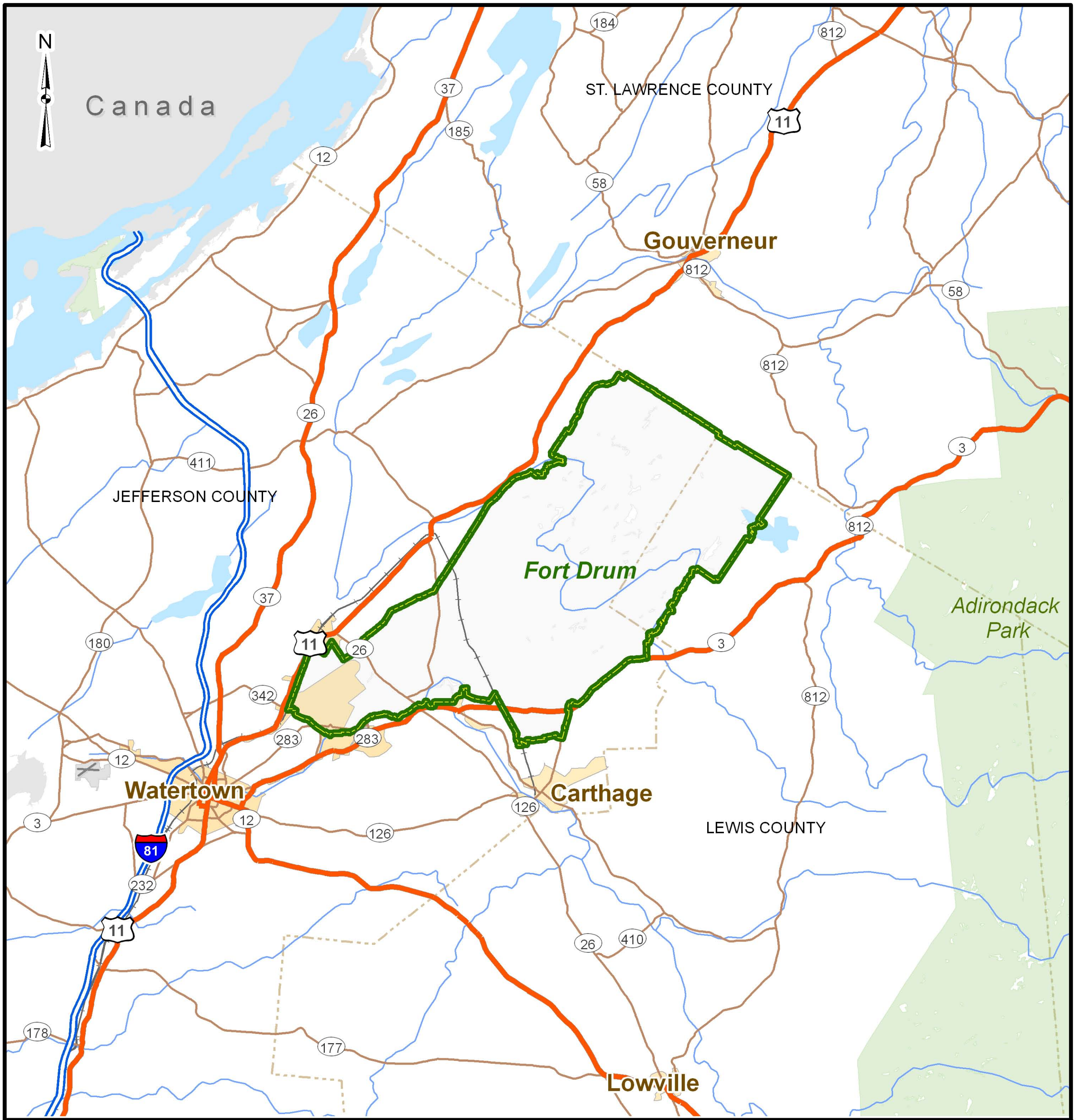

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FIGURE 1
Site Location Map

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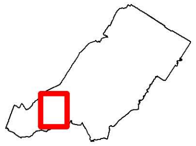
CJK	FDJR	FDJR	JMB	AS SHOWN	JANUARY 2012	6239301	G:\Projects\Federal\DOD\ Fort Drum Projects\ 6239301 (Oasis)



- Old Well Field Water Supply Well
- New Well Field Water Supply Well
- Sentinel Well

Miles

0 0.2 0.4 0.6 0.8 1

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FIGURE 2
Site Map and
Fort Drum Production Wells

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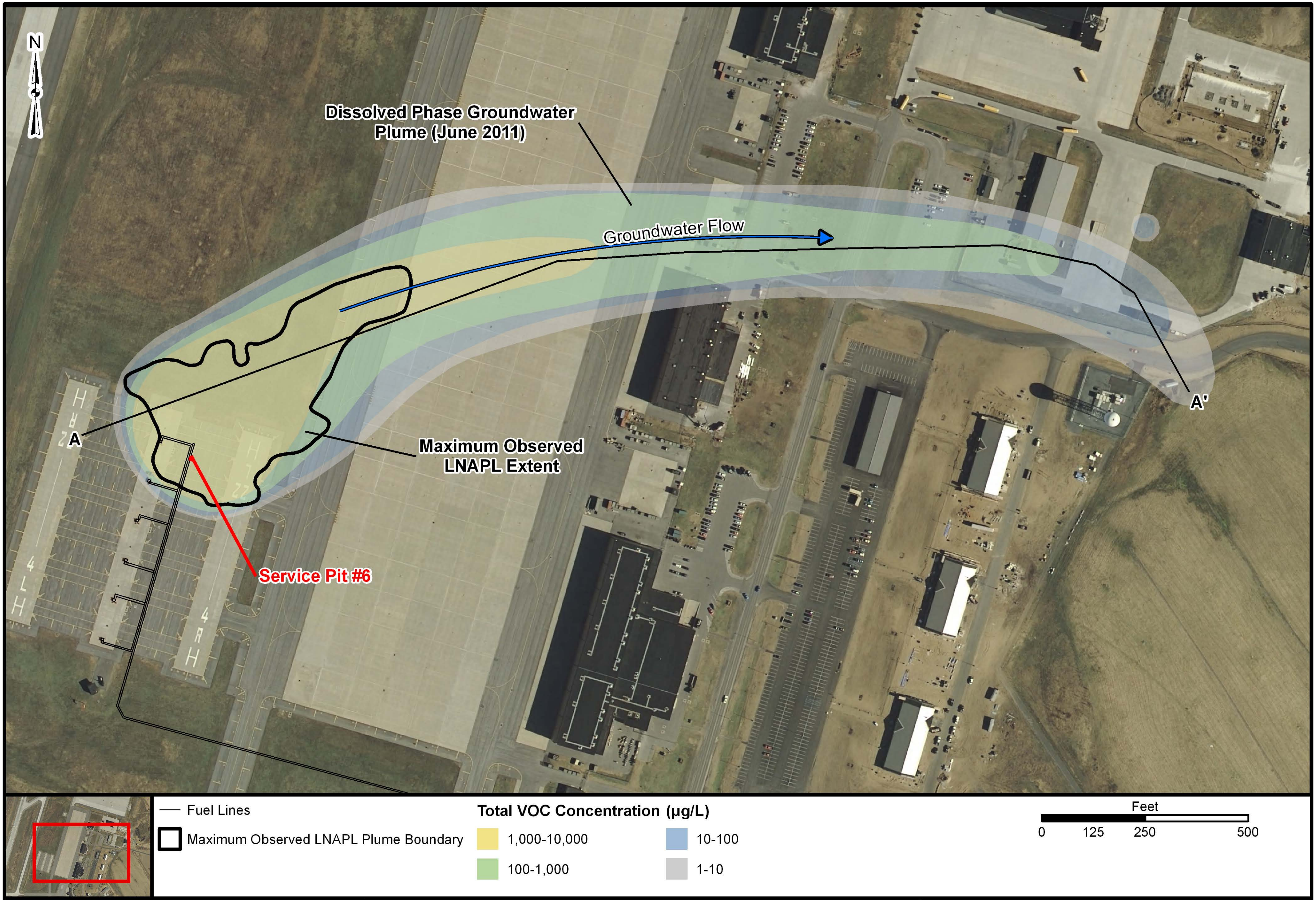

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FIGURE 3
Maximum Observed LNAPL Plume Boundary and Dissolved-Phase Plume Extent (June 2011)

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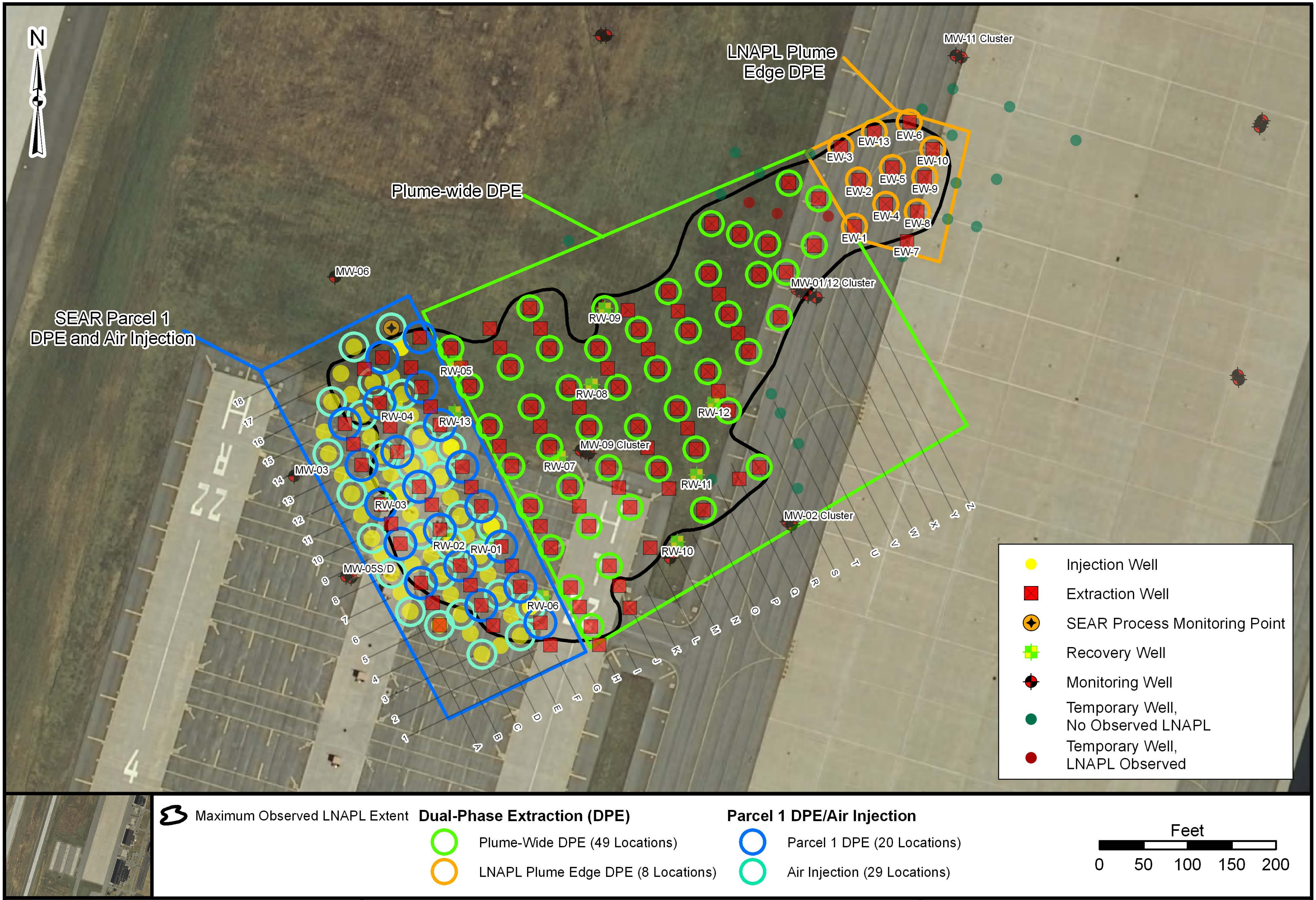

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Figure 4
LNAPL IRM Strategy

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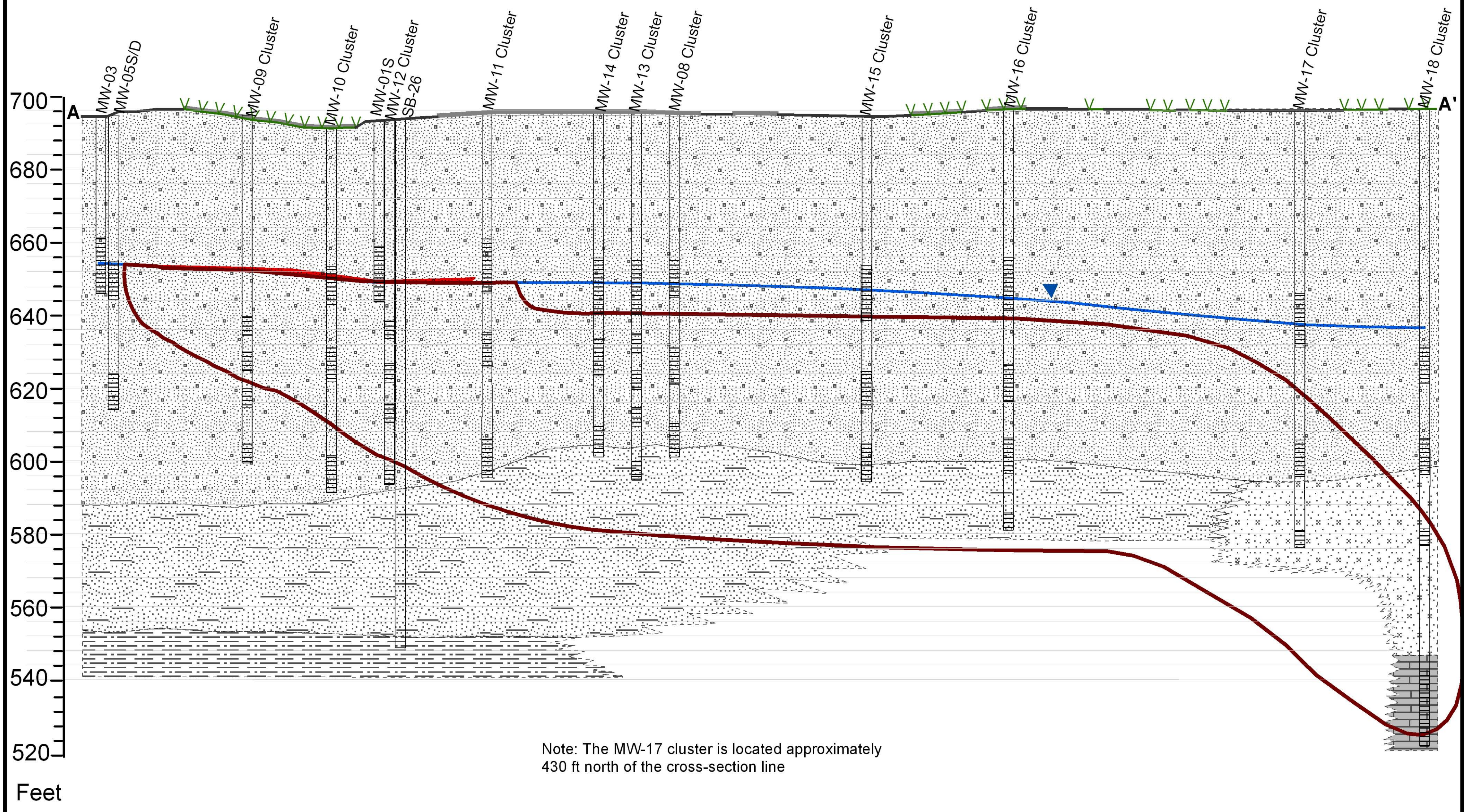
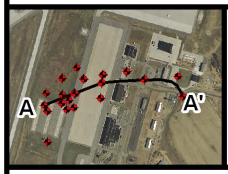


Note: The MW-17 cluster is located approximately
430 ft north of the cross-section line



- ▬ Asphalt
- ▬ Concrete
- V V Grass
- 🟥 LNAPL Plume
- ▬ June 2011 Groundwater Elevation
- ☐ June 2011 Dissolved-Phase Plume Boundary
- ▨ Fine to Medium Sand
- ▨ Very-Fine Sand / Sandy Silt
- ▤ Silt and Clay
- ▨ Medium to Coarse Sand and Gravel
- ▦ Bedrock

Feet

0 125 250 500

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FIGURE 5
Subsurface Geology

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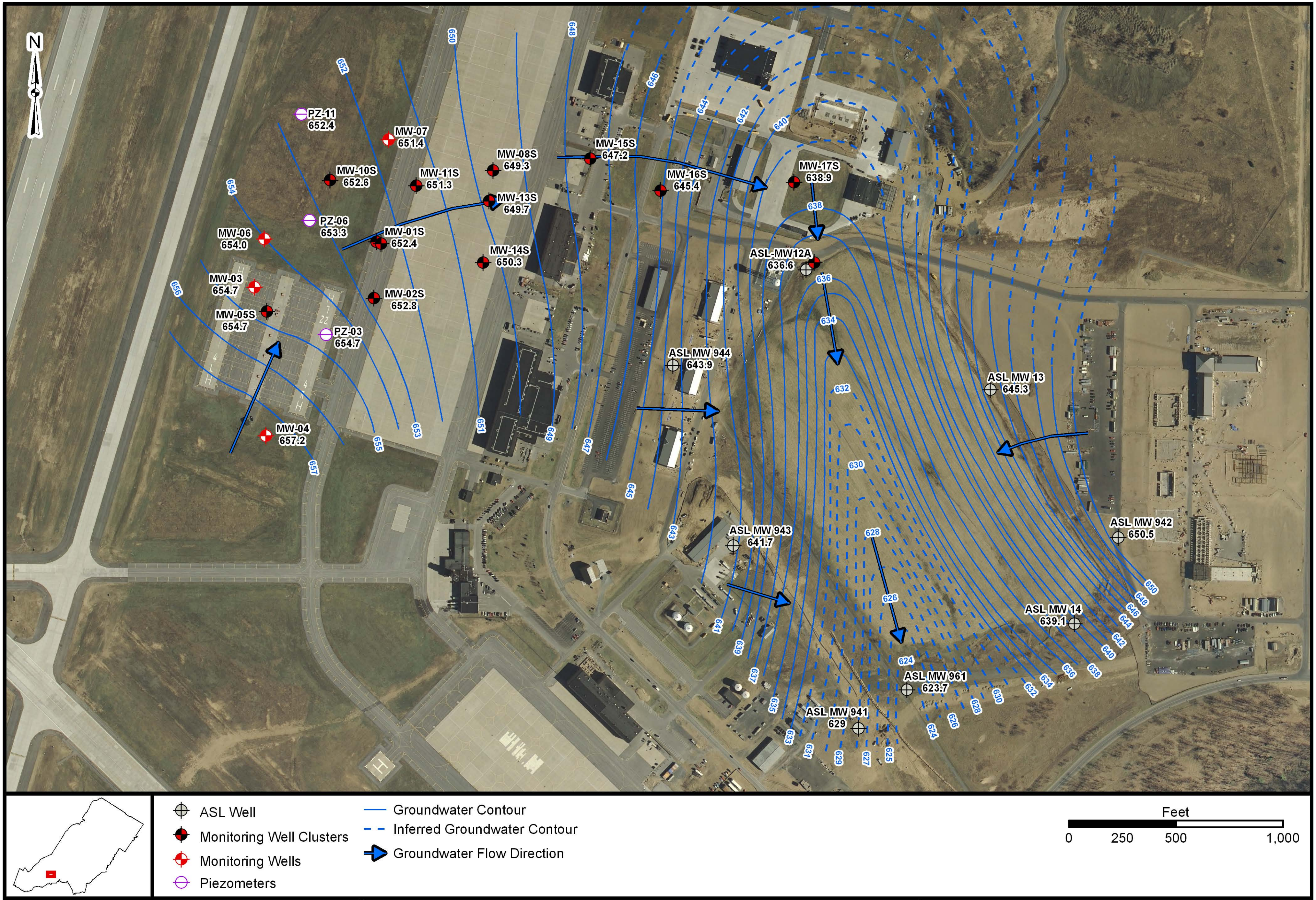

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FIGURE 6
June 2011 Interpreted Groundwater Contours
and Groundwater Flow Direction

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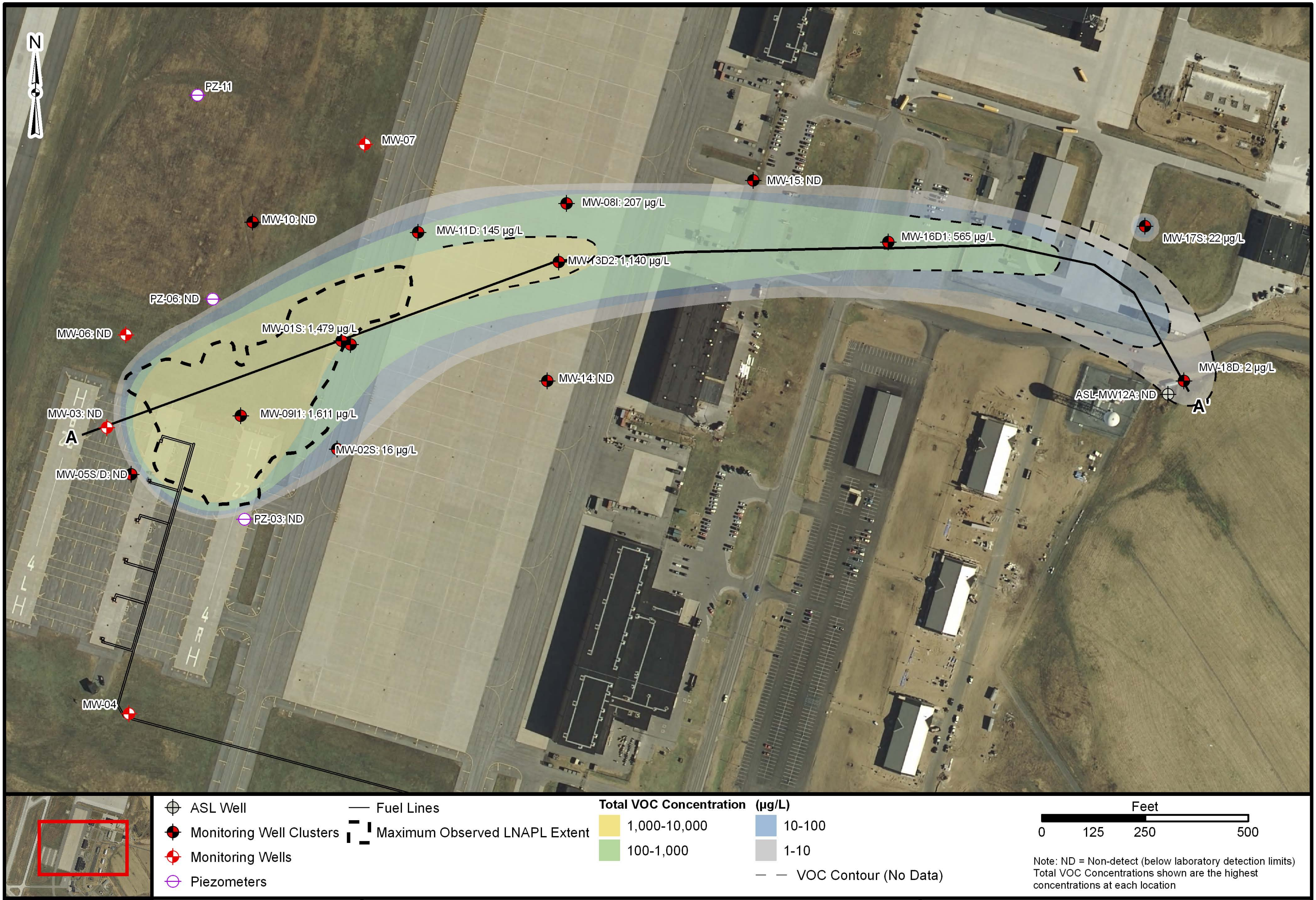

Note: ND = Non-detect (below laboratory detection limits)
Total VOC Concentrations shown are the highest concentrations at each location

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FIGURE 7a
June 2011 Groundwater Sampling Event Results:
Total VOC Concentrations

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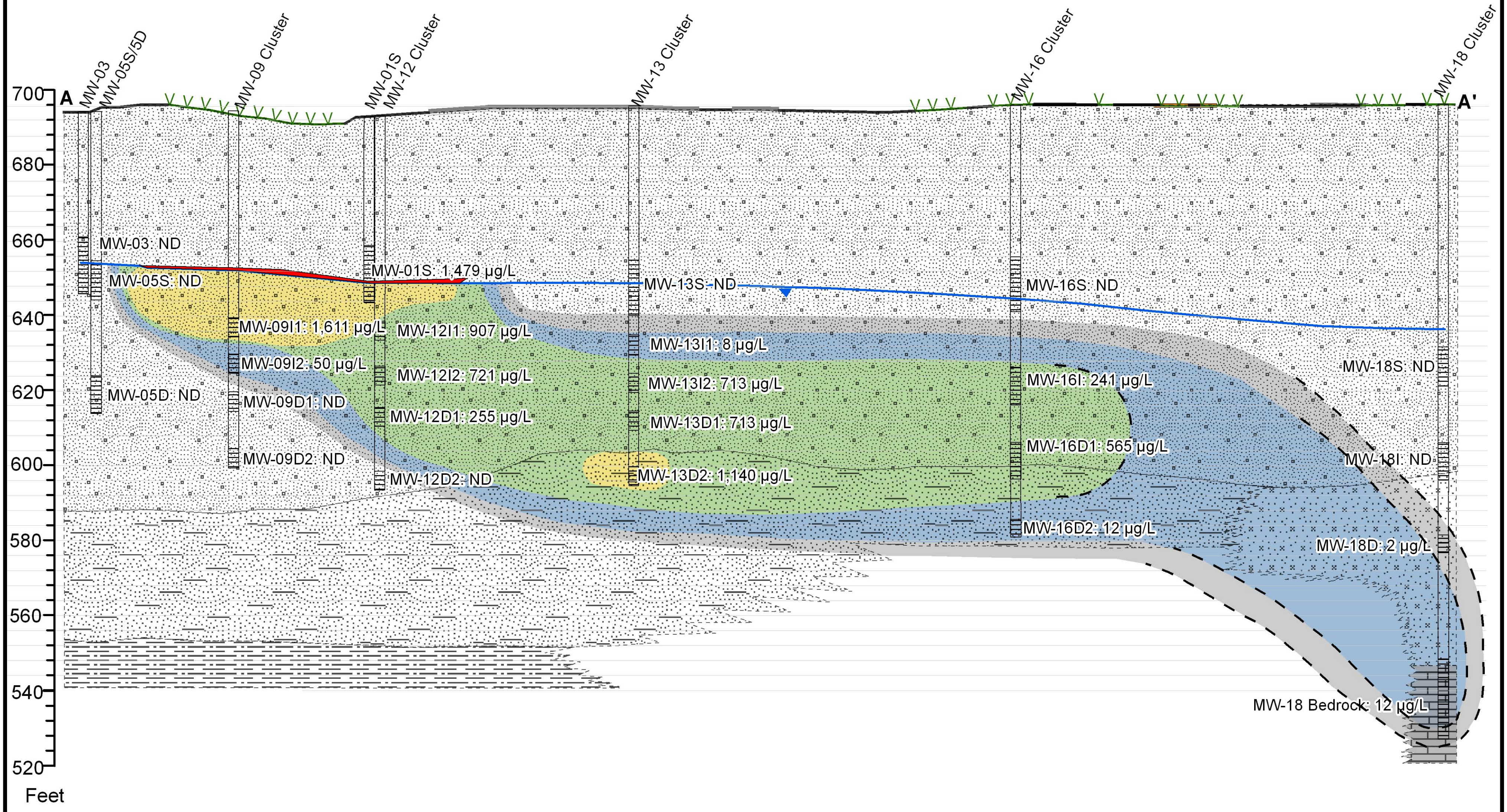

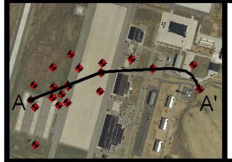

▬ Concrete	⁘ Medium to Coarse Sand and Gravel	⁘ Very-Fine Sand / Sandy Silt	🟥 June 2011 LNAPL Plume
▬ Building	⁘ Fine to Medium Sand	☰ Silt and Clay	— June 2011 Groundwater Elevation
V V Grass		▦ Bedrock	
▬ Asphalt			

Total VOC Concentration (µg/L)

🟨 >1,000	🟦 10-100
🟩 100-1,000	⬜ 1-10
	- - VOC Contour (No Data)

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FIGURE 7b
June 2011 Groundwater Sampling Results:
Total VOC Cross Section

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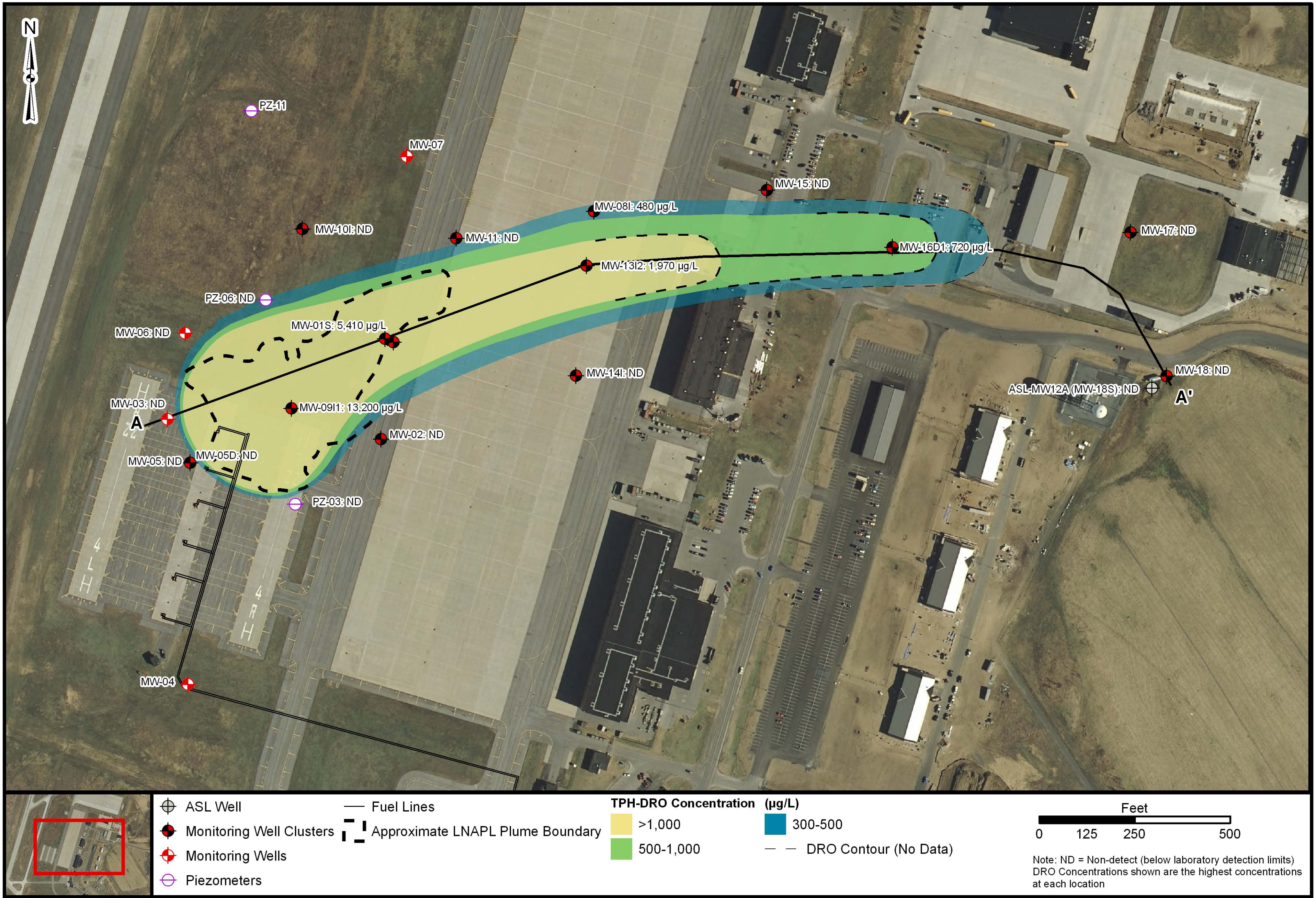

Note: ND = Non-detect (below laboratory detection limits)
DRO Concentrations shown are the highest concentrations at each location

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FIGURE 8a
June 2011 Groundwater Sampling Event Result:
TPH-DRO Concentration

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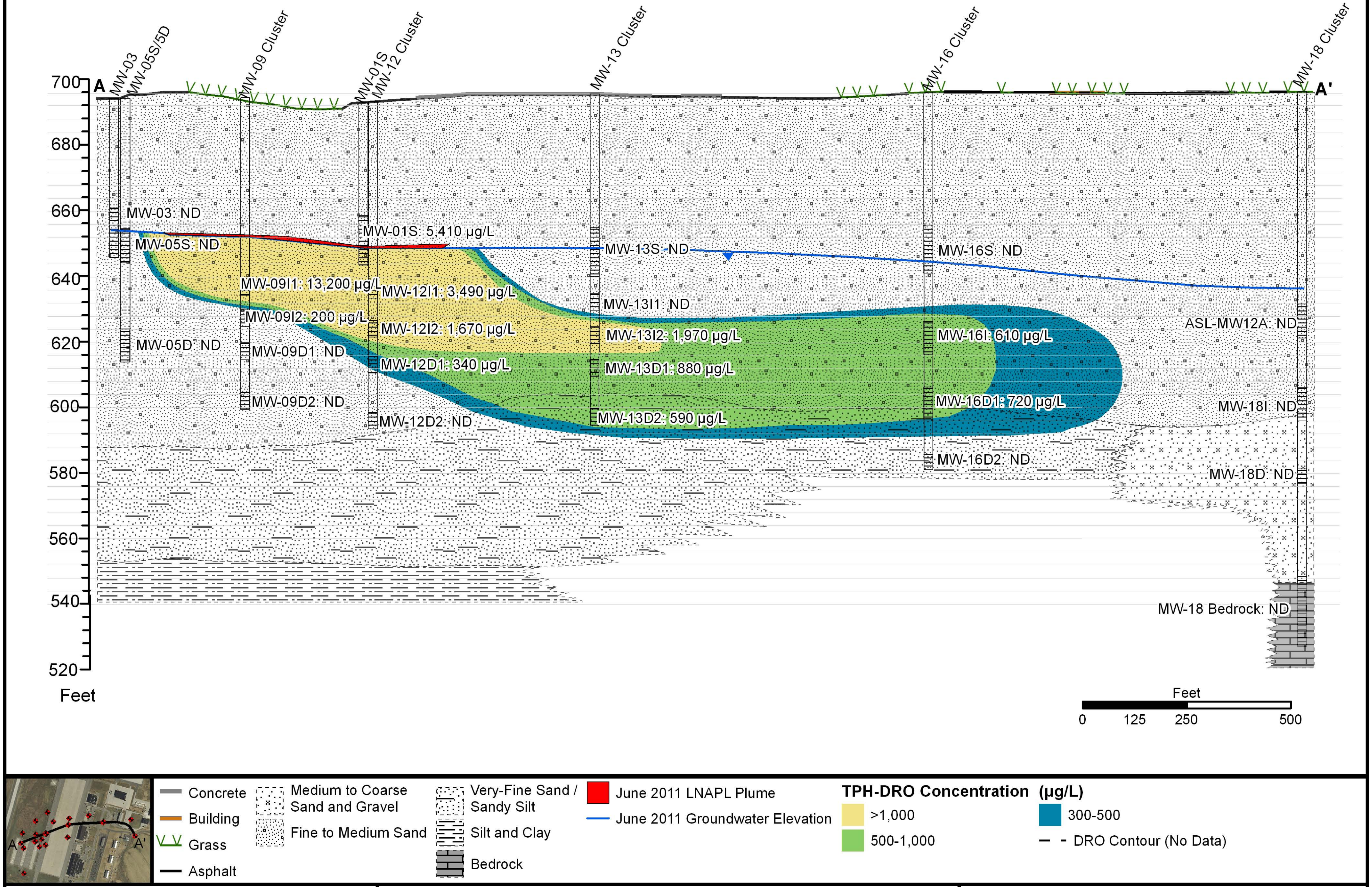

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FIGURE 8b
June 2011 Groundwater Sampling Results:
TPH-DRO Cross Section

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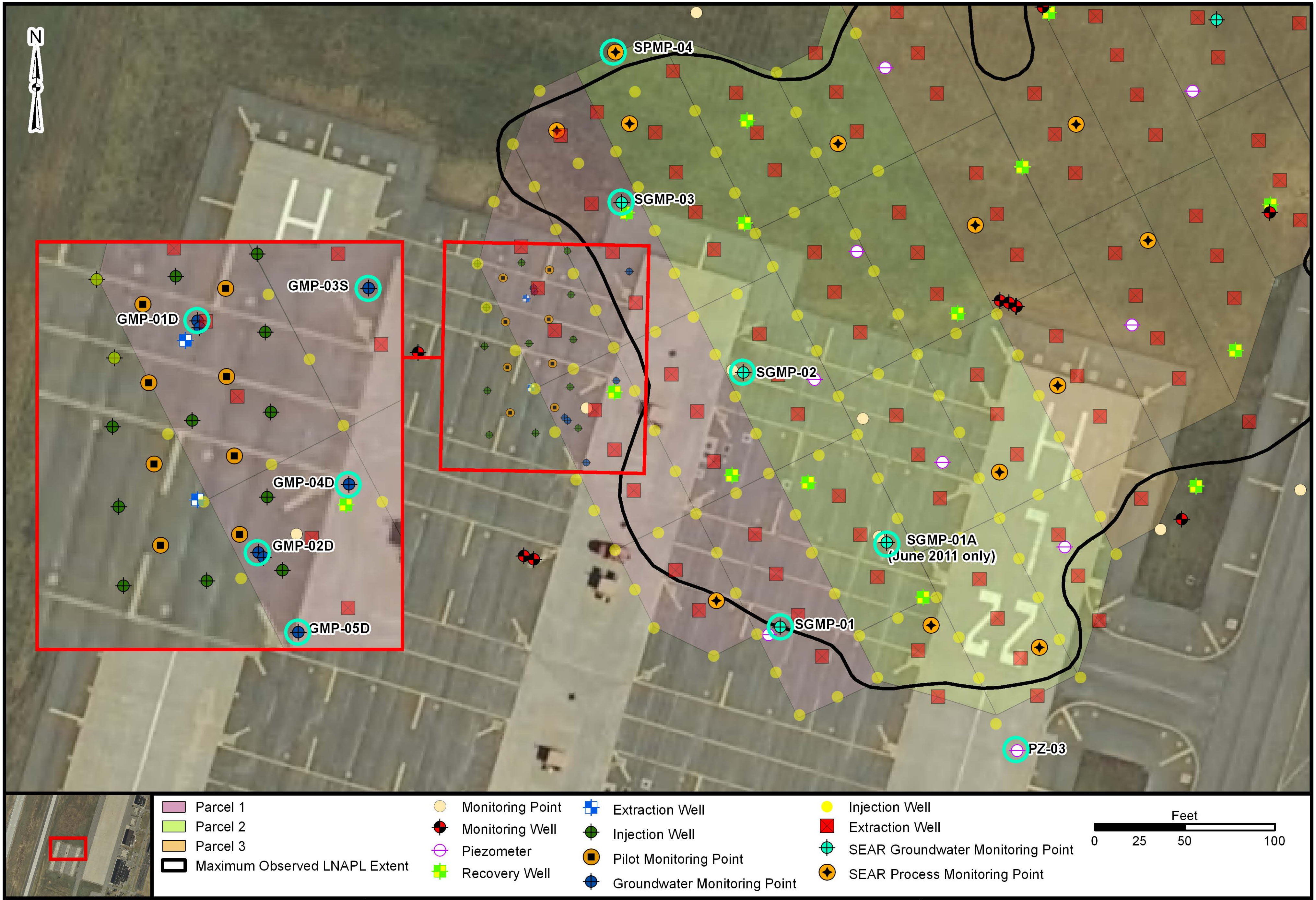

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FIGURE 9
Post-SEAR Groundwater Sampling Locations (Parcel 1)

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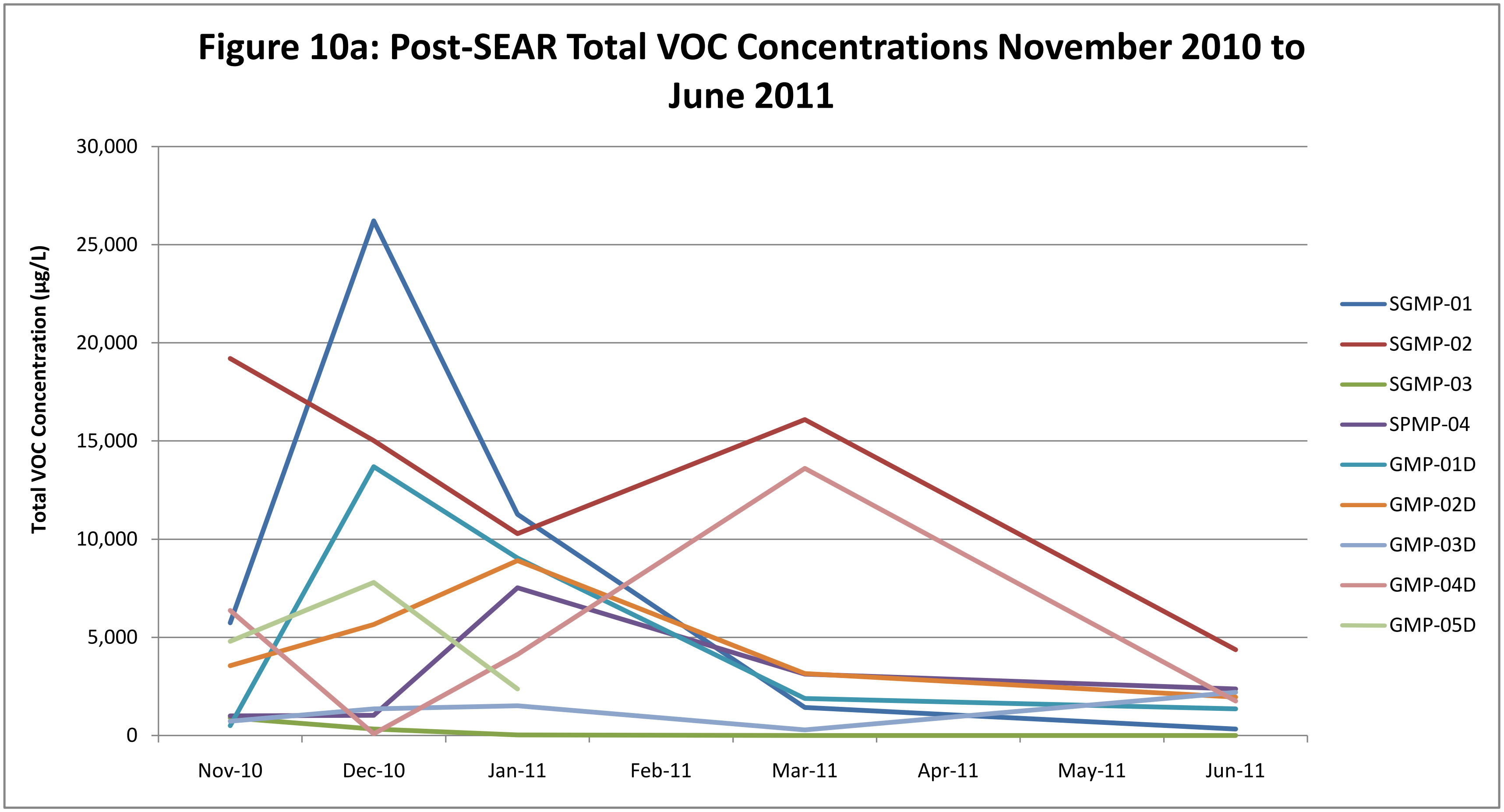


Figure 10a: Post-SEAR Total VOC Concentrations November 2010 to June 2011

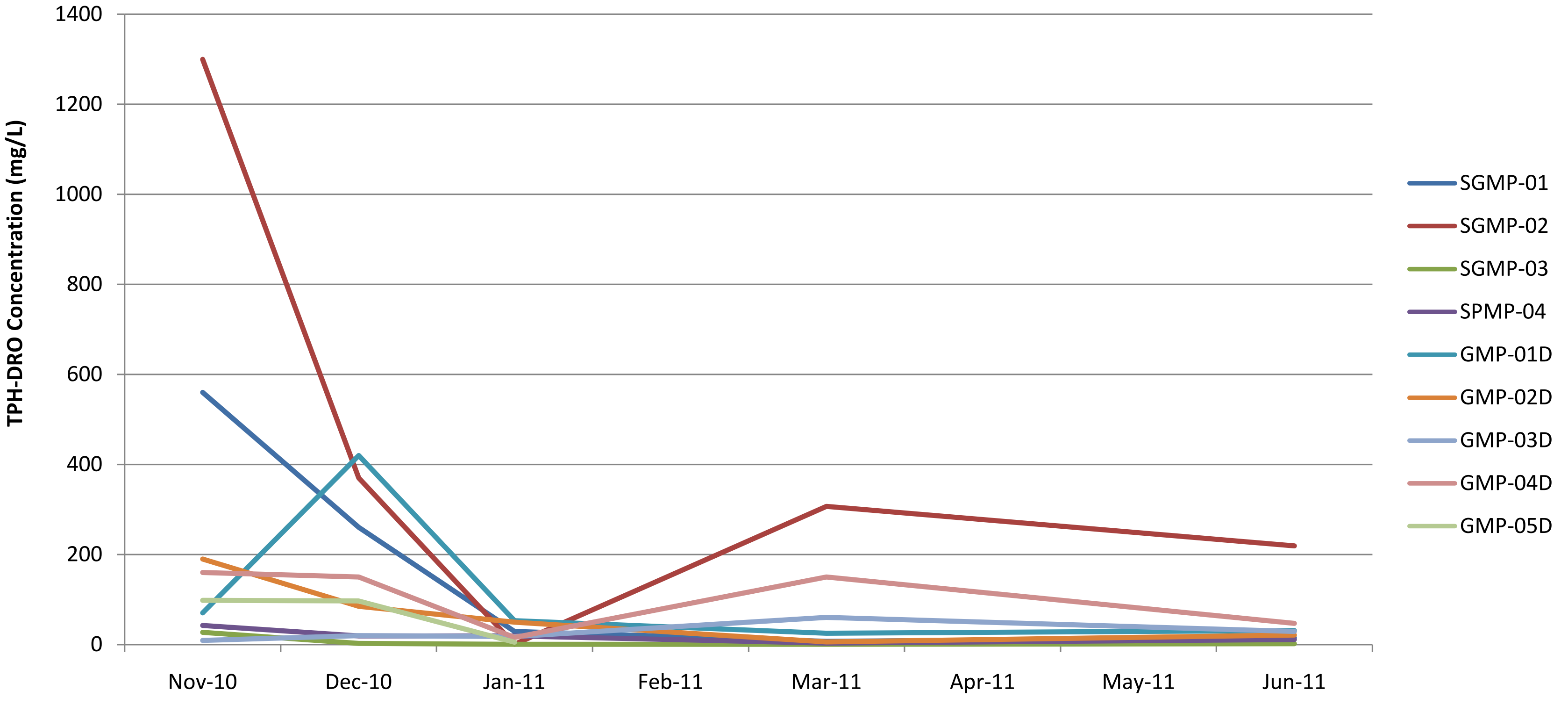


Figure 10b: Post-SEAR TPH-DRO Concentrations November 2010 to June 2011

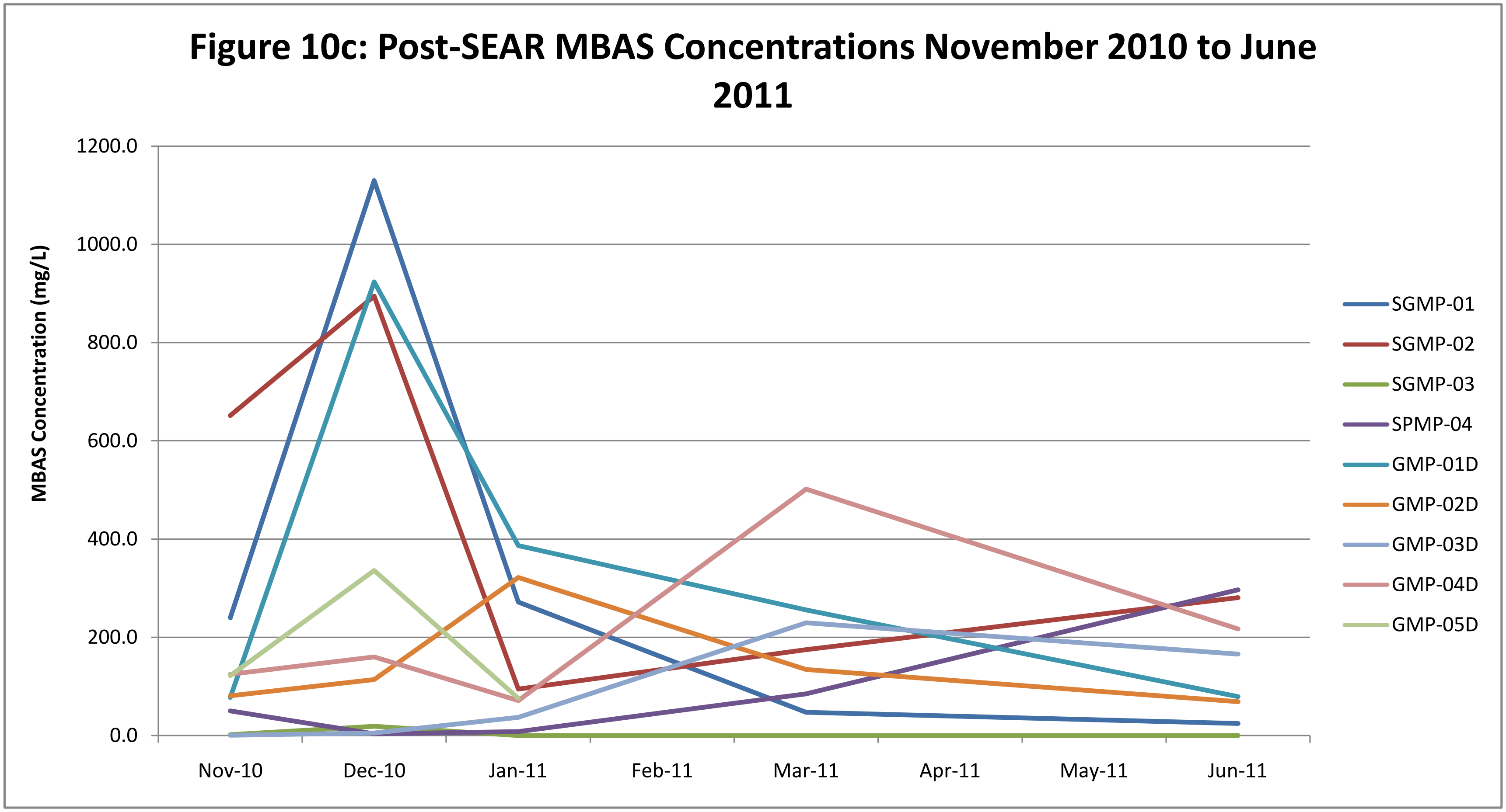
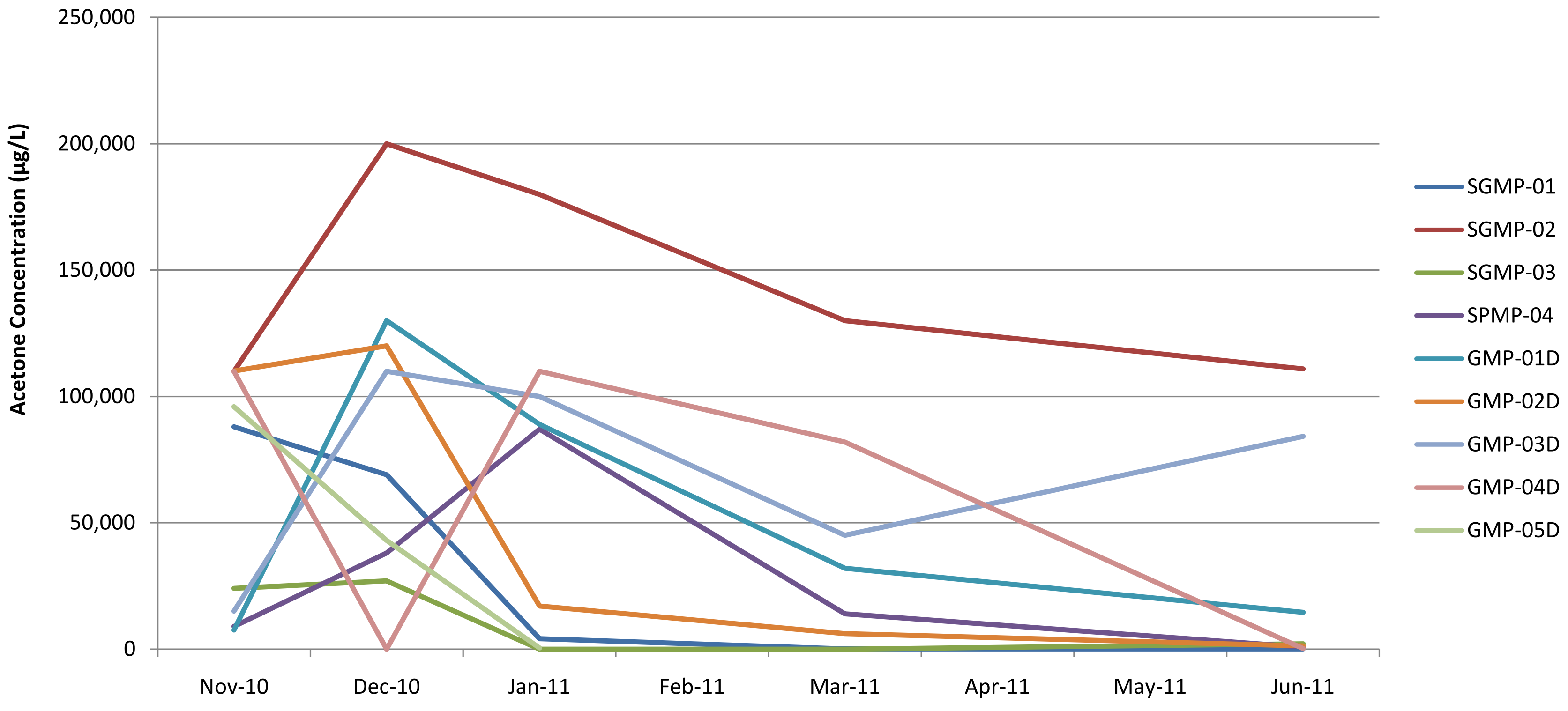
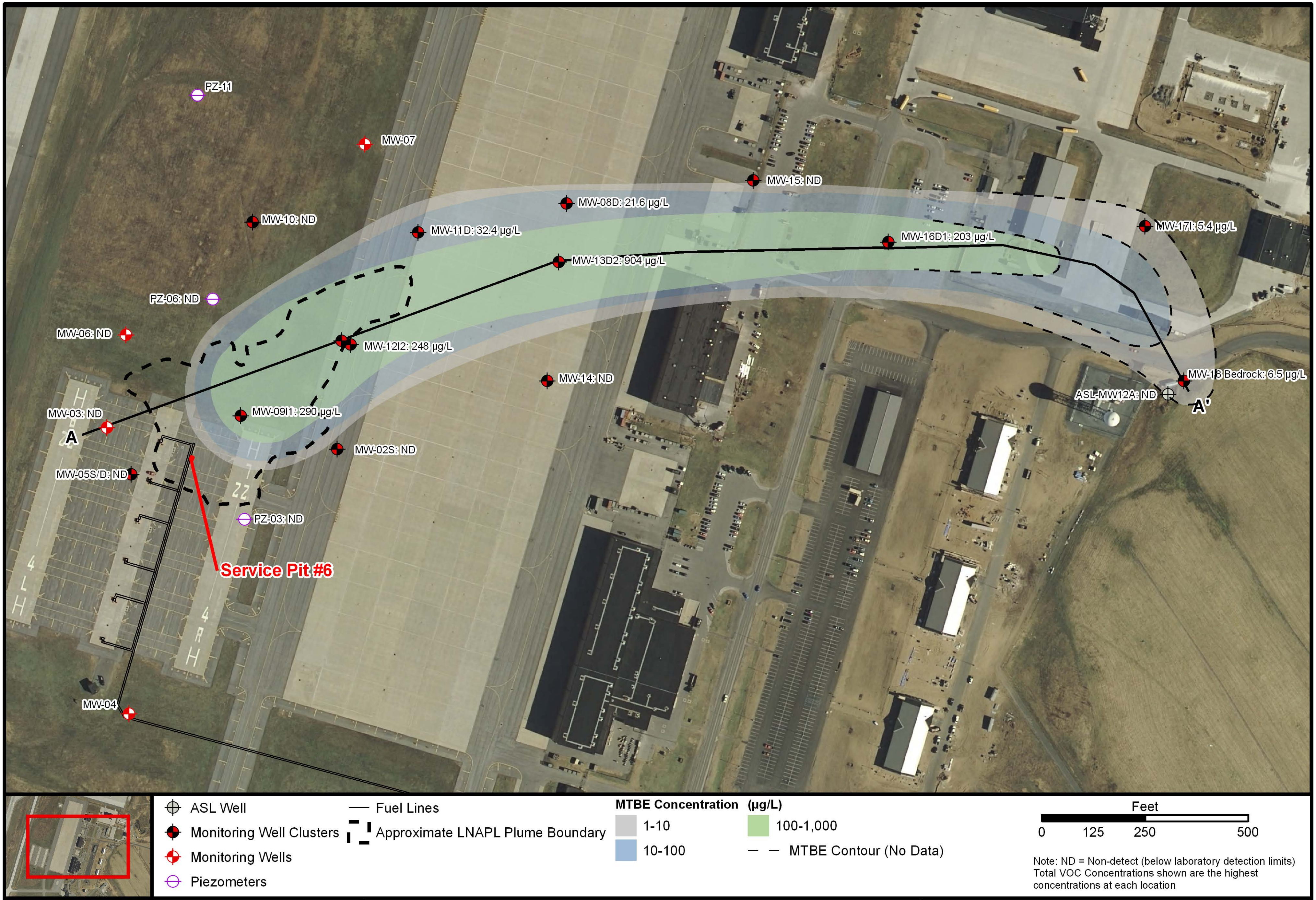


Figure 10c: Post-SEAR MBAS Concentrations November 2010 to June 2011
MBAS Concentration (mg/L)
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
Nov-10
Dec-10
Jan-11
Feb-11
Mar-11
Apr-11
May-11
Jun-11
SGMP-01
SGMP-02
SGMP-03
SPMP-04
GMP-01D
GMP-02D
GMP-03D
GMP-04D
GMP-05D

Figure10d: Post-SEAR Acetone Concentrations November 2010 to June 2011





Note: ND = Non-detect (below laboratory detection limits)
Total VOC Concentrations shown are the highest concentrations at each location

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FIGURE 11a
June 2011 Groundwater Sampling Event Results:
MTBE Concentrations

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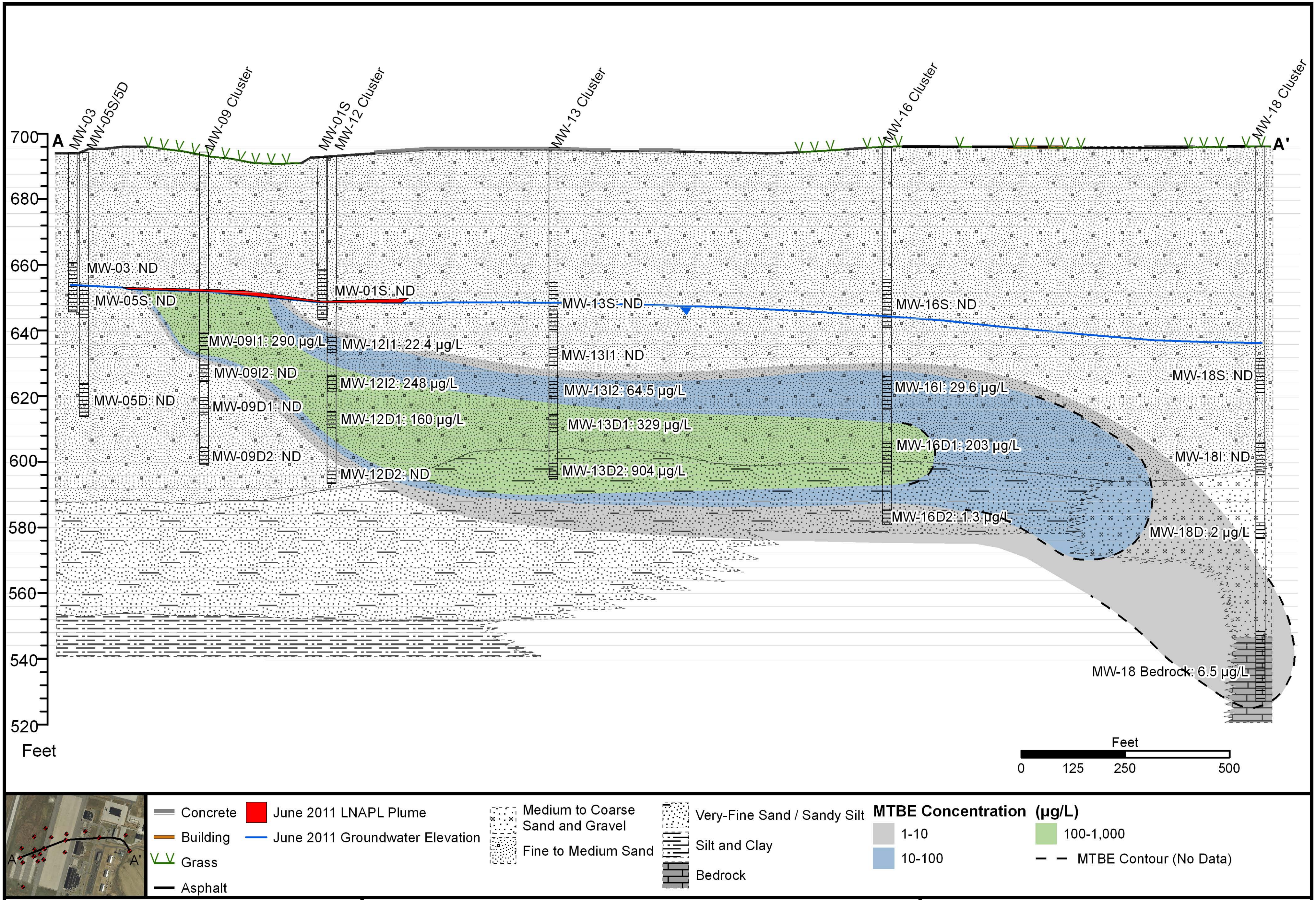

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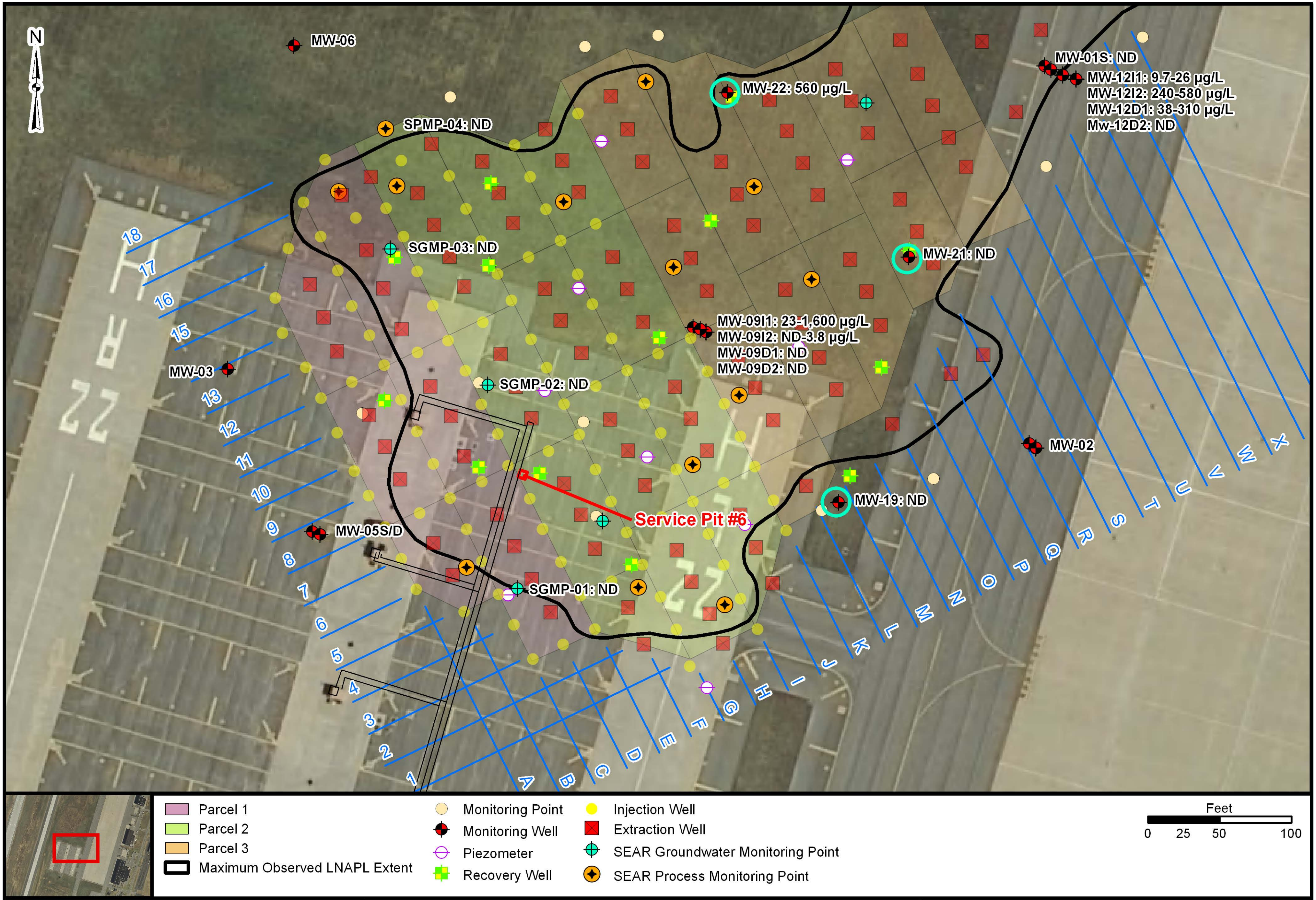
FIGURE 11b
June 2011 Groundwater Sampling Results:
MTBE Cross Section

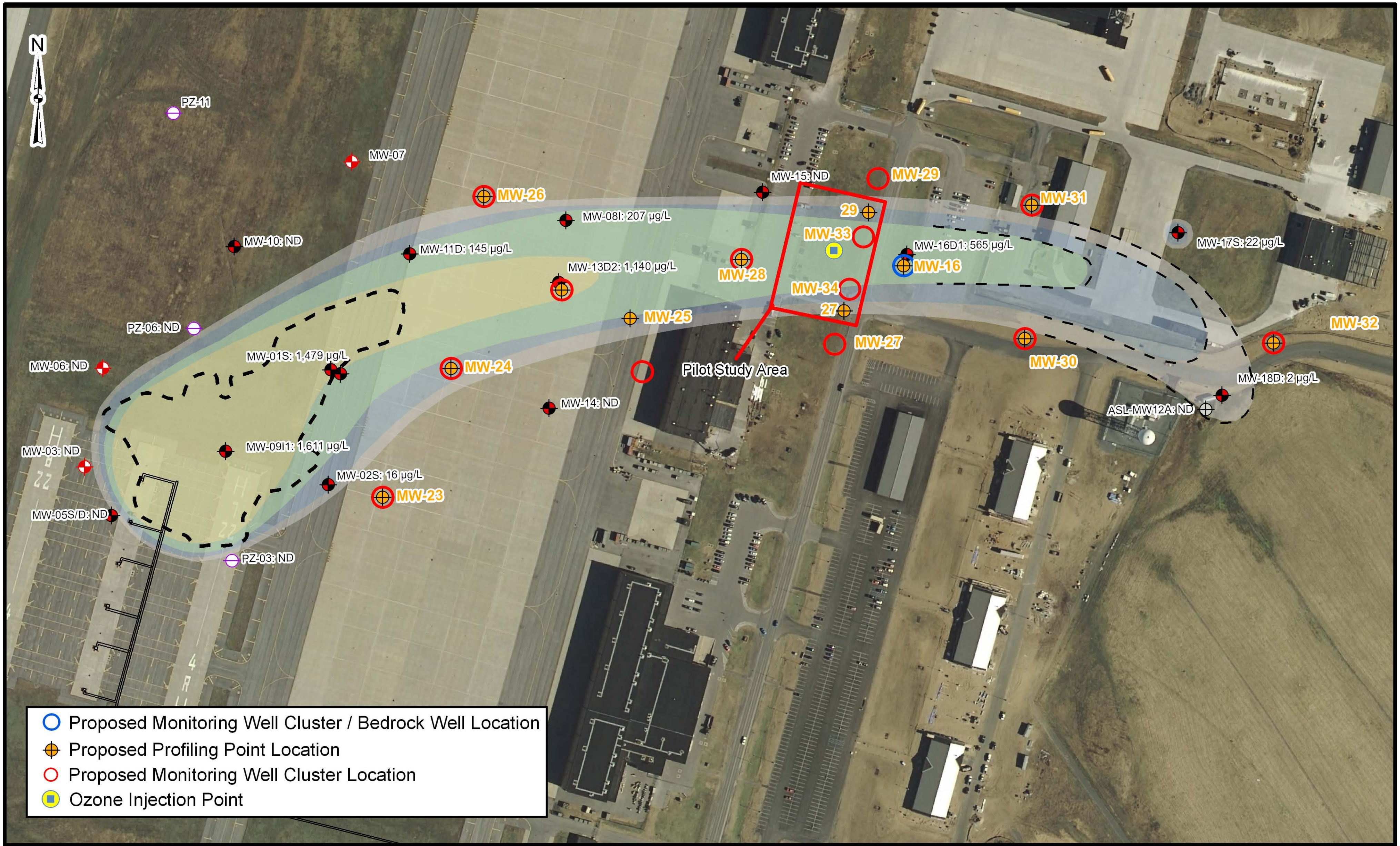
PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FILE NO:
CJK	ALK	ALK	JMB	AS SHOWN	JANUARY 2012	6239301	G:\Projects\Federal\DOD\ Fort Drum Projects\ 6239301 (Oasis)

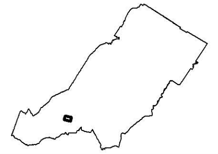


Oasis Fuel Point
Wheeler-Sack Army Airfield
Fort Drum, New York

FIGURE 12
LNAPL Plume Monitoring Well Locations
and historical MTBE Concentrations

PROJECT MGR: CJK	DESIGNED BY: MJS	CREATED BY: ALK	CHECKED BY: JMB	SCALE: AS SHOWN	DATE: JANUARY 2012	PROJECT NO: 6239301	FILE NO: G:\Projects\Federal\DOD\ Fort Drum Projects\ 6239301 (Oasis)





- ⊕ ASL Well
- ● Monitoring Well Clusters
- ● Monitoring Wells
- ○ Piezometers
- — Fuel Lines
- ▭ Approximate LNAPL Plume Boundary

Total VOC Concentration (µg/L) June 2011

🟨 1,000-10,000	🟦 10-100
🟩 100-1,000	⬜ 1-10
	— — VOC Contour (No Data)

Feet
0 125 250 500

Note: ND = Non-detect (below laboratory detection limits)
Total VOC Concentrations shown are the highest concentrations at each location

FORT DRUM, NEW YORK

Oasis Fuel Point
Wheeler-Sack Army Airfield
Fort Drum, New York

Figure 13
Proposed Profiling Point, Monitoring Well Cluster
and Bedrock Monitoring Well Locations

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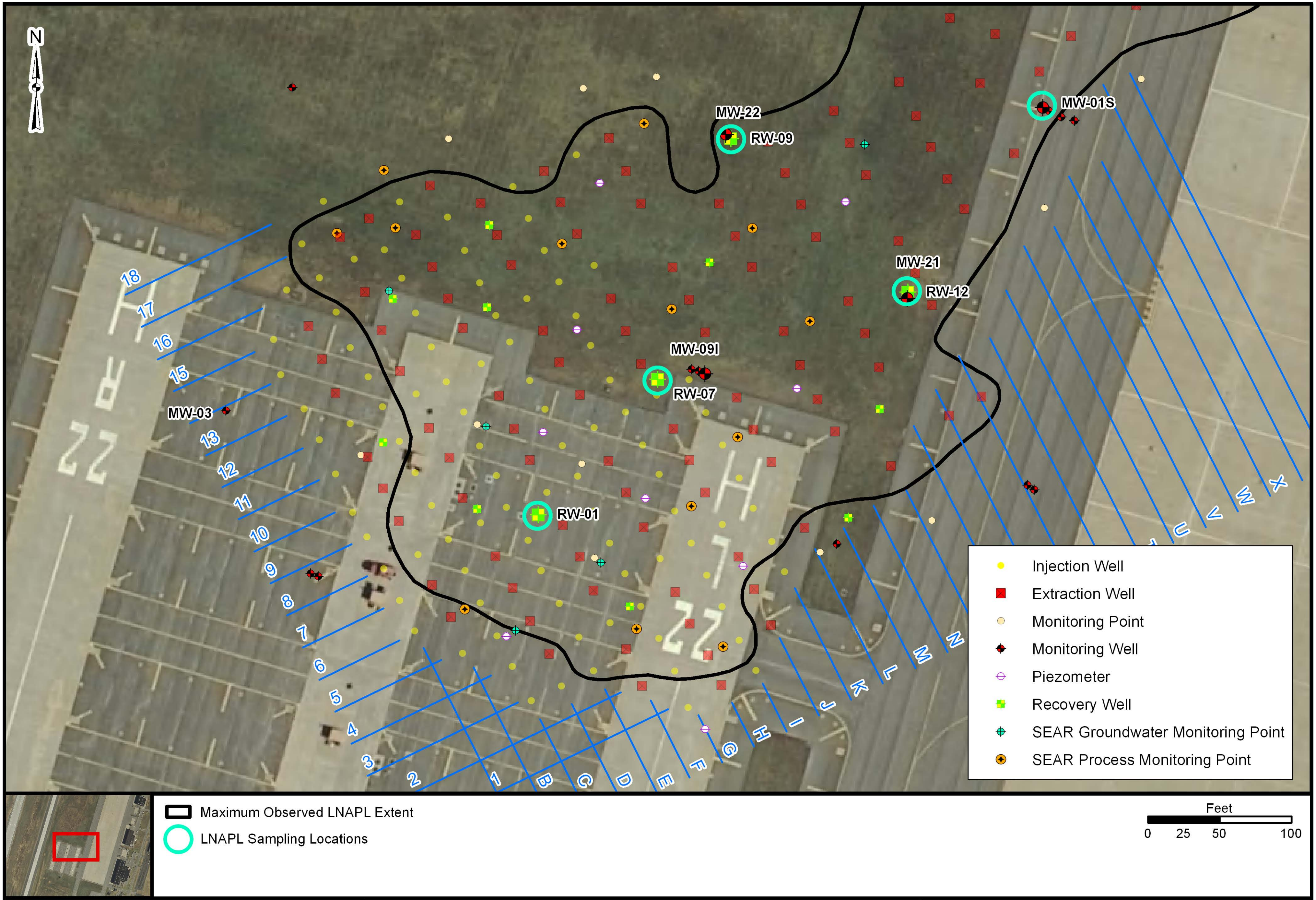
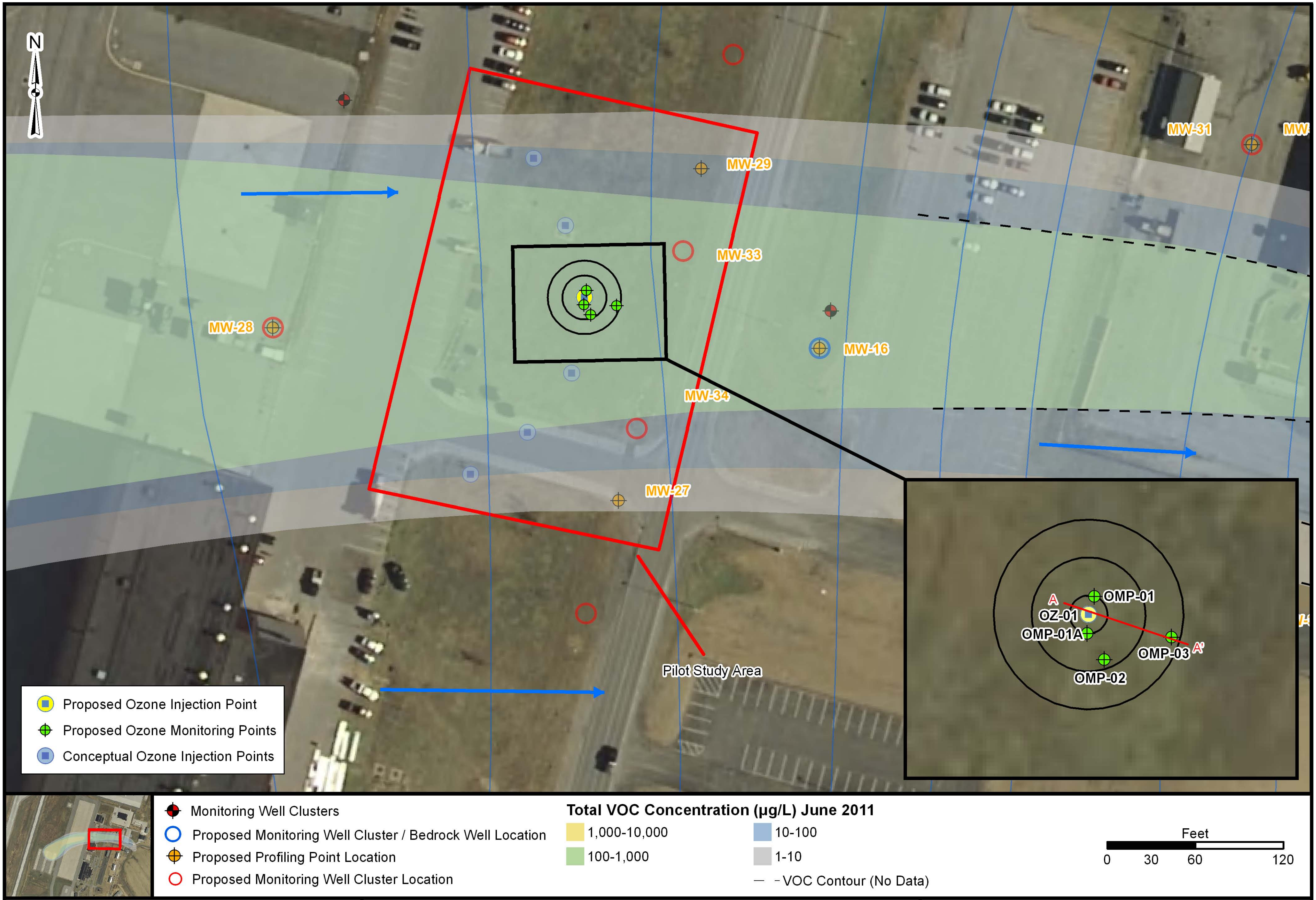
CJK	MJS	ALK	JMB	AS SHOWN	JANUARY 2012	6239301	G:\Projects\Federal\DOD\ Fort Drum Projects\ 6239301 (Oasis)



Oasis Fuel Point
Wheeler-Sack Army Airfield
Fort Drum, New York

FIGURE 14
LNAPL-Groundwater Flux Sampling Locations

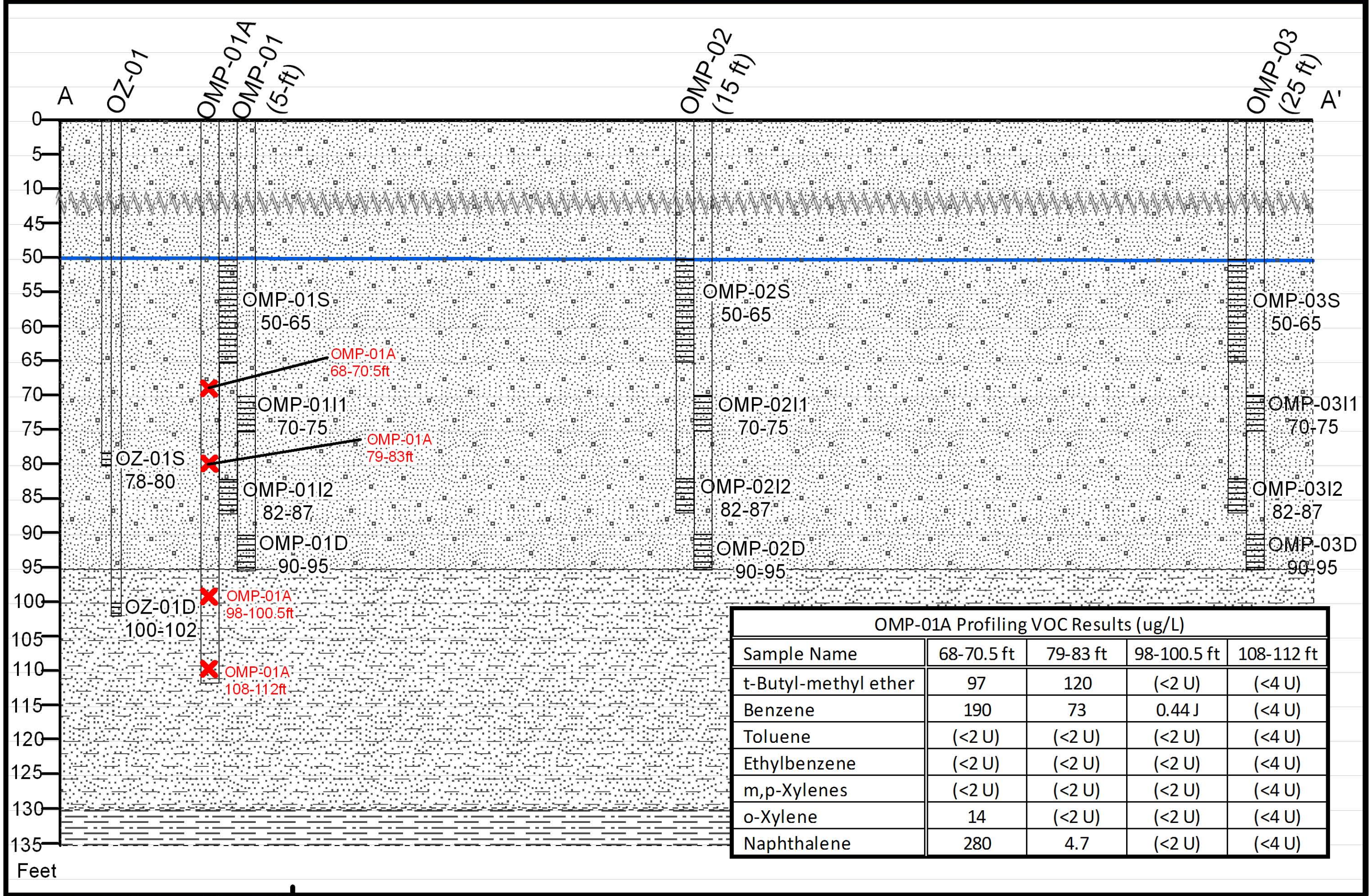
PROJECT MGR: CJK	DESIGNED BY: MJS	CREATED BY: ALK	CHECKED BY: JMB	SCALE: AS SHOWN	DATE: JANUARY 2012	PROJECT NO: 6239301	FILE NO: G:\Projects\Federal\DOD\ Fort Drum Projects\ 6239301 (Oasis)



Oasis Fuel Point
Wheeler-Sack Army Airfield
Fort Drum, New York

FIGURE 15A
Downgradient Ozone
Pilot Study Area

PROJECT MGR: CJK	DESIGNED BY: MJS	CREATED BY: ALK	CHECKED BY: JMB	SCALE: AS SHOWN	DATE: JANUARY 2012	PROJECT NO: 6239301	FILE NO: G:\Projects\Federal\DOD\ Fort Drum Projects\ 6239301 (Oasis)



OMP-01A Profiling VOC Results (ug/L)

Sample Name	68-70.5 ft	79-83 ft	98-100.5 ft	108-112 ft
t-Butyl-methyl ether	97	120	(<2 U)	(<4 U)
Benzene	190	73	0.44 J	(<4 U)
Toluene	(<2 U)	(<2 U)	(<2 U)	(<4 U)
Ethylbenzene	(<2 U)	(<2 U)	(<2 U)	(<4 U)
m,p-Xylenes	(<2 U)	(<2 U)	(<2 U)	(<4 U)
o-Xylene	14	(<2 U)	(<2 U)	(<4 U)
Naphthalene	280	4.7	(<2 U)	(<4 U)

- ● Ozone Injection
- ⊕ Ozone Monitoring Point
- ▨ Fine to Medium Sand
- ▨ Interbedded Sand, Silt, Clay
- ☰ Silt and Clay
- — Approximate Water Table

US ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

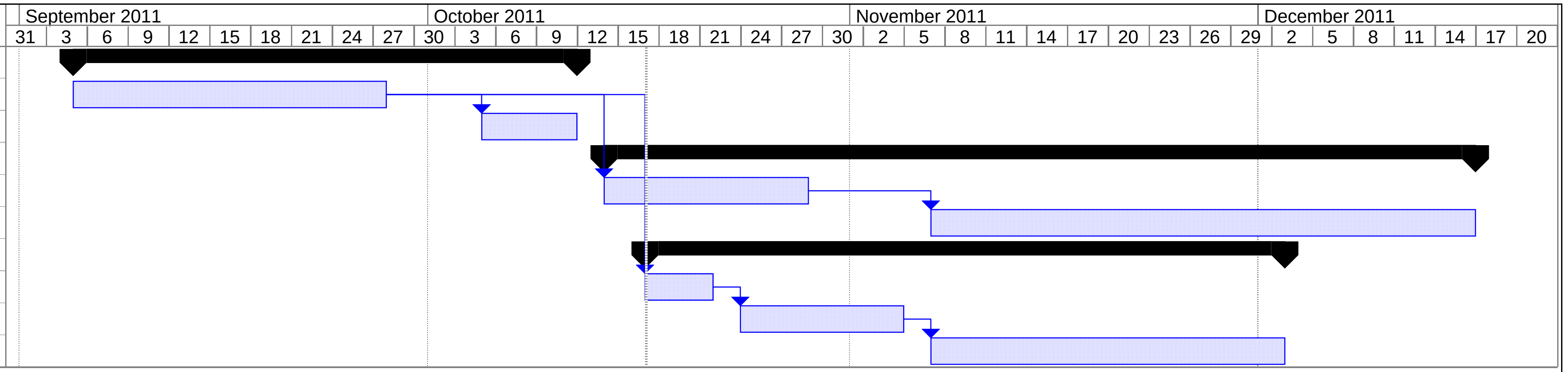
PUBLIC WORKS
FORT DRUM, NEW YORK

Oasis Fuel Point
Wheeler-Sack Army Airfield
Fort Drum, New York

FIGURE 15B
Downgradient Ozone
Pilot Study Area

PROJECT MGR:	DESIGNED BY:	CREATED BY:	CHECKED BY:	SCALE:	DATE:	PROJECT NO:	FILE NO:
CJK	ALK	ALK	JMB	AS SHOWN	JANUARY 2012	6239301	G:\Projects\Federal\DOD\ Fort Drum Projects\ 6239301 (Oasis)

ID	Task Name	Duration	Start	Finish
1	**Work Plan**	**27 days**	**Mon 9/5/11**	**Tue 10/11/11**
2	Draft	17 days	Mon 9/5/11	Tue 9/27/11
3	Final	5 days	Wed 10/5/11	Tue 10/11/11
4	**Remedial Investigation**	**46 days**	**Fri 10/14/11**	**Fri 12/16/11**
5	Groundwater Profiling	11 days	Fri 10/14/11	Fri 10/28/11
6	Monitoring Well Installation	30 days	Mon 11/7/11	Fri 12/16/11
7	**Ozone Pilot Test**	**35 days**	**Mon 10/17/11**	**Fri 12/2/11**
8	Well Installation	5 days	Mon 10/17/11	Fri 10/21/11
9	Well Development and Sampling	10 days	Mon 10/24/11	Fri 11/4/11
10	Ozone Pilot Test	20 days	Mon 11/7/11	Fri 12/2/11



Date: Mon 10/17/11

Task ▭
Split ┈
Milestone ◆
Summary ▬
Project Summary ▬
External Tasks ▭
External Milestone ◆
Inactive Task ▼
Progress ▬
Deadline ⇩

Figure 16
Project Schedule

TABLE 1 SUMMARY OF GROUNDWATER TRENDS FROM MAY 2009 TO JUNE 2011

	MW-02S									NYSDEC Class GA Value(a)
Analyte	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (μg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
4-Isopropyltoluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Benzene	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<1.0 U)	(<0.5 U)	(<0.5 U)	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Isopropylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
Methyl-t-butyl ether	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<1.0 U)	(<0.5 U)	(<1 U)	10
Naphthalene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	**16.4**	10
n-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
o-Xylene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
sec-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<1.0 U)	(<5 U)	(<20 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
BTEX	ND	ND	ND	ND	ND	ND	ND	ND	ND	--
Total VOC	ND	ND	ND	ND	ND	ND	ND	ND	16	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (μg/L)										
Diesel Range Organics	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<310 U)	(<300 U)	(< 200 U)	--

(a) NYS Regulation 6 New York Code of Rules and Regulations Part 703 Class GA standards and/or NYSDEC 1998 Ambient Water Quality Standards and Guidance Values.

NOTE:

NYSDEC = New York State Department of Environmental Conservation
μg/L = Micrograms/Liter
U = Analyzed but not detected at concentrations abve the report limit. Sample quantitation limits are shown as (<__ U)
--- = Indicates no standard or guidance value exists
BTEX = Benzene, toluene, ethylbenzene, and total xylenes
ND = Non-Detect
VOC = Volatile Organic Compound

Bold values indicate exceedance of NYSDEC Class GA Groundwater Standards and Guidance Values

Results for wells that have been continuously non-detect for VOCs and TPH-DRO are not provided.

TABLE 1 (Continued)

Analyte	MW-08I									NYSDEC Class GA Value(a)
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	**37.7**	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
4-Isopropyltoluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Benzene	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	**20**	**6.1**	**10.2**	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Isopropylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	**12**	**6.8**	**13.8**	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
Methyl-t-butyl ether	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	4	(<0.5 U)	(<1 U)	10
Naphthalene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	**18**	**33**	**45.6**	10
n-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	**100**	5
o-Xylene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	130	59	(<5 U)	--
sec-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5 U)	(<20 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	**130**	**59**	**100**	5
BTEX	ND	ND	ND	ND	ND	ND	150	65.10	110	--
Total VOC	ND	ND	ND	ND	ND	ND	184	164	207	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	420	(<300 U)	480	--

TABLE 1 (Continued)

Analyte	MW-08D									NYSDEC Class GA Value[a]
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
4-Isopropyltoluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Benzene	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	0.52	**3.6**	**5.6**	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Isopropylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	1.7	--
Methyl-t-butyl ether	(<0.5 U)	(<0.5 U)	(<0.5 U)	0.86	1.3	3.2	9.4	**13**	**21.6**	10
Naphthalene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	10
n-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
o-Xylene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	--
sec-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5 U)	(<20 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	1.7	5
BTEX	ND	ND	ND	ND	ND	ND	0.52	3.6	7	--
Total VOC	ND	ND	ND	0.86	1.3	3.2	9.92	17	29	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<310 U)	(<300 U)	(<200 U)	--

TABLE 1 (Continued)

Analyte	MW-09I1									NYSDEC Class GA Value(a)
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	**530**	**520**	**9**	**460**	**36**	**270**	**31**	(<10 U)	(<5 U)	5
1,3,5-Trimethylbenzene	**140**	**150**	(<1.0 U)	**120**	**11**	**79**	**20**	**14**	**20.7**	5
4-Isopropyltoluene	**22**	**34**	**25**	**33**	**13**	**34**	**33**	(<10 U)	**81.9**	5
Benzene	**630**	**820**	**400**	**650**	**230**	**530**	**780**	**780**	**453**	1
Ethylbenzene	**300**	**440**	**9.4**	**180**	**41**	**190**	**370**	**430**	**311**	5
Isopropylbenzene	**62**	**83**	**63**	**77**	**55**	**89**	**93**	**48**	**77.5**	5
m&p-Xylenes	650	750	7.5	690	26	330	(<5 U)	13	8.7	--
Methyl-t-butyl ether	**1,600**	**1,100**	**170**	**570**	**23**	**130**	**300**	**770**	**290**	10
Naphthalene	**260**	**390**	**250**	**420**	**220**	**370**	**270**	**290**	**315**	10
n-Butylbenzene	**18**	**16**	**17**	**21**	**13**	**24**	**15**	(<10 U)	(<5 U)	5
n-Propylbenzene	**75**	**91**	**9.5**	**52**	**14**	**48**	**83**	**46**	(<1 U)	5
o-Xylene	760	1,100	680	570	99	130	(<5 U)	(<10 U)	**25.7**	--
sec-Butylbenzene	**33**	**31**	**27**	**34**	**25**	**43**	**37**	**11**	**27.4**	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<25 U)	(<250 U)	(<20 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	1.4	(<1.0 U)	(<5 U)	(<10 U)	(<5 U)	5
Toluene	**47**	**26**	**5.6**	**12**	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<1 U)	5
Xylenes (Total)	**1,410**	**1,850**	**687.5**	**1260**	**125**	**460**	**17**	**13**	**8.7**	5
BTEX	2,387	3,136	1,102.5	2,102	396	1,180	1,167	1,223	773	--
Total VOC	5,127	5,551	1,673	3,889	807	2,267	2,032	2,402	1,611	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	9,300	10,000	3,600	11,000	1,600	5,000	6,000	7,300	13,200	--

TABLE 1 (Continued)

Analyte	MW-09I2									NYSDEC Class GA Value$^{(a)}$
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	**150**	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<50 U)	5
1,3,5-Trimethylbenzene	**39**	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<50 U)	5
4-Isopropyltoluene	**12**	1.4	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<50 U)	5
Benzene	0.92	**3.3**	0.54	**1.8**	0.99	(<0.5 U)	**1**	(<0.5 U)	**39.4**	1
Ethylbenzene	**15**	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<10 U)	5
Isopropylbenzene	**9.7**	4.6	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<50 U)	5
m&p-Xylenes	57	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<10 U)	--
Methyl-t-butyl ether	0.83	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	3.8	(<0.5 U)	(<0.5 U)	(<10 U)	10
Naphthalene	**24**	**10**	6.7	4.4	(<1.0 U)	(<1.0 U)	2	(<1 U)	(<50 U)	10
n-Butylbenzene	**7.9**	1.5	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<50 U)	5
n-Propylbenzene	**22**	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<10 U)	5
o-Xylene	31	1.3	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<50 U)	--
sec-Butylbenzene	**14**	1.9	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<50 U)	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<25 U)	(<200 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<50 U)	5
Toluene	**5.2**	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<10 U)	5
Xylenes (Total)	**88**	1.3	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<10 U)	5
BTEX	109	5	0.54	1.8	0.99	ND	1	ND	39	--
Total VOC	389	24	7.24	6.2	0.99	3.8	3	ND	50	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	2,000	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<320 U)	(<300 U)	200	--

TABLE 1 (Continued)

Analyte	MW-09D1									NYSDEC Class GA Value$^{(a)}$
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	**15**	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<50 U)	5
1,3,5-Trimethylbenzene	**10**	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<50 U)	5
4-Isopropyltoluene	**3.9**	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<50 U)	5
Benzene	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<5 U)	1
Ethylbenzene	2.3	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<10 U)	5
Isopropylbenzene	2.1	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<50 U)	5
m&p-Xylenes	3.7	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<10 U)	--
Methyl-t-butyl ether	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<10 U)	10
Naphthalene	5	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<50 U)	10
n-Butylbenzene	3.3	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<50 U)	5
n-Propylbenzene	**5**	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<10 U)	5
o-Xylene	5.2	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<50 U)	--
sec-Butylbenzene	4.2	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<50 U)	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<25 U)	(<200 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<50 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<10 U)	5
Xylenes (Total)	**8.9**	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<10 U)	5
BTEX	11	ND	ND	ND	ND	ND	ND	ND	ND	--
Total VOC	60	ND	ND	ND	ND	ND	ND	ND	ND	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	640	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<330 U)	(<310 U)	(< 210 U)	--

TABLE 1 (Continued)

Analyte	MW-11I									NYSDEC Class GA Value[(a)]
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
4-Isopropyltoluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Benzene	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Isopropylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
Methyl-t-butyl ether	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<1 U)	10
Naphthalene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	1.2	(<5 U)	10
n-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
o-Xylene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
sec-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5 U)	(<20 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
BTEX	ND	ND	ND	ND	ND	ND	ND	ND	ND	--
Total VOC	ND	ND	ND	ND	ND	ND	ND	1	ND	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<310 U)	(<300 U)	(< 210 U)	--

TABLE 1 (Continued)

Analyte	MW-11D									NYSDEC Class GA Value(a)
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
4-Isopropyltoluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Benzene	(<0.5 U)	(<0.5 U)	**7.4**	**22**	**41**	**65**	**48**	**41**	**25**	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Isopropylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
Methyl-t-butyl ether	1.2	(<0.5 U)	6.7	**13**	**23**	**24**	**25**	**24**	**32.4**	10
Naphthalene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	10
n-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
o-Xylene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	8.1	170	180	87.8	--
sec-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<25 U)	(<20 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	**8.1**	**170**	**180**	**87.8**	5
BTEX	ND	ND	7.4	22	41	73.1	218	221	113	--
Total VOC	1.2	ND	14.1	35	64	97	243	245	145	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<310 U)	(<310 U)	(< 230 U)	--

TABLE 1 (Continued)

Analyte	MW-01S									NYSDEC Class GA Value[(a)]
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	**350**	**340**	**690**	**840**	**440**	**440**	**620**	NS	**131**	5
1,3,5-Trimethylbenzene	**150**	**150**	**290**	**280**	**220**	**250**	**340**	NS	**210**	5
4-Isopropyltoluene	**25**	**23**	**36**	**34**	**21**	**29**	**44**	NS	**28.3**	5
Benzene	**70**	**72**	**120**	**49**	**26**	**66**	**130**	NS	**21.2**	1
Ethylbenzene	**240**	**280**	**390**	**410**	**250**	**290**	**480**	NS	**375**	5
Isopropylbenzene	**53**	**48**	**78**	**66**	**63**	**61**	**99**	NS	**69.3**	5
m&p-Xylenes	290	370	750	750	240	420	470	NS	288	--
Methyl-t-butyl ether	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<2.5 U)	NS	(<1 U)	10
Naphthalene	**310**	**300**	**390**	**380**	**300**	**290**	**350**	NS	**194**	10
n-Butylbenzene	**9.4**	**11**	**14**	**13**	**9.8**	**8.8**	**18**	NS	**31.8**	5
n-Propylbenzene	**75**	**65**	**99**	**95**	**77**	**82**	**120**	NS	**87.6**	5
o-Xylene	70	67	68	16	(<1.0 U)	1.3	160	NS	16.3	--
sec-Butylbenzene	**21**	**18**	**28**	**26**	**22**	**21**	**34**	NS	**24.1**	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<25 U)	NS	(<20 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	2.7	2.4	(<5 U)	NS	(<5 U)	5
Toluene	9.8	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	**30**	NS	1.9	5
Xylenes (Total)	**360**	**437**	**818**	**766**	**240**	**421**	**630**	NS	**305**	5
BTEX	680	789	1,328	1,225	516	777	1,270	NS	703	--
Total VOC	1,673	1,744	2,953	2,959	1,672	1,962	2,895	NS	1,479	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	2,600	2,800	2,600	3,000	1,500	6,000	5,300	NS	5,410	--
NOTE:	NS = Not Sampled									

TABLE 1 (Continued)

Analyte	MW-12I1									NYSDEC Class GA Value$^{(a)}$
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	1.9	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<5 U)	5
1,3,5-Trimethylbenzene	**22**	**36**	**26**	**15**	**16**	(<1.0 U)	**24**	**29**	**11.6**	5
4-Isopropyltoluene	**28**	**23**	**31**	**30**	(<1.0 U)	**29**	**47**	**32**	**30.1**	5
Benzene	**220**	**150**	**170**	**250**	**290**	**350**	**130**	**94**	**45.7**	1
Ethylbenzene	**280**	**290**	**330**	**390**	**510**	**490**	**510**	**460**	**375**	5
Isopropylbenzene	**71**	**54**	**73**	**78**	**110**	**72**	**120**	**91**	**77.4**	5
m&p-Xylenes	20	11	14	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	13	6	--
Methyl-t-butyl ether	**12**	**26**	9.7	**23**	**37**	**16**	**23**	**18**	**22.4**	10
Naphthalene	**460**	**430**	**440**	**580**	**650**	**700**	**510**	**430**	**200**	10
n-Butylbenzene	**13**	**13**	**17**	**19**	**22**	**20**	**21**	**15**	**13.9**	5
n-Propylbenzene	**96**	**75**	**110**	**110**	**140**	**120**	**150**	**110**	**96.9**	5
o-Xylene	25	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<1 U)	--
sec-Butylbenzene	**23**	**16**	**25**	**25**	**33**	**23**	**39**	**31**	**26.4**	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	7.3	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<25 U)	(<50 U)	(<20 U)	--
t-Butylbenzene	4.9	(<1.0 U)	4	(<1.0 U)	**5.9**	(<1.0 U)	5.8	(<10 U)	(<5 U)	5
Toluene	1	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	1.9	5
Xylenes (Total)	**45**	**11**	**14**	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	**13**	**6**	5
BTEX	546	451	514	640	800	840	640	567	429	--
Total VOC	1,278	1,124	1,257	1,520	1,814	1,820	1,580	1,323	907	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	2,700	4,600	4,000	4,200	3,100	4,000	4,500	3,400	3,490	--

TABLE 1 (Continued)

Analyte	MW-12I2									NYSDEC Class GA Value(a)
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	**99**	(<1.0 U)	(<1.0 U)	(<5 U)	**81**	(<5 U)	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<5 U)	5
4-Isopropyltoluene	**11**	**14**	**19**	**19**	**7.2**	**8.8**	**25**	**12**	**12.8**	5
Benzene	**120**	**340**	**370**	**410**	**320**	**350**	**570**	**410**	**262**	1
Ethylbenzene	1.2	(<1.0 U)	**2.4**	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	**(<10 U)**	(<1 U)	5
Isopropylbenzene	**24**	**40**	**56**	**59**	**49**	**27**	**76**	**42**	**40.4**	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<1 U)	--
Methyl-t-butyl ether	**290**	**240**	**480**	**260**	**320**	**580**	**430**	**250**	**248**	10
Naphthalene	**150**	**230**	**250**	**340**	**200**	**160**	**260**	**230**	**95.4**	10
n-Butylbenzene	**6.8**	**6.5**	**12**	**12**	**9**	**5.8**	**16**	**10**	**7.6**	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	2.3	1.4	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<5 U)	5
o-Xylene	150	160	220	210	200	120	380	140	38.6	--
sec-Butylbenzene	**13**	**15**	**21**	**23**	**18**	**10**	**30**	**15**	**16.1**	5
t-Butyl Alcohol	40	(<5.0 U)	21	23	14	27	(<25 U)	(<250 U)	(<20 U)	--
t-Butylbenzene	1.1	(<1.0 U)	2	2.3	1.5	(<1.0 U)	(<5 U)	(<10 U)	(<5 U)	5
Toluene	1.3	(<1.0 U)	1.9	2.4	2.1	(<1.0 U)	(<5 U)	(<10 U)	(<1 U)	5
Xylenes (Total)	**150**	**160**	**220**	**210**	**200**	**120**	**380**	**140**	**38.6**	5
BTEX	273	500	594.3	1,032	522	470	950	550	301	--
Total VOC	808	1,046	1,457.60	1,461	1,141	1,289	1,787	1,190	721	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	1,400	1,600	1,300	2,300	1,000	2,100	1,800	1,200	1,670	--

TABLE 1 (Continued)

Analyte	MW-12D1									NYSDEC Class GA Value[(a)]
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	(<5 U)	5
4-Isopropyltoluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	(<5 U)	5
Benzene	**14**	**24**	**14**	**34**	**97**	**62**	**130**	**110**	**74.7**	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<2.5 U)	(<1 U)	(<1 U)	5
Isopropylbenzene	(<1.0 U)	(<1.0 U)	3.4	3.2	**8.8**	3.5	**14**	**6.2**	(<5 U)	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	(<1 U)	--
Methyl-t-butyl ether	**110**	**120**	**38**	**180**	**290**	**160**	**310**	**210**	**160**	10
Naphthalene	5.8	(<1.0 U)	**12**	**14**	**36**	8.8	**41**	**18**	**20.1**	10
n-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	(<5 U)	5
o-Xylene	(<1.0 U)	(<1.0 U)	7.5	4.3	48	6.3	27	2.8	(<1 U)	--
sec-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	2.4	(<1.0 U)	(<5 U)	1.1	(<5 U)	5
t-Butyl Alcohol	15	15	(<5.0 U)	19	19	14	(<25 U)	(<25 U)	(<20 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	(<5 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	(<1.0 U)	(<1.0 U)	**7.5**	4.3	**48**	**6.3**	**27**	2.8	(<1 U)	5
BTEX	14	24	21.5	38	145	68	157	113	75	--
Total VOC	145	159	74.9	255	501	255	522	120	255	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	(<300 U)	(<300 U)	(<300 U)	370	550	400	610	(<310 U)	340	--

TABLE 1 (Continued)

Analyte	MW-12D2									NYSDEC Class GA Value$^{(a)}$
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	**27**	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	**9.9**	(<1 U)	(<5 U)	5
4-Isopropyltoluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	1.8	(<1 U)	(<5 U)	5
Benzene	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	**5.1**	(<1 U)	(<1 U)	5
Isopropylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	2.2	(<1 U)	(<5 U)	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	14	(<1 U)	(<1 U)	--
Methyl-t-butyl ether	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<1 U)	10
Naphthalene	1	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	7	(<1 U)	(<5 U)	10
n-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	3	(<1 U)	(<5 U)	5
o-Xylene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	10	(<1 U)	(<1 U)	--
sec-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	1.8	(<1 U)	(<5 U)	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5 U)	(<25 U)	(<20 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	(<5 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	**24**	(<1 U)	(<1 U)	5
BTEX	ND	ND	ND	ND	ND	ND	29.1	ND	ND	--
Total VOC	1	ND	ND	ND	ND	ND	82	ND	ND	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<320 U)	(<330 U)	(< 220 U)	--

TABLE 1 (Continued)

Analyte	MW-13I1									NYSDEC Class GA Value(a)
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
4-Isopropyltoluene	1.4	(<1.0 U)	1.6	1.2	(<1.0 U)	1.1	3	(<1 U)	(<5 U)	5
Benzene	**13**	**7.9**	**25**	**23**	**22**	**18**	**26**	**3.6**	**7.9**	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Isopropylbenzene	4.6	3.4	**6.5**	**5.8**	**8.7**	**5.6**	**9.9**	1.8	(<5 U)	5
m&p-Xylenes	3.8	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
Methyl-t-butyl ether	(<0.5 U)	(<0.5 U)	2	1.3	1.3	3.2	8.4	(<0.5 U)	(<1 U)	10
Naphthalene	**27**	**13**	**41**	**41**	**58**	**38**	**48**	9.9	(<5 U)	10
n-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	1.9	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
o-Xylene	3.1	1.5	23	6.3	2	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
sec-Butylbenzene	1.3	(<1.0 U)	1.4	1.1	3	1.5	2.9	(<1 U)	(<5 U)	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5 U)	(<20 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	**6.9**	1.5	**23**	**6.3**	2	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
BTEX	20	9.4	48	29	24	18	26	4	8	--
Total VOC	56	26	100.5	80	95	67	98	15	8	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	(<300 U)	(<300 U)	(<300 U)	330	(<300 U)	(<300 U)	(<300 U)	(<320 U)	(< 220 U)	--

TABLE 1 (Continued)

Analyte	MW-13I2									NYSDEC Class GA Value(a)
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<20 U)	(<20 U)	(<5 U)	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<20 U)	(<20 U)	(<5 U)	5
4-Isopropyltoluene	**22**	**15**	**17**	**21**	**16**	**21**	**25**	**26**	**20.9**	5
Benzene	**350**	**250**	**350**	**380**	**320**	**530**	**470**	**440**	**258**	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<10 U)	(<20 U)	(<1 U)	5
Isopropylbenzene	**65**	**34**	**50**	**69**	**75**	**64**	**82**	**88**	**67.8**	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<20 U)	(<20 U)	(<1 U)	--
Methyl-t-butyl ether	**610**	**500**	**430**	**590**	**420**	**550**	**460**	**830**	**64.5**	10
Naphthalene	**330**	**210**	**240**	**480**	**360**	**400**	**450**	**680**	**265**	10
n-Butylbenzene	**11**	**7.2**	**7.8**	**11**	**13**	**12**	(<20 U)	**21**	**13.5**	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<20 U)	(<20 U)	(<5 U)	5
o-Xylene	230	120	100	73	86	29	20	(<20 U)	1.3	--
sec-Butylbenzene	**22**	**15**	**19**	**27**	**29**	**22**	**26**	**22**	**21.8**	5
t-Butyl Alcohol	(<5.0 U)	31	22	(<5.0 U)	10	(<5.0 U)	(<100 U)	(<100 U)	(<20 U)	--
t-Butylbenzene	(<1.0 U)	1.6	2	(<1.0 U)	3.3	(<1.0 U)	(<20 U)	(<20 U)	(<5 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<20 U)	(<20 U)	(<1 U)	5
Xylenes (Total)	**230**	**120**	**100**	**73**	**86**	**29**	**20**	(<20 U)	**1.3**	5
BTEX	580	370	450	453	406	559	490	440	259	--
Total VOC	1,640	1,184	1,237.8	1,651	1,332	1,628	1,622	2,081	713	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	(<300 U)	1,600	1,500	2,400	1,200	2,400	1,600	1,900	1,970	--

TABLE 1 (Continued)

Analyte	MW-13D1									NYSDEC Class GA Value(a)
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	**14.3**	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	**29**	**14**	5
4-Isopropyltoluene	4.4	**7**	3.8	**5.1**	(<1.0 U)	(<1.0 U)	(<5 U)	**6.5**	(<5 U)	5
Benzene	**150**	**130**	**160**	**220**	**330**	**310**	**360**	**230**	**185**	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	(<1 U)	5
Isopropylbenzene	**24**	**27**	**24**	**30**	**48**	**34**	**50**	**39**	**33.6**	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	(<1 U)	--
Methyl-t-butyl ether	**270**	**250**	**360**	**430**	**940**	**730**	**850**	**480**	**329**	10
Naphthalene	**110**	**110**	**130**	**220**	**220**	**160**	**210**	**180**	**109**	10
n-Butylbenzene	1.3	2.4	2.3	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	2.1	(<5 U)	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	(<5 U)	5
o-Xylene	10	14	19	31	59	35	28	32	18	--
sec-Butylbenzene	**5.5**	**7.7**	**7.3**	**11**	**11**	(<1.0 U)	**15**	**11**	**9.7**	5
t-Butyl Alcohol	20	12	25	(<5.0 U)	26	(<5.0 U)	37	(<25 U)	(<20 U)	--
t-Butylbenzene	(<1.0 U)	1.4	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	2	(<5 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	**10**	**14**	**19**	**31**	**59**	**35**	**28**	**32**	**18**	5
BTEX	160	144	179	251	389	345	388	262	203	--
Total VOC	595	561	731.4	947	1,634	1,269	1,550	1,005	713	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	(<300 U)	740	690	900	640	1,400	770	760	880	--

TABLE 1 (Continued)

Analyte	MW-13D2									NYSDEC Class GA Value(a)
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<5 U)	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<5 U)	5
4-Isopropyltoluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<5 U)	5
Benzene	(<0.5 U)	(<0.5 U)	**8.5**	**27**	**80**	**180**	**180**	**41**	**177**	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<1 U)	5
Isopropylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<5 U)	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<1 U)	--
Methyl-t-butyl ether	2.5	**14**	**110**	**140**	**450**	**1,200**	**920**	**830**	**904**	10
Naphthalene	(<1.0 U)	(<1.0 U)	(<1.0 U)	3.5	3.4	(<1.0 U)	8.7	**12**	(<5 U)	10
n-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<5 U)	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<5 U)	5
o-Xylene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<1 U)	--
sec-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<5 U)	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	7.6	20	(<5.0 U)	40	(<250 U)	59.2	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<5 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<1 U)	5
Xylenes (Total)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<10 U)	(<1 U)	5
BTEX	ND	ND	8.5	27	80	180	180	41	177	--
Total VOC	2.5	14	118.5	178	553	1,380	1,149	883	1,140	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<330 U)	590	--

TABLE 1 (Continued)

Analyte	MW-15I									NYSDEC Class GA Value[a]
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	5
4-Isopropyltoluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	5
Benzene	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	5
Isopropylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	--
Methyl-t-butyl ether	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<1 U)	10
Naphthalene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	**11**	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	10
n-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	5
o-Xylene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	--
sec-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<20 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	5
Xylenes (Total)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	5
BTEX	ND	ND	ND	ND	ND	ND	ND	ND	ND	--
Total VOC	ND	ND	ND	ND	11	ND	ND	ND	ND	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<320 U)	(<310 U)	(< 200 U)	--

TABLE 1 (Continued)

Analyte	MW-16I									NYSDEC Class GA Value[(a)]
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
4-Isopropyltoluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	2.2	(<1 U)	(<5 U)	5
Benzene	**68**	**34**	**100**	**64**	**82**	**140**	**120**	**100**	**82.7**	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Isopropylbenzene	(<1.0 U)	**6.9**	3	**6.6**	**17**	**21**	**34**	**28**	**20.5**	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
Methyl-t-butyl ether	**73**	**39**	**34**	**16**	**34**	**80**	**38**	**33**	**29.6**	10
Naphthalene	(<1.0 U)	7.1	6.3	**12**	**78**	**140**	**130**	**130**	**108**	10
n-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
o-Xylene	(<1.0 U)	1.5	1.3	2.5	1.8	2.9	5	3	(<1 U)	--
sec-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	1.6	1.7	(<5 U)	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	6	(<20 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	1.1	1.3	1.7	(<1 U)	(<5 U)	5
Toluene	1.4	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	(<1.0 U)	1.5	1.3	2.5	1.8	2.9	**5**	3	(<1 U)	5
BTEX	69	35	101.3	66.5	84.0	143	125	103	83	--
Total VOC	142	89	144.6	101	214	385	333	302	241	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	630	(<300 U)	310	350	(<300 U)	620	500	550	610	--

TABLE 1 (Continued)

Analyte	MW-16D1									NYSDEC Class GA Value(a)
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	**15.9**	5
1,3,5-Trimethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	**15.5**	5
4-Isopropyltoluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<5 U)	5
Benzene	**79**	**130**	**110**	**83**	**95**	**160**	**160**	**330**	**216**	1
Ethylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	5
Isopropylbenzene	(<1.0 U)	**7.7**	3.4	2.4	**6.2**	**9.5**	**22**	**45**	**36.1**	5
m&p-Xylenes	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	--
Methyl-t-butyl ether	**90**	**110**	**76**	**82**	**100**	**290**	**160**	**310**	**203**	10
Naphthalene	(<1.0 U)	**11**	**23**	**29**	**22**	**44**	**57**	**140**	**72.9**	10
n-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<5 U)	5
n-Propylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<5 U)	5
o-Xylene	3.3	4.3	1.6	1.3	2	2.9	4.7	7.8	5.3	--
sec-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<5 U)	5
t-Butyl Alcohol	(<5.0 U)	(<5.0 U)	(<5.0 U)	5.3	(<5.0 U)	7.9	5	(<25 U)	(<20 U)	--
t-Butylbenzene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	1.2	(<5 U)	(<5 U)	5
Toluene	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<5 U)	(<1 U)	5
Xylenes (Total)	3.3	4.3	1.6	1.3	2	2.9	4.7	**7.8**	**5.3**	5
BTEX	82	134	111.6	84.3	97.0	163	165	338	221	--
Total VOC	172	263	214	203	225	514	410	883	565	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	470	350	(<300 U)	330	(<300 U)	490	360	440	720	--

TABLE 1 (Continued)

Analyte	MW-16D2									NYSDEC Class GA Value$^{(a)}$
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
4-Isopropyltoluene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Benzene	NI	(<0.5 U)	0.55	0.57	(<0.5 U)	**1.2**	0.76	(<0.5 U)	(<0.5 U)	1
Ethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Isopropylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
m&p-Xylenes	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
Methyl-t-butyl ether	NI	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	2.9	1.3	3.2	1.3	10
Naphthalene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	**11.1**	10
n-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
o-Xylene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
sec-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
t-Butyl Alcohol	NI	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5 U)	(<20 U)	--
t-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Toluene	NI	(<1.0 U)	1	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
BTEX	NI	ND	1.55	0.57	ND	1.2	0.76	ND	ND	--
Total VOC	NI	ND	1.55	0.57	ND	4.1	2.06	3	12	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	NI	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<330 U)	(< 200 U)	--
NOTE: NI = Not Installed										

TABLE 1 (Continued)

Analyte	MW-17S									NYSDEC Class GA Value$^{(a)}$
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
4-Isopropyltoluene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Benzene	NI	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	0.66	1
Ethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	2.2	5
Isopropylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
m&p-Xylenes	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	7.1	--
Methyl-t-butyl ether	NI	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<1 U)	10
Naphthalene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	10
n-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
o-Xylene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	2.5	--
sec-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
t-Butyl Alcohol	NI	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5 U)	(<20 U)	--
t-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Toluene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	**9.5**	5
BTEX	NI	ND	ND	ND	ND	ND	ND	ND	12	--
Total VOC	NI	ND	ND	ND	ND	ND	ND	ND	22	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	NI	590	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<320 U)	(<310 U)	(< 200 U)	--

TABLE 1 (Continued)

Analyte	MW-17I									NYSDEC Class GA Value[(a)]
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
4-Isopropyltoluene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Benzene	NI	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	1
Ethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Isopropylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
m&p-Xylenes	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	1.5	--
Methyl-t-butyl ether	NI	(<0.5 U)	(<0.5 U)	0.61	0.77	1.3	0.83	(<0.5 U)	5.4	10
Naphthalene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	10
n-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
o-Xylene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
sec-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
t-Butyl Alcohol	NI	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5 U)	(<20 U)	--
t-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Toluene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	1.5	5
BTEX	NI	ND	ND	ND	ND	ND	ND	ND	2	--
Total VOC	NI	ND	ND	0.61	0.77	1.3	0.83	6	14	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	NI	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<320 U)	(<300 U)	(< 210 U)	--

TABLE 1 (Continued)

Analyte	MW-18I									NYSDEC Class GA Value[(a)]
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
4-Isopropyltoluene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Benzene	NI	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	1
Ethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Isopropylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
m&p-Xylenes	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
Methyl-t-butyl ether	NI	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	1.3	(<0.5 U)	(<0.5 U)	(<1 U)	10
Naphthalene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	1.5	(<5 U)	10
n-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
o-Xylene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
sec-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
t-Butyl Alcohol	NI	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5 U)	(<20 U)	--
t-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Toluene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
BTEX	NI	ND	ND	ND	ND	ND	ND	2	ND	--
Total VOC	NI	ND	ND	ND	ND	1.3	ND	2	ND	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	NI	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<310 U)	(<300 U)	(< 200 U)	--

TABLE 1 (Continued)

Analyte	MW-18D									NYSDEC Class GA Value[(a)]
	May 2009	August 2009	Nov/Dec 2009	March 2010	June 2010	September 2010	December 2010	March 2011	June 2011	
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)										
1,2,4-Trimethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
4-Isopropyltoluene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Benzene	NI	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	(<0.5 U)	0.56	1
Ethylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Isopropylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
m&p-Xylenes	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
Methyl-t-butyl ether	NI	(<0.5 U)	0.78	0.8	1.4	2.8	1.8	1.2	(<1 U)	10
Naphthalene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	10
n-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
n-Propylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
o-Xylene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	--
sec-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
t-Butyl Alcohol	NI	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5.0 U)	(<5 U)	(<20 U)	--
t-Butylbenzene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<5 U)	5
Toluene	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
Xylenes (Total)	NI	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1.0 U)	(<1 U)	(<1 U)	5
BTEX	NI	ND	ND	ND	ND	ND	ND	ND	1	--
Total VOC	NI	ND	0.78	0.8	1.4	2.8	1.8	1	2.4	--
DIESEL RANGE ORGANICS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)										
Diesel Range Organics	NI	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<300 U)	(<310 U)	(<300 U)	(< 210 U)	--

TABLE 1 (Continued)

Analyte	MW-18 Bedrock		NYSDEC Class GA Value[(a)]
	March 2011	June 2011	
VOC BY U.S. EPA METHOD 8260B (µg/L)			
1,2,4-Trimethylbenzene	(<1 U)	(<5 U)	5
1,3,5-Trimethylbenzene	(<1 U)	(<5 U)	5
4-Isopropyltoluene	(<1 U)	(<5 U)	5
Benzene	(<0.5 U)	(<0.5 U)	1
Ethylbenzene	(<1 U)	(<1 U)	5
Isopropylbenzene	(<1 U)	(<5 U)	5
m&p-Xylenes	(<1 U)	(<1 U)	--
Methyl-t-butyl ether	2.3	6.5	10
Naphthalene	(<1 U)	(<5 U)	10
n-Butylbenzene	(<1 U)	(<5 U)	5
n-Propylbenzene	(<1 U)	(<5 U)	5
o-Xylene	(<1 U)	(<1 U)	--
sec-Butylbenzene	(<1 U)	(<5 U)	5
t-Butyl Alcohol	(<5 U)	(<20 U)	--
t-Butylbenzene	(<1 U)	(<5 U)	5
Toluene	(<1 U)	(<1 U)	5
Xylenes (Total)	(<1 U)	(<1 U)	5
BTEX	ND	ND	--
Total VOC	ND	12	--
TPH-DRO BY U.S. EPA METHOD 8015 (µg/L)			
Diesel Range Organics	(<310 U)	(< 210 U)	--

TABLE 2 SUMMARY OF PARCEL 1 POST-SEAR SAMPLING RESULTS

Analyte	SGMP-01					SGMP-02					Groundwater Standards [(a)]
	Nov-10	Dec-10	Jan-11	Mar-11	Jun-11	Nov-10	Dec-10	Jan-11	Mar-11	Jun-11	
VOC BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (μg/L)											
1,2,4-Trimethylbenzene	**1,500**	**8,500**	**3,800**	**430**	**213**	**5,600**	**4,100**	**2,400**	**4,400**	**1,250**	5
1,3,5-Trimethylbenzene	**560**	**2,900**	**1,300**	**140**	**60**	**2,000**	**1,500**	**780**	**1,800**	**377**	5
Benzene	**130**	**81**	**(<50 U)**	(<5 U)	(<5 U)	**390**	**220**	**310**	**210**	**139**	1
Chloroform	**(<100 U)**	**(<100 U)**	**(<100 U)**	**(<10 U)**	**(<10 U)**	**(<100 U)**	**(<100 U)**	**(<100 U)**	**(<100 U)**	**(<50 U)**	7
Ethylbenzene	**250**	**1,200**	**510**	**100**	**10.6**	**950**	**860**	**730**	**1,000**	**378**	5
Isopropylbenzene	**110**	**610**	**280**	**45**	**(<50 U)**	**460**	**310**	**210**	**400**	**(<250 U)**	5
m&p-Xylenes	980	4,000	1,800	250	36.3	3,400	3,000	2,300	2,800	1,110	---
Methyl-t-butyl ether	**(<50 U)**	**(<100 U)**	**(<50 U)**	(<5 U)	(<10 U)	**(<50 U)**	**(<100 U)**	**(<50 U)**	**(<50 U)**	**(<50 U)**	10
Methylene chloride	**(<100 U)**	**(<100 U)**	**(<100 U)**	**(<10 U)**	**(<20 U)**	**(<100 U)**	**(<100 U)**	**(<100 U)**	**(<100 U)**	**(<100 U)**	5
Naphthalene	**620**	**1,800**	**780**	**130**	**(<50 U)**	**1,600**	**1,200**	**630**	**1,100**	**268**	10
n-Butylbenzene	**110**	**870**	**350**	**19**	**(<50 U)**	**540**	**460**	**170**	**440**	**(<250 U)**	5
n-Propylbenzene	**180**	**1,200**	**470**	**75**	**(<50 U)**	**810**	**570**	**310**	**680**	**(<250 U)**	5
o-Xylene	730	2,600	1,200	170	18.6	2,100	1,600	1,600	1,900	669	---
p-Isopropyltoluene	**150**	**1,000**	**310**	**28**	**(<50 U)**	640	**460**	180	500	(<250 U)	5
sec-Butylbenzene	**130**	**990**	**310**	**30**	**(<50 U)**	**600**	**500**	**190**	**510**	**(<250 U)**	5
t-Butyl Alcohol	(<500 U)	(<500 U)	(<500 U)	(<250 U)	(<200 U)	(<500 U)	(<500 U)	(<500 U)	(<500 U)	(<1000 U)	---
t-Butylbenzene	**(<100 U)**	**(<100 U)**	**(<100 U)**	**(<1 U)**	**(<50 U)**	**(<100 U)**	**(<100 U)**	**(<100 U)**	**(<100 U)**	**(<250 U)**	5
Toluene	**300**	**470**	**160**	**17**	**(<10 U)**	**120**	**240**	**480**	**360**	**183**	5
Xylenes (Total)	**1,710**	**6,600**	**3,000**	**420**	**54.8**	**5,500**	**4,600**	**3,900**	**4,700**	**1,770**	5
BTEX	2,390	8,351	3,670	535	65	6,960	5,920	5,240	6,270	2,470	---
Total VOC	5,750	26,221	11,270	1,434	339	19,210	15,020	10,290	16,100	4,374	
OTHER VOC BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260 (μg/L)											
2-Propanol	1,600	NA	NA	NA	NA	1,400	1,100	1,300	NA	NA	---
Acetone	**88,000**	**69,000**	**4,100**	**(<100 U)**	**(<50 U)**	**110,000**	**200,000**	**180,000**	**130,000**	**111,000**	50
TPH-DRO BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (mg/L)											
TPH-DRO	560	260	---	7	15.2	1,300	370	---	307	192	---
MBAS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 425.1 (mg/L)											
MBAS	240.0	1,130	272.0	48.0	25.0	652.0	895.0	94.7	175.0	281	---

(a) New York State Regulation 6NYCRR Part 703 Class GA standards and/or New York State Department of Environmental Conservation (NYSDEC) 1998 AmbientWater Quality Standards

NOTE: VOC = Volatile Organic Compounds
μg/L = Micrograms/LiterLiter
U = Analyzed but not detected at a concentration above the reporting limit. Sample quantitation limits are shown as (<__ U)
--- = Indicates no standard or guidance value exists
BTEX = Benzene, toluene, ethylbenzene, and total xylenes
ND = Non-Detect
NA = Not Analyzed
TPH-DRO = Total Petroleum Hydrocarbon-Diesel Range Organics
MBAS = Methylene Blue Active Substance
NS = Not Sampled

Bold values indicate exceedance of groundwater standard

TABLE 2 (Continued)

Analyte	SGMP-03					SPMP-04					Groundwater Standards [(a)]
	Nov-10	Dec-10	Jan-11	Mar-11	Jun-11	Nov-10	Dec-10	Jan-11	Mar-11	Jun-11	
VOC BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)											
1,2,4-Trimethylbenzene	**160**	**58**	**2**	(<1 U)	(<50 U)	**160**	**120**	**640**	**510**	**646**	5
1,3,5-Trimethylbenzene	**64**	**25**	**(<1 U)**	(<1 U)	(<50 U)	**54**	**35**	**170**	180	(<250 U)	5
Benzene	**62**	**33**	**4**	**1**	**(<5 U)**	**19**	**25**	**98**	86	(<25 U)	1
Chloroform	(<1 U)	**(<10 U)**	(<1 U)	(<1 U)	10.4	**(<10 U)**	**(<10 U)**	**(<50 U)**	(<20 U)	(<50 U)	7
Ethylbenzene	**71**	**44**	(<1 U)	(<1 U)	(<10 U)	**82**	**110**	**260**	320	242	5
Isopropylbenzene	**18**	**11**	**3**	(<1 U)	(<50 U)	**17**	**25**	**54**	47	(<250 U)	5
m&p-Xylenes	200	87	2	(<1 U)	(<10 U)	170	160	870	740	731	---
Methyl-t-butyl ether	(<0.5 U)	(<5 U)	(<0.5 U)	(<0.5 U)	(<10 U)	(<5 U)	(<5 U)	**(<25 U)**	(<10 U)	(<50 U)	10
Methylene chloride	(<1 U)	**(<10 U)**	(<1 U)	(<1 U)	(<20 U)	**(<10 U)**	**(<10 U)**	**(<50 U)**	**(<50 U)**	**(<100 U)**	5
Naphthalene	**96**	**60**	**28**	**10**	**(<50 U)**	**95**	**100**	**220**	**230**	**(<250 U)**	10
n-Butylbenzene	1.4	**(<10 U)**	(<1 U)	(<1 U)	(<50 U)	**(<10 U)**	**(<10 U)**	**(<50 U)**	21	(<250 U)	5
n-Propylbenzene	**17**	(<10 U)	(<1 U)	(<1 U)	(<50 U)	**24**	**28**	**75**	70	(<250 U)	5
o-Xylene	160	12	3	5	(<10 U)	270	320	720	720	520	---
p-Isopropyltoluene	**7.7**	(<10 U)	**2**	(<1 U)	(<50 U)	**12**	**11**	**(<50 U)**	24	(<250 U)	5
sec-Butylbenzene	4	**(<10 U)**	(<1 U)	(<1 U)	(<50 U)	**11**	**12**	**(<50 U)**	21	(<250 U)	5
t-Butyl Alcohol	(<5 U)	(<50 U)	(<5 U)	(<25 U)	(200 U)	(<50 U)	(<50 U)	(<250 U)	(<100 U)	(<1000 U)	---
t-Butylbenzene	(<1 U)	**(<10 U)**	(<1 U)	(<1 U)	(<50 U)	**(<10 U)**	**(<10 U)**	**(<50 U)**	(<20 U)	(<250 U)	5
Toluene	3.8	**(<10 U)**	(<1 U)	(<1 U)	(<10 U)	**83**	**84**	**220**	160	223	5
Xylenes (Total)	**360**	**99**	4	**5**	**(<10 U)**	**440**	**480**	**1,590**	**1,460**	**1,250**	5
BTEX	497	176	9	7	ND	624	699	2,168	2,026	1,715	---
Total VOC	904	330	43	16	10	997	1,030	7,527	3,129	2,362	
OTHER VOC BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260 (µg/L)											
2-Propanol	770	270	ND	NA	NA	26	500	700	NA	NA	---
Acetone	**24,000**	**27,000**	**64**	(<10 U)	2,100	**9,000**	**38,000**	**87,000**	**14,000**	**826**	50
TPH-DRO BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (mg/L)											
TPH-DRO	27	3	---	(<0.330 U)	1.86	42	19	---	3.000	10.9	---
MBAS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 425.1 (mg/L)											
MBAS	1.74	18.9	0.130 J	0.186	0.2	50.2	3.62	8.26	85.2	297	---

TABLE 2 (Continued)

Analyte	GMP-01D					GMP-02D					Groundwater Standards $^{(a)}$
	Nov-10	Dec-10	Jan-11	Mar-11	Jun-11	Nov-10	Dec-10	Jan-11	Mar-11	Jun-11	
VOC BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)											
1,2,4-Trimethylbenzene	**140**	**4,600**	**2,600**	**410**	**359**	**700**	**1,200**	**2,200**	**570**	**570**	5
1,3,5-Trimethylbenzene	**50**	**1,400**	**830**	**140**	**(<250 U)**	**280**	**410**	**760**	**180**	**125**	5
Benzene	**12**	**50**	**98**	**(<25 U)**	**(<25 U)**	**220**	**290**	**60**	**(<10 U)**	**(<5 U)**	1
Chloroform	(<1 U)	**(<100 U)**	**(<100 U)**	**(<50 U)**	**(<50 U)**	**(<20 U)**	**(<50 U)**	**(<50 U)**	**(<20 U)**	**(<10 U)**	7
Ethylbenzene	**25**	**720**	**490**	**150**	**159**	**270**	**400**	**680**	**320**	**164**	5
Isopropylbenzene	**11**	**320**	**170**	**(<50 U)**	**(<250 U)**	**56**	**86**	**140**	**46**	**(<50 U)**	5
m&p-Xylenes	74	2,300	1,600	420	522	780	1,300	2,000	990	551	---
Methyl-t-butyl ether	(<0.5 U)	**(<50 U)**	**(<50 U)**	**(<50 U)**	**(<50 U)**	**(<10 U)**	**(<25 U)**	**(<25 U)**	**(<10 U)**	**(<10 U)**	10
Naphthalene	**20**	**720**	**440**	**95**	**(<250 U)**	**170**	**240**	**380**	**180**	**207**	10
n-Butylbenzene	**13**	**(<100 U)**	**300**	**(<50 U)**	**(<250 U)**	**24**	**50**	**170**	**22**	**(<50 U)**	5
n-Propylbenzene	**20**	**620**	**310**	**51**	**(<250 U)**	**72**	**120**	**240**	**63**	**(<50 U)**	5
o-Xylene	66	1,500	1,200	400	318	610	1,000	1,500	630	319	---
p-Isopropyltoluene	**16**	**540**	**290**	**(<50 U)**	**(<250 U)**	**43**	**76**	**200**	**23**	**(<50 U)**	5
sec-Butylbenzene	**15**	**570**	**290**	**(<50 U)**	**(<250 U)**	**35**	**68**	**160**	**21**	**(<50 U)**	5
t-Butyl Alcohol	(<5 U)	(<500 U)	(<500 U)	(<250 U)	(<1000 U)	(<100 U)	(<250 U)	(<250 U)	(<500 U)	(<200 U)	---
t-Butylbenzene	(<1 U)	**(<100 U)**	**(<100 U)**	**(<50 U)**	**(<250 U)**	**(<20 U)**	**(<50 U)**	**(<50 U)**	**(<20 U)**	**(<50 U)**	5
Toluene	**35**	**360**	**430**	**220**	**(<50 U)**	**300**	**420**	**430**	**110**	**20.7**	5
Xylenes (Total)	**140**	**3,800**	**2,800**	**820**	**840**	**1390**	**2,300**	**3,500**	**1,620**	**870**	5
BTEX	212	4,930	3,818	1,190	999	2,180	3,410	4,670	2,050	1,055	---
Total VOC	497	13,700	9,048	1,886	1,358	3,560	5,660	8,920	3,155	1,957	---
OTHER VOC BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260 (µg/L)											
2-Propanol	NA	NA	170	NS	NA	1900	1,300	NA	NS	NA	---
Acetone	**7,600**	**130,000**	**89,000**	**32,000**	**14,600**	**110,000**	**120,000**	**17,000**	**6,100**	**1,260**	50
TPH-DRO (original)	70	420	---	25	31.3	190	85	---	6	21.3	---
MBAS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 425.1 (mg/L)											
MBAS	77.5	924	387	256	79.1	81.5	114	322	135	69.3	---

TABLE 2 (Continued)

Analyte	GMP-03D					GMP-04D					GMP-05D			Groundwater Standards (a)
	Nov-10	Dec-10	Jan-11	Mar-11	Jun-11	Nov-10	Dec-10	Jan-11	Mar-11	Jun-11	Nov-10	Dec-10	Jan-11	
VOC BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)														
1,2,4-Trimethylbenzene	**28**	**76**	**100**	**(<50 U)**	**659**	**1200**	**31**	**870**	**4,200**	**877**	**900**	**1,700**	**610**	5
1,3,5-Trimethylbenzene	**6.4**	**(<50 U)**	**(<50 U)**	**(<50 U)**	**(<250 U)**	**470**	**11**	**290**	**1,500**	**(<250 U)**	**250**	**480**	**160**	5
Benzene	**110**	**100**	**120**	**(<25 U)**	**119**	**240**	(<0.5 U)	**(<100 U)**	**140**	**45.5**	**220**	**110**	**7**	1
Chloroform	1.1	**(<50 U)**	**(<50 U)**	**(<50 U)**	**(<50 U)**	**(<20 U)**	(<1 U)	**(<200 U)**	**(<100 U)**	**(<50 U)**	**(<20 U)**	**(<50 U)**	(<5 U)	7
Ethylbenzene	**49**	**88**	**100**	**(<50 U)**	**204**	**400**	4	**520**	**230**	**120**	**390**	**620**	**190**	5
Isopropylbenzene	**30**	**52**	**(<50 U)**	**(<50 U)**	**(<250 U)**	**110**	2	**(<200 U)**	**360**	**(<250 U)**	**76**	**140**	**43**	5
m&p-Xylenes	46	110	140	53	524	1600	16	1,400	3,100	420	1100	1,900	590	---
Methyl-t-butyl ether	(<0.5 U)	**(<25 U)**	**(<25 U)**	**(<50 U)**	**(<50 U)**	**(<10 U)**	(<0.5 U)	**(<100 U)**	**(<50 U)**	**(<50 U)**	**(<10 U)**	**(<25 U)**	(<2.5 U)	10
Naphthalene	**120**	**270**	**280**	**59**	**(<250 U)**	**530**	5	**250**	**720**	**(<250 U)**	**280**	**360**	**120**	10
n-Butylbenzene	**14**	**(<50 U)**	**(<50 U)**	**(<50 U)**	**(<250 U)**	**87**	(<1 U)	**(<200 U)**	**430**	**(<250 U)**	**77**	**180**	**17**	5
n-Propylbenzene	**33**	**(<50 U)**	**(<50 U)**	**(<50 U)**	**(<250 U)**	**170**	3	**(<200 U)**	**510**	**(<250 U)**	**120**	**200**	**63**	5
o-Xylene	200	570	570	110	463	1100	11	800	1,500	192	840	1,400	420	---
p-Isopropyltoluene	**18**	**(<50 U)**	**(<50 U)**	**(<50 U)**	**(<250 U)**	**98**	2	**(<200 U)**	**430**	**(<250 U)**	**92**	**180**	**27**	5
sec-Butylbenzene	**20**	**(<50 U)**	**(<50 U)**	**(<50 U)**	**(<250 U)**	**84**	2	**(<200 U)**	**490**	**(<250 U)**	**80**	**170**	**26**	5
t-Butyl Alcohol	(<5 U)	(<250 U)	(<250 U)	(<250 U)	(<1000 U)	(<100 U)	(<5 U)	(<1,000 U)	(<500 U)	(<1000 U)	(<100 U)	(<250 U)	(<25 U)	---
t-Butylbenzene	(<1 U)	**(<50 U)**	**(<50 U)**	**(<50 U)**	**(<250 U)**	**(<20 U)**	(<1 U)	**(<200 U)**	**(<100 U)**	**(<250 U)**	**(<20 U)**	**(<50 U)**	**(<5 U)**	5
Toluene	**56**	**94**	**210**	**69**	**232**	**280**	(<1 U)	**(<200 U)**	**(<100 U)**	**107**	**370**	**360**	**99**	5
Xylenes (Total)	**246**	**680**	**710**	**163**	**988**	**2700**	**27**	**2,200**	**4,600**	**612**	**1940**	**3,300**	**1,010**	5
BTEX	461	962	1,140	232	1,543	3,620	31	2,720	4,970	885	2,920	**4,390**	1,306	---
Total VOC	732	1,360	1,520	291	2,201	6,369	87	4,130	13,610	1,762	4,795	7,800	2,372	---
OTHER VOC BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260 (µg/L)														
2-Propanol	210	1,400	700	NS		1900	NA	610	NS	NA	1900	NA	NA	---
Acetone	**15,000**	**110,000**	**100,000**	**45,000**	**84,200**	**110,000**	(<5 U)	**110,000**	**82,000**	**(<250 U)**	**96,000**	**43,000**	**390**	50
TPH-DRO (original)	9.3	20.0	---	60.0	29.1	160	150	---	150	48	98	97	---	---
MBAS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 425.1 (mg/L)														
MBAS	1.11	5.77	37.8	230	166	125	160	71.4	502	217	122	336	76.2	---

TABLE 2 (Continued)

Analyte	MW-09I1					MW-09I2					Groundwater Standards [(a)]
	Nov-10	Dec-10	Jan-11	Mar-11	Jun-11	Nov-10	Dec-10	Jan-11	Mar-11	Jun-11	
VOC BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)											
1,2,4-Trimethylbenzene	NS	**31**	**17**	**(<10 U)**	**(< 5 U)**	NS	(<1 U)	(<1 U)	(<1 U)	(< 50 U)	5
1,3,5-Trimethylbenzene	NS	**20**	**18**	**14**	**21**	NS	(<1 U)	(<1 U)	(<1 U)	(< 50 U)	5
Benzene	NS	**780**	**760**	**780**	**453**	NS	**1**	(<0.5 U)	(<0.5 U)	39	1
Ethylbenzene	NS	**370**	**450**	**430**	**311**	NS	(<1 U)	(<1 U)	(<1 U)	(< 10 U)	5
Isopropylbenzene	NS	**93**	**97**	**48**	**78**	NS	(<1 U)	(<1 U)	(<1 U)	(< 50 U)	5
m&p-Xylenes	NS	17	(<10 U)	13	9	NS	(<1 U)	(<1 U)	(<1 U)	(< 10 U)	--
Methyl-t-butyl ether	NS	**300**	**910**	**770**	**290**	NS	(<0.5 U)	(<0.5 U)	(<0.5 U)	(< 10 U)	10
Naphthalene	NS	**270**	**350**	**290**	**315**	NS	2	(<1 U)	(<1 U)	(< 50 U)	10
n-Butylbenzene	NS	**15**	**21**	**(<10 U)**	**(< 5 U)**	NS	(<1 U)	(<1 U)	(<1 U)	(< 50 U)	5
n-Propylbenzene	NS	**83**	**110**	**46**	**82**	NS	(<1 U)	(<1 U)	(<1 U)	(< 50 U)	5
o-Xylene	NS	(<5 U)	(<10 U)	(<10 U)	(< 1 U)	NS	(<1 U)	(<1 U)	(<1 U)	(< 10 U)	--
p-Isopropyltoluene	NS	**33**	**34**	**(<10 U)**	**26**	NS	(<1 U)	(<1 U)	(<1 U)	(< 50 U)	5
sec-Butylbenzene	NS	**37**	**37**	**11**	**27**	NS	(<1 U)	(<1 U)	(<1 U)	(< 50 U)	5
t-Butyl Alcohol	NS	**(<25 U)**	(<50 U)	(<250 U)	(< 20 U)	NS	(<5 U)	(<5 U)	(<1 U)	(< 200 U)	--
t-Butylbenzene	NS	**(<5 U)**	**(<10 U)**	**(<10 U)**	**(< 5 U)**	NS	(<1 U)	(<1 U)	(<1 U)	(< 50 U)	5
Toluene	NS	**(<5 U)**	**(<10 U)**	**(<10 U)**	**(< 1 U)**	NS	(<1 U)	(<1 U)	(<1 U)	(< 10 U)	5
Xylenes (Total)	NS	**17**	**(<10 U)**	**13**	**9**	NS	(<1 U)	(<1 U)	(<1 U)	(< 10 U)	5
BTEX	---	1,167	1,210	1,223	773	---	1	ND	ND	39	--
Total VOC (STARS List)	---	2,049	2,804	2,402	1,611	---	3	ND	ND	50	--
Total VOC	---	2,049	2,804	2,402	1,611	---	3	ND	ND	50	--
OTHER VOC BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260 (µg/L)											
2-Propanol	NS	NA	NA	NS	NS	NS	NA	NA	NS	NS	--
Acetone	NS	(<25 U)	**(<50 U)**	**(<100 U)**	(< 5 U)	NS	(<5 U)	(<5 U)	(<10 U)	**(< 50 U)**	50
TPH-DRO BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (mg/L)											
TPH-DRO	NS	6	---	7	13	NS	(<0.320 U)	---	(<0.300 U)	0.205	--
MBAS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 425.1 (mg/L)											
MBAS	NS	0.063	0.04 J	0.049	(<0.10 U)	NS	0.123	0.02 J	0.1	(<0.10 U)	--
BROMIDE BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 9056a (mg/L)											
Bromide	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	---

TABLE 2 (Continued)

Analyte	MW-09D1					MW-09D2					Groundwater Standards (a)
	Nov-10	Dec-10	Jan-11	Mar-11	Jun-11	Nov-10	Dec-10	Jan-11	Mar-11	Jun-11	
VOC BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)											
1,2,4-Trimethylbenzene	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	5
1,3,5-Trimethylbenzene	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	5
Benzene	NS	(<0.5 U)	(<0.5 U)	(<0.5 U)	**(< 5 U)**	NS	(<0.5 U)	(<0.5 U)	(<0.5 U)	**(< 5 U)**	1
Ethylbenzene	NS	(<1 U)	(<1 U)	(<1 U)	**(< 10 U)**	NS	(<1 U)	(<1 U)	(<1 U)	**(< 10 U)**	5
Isopropylbenzene	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	5
m&p-Xylenes	NS	(<1 U)	(<1 U)	(<1 U)	(< 10 U)	NS	(<1 U)	(<1 U)	(<1 U)	(< 10 U)	--
Methyl-t-butyl ether	NS	(<0.5 U)	(<0.5 U)	(<0.5 U)	**(< 10 U)**	NS	(<0.5 U)	(<0.5 U)	(<0.5 U)	**(< 10 U)**	10
Naphthalene	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	10
n-Butylbenzene	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	5
n-Propylbenzene	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	5
o-Xylene	NS	(<1 U)	(<1 U)	(<1 U)	(< 10 U)	NS	(<1 U)	(<1 U)	(<1 U)	(< 10 U)	--
p-Isopropyltoluene	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	5
sec-Butylbenzene	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	5
t-Butyl Alcohol	NS	(<5 U)	(<5 U)	(<5 U)	(< 200 U)	NS	(<5 U)	(<5 U)	(<5 U)	(< 200 U)	--
t-Butylbenzene	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	NS	(<1 U)	(<1 U)	(<1 U)	**(< 50 U)**	5
Toluene	NS	(<1 U)	(<1 U)	(<1 U)	**(< 10 U)**	NS	(<1 U)	(<1 U)	(<1 U)	**(< 10 U)**	5
Xylenes (Total)	NS	(<1 U)	(<1 U)	(<1 U)	**(< 10 U)**	NS	(<1 U)	(<1 U)	(<1 U)	**(< 10 U)**	5
BTEX	---	ND	ND	ND	ND	---	ND	ND	ND	ND	--
Total VOC (STARS List)	---	ND	ND	ND	ND	---	ND	ND	ND	ND	--
Total VOC	---	ND	ND	ND	ND	---	ND	ND	ND	ND	--
OTHER VOC BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260 (µg/L)											
2-Propanol	NS	NA	NA	NS	NS	NS	NA	NA	NS	NS	--
Acetone	NS	(<5 U)	(<5 U)	(<10 U)	**(< 50 U)**	NS	(<5 U)	(<5 U)	(<10 U)	**(< 50 U)**	50
TPH-DRO BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (mg/L)											
TPH-DRO	NS	(<0.330 U)	---	(<0.310 U)	(< 0.21 U)	NS	(<0.320 U)	---	(<0.310 U)	(< 0.20 U)	--
MBAS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 425.1 (mg/L)											
MBAS	NS	0.182	(<10 U)	0.1	(<0.10 U)	NS	0.119	(<10 U)	0.051	(<0.10 U)	--
BROMIDE BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 9056a (mg/L)											
Bromide	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	---

TABLE 3 SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
AUGUST 2010 ADDITIONAL MONITORING WELLS

Analyte	MW-19	MW-21	MW-22	NYSDEC Class GA Value(a)
VOLATILE ORGANIC COMPOUNDS BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8260B (µg/L)				
1,2,4-Trimethylbenzene	(<1.0 U)	**680**	(< 10 U)	5
1,3,5-Trimethylbenzene	(<1.0 U)	**380**	(< 10 U)	5
4-Isopropyltoluene	(<1.0 U)	**36**	**24**	5
Benzene	(<0.5 U)	**590**	**530**	1
Ethylbenzene	(<1.0 U)	**630**	(< 10 U)	5
Isopropylbenzene	(<1.0 U)	**91**	**69**	5
m&p-Xylenes	(<1.0 U)	1100	(< 10 U)	--
Methyl-t-butyl ether	(<0.5 U)	(< 5.0 U)	**560**	10
Naphthalene	(<1.0 U)	**460**	**340**	10
n-Butylbenzene	(<1.0 U)	**15**	**12**	5
n-Propylbenzene	(<1.0 U)	**140**	(< 10 U)	5
o-Xylene	(<1.0 U)	13	930	--
sec-Butylbenzene	(<1.0 U)	**35**	**22**	5
t-Butyl Alcohol	(< 5.0 U)	(< 50 U)	(< 50 U)	--
t-Butylbenzene	(<1.0 U)	(< 10 U)	(< 10 U)	5
Toluene	(<1.0 U)	(< 10 U)	(< 10 U)	5
Xylenes (Total)	(<1.0 U)	**1,113**	**930**	5
BTEX	ND	2,333	1,460	--
Total VOC	ND	4,170	2,487	--
TPH-DRO BY U.S. ENVIRONMENTAL PROTECTION AGENCY METHOD 8015 (µg/L)				
TPH-DRO	(< 300 U)	7,900	5,300	--

(a) New York State Department of Environmental Conservation (NYSDEC) 1998 Ambient Water Quality Standards and Guidance Values.

NOTE: µg/L = Micrograms/Liter
U = Analyzed but not detected at concentrations above the reporting limit. Sample quantitation limits are shown as (<__ U)
-- = Indicates no standard or guidance value exists
BTEX = Benzene, toluene, ethylbenzene, and total xylenes
ND = Non-Detect
VOC = Volatile Organic Compound
TPH-DRO = Total Petroleum Hydrocarbon-Diesel Range Organics
Bold values indicate exceedance of NYSDEC Class GA Groundwater Standards and Guidance Values

TABLE 4 PROFILING POINT CONSTRUCTION DETAILS

Profiling Point ID	Location	Sampling Interval (ft bgs)	Sample Depth[a] (ft bgs)	Lab Type
MW-23	Bravo Taxiway	60 to 160 max[b]	60	On-site Lab
			70	
			80	
			90	
			100	
			110	
			120	
			130	
			140	
			150	
			160	
MW-24	Northramp	60 to 160 max	60	On-site Lab
			70	
			80	
			90	
			100	
			110	
			120	
			130	
			140	
			150	
			160	
MW-13	Northramp	110 to 160 max	110	Fixed lab
			120	
			130	
			140	
			150	
			160	
MW-25	Inner Loop	60-max 160[b]	60	On-site Lab
			70	
			80	
			90	
			100	
			110	
			120	
			130	
			140	
			150	
			160	

(a) Samples collected at 10-foot intervals to depth at which concentrations are no longer detected

(b) Installed to top of bedrock, anticipated at 160 ft bgs

NOTE: bgs = below ground surface
NA = Not Applicable
Profiling points will be installed in a minimum 3-in. diameter hole.

TABLE 4 (Continued)

Profiling Point ID	Location	Sampling Interval (ft bgs)	Sample Depth (ft bgs)	Lab Type
MW-26	Northramp	60-max 160[(b)]	60	On-site Lab
			70	
			80	
			90	
			100	
			110	
			120	
			130	
			140	
			150	
			160	
MW-16	Downgradient Ozone Pilot Area	110 to 160 max	110	Fixed Lab
			120	
			130	
			140	
			150	
			160	
MW-27	Downgradient Ozone Pilot Area	60-max 160[(b)]	60	On-site Lab
			70	
			80	
			90	
			100	
			110	
			120	
			130	
			140	
			150	
			160	
MW-28	Downgradient Ozone Pilot Area	60-max 160[(b)]	60	On-site Lab
			70	
			80	
			90	
			100	
			110	
			120	
			130	
			140	
			150	
			160	

TABLE 4 (Continued)

Profiling Point ID	Location	Sampling Interval (ft bgs)	Sample Depth (ft bgs)	Lab
MW-29	Downgradient Ozone Pilot Area	60-max 160[b]	60	On-site Lab
			70	
			80	
			90	
			100	
			110	
			120	
			130	
			140	
			150	
			160	
MW-30	Downgradient	60-max 160[b]	60	On-site Lab
			70	
			80	
			90	
			100	
			110	
			120	
			130	
			140	
			150	
			160	
MW-31	Downgradient	60-max 160[b]	60	On-site Lab
			70	
			80	
			90	
			100	
			110	
			120	
			130	
			140	
			150	
			160	
MW-32	Downgradient	60-max 160[b]	60	On-site Lab
			70	
			80	
			90	
			100	
			110	
			120	
			130	
			140	
			150	
			160	

TABLE 5 MONITORING WELL CONSTRUCTION DETAILS

Cluster ID	Monitoring Wells	Well Type	Screened Interval (ft bgs)[(a),(b)]
MW-13	MW-13D3	Nested	115-120
	MW-13D4		135-140[(c),(d)]
MW-16	MW-16D3	Nested	120-125
	MW-16D4		135-140
	MW-16 Bedrock	Single	150-160[(c),(d)]
MW-24	MW-24S	Multi-Port	40-50
	MW-24I1		65-70
	MW-24I2		85-90
	MW-24D		100-105
MW-25	MW-25S	Multi-Port	42-52
	MW-25I1		70-75
	MW-25I2		100-105
	MW-25D		125-130
MW-26	MW-26S	Multi-Port	40-50
	MW-26I1		65-70
	MW-26I2		85-90
	MW-26D		105-110
MW-27	MW-27S	Multi-Port	45-55
	MW-27I1		75-80
	MW-27I2		100-105
	MW-27D		125-130

a) Shallow well screened across the water table (10-ft screen, 5 feet above and 5 feet below water table).
b) Actual depths of intermediate and deep well screen intervals will be based on results of groundwater profiling.
c) Bedrock is estimated to be at a depth of 160 feet bgs.
d) Bedrock well will be drilled with mud rotary to top of bedrock. A 4-in. diameter casing will be set to top of bedrock and the bedrock will be HQ cored. A 2-in. diameter PVC well will be installed a minimum of 20 feet into bedrock.

NOTE: bgs = Below ground surface
NA = Not Applicable

TABLE 5 (Continued)

Cluster ID	Monitoring Wells	Well Type	Screened Interval (ft bgs)[(a),(b)]
MW-28	MW-28S	Multi-Port	43-53
	MW-28I1		70-75
	MW-28I2		90-95
	MW-28D1		110-115
	MW-28D2		125-130
MW-29	MW-29S	Multi-Port	45-55
	MW-29I1		75-80
	MW-29I2		100-105
	MW-29D		125-130
MW-30	MW-30S	Multi-Port	48-58
	MW-30I1		85-90
	MW-30I2		105-110
	MW-30D2		125-130
MW-31	MW-31S	Multi-Port	48-58
	MW-31I1		80-85
	MW-31I2		95-100
	MW-31D		115-120
MW-32	MW-32S	Multi-Port	51-61
	MW-32I1		80-85
	MW-32I2		95-100
	MW-32D		115-120
MW-33	MW-33S	Multi-Port	45-55
	MW-33I1		75-80
	MW-33I2		100-105
	MW-33D		125-130
MW-34	MW-34S	Multi-Port	45-55
	MW-34I1		75-80
	MW-34I2		100-105
	MW-34D		125-130

TABLE 6 SUMMARY OF PERFORMANCE MONITORING, OZONE PILOT TEST

Type of Monitoring	Location	Frequency[a]	Method
Air Flow Rate (shallow and deep)	Flow meter in system trailer	Every hour during the first 8 hours. Daily thereafter.	Flow meter
Air Injection Pressure (shallow and deep)	Pressure gauges in system trailer	Every hour during the first 8 hours. Daily thereafter.	Pressure Gauges
Ozone injection concentration	Sample port in system trailer	Daily.	Draeger tube
DO and ORP	All monitoring points	Daily for first week. Every other day thereafter.	Water quality meter
Ozone			Ozone meter
Soil Gas Pressures	Shallow monitoring points	Daily for the first week. Every other day thereafter.	Magnehelic gauge
Water Levels			Water level indicator
Soil Vapor VOC			Photoionization detector
VOC and TPH-DRO	Monitoring points	Prior to system startup. After two weeks of operation. After four weeks of operation.	Off-site laboratory

(a) The same field monitoring frequency steps will be repeated for both the low-flow rate and high-flow rate portions of the test.

NOTE: DO = Dissolved Oxygen
ORP = Oxidation-Reduction Potential
VOC = Volatile Organic Compounds
TPH-DRO = Total Petroleum Hydrocarbons-Diesel Range Organics

Appendix A

Safety, Health, and Emergency Response Plan Addendum

Safety, Health, and Emergency Response Plan
for the Remedial Investigation
Wheeler-Sack Army Airfield
Fort Drum, New York

Prepared for

U.S. Army Corps of Engineers–Baltimore District
Engineering Division–HTRW Branch
10 South Howard Street
Baltimore, Maryland 21201

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January 2012
62393.01

Safety, Health, and Emergency Response Plan for the Remedial Investigation Wheeler-Sack Army Airfield Fort Drum, New York

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CPR	Cardiopulmonary resuscitation
CRZ	Contamination Reduction Zone
DBA	Decibels, A-weighted scale
EPA	U.S. Environmental Protection Agency
EZ	Exclusion Zone
IRM	Interim Remedial Measure
MSDS	Material Safety Data Sheet
OSHA	Occupational Safety and Health Administration
PPE	Personal protective equipment
ppm	Parts per million
SHERP	Safety, Health, and Emergency Response Plan
SVOC	Semivolatile organic compounds
SZ	Support Zone
USACE	U.S. Army Corps of Engineers
VOC	Volatile organic compounds

1. INTRODUCTION

1.1 OBJECTIVE

The objective of this Safety, Health, and Emergency Response Plan (SHERP) is to provide personnel with protection standards and mandatory safety practices, procedures, and contingencies to be followed while performing field activities as part of the Remedial Investigation at the Oasis Fuel Point, Wheeler-Sack Army Airfield, Fort Drum, New York (Figure 1). The SHERP as developed defines actions to be taken with respect to personal safety during work activities associated with the additional groundwataer investigation and ozone sparging pilot test. Work activities for characterization include installation of soil borings and monitoring wells, as well as associated soil and groundwater sampling activities and investigative-derived material handling. Activities for the ozone pilot testing include installation of wells and associated monitoring points as well as operation of the injection system. One copy of this SHERP will be maintained for use during the scheduled field activities. The copy will be made available for site use/employee review at all times. In addition, EA will coordinate with the Wheeler-Sack Army Airfield safety and health representative for all site-related safety manuals.

1.2 SITE AND FACILITY DESCRIPTION

The Oasis Fuel Point is located on the runway of Wheeler-Sack Army Airfield, and is bounded to the south by taxiway A, to the west by taxiway J, and to the east by taxiway B (Figure 2). A small, grassy area adjoins the Oasis Fuel Point to the north. The closest structure is Building P-2069 (Oasis Fuel Point operations building) located to the south. The Oasis Fuel Point is a refueling area for helicopters consisting of an asphalt foundation that is approximately 600 ft × 400 ft. The site contains six fuel dispensers and associated piping/equipment to transport JP-8 from the above ground fuel storage tanks to the fueling dispensers.

1.3 POLICY STATEMENT

EA Science and Technology and its subcontractor employees will be familiar with the SHERP for the project activities in which they are involved. Prior to entering the site, this SHERP will be reviewed and the agreement to comply with the requirements will be signed by EA personnel, including subcontractors and visitors (Appendix A). By signing this agreement, the subcontractors and visitors acknowledge their responsibility to comply with the occupational safety and health requirements defined in this SHERP. Prior to accessing the site, EA and EA subcontractor personnel will meet onsite with Fort Drum's aviation safety office in order to be informed of site emergency response procedures and potential safety or health hazards associated with operations conducted in support of this project.

1.4 REFERENCES

This SHERP addresses the following regulations and guidance documents:

- Occupational Safety and Health Administration (OSHA) Standards for Construction Industry, 29 CFR 1926, including 29 CFR 1926.65, *Hazardous Waste Operations and Emergency Response* and 29 CFR 1926.59, *Hazard Communications*
- U.S. Army Corps of Engineers (USACE) *Safety and Health Requirements Manual*, EM 385-1-1
- USACE *Safety and Occupational Health Document Requirements for Hazardous, Toxic, and Radioactive Waste Activities,* ER 385-1-92
- National Institute of Occupational Safety and Health/OSHA/U. S. Coast Guard/ U.S. Environmental Protection Agency (EPA) *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*
- Federal Acquisition Regulation, Clause 52.236-13: *Accident Prevention*.
- Wheeler-Sack Army Airfield Standard Operating Procedure, Chapter 28, *Flightline Vehicle Operations and Driving Guide*, and Chapter 5, *Fuel Operations*.

2. ROLES AND RESPONSIBILITIES

2.1 PERSONNEL

EA and subcontractor employees are responsible for reading, understanding, and meeting the safety and health requirements contained in this SHERP, and any additional site-specific plans and addendums. A SHERP Review Record sign-off sheet is provided in Appendix A. Employees are required to implement these procedures when carrying out daily operations. This will include receiving appropriate training and medical monitoring and utilization of EA provided safety and health equipment (to include all forms of personal protective equipment [PPE]) to safely conduct and carry out site operations. Employees will review each task prior to commencement to consider the potential safety and health hazards, and the measures to be taken in the event of an emergency. Employees should know where material safety data sheets (MSDS), first aid supplies, and emergency equipment are maintained. The Field Manager or Site Safety and Health Officer should be notified of potential safety and health hazards, near-miss conditions, or incidents present on the job site or unusual effects believed to be related to hazardous chemical exposures. Failure to follow established safety and health procedures could result in immediate dismissal from the site and, if repeated, a potential loss of employment.

2.1.1 Responsibilities

Clear lines of authority will be established for enforcing compliance with the safety, health, and contingency procedures consistent with industry policies and procedures. Designated EA personnel are responsible for implementation of the SHERP during field activities. This includes field supervision; implementing and directing emergency operations; coordinating with onsite and offsite emergency responders; enforcing safe work practices and decontamination procedures (if needed); ensuring proper use of PPE; communicating site safety program modifications and requirements to site personnel; proper reporting of injuries, illnesses, and incidents to the appropriate internal and external organizations; and containing and controlling the loss of potentially hazardous materials to soil, air, and surface/groundwater during all phases of field operations.

In the event of an on-site injury, occupational illness, near miss, or environmental contamination incident, the following organizations/individuals will be notified as appropriate (Chapter 11):

- Field Manager
- Project Manager
- Program Safety and Health Officer
- Corporate Safety and Health Officer
- USACE–Baltimore District Field Manager
- Fort Drum Environmental Division
- Other organizations or persons as appropriate as defined by USACE–Baltimore.

2.1.2 Key Project Personnel

The following table contains information on key project personnel for the remedial investigation.

Project Officer/Program Manager	Brenda Herman
Project Manager	Christopher Canonica, P.E.
Quality Assurance/Quality Control Officer/Senior Technical Review	Frank Barranco, P.G.
Program Safety and Health Officer	Peter Garger, CIH
Remedial Investigation Manager	Jennifer Martin Bouchard, P.G.
Site Manager/Site Safety and Health Officer	Mike Valvo

2.2 PROGRAM SAFETY AND HEALTH OFFICER (OR DESIGNEE)

The ***Program Safety and Health Officer*** has overall project responsibility for the development and implementation of this SHERP and conformance with project requirements. The Program Safety and Health Officer will also be consulted and approve changes to this SHERP or significant modifications of safety and health procedures. Authorization for personnel to perform work onsite (i.e., relative to medical examinations and training) is also the responsibility of the Program Safety and Health Officer.

2.3 SITE SAFETY AND HEALTH OFFICER

The ***Site Safety and Health Officer*** is responsible for coordination of onsite contingency operations and the Site Safety and Health Program. The Site Safety and Health Officer (and/or the alternate) will be onsite at all times throughout the project and will be responsible for daily compliance with site safety and health requirements. The Site Safety and Health Officer’s responsibilities include:

-
- Conduct visual inspections of the area of concern to be sampled
- Stop work when imminent safety and health risks exist or as outlined in the SHERP
- Implement the use of forms in this SHERP
- Implement the guidance within this SHERP
- Provide an initial safety and health briefing to site workers and visitors
- Evaluate reported hazardous conditions and recommend corrective actions
- Conduct necessary safety and health monitoring
- Identify, investigate, and prepare incident reports as necessary

- Consult with the Program Safety and Health Officer or Project Manager for guidance on occupational safety and health and contingency issues affecting this project

- Maintain an OSHA Log No. 300, Summary of Occupational Injuries and Illnesses, and posting an OSHA Poster No. 2203 during times that site work occurs

- Provide technical support and guidance in the modification of site SHERP requirements

- Evaluate onsite environmental monitoring results and provide reporting requirements to the Project Manager.

During an emergency, the Field Manager (or the Alternate in the absence of the Field Manager) will be responsible for initiating and coordinating emergency responses/contingency operations.

Both the Program Safety and Health Officer and the Site Safety and Health Officer will have the authority to make on-the-spot corrections dealing with safety, health, and environmental pollution infractions. If it is determined that the infraction cannot be remedied immediately and continuing the job could result in significant illness, injury, environmental contamination, and violations, the Program Safety and Health Officer and/or Site Safety and Health Officer will have the authority to order a cessation of the activity until the problem can be remedied.

2.4 PROJECT MANAGER

The ***Project Manager*** will have overall responsibility for site activities and will be the primary contact during the work activities. The primary responsibilities of the Project Manager include:

-
- Assure compliance with this SHERP

- Coordinate with the Field Manager

- Approve the SHERP and amendments

- Review individual training and medical records prior to work start

- Provide overall supervisory control for safety and health protocols in effect for this project

- Assign the Field Manager and Site Safety and Health Officer

- Assure adequate resources are available for carrying out this SHERP

- Prepare and submit project reports.

2.5 TASK MANAGER

The ***Task Manager's*** responsibilities include, but are not limited to:

- Provide technical support to the Site Safety and Health Officer
- Evaluate onsite environmental monitoring results and report to the Project Manager and Program Safety and Health Officer
- Be responsible for initiating the evacuation of the work site when needed, communicating with offsite emergency responders, and coordinating activities of onsite and offsite emergency responders
- Determine if the abatement of hazardous conditions is sufficient prior to allowing resumption of work operations after an emergency

2.6 SUBCONTRACTORS

Responsibilities of EA and subcontractor personnel include:

- Follow the SHERP and applicable safety and health rules, regulations, and procedures
- Understand and comply with all 29 CFR 1910 and 29 CFR 1926 rules and regulations applicable to the operations they are conducting to ensure the safety and health of their personnel
- Use required controls, procedures, and safety devices, including PPE
- Notify his/her supervisor of identified or suspected emergencies, safety, or health hazards
- Comply with training and medical requirements.

2.7 VISITORS

Visitors entering the site area will be required to sign in on the entry/exit log (Appendix B) and to read and verify their understanding and willingness to comply with this SHERP. Visitors will remain in an observation area and will not be allowed in the Exclusion Zone (EZ) or Support Zone (SZ) unless they have met the appropriate OSHA and medical requirements, and have received clearance by the EA Project Manager and the Site Safety and Health Officer.

3. RISK ANALYSIS

3.1 PROJECT SCOPE OF WORK

The scope of work for the activities covered by this SHERP is presented in the remedial investigation work plan.

The specific activities for the pre-design investigation program include the following:

- Soil Boring/Groundwater Profiling
    - — Completion of 14 *in situ* groundwater monitoring points using mud rotary drilling.
    - — Collection of groundwater samples at 10-ft intervals in each borehole, throughout the thickness of the impacted aquifer
    - — Groundwater analysis for volatile organic compounds (VOCs) including MTBE and naphthalene by USEPA Method 8260.
- Monitoring Well Installation and Sampling
    - — Installation of multi-port monitoring wells in nine of the boreholes used for groundwater profiling (seven within the unconsolidated material and two within bedrock).
    - — Collection of groundwater samples from the monitoring wells for analysis of VOCs and TPH as DRO.
- Surveying of the new monitoring well locations by a New York State licensed surveyor
    - — Horizontal and vertical coordinates for each new location will be integrated with existing survey information located at the Oasis Fuel Point site.
- Managing investigation-derived material
    - — Containerizing soil cuttings and purge waters from the borings and monitoring wells.

The specific activities associated with the ozone sparging pilot test include the following:

- Installation of ozone sparging points
    - — Two ozone injection points

  - Three ozone monitoring points, with four vertical intervals per location, and an additional single depth monitoring point.

- Sampling of soils from the monitoring well locations and ozone sparge points for grain size analysis.

- Analysis of two subsurface soil samples for TOC.

  - Installation of two ozone sparge points, using stainless steel tubing with an ozone diffuser, at different depths within a single borehole.

- Installation of a trailer-mounted ozone test unit

  - Installation of the unit including an ozone generation subsystem, compressed air subsystem, and pressure gauges.

- Operations and maintenance of the ozone injection system

  - Operation of the system for approximately 4 weeks.

- Field Monitoring

  - Hourly measurements of flow, pressure, ozone concentration, groundwater levels, DO, and ORP in the sparging points and surrounding monitoring wells for the first week, and daily thereafter.

Based upon the above field activities, the following potential hazard conditions may be anticipated:

- The use of mechanical equipment such as drill rigs, powered augers, and hammer drills can create a potential for crushing and pinching hazards due to movement and positioning of the equipment; movement of lever arms and hydraulics; entanglement of clothing and appendages in exposed drives and augers; and impact of steel tools, masts, and cables should equipment rigging fail or other structural failures occur during hydraulic equipment operation; and drilling mast extension and operation. Heavy equipment work must be conducted only by trained, experienced personnel. If possible, personnel must remain outside the turning radius of large, moving equipment. At a minimum, personnel must maintain visual contact with the equipment operator. When not operational, equipment must be set and locked so that it cannot be activated, released, dropped, etc.

- Equipment can be energized due to contact with overhead or underground electrical lines, utilities impaired by excavation of communication or potable/wastewater lines, or a potential for fire or explosion may occur due to excavation of below ground propane/natural gas lines. Prior to commencement of invasive operations, a drilling/excavation permit will be obtained and the area will be inspected and flagged. Furthermore, well locations will be hand cleared to a depth of 5 ft below ground surface with the use of "soft digging" with a minimum 12-in. inner diameter. Personnel should be aware that although an area may be cleared, it does not mean that unanticipated hazards will not appear. Safe distances will be maintained from live electrical equipment as specified in original SHERP. Workers should always be alert for unanticipated events such as snapping cables, digging into unmarked underground utilities, etc. Such occurrences should prompt involved individuals to halt work immediately and take appropriate corrective measures to gain control of the situation.

- Work around large equipment often creates excessive noise. Noise can cause workers to be startled, annoyed, or distracted; can cause physical damage to the ear, pain, and temporary and/or permanent hearing loss; and can interfere with communication. If workers are subjected to noise exceeding an 8-hour time-weighted average sound level of 85 decibels (acoustic), hearing protection will be selected with an appropriate noise reduction rating to comply with 29 CFR 1910.95 and to reduce noise below levels of concern.

- Personnel may be injured during physical lifting and handling of heavy equipment, construction materials, or containers. Additionally, personnel may experience slip, trip, and fall hazards associated with excavations, man ways, and construction debris and materials.

- Workers who are exposed to extreme heat or work in hot environments may be at risk of heat stress. Exposure to extreme heat can result in occupational illnesses and injuries. Heat stress can result in heat stroke, heat exhaustion, heat cramps, or heat rashes. Heat can also increase the risk of injuries in workers as it may result in sweaty palms, fogged-up safety glasses, and dizziness. Workers should avoid exposure to extreme heat, sun exposure, and high humidity when possible. When these exposures cannot be avoided, workers should take the following steps to prevent heat stress: wear light-colored, loose-fitting, breathable clothing such as cotton; schedule heavy work during the coolest parts of day; take more breaks in extreme heat and humidity; drink water frequently and drink enough water that you never become thirsty; avoid drinks with caffeine, alcohol, and large amounts of sugar; and constantly monitor your physical condition and that of your coworkers.

- Field operations conducted during cold winter months can expose personnel to extreme temperatures and wind chill.

- Entry into a confined space in support of this project by EA personnel is forbidden. However, confined space entry by a certified contractor will be required for cleaning several aboveground storage tanks. This will occur upon project winterization, and the contractor will be responsible for ensuring their technicians are trained per OSHA 1910.146.

- Water collected during well development and groundwater sampling activities may contain toxic vapors, liquids, and gases and may be inhaled during normal operations or splashed onto the skin or eyes. Toxic materials contained in dusts or particulates can be ingested if eating, smoking, drinking, and gum chewing are permitted prior to personnel washing their hands and face, or removing contaminated work clothing and personal protective equipment. Some chemicals may be absorbed directly through the skin. Personal protective equipment, properly designed for the chemicals of concern, will always be provided and worn when a potential for skin contact is present.

- Table 1 provides exposure limits for ozone and for major components of gasoline, diesel fuels, and JP-8. Material Safety Data Sheets for the major components (i.e., ozone, JP-8, etc.) are contained in Appendix H of this addendum. Material Safety Data Sheets for other chemicals of concern associated with this work (i.e., gasoline) are maintained on file in the job trailer.

- Activities associated with the pre-design investigation and the ozone pilot testing may require employees to be in direct proximity or contact with hazardous substances. Employees may be exposed through dermal contact with or inhalation of toxic dusts, vapors, or gases. Normal dust particulates from surficial soil may have adsorbed or absorbed petroleum compounds. Air monitoring equipment will be used to monitor airborne organic vapors and particulates. In addition, employees could be exposed to ozone due to fugitive ozone emissions from the ozone generator, supply piping, or treatment system. Exposure to ozone may cause irritation of the eyes, dryness of the nose and throat, and a cough. If the concentration of ozone continues to rise, more severe symptoms may occur, including headache, upset stomach or vomiting, pain or tightness in the chest, shortness of breath, or tiredness, which may last for several days or weeks.

- Specific hazards associated with ozone include its ability to increase the flammability of other materials (i.e., petroleum compounds). The work area must be kept free of all materials that burn, including oil and grease. Welding, cutting, soldering, drilling or other work on an empty vessel or piping will not be performed until it has been thoroughly purged and all traces of ozone have been removed. A permit lock-out system will be implemented for all maintenance activities in the work area. The ozone handling system will be checked for leaks after maintenance work and have suitable emergency equipment for fires and leaks readily available. Field personnel will practice good housekeeping, maintain handling equipment, and comply with applicable regulations.

3.2 HAZARD COMMUNICATION

A written OSHA Hazard Communication Program for Construction (required by 29 CFR 1926.59) will be maintained onsite during investigative activities. Employees will be informed of the Hazard Communication Program's existence, contents, and location. This Program will be kept with the MSDS and contain a list of site-specific chemicals present. The list will be cross-referenced with the applicable MSDS for ease in MSDS accessibility.

An MSDS for each chemical brought onsite during field activities will be kept onsite by the Site Safety and Health Officer. Subcontractors must inform the Field Manager and Site Safety and Health Officer about hazardous substances brought onsite and provide an appropriate MSDS to the Site Safety and Health Officer. Chemicals brought onsite must be labeled in accordance with OSHA Hazard Communication Requirements, 29 CFR 1910.1200. Site workers and visitors will be informed of the Hazard Communication Program, their legal rights under the program, the location of the chemical inventory, and the location of the MSDS. Subcontractors will coordinate with EA to provide a list of the hazardous materials that will be used onsite in support of their operations. This information will be shared jointly with all site employees and visitors to the site.

The following chemicals will be supplied by the contractor/subcontractors:

- Portland cement
- Silica sand
- Sodium bentonite.

Employee awareness of chemical identities, health and physical hazards, and characteristics is essential to safely handle chemicals and minimize potential hazards. The Hazard Communication Program must follow the OSHA requirements listed in 29 CFR 1926.59.

3.2.1 Hazardous Substance List

EA will maintain a dynamic list of hazardous materials (Table 1). Examples of hazardous materials that might be present at the site include solvents, adhesives, irritants, corrosives, flammables, combustibles, compressed gases, organic peroxides (curing agents), and oxidizers (ozone and other sanitizing agents). This list will be used in the Hazard Communication Program. Additionally, other potential hazardous substances that could be present onsite may also be listed. Examples of other hazardous substances associated with site operations may include: carbon monoxide generation from generators or internal combustion engines, contaminants which could be present on the site and encountered in the process of site assessment, and potential atmospheric contaminants present in confined spaces.

3.2.2 Hazard Communication Labeling

EA will ensure that in-house containers are properly labeled and that workers understand the contents of containers. Container labels will contain at least information on the name of product or container, chemical(s) in product, manufacturer's name and address, PPE required for the safe handling of the product, and first aid procedures in case of overexposure to product contents.

Any pipes, tubing, or containers containing ozone will also be clearly marked to indicate a potential hazard due to fire and inhalation hazards. Labels will indicate that intervention with the pipework while the system is operating is not permissible.

3.2.3 Hazard Communication Training

Every site employee and visitor must be informed of EA’s Hazard Communication Program, their legal rights under the program, and location of chemical inventory and MSDS files. The employee’s supervisor must describe hazardous substances routinely used and provide information concerning:

- Nature of potential hazards
- Appropriate work practices
- Appropriate control programs
- Appropriate protective measures
- Methods to detect presence or release of hazardous substances
- Emergency procedures.

3.3 CHEMICAL HAZARDS

3.3.1 Site-Related Chemical Hazards

Previous soil and groundwater investigations at the site have reported impacts by petroleum hydrocarbons and LNAPL (primarily JP-8). Specific compounds and their relevant properties are shown in Table 1.

Field operation precautions and preventive measures for the pre-design investigation and ozone pilot testing activities are described in the following paragraphs:

Soil Boring/Groundwater Profiling, Monitoring Well Installation and Sampling, Managing Investigation-Derived Material, Installation of Ozone Sparging Test Wells, Groundwater and Soil Sampling for Pilot Test—VOCs/SVOCs may be encountered. Continuous organic vapor monitoring, upwind worker positioning, and PPE are required (see Chapter 5 for specific PPE).

Dermal contact is a potential concern during the above tasks due to the possible presence of skin irritants and other toxic substances that may be absorbed through the skin. This information is based upon a worst-case scenario. Dermal protection listed in Chapter 5 must be worn during work tasks involving contact with soil and groundwater.

A description of the requirements for the different levels of PPE, as well as upgrade/downgrade requirements, is provided in Chapter 5. Although ingestion of contaminants is also a primary source of exposure, vigilance by site safety and health personnel will ensure proper use of PPE and personal hygiene to practically eliminate this route of exposure.

Installation of Ozone Test Unit, Operations and Maintenance of Ozone Injection System—Primary chemical hazard is inhalation or dermal contact with ozone, which, given sufficient exposure, can cause symptoms including irritation of eyes, nose, skin, and throat; headache, fatigue, dizziness, drowsiness, nausea, vomiting, cough, shortness of breath, pulmonary edema, tachycardia, and/or hypotension, depending on the duration and concentration of exposure. Ozone is a colorless gas that has a distinct, pungent odor usually associated with electrical sparks. Ozone odor is generally detectable at concentrations of 0.02-0.05 ppm; however, olfactory fatigue may limit the time that ozone is detectable at this level. Although ozone will be generated onsite in a closed system and then diluted prior to injection, ozone monitoring is required (see Table 4 and Section 8), to protect against direct contact with unacceptable ozone concentrations.

3.3.2 Chemicals for Equipment Calibrations, Operations, and Sampling

In addition to the compounds detected on the site, the following chemicals are typically used by the primary investigation team:

- Isobutylene calibration gas
- Methanol
- Hexane
- Sample preservatives (i.e., hydrochloric acid).

These chemicals will be used for equipment calibrations and operations as well as processing of samples and decontamination of equipment. The quantities to be used will typically not exceed 1-oz, and will be used within controlled conditions. The anticipated occupational exposures from these operations will be negligible.

3.4 PHYSICAL HAZARDS

Physical hazards can potentially be present during field activities. These physical hazards may include, but not be limited to:

- Fire/explosion hazards
- Heat stress
- Cold related illness
- Equipment hazards
- Vehicle and pedestrian hazards
- Noise hazards
- Electrical hazards
- Utilities
- Weather hazards

Physical hazards are listed below for each work task. Physical and Biological Hazard Information Sheets contained in Appendix C list potential hazards and protective measures.

- **Flightline Vehicle Operations and Driving—**Hazards relative to operation of ground vehicles on flightlines and runway incursions. Refer to Wheeler-Sack

Army Airfield Standard Operating Procedure *Flightline Vehicle Operations and Driving Guide.*

- **Drilling and Installation of Monitoring Wells—**General safety hazards, heavy equipment hazards, electrical hazards, underground utilities, fire/explosion, noise hazards, cold/heat stress, and biological hazards.

- **Mobilization/Demobilization of Extraction Technologies**—The mobilization of equipment for the pilot study can create a potential for crushing and pinching hazards due to movement and positioning of equipment.

The site will be visually inspected for the presence of general safety hazards (e.g., trip/slip hazards, unstable surfaces or steep grades, and sharp objects) prior to beginning work. If hazards are present, these hazards will be recorded and precautionary measures taken to prevent injury.

3.4.1 Fire/Explosion Hazards

The potential for fire and/or explosion emergencies is always present on the site. Substances capable of creating fire and explosion at the site include methane gas, petroleum-contaminated soils, and other flammable vapors. Furthermore, the presence of ozone onsite increases explosion and fire hazards. Ozone is an unstable gas, which at normal temperatures will decompose into biatomic oxygen. At elevated temperatures and in the presence of catalysts such as hydrogen, iron, copper, and chromium, this decomposition may be explosive. In addition, ozone reacts with non-saturated organic compounds to produce ozonides, which are unstable and may decompose with explosive violence. Workers must continuously monitor the work area for combustible or explosive gases when operations have the potential to generate sparks. Regular ozone monitoring will also be conducted to help ensure that leaks are identified and repaired and thus to minimize the risk of fires and explosions promoted by ozone.

Employees should always be alert for unexpected events, such as ignition of chemicals or sudden release of materials under pressure, and be prepared to act in these emergencies.

EA field vehicles will be equipped with a fire extinguisher. EA employees must be trained in the proper use of fire suppression equipment. However, large fires that cannot be controlled with a fire extinguisher should be handled by professionals. The proper authorities should be notified in these instances.

3.4.2 Heat Stress and Heat-Related Illness

The use of PPE, if required, may create heat stress. Monitoring of personnel wearing impermeable or semipermeable personal protective clothing should commence when the ambient temperature is 70°F or above. Monitoring frequency should increase as ambient temperature increases or as slow recovery rates are observed. Heat stress monitoring will be performed by a person with a current first-aid certification who is trained to recognize heat stress symptoms.

For monitoring the body's recuperative abilities to excess heat, one or more of the following techniques will be used.

Other methods for determining heat stress monitoring, i.e., the wet bulb globe temperature index from the American Conference of Governmental Industrial Hygienist Threshold Limit Value Booklet, can be used.

To monitor the worker:

- Measure heart rate by counting the radial pulse during a 30-second period as early as possible in the rest period.

- If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same.

- If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one-third.

- Measure oral temperature using a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).

- If oral temperature exceeds 99.6°F (37.6°C), shorten the next work cycle by one-third without changing the rest period.

- If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following work cycle by one-third.

- Do not permit a worker to wear a semipermeable or impermeable garment when oral temperature exceeds 100.6°F (38.1°C).

3.4.2.1 Prevention of Heat Stress

Proper training and preventive measures will aid in averting loss of worker productivity and serious illness. Heat stress prevention is particularly important because once a person suffers from heat stroke or heat exhaustion, that person may be predisposed to additional heat-related illness. To avoid heat stress, the following steps should be taken:

- Adjust work schedules.

- Modify work/rest schedules according to monitoring requirements.

- Mandate work slow downs as needed.

- Perform work during cooler hours of the day if possible or at night if adequate lighting can be provided.

- Provide shelter (air-conditioned, if possible) or shaded areas to protect personnel during rest periods.

- Maintain worker's body fluids at normal levels. This is necessary to ensure that the cardiovascular system functions adequately. Daily fluid intake must approximately equal the amount of water lost in sweat, i.e., 8 fluid oz (0.23 L) of water must be ingested for approximately every 8 oz (0.23 kg) of weight lost. The normal thirst mechanism is not sensitive enough to ensure that enough water will be consumed to replace lost sweat. When heavy sweating occurs, encourage the worker to drink more. The following strategies may be useful:

  - Maintain water temperature 50-60°

  - Provide small disposable cups that hold about 4 oz (0.1 L)

  - Have workers drink 16 oz (0.5 L) of fluid (preferably water or dilute drinks) before beginning work

  - Urge workers to drink a cup or two every 15-20 minutes, or at least each monitoring break. A total of 1-1.6 gal (4-6 L) of fluid per day are recommended, but more may be necessary to maintain body weight.

- Train workers to recognize the symptoms of heat-related illness.

3.4.3 Cold-Related Illness

If work on this project begins in the winter months, effects of cold exposure are possible during the performance of field activities at the Oasis Fuel Point. Injury from cold exposure may occur in persons working outdoors during a period when temperatures average below freezing. The extremities, such as fingers, toes, and ears, are the most susceptible to frostbite. Tables 2 and 3 present the safety precautions that should be followed for cold weather and wind chill conditions.

3.4.3.1 Prevention of Cold-Related Illness

To avoid cold-related illness, the following steps should be taken:

- Educate workers to recognize the symptoms of frostbite and hypothermia
- Identify and limit known risk factors
- Assure the availability of enclosed, heated environment on or adjacent to the site
- Assure the availability of dry changes of clothing
- Develop the capability for temperature recording at the site

- Assure the availability of warm drinks.

3.4.4 Heavy Equipment Hazards

The use of heavy equipment (e.g., drill rigs, generators, compressors, etc.) may pose safety hazards to site workers. Heavy equipment work must be conducted only by trained, experienced personnel. If possible, personnel must remain outside the turning radius of large, moving equipment. At a minimum, personnel must maintain visual contact with the equipment operator. No guards, safety appliances, or other devices may be removed or made ineffective unless repairs or maintenance are required, and then only after power has been shut off and locked out. Safety devices must be replaced once repair or maintenance is complete. Exhaust from equipment must be directed so that it does not endanger workers or obstruct the view of the operator. When not operational, equipment must be set and locked so that it cannot be activated, released, dropped, etc.

3.4.5 Vehicle and Pedestrian Hazards

Vehicle traffic or pedestrians, particularly in busy areas, may be susceptible to site hazards or may present a hazard to site workers. Equipment must be located in an area that does not present a hazard to bystanders. Barriers must be used to separate the work areas from both vehicular and pedestrian traffic areas and to prevent inadvertent entry into the work area. When possible, work in high traffic areas will be performed when traffic is minimal. Safety cones (with a minimum height of 28 in.) will be placed around the work area to create a buffer zone. Workers should wear safety vests or reflective material to enhance visibility in these areas. The buffer zone will be maintained even when work is not being performed in the area to prevent unauthorized access and to make the work site visible.

3.4.6 Noise Hazards

Work around large equipment often creates excessive noise. Noise can cause workers to be startled, annoyed, or distracted; can cause physical damage to the ear, pain, and temporary and/or permanent hearing loss; and can interfere with communication. If workers are subjected to noise exceeding an 8-hour time-weighted average sound level of 85 dBA (decibels on the A-weighted scale), hearing protection will be selected with an appropriate noise reduction rating to comply with 29 CFR 1910.95 and to reduce noise levels below levels of concern.

3.4.7 Electrical Hazards

Overhead power lines, electrical wiring, electrical equipment, and buried cables pose risks to workers of electric shock, burns, heart fibrillation, and other physical injuries, as well as fire and explosion hazards. Workers will take appropriate protective measures when working near live electrical parts, including inspection of work areas to identify potential spark/ignition sources, maintenance of a safe distance, proper illumination of work areas, provision of barriers to prevent inadvertent contact, and use of non-conductive equipment. If overhead lines cannot be de-energized prior to the start of work, a 10-ft distance must be maintained between overhead energized power lines with a voltage of 50 kV and elevated equipment parts. See Appendix C for minimum distances for voltage greater than the 50 kV.

3.4.8 Utilities

Underground utilities pose hazards to workers involved in drilling and other invasive operations. These hazards include electrical hazards, explosion, and asphyxiation, as well as costly and annoying hazards associated with damaging communication, sewer, and water lines. Prior to commencement of invasive operations, Dig-Safe will be contacted to inspect and flag the area of investigation. Personnel should be aware that although an area may be cleared, it does not mean that unanticipated hazards will not appear. Workers should always be alert for unanticipated events such as snapping cables, drilling into unmarked underground utilities, drilling into a heavily contaminated zone, etc. Such occurrences should prompt involved individuals to halt work immediately and take appropriate corrective measures to gain control of the situation.

3.4.9 Weather Hazards

Weather conditions should always be taken into consideration. Heavy rains, electrical storms, high winds, and extreme temperatures, for example, may create extremely dangerous situations for employees. Equipment performance may also be impaired because of inclement weather.

Whenever unfavorable conditions arise, the Field Manager and Site Safety and Health Officer will evaluate both the safety hazards and ability of the employees to effectively perform given tasks under such conditions. Activities will be halted at their discretion.

Wind direction should be accounted for when positioning equipment at sampling locations.
If exposure to organic vapors is anticipated, workers should locate upwind of the sampling point. Wind direction often changes abruptly and without warning, so personnel should always be prepared to reposition, if necessary.

3.5 BIOLOGICAL HAZARDS

Potential hazards may be present at the site due to bites from stray domestic and wild animals (to include rodents), spiders, bees, and other venomous anthropods; ticks may be encountered during any field operation potentially resulting in Lyme disease; or punctures from sharp objects presenting a possible hazard from Tetanus. In case of an animal or insect bite which can be serious or fatal, workers must seek immediate medical attention and report the incident to the Site Safety and Health Officer prior to leaving the site. Any employee known to be allergic or sensitive to poisonous insects should alert the Field Manager and Site Safety and Health Officer. Prompt medical attention will be provided in the event of animal bites (since many animals carry rabies or other diseases/viruses) following procedures outlined in Section 11.2 of this SHERP.

3.5.1 Bloodborne Pathogens

During the conduct of site operations, EA employees may be exposed to blood and body secretions in support of emergency response operations where site personnel have been injured, and require first aid and/or cardiopulmonary resuscitation (CPR). Due to the potential that blood and body secretions may contain disease-causing organisms such as Hepatitis B Virus and Human Immunodeficiency Virus, employees electing to provide first aid and CPR support, until the arrival of a competent onsite medical responder, should take appropriate measures to reduce or eliminate their potential for contact and exposure. The concept of "Universal Precautions" will be followed, assuming a potential hazard is present. Employees providing first aid support should wear the appropriate PPE to prevent or reduce their potential for contact and exposure. This will typically be accomplished through the use of rubber gloves, splash-proof eye protection, and the use of mouth-to-mouth guards and proper cleanup (good sanitation and hygiene) following an incident.

Hands and face should be thoroughly washed with water and an antiseptic soap or cleanser following an incident, or antiseptic containing disposable towelettes used in the absence of appropriate field washing facilities. The Program Safety and Health Officer should be notified of potential employee exposures to blood and body fluids while conducting work in support of this project.

3.6 CONFINED SPACE

A confined space is a space which is large enough and so configured that an employee can bodily enter and perform work, has limited or restricted means for entry or exit, is not designed for continuous employee occupancy, and requires a permit if it has one or more of the following characteristics:

- Contains a potentially hazardous atmosphere due to accumulation of toxic or flammable contaminants or has an oxygen deficient atmosphere
- Contains a material with the potential for suffocation of an entrant
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls, or a floor that slopes downward and tapers to a smaller cross-section
- Contains other recognized safety or health hazards.

Confined spaces include, but are not limited to, storage tanks, process vessels, bins, boilers, ventilation or exhaust ducts, sewers, underground utility vaults, tunnels, pipelines, and open top spaces more than 4 ft in depth such as excavation pits, tubs, vaults, and vessels.

Based on the definition of a confined space, it is not anticipated that confined space entry will be required during the field investigation at the Oasis Fuel Point.

Entry into a confined space in support of this project is forbidden until the potential confined space is thoroughly assessed by the Site Safety and Health Officer. Only those personnel properly trained and certified will be allowed to conduct confined space entries.

4. GENERAL SAFETY PRACTICES

4.1 SAFETY PROCEDURES

Rules for safe work practices that must be followed by site workers include the following:

- At least one copy of this SHERP must be at the project site, in a location readily available to all personnel, and reviewed by all project personnel prior to starting work.

- Site personnel must use the buddy system.

- Potentially contaminated PPE must not be removed from the work area before being cleaned or properly packaged and labeled.

- Potentially contaminated waste, debris, and clothing must be properly contained, and legible and understandable precautionary labels affixed to each container to define its content.

- Removing potentially contaminated soil or debris from protective clothing or equipment with compressed air, shaking, or any other means that may resuspend contaminants into the air is prohibited.

- Eat, drink, and smoke only in those areas designated by the Field Manager/Site Safety and Health Officer. These activities will not take place within a work zone.

- Large bulk containers, such as 55-gal drums, must only be moved with the proper equipment, and must be secured to prevent dropping or loss of control during transport.

- Emergency equipment, i.e., eyewash, fire extinguishers, portable shower, etc., must be removed from storage areas and staged in readily accessible locations.

- Employees must be aware, and inform their partners or fellow team members, of the potential non-visible effects of exposure to toxic materials. The symptoms of such exposures may include:

  — Headaches
  — Dizziness
  — Nausea
  — Blurred vision
  — Cramps
  — Irritation of eyes, skin, or respiratory tract

- Visitors to the site must abide by the following:
  - Visitors must be instructed to stay outside the EZ and Contamination Reduction Zone (CRZ), and remain within the SZ during the extent of their stay. Visitors must be cautioned to avoid skin contact with surfaces that are contaminated or suspected to be contaminated.
  - Visitors requesting to observe work in the EZ must don all appropriate PPE prior to entry into that zone, and must be cleared for hazardous site work as evidenced by a complete physical examination; have 40 hours of hazardous waste operations training; and have 8 hours of refresher training within the past 12 months. If respiratory protective devices are necessary, visitors who wish to enter the CRZ must be respirator-trained and fit tested for a respirator within the past 12 months.
  - Visitor inspection or access of the EZ will be made at the discretion of the Field Manager. Only those personnel fully qualified to access the EZ as defined by 29 CFR 1926.65 will be allowed to enter.
- Each employee required to take prescription drugs will notify the Site Safety and Health Officer prior to the start of work. Controlled or unauthorized drugs will **not** be permitted onsite at any time.

4.2 BUDDY SYSTEM

Onsite personnel must use the buddy system. Visual contact must be maintained between crew members at all times, and crew members must observe each other for signs of chemical exposure, or heat or cold stress. Indications of adverse effects include, but are not limited to:

- Changes in complexion and skin coloration
- Changes in coordination
- Changes in demeanor
- Excessive salivation and pupillary response
- Changes in speech pattern.

Team members must also be aware of potential exposure to possible safety hazards, unsafe acts, or noncompliance with safety procedures.

If PPE or noise levels impair communications, pre-arranged hand signals must be used for communication. Personnel must stay within line of sight of another team member.

4.3 EMERGENCY EQUIPMENT

Adequate emergency equipment for the activities conducted onsite and as required by applicable sections of 29 CFR 1910 and 29 CFR 1926 must be maintained onsite. Personnel will be provided with access to emergency equipment including, but not limited to, the following:

- Emergency eyewash and shower meeting ANSI Z358.1-1990

- Fire extinguishers of adequate size, class, number, and location as required by applicable sections of 29 CFR 1910 and 29 CFR 1926

- Industrial first aid kit of adequate size for the number of personnel onsite.

4.4 PERSONAL HYGIENE AND SANITATION

4.4.1 Break Area

Breaks will be taken in the SZ, away from the active work area after site personnel go through decontamination procedures. There will be no smoking, eating, drinking, or chewing gum or tobacco in the work area.

4.4.2 Potable Water

The following rules apply for project field operations:

- An adequate supply of potable water will be provided at the work site. Potable water must be kept away from hazardous materials, contaminated clothing, and contaminated equipment.

- Portable containers used to dispense drinking water must be capable of being tightly closed, and must be equipped with a tap dispenser. Water must not be consumed directly from the container, nor dipped from the container.

- Containers used for drinking water must be clearly marked and not used for any other purpose.

- Disposable cups will be supplied; both a sanitary container for unused cups and a receptacle for disposing of used cups must be provided.

4.4.3 Sanitary Facilities

Access to facilities for washing before eating, drinking, or smoking will be provided. Personnel are required to wash off exposed skin surfaces prior to eating, smoking or drinking, following site operations and work activities.

4.4.4 Lavatory

If permanent toilet facilities are not available, an appropriate number of portable chemical toilets will be provided.

4.4.5 Trash Collection

Trash collected from the CRZ will be separated as routine hazardous waste. Trash collected in the SZ and break areas will be disposed of as non-hazardous waste. Labeled trash receptacles will be set up in the CRZ and SZ.

4.5 LOCKOUT/TAGOUT PROCEDURES

Maintenance procedures will only be performed by fully qualified and trained individuals. Before maintenance begins, lockout/tagout procedures per OSHA 29 CFR 1910.147 will be followed.

Lockout is the placement of a device that uses a positive means such as a lock to hold an energy or material-isolating device or system ensuring that the equipment cannot be operated until the lockout device is removed. If a device cannot be locked out, a tagout system will be used. Tagout is the placement of a warning tag on an energy or material-isolating device indicating that the equipment controlled may not be operated until the tag is removed. Only personnel properly trained in lockout/tagout procedures, and having knowledge of the system requiring maintenance will conduct these activities. Lockout/tagout procedures will be reviewed and assessed by the Site Safety and Health Officer prior to maintenance being conducted on the system.

5. PERSONAL PROTECTIVE EQUIPMENT

5.1 RESPIRATORY PROTECTION PROGRAM

Respiratory protection is an integral part of employee safety and health at sites with potential airborne contamination.

The site respiratory protection program will consist of the following:

- Site personnel who may use respiratory protection will have an assigned respirator.
- Site personnel who may use respiratory protection will have been fit tested and trained in the use of a full-face air-purifying respirator within the past 12 months.
- Site personnel who may use respiratory protection must within the past year have been medically certified as capable of wearing a respirator. Documentation of the medical certification must be provided to the Site Safety and Health Officer prior to commencement of site work.
- Only cleaned, maintained, National Institute for Occupational Safety and Health approved respirators are to be used onsite.
- If respirators are used, the respirator cartridge is to be properly disposed of at the end of each work shift, or when load-up or breakthrough occurs.
- Contact lenses are not to be worn when a respirator is worn.
- Site personnel who may use respiratory protection must be clean shaven. Mustaches and side burns are permitted, but they must not touch the sealing surface of the respirator.
- Respirators will be inspected, and a positive/negative pressure test performed prior to each use.
- After each use, the respirator will be wiped with a disinfectant. When used, the respirator will be thoroughly cleaned at the end of the work shift. The respirator will be stored in a clean plastic bag, away from direct sunlight in a clean, dry location, in a manner that will not distort the face piece and labeled with the user’s name.

5.2 LEVELS OF PROTECTION

Based upon currently available information, the site is considered non-hazardous and will require Level D protection for currently anticipated conditions and activities. In the event that potential chemical hazards are identified, the level of protection may be upgraded appropriately to the potential hazard conditions. Table 4 shows the environmental monitoring requirements. Only those personnel identified and qualified for hazardous waste work as defined in 29 CFR 1926.65 will be allowed to upgrade beyond Level D or provide support of hazardous material/substance contingency operations. Only the Field Manager and Site Safety and Health Officer, in conjunction with the Program Safety and Health Officer, will be allowed to approve PPE upgrade beyond Level D and site re-entry for the purpose of hazardous conditions assessment. The following is a list of the PPE components for the maximum levels of protection authorized for use during this project.

5.2.1 Level D Personal Protective Equipment

Level D to be worn for initial entry onsite and initially for activities will consist of the following:

- Coveralls
- Steel-toe, steel-shank safety boots/shoes
- Hard hats (personnel are required to wear a hard hat at all times when on the project site in accordance with EM 385-1-1 Section 05.D)
- Chemical resistant gloves (nitrile/neoprene) when contact with potentially contaminated soil or water is expected
- Safety glasses
- Hearing protectors (during drilling)
- Boot covers (optional)
- Poly-coated coveralls (when contact with contaminated soil and water is anticipated, e.g., when surging/pumping wells and pressure-washing equipment).

Insulated clothing, hats, etc. must be worn when temperatures fall below 40°F.

5.2.2 Level C Personal Protective Equipment

Based upon the preliminary information concerning the site, contaminant concentrations are not expected to require the use of Level C PPE. However, should the following conditions be identified, the Site Safety and Health Manager is authorized to increase the level of PPE to be worn. Refer to Section 5.3 for PPE upgrade criteria. Respirator cartridges will be charged at least daily or sooner if breakthrough is detected or if manufacturer recommendations apply.

If the aforementioned action levels continue to be exceeded, the level of personal protection will be upgraded to Level C. Level C protection will consist of the following:

- Full face piece, air purifying respirator equipped with combination organic vapor and high efficiency particulate cartridges
- Tyvek or other water resistant coveralls
- Steel-toe, steel-shank neoprene safety boots/shoes
- Chemical-resistant boot covers
- Hard hat
- Hearing protectors (during drilling)
- Chemical resistant inner (latex) and outer gloves (nitrile/neoprene).

5.3 UPGRADE OR DOWNGRADE OF PERSONAL PROTECTIVE EQUIPMENT LEVEL

As the site-specific conditions are known, upgrade/downgrade levels are defined in this SHERP. Only the Site Safety and Health Officer can authorize an upgrade or downgrade in the PPE level worn onsite, using only the criteria presented in this SHERP. Changes in PPE levels must be documented on the SHERP Activity Record provided in Appendix D, along with the rationale for the PPE changes.

The following general guidelines will be used by the Site Safety and Health Officer to help define conditions requiring upgrade to Level C:

1. Any constant photoionization detector reading indicating the presence of VOCs greater than 1-5 parts per million (ppm) above background.

2. A combination combustible gas detector/oxygen meter reading of 5 percent of the lower flammable limit or an oxygen reading ≤20 percent. The level should be reproducible over a 1- to 2-minute period. Any reading of 10 percent of the lower flammable limit or greater, or reduction of oxygen at or below 19.5 percent, will require immediate evacuation of the EZ.

3. The use of hand-held ozone meters will ensure that the OSHA and NIOSH exposure limit of 0.2 mg/m^3 (0.1 ppm) for ozone is not exceeded. The hand held meter has a detection rate of 0 to 2 ppm (0 to 4 mg/m^3). The fixed sensors have a range of 0.03 to 0.1 ppm (0.06 to 0.2mg/m^3). This sampling will be performed continuously during the operation and at any time site personnel report the smell of ozone. NIOSH/OSHA recommendations

for ozone concentrations in air include SAR with a tight-fitting facepiece operated in a continuous-flow mode; or full-facepiece SCBA; or full-face SAR if ozone is detected up to 5 ppm.

4. A visible condition, odor, or employee perception that a chemical of concern may be released or be present requiring respiratory protection or additional skin protection. This condition should always be brought to the attention of the Site Safety and Health Manager.

Sustained readings of >1 mg/m^3 on the dust monitor.

These endpoints are intended to address fuel oil, waste oil, gasoline, methane, oxygen, and other volatile organic vapors and gases.

5.4 HEARING PROTECTION

Hearing protection must be available and properly worn whenever noise levels exceed 85 dBA (noise level at which a normal conversation cannot be understood at a 3-ft distance). When the Site Safety and Health Officer determines that a potential excessive noise exposure exists, a sound level meter will be used for measurements. Two types of hearing protection will be available onsite: foam earplugs and ear muffs. The hearing protectors will have a Noise Reduction Rating sufficient to reduce the sound level to below 85 dBA.

5.5 SELECTION AND USE OF PERSONAL PROTECTIVE EQUIPMENT

Equipment for personal protection will be selected based on the potential for contact, site conditions, ambient air quality, and the judgment of supervising site personnel and safety and health professionals. The PPE used will be chosen to be effective against the compound(s) present at the site. Based on an evaluation of the potential safety and health hazards, the required initial levels of PPE are presented in the following table for each task work covered in the SHERP:

Work Task	Initial Level of Protection	Specific PPE
Soil boring/Groundwater Profiling/Monitoring well installation	D	Steel toe/steel shank safety boots, cotton coveralls, safety glasses, hardhat, latex inner gloves, butyl/neoprene outer gloves[(a)], hearing protection.
Groundwater sampling	D	Steel toe/steel shank safety boots, cotton coveralls, safety glasses, nitrile gloves.
Surveying Wells	NA	
Managing Investigation-Derived Waste	D	Steel toe/steel shank safety boots, cotton coveralls, safety glasses, nitrile gloves.
Installation of ozone sparging pilot test well	D	Steel toe/steel shank safety boots, cotton coveralls, safety glasses, hardhat, latex inner gloves, butyl/neoprene outer gloves[(a)], hearing protection.
Installation of trailer-mounted ozone test unit	D	Steel toe/steel shank safety boots, cotton coveralls, hardhat.
Operations and maintenance of the ozone injection system	D	Steel toe/steel shank safety boots, cotton coveralls, safety glasses, hardhat.
Groundwater and soil sampling for pilot test	D	Steel toe/steel shank safety boots, cotton coveralls, safety glasses, nitrile gloves.

Depending upon the level of protection selected, specific donning and doffing procedures may be required. The procedures listed in this section are mandatory when Level D or higher PPE is used.

Persons entering the EZ must put on the required PPE in accordance with the requirements of this SHERP. When leaving the EZ, PPE will be removed in accordance with the procedures listed, to minimize the spread of contamination.

5.5.1 Donning Procedures

These procedures are mandatory when Level D or higher PPE is used at the site:

- Remove bulky outerwear; remove street clothes and store in a clean location
- Put on work clothes or coveralls
- Put on chemical protective coveralls or rain gear (if required)
- Put on chemical protective boots or boot covers (if required)
- Tape the legs of the coveralls to the boots with duct tape
- Put on chemical protective gloves (if required)
- Tape the wrists of the protective coveralls to the gloves
- Don the required respirator (Level C only) and perform appropriate fit check

- Put hood or head covering over head and respirator straps (Level C only) and tape hood to facepiece

- Don remaining PPE, such as safety glasses or goggles and hard hat.

When these procedures are instituted, one person must remain outside the work area to ensure that each person entering has the proper PPE.

5.5.2 Doffing Procedures

These procedures are mandatory when Level D or higher PPE is used at the site. Whenever a person leaves a Level D or higher work area, the following decontamination sequence will be followed:

- Upon entering the CRZ, rinse contaminated materials from the boots or remove contaminated boot covers

- Clean reusable PPE

- Remove protective garments, equipment, and respirator (if necessary); all disposable clothing should be placed in plastic bags, which are labeled with contaminated waste labels

- Wash hands, face, and neck or shower (if necessary)

- Proceed to clean area and dress in clean clothing

- Clean and disinfect respirator (if necessary) for next use.

Disposable equipment, garments, and PPE must be bagged in plastic bags and labeled for disposal.

6. SITE CONTROL

6.1 AUTHORIZATION TO ENTER

Only personnel who have completed hazardous waste operations initial training as defined under OSHA Regulation 29 CFR 1910.120, have completed their training or refresher training within the past 12 months, and have been certified by a physician as fit for hazardous waste operations will be allowed within a site area designated as an EZ or CRZ. Personnel without such training or medical certification may enter the designated SZ only. The Site Safety and Health Officer will maintain a list of authorized persons, and only personnel on the list will be allowed within the EZ or CRZ.

6.2 SITE ORIENTATION AND HAZARD BRIEFING

Prior to entering the site, personnel will attend a pre-entry orientation session presented by the Site Safety and Health Officer. Personnel will verify attendance of this meeting by signing the SHERP Review Record shown in Appendix A.

Visitors entering designated work areas will be subject to applicable safety and health regulations during field operations at the site. The Site Safety and Health Officer is responsible for briefing the personnel onsite of potential hazards that may be encountered on the site, the presence and location of the site SHERP, and emergency response procedures. Visitors will be under the direct supervision of the Site Safety and Health Officer or his/her representative.

At a minimum, the pre-entry orientation session will discuss the contents of this SHERP, potential health effects of hazards associated with onsite activities, and the potential hazards presented by unearthing unidentified hazardous materials. Personnel will be instructed in the emergency notification and evacuation procedures to include onsite communications and implementation of the site-specific contingency plans. Additionally, personnel will be briefed on safe work practices and the proper use and wear of required PPE.

6.3 CERTIFICATION DOCUMENTS

A training and medical file will be established for the project and kept onsite during all site operations. The 24- or 40-hour training, updates, and specialty training (i.e., CPR/first aid certificates), as well as the current annual medical clearance for all project field personnel, will be maintained within the file. Site personnel and subcontractor personnel must provide their training and medical documentation to the Site Safety and Health Officer prior to the start of field work.

6.4 ENTRY LOG

A log-in/log-out sheet must be maintained at the site by the Field Manager. Personnel may sign in and out on a log sheet as they enter and leave the CRZ, or the Field Manager may document entry in the field notebook.

6.5 ENTRY REQUIREMENTS

In addition to the authorization, hazard briefing, and certification requirements listed above, personnel will not be allowed on any field site unless the individual is wearing the minimum SZ PPE as described in Chapter 5. Personnel entering the EZ or CRZ must wear the required PPE for those locations.

6.6 EMERGENCY ENTRY AND EXIT

People who must enter the site on an emergency basis will be briefed of the hazards by the Field Manager. Hazardous activities will cease in the event of an emergency and any sources of emissions will be controlled, if possible.

People exiting the site because of an emergency will gather in a safe area for a head count. The Field Manager is responsible for ensuring that all people who entered the work area have exited in the event of an emergency.

Emergency procedures are discussed in more detail in Chapter 11.

7. WORK ZONES AND DECONTAMINATION

7.1 SITE WORK ZONES

In order to reduce the spread of hazardous materials by workers from the contaminated areas to the clean areas, separate work zones have been established at the site, including the EZ, CRZ, and SZ. The flow of personnel between the zones will be controlled. Establishment of these work zones will help ensure that personnel are properly protected against the hazards present where they are working, work activities and contamination are confined to the appropriate areas, and personnel can be located and evacuated in case of an emergency.

7.1.1 Exclusion Zone

A 25-ft radius EZ will be established at any drilling or sampling location. This area has the highest potential for exposure to chemicals onsite.

7.1.2 Contamination Reduction Zone

If appropriate, a CRZ will be established by the Site Safety and Health Officer between the EZ and SZ. This zone will include personnel and equipment necessary for decontamination. There will be one access point between the EZ and CRZ. Personnel and equipment in the EZ must pass through this zone before entering the SZ.

7.1.3 Support Zone

The SZ will include the remaining areas of the job site, i.e., the EA vehicle and equipment staging area. Break areas, operational direction, and support facilities will be located in this zone. No equipment or personnel will be permitted to enter the SZ from the EZ without passing through the personnel or equipment decontamination station. Eating, smoking, and drinking will be allowed only in this area.

7.2 POSTING

The EZ, CRZ, and SZ will be prominently marked and delineated using cones or caution tape.

7.3 DECONTAMINATION

7.3.1 Decontamination of Personnel

The following procedures will be used for the decontamination of personnel:

- Remove and discard boot covers if worn
- Wash boots with detergent and water and rinse
- Wash outer gloves with detergent and water, rinse, and remove
- Remove coveralls then respirator if worn
- Remove and discard inner gloves
- Wash hands, face, and other exposed skin with soap and water; shower and shampoo as soon as possible at the end of the work day, before any social activities
- Place non-disposable coveralls in plastic bags prior to leaving the site and prior to entering any EA vehicle
- Launder non-disposable clothing worn in EZ prior to reuse, separately from other laundry items.

7.3.2 Decontamination of Equipment

The following procedures will be used for the decontamination of equipment:

- Instruments used onsite must be wet-wiped with clean water prior to leaving the site; wet-wipe respirator exteriors whenever exiting work areas
- Clean respirators with a manufacturer-recommended sanitizer, then hang to drip dry, and place in plastic bags for protection against dust
- Change respirator cartridges at least daily, when breakthrough occurs, or when breathing resistance becomes high, whichever occurs first; used cartridges will be damaged to prevent accidental reuse
- Drilling and sampling equipment must be decontaminated in accordance with federal and state requirements as specified in the Work Plan.

7.3.3 Personal Protective Equipment Decontamination

Where and whenever possible, single use, external protective clothing must be used for work within the EZ or CRZ. This protective clothing must be disposed in properly labeled containers.

Reusable protective clothing will be rinsed at the site with detergent and water. The rinsate will be collected for disposal.

When removed from the CRZ, the respirator will be thoroughly cleaned with soap and water. The respirator face piece, straps, valves, and covers must be thoroughly cleaned at the end of each work shift, and ready for use prior to the next shift. Respirator parts may be disinfected with a solution of bleach and water, or by using a spray disinfectant.

8. SITE MONITORING

8.1 ENVIRONMENTAL MONITORING AND ACTION LEVELS

Task-specific environmental monitoring requirements for the work scheduled at the Oasis Fuel Point site are shown in Table 4, including the type of monitoring to be performed, the frequency and location of monitoring, action levels, and required responses if action levels are detected.

For the intrusive work (e.g., well installation) conducted onsite, the environmental monitoring for toxic, flammable/combustible gases, and oxygen will be performed as needed using a combustible gas indicator and a flame ionization detector or photoionization detector. Instruments will only be used by employees who have been trained in the proper operation, use limitations, and calibration of the monitoring equipment. Monitoring will be conducted at intervals not less than once every 30 minutes using either the photoionization or flame ionization detector and the combustible gas indicator.

Environmental monitoring will include sufficient monitoring of air quality in work zones during intrusive field operations to assess levels of employee exposure and to verify that the level of PPE being worn by personnel is adequate. Monitoring will be conducted to ensure that contaminants are not migrating offsite to minimize the exposure to nearby populations and/or workers.

Ozone monitoring will also be performed to detect any leaks that develop in the system. All pipes and tubing containing ozone will be checked daily for deterioration (particularly at joints) and tightness, and all unions will be firmly tightened. In addition, aboveground parts of the ozone generation and injection system will be scanned with an ozone monitor daily. If work is being done in the immediate vicinity of the ozone system, then measurements will be taken in the breathing zone, hourly or at the first sign of detection of ozone odors (detection of odors is expected in the 0.003 to 0.01 ppm range).

8.2 CALIBRATION AND MAINTENANCE

Direct-reading instruments will be calibrated on a daily basis with a known concentration of calibration gas (typically isobutylene or methane, depending on the instrument) following the instrument manufacturer’s guidance. Instructions in the manufacturer’s operations manual regarding storage, cleaning, and maintenance of the instruments will be followed. Calibration will be properly recorded in the field logbook to show the date, calibration material type and concentration, and the actual reading obtained. Equipment failing to meet the manufacturer’s standards for accuracy and repeatability will be considered suspect and replaced with an alternate, properly functioning piece of equipment.

8.3 ON-SITE MONITORING PLAN AND RESPONSE ACTIVITIES

As mentioned above, air monitoring will include sufficient monitoring of air quality in worker breathing zones and other onsite areas during intrusive field operations to assess levels of employee exposure, to determine that the constituent levels do not constitute a fire/explosion hazard, and to verify that the level of PPE being worn by personnel is adequate. Air monitoring is also designed to ensure that contaminants are not migrating offsite to minimize the exposure to nearby populations and/or workers.

Monitoring during borings and well installation will be conducted:

- Upon commencement of each different phase of operation
- During invasive field procedures (at intervals not less than once every 30 minutes using both the photoionization or flame ionization detector and the combustible gas indicator)
- Upon worker or local community complaints or concerns.

Instruments will only be used by employees who have been trained in the proper operation, use limitations, and calibration of the monitoring equipment at a sufficient interval during invasive field operations or emergency conditions to properly quantify the suspected hazard. This will be at least every 30 minutes for invasive procedures.

If action levels in the worker breathing zone are exceeded, air monitoring will be required at various onsite/perimeter locations to determine appropriate response activities that are protective of personnel onsite who are not directly involved with the investigation, personnel at adjacent commercial sites, and the surrounding community. Additional monitoring (and appropriate response activities) will be implemented if the total organic vapor and particulate levels in the worker breathing zone exceed action levels that are discussed below.

8.3.1 Monitoring and Response Activities

If the sustained level of total organic vapors in the worker breathing zone exceeds 1 ppm above background, then the level of total organic vapors will be manually recorded at the downwind perimeter of the work area (i.e., EZ) at 30-minute intervals. If the level of total organic vapors at the downwind perimeter of the work area exceeds 1 ppm above background, then work activities will be halted and additional downwind monitoring will be performed. Efforts will be undertaken to mitigate the source of organic vapors. The work area will be enlarged, if necessary, to keep personnel who are not involved with the investigation from being exposed to organic vapor levels exceeding 1 ppm above background.

During the investigation, it is also possible that the downwind perimeter of the work area will coincide with the fenced site perimeter. If, at any time, the level of total organic vapors adjacent to the downwind site perimeter reaches 1 ppm above background, then the level of total organic vapors adjacent to the nearest downwind residential or commercial property from the work zone will be monitored. If, after 30 minutes the total organic vapor level adjacent to the residential or commercial property has not subsided below 1 ppm above background, then the Site Health and Safety Officer will inform the local emergency response contacts listed in Chapter 11 and persons who may be exposed at the residential or commercial properties until after the level of total organic vapors on the properties subsides to below 1 ppm above background.

If the ozone concentration in the breathing zone is found to exceed 0.05 ppm, then the system will be shut down and the ozone system area will be evacuated and retested after 15 minutes. Once ozone levels fall below 0.05 ppm, the source of the ozone leak will be investigated. If, during monitoring of the ozone generation and injection system, the ozone concentration is found to exceed 0.1 ppm, then the system will be shut down and a breathing zone measurement will be taken. If the concentration in the breathing zone is more than 0.1 ppm, then the above procedures will be performed; if the breathing zone concentration is less than 0.1 ppm, then the worker will inspect the systems to identify the leak. Any leaks, if identified, should be repaired as soon as possible.

8.4 NOISE MONITORING

Noise monitoring will be conducted as required. Hearing protection is mandatory for employees in noise hazardous areas, i.e., around heavy equipment. As a general rule, sound levels that cause speech interference at a normal conversation distance should require the use of hearing protection.

8.5 ODOR CONTROL

If any odor complaints are received from members of the surrounding community, then the site activities will be suspended, subsurface openings will be covered, and onsite personnel (in consultation with USACE and project managers) will evaluate an alternative course of action.

9. EMPLOYEE TRAINING

9.1 SITE WORKERS

Personnel who will be performing non-hazardous onsite tasks are not required to have been trained according to U.S. Department of Labor OSHA Standard, 29 CFR 1926.65 *Hazardous Waste Operations and Emergency Response.* These workers will have appropriate safety and health training based upon their specific job tasks and activities.

The Field Manager, Site Safety and Health Officer, and personnel conducting the field sampling and monitoring for site gases and vapors during intrusive operations (e.g., soil borings) will be trained as required to meet the U.S. Department of Labor OSHA Standard, 29 CFR 1926.65, *Hazardous Waste Operations and Emergency Response* to qualify as a hazardous waste site workers and supervisor. Training will include:

- A minimum of 40 hours of initial offsite instruction
- A minimum of 3 days of actual field experience under the direct supervision of a trained, experienced supervisor
- An 8-hour “refresher” training period annually
- Additional training that addresses unique or special hazards/operational requirements
- First aid and CPR.

Onsite management and supervisors who are directly responsible for or who supervise employees will receive at least 8 additional hours of specialized management training. Copies of training certificates and dates of attendance will be available through the Site Safety and Health Officer upon request.

Table 5 documents and summarizes the dates of training for EA personnel and subcontractors.

9.1.1 Subcontractor Training

Prior to start of work operations, the Project Manager will obtain a written list of subcontractor personnel to be onsite, and written certification from subcontractor management that these workers meet the training requirements for their assigned tasks.

9.1.2 Pre-Entry Orientation Session

Prior to entering the site, personnel will attend a pre-entry orientation session presented by the Site Safety and Health Officer. Personnel will verify attendance of this meeting by signing the SHERP Review Record shown in Appendix A.

Visitors entering designated work areas will be subject to applicable safety and health regulations during field operations at the site. The Site Safety and Health Officer is responsible for briefing the personnel onsite of potential hazards that may be encountered on the site, the presence and location of the site SHERP, and emergency response procedures. Visitors will be under the direct supervision of the Site Safety and Health Officer or his/her representative.

At a minimum, the pre-entry orientation session will discuss the contents of this SHERP, potential health effects of hazards associated with onsite activities, and the potential hazards presented by unearthing unidentified hazardous materials. Personnel will be instructed in the emergency procedures to include onsite communications and implementation of the site-specific contingency plans.

9.2 SITE-SPECIFIC TRAINING

The Site Safety and Health Officer will be responsible for developing a site-specific occupational hazard training program and providing training to all personnel who are to work at the site. At a minimum, this training will consist of the following topics:

- Names of personnel responsible for site safety and health
- Safety, health, and other hazards at the site
- Proper use of PPE
- Work practices by which the employee can minimize risk from hazards
- Safe use of engineering controls and equipment on the site
- Acute effects of compounds at the site
- Decontamination procedures.

10. MEDICAL SURVEILLANCE

10.1 MEDICAL EXAMINATIONS

Site workers potentially involved with the field sampling operations must have satisfactorily completed a comprehensive medical examination by a licensed occupational physician within 12 months (or 24 months with the approval of the consulting physician) prior to the start of site operations. The date of medical examination of each qualified person will be onsite with the project field team. Medical surveillance protocols must comply with 29 CFR 1926.65.

Medical examinations and consultations must be provided for employees covered by this program on the following schedule:

- Prior to assignment
- At least biennially (every 2 years) for employees covered by the program
- At termination of employment or reassignment to an area where the employee would not be covered if the employee has not been examined within the past 6 months
- As soon as possible upon the development of signs or symptoms that may indicate an overexposure to hazardous substances or health hazards
- More frequently if the physician deems such examination necessary to maintain employee health.

10.2 RECORDS

An accurate record of the medical surveillance will be maintained for each employee for a period of no less than 30 years after the termination of employment. Records must include at least the following information about the employee:

- Name and social security number
- Physician’s written opinions, recommendations, limitations, and test results
- Employee medical complaints related to hazardous waste operations
- Information provided to the physician by the employee concerning possible exposures, accidents, etc.

Subcontractors must provide medical surveillance information in writing to the Project Manager for their workers prior to mobilization onsite.

10.3 FIRST AID AND MEDICAL TREATMENT

Persons onsite must report near-miss incident, accident, injury, or illness to their immediate supervisor or the Field Manager. First aid will be provided by the designated site first aid individual. Injuries and illnesses requiring medical treatment must be documented. The Field Manager must conduct an accident investigation as soon as emergency conditions no longer exist and first aid and/or medical treatment has been ensured. These two reports must be completed and submitted to the EA Corporate Safety and Health Officer and the USACE Project Manager within 24 hours after the incident (Appendix E).

If first aid treatment is required, first aid kits are maintained at the CRZ. If treatment beyond first aid is required, the injured individual(s) should be transported to the medical facility. If the injured is not ambulatory, or shows signs of not being in a comfortable or stable condition for transport, then an ambulance/paramedics should be summoned. If there is any doubt as to the injured worker’s condition, it is best to let the local paramedic or ambulance service examine and transport the worker.

11. ACCIDENT PREVENTION AND CONTINGENCY PLAN

11.1 ACCIDENT PREVENTION

Field personnel will receive safety and health training prior to the initiation of site activities. On a day-to-day basis, individual personnel should be constantly alert for indicators of potentially hazardous situations and for signs and symptoms in themselves and others that warn of hazardous conditions and exposures. Rapid recognition of dangerous situations can avert an emergency. Before daily work assignments, regular meetings should be held. Discussion should include:

- Tasks to be performed
- Time constraints (e.g., rest periods, cartridge changes)
- Hazards that may be encountered, including their effects, how to recognize symptoms and monitor them, concentration limits, or other danger signals
- Emergency procedures.

11.1.1 Drilling

Prior to drilling activity, efforts will be made to determine whether underground installations will be encountered and, if so, where these installations are located. Hard hats, safety glasses, and safety boots must be worn within 50 ft of the drill rig. The drill rig cannot be operated within 10 ft of energized power lines with a voltage of 50 kV. The Field Manager or Site Safety and Health Officer will provide constant onsite supervision of the drilling subcontractor to ensure that they are meeting the safety and health requirements. If deficiencies are noted, work will be stopped and corrective action will be taken (e.g., retrain, purchase additional safety equipment). Reports of safety and health deficiencies and the corrective action taken will be forwarded to the Project Manager.

11.1.2 Vehicles and Heavy Equipment

Working with large motor vehicles and heavy equipment could be a major hazard at this site. Injuries can result from equipment hitting or running over personnel, impacts from flying objects, or overturning of vehicles. Vehicle and heavy equipment design and operation will be in accordance with 29 CFR, Subpart O, 1926.600 through 1926.602. In particular, the following precautions will be utilized to help prevent injuries/accidents.

- Brakes, hydraulic lines, light signals, fire extinguishers, fluid levels, steering, tires, horn, and other safety devices will be checked at the beginning of each shift.

- Large construction motor vehicles will not be backed up unless the vehicle has a reverse signal alarm audible above the surrounding noise level, or the vehicle is backed up only when an observer signals that it is safe to do so.

- Heavy equipment or motor vehicle cable will be kept free of all non-essential items, and all loose items will be secured.

- Large construction motor vehicles and heavy equipment will be provided with necessary safety equipment (seat belts, rollover protection, emergency shut-off in case of rollover, backup warning lights and audible alarms).

- Blades and buckets will be lowered to the ground and parking brakes will be set before shutting off any heavy equipment or vehicles.

11.1.3 Flightline Vehicle Operations

Based on the proximity of the site characterization area to Wheeler-Sack Army Airfield and associated flightlines (by definition all of the area within the Airfield security fence), accidents and runway incursions could be a major hazard at this site. Therefore, all contractor vehicles must comply with the Wheeler-Sack Army Airfield Standard Operating Procedure *Flightline Vehicle Operations and Driving Guide*.

11.2 CONTINGENCY PLAN

11.2.1 Emergency Recognition

Prior to work start-up, personnel must be familiar with emergency condition identification, notification, and response procedures. The emergency telephone numbers for local emergency response and reporting organizations and directions to the nearest hospital are shown in Table 6. Figure 3 shows the map with directions to the hospital. The Field Manager and Site Safety and Health Officer will rehearse/review emergency procedures and/or applicable site contingencies initially during site orientation and as part of the ongoing site safety program with EA and subcontractor personnel. Onsite emergencies will ultimately be handled by offsite emergency personnel. Initial response and first-aid treatment, however, will be provided onsite.

Person(s) identifying an accident, injury, emergency condition, or a scenario requiring implementation of a response in support of this SHERP will immediately take actions to report the situation to the Field Manager. Notification may take place by runner, hand-held radio, or telephone. The Field Manager/Site Safety and Health Officer will initiate the required response based upon the type of incident, following the procedures contained in this SHERP. Additionally, notification must be made to the control tower (Sack Ground). A chain-of-command and sign-in sheets for personnel onsite will be established at the beginning of each work day to ensure personnel are accounted for and who will take control should the Field Manager or Site Safety and Health Officer become injured. The following items constitute those site conditions requiring an emergency response or contingency action in accordance with this SHERP:

- Fire/Explosion
    - The potential for human injury exists
    - Toxic fumes or vapors are released
    - The fire could spread onsite or offsite and possibly ignite other flammable materials or cause heat-induced explosions
    - The use of water and/or chemical fire suppressants could result in contaminated runoff
    - An imminent danger of explosion exists
- Heavy Equipment Accident
    - Onsite traffic accident where personal injury has occurred
- Natural Disaster
    - A rain storm exceeds the flash flood level
    - The facility is in a projected tornado/hurricane path or a tornado/hurricane has damaged facility property
    - Severe wind gusts are forecasted or have occurred and have caused damage to the facility
- Medical Emergency
    - Overexposure to hazardous materials
    - Trauma injuries (broken bones, severe lacerations/bleeding, burns, animal bites)
    - Eye or significant skin contact with hazardous materials
    - Loss of consciousness
    - Heat stress (heat stroke)
    - Heart attack
    - Respiratory failure
    - Allergic reaction.
- Discovery of unanticipated hazards (e.g., unmarked utility lines, heavily contaminated material).

Follow-up operations to evaluate and control the source of fire, explosions, and hazardous materials incidents will occur only after discussion with the Project Manager and Field Manager. The Field Manager will act as the Emergency Coordinator at the site to coordinate onsite activities and contingencies with outside response organizations. If the Field Manager is unable to act as the Emergency Coordinator, then the authority to take action will be transferred to the Site Safety and Health Officer, or other designee, as indicated in the daily updated chain-of-command.

11.2.2 Pre-Emergency Procedures

The Site Safety and Health Officer will contact the applicable local emergency response organizations contained in Table 6 prior to work start to identify the emergency response requirements and commitments required to support this project. The Project Manager, in coordination with USACE or their designee, will contact those local authorities potentially required to respond in the event of an onsite emergency incident or contingency. This notification will inform each applicable agency of the start date, anticipated scope of work, and existence of the SHERP. A copy of the SHERP will be made available to each emergency response agency upon request to the Project Manager. At a minimum, the installation police, Fire Department, emergency medical services, and hospital will be notified. Emergency activities will be coordinated (as applicable) with the local emergency planning committee, as required in accordance with Superfund Amendments and Reauthorization Act Title III requirements.

11.2.3 Emergency Procedures

NOTE: THE SHERP WILL BE LEFT OPEN TO THIS PAGE AT ALL TIMES DURING SITE ACTIVITIES.

In the event of an emergency, the information available at that time must be properly evaluated and the appropriate steps taken to implement the emergency response plan. The Field Manager (or Site Safety and Health Officer if the Field Manager is part of the emergency) will assume command of the situation. He/she will alert the emergency management system per Table 6, and evacuate personnel to the predesignated evacuation location. In any site emergency, the Field Manager (or the Site Safety and Health Officer if the Field Manager is not available) must sound the emergency alarm, upon which work must stop and personnel must move to the predesignated evacuation location. **If the emergency situation cannot be conveyed by word of mouth, a whistle or other horn will be sounded. Three short blasts, separated by a 2-second silence, will be used as the emergency signal.** First aid will be administered only to limit further injury and stabilize the victim. The local Emergency Medical Services must be notified immediately if needed. **The routes to the nearest hospital are shown on Figure 3**. The Field Manager/Site Safety and Health Officer will make required notifications to include, but not be limited to, the USACE-appointed representative, EA Project Manager, and EA Program Manager, as defined in Section 2.2 and Table 6, and the appropriate federal and state agencies.

Site personnel will have the capability of notifying emergency responders directly from the site using the phone in the company vehicle or in the site support office. In the event of an accident/incident, the USACE-appointed representative will be immediately notified of a reportable accident/incident or contingency. The Project Manager will complete and submit to the USACE-appointed representative an Accident/Loss and Incident Report using the format contained in Appendix E.

The following information will be provided when reporting an emergency:

1. Name and location of person reporting
2. Location of accident/incident
3. Name and affiliation of injured party
4. Description of injuries, fire, spill, or explosion
5. Status of medical aid and/or other emergency control efforts
6. Details of chemicals involved
7. Summary of accident, including suspected cause and time it occurred
8. Temporary control measures taken to minimize further risk.

This information is not to be released under any circumstances to parties other than those listed in this section and emergency response team members. Once emergency response agencies have been notified, the Project Manager will be notified immediately.

11.2.4 Chemical Exposure

If a member of the field crew demonstrates symptoms of chemical exposure, the procedures outlined below should be followed:

- Another team member (buddy) should remove the individual from the immediate area of contamination. The buddy should communicate to the Field Manager (via voice and hand signals) of the chemical exposure. The Field Manager should contact the appropriate emergency response agency.

- Precautions should be taken to avoid exposure of other individuals to the chemical.

- If the chemical is on the individual’s clothing, the chemical should be neutralized or removed if it is safe to do so.

- If the chemical has contacted the skin, the skin should be washed with copious amounts of water.

- In case of eye contact, an emergency eyewash should be used. Eyes should be washed for at least 15 minutes.

- All chemical exposure incidents must be reported in writing to the Program Safety and Health Representative. The Site Safety and Health Officer or Field Manager is responsible for completing the Accident/Loss and Incident Report (Appendix E).

11.2.5 Personal Injury

Personnel should always be alert for signs and symptoms of illnesses related to chemical, physical, and onsite health hazards. Severe injuries resulting from accidents must be recognized as emergencies and treated as such. At least one person currently trained in first aid/CPR must be present onsite at all times. This will normally be the Field Manager and Site Safety and Health Officer.

In a medical emergency, the Field Manager (or the Site Safety and Health Officer if the Field Manager is not available) must sound the emergency alarm, upon which work must stop and personnel must move to the predesignated evacuation location. **If the emergency situation cannot be conveyed by word of mouth, a whistle or other horn will be sounded. Three short blasts, separated by a 2-second silence, will be used as the emergency signal.** Personnel currently trained in first aid will evaluate the nature of the injury, decontaminate the victim (if necessary), and initiate first aid assistance immediately and transport if appropriate. First aid will be administered only to limit further injury and stabilize the victim. The local Emergency Medical Services must be notified immediately if needed. **The routes to the nearest hospital are shown on Figure 3.** Although not anticipated, victims who are heavily contaminated with toxic or dangerous materials must be decontaminated before being transported from the site. Since no hazardous materials are anticipated, a formal decontamination station will not be available; however, there is an emergency eyewash station in each of the EA vehicles. Decontamination will consist of removal of contaminated coveralls/clothing, and wrapping the victim in a sheet or other cloth-like material. No persons will re-enter the site of injury/illness until the cause of the injury or symptoms has been determined and controlled. At no time will personnel transport victims to emergency medical facilities unless the injury does not pose an immediate threat to life and transport to the emergency medical facility can be accomplished without the risk of further injury. Emergency Medical Services will be used to transport serious injuries offsite unless deemed otherwise by the Field Manager/Site Safety and Health Officer.

The Field Manager must complete an Accident/Loss and Incident Report (Appendix E) and submit it to the Project Manager within 24 hours of the following types of incidents:

- Job-related injuries and illnesses
- Accidents resulting in loss or damage to property
- Accidents involving vehicles and/or vessels, whether or not they result in damage to property or personnel

- Accidents in which there may have been no injury or property damage, but which have a high probability of recurring with at least a moderate risk to personnel or property

- Near-miss incidents that could have resulted in any of the conditions defined above.

An accident that results in a fatality or the hospitalization of three or more employees must be reported within 8 hours to the U.S. Department of Labor through the Project Manager.

In order to support onsite medical emergencies, first aid/emergency medical equipment will be available at the following locations:

- **First-aid kit—**Company vehicle
- **Eyewash—**Company vehicle
- **Emergency alarm—**Horn on the company vehicle
- **Copy of the SHERP—**Company vehicle
- **Telephone—**Company vehicle.

The eyewash kit must be portable and capable of supplying at least a 15-minute supply of potable water to the eyes.

11.2.6 Operations Shutdown

Operations shutdown may be mandated by the Field Manager, Site Safety and Health Officer, or Project Manager. Conditions warranting work stoppage will include (but are not limited to):

- Uncontrolled fire
- Explosion
- Uncovering potentially dangerous buried hazardous materials
- Condition immediately dangerous to life and health or the environment
- Potential for electrical storms
- Treacherous weather-related conditions
- Limited visibility
- Air contaminant concentrations in excess of the action levels contained in Table 4.

11.2.7 Evacuation Procedures

In the event the site must be evacuated, the following procedures should be followed:

- The Field Manager will initiate evacuation procedures by signaling to leave the site.

- All personnel in the work area should evacuate the area and meet in the common designated area.

- All personnel suspected to be in or near the work area should be accounted for and the whereabouts of missing persons determined immediately

- Further instruction will then be given by the Field Manager.

11.2.8 Procedures Implemented in the Event of a Major Fire, Explosion, or Onsite Health Emergency Crisis

Fire and explosion must be immediately recognized as an emergency. The Site Safety and Health Officer (or Field Manager if Site Safety and Health Officer is not available) must sound an emergency signal, and personnel must be decontaminated (if necessary) and evacuated to the predesignated evacuation location. The procedures for alerting fire/explosion emergencies will be the same as those defined for medical emergencies (Subsection 11.2.3).

Only persons properly trained in fire suppression and other emergency response procedures will support control activities. Control activities will consist of the use of onsite portable fire extinguishers for limited fire suppression and employee evacuation. Upon sounding the emergency alarm, personnel will evacuate the hazard location and assemble at the designated site meeting area.

Only the Field Manager, Site Safety and Health Officer, or those site personnel trained in the use of portable fire extinguisher use will attempt to suppress a site fire. Small, multipurpose dry chemical extinguishers will be maintained in each EA vehicle onsite. Fires not able to be extinguished using onsite extinguishers will require the support of the local Fire Department.

The Field Manager should take measures to reduce injury and illness by evacuating personnel from the hazard location as quickly as possible. The Field Manager must then notify USACE and the local Fire Department. The Field Manager, in conjunction with the USACE appointed representative, will determine proper follow-up actions. Site personnel will not resume work during or after a fire/explosion incident until the Emergency Coordinator has directed that the incident is over and work may resume. During the incident, site personnel will remain outside the incident area and obey the instructions of the Emergency Coordinator.

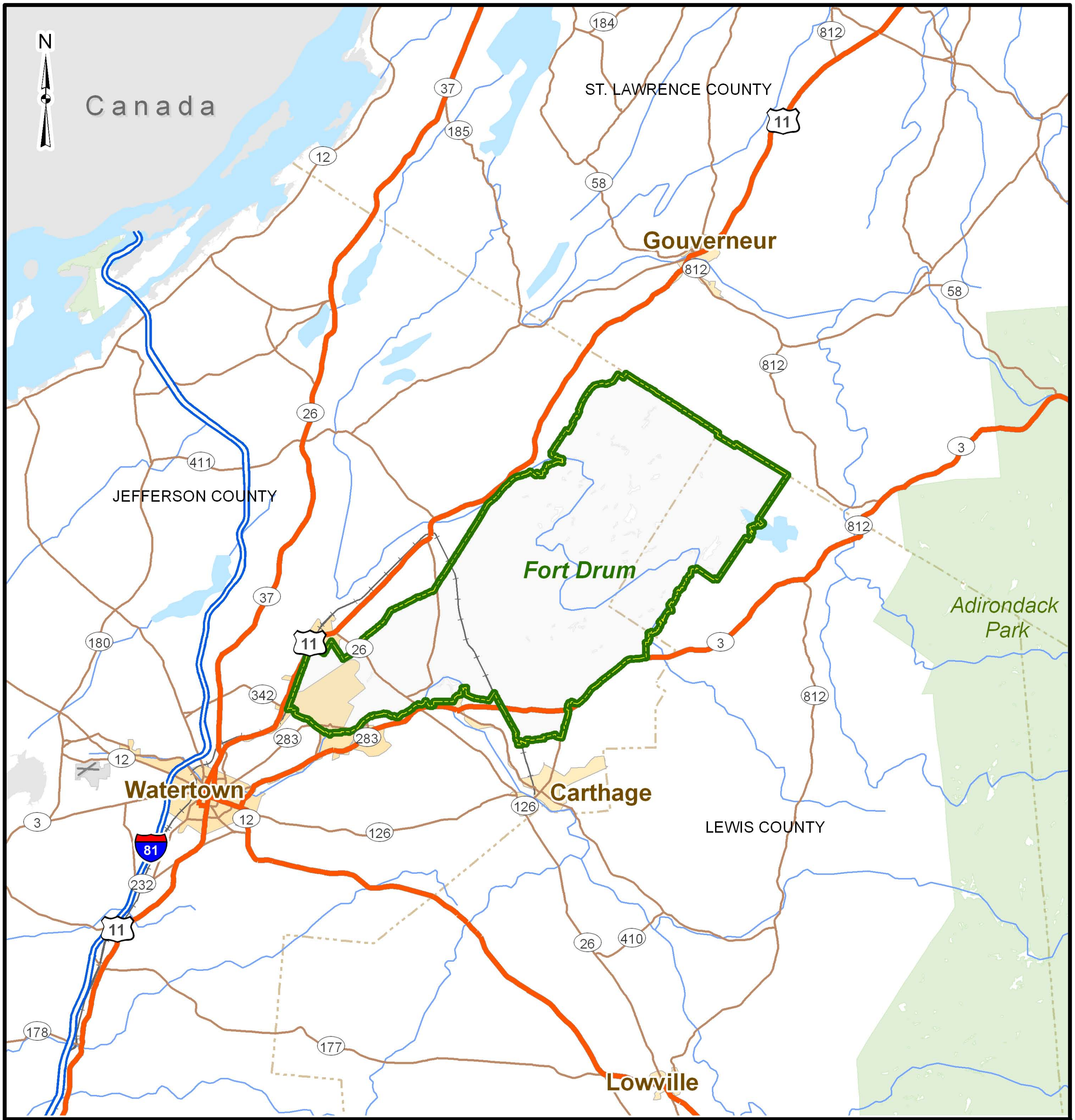
11.2.9 Emergency Telephone Numbers

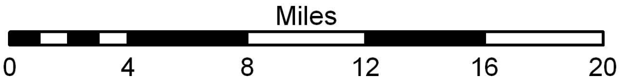
Communications will be by telephones located in the EA vehicle onsite, and the field personnel will have access to this telephone to directly contact off-site emergency response organizations. Refer to Table 6 for a listing of emergency telephone numbers.

11.3 SPILL CONTAINMENT PROCEDURES

Small incidental spills, i.e., those which cause no injury to personnel or the public, may be cleaned up quickly and easily. For large spills, i.e., those that contaminate personnel or the environment, attend to first aid measures first, stop the source of the spill if possible, and then notify appropriate emergency response services.

Spills of hazardous materials or wastes which are listed by EPA as having a reportable quantity value must be reported to appropriate federal, state, and local agencies if a reportable quantity or greater is released. The Field Manager is responsible for determining the appropriate agencies prior to work startup.





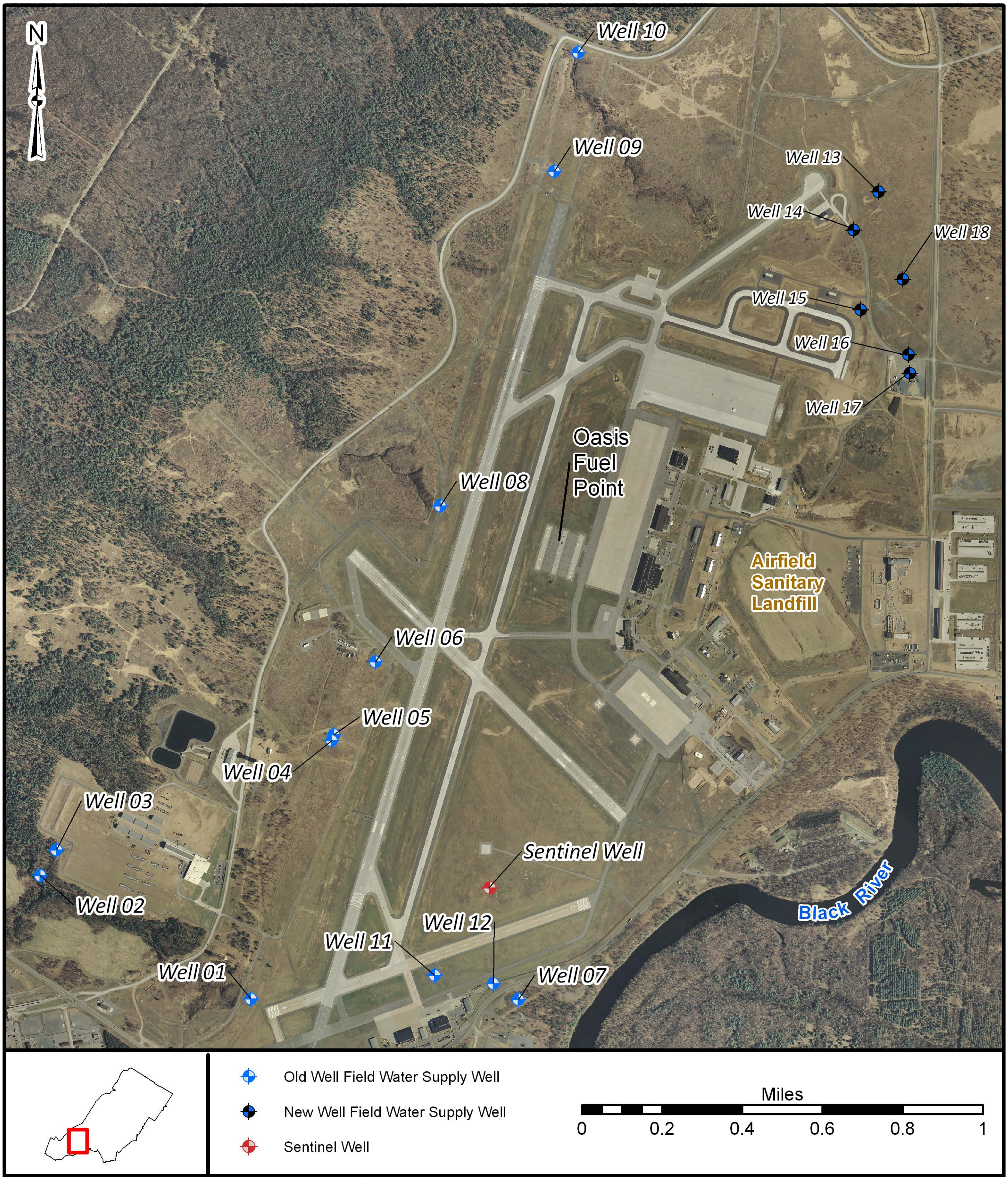
US ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

PUBLIC WORKS
FORT DRUM, NEW YORK

Oasis Fuel Point
Wheeler-Sack Army Airfield
Fort Drum, New York

FIGURE 1
Site Location Map

PROJECT MGR: CJK	DESIGNED BY: FDJR	CREATED BY: FDJR	CHECKED BY: JMB	SCALE: AS SHOWN	DATE: JANUARY 2012	PROJECT NO: 6239301	FILE NO: G:\Projects\Federal\DOD\ Fort Drum Projects\ 6239301 (Oasis)



US ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

PUBLIC WORKS
FORT DRUM, NEW YORK

Oasis Fuel Point
Wheeler-Sack Army Airfield
Fort Drum, New York

FIGURE 2
Site Map and
Fort Drum Production Wells

PROJECT MGR: CJK	DESIGNED BY: MJS	CREATED BY: MJS	CHECKED BY: JMB	SCALE: AS SHOWN	DATE: JANUARY 2012	PROJECT NO: 6239301	FILE NO: G:\Projects\Federal\DOD\ Fort Drum Projects\ 6239301 (Oasis)

Directions from Oasis (A) to Carthage Area Hospital (B)

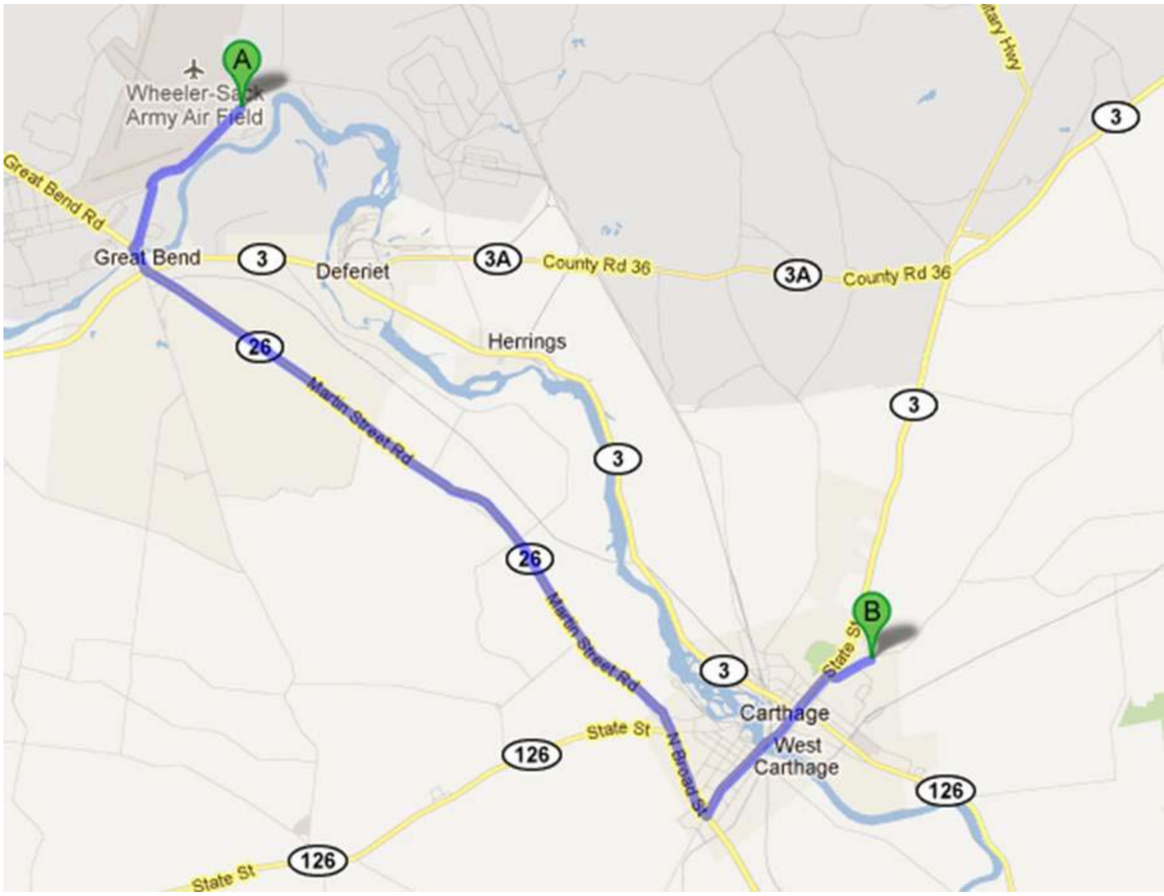


TABLE 1 OCCUPATIONAL EXPOSURE LIMITS FOR OZONE AND MAJOR COMPONENTS OF GASOLINE AND DIESEL FUELS

Contaminant	PEL/TLV[(a)] (ppm)	Signs and Symptoms of Exposure
VOLATILE ORGANIC COMPOUNDS		
Benzene	1 skin	Irritation of eyes, nose, skin, and respiratory system; headache, fatigue, weakness, exhaustion, dermatitis, nausea, and staggered gait
Butane	800	Drowsiness, narcosis, and asphyxia
Cyclopentane	600	Irritation of eyes, nose, skin, and throat; light-headedness, dizziness, euphoria, loss of coordination, nausea, vomiting, dryness, and cracking skin
Ethylbenzene	100	Irritation of eyes, skin, and mucous membrane; headache, dermatitis, narcosis, and comatose
Gasoline	300	Irritation of eyes, skin, and mucous membrane; headache, dermatitis, fatigue, blurred vision, slurred speech, confusion, convulsion, aspiration, and possible liver and kidney damage
Isobutane	NA	Drowsiness, narcosis, and asphyxia
Isopentane	NA	NA
JP-8	50 skin	Irritation of eyes, nose, skin, and respiratory system; headache, fatigue, weakness, nausea, vomiting, weakness, loss of coordination, blurred vision, drowsiness, confusion, or disorientation
Methyl ethyl ketone	200	Irritation of eyes, nose, skin, and throat; coughing, difficulty breathing, pulmonary dysfunction, blurred vision, abdominal pain, nausea, vomiting, diarrhea, blisters, and dermatitis
2-Methyl naphthalene	NA	NA
Trans-2-Pentene	NA	NA
2-Methyl-2-butene	NA	NA
Ozone	0.1	Irritation of eyes, nose, skin, and throat; headache, fatigue, dizziness, drowsiness, nausea, vomiting, cough, shortness of breath, pulmonary edema, tachycardia, hypotension
Toluene	50 skin	Irritation of eyes, nose, and throat; dermatitis, nausea, vomiting, dizziness, nervousness, headache, dilated pupils, discharge of tears, muscle fatigue, insomnia, euphoria, and possible liver and kidney damage
Xylene	100	Irritation of eyes, nose, skin, and throat; dizziness, excitement, drowsiness, staggering gait, loss of coordination, corneal vacuolization, nausea, vomiting, abdominal pain, and dermatitis
SEMIVOLATILE ORGANIC COMPOUNDS		
Naphthalene	10	Eye irritation, headache, nausea, vomiting, bladder irritation, and dermatitis

(a) Permissible Exposure Limit (PEL) Occupational Safety and Health Administration or Threshold Limit Value (TLV) American Conference of Governmental Industrial Hygienists; time-weighted average inhalation exposure concentrations for an 8-hour workday or 40-hour workweek. When both TLVs and PELs are available for a chemical, the lowest (i.e., most conservative) value is presented.

NOTE: NA = Not available.

TABLE 2 THRESHOLD LIMIT VALUES WORK/WARM-UP SCHEDULE FOR FOUR-HOUR SHIFT[(a)]

Air Temperature – Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C (approximate)	°F (approximate)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
-26 to -28	-15 to -19	Normal breaks	1	Normal breaks	1	75 min	2	55 min	3	40 min	4
-29 to -31	-20 to -24	Normal breaks	1	75 min	2	55 min	3	40 min	4	30 min	5
-32 to -34	-25 to -29	75 min	2	55 min	3	40 min	4	30 min	5	Non-emergency work should cease	
-35 to -37	-30 to -34	55 min	3	40 min	4	30 min	5	Non-emergency work should cease		↓	
-38 to -39	-35 to -39	40 min	4	30 min	5	Non-emergency work should cease		↓		↓	
-40 to -42	-40 to -44	30 min	5	Non-emergency work should cease		↓		↓		↓	
-43 and below	-45 and below	Non-emergency work should cease		↓		↓		↓		↓	

(a) Adopted from Occupational Health and Safety Division, Saskatchewan Department of Labor.

NOTE: Schedule applies to any 4-hour work period with moderate to heavy work activity, with warm-up periods of 10 minutes in a warm location and with an extended break (e.g., lunch) at the end of the 4-hour work period in a warm location. For light-to-moderate work (limited physical movement), apply the schedule one step lower. For example, at -35°C (-30°F) with no noticeable wind (Step 4), a worker at a job with little physical movement should have a maximum work period of 40 minutes with 4 breaks in a 4-hour period (Step 5).

The following is suggested as a guide for estimating wind velocity if accurate information is not available: 5 mph—light flag moves, 10 mph—light flag fully extended, 15 mph—raises newspaper sheet, and 20 mph—blowing and drifting snow.

If only the wind chill cooling rate is available, a rough rule of thumb for applying it rather than the temperature and wind velocity factors given would be: (a) special warm-up breaks should be initiated at a wind chill cooling rate of about 1,750 W/m^2, and (b) all non-emergency work should have ceased at or before a wind chill of 2,250 W/m^2. In general, the warm-up schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing appropriate for winter work. On the other hand, the chart slightly overcompensates for the actual temperatures in the colder ranges because windy conditions rarely prevail at extremely low temperatures.

Threshold Limit Values apply only for workers in dry clothing.

TABLE 3 COOLING POWER OF WIND ON EXPOSED FLESH EXPRESSED AS EQUIVALENT TEMPERATURE (UNDER CALM CONDITIONS)[a]

Estimated Wind Speed (in mph)	Actual Temperature Reading (°F)											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
	Equivalent Chill Temperature (°F)											
calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-24	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-32	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-121
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-118	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	-140
35	27	11	-4	-20	-35	-51	-67	-82	-98	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148
(Wind speeds greater than 40 mph have little additional effect)	LITTLE DANGER In <hour with dry skin, maximum danger of false sense of security				INCREASING DANGER Danger from freezing of exposed flesh within one minute			GREAT DANGER Flesh may freeze within 30 seconds				

(a) Developed by U.S. Army Research Institute of Environmental Medicine, Natick, Massachusetts.

NOTE: Trenchfoot and immersion foot may occur at any point on this chart.

TABLE 4 ENVIRONMENTAL MONITORING REQUIREMENTS

Task	Instrument	Frequency and Location	Action Levels[a]	Required Response
Borings/Well Installation	PID or FID	Initially and every 30 minutes in the Breathing Zone	1 ppm for 5 minutes	Continue work.
			1-5 ppm	Evacuate to a safe upwind location and wait for levels to dissipate. Retest the area after 15 minutes. If levels have not dissipated, continue work in Level C personal protective equipment.
		Initially and every 30 minutes in the Breathing Zone	>5 ppm above background	Evacuate to a safe upwind location immediately. Retest area after 15 minutes wearing Level C personal protective equipment. Conduct direct read sampling in Breathing Zone for benzene concentrations using a Draeger portable sample pump and benzene colorimetric tubes. If results of colorimetric tube sampling indicate a benzene concentration greater than 0.5 ppm in the Breathing Zone, and if levels have not dissipated in 30 minutes, contact the Site Safety and Health Officer and Project Manager.
	CGI	Initially and every 10 minutes during soil disturbance; measure at surface of hole/ excavation	0-10% LEL	Continue.
			>10% LEL	Evacuate the Exclusion Zone. Retest area after 15 minutes wearing Level C personal protective equipment. Contact Site Safety and Health Officer and Project Manager.
	Dust monitor	Initially and every 30 minutes (if visible emissions in breathing zone)	>1 mg/m^3	Upgrade to Level C personal protective equipment.
Ozone Injections	Ozone monitor	Daily, along aboveground portions of the ozone system (tanks, pipes, etc.)	0.05 ppm	Shut down the system. Evaluate whether ozone levels in the breathing zone also exceed 0.1 ppm. If not, inspect system for leaks and repair any that are identified. If levels in the breathing zone exceed 0.1 ppm, follow procedures below.
		Hourly, in the breathing zone, when working in the immediate vicinity of the ozone system, or when odor is detectable	0.05 ppm	Shut down the system. Evacuate to a well-ventilated location and retest the area after 15 minutes. When levels fall below the action limit, investigate the source of the leak.

(a) Action levels for PID or FID are based on measurements taken above background concentrations when background concentration is less than 1 ppm. When background concentrations exceed 1 ppm total volatile hydrocarbons, PID, or FID action levels will be inclusive of background concentrations and so noted on the Environmental Monitoring Record.

NOTE: PID = Photoionization detector; FID = Flame ionization detector; CGI = Combustible gas indicator; LEL = Lower exposure limit.

TABLE 5 SITE WORKER TRAINING AND PHYSICAL EXAMINATION RECORD

Name	OSHA 40-Hour Hazardous Waste Operations Training		OSHA Hazardous Waste Supervisor Training	OSHA 30-Hour Construction Safety Training	CPR/First Aid (Date of Expiration)	Date of Last Physical Examination
	Initial	Annual (Expiration)				
Mike Valvo (Site Manager)	2/22/02	6/16/12	7/21/09	3/25/10	1/13/13	7/11
Richard Chisholm	6/10/04	5/12/12	7/21/09	3/25/10	1/13/13	7/11
Amanda Buboltz	6/15/07	7/12/12	8/27/08	---	6/30/13	8/11
Rachel Ribaudo	9/17/09	6/16/12	---	---	---	9/10
SUBCONTRACTOR OR ADDITIONAL PERSONNEL						

NOTE: Prior to performing work at the site, this Site-Specific Safety, Health, and Emergency Response Plan must be reviewed and an agreement to comply with the requirements must be signed by personnel, including contractors, subcontractors, and visitors. Contractors and subcontractors are ultimately responsible for ensuring that their own personnel are adequately protected. In signing this agreement, the contractors and subcontractors acknowledge their responsibility for the implementation of the Site-Specific Safety, Health, and Emergency Response Plan requirements. Personnel onsite shall be informed of the site emergency response procedures and potential safety or health hazards of the operations.

TABLE 6 EMERGENCY TELEPHONE NUMBERS AND HOSPITAL DIRECTIONS

SITE: Oasis Fuel Point Site, Fort Drum, New York	
Base Police/Security	911 [(a)]
Base Fire	2-4131 or (315) 772-4131 [(b)]
Base Ambulance	911
Base Hospital: Carthage Area Hospital	315-493-1000
Poison Control Center	(800) 492-2414
Directions to Carthage Area Hospital: Head southwest on County Rd 37/Munns Corner Rd. Turn left onto NY-26 S/Great Bend Rd. Continue to follow NY-26 S for 7.5 miles. Turn left onto NY-126 E/Bridge St, and continue to follow NY-126 E for 1.3 miles. Continue onto State St for 0.4 miles. Turn right onto Thorpe St and continue 360 ft. Turn left onto West St and continue 0.3 miles. Hospital will be on the left (1001 West Street, Carthage Area Hospital). See figure below.	
Program Safety and Health Officer Peter Garger, CIH	(410) 527-2425 (work) (410) 790-6338 (cell)
Project Manager Chris Canonica, P.E.	(315) 431-4610 (work)
In case of spill, contact Fort Drum Fire Department	2-4131 or (315) 772-4131
In case of accident or exposure incident contact: Peter Garger, CIH	(410) 527-2425 (work) (410) 790-6338 (cell)
EA Medical Services Health Resources 600 West Cummings Park Suite 3400 Woburn, Massachusetts 01801-6350 Contact: Dr. Jerry Berket	(800) 350-4511
USACE Contact Steve Wood	(410) 962-4874
Fort Drum Public Works – Environmental Division Paul Zang	(315) 772-6312
Site Manager/Site Safety and Health Officer Mike Valvo	(315) 408-4300
(a) For non-emergency police assistance, call 772-5156 or 772-5157. (b) For non-emergency fire assistance, call 772-4131 or 772-9687.	

Appendix A

Safety, Health, and Emergency Response Plan Review Record

APPENDIX A

SAFETY, HEALTH, AND EMERGENCY RESPONSE PLAN REVIEW RECORD

I have read this Safety, Health, and Emergency Response Plan for this site. I agree to conform to all the requirements of this Plan.

SITE: Oasis Fuel Point Site, Wheeler-Sack Army Airfield, Fort Drum, New York

Name	Signature	Affiliation	Date

Appendix B

Site Entry and Exit Log

APPENDIX B

SITE ENTRY AND EXIT LOG

SITE: Oasis Fuel Point Site, Wheeler-Sack Army Airfield, Fort Drum, New York				
Name	Date	Time of Entry	Time of Exit	Initials

Appendix C

Physical and Biological Hazard Information Sheets

APPENDIX C

BIOLOGICAL HAZARD INFORMATION SHEET

Insect Bites/Stings

Protective outer clothing such as gloves, hard hats, and coveralls can help reduce the potential for insect bites and stings. Insect bite symptoms include redness, rash, swelling, chills, fever, diarrhea, and vomiting. Any worker who has been bit or stung and shows symptoms of a severe reaction should seek medical assistance immediately. Workers who know of any allergies they may have to any insects must advise their employer prior to engaging in any field activities and may want to carry antidote kits.

To prevent contact with disease-carrying ticks, wear long-sleeved shirts, long pants, and boots that extend above the ankle with socks pulled over pants cuffs. Permanone insecticide may be used to kill disease-bearing ticks and may be sprayed only on the outside of clothing (not directly on skin). Frequently check clothing, skin, and hair for the presence of ticks at the end of the work day. If a tick attaches to the body, remove by gently tugging with tweezers where the mouth parts enter the skin. Do not kill the tick prior to removal.

Poisonous Plants

Poisonous plants such as poison ivy may be present on certain sites during part of the year. Know how to recognize these plants and avoid contact. If contact occurs, wash affected areas with soap and water immediately.

Snakes/Rodents

On occasion, field workers may come into contact with snakes and/or rodents (rats, gophers, etc.). In case of a snake bite, which can be fatal, workers must immediately seek medical assistance and report the incident to the Site Safety and Health Officer and Field Manager, according to the procedures delineated in the Site Safety and Health Plan. Prompt medical attention is also required for rodent bites since many rodents carry rabies and other diseases. Field workers must report rodent bites to the Site Safety and Health Officer and Field Manager immediately according to Site Safety and Health Plan requirements.

Site-Specific Hazards and Protective Measures: Biological hazards are expected to be minimal due to the location of the planned activities. However, workers should keep as much skin as possible covered to protect against bites, stings, etc.

PHYSICAL HAZARD INFORMATION SHEET: DRILLING

The selection of locations for each drilling activity site will take into account buried utility pipes, wires, conduits, and tanks, or other potentially dangerous structures. Overhead power lines and obstructions will also be surveyed. Prior to raising the mast, the area overhead and surrounding the rig will be checked by the drilling foreman and the Site Safety and Health Officer (Site Safety and Health Officer). In accordance with USACE ER 385-1-92, the longest conductive object on the drill rig will be located based upon the following minimum clearances:

- 10 ft from overhead lines with voltages of 50 kV or less
- 12 ft from overhead lines with voltages between 51-100 kV
- 15 ft from overhead lines with voltages between 101-200 kV
- 20 ft from overhead lines with voltages between 201-300 kV
- 25 ft from overhead lines with voltages between 301-500 kV
- 35 ft from overhead lines with voltages between 501-750 kV
- 45 ft from overhead lines with voltages between 751-1,000 kV.

When rotary drilling/sampling, drill rods will not be racked more than 1.5 times the height of the mast. During drilling operations and rig setup and takedown, all persons who enter the Exclusion Zone will wear hard hats, safety shoes/boots, and safety glasses/face shields to protect personnel from the physical hazards.

If during drilling there is any indication that underground tanks, drums, or other containers are being encountered, the drilling will be halted immediately and the Site Safety and Health Officer will notify the Project Manager and the Program Safety and Health Officer. Indications that a waste container may have been encountered include: (1) change in speed or momentum of the auger, (2) visual examination of auger cuttings, (3) odor noted in the cuttings, and/or (4) the presence of airborne total volatile organics as measured with a direct-reading instrument.

Work around drilling equipment also involves basic safety hazards (e.g., snapping cables, slings, ropes, moving heavy equipment, slip and trip hazards, etc.). Accidents may include head injuries from falling tools and equipment, hand and feet injuries due to moving equipment, and crushing injuries from unstable equipment, or careless moving of equipment. If possible, EA personnel must remain outside the turning radius of any large moving equipment. If this is not feasible then, at a minimum, EA personnel must maintain visual contact with the equipment operator at all times when equipment is active.

PHYSICAL HAZARD INFORMATION SHEET:
ELECTRICAL HAZARDS

Overhead power lines, electrical wiring, electrical equipment, and buried cables pose risks to workers of electric shock, burns, muscle twitches, heart fibrillation, and other physical injuries, as well as fire and explosion hazards. In accordance with OSHA's standard for Electrical Safety-Related Work Practices (29 CFR 1910.331-.335), protective measures must be taken when working near live electrical parts, including but not limited to:

- Insulation and guarding of live parts
- Grounding
- De-energizing live parts followed by lockout/tagout to prevent inadvertent re-activation of the parts
- Electric protective devices (e.g., insulated tools)
- Safe work practices, including:

    - Inspection of work area to identify potential spark sources
    - Maintenance of a safe distance from all live electrical parts
    - Proper illumination of work areas
    - No "blind reaching" around live electrical equipment
    - Provision of barriers, shields, or insulation to prevent inadvertent contact with live parts
    - Use of nonconductive, intrinsically safe equipment near live parts.

Overhead lines pose electrical hazards at many sites, particularly for work involving the use of equipment with elevated parts (e.g., drill rigs, backhoes). In accordance with USACE ER 385-1-92, if overhead lines cannot be de-energized prior to the start of work, the following minimum distances must be maintained between the lines and both site workers and the longest conductive object present (including vehicles with elevated structural parts):

- 10 ft from overhead lines with voltages of 50 kV or less
- 12 ft from overhead lines with voltages between 51-100 kV
- 15 ft from overhead lines with voltages between 101-200 kV
- 20 ft from overhead lines with voltages between 201-300 kV
- 25 ft from overhead lines with voltages between 301-500 kV
- 35 ft from overhead lines with voltages between 501-750 kV
- 45 ft from overhead lines with voltages between 751-1,000 kV.

EA personnel are not permitted to work on electric parts of equipment that have not been de-energized, locked out, and tagged by personnel trained to work with electrical equipment. No EA employee may work near energized exposed live parts without the use of any protective measures. Personal protective equipment designed to protect against electrical hazards may be specified for certain work operations. The Project Manager is responsible for ensuring that appropriate safety measures are implemented to protect against electrical safety hazards on their sites.

Lightning is a hazard during outdoor operations, particularly for workers handling metal equipment. To eliminate this hazard, weather conditions should be monitored and work suspended at the discretion of the Site Safety and Health Officer during electrical storms.

PHYSICAL HAZARD INFORMATION SHEET: FIRE/EXPLOSION HAZARDS

Explosion and fire hazards may be present at various sites due to ignition of chemicals, agitation of shock-sensitive compounds, the sudden release of materials under pressure, etc. The presence of ozone onsite increases explosion and fire hazards, as it can increase the flammability of flammable materials. All site operations must be conducted in accordance with local fire codes and regulations. Continuous monitoring for combustible gases is required at sites where such gases may be present during spark-generating operations. Regular ozone monitoring will also be conducted to help ensure that leaks are identified and repaired and thus to minimize the risk of fires and explosions promoted by ozone. Fire extinguishers and other fire-fighting provisions may also be necessary. Site personnel must be trained in the use of such fire-fighting equipment prior to the start of work operations. Site-specific requirements for monitoring and fire emergency equipment must be specified in the Site Safety and Health Plan.

PHYSICAL HAZARD INFORMATION SHEET:
GENERAL PHYSICAL HAZARDS

Hazardous waste and other field operation sites include many basic safety hazards, such as:

- Holes, ditches, etc., posing fall, cave-in, and other hazards
- Precariously positioned objects, which may cause crushing or other injuries
- Sharp objects (e.g., nails, metal shards, glass), which may cause cuts, injection, or other injuries
- Slippery surfaces, posing slip and fall hazards
- Steep grades and/or uneven terrain, posing slip, trip, and fall hazards
- Unstable surfaces (e.g., walls that may cave-in, unstable underground structures) which may pose fall, crushing, or other injuries.

Basic safety hazards can directly injure workers and create additional hazards. For example, a person may trip due to uneven terrain, fall and be cut on rusty metal shards, and become inoculated with contaminants adhering to the metal.

Site personnel should look constantly, closely, and carefully for these basic safety hazards and immediately inform the Site Safety and Health Officer of any conditions that they feel may be hazardous.

PHYSICAL HAZARD INFORMATION SHEET:
HEAT STRESS

Personnel working under high-temperature conditions or wearing protective clothing while working in warm temperatures are subject to heat stress. Symptoms of heat stress may include:

- **Heat Cramps—**Muscle spasms in the abdomen or limbs. Frequent rest periods and fluid intake are appropriate measures to prevent or reduce heat cramps.

- **Heat Exhaustion—**Severe dehydration; pale, clammy skin; profuse sweating; dizziness, light-headedness; slurred speech; rapid pulse; confusion; fainting; fatigue; cool skin; nausea. Affected personnel should be escorted from the site, decontaminated promptly, set in cool, shaded area, and given fluids slowly.

- **Heat Stroke—**Life-threatening condition occurring when the body's temperature-regulating system improperly functions. Hot dry skin; rapid, deep breathing; lack of perspiration; delirium; high fever (often 106 F or more), nausea; unconsciousness. Brain damage and/or death may occur, if body temperature is not reduced. Provide fluids, use cooling devices (hose-down or shower), call emergency medical services or transport to hospital immediately.

Prevent heat stress by resting frequently in a shaded area and consuming large quantities of fresh potable water (<u>more</u> than amount needed to simply "quench thirst"). Drink at least 8 oz of water or Gatorade every 2 hours when temperatures exceed 75 F.

If heat stress symptoms are wide-spread among workers or observed frequently, the Site Safety and Health Officer should implement an appropriate work-rest period so that after 1 minute of rest, a person's heart rate does not exceed 110 beats per minute (bpm) based on pulse. If the heart rate exceeds 110 bpm, the next work period should be shortened by 33 percent, while the length of the rest period remains the same. If the heart rate is 110 bpm at the beginning of the next rest period, the following work cycle should be reduced by 33 percent. A healthy individual's resting heart rate is usually 60-72 bpm.

PHYSICAL HAZARD INFORMATION SHEET:
HEAVY EQUIPMENT HAZARDS

The use of heavy equipment (e.g., backhoes, dump trucks, generators, compressors, etc.) may pose a variety of safety and health hazards to site workers.

All heavy equipment work must be conducted only by trained, experienced personnel. Equipment backing up, swinging loads, buckets, booms, and counter-weights pose serious hazards to ground personnel. If possible EA personnel must remain outside the turning radius of any large, moving equipment. At a minimum, EA personnel must maintain visual contact with the equipment operator when the equipment is active.

No EA personnel are permitted to work underneath heavy equipment, because this practice poses serious crushing hazards.

Belts, pulleys, sheaves, gears, chains, shafts, clutches, drums, flywheels, and other moving parts of equipment can pose injury hazards. No guard, safety appliance, or other device may be removed or made ineffective unless repairs or maintenance are required, and then only after power has been shut off and locked out. Safety devices must be replaced once repair/ maintenance is complete.

Exhaust from all equipment powered by steam or combustion engines must be properly located so that release of exhaust does not endanger workers or obstruct the view of the operator. Gasoline-operated equipment must be re-fueled properly to prevent fire hazards; power must be off, no smoking allowed, and proper dispensing equipment must be used.

When not operational, equipment will be set and locked so that it cannot be activated, released, dropped, etc. Backhoe buckets must be lowered to the ground.

PHYSICAL HAZARD INFORMATION SHEET:
NOISE HAZARDS

Work around large equipment often creates excessive noise. The effects of noise can include:

- Workers being startled, annoyed, or distracted
- Physical damage to the ear, pain, and temporary and/or permanent hearing loss
- Communication interference that may increase potential hazards due to the inability to warn of danger and provide for proper safety precautions to be taken.

If workers are subjected to noise exceeding an 8-hour time-weighted average (TWA) sound level of 85 dBA (decibels on the A-weighted scale), feasible administrative or engineering controls will be instituted to reduce noise levels to or below the permissible values. All personnel exposed to excessive noise levels will be provided with and will wear hearing protection which effectively protects the worker. OSHA regulations on noise can be found in 29 CFR Part 1910.95.

Site-Specific Hazards and Protective Measures: Hearing protection is optional during drilling work unless worker exposure exceeds an 8-hour TWA sound level of 85 dBA.

PHYSICAL HAZARD INFORMATION SHEET:
MATERIAL HANDLING/MOVING/LIFTING

Improper materials handling accounts for a large number of occupational injuries. Materials handling at hazardous waste sites can vary from heavy equipment handling to manually handling items. Hazards associated with materials handling include physical injury, detonation, fire, explosion, and vapor generation.

When using equipment to move materials, proper work practices must be followed. Equipment used must be designed for the task to be performed. Equipment must be inspected regularly by the Site Safety and Health Officer and the Field Manager, and damaged or defective equipment must be removed from service. Planning is critical when handling materials. The Field Manager, in conjunction with the Project Manager, must plan where the materials are to be moved, taking into consideration the current location of such materials and hazards associated with moving them. Routes for moving materials must be clearly outlined, with paths cleaned of all obstructions so materials may be transported.

Injuries to the back and abdominal muscles from improper lifting of loads is one of the most common occupational injuries reported. Such injuries can range from relatively mild strains to major permanently disabling injuries. Before lifting any load, personnel should consider the overall weight, distribution of weight, unwieldiness or awkwardness of the load, distance to be carried, obstacles to be negotiated, site conditions, and visibility. Loads should be inspected for slivers, sharp edges, slippery surfaces, etc. prior to lifting.

Loads should be lifted using the power of the leg muscles rather than the back, stomach, or arm muscles. Approach the item to balance the load evenly. Never bend over when lifting. The back should be kept straight and the arms nearly parallel with the body. The knees should be bent to grasp the load. Lifting should be done by straightening the legs, holding the load as close to the body as possible and the back remaining as straight as possible.

Bulky, heavy loads should be handled by at least two people, ensuring that the load is level and evenly distributed between all personnel helping to carry it. All carriers should know the destination and path for the load.

PHYSICAL HAZARD INFORMATION SHEET:
UNDERGROUND UTILITIES

Underground utilities pose hazards to workers involved in drilling, excavation, soil vapor contaminant analysis, and other invasive operations. These hazards include electrical hazards, explosion, and asphyxiation, as well as costly and annoying hazards associated with damaging communication, sewer, water, and/or irrigation lines.

The estimated location of underground installations, including sewer, telephone, fuel, electric, water lines, or other underground installations that reasonably may be expected to be encountered during invasive work will be determined prior to the start of any invasive work. This may be determined by contacting appropriate utilities, contacting a utility clearance service, using site maps and prominent site features, using a pipe and cable locator, etc. Buried utilities encountered during invasive operations must be protected while digging to prevent risks to site personnel and damage to the utilities.

PHYSICAL HAZARD INFORMATION SHEET:
VEHICLE AND PEDESTRIAN TRAFFIC

Traffic at certain sites, particularly active sites in busy areas, presents a hazard to site personnel. Equipment must be located in an area that does not present hazards to bystanders. Barriers must be used to separate the work areas from both vehicle and pedestrian traffic areas and to prevent inadvertent entry of either type of traffic into the work area. The demarcated area must include adequate buffer zones between the actual work area and traffic areas. Standard traffic cones are not considered adequate for these situations, due to their low vertical profile. Taller, 28-in. cones can be effectively modified with warning flags and barricade tape. Safety pennants and plastic or steel “A” frame type barricades may also be used in high traffic areas. Flashing warning lights may also be necessary. Barriers demarcating the work area and buffer zone are required even if the site is inactive during work operations.

Employees exposed to public vehicular traffic will be provided with, and will wear, warning vests or other suitable garments marked with or made of reflectorized or high-visibility material.

In excavation areas, excavated soil materials may be placed between the hole and traffic areas to act as a barrier to both vehicle and pedestrian traffic. Such material must be placed in a manner which will not pose engulfment hazards to either site workers or bystanders.

Appendix D

Safety, Health, and
Emergency Response Plan
Activity Record

APPENDIX D

SAFETY, HEALTH, AND EMERGENCY RESPONSE PLAN ACTIVITY RECORD

SITE: Oasis Fuel Point Site, Wheeler-Sack Army Airfield, Fort Drum, New York

Weather Condition:	Onsite Hours: From To

Changes in Personal Protective Equipment Levels[(a)]	Work Operations	Reasons for Change

Site Safety and Health Plan Violations	Corrective Action Specified	Corrective Action Taken (yes/no)

Observations and Comments:

Completed by:

____

Site Safety and Health Officer Date

(a) Only the Site Safety and Health Officer may change personal protective equipment levels, using only criteria specified in the Safety, Health, and Emergency Response Plan.

Appendix E

Accident/Loss and Incident Report

ACCIDENT/LOSS REPORT

THIS REPORT MUST BE COMPLETED BY THE INJURED EMPLOYEE OR SUPERVISOR AND FAXED TO EA CORPORATE HUMAN RESOURCES WITHIN 24 HOURS OF ANY ACCIDENT. THE FAX NUMBER IS **(410) 771-1780**.

NOTE WHENEVER AN EMPLOYEE IS SENT FOR MEDICAL TREATMENT FOR A WORK RELATED INJURY OR ILLNESS, PAGE 4 OF THIS REPORT MUST ACCOMPANY THAT INDIVIDUAL TO ENSURE THAT ALL INVOICES/BILLS/CORRESPONDENCE ARE SENT TO HUMAN RESOURCES FOR TIMELY RESPONSE.

A. DEMOGRAPHIC INFORMATION:

NAME OF INJURED EMPLOYEE: ____
HOME ADDRESS: ____
HOME PHONE: ____________________ DATE OF BIRTH: __________________________
AGE: ___________ SEX: M F
MARITAL STATUS: ________________ HOURLY RATE: ___________________________
SOCIAL SECURITY NUMBER: ___________________ DATE OF HIRE: _____________
NUMBER OF DEPENDENTS: ____
EMPLOYEES JOB TITLE: ____
DEPT. REGULARLY EMPLOYED: ____
WAS THE EMPLOYEE INJURED ON THE JOB: Y N
PRIMARY LANGUAGE OF THE EMPLOYEE: _______________________________________

B. ACCIDENT/INCIDENT INFORMATION:

DATE OF ACCIDENT: ___________________ TIME OF ACCIDENT: ___________________
REPORTED TO WHOM: ___________________ NAME OF SUPERVISOR_________________
EXACT LOCATION WHERE ACCIDENT OCCURRED (**including street, city, state, and County**):
____
____

EXPLAIN WHAT HAPPENED (include what the employee was doing at the time of the accident and how the accident occurred): ____
____
____
____

DESCRIBE THE INJURY AND THE SPECIFIC PART OF THE BODY AFFECTED (i.e. laceration, right hand, third finger):
____
____

OBJECT OR SUBSTANCE THAT DIRECTLY INJURED EMPLOYEE: ______________________
____
NUMBER OF DAYS AND HOURS EMPLOYEE USUALLY WORKS PER WEEK: ____________
IS THE EMPLOYEE EXPECTED TO LOSE AT LEAST ONE FULL DAY OF WORK? _________
DOES THE EMPLOYEE HAVE A PREVIOUS CLAIM? Y N if yes, STATUS: Open Closed
WAS THE EMPLOYEE ASSIGNED TO RESTRICTED DUTY? _____________________________

C. ACCIDENT INVESTIGATION INFORMATION

WAS SAFETY EQUIPMENT PROVIDED? Y N If yes, was it used? Y N
WAS AN UNSAFE ACT BEING FORMED? Y N If yes, describe___________________________
WAS A MACHINE PART INVOLVED? Y N If yes, describe ______________________________
WAS THE MACHINE PART DEFECTIVE? Y N If yes, in what way ________________________
WAS A 3RD PARTY RESPONSIBLE FOR THE ACCIDENT/INCIDENT? Y N
If yes, list Name, address, and phone number____
WAS THE ACCIDENT/INCIDENT WITNESSED? Y N
If yes, list Name, address, and phone number: ____

D. PROVIDER INFORMATION

WAS FIRST AID GIVEN ON SITE? Y N
If yes, what type of medical treatment was given ____
PHYSICIAN INFORMATION (if medical attention was administered)
NAME: ____
ADDRESS (incl. city, state, and zip):____
PHONE: ____
HOSPITAL ADDRESS (incl. Name, address, city, state, zip code, & phone)______________________
____
WAS THE EMPLOYEE HOSPITALIZED? Y N If yes, on what date________________________
WAS THE EMPLOYEE TREATED AS AN OUTPATIENT, RECEIVE EMERGENCY TREATMENT OR AMBULANCE SERVICE? ____

PLEASE ATTACH THE PHYSICIAN'S WRITTEN RETURN TO WORK SLIP

***NOTE* A PHYSICIAN'S RETURN TO WORK SLIP IS REQUIRED PRIOR TO ALLOWING THE WORKER TO RETURN TO WORK**

E. AUTOMOBILE ACCIDENT INFORMATION (complete if applicable)

AUTHORITY CONTACTED AND REPORT #____
EA EMPLOYEE VEHICLE YEAR, MAKE, AND MODEL___________________________________
V.I.N.________________________ PLATE/TAG #____

OWNER'S NAME AND ADDRESS: ____

____

DRIVER'S NAME AND ADDRESS: ____

____

RELATION TO INSURED: __________________DRIVER'S LICENSE #_______________________

DESCRIBE DAMAGE TO YOUR PROPERTY: ____

____

____

DESCRIBE DAMAGE TO OTHER VEHICLE OR PROPERTY: _______________________________

____

____

OTHER DRIVER'S NAME AND ADDRESS: ____

____

OTHER DRIVER'S PHONE: ____

OTHER DRIVER'S INSURANCE COMPANY AND PHONE__________________________________

____

LOCATION OF OTHER VEHICLE: ____

NAME, ADDRESS, AND PHONE OF OTHER INJURED PARTIES:___________________________

____

____

WITNESSES NAME: __________________________ PHONE:_____________________________

ADDRESS: ____

STATEMENT:____

____

SIGNATURE: ____

NAME: _______________________________________ PHONE: _______________________________

ADDRESS:____

STATEMENT:____

____

SIGNATURE: ____

F. ACKNOWLEDGEMENT

NAME OF SUPERVISOR: ____

DATE OF THIS REPORT: ____________ REPORT PREPARED BY:__________________________

I have read this report and the contents as to how the accident/loss occurred is accurate to the best of my knowledge.

Signature: _____________________________________ Date: ___________________________

Injured Employee

I am seeking medical treatment for a work related injury/illness.

Please forward all bills/invoices/correspondence to:

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

11019 McCORMICK ROAD

HUNT VALLEY, MD 21031

ATTENTION: Michele Bailey
HUMAN RESOURCES

(410) 584-7000
(410) 771-1780 – FAX

Appendix B

Quality Assurance Program Plan Procedures

FORT DRUM, NEW YORK

FINAL

Environmental Investigation for Fort Drum

Quality Assurance Program Plan

Fort Drum Military Installation
Fort Drum, New York

Prepared by:
Malcolm Pirnie, Inc
104 Corporate Park Drive
White Plains, NY 10602-0751

for:
US Army Corps of Engineers - Baltimore District
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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

A/E	Architect/Engineering
ARAR	Applicable or Relevant and Appropriate Requirement
CFR	Code of Federal Regulation
CLP	Contract Laboratory Program
CMI	Corrective Measures Implementation
CMS	Corrective Measure Study
COC	Chain-of-Custody Record
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantification Limit
DOT	Department of Transportation
DQCR	Daily Quality Control Report
DQO	Data Quality Objective
DUSR	Data Usability Summary Report
FID	Flame Ionization Detector
GC	Gas Chromatograph
GC/MS	Gas Chromatograph with Mass Spectrometer
GPS	Global Positioning System
HASP	Health and Safety Plan
HWMP	Hazardous Waste Management Plan
IDL	Instrument Detection Limit
IDW	Investigation-Derived Waste
IRP	Installation Restoration Program

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

Continued

LQAM	Laboratory Quality Assurance Manager
MCL	Maximum Contaminant Level
MD	Matrix Duplicate
MP	Measuring Point
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NAD	North American Datum
NAPL	Non-aqueous Phase Liquid
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NORM	Naturally Occurring Radioactive Material
O&M	Operation & Maintenance
PARCCS	Precision, Accuracy, Representativeness, Completeness, Comparability, and Sensitivity
PID	Photoionization Detector
PM	Project Manager
PQL	Practical Quantitation Limit
QAPjP	Quality Assurance Project Plan
QAPP	Quality Assurance Program Plan
QA/QC	Quality Assurance/Quality Control
QAO	Quality Assurance Objective

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

Continued

QCSR	Quality Control Summary Report
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessments
RFI	RCRA Facility Investigations
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SSHO	Site Safety and Health Officer
SVOC	Semi-volatile Organic Compounds
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCL	Target Compound List
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
WP	Work Plan

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

This Quality Assurance Program Plan (QAPP) has been developed for environmental investigations at Fort Drum, New York. The principal purpose of this QAPP is to provide procedures for the collection, analysis, and evaluation of data that will be legally and scientifically defensible.

1.2 QAPP ORGANIZATION

This QAPP provides general information and standard operating procedures applicable to all work performed at Fort Drum. The information includes definitions and generic goals for data quality and required types and quantities of QA/QC samples. The procedures address sampling and decontamination protocols; field documentation; sample handling, custody, and shipping; instrument calibration and maintenance; auditing; data reduction, validation, and reporting; corrective action requirements; and quality assurance reporting. The Site Specific Quality Assurance Project Plans (QAPjPs) contain a site description, intended data uses, project specific data quality objectives, and information on site field activities, such as sample locations, sampling procedures, analytical methods and reporting limits. The Site Specific QAPjPs will be submitted under separate cover as addenda to this QAPP.

1.3 SITE DESCRIPTION AND HISTORY

The following discussion is adopted from the Final Site Investigation Report, EOD Burn Sites Range 35 and Range 17, Fort Drum, New York, October 1991.

1.3.1 Site Description

Fort Drum is located in the north-central portion of New York State; approximately 10 miles northeast of Watertown, 80 miles north of Syracuse and 25 miles southeast of the United States and Canadian border. The installation occupies a large portion of northeastern Jefferson County and a small portion of western Lewis County. (Figure 1-1 in Appendix G)

1.3.2 Site History

Fort Drum was established in 1906 as a National Guard training area. In 1908, the United States government leased and subsequently purchased 10,000 acres known as Pine Plains from the City of Watertown. An additional parcel of approximately 97,300 acres was purchased between 1930 and 1940. During this period, construction began on the present cantonment area.

During World War II, Fort Drum was used as an operations base and firing range and provided combat skill training facilities for the 45th Infantry Division and the 4th and 5th Armored Division. In addition, Fort Drum housed prisoners of war. Presently, the primary mission of Fort Drum is to provide training facilities and services to the National Guard and the United States Armed Forces, specifically land and air space for firing range and combat skill practices. It has also become the operations headquarters for the 10th Mountain Division, Light Infantry. This new mission has resulted in a significant buildup in resident population, service and training facilities, and infrastructure encompassing the new cantonment area.

1.3.3 Environmental Setting

1.3.3.1 Meteorology

The climate of Fort Drum is characterized by cold winters and moderately warm summers. Located in the foothills of the Adirondack Mountains east of Lake Ontario, the site is subject to coastal storms from disturbances along the Atlantic Seaboard. In general, precipitation is fairly uniform throughout the year. The area has one of the largest average annual snow accumulations in the state.

Climatic data, obtained from the Public Affairs Office at Fort Drum and the National Climatic Data Center, Asheville, North Carolina, indicate an average annual temperature of 45.1°F. The average temperature for July, the warmest month, is 71.9°F. The average temperature for February, the coldest month, is 19.1°F. The monthly average rainfall is 3.28 inches; while the monthly average snowfall is 9.51 inches. Monthly average rainfall ranges from 4.08 inches in November to 2.52 inches in February. Monthly average snowfall ranges from 25.9 inches in January to none during the summer months. The prevailing wind direction is from the west-northwest. Monthly average windspeed is highest in April, at 12 miles per hour.

1.3.3.2 Surface Features

The facility lies within two physiographic regions; the predominantly flat Lake Ontario Lowlands to the southwest and the fairly rugged Adirondack Uplands to the northeast. The southwestern part of Fort Drum consist of an outwash delta, commonly known as the "Pine Plains," that is relatively flat and underlain by limestone. This area, which was part of the floor of the great glacial Lake Iroquois, received the inflow sediments from the Black River. It is characterized by a broad expanse of mostly flat, sandy surface which usually includes small sand plains, drumlin fields, swamps, and disturbed drainage patterns. The hummocky terrain is a result of Pleistocene continental glaciation.

The northeastern part of Fort Drum is characterized by a broad belt of low, rounded hills covered by a thin mantle of glacial drift of lacustrine deposits laid down in old glacial lakes. Part of the belt has bedrock knobs projecting through or lying close to the surface. Relief decreases from east to west toward the flat plains of the Central Lowland Provinces.

The Indian River and the Black River drainage basins are the two major river drainage basins in the area. Most of Fort Drum lies within the Indian River drainage system. The Indian River flows from east to west across the northern center of the facility. It has numerous tributaries including West Branch, Black Creek, and Pleasant Creek which drain the northern and central portions of Fort Drum. The Black River flows from east to west and passes along the southern corner of Fort Drum. A small portion of the southwest corner of Fort Drum lies within the Black River drainage basin.

1.3.3.3 Regional Geology

The surficial geology of Fort Drum consists of the uppermost fine to medium deltaic sand deposits of the Pine Plain Delta. Generally, sediments in the lower parts of the delta are finer grained than those stratigraphically higher, and are underlain by stratified lacustrine deposits consisting of silt, silty clay and clay. The sand delta deposits range in thickness from less than 10 feet along the boundary of the delta to a maximum thickness of about 150 feet near Wheeler Sack Air Field. This thickening is due to an east-west trending bedrock paleochannel just north of the Black River. The channel cuts through a limestone unit of the Black River group and is probably a former drainage channel of the Black River.

The sand plain was deposited by glacial meltwater streams entering glacial Lake Iroquois during the Wisconsin glaciation. As the Black River flowed into the lake, it deposited the fine to medium sand as a delta (Pine Plains Delta) and the silt and clay beyond the delta directly atop of glacial till on bedrock. A smaller delta was formed by the meltwater streams during an earlier lake stage and merged with the adjacent Pine Plain delta to form a relatively homogenous continuous sand unit which covers much of the southern part of the base.

The oldest and lowermost sedimentary rocks belong to the Cambrian Potsdam and the overlying Theresa Formation. Overlying these formations is the Ordovician Black River Group. The Black River group is comprised of thin to thickly-bedded limestone. These sedimentary units are not present in the northeastern and southeastern part of the installation. The sedimentary rocks are underlain by Precambrian metamorphic and igneous rocks.

The Potsdam Sandstone generally consists of tan to white, well sorted sand with siliceous and calcareous cementation. Locally, some of the basal sandstone beds are red from hematite or green from chlorite content and beds of coarse conglomerate are present. The thickness of the Potsdam Sandstone near Fort Drum is estimated to be from 15 to 25 feet and occurs as surface and subsurface units.

The Theresa Formation overlies the Potsdam Sandstone and consists primarily of hard, bluish gray, thinly-bedded sandy dolomite with calcareous sandstone layers dominant in the basal part. The upper beds of the formation vary in composition ranging from calcareous and dolomitic sandstone to sandy dolomite. The thickness of this formation at Fort Drum is approximately 35 feet. Both the Potsdam Sandstone and Theresa Formations probably underlie most of the sand plain delta complex, except for the southeastern and northeastern part of Fort Drum.

Overlying the Potsdam Sandstone and Theresa Formations are Ordovician carbonate units of the Black River Group, consisting primarily of the Chaumont, Lowville, and Pamelia Formations, from youngest to oldest respectively. The Chaumont Formation consists of massive, gray, finely-textured, cherty limestone containing abundant fossils. The Lowville Formation consists of medium-gray, fossiliferous, thick to thinly-bedded limestone with shale partings. The Pamelia Formation consists of dolomite with some gray limestone interbeds and basal quartz sand. Together these units are approximately 140 feet thick in the vicinity of the Black River south of the cantonment area.

1.3.3.4 Hydrogeology

The two aquifers of concern present beneath the Fort Drum area are the shallow, unconfined (water table) aquifer in the unconsolidated glacial sediments of the Pine Plains physiographic province and the bedrock aquifer, which may be locally confined or unconfined depending upon whether the unconsolidated glacial deposits are present or absent. The bedrock aquifer consists of fractured Ordovician carbonates and Cambrian dolomites and sandstones.

The shallow unconsolidated aquifer, which consists of fine-grained to silty sands and silts, ranges from less than 10 to more than 100 feet thick. The aquifer is relatively homogeneous, having been deposited as a deltaic sand sheet by glacial meltwater streams feeding the ancient Lake Iroquois. The sands contain little to no interbedded clay seams or horizons.

The unconsolidated aquifer, where present at Fort Drum, is recharged mainly by snow melt and precipitation. Recharge usually increases in the fall, as evapotranspiration is diminished, and continues into the winter as rainfall and snowmelt provide water. Generally, recharge ceases in mid-winter when precipitation changes to snow, temperatures drop and the land surface freezes. Recharge begins again in spring as temperatures rise and the overlying snowpack begins to melt. Recharge is greater in the spring than in the fall. Soil moisture deficiencies are wholly or partly fulfilled from the fall recharge.

1.3.3.5 Ecology

The woody vegetation of Fort Drum occupies approximately 154 square miles. Fish and wildlife management is carried out in the non-developed area, including 1.1 square miles of ponds and lakes and 39.1 miles of streams and rivers. The lakes and streams are annually stocked with brown trout, rainbow trout and speckled trout. Northern pike, sunfish, and black bass are also found in the ponds. The ponds and lakes are, for the most part, shallow (less than 65 feet deep).

As of the most recent survey conducted (July 8, 1999), no endangered species of flora or fauna have been identified on the site. However, many species of plants in the area have "protected status" under the auspices of the New York State Department of Environmental Conservation Guidelines. Waterfowl, including ducks and geese, are migrants through the area (estimated transient population of greater then 20,000). Whitetail deer, gray squirrel, hare, and rabbit are also common to the area.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

For each individual project, the United States Army Corps of Engineers (USACE) assigns a Project Manager to provide technical direction and monitor consultant technical performance. The consultant technical team is comprised of the following personnel. The project personnel are selected based on appropriate skills, experience and availability.

Laboratories conducting analyses for samples collected at Fort Drum will be capable of providing complete environmental analytical services consistent with the United States Environmental Protection Agency (USEPA) protocols, certified by the New York State Department of Health (NYSDOH), and validated by the USACE. Detailed information regarding the laboratory personnel, facilities and procedures are presented in the Site Specific QAPjPs.

Project personnel responsibilities are summarized below. Project specific responsibilities are presented in the Site Specific QAPjPs to this QAPP.

Project Officer: The Project Officer is the representative with contract authority. The Project Officer is responsible for the commitment of the resources required for the project's needs.

Project QA/QC Officer: The Project QA/QC Officer provides guidance on technical matters and reviews all technical documents relating to the project. Furthermore, the QA/QC Officer has the responsibility to assess the effectiveness of the QA/QC program and to recommend modifications to the program when applicable. The QA/QC Officer may delegate technical guidance to specially trained individuals under his direction.

Project Manager: The Project Manager is accountable to the Project Officer throughout the duration of the project. The Project Manager is responsible for:

- Coordination with USACE,
- Budget control,
- Subcontractor performance,

- Project coordination to implement Work Plan,
- Allocation of resources and staffing to implement the QA/QC program,
- Allocation of resources and staffing to implement the Site Safety and Health Plan (SSHP), and
- Review of engineering and interim reports.

Project QA/QC Coordinator: The Project QA/QC Coordinator is responsible for project specific supervision and monitoring of the QA/QC program. These responsibilities include:

- Ensuring that field personnel are familiar with and adhere to proper sampling procedures, field measurement techniques, and sample identification and chain-of-custody procedures,
- Coordinating with the analytical laboratory for the receipt of samples, the reporting of analytical results and recommending corrective actions to correct deficiencies in the analytical protocol or sampling, and
- Preparing QA reports to management.

Site Field Manager: The Site Field Manager will serve as the on-site contact person for field investigations and tests. The Manager will be responsible for the logistics of the field activities. The Field Manager will:

- Inspect and replace equipment,
- Prepare daily and interim reports,
- Prepare samples for shipment,
- Coordinate field activities, and
- Schedule sampling and other field activities.

Site Safety and Health Officer: The Site Safety and Health Officer (SSHO) is responsible for ensuring that the field activities are carried out in accordance with the Health and Safety Plan. The SSHO will provide technical assistance to the Project Manager and field personnel to help assure site safety. In addition, the SSHO will:

- Monitor field activities,
- Monitor personal exposure to chemical toxins,
- Develop emergency response procedures,
- Monitor for temperature stress,
- Establish personnel decontamination procedures, and
- Stop work in the event unsafe work conditions are encountered.

Laboratory Quality Assurance Manager: The Laboratory Quality Assurance Manager (LQAM) provides technical direction to, and supervision of, the QA program within the laboratory. In brief, these responsibilities include:

- Monitoring effectiveness of QA Program;
- Ensuring appropriate maintenance, implementation and updating of laboratory Standard Operating Procedures (SOPs) and records;
- Performing regular internal facility audits and periodic external (subcontractor) audits;
- Overseeing programs designed to ensure adequate standard traceability, sample chain of custody and corrective action;
- Providing regular reports to management addressing QA Program status and laboratory certification status;
- Ensuring proper laboratory personnel training; and
- Serving as liaison for the laboratory to federal and state agencies on QA-related issues.

Laboratory Sample Custodian: The Sample Custodian is responsible for the preparation of sample containers and the receipt of collected samples. Specifically, the sample custodian undertakes the following duties:

- Prepares sample containers for shipping to sample collection sites and coordinates shipping/receiving of samples and containers.
- Receives samples into the laboratory and logs the sample through the laboratory tracking system. Tracks samples through analysis, storage, and disposal.

3.0 QUALITY ASSURANCE AND CONTROL OBJECTIVES FOR DATA MANAGEMENT

3.1 INTRODUCTION

This section discusses quality assurance objectives (QAOs) for the environmental investigation activities at Fort Drum. QAOs are the requirements specifying the quality of the environmental data needed to support the decision-making process. The uncertainty must be maintained at levels that will allow the resultant data to be used for its intended purposes.

3.2 DATA QUALITY CONTROL OBJECTIVES

Data quality objectives (DQOs) are qualitative and quantitative statements which specify the quality of the data required to support decisions, and are developed to achieve the level of data quality required for the anticipated data use and are implemented so, that for each task, the data is legally and scientifically defensible. The development of DQOs for a specific site and measurement takes into account project needs, data uses and types and needs, and data collection. These factors determine whether the quality and quantity of data are adequate for its end use. Sampling protocols have been developed and sample documentation and handling procedures have been identified to realize the required data quality.

DQOs are determined based on the end uses of the data to be collected. DQOs are applicable to all data collection activities including those performed for RCRA Facility Assessments (RFAs), RCRA Facility Investigations (RFIs), Corrective Measure Study (CMS), Corrective Measures Implementation (CMI), and Operation and Maintenance (O&M). The level of detail and data quality needed will vary based on the intended use of the data. The variability of site characterization makes it impossible to apply a generic set of DQOs to all activities.

DQOs are established prior to data collection and are not considered a separate deliverable. Rather, the DQO development process is integrated with the project planning process, and the results are incorporated into the field sampling plan, QAPjP, and the WP for the solid waste management units (SWMUs) or site location. Data quality objectives should be specified for each data collection activity that is planned. The DQO process results in a well thought out plan which details the chosen sampling and analysis options and the statements of the confidence in decisions made during the corrective action process. Confidence statements are possible through the application of statistical techniques to the data.

3.2.1 Data Quality Objective Development Process

Data quality objectives are identified during project scoping and development of sampling and analysis. DQOs are established to ensure that the data collected are sufficient and of adequate quality for their intended uses. Data collected and analyzed in conformance with the DQO process can be used in assessing the uncertainty associated with decisions related to corrective action.

3.2.1.1 DQO Stages

Data quality objectives are developed through a three-stage process. This three stage process is an interactive and iterative process, whereby all the DQO elements are continually reviewed and reevaluated. As such, the DQO process is integrated with development of the field sampling plan and QAPjP and is revised as needed based upon the results of each data collection activity.

3.2.1.1.1 Stage 1 – Identify Decision Types

This stage defines the types of decisions that must be made through identifying data users, evaluating available data, developing a conceptual model, and specifying goals for the project. During this stage, any available information is compiled and analyzed to develop a conceptual model. This model describes suspected sources, contaminant pathways, and potential receptors. The model facilitates identification of decisions that must be made and deficiencies in the existing information. This stage results in the specification of the decision making process and identification of why new data are needed.

3.2.1.1.2 Stage 2 – Identify Data Uses and Needs

This stage stipulates criteria for determining data adequacy. This stage involves specifying the data necessary to meet the objectives established in Stage 1. This stage includes selection of the sampling approaches and analytical options for an investigation.

3.2.1.1.3 Stage 3 – Design Data Collection Program

This stage results in the specification of the method by which data of acceptable quality and quantity will be obtained to make decisions. This information shall be provided in documents such as the QAPjP.

3.2.1.2 Phased Investigative Approach

The amount and quality of data required to support selection of a corrective measures alternative will vary by facility. In many situations it may not be possible to identify all data needs during the initial scoping activities. Rather, data needs will become more clearly defined as additional data are obtained and evaluated. By separating the investigation into phases, data can be collected and evaluated sequentially, with a refinement or redefinition of data collection needs at the completion of each phase.

3.2.2 Identify Decision Types

Stage 1 of the DQO process should identify and involve the data users, evaluate all available information, consider developing a conceptual model, and specifying investigation goals and decisions.

3.2.2.1 Data Users

Due to the interdisciplinary nature of environmental investigations and/or sampling, it becomes important that all personnel involved with the investigation be identified, including individuals associated with collecting and analyzing environmental samples, and individuals at the regulatory agencies that will review investigative results. The QAPjP will identify the individuals responsible for data collection and data quality. During the DQO process those individuals responsible for developing the QAPjP should coordinate with appropriate regulatory personnel who will be involved with the review and approval of the QAPjP. Within the lead regulatory agency, identify the project manager who will coordinate all regulatory reviews and comments, and be responsible for regulatory decisions. Determine which project engineer and scientists within the regulatory agencies will evaluate the data generated during the corrective action process.

If groundwater contamination is a concern, geologists/hydrogeologists will be involved. If surface water contamination is a concern, aquatic biologists may be involved. Analytical chemists will assist in specifying the types of analyses to be used and the limitations of the particular techniques or methods. Engineers or scientists familiar with the interactions of chemicals in the environment will be involved to assess environmental impacts and provide assistance in evaluating spatially distributed data. Engineers and scientists familiar with risk assessments will also be involved early in the scoping process to ensure that appropriate consideration is given to potential migration pathways, receptors, contaminants of concern, and cleanup target levels or standards. As the data collection process proceeds and alternative remedial designs are being considered, direct involvement with regulatory engineers responsible for review and approval of design shall be through the appropriate Fort Drum program contact. This involvement will assure that sufficient and relevant data is collected on which to base designs.

3.2.2.2 Available Information

Available information should be reviewed and evaluated as the initial step in the corrective action process. This review provides the foundation for additional on-site activities and serves as the database for scoping the investigation. For example, for many SWMUs, previous studies have provided useful information upon which further investigations can be based. The quality of the data should be analyzed to determine if it can be used. These evaluations determine the uncertainty associated with the conclusions drawn from the data.

3.2.2.2.1 Data Quality for Sample Analysis

A number of factors relate to the quality of data and its adequacy for use in the corrective action process, including the following considerations:

a. Age of the data;
b. Analytical methods used;
c. Detection limits of method; and
d. QA/QC procedures and documentation.

3.2.2.2.2 Data Quality for Sample Collection

Methods used for sample collection are as important to consider as the methods used for sample analysis. These considerations fall into two broad categories: statistical and SOPs. The statistical considerations relate to the representativeness of the data and the level of confidence that may be placed in conclusions drawn from the data.

Following SOPs ensure sample integrity and data comparability and reduces sampling and analytical error. Typical issues to consider include the following:

a. Sampling objective and approach;
b. Sample collection methods;
c. Chain-of-Custody documentation;
d. Sample preservation techniques;
e. Sample shipment methods; and
f. Holding times.

If limited or no information exists on sample collection, preservation techniques, or holding times, the data should be interpreted with caution, if they can be accepted at all.

3.2.2.2.3 Data Adequacy

The uncertainty associated with each data measurement activity should be considered when data are evaluated. Although data may be validated analytically, the level of precision of a particular data point may not provide sufficient certainty for use in a decision. The uncertainty associated with a decision is a function of the statistical distribution of the factors that were used in reaching the decision. Assessment of data adequacy has two steps. The first step is data validation. The second step is determining if the data is sufficient to reduce the uncertainty surrounding a decision to an acceptable level.

Data validation identifies invalid data and qualifies the usability of the remaining data. The output of data validation is qualitative or quantitative statements of data quality. Once the quality of individual measurements are known, a compilation of all data points into a cohesive statement can be made. The confidence associated with a statement incorporates both the confidence in individual measurements as well as in the decision.

3.2.2.3 Conceptual Model

Conceptual models describe a site and its environs and present hypotheses regarding the contaminants present, their route of migration, and their potential impact on sensitive receptors. The hypotheses are tested, refined and modified throughout the investigation.

3.2.2.3.1 Model Evaluation

The conceptual model should be detailed enough to address potential or suspected sources, types and concentrations of contaminants, affected media, rates and routes of migration, and receptors. The following are assessed during development of the conceptual model to determine appropriate corrective action at a SWMU:

a. Population, environmental, and welfare concerns at risk;

b. Routes of exposure;

c. Spatial distribution of contaminants;

d. Atmospheric dispersion potential and proximity of targets;

e. Amount, concentration, hazardous properties, environmental fate and form of the substance (s) present;

f. Hydrogeological factors;

g. Climate;

h. Extent to which the source can be adequately identified and characterized;

i. Potential for reuse, recycling or treatment of substances at the SWMU;

j. Likelihood of future releases if the substances remain on-site;

k. Extent to which natural or man-made barriers currently contain the substances and the adequacy of the barriers;

l. Assessment of the potential pathways of migration and a model of such;

m. Extent to which the substances have migrated or are expected to migrate from their source and whether migration poses a threat to public health, welfare, or the environment; and

n. Extent to which contamination levels exceed health or environmental standards and criteria.

Data evaluation should be undertaken at the initiation of and at each point within the program that additional data are obtained. Additional data collected during the investigation are used to expand the conceptual model and determine if sufficient data are of adequate quality have been obtained to address the issues of concern.

3.2.2.3.2 Computer Model

If computer models (groundwater models, air quality models, and/or geostatistical methods) will be used to define the extent of contamination, it is important to determine the level of analysis that is required to meet the objectives of the study. Modeling techniques can be applied throughout the investigation, and early in the investigation, can be used to guide the data collection program.

3.2.2.4 Objectives and Decisions

Specifying the objectives is similar to identifying problems to be solved. Objectives are typically geared towards separate media or sources, however, these objectives should be consistent with the ultimate objective of selecting a remedial action alternative (s). Some general objectives that should be considered during an investigation include:

a. Establishing the nature and presence or absence of suspected or potential hazardous waste or constituent release(s);
b. Determining the mechanism of the contaminant release(s) to the environmental media pathway(s);

c. Estimating the boundaries of contamination by initial screening methods such as soil gas analysis and geophysical techniques;

d. Establishing horizontal/vertical boundaries of contamination in the environmental media acting as a pathway for the release(s);

e. Determining concentrations of contaminants and their gradients, direction of flow, and within the environmental media acting as a pathway for the release (s); and

f. Identifying the potential receptor(s) for the release(s) and the concentration(s) of the contaminant (s) at the receptor(s).

3.2.2.5 Decisions

The consequences of a wrong decision must be weighed for each major decision that is made. Where the consequence of a wrong decision carry significant public health, safety or environmental impacts, greater attention must be paid to obtaining the data required to ensure that the decision is sound.

The risk of making a wrong decision is related to the quantity and quality of information available. As the quantity and quality of data increase, the risk of making a wrong decision generally decreases. It is important to note the following: the collection of additional data or improvement of data quality will not significantly decrease the risk of making a wrong decision.

Data quantity and data quality are independent variables that must be considered jointly during assessment of the consequences of making a wrong decision. Collecting increasing quantities of data points that are of low quality may not add significantly to the reduction of risk of making a wrong decision. Increasing the data quality of a limited number of samples may not add significantly to the body of knowledge to be used in making a decision.

The value of obtaining additional data or increasing data quality has traditionally been based on professional judgment. The intent of the DQO process is to provide a systematic approach for the evaluation of the risk associated with making a wrong decision and for determining levels of uncertainty associated with decisions to provide a framework for the project managers.

3.2.3 Identify Data Uses and Needs

Stage 2 of the DQO process defines data uses and specifies the types of data needed to meet the project objectives. This process begins when the project objectives are established. The conceptual model and the general decisions become the basis for determining data uses and data needs. Stage 1 determines if existing data meet the project objectives. If the existing data are sufficient, there is no need to collect additional data. If the data are insufficient, the types, quality, and quantity of data that must be collected are determined in Stage 2.

3.2.3.1 Identifying Data Use Categories

The following data use categories provide examples of different uses, which may require data of a given quality. Data collected for a site at a given level of quality may be used for different purposes.

1. **SWMU Characterization:** Data are used to determine the nature and extent of contamination at a SWMU. This category is usually the one that requires the most data collection. SWMU characterization data are generated through the sampling and analysis of waste sources and environmental media.

2. **Health and Safety:** Data are typically used to establish the level of protection needed for investigators or workers at a SWMU and if there should be an immediate concern for the population living within the facility vicinity.

3. **Risk Assessment:** Data are used to evaluate the threat posed by SWMU(s) to public health and the environment. Risk assessment data are generally through the sampling and analysis of environmental and biological media, particularly where the potential for human exposure is great.

4. **Evaluation of Alternatives:** Data are used to evaluate various corrective measures or remedial technologies. Engineering data are collected in support of remedial alternative evaluation and to develop cost estimates. This may involve performing bench-scale or pilot scale studies to determine if a particular process or material may be effective in mitigating site contamination.
5. **Engineering Design of Alternatives:** Data collected during the investigation can be used for engineering design purposes to develop a preliminary data base in reference to the performance of various remedial

technologies. Data types collected during the investigation that are applied to the design process include waste characterization and volume data.

6. **Monitoring During Corrective Measures Implementation:** During the implementation of a remedial design, samples can be taken to assess the effectiveness of the design. Based on the analysis of these samples, adjustments may be made to the design.

7. **Waste Characterization:** As part of the daily activities conducted at Fort Drum, wastes are generated through a variety of processes. Appropriate characterization of these wastes is required. Detailed information about Fort Drums hazardous waste management program is included in the document entitled “Hazardous Waste Management Plan” Fort Drum Public Works Environmental Division (February 2000).

Once the data use categories are identified, the intended uses should be prioritized. Establishing an order of priority for the intended data uses will help identify the most demanding use of each type of data, i.e., the use requiring the highest level of confidence, and therefore, the lowest level of uncertainty. The data quality required will be a function of the acceptable limits of uncertainty established by the decision maker. The limits on uncertainty will drive the selection of both the analytical and sampling approaches.

3.2.3.2 Identifying Data Uses

During the evaluation of data uses, the potential remedial options that will be considered during the corrective action process must be reviewed. For each of the appropriate data use categories, the following information or analyses should be considered during the DQO process:

1. List of candidate remedial actions;

2. Method by which the initial alternatives will be screened, including effectiveness criteria, implementation criteria, and cost criteria;

3. Detailed effectiveness screening will exam whether the alternatives protect public health and the environment and meet appropriate standards or criteria levels;

4. Detailed implementability screening will examine the technical feasibility, availability, and administrative feasibility of each alternative;

5. Detailed cost screening will examine the capital, operation and maintenance, and replacement cost as well as the present worth of the alternatives; and

6. Both the short and long-term effects of the screening factors must be assessed and the alternatives must be compared to identify their relative strengths and weaknesses.

The corrective action process involves a number of data collection activities, each having specific objectives. Since the objectives require varying degrees of data quality, it is critical to identify the specific use to which each set of data will be applied.

3.2.3.3 Identifying Data Types

Data use categories define the general purposes for which data will be collected during the investigation. Based upon the intended uses, a concise statement regarding the data types needed can be developed. After identifying the data types and uses, data quality needs can be defined, and a systematic evaluation of sampling and analysis options can be performed.

The types of analyses performed on each sample must be determined while identifying data types. The analytical requirements are dictated by the use of the data.

The data types specified in Stage 2 should not be limited to chemical analytical data parameters, but should also include physical parameters such as permeability and porosity, which are needed to evaluate contaminant migration and liner leachate tests to assess liner performance for remedial design. The level of detail type definition must be sufficient to allow for evaluation of sampling/analysis options during subsequent stages of the DQO process.

3.2.3.4 Identifying Data Quality Needs

The identification of data uses and data types must be defined during the initial phases of the investigation. As the project proceeds and more data becomes available, data types may change.

3.2.3.4.1 Appropriate Analytical Levels

The following analytical levels can be used as a guidance to help achieve data types, and are defined by the NYSDEC as follows:

a. **Level I -** field screening or analysis using portable instruments. Results are often not compound specific and not quantitative but results are available in real-time.

b. **Level II -** field analyses using more sophisticated portable analytical instruments (i.e., mobile or on-site lab). There is a wide range in the quality of data that can be generated, depending on such factors as suitable calibration standards, sample preparation equipment, and the training of the operator. Results are available in real-time or several hours.

c. **Level III -** SW-846 routine analytical parameters. All analyses are performed in an off-site laboratory following SW-846 protocols. Level III is characterized by rigorous QA/QC procedures and documentation.

d. **Level IV -** analytical analysis by pre-approved non-standard methods. All analyses are performed in an off-site approved analytical laboratory. Method development or method modification may be required for specific constituents or detection limits. Level IV should be characterized by rigorous QA/QC procedures and documentation.

e. **Level V -** physical property and engineering material analysis by approved standard or non-standard methods. All analyses are performed in an off-site laboratory. QA/QC protocols and documentation may be required for some analyses.

The following analytical types can also be used as a guidance to help achieve data types, and are defined by the USACE as follows:

a. **Screening Data with Definitive Confirmation** – Screening data are generated by rapid, less precise methods of analysis with less rigorous sample preparation. Sample preparation steps may be restricted to simple procedures such as dilution with a solvent, instead of elaborate extraction/digestion and cleanup. Screening data provide analytical identification and quantification, although the quantification may be relatively imprecise. At least 10% of the screening data are confirmed using analytical methods and QA/QC procedures and criteria associated with definitive data. Screening data without associated confirmation data are not considered to be data of known quality. The QA/QC elements of screening data include the following: sample documentation; chain-of-custody; sampling design approach; initial and continuing calibration; determination and documentation of detection limits; analyte identification; analyte quantification; analytical error determination; and definitive confirmation of at least 10% of the samples. This data type is equivalent to the NYSDEC levels I and II.

b. **Definitive Confirmation –** Definitive data are generated using rigorous analytical methods, such as EPA reference methods. Data are analyte-specific, with confirmation of analyte identity and concentration. Methods produced are tangible raw data (e.g., chromatograms, spectra, digital values) in the form of paper printouts or computer-generated electronic files. Data may be generated at the site or at an off-site location, as long as the QA/QC requirements are satisfied. For the data to be definitive, either analytical or total measurement error must be determined. The QA/QC elements of definitive data include the following: chain-of-custody; sampling design approach; initial and continuing calibration; determination and documentation of detection limits; analyte identification; analyte quantification; QC blanks; matrix spike recoveries; performance evaluation sample results (when specified); analytical error determination (precision of analytical method); and total measurement error determination (over all precision of measurement system). This data type is equivalent to the NYSDEC levels III and IV.

For each generic data use, several of the analytical levels may be appropriate, and the decision maker needs further criteria to select the most appropriate level. Important criteria driving the decision are the contaminants of concern and the level of concern for each contaminant.

Engineering design typically requires information beyond analytical levels for chemical analyses. Physical property data (viscosity, soil organic carbon, etc.) may be necessary for engineering design, and in all likelihood would require more than one analytical level.

3.2.3.4.2 Contaminants of Concern

Historical information or previous data sets at a particular site will help determine a list of potential contaminants of concern. When the list is identified, the list must be included in the QAPjP.

3.2.3.4.3 Action and Target Levels

The action level specifies a concentration above which some form of corrective action may need to be taken. The action level is defined by the regulatory agency to be a health and environmental standard or criteria value. The action level is intimately linked with a target level that defines the level of cleanup for corrective action or waste disposal under RCRA. Other target levels include appropriate waste characterization levels such as those contained in 40 CFR 261.24.

A rough estimate of a target level is necessary to ensure that the chosen analytical methods are accurate at the target level. In addition, knowledge of the target level can influence the number of samples required and the selection of the analytical method.

3.2.3.4.4 Detection Limit Requirements

The action level can directly affect data quality requirements. The sampling and analysis methods used must be accurate at the detection limit. Since sampling accuracy is hard to evaluate or control, it is extremely important that the analytical technique chosen has a detection limit well below the action level. This must be considered when evaluating analytical options.

3.2.3.4.5 Critical Samples

Critical samples are those for which valid data must be obtained to satisfy the objective of the sampling and analysis program. Critical samples may be taken in duplicate, or as appropriate.

3.2.3.4.6 Identify Data Quantity Needs

The number of samples that should be collected can be determined using a variety of approaches. The validity of the approach utilized is dependent on the characteristics of the media under investigation and the assumptions used to select sample locations. In situations where data are unavailable or limited, a phased sampling approach may be appropriate. Phase I data can be evaluated to determine the appropriate number of samples to be obtained in subsequent phases of the investigation.

In the absence of available data, the data users and decision makers will be required to develop a rationale for selecting sampling locations. Questions to guide the data users in selecting appropriate locations could include the following:

a. Do source materials still exist on the soil surface?
b. Is there evidence of soil disturbance or vegetative stress based upon review of aerial photographs?
c. Do geologic features in the area control ground water and surface water flow patterns?
d. Do site conditions favor surficial soil erosion or wind erosion?
e. Are sensitive receptors located in the vicinity of the site?

These types of questions can be addressed in the absence of any analytical data and will assist in identifying additional data needs. Subsequent evaluations may lead to the recommendations that geophysical surveys or soil gas and other field screening studies be conducted in areas of soil disturbances. The collection of a limited number of samples from identified source materials or pathways, such as streams, may also be considered. Limited air sampling may also be warranted during the early stages of the investigation to determine if organic vapors or particulates could pose a problem.

In situations where data are available, or as new data are added to a database, statistical techniques may be utilized in determining the number of data required.

Following an evaluation of the data, the adequacy of the data to support a decision can be determined. If a higher degree of certainty in the decision is required (e.g., a more definitive statement regarding the extent of contamination), then additional data should be obtained in subsequent sampling phases. In all cases, the actual level of confidence in a decision can only be established following collection and evaluation of data. Therefore, at the completion of each data collection activity, data evaluation is critical.

3.2.3.4.7 Evaluate Sampling/Analysis Options

Following the identification of data uses, data types, and data quality needs, an evaluation of sampling and analysis options can be performed. A number of different sampling and analysis options can be developed for any data collection activity. The following provides an example of a phasing sample approach.

3.2.3.4.7.1 Sampling and Analysis Approach (Phasing)

Data collection activities must be designed to ensure maximum use of the data. Developing a sampling and analysis approach that ensures that appropriate levels of data quantity and quality are obtained may be accomplished by implementing a "phased" approach coupled with the use of field screening techniques to direct the data collection activities. By subdividing the data collection program into a number of phases, the data can be obtained in a sequence that allows it to be used to direct subsequent data collection activities.

The time required to receive and evaluate analytical data from an off-site laboratory typically results in delays in an investigation. The use of field instrumentation and/or field test kits can assist in assessing contaminants concentrations or media characteristics, the investigation can proceed with fewer delays.

Instruments that should be considered for use during the evaluation of a sampling/analysis approach include:

a. Field test kits;
b. Photoionization detectors (PID);
c. Flame ionization detectors (FID);
d. Hydrogen sulfide analyzers;
e. pH and conductivity meters;
f. Oxygen/explosimeters; and

g. Radiation meters.

These direct reading instruments can be taken into the field to obtain data without extensive calibration procedures.

During use of an analytical approach, a large number of samples are analyzed quickly in the field, with a smaller number of samples analyzed further using successively more sophisticated procedures. The type and design of the analytical approach is determined by how the data will be used. By strategically selecting the samples analyzed at each level, a much high degree of certainty can be obtained for the overall data set without sacrificing either the quantity of samples analyzed or the quality of data produced.

3.2.3.4.8 PARCCS Parameters

Data quality is measured by how well the data meet the quality assurance/quality control (QA/QC) goals for the project. Quality control elements include precision, accuracy, representativeness, completeness, comparability, and sensitivity:

- <u>Precision</u> is a measure of mutual agreement among individual measurements of the same property, usually under prescribed conditions. Assessing precision measures the random error component of the data collection process. Precision is determined by measuring the agreement among individual measurements of the same property, under similar conditions. The degree of agreement, expressed as the relative percent difference (RPD), is calculated using the formula below.

  $$\text{RPD} = \frac{(V_1 - V_2)}{\frac{(V_1 + V_2)}{2}} \times 100$$

  where: *V1 = value 1*
  V2 = value 2

  Analytical precision is assessed by analyzing matrix spike/matrix spike duplicate pairs and laboratory duplicate samples. Field precision is assessed by measurement of field duplicate samples. The objective for precision is to equal or exceed the precision demonstrated for similar samples and should be with the established control limits for the methods. Precision control limits and QC RPD limits are presented as part of the QAPjPs.

- Accuracy is the degree of agreement of a measurement with an accepted reference or true value. Accuracy measures the bias or systematic error of the entire data collection process. Sources of these errors include the sampling process, field and laboratory contamination, sample preservation and handling, sample matrix interferences, sample preparation methods, and calibration and analytical procedures. To determine accuracy, a reference material of known concentration is analyzed or a sample which has been spiked with a known concentration is reanalyzed. Accuracy is expressed as a percent recovery and is calculated using the following formula:

$$\%\ \text{Recovery} = 100 \times \frac{\text{measured value}}{\text{true value}}$$

  Recoveries are assessed to determine method efficiency and matrix interference effects. Analytical accuracy is measured by the analysis of calibration checks, system blanks, quality control samples, surrogate spikes, matrix spikes, and other checks required by the selected analytical methods. Sampling accuracy is assessed by evaluating the results of field and trip blanks. Sampling accuracy is also maintained by frequent and thorough review of field procedures. The objective is to meet or exceed the demonstrated accuracy for the analytical methods on similar samples and should be within established control limits for the methods. Accuracy control limits and MS/MSD and surrogate recovery limits are presented as part of the Site Specific QAPjPs.

- Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is achieved through proper development of the field sampling program. The sampling program must be designed so that the samples collected are as representative as possible of the medium being sampled and that a sufficient number of samples will be collected. The objective of obtaining representativeness of samples will be met through the implementation of the work plan and QAPP.

- Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. Data is complete and valid if it meets all acceptance criteria including accuracy, precision, and any other criteria specified by the particular analytical method being used. Completeness is

$$\%\ \text{Completeness} = 100 \times \frac{V}{n}$$

calculated as follows:

where: V = *number of measurements judged valid*
n = *total number of measurements*

The objective is to generate a sufficient database with which to make informed decisions. To help meet the completeness objective, every effort must be made to avoid sample loss through accidents or inadvertence. The completeness objective for each project is stated in the Site Specific QAPjP.

- Comparability expresses the confidence with which one data set can be compared to another. Comparability cannot be described in quantitative terms, but must be considered in designing the sampling program. Thus, this objective will be met by using standard methods for sampling and analyses and by following techniques and methods set forth in the project specific work plan and QAPP.
- Sensitivity is the capability of a method or instrument to discriminate between small differences in analyte concentration. The sensitivity and detection limits of a method will be reviewed to determine a method's applicability while developing project specific work plans and QAPjPs.

3.2.4 Design Data Collection Program

Stage 3 of the DQO process entails design of the detailed data collection program for the investigation. The process of addressing elements in Stages 1 and 2, all of the components required for the completion of Stage 3, are available.

3.2.4.1 Assemble Data Collection Components

During Stage 2, specific DQOs were developed by media or sampling activity. The intent of Stage 3 is to compile the information and DQOs developed for specific tasks into a comprehensive data collection program. A detailed list of all samples to be obtained should be assembled in a format which includes phase, media, sample type, number of samples, sample location, analytical methods, and QA/QC samples (type and number). In addition, a schedule for all sampling activities should be developed in bar chart or critical path method format.

3.2.4.2 Develop Data Collection Documentation

The output of the DQO process is a well defined QAPjP including a field sampling plan. The DQO process provides a framework to ensure that all the pertinent issues related to the collection of data with known quality are addressed. The DQO levels for sampling at Fort Drum will be outlined in Site Specific QAPjPs.

4.0 FIELD SAMPLING PLAN

4.1 OVERVIEW

The following section describes SOPs applicable to work conducted at Fort Drum. The sampling procedures outlined below are a generic collection of sampling procedures that will be followed for sample collection in order that representative samples will be collected. Table 4-1 outlines the types of sample containers and preservatives required for sample collection. (It should be noted: liquid waste samples that exhibit an oily characteristic do not require acid preservation.)

The following SOPs will be followed unless otherwise indicated in site specific QAPjPs; SOPs shall also be prepared for site-specific projects at Fort Drum and submitted under separate cover as addenda to this document. All field teams will be required to strictly adhere to the procedures provided in the QAPP and the Health and Safety protocols provided in the Site Safety and Health Plan. Prior to commencement of field activities, all on-site personnel will be trained in health and safety techniques and site-specific operations.

This section of the FSP should contain sufficient information to permit a technical person unfamiliar with the project to evaluate the sampling and analytical approach. This section should describe the location, size, and important physical features of the site, such as roads, streams, and landmarks. A figure showing the site location and layout is required. A chronological site history including descriptions of the use of the site and use of chemicals should be provided. All historical data from previous sampling efforts at the site should be identified and summarized. In addition, a signature block identifying the individuals responsible for preparing the QAPjP shall be included.

4.2 SAMPLING RATIONALES

The sampling rationales presented within each QAPjP will discuss the rationale for each planned field activity. Each of the matrices to be sampled should include the rationale behind the required number of field samples collected; the strategy for selection of the particular sampling location; a summary of the required number of field, background/upgradient, and field QC samples; and the type of samples collected. A rationale and frequency of the QC samples collected should also be discussed. The QAPjP will include a list of all measurements that will be made during the project, and summarized in tabular form. This table will include the number of samples for each sample location, including QA and QC samples. The frequency of QA and QC samples will be expressed as a percentage of the total number of samples collected for that matrix. The QAPjP will also include intended data uses, project-specific data quality objectives, analytical methods and reporting limits.

4.3 SAMPLING STRATEGIES

To ensure that samples collected are representative of the site conditions, various sampling strategies can be used. Sampling strategies must be used in accordance with those outlined in the document *"Requirements for the Preparation of Sampling and Analysis Plans"* (EM 200-1-3, September 1994). The following provides a brief explanation of the two categories of sampling strategies, classical statistical sampling and non-statistical sampling.

4.3.1 Classical Statistical Sampling

4.3.1.1 Simple Random Sampling - This statistical approach is usually applied when minimal site background information is available and visible signs of contamination are not evident during the initial site survey. This strategy uses the theory of random chance probabilities to chose sampling locations. Each sample location is chosen independent of any previously chosen sample location.

4.3.1.2 Stratified Random Sampling - This statistical approach divides the site into several sampling areas, or strata, based on background or site survey information; each stratum is evaluated using a separate random sampling strategy. This sampling strategy is applicable to large sites characterized by a number of soil types, topographic features, past/present uses, or manufacturing/storage areas.

4.3.1.3 Systematic Grid Sampling - This strategy involves collecting samples at predetermined, regular intervals within a grid pattern. This strategy minimizes bias and provides complete site coverage, and can be used effectively at sites where no background information exists. This approach also ensures that samples will not be taken too close together.

4.3.1.4 Hot-spot Sampling - This strategy uses systematic grid sampling tailored to search for hot spots. Hot spots are defined as small localized areas of media that are characterized by high contaminant concentrations. This approach is used when background information or site survey data indicate that hot spots may exist.

4.3.1.5 Geostatistical Approach - In this strategy, representative sampling locations are chosen based on spatial variability of media. The resulting data are analyzed using kriging, which creates contour maps of the contaminant concentrations and the precision of concentration estimates. This approach takes into account spatial variability of media and is applicable to sites where presence of contamination is unknown.

4.3.2 Non-Statistical Sampling Strategies

4.3.2.1 Biased Sampling - Sampling locations are chosen based on available information. This approach is used when specific known contamination sources exist on-site.

4.3.2.2 Judgmental Sampling - This strategy is used when an individual subjectively selects sampling locations that appear to be representative of average conditions. This sampling is applied to homogeneous, well-defined sites.

4.4 SAMPLE COLLECTION

Unless otherwise stated, the order of sample collection for groundwater/surfacewater samples will be:

1. In-situ measurements.
2. Volatile organic compounds (VOCs).
3. Purgeable organic carbon (POC).
4. Purgeable organic halogens (POX).
5. Total organic halogens (TOX).
6. Total organic carbon (TOC).
7. Extractable organics.
8. Total metals.
9. Dissolved metals.
10. Phenols.
11. Cyanide.
12. Sulfate and chloride.
13. Turbidity.
14. Nitrate and ammonia.
15. Radionuclides.

Unless otherwise stated, the order of sample collection for soil/sediment samples will be:

1. In-situ measurements.
2. Volatile organic compounds (VOCs).
3. Purgeable organic carbon (POC).
4. Purgeable organic halogens (POX).
5. Total organic halogens (TOX).
6. Total organic carbon (TOC).
7. Extractable organics.
8. Total metals.
9. Phenols.
10. Cyanide.
11. Radionuclides.
12. Geotechnical parameters.

Samples will be immediately placed in a cooler and held at 4^0 C. Disposable gloves will be worn by the sampling personnel and changed between sampling points. The information presented in Section 5.2 shall be recorded in the field logbook at the time of sampling.

Sampling equipment will be decontaminated as discussed in Section 4.14. While performing any equipment decontamination, phthalate-free gloves will be worn in order to prevent phthalate contamination of the sampling equipment by interaction between the gloves and the organic solvent(s).

4.5 GEOPHYSICAL SAMPLING PROCEDURES

There are various geophysical techniques for the investigation of hazardous waste and groundwater pollution sites. If geophysical sampling procedures are used at Fort Drum, the QAPjP shall include a description of the procedures, the advantages and limitations to the technique chosen, the instrumentation, survey design, and data reduction and interpretation.

4.5.1 Ground Penetrating Radar (GPR)

4.5.1.1 Description

The GPR method uses a transmitter that emits pulses of high-frequency electromagnetic waves into the subsurface. The transmitter is either moved slowly across the ground surface or moved at fixed station intervals. The penetrating electromagnetic waves are scattered at changes in the complex dielectric permittivity, which is a property of the subsurface material dependent primarily upon the bulk density, clay content and water content of the subsurface. The electromagnetic energy is reflected back to the subsurface receiving antenna and is recorded as a function of time.

Attenuation and/or absorption of the transmitted electronic (radar) waves into the ground limit depth penetration of GPR.

The analog plot produced is analogous to a seismic reflection profile. The data are presented with the horizontal axis as distance units along the GPR traverse and the vertical axis as time units.

Under optimal conditions, GPR data can resolve changes in soil horizons, bedrock fractures, water-insoluble contaminants, geological features, and man-made buried objects.

4.6 SOIL GAS SAMPLING PROCEDURES

4.6.1 Soil Gas Surveys

4.6.1.1 Description

Subsurface contamination by volatile contaminants produces a concentration gradient in soil gas that decreases in a direction away from the major source or body of contamination.

For volatile organics in groundwater to be detected in the vadose zone, they must move upward from the saturated zone, through the capillary fringe, and into the area where the gas samples are obtained. Volatile organics evaporate out of the groundwater and into the vadose zone by molecular diffusion. The concentration of volatile organics in soil is a function of their concentration in the groundwater, aqueous solubility and vapor pressure.

4.6.1.2 Techniques

4.6.1.2.1 Passive Sorbent Samplers

This collector consists of activated charcoal chemically fused to the tip of a Curie-point ferromagnetic wire and inserted in a glass tube. The collector is then buried at a depth of 2 to 4 feet in an inverted position with the glass tube acting as a flux chamber for an optimal period of time determined by loading checks of replicate probes.

This type of collector provides an integrated sample that compensates for any short-term fluxes in soil gas concentrations.

Sample analysis is by thermal desorption onto a Gas Chromatograph.

4.6.1.2.2 Pipe Probes

This collector consists of a hollow tube to obtain a sample. The probes can be passively placed into a predrilled hole or driven to their desired depth.

The probe, designed with predrilled holes on the sealed leading end or open end, is inserted into the hole to allow soil gas entry. The annular space at the surface is then sealed with an inert impermeable material such as clay. Once sealed, the probe is evacuated and a sample withdrawn for analysis by GC.

4.7 GROUNDWATER SAMPLING PROCEDURES

4.7.1 Well Construction Procedures

Groundwater samples are collected in order to assess the chemical quality of an aquifer at a distinct vertical interval within the aquifer. Groundwater samples that represent the chemical quality of the target aquifer interval are obtained from properly constructed and developed monitoring wells. In addition, monitoring wells provide access to measure the potentiometric surface of the aquifer at a select interval, determined by the project-specific well design.

A variety of drilling methods and well construction techniques are used to ensure the proper installation and construction of monitoring wells. Based on site-specific conditions and the project-specific groundwater sampling rationale, wells can be constructed as overburden (unconsolidated soils) or openhole bedrock wells and range in well diameters, typically from two-inch to eight-inch diameters.

Overburden wells typically consist of the following design/construction elements:

- Slotted well screen in direct communication with the aquifer at a selected interval (depth and length of screen)
- Solid casing (well riser) extending from the top of the screen to the ground surface;
- Sand filter pack placed within the annular space between the screen and the borehole walls which extends three to five feet above the top of the well screen.
- Bentonite seal placed within the annular space three to five feet above the filter pack
- Grout mixture placed above the seal, surrounding the well riser, and extending upward to the surface.
- Protective steel casing seated approximately three feet below ground surface and two feet above ground completed at the surface with a concrete pad in such a way that surface water is prevented from entering the borehole or the well.

Bedrock wells are installed by drilling an oversized borehole through the overburden material setting a steel casing and advancing an open hole into competent bedrock to the intended monitoring depth. These wells typically consist of the following design/construction elements:

- Steel casing installed into an oversized borehole and seated into the bedrock (5-10 feet) to seal off the overburden.
- Cement-grout mixture placed in the annular space between the borehole and steel casing and allow setting for 24 hours.
- Nominal open hole drilled and advanced into the bedrock to the target monitoring depth.
- Steel casing should rise two feet above the ground surface and completed with a concrete pad, locking cap and weep hole, unless a flush mounted well is required.

Depending on site-specific conditions and design parameters, additional drilling and well installation/construction techniques may be required (e.g., double-cased wells for bedrock or confined unconsolidated aquifers, etc.), and should be detailed in the QAPjP. The placement and length of the well screen and/or openhole bedrock are dependent on the project-specific goals. However, the objective is to identify discrete aquifer intervals to be sampled, minimize the potential for stagnant or no-flow areas near the screen/openhole, and prevent unwanted backfill materials (i.e., bentonite, grout) from entering or passing through the interval to be screened and sampled. Packer sampling in bedrock wells may be required in certain instances and should be detailed in the QAPjP.

4.7.2 Well Development

Subsequent to drilling and installing a newly constructed monitoring well, and prior to obtaining physical and chemical parameters of the groundwater sample, adequate well development will be performed. Well development is necessary to mitigate the effects of the drilling process on the borehole walls and adjacent formation, and to improve or restore the original hydraulic conductivity of the aquifer. Well drilling fluids, muds and formation fines, cuttings, mobile particulates, and entrapped gases from within and adjacent to a newly installed well are removed during well development. Acceptable well development methods include mechanical surging, alternated with water extraction; pumping at a higher rate than what will be used during purging and sampling (overpumping), accompanied by occasional sediment removal; backwashing; bailing; and high-velocity hydraulic jetting. The appropriate well development method/procedure will be determined by the hydrologic and geologic characteristics of the aquifer, the drilling method(s) used, and the type of screen installed (e.g., slotted, continuously/wire-wound). The preferred well development method(s) will be detailed in the project-specific QAPjP.

Final well development will be initiated no sooner than 48 hours and no later than seven days after final grouting of the well. Preliminary development may be performed to eliminate any mudcake that may have formed on the borehole walls, but should be performed after the installation of the well screen and filter pack and prior to emplacement of the bentonite annular seal.

At a minimum, well development will continue until:

1. Three times the volume of fluids lost to the formation, or introduced into the well, during the drilling process is removed.
2. Three times the standing water volume in the completed well and filter pack (assuming 30% porosity) is removed. (A formula for determining the standing water volume is presented in Section 4.7.4.2 below.)
3. Federal, state and local regulatory requirements are satisfied. Some of these may specify that indicator parameters such as pH, temperature, specific conductance (conductivity), oxidation-reduction potential (ORP, or redox), turbidity and dissolved oxygen (DO) have stabilized. Generally, three successive readings should be within +/-0.2 units for pH, +/-1^{0}C for temperature, +/-3% for conductivity, +/-10 mV for redox potential, and +/-10% for turbidity and DO. Some regulators may require a specific criteria for turbidity, as measured in nephlometric turbidity units (NTUs); however, natural groundwater turbidity may not meet this criteria.
4. Sediment thickness remaining within the well is less than 1% of the screen length, or less than 0.1 feet for screens equal to or less than 10 feet long.

Wells installed in formations having a low hydraulic conductivity (slow recharging wells), and precluding the timely removal of the appropriate fluid volumes will be addressed on a project-specific basis. Well development should be completed at least 14 days prior to purging/sampling a monitoring well, to allow adequate time for the well and backfill materials to come to chemical equilibrium with the local aquifer. Should technical data or project-specific considerations indicate a change in this hiatus period, the change shall be evaluated and, upon approval, implemented.

4.7.3 Determination of Groundwater Level

Prior to purging and sampling a monitoring well, the standing water volume in the well and filter pack will be determined. To accomplish this, sampling personnel should have access to well construction data such as borehole diameter and depth; screen internal diameter, length and depth placement; and the length/thickness of the installed filter pack. A porosity of 30% will be assumed for the filter pack. A formula for determining the standing water volume is presented in Section 4.7.4.2 below. The height of the water column will be determined by measuring the depth to groundwater and to the bottom of the well, using an electronic water level probe, which has been properly decontaminated and confirmed to be operational. The depths will be measured to the nearest 0.01 feet from the highest point of the top of the well riser, inside the protective casing, typically referred to as the measuring point (M.P.). This point will be permanently marked to ensure that measurements are always taken from the same point, and should be surveyed for vertical control. The probe will be turned on and lowered into the well slowly until audible alarm sounds, indicating water. The measurement will be repeated for confirmation and recorded. The probe will then be tuned off, and lowered to the bottom of the well. The depth from the M.P. to the bottom of the well will be recorded, taking care to account for any portion of the probe between the electronic sensor and the bottom of the probe resting on the bottom of the well. Sounding the bottom of the well allows for the determination of the water column height, and of the amount of accumulated sediment since well development/previous sampling events.

4.7.4 Groundwater Sampling

4.7.4.1 Sampling Equipment

- Electric water level indicator
- Groundwater pump (e.g., submersible, centrifugal, peristaltic, pneumatic bladder pump)
- Polyethylene or nalgene tubing
- External power source (e.g., generator, portable battery); compressed air source for pneumatic pumps

- Bailer
- Teflon-coated leader
- Bailer cord
- Portable water quality meters (i.e., temperature, pH, dissolved oxygen, specific conductance, redox potential and turbidity)
- PID monitoring equipment
- Explosimeter
- Polyethylene sheeting, volume-incremented bucket, garbage bags, paper towels, field notebook
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.7.4.2 Purging and Sampling Procedures

1. A piece of polyethylene sheeting will be fitted over the monitoring well and laid on the ground. The sampling equipment will be placed on the polyethylene sheeting. The well cap will be removed, and the concentration of volatile organic vapors and explosive gases emanating from the well will be measured with the PID and Explosimeter**.** This step should be performed even if a well has previously been monitored and exhibited no or insignificant amounts of vapors or gases.

2. The well volume is calculated by combining the water volume in the well casing and the water volume in the filter pack. The well casing volume is calculated by using the following equation:

$$V = (L_2 - L_1)(C_c)$$

where: D = Casing Diameter (in.)
L_1 = Depth to Water (ft.)
L_2 = Depth of Well (ft.)
C_c = Casing Capacity

Casing Diameter	C_c (Gallons/Linear Ft.)
2 inch	0.1632
4 inch	0.6528
6 inch	1.4688
8 inch	2.6112
10 inch	4.080
12 inch	5.8752

Note: The volume of water in the filter pack should be calculated assuming a porosity of 30 percent within the filter pack. Take care to keep the units consistent in calculating the water volume; i.e., make sure the diameters and the lengths are all measured in feet (except where conversions to gallons per foot are already provided for casing/borehole diameters in inches).

3. The monitoring wells will be purged by conventional purging methods or by low-flow (also described as low-stress or minimal-drawdown) purging methods, according to the sampling rationale and strategy indicated in the QAPjP.

Conventional purging methods include purging by means of various groundwater pumps or a bailer. Since centrifugal and peristaltic pumps are limited to a maximum lift of approximately 25 feet, these pumps may only be used when the depth to water is less than 25 feet below ground surface.

During conventional purging, water quality field parameter measurements of temperature, pH, dissolved oxygen, and specific conductance will be taken prior to, after each well volume is evacuated, and immediately before sampling. Each well will be purged of a minimum of three well volumes of water; if field parameters have not stabilized after three volumes, purging will continue until stabilization is reached, or until a maximum of 10 well volumes have been removed.

Stabilization of field parameters is defined as three consecutive measurements within +/-0.1 unit for pH, +/- 1^0C for temperature, +/-3% for conductivity, +/-10 mV for redox potential, and +/-10% for turbidity and DO. All steps possible (adjustment to flow rates) will be taken to prevent the monitoring well from purging to dryness. When the field parameters have stabilized, the volume of water will be recorded, and, within two hours of purging, the well will be sampled.

In low-yielding wells with slow recovery rates, the removal of three volumes may not be practical. In this case, the well will be purged to near dryness once and allowed to recover sufficiently for sample collection. Field parameters will be measured prior to purging, after approximately one-half well volume is removed, when purging is completed, and again immediately prior to sample collection.

Low-flow purging methods serve to minimize drawdown in the well, and to minimize stress applied to the formation during pumping. Pneumatic bladder pumps are commonly employed; however, other types of groundwater pumps may be used if the pump has the capacity to operate at flow rates low enough to minimize drawdown**,** ideally 0.3 feet or less. Low-flow purging and sampling procedures and stabilization criteria are described in detail under 3g below.

If dense non-aqueous phase liquids (DNAPL) are present, as detected by the visual inspection on split-spoon samples during drilling or by previous sampling events, point source and double check valve bailers will be employed to collect samples. Stainless steel bailers will be used whenever product (DNAPL or LNAPL) or high concentrations of solvents are present.

4.7.4.2.1 Conventional Purging and Sampling Well with Submersible Pump - Sampling Procedures

1. The submersible pump will be constructed of stainless steel and new, dedicated polyethylene tubing will be attached to the decontaminated pump. Lower the pump to below the water level near the top of the water column and begin pumping. Collect or dispose of purged water in accordance with the QAPjP. Monitor the depth to water frequently and lower the pump as required to maintain submergence.
2. Measure rate of discharge and gallons purged frequently, avoid dewatering the well. A volume-incremented bucket and stopwatch may be used. Containerize or dispose of purge water according to the QAPjP.
3. Purge well until the pH, temperature, and specific conductance have stabilized; field parameters should be measured after each well volume is evacuated. The well should be allowed to recharge to within 10% of the initial or static water level before sampling. Water quality equilibrium criteria for conventional purging methods are described above.
4. The pump may be used to collect samples for metals analyses only: the pump discharge rate will be reduced to eliminate aeration of the groundwater and turbulent filling of the sample container. Sample containers will be prepared and appropriate labels affixed. Fill sample bottles by allowing pump discharge to flow gently down the side of the sample bottle with minimum entry disturbance. Cap each bottle as filled. Preserve the sample as

necessary and verify that the pH is sufficient for the criteria; place filled containers in iced cooler immediately. *Note: If samples are being collected for analytical parameters in addition to metals, the pump should be removed following purging and* ***all*** *sample volumes shall be collected by using a bailer as described below.*

5. A dedicated or decontaminated bailer constructed of stainless steel, Teflon or PVC bailer will be used to collect samples for all other analyses. A disposable polyethylene bailer may be used to sample if necessary (i.e., a dedicated or decontaminated bailer is not available). If a disposable bailer is used, it will first be rinsed with deionized or analyte-free water, and will be disposed of after each sampling event. A Teflon-coated leader will be attached to the bailer and to the bailer cord. The pump will be removed from the well and put aside for decontamination.

6. Sample containers will be prepared and appropriate labels affixed. Collect sample volumes, beginning with VOCs if applicable, with the bailer: the bailer will be gently lowered into the well, avoiding aeration of the well and water column, and slowly submerged to a level corresponding to the center of the screened portion of the well. The bailer cord will be pulled up slightly to set the check ball in the bailer. The bailer will be retrieved slowly and the sample transferred to the appropriate sample containers. Empty the bailer by tipping to allow slow discharge from top to flow gently down the side of the sample bottle with minimum entry disturbance. If a bottom drain is present on the bailer, it is recommended that a slow steady flow be achieved through the bottom drain. Repeat sample collection steps as needed to acquire sufficient volume to fill all sample containers. Preserve the sample as necessary and verify that the pH is appropriate for sample preservation criteria; place filled containers in iced cooler immediately. If field filtration is required, the sample will be transferred from the bailer into the sample containers via a disposable vacuum filter system. The unfiltered water will be drawn through a filter by the vacuum and accumulate in a receiving container. Upon completion of filtering each sample, the tubing and filter membrane will be disposed of.

4.7.4.2.2 Conventional Purging and Sampling Well with Centrifugal Pump - Sampling Procedures

1. Centrifugal pumps are used at ground surface with new, dedicated polyethylene tubing inserted into the well. The tubing should be fitted with a (new and decontaminated) check valve to avoid having aerated water fall back into the well. Lower the decontaminated intake hose into the well.

2. Prime pump with distilled water and begin purging. Measure rate of discharge and gallons purged frequently and avoid dewatering the well. A volume-incremented bucket and stopwatch may be used. Containerize or dispose of purge water according to the QAPjP.

3. Purge well until the pH, temperature, and specific conductance have stabilized; field parameters should be measured after each well volume is evacuated. The well should be allowed to recharge to within 10% of the initial or static water level before sampling. Water quality equilibrium criteria for conventional purging methods are described above.

4. Sample containers will be prepared and appropriate labels affixed. Collect sample volumes, beginning with VOCs if applicable, with the bailer: tip bailer to allow slow discharge from top to flow gently down the side of the sample bottle with minimum entry disturbance. If a bottom drain is present on the bailer, it is recommended that a slow steady flow be achieved through the bottom drain. Repeat sample collection steps as needed to acquire sufficient volume to fill all sample containers. Preserve the sample as necessary and verify that the pH is sufficient for the criteria; place filled containers in iced cooler immediately.

4.7.4.2.3 Conventional Purging and Sampling Well with hand pump - Sampling Procedures

1. Lower the decontaminated hand pump assembly into the well and begin operating the pump in a steady motion. Measure rate of discharge and gallons purged

frequently, avoid dewatering the well. A volume-incremented bucket and stopwatch may be used. Containerize or dispose of purge water according to the QAPjP.

2. Purge well until the pH, temperature, and specific conductance have stabilized; field parameters should be measured after each well volume is evacuated. The well should be allowed to recharge to within 10% of the initial or static water level before sampling. Water quality equilibrium criteria for conventional purging methods are described above.

3. Sample containers will be prepared and appropriate labels affixed. Collect sample volumes, beginning with VOCs if applicable, with the bailer: tilt bailer to allow slow discharge from top to flow gently down the side of the sample bottle with minimum entry disturbance. If a bottom drain is present on the bailer, it is recommended that a slow steady flow be achieved through the bottom drain. Repeat sample collection steps as needed to acquire sufficient volume to fill all sample containers. Preserve the samples as necessary and verify that the pH is sufficient for the criteria; place filled containers in iced cooler immediately.

4.7.4.2.4 Conventional Purging and Sampling Well with a Peristaltic Pump – Sampling Procedures

1. Install clean medical grade silicon tubing in the peristaltic pump head and attach the silicon tubing to the glass tubing outlet from the sample bottle.

2. Attach the inlet glass tubing from the sample bottle to the required length of the PTFE suction line and lower to the midpoint of the well screen, if known, or slightly below the existing water level.

3. Purge well until the pH, temperature, and specific conductances have stabilized; field parameters should be measured after each well volume is evacuated. The well should be allowed to recharge to within 10% of the initial or static water level before sampling. Water quality equilibrium criteria for conventional purging methods are described above.

4. Sample containers will be prepared and appropriate labels affixed. Collect sample volumes, beginning with VOCs if applicable, with the bailer: tilt bailer to allow slow

discharge from top to flow gently down the side of the sample bottle with minimum entry disturbance. If a bottom drain is present on the bailer, it is recommended that a slow steady flow be achieved through the bottom drain. Repeat sample collection steps as needed to acquire sufficient volume to fill all sample containers. Preserve the samples as necessary and verify that the pH is appropriate for sample preservation criteria; place filled containers in iced cooler immediately.

4.7.4.2.5 Conventional Purging and Sampling Well with Bailer - Sampling Procedures

1. A dedicated and decontaminated bailer constructed of stainless steel, Teflon, or PVC will be used. A Teflon-coated leader will be attached to the bailer and to the bailer cord. A disposable polyethylene bailer may be used to purge and sample if necessary (i.e., a dedicated and decontaminated bailer is not available) If a disposable bailer is used, it will first be rinsed with deionized or analyte-free water, and will be disposed of after each sampling event.
2. The bailer will be gently lowered into the well, avoiding aeration of the well and water column, and slowly submerged to a level corresponding to the center of the screened portion of the well. The bailer cord will be pulled up slightly to set the check ball in the bailer.
3. Slowly raise bailer to surface. Do not allow bailer line or bailer to contact ground.
4. The bailer will be retrieved slowly and emptied into a bucket with known volume. The volume of water purged will be measured and water quality parameters will be measured after each well volume.
5. Purge well until the pH, temperature, and specific conductances have stabilized. The well should be allowed to recharge to within 10% of the initial or static water level before sampling. Water quality equilibrium criteria for conventional purging methods are described above.
6. Sample containers will be prepared and appropriate labels affixed. Collect sample volumes, beginning with VOCs if applicable, with the bailer: tilt bailer to allow slow

discharge from top to flow gently down the side of the sample bottle with minimum entry disturbance. If a bottom drain is present on the bailer, it is recommended that a slow steady flow be achieved through the bottom drain. Repeat sample collection steps as needed to acquire sufficient volume to fill all sample containers. Preserve the sample as necessary and verify that the pH is appropriate for sample preservation criteria; place filled containers in iced cooler immediately.

4.7.4.2.6 Air Lift Pump

Sampling Procedures

These sampling procedures are usually used for developing or purging recovery wells and are not recommended for sampling monitoring wells. If this technique is required, a complete description will be detailed in the QAPjP.

4.7.4.2.7 Low-Flow Purging and Sampling

Sampling Procedures

Low-flow purging and sampling is accomplished by purging the well at a low flow rate and by pumping from the mid-point of the screened interval. Low flow rates minimize drawdown in the well, and pumping from the mid-point of the screen minimizes the mixing between the overlying stagnant water and particulate matter on the bottom of the well with the water present within the screened interval. In addition, low-flow sampling minimizes aeration of the groundwater during purging and sampling; and significantly reduces the amount of purged groundwater which has the potential to be associated with significant costs for proper treatment and disposal. An EPA Region II document (Groundwater Sampling Procedure Low Stress (Low Flow) Purging and Sampling, March 1998) will be used as a guidance document during groundwater purging and sampling and is included in Appendix B.

Stainless steel or PVC pneumatic bladder pumps are commonly used for low-flow purging and sampling; however, additional types of groundwater pumps may be used provided the pump is capable of operating at flow rates low enough to maintain minimal drawdown. Typical flow rates used range from 100 to 500 milliliters per minute (ml/min);

however, the decisive criterion is the drawdown, which is directly affected by the site-specific hydrogeology as well as the flow rate. Low-flow procedures may be performed successfully at higher flow rates depending on the hydrogeology of the formation. The suggested goal for minimal drawdown is less than 0.3 feet.

Pumps used to purge and sample wells will be dedicated and decontaminated, and will be and fitted with polyethylene tubing (dedicated or disposable) used for the compressed air supply line and for the water discharge line. Pumps that are not dedicated will be decontaminated prior to being installed in each well according to the procedures outlined in Section 4.15. Bailers are inappropriate devices for low-flow sampling.

4.7.4.3 Field Observations

Data to be recorded in the field logbook will include the information presented in Section 5.2; purging and sampling methods; depth to water; volume of water removed during purging; all field parameters, PID, and Explosimeter readings shall be recorded in the field logbook.

4.7.5 Hydropunch Sampling

4.7.5.1 Sampling Equipment

- Drill rig
- Hydropunch sampler
- Electronic water level indicator
- pH, dissolved oxygen, temperature, and specific conductivity meters
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.7.5.2 Sampling Procedure

1. The Hydropunch will be connected to conventional drill rods via a subassembly and driven/pushed into the undisturbed soils below the augers, in a similar manner as a split-spoon sampler. As the unit is pushed through the soils, the sample intake is shielded from the formation in a watertight housing, preventing contamination from entering the sample chamber.

2. Once the unit has been driven approximately 12 to 18 inches into the undisturbed soils, the shield and rods are raised to expose the sample intake to the formation. The groundwater then flows under hydrostatic pressure through the stainless steel screen into the Teflon sample chamber.

3. As the unit is brought to the surface, care must be taken to maintain the unit in a vertical position, so as not to allow the water to drain.

4. When at the surface, the sample is removed from the chamber via a Teflon discharge tube and placed into the appropriate pre-cleaned laboratory-supplied sample jars.

5. The two 40 ml vials for VOC organic analysis will be filled first, leaving no head space or air bubbles. All other sample bottles will be filled such that some head space remains in the bottle.

Water Table Sample Collection Procedure

If a water table sample is being collected, the Hydropunch sampler will be used in the Hydropunch II "hydrocarbon mode." This is basically the Hydropunch with the inner sample chamber and check balls removed. The screened interval of the Hydropunch will be placed straddling the water table and a one-inch bailer will be lowered to the water table and a sample collected.

4.8 SOIL SAMPLING PROCEDURES

4.8.1 Spade and scoop

4.8.1.1 Sampling Equipment

- Stainless steel spade or stainless steel scoop
- Roll of polyethylene sheeting
- Stainless steel bowl
- Stainless steel spoon
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.8.1.2 Sampling Procedures

1. Prepare the work area outside the well by placing polyethylene sheeting around the sampling location to avoid cross-contamination.

2. Remove the top layer of soil to the desired depth with a precleaned or decontaminated spade.

3. Using a precleaned or decontaminated stainless steel scoop or trowel, collect the sample aliquot for VOCs analysis first, then homogenize enough soil in a stainless steel bowl for the remaining sample containers.

4. Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.

5. Verify that a PTFE liner is present in cap and secure the cap tightly.

6. Label the sample bottle with the appropriate label.

7. Place filled containers on ice immediately.

Soil Sample Homogenization

1. Remove the soil from the sampling device and place it in a stainless steel bowl.

2. Remove rocks, twigs, leaves and other debris if they are not considered part of the sample.

3. Thoroughly mix the sample using a stainless steel spoon. The material in the pan should be scraped from the sides and bottom of the pan, rolled to the middle of the pan and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually and then rolled to the center of the container and the entire sample mixed again.

4. Transfer the sample to the appropriate sample containers.

4.8.1.3 Field Observations

At each sampling location, the information presented in Section 5.2, a soil description and the PID readings will be recorded in the field logbook.

4.8.2 Hand Auger and Tube Sampler

4.8.2.1 Sampling Equipment

- Stainless steel hand auger and stainless steel tube sampler
- Roll of polyethylene sheeting
- Stainless steel bowl
- Stainless steel spoon
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.8.2.2 Sampling Procedures

1. Prepare the work area outside the well by placing polyethylene sheeting on the ground to avoid cross-contamination.

2. Attach the auger bit to a drill rod extension and attach the T handle to the drill rod.

3. Clear the area to be sampled of any surface debris. It may be advisable to remove the first 8 to 15 cm of surface soil for an area approximately 15 cm in radius around the drilling location.

4. Begin drilling and periodically remove accumulated sediment. This prevents accidentally brushing loose material into the borehole when removing the auger or adding drill rods.

5. After reaching the desired depth, slowly and carefully remove the auger from boring.

6. Remove auger tip from drill rods and replace with precleaned or decontaminated thin-walled tube sampler. Install proper cutting tip.

7. Carefully lower corer down borehole. Gradually force corer into sediment. Avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring because vibrations may cause the boring wall to collapse.

8. Remove corer by twisting to prevent losing core, and unscrew drill rods.

9. Remove cutting tip and remove core from device.

10. Discard top of core (2.5 cm), which represents any material collected by the corer before penetration of the layer in question. Place remaining core into VOC sample container or stainless steel bowl for homogenization. (Note: VOC samples are not homogenized, and should be collected prior to that procedure.)

11. Verify that a PTFE liner is present in cap and secure the cap tightly.

12. Label the sample bottle with the appropriate label.

13. Place filled containers on ice immediately.

Soil Sample Homogenization

1. Remove the soil from the sampling device and place it in a stainless steel bowl.

2. Remove rocks, twigs, leaves and other debris if they are not considered part of the sample.

3. Thoroughly mix the sample using a stainless steel spoon. The material in the pan should be scraped from the sides and bottom of the pan, rolled to the middle of the pan and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually and then rolled to the center of the container and the entire sample mixed again.

4. Transfer the sample to the appropriate sample containers.

4.8.2.3 <u>Field Observations</u>

At each sampling location, the information presented in Section 5.2, a soil description and the PID readings will be recorded in the field logbook.

4.8.3 Ring-Lined Barrel Sampler

4.8.3.1 <u>Sampling Equipment</u>

- Ring - lined barrel sampler
- Roll of polyethylene sheeting
- Stainless steel bowl
- Stainless steel spoon
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.8.3.2 <u>Sampling Procedures</u>

1. Prepare the work area outside the well by placing polyethylene sheeting on the ground to avoid cross-contamination.

2. Assemble the sampler by placing eight 3-inch-long rings in the 2-foot-long sampler. Align both sides of the barrel and screw the drive shoe on the bottom and the heavier headpiece on top.

3. Place the sampler in a perpendicular position on the material to be sampled.

4. Drive the tube utilizing a sledge hammer or drill rig if available. Do not drive past the bottom of the headpiece because this will result in compression of the sample.

5. Record the length of the tube that penetrated the material being sampled and the number of blows during each 6-inch increment.

6. Withdraw the sampler and open it by unscrewing the drive shoe and head and the splitting barrel. Remove the sampling rings. Trim the soil at the end of the rings so that it is flush with the endings. For chemical samples, cap the end of the rings with a PTFE-lined plastic cap. For Geotechnical samples, a plastic cap is suitable. Seal each cap with plastic electrical tape.

7. Label the sample ring with the appropriate label. Complete the label by including all parameters requested.

8. Place sealed rings on ice immediately.

4.8.3.3 Field Observations

At each sampling location, the information presented in Section 5.2, a soil description and the PID readings will be recorded in the field log book.

4.8.4 Thin-Walled (Shelby) Tube Sampler

4.8.4.1 Sampling Equipment

- Shelby tube sampler
- Roll of polyethylene sheeting
- Stainless steel bowl
- Stainless steel spoon
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.8.4.2 Sampling Procedures

1. Prepare the work area outside the well by placing polyethylene sheeting on the ground to avoid cross-contamination.

2. Place the sampler in a perpendicular position on the material to be sampled.

3. Push the tube into the soil by a continuous and rapid motion, without impact or twisting. In no instance should the tube be pushed further than the length provided for the soil sample.

4. When the soil is so hard that a pushing motion will not penetrate the sample sufficiently for recovery, it may be necessary to collect a disturbed sample with the split-spoon sampler.

5. Before pulling out the tube, rotate the tube at least two revolutions to shear off the sample at the bottom. For Geotechnical analysis, fill any void spaces remaining at the top of the tube with inert packing material to maintain the soil compaction and moisture content; seal the ends of the tube with wax or rubber packers to preserve the moisture content. For chemical analysis, seal the ends of the tube with PTFE-lined plastic caps. Seal each end cap with plastic electrical tape.

6. Label the sample tube with the appropriate label. Complete the label by including all parameters requested.

7. Place sealed rings on ice immediately.

4.8.4.3 Field Observations

At each sampling location, the information presented in Section 5.2, a soil description and the PID readings will be recorded in the field log book.

4.8.5 Central Mine Equipment (CME) sampler

4.8.5.1 Sampling Equipment

- CME sampler
- Roll of polyethylene sheeting
- Stainless steel bowl
- Stainless steel spoon
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.8.5.2 Sampling Procedures

1. Prepare the work area outside the well by placing polyethylene sheeting on the ground to avoid cross-contamination.

2. Assemble the sampler by aligning both sides of the barrel and then screwing the device shoe on the bottom and the heavier headpiece on top.

3. Attach the sampler and the drill rod extension and place the sampler inside the lead auger bit.

4. Drive the sampler and lead auger bit utilizing a well rig.

5. Withdraw the sampler and open it by unscrewing the drive shoe and head and the splitting barrel. For chemical samples, a decontaminated stainless steel knife should be utilized to divide the tube contents in half longitudinally.

6. Transfer the sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.

7. Secure the cap tightly.

8. Label sample container and place field sample containers on ice immediately.

4.8.5.3 Field Observations

At each sampling location, the information presented in Section 5.2, a soil description and the PID readings will be recorded in the field log book.

4.8.6 Core Barrel

4.8.6.1 Sampling Equipment

- Stainless steel hand auger or stainless steel scoop
- Roll of polyethylene sheeting
- Stainless steel bowl
- Stainless steel spoon
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.8.6.2 Sampling Procedures

1. Place the core barrel into position with the bit touching the ground or the surface to be cored.

2. Continue core drilling until core blockage occurs or until the net length of the core barrel has been drilled.

3. Remove the core barrel from the hole and disassemble it as necessary to remove the core.

4. Place the recovered core in a core box in accordance with ER 1110-1-1802, and ER 1110-1-1803. The core is placed in the core box with the upper end of the core at the upper left corner of the core box. Cores should be placed in the core box from left to right and top to bottom, within longitudinal separators. Space blocks or plugs should be placed at the beginning of each core run. Core boxes should be marked on the outside to indicate the top and bottom, and the inside upper left corner of the box should be permanently marked with the letters UL to indicate the upper left corner. Soft or friable cores should be wrapped in plastic film or sealed in wax.

4.8.6.3 Field Observations

At each sampling location, the information presented in Section 5.2, a soil description and the PID readings will be recorded in the field log book.

4.8.7 Cone Penetrometer Rigs

4.8.7.1 Sampling Equipment

- Stainless steel hand auger or stainless steel scoop
- Roll of polyethylene sheeting
- Stainless steel bowl
- Stainless steel spoon
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.8.7.2 Sampling Procedures

1. Assemble decontaminated cone Penetrometer device that will be pushed into the ground to collect data or samples.

2. Push the data collection tip to the desired depth and record the data on the onboard computer. For the soil sampler, advance the sampler to the top of the interval to be sampled, release the tip, and advance the sampler to collect the soil sample.

3. While removing the data collection tip, backfill the hole with grout by pumping grout through the tip as it is retracted. Following removal of the soil sample, backfill the hole with grout using the tremie method or by pouring the grout into the hole from the ground surface.

4. Remove the liner from the soil sampler and begin sampling with the acquisition of any VOC samples, conducting the sampling with as little disturbance as possible to the media. (Note: VOC samples are not homogenized, and should be collected prior to that procedure.)

5. If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowel for mixing.

6. Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.

7. Verify that a PTFE liner is present in cap and secure the cap tightly.

8. Label the sample bottle with the appropriate label.

9. Place filled containers on ice immediately.

Soil Sample Homogenization

1. Remove the soil from the sampling device and place it in a stainless steel bowl.

2. Remove rocks, twigs, leaves and other debris if they are not considered part of the sample.

3. Thoroughly mix the sample using a stainless steel spoon. The material in the pan should be scraped from the sides and bottom of the pan, rolled to the middle of the pan and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually and then rolled to the center of the container and the entire sample mixed again.

4. Transfer the sample to the appropriate sample containers.

4.8.7.3 Field Observations

At each sampling location, the information presented in Section 5.2, a soil description and the PID readings will be recorded in the field log book.

4.8.8 Piston Sampler

4.8.8.1 Sampling Equipment

- Stainless steel hand auger or stainless steel scoop
- Roll of polyethylene sheeting
- Stainless steel bowl
- Stainless steel spoon
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.8.8.2 Sampling Procedures

1. Assemble decontaminated piston sampler and attach to rods that will lower the sampler down the borehole.

2. Lower sampler to the desired depth. Advance the sampler into the soil while actuating the piston to create a vacuum within the sample barrel.

3. Carefully remove the piston sampler from the bore hole.

4. Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as possible to the media. (Note: VOC samples are not homogenized, and should be collected prior to that procedure.)

5. If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowel for mixing.

6. Verify that a PTFE liner is present in cap and secure the cap tightly.

7. Label the sample bottle with the appropriate label.

8. Place filled containers on ice immediately.

Soil Sample Homogenization

1. Remove the soil from the sampling device and place it in a stainless steel bowl.

2. Remove rocks, twigs, leaves and other debris if they are not considered part of the sample.

3. Thoroughly mix the sample using a stainless steel spoon. The material in the pan should be scraped from the sides and bottom of the pan, rolled to the middle of the pan and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually and then rolled to the center of the container and the entire sample mixed again.

4. Transfer the sample to the appropriate sample containers.

4.8.8.3 Field Observations

At each sampling location, the information presented in Section 5.2, a soil description and the PID readings will be recorded in the field log book.

4.8.9 Split-Spoon Soil Sampling

4.8.9.1 Sampling Equipment

- PID monitoring equipment
- Drill rig
- Roll of polyethylene sheeting
- Stainless steel spatula or spoon
- Stainless steel bowl
- Aluminum foil
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.8.9.2 Sampling Procedures

1. Split-spoon soil samples will be collected from soil borings drilled using stainless steel split-spoons by ASTM Standard D 1586-84.

2. After a sample is collected, the split-spoon sampling tool will be opened and laid on a piece of clean polyethylene sheeting, and the soil cut along its length into two equal halves.

3. The contents of the split-spoon will be screened with a PID immediately upon opening; headspace samples, if required will be collected immediately and stored in an airtight container, and will be measured with a PID after the samples have been warmed at least room temperature (70.0^{0}F).

4. Soil samples will be removed from the central, least disturbed portion of soil contained within the sampler using a stainless steel spatula or spoon.

5. Soil samples for VOC organic analysis will be immediately packed tightly into two 4 ounce Clear Wide Mouth glass jars, placed in a cooler at 4 C and held for laboratory analysis.

6. Prior to homogenizing the remaining sample volume, a representative sample will be transferred to glass jars, which will be labeled with the site name, date, and boring and sample identification number. The jars will be sealed with aluminum foil, capped and allowed to stand for one-half hour in order to allow time for any gases to accumulate in the jar head space. One-half hour after the soil sample has been collected, the head space in the jar will be monitored using the PID by inserting the probe through the foil covering.

7. The remaining soil will be homogenized and placed in the appropriate jars for analysis.

8. Soils will be visually classified according to the Unified Soils Classification System.

4.8.9.3 Field Observations

Data to be recorded in the field log will include the information contained in Section 5.2, method of drilling and sample acquisition, blow counts, soil description and PID readings. Additionally, borings will be logged on standard USACE borehole logs in accordance with USACE protocols.

4.8.10 Screened Auger Sampling

4.8.10.1 Sampling Equipment

- Drilling rig
- Generator
- Air compressor
- Packer and pump assembly
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.8.10.2 Sampling Procedures

1. A screened lead auger approximately 5-feet in length with 0.007 inch slots, or similar, will be used. The boring will be advanced in accordance with ASTM D 1586-84, collecting continuous soil samples. Upon reaching the desired depth of groundwater sampling, the drilling rods will be removed and a bladder pump and double packer system attached to a discharge hose will be lowered into the augers.

2. Once the pump and packers have been lowered into the augers and are placed approximately 0.5 to 1.0 feet from the bottom of the augers, the packers will be inflated, isolating the pump in the screened auger section. If the air compressor is oil lubricated, an air filter should be used as a precautionary device to prevent contamination in case of packer rupture. Extreme care will be taken to ensure that the tubing, packers and pump do not leak air into the sampling interval. This will be done by regular inspection of the assembly and checking for any loose fittings.

3. The pump will then be activated and the flow regulated to a maximum of 2 gallons per minute for purging of the sample zone. A lower flow rate, approximately 100 ml/min, will be used for sample collection. A low flow rate is desirable so as to induce only horizontal flow and reduce vertical mixing of the groundwater.

4. The screened auger section will be purged for a total of approximately 5 volumes of water and will be sampled within two hours of evacuating, if the augers have recharged approximately 75 percent of the pre-purging level.

5. All samples will be collected from the Teflon discharge hose of the pump. The two 4 ounce Clear Wide Mouth glass jars for VOC organic analysis will be filled first, leaving no head space or air bubbles. All other sample bottles will be filled such that some headspace remains in the bottle.

4.8.10.3 Field Observations

Data to be recorded in the field logbook will include the information presented in Section 5.2; purging and sampling methods; depth to water; volume of water removed during purging; pH, dissolved oxygen, temperature and specific conductivity values.

4.8.11 Direct Push Soil Sampling

4.8.11.1 Sampling Equipment

- Piston-type Sampler
- Stainless steel bowls
- Stainless steel spatula or spoons
- Roll of polyethylene sheeting or aluminum foil
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.8.11.2 Sampling Procedures

Soil samples will be collected by hydraulically driving a piston-type sampler to the top of the desired sample interval (conditions permitting). The pipe is withdrawn and the piston tip soil sampler is attached with a liner to the probe rods. The sampler is then advanced to just above the target interval, coupled three foot stainless steel rods are inserted though the pipe and the piston pin is removed by turning the rod clockwise. The sample is then advanced through the target interval. The soil core will enter the sampler, which contains a new non-reactive plastic or stainless steel liner. After the drive rod is removed from the soil, the piston tip sampler is unscrewed from the probe rods and the liner containing the soil column can be removed. The liner may be capped at the ends or the soil may be extruded into sample containers. If a plastic liner is used, it may be opened longitudinally to expose the soil.

4.8.11.3 Field Observations

The information presented in Section 5.2, PID readings, a description of the soil, and any evidence of refusal shall be recorded in the field logbook.

4.9 SURFACE AND SUBSURFACE SEDIMENT/SHALLOW WATER SAMPLING PROCEDURES

4.9.1 Surface Sediment/Shallow Water Sampling - Scoop or Trowel

4.9.1.1 Sampling Equipment

- Stainless steel hand auger or stainless steel scoop
- Roll of polyethylene sheeting
- Stainless steel bowl
- Stainless steel spoon
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.9.1.2 Sampling Procedures

1. Prepare the work area by placing polyethylene sheeting on the ground to avoid cross-contamination.

2. Sketch the sample area or note recognizable features for future reference.

3. Insert scoop or trowel into material and remove sample. In the case of sludges exposed to air, remove the first 1-2 cm of material prior to collecting the sample.

4. Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media. The VOC organic samples will be collected directly from the sampling device, with no homogenization, tightly packed into two 4 ounce Clear Wide Mouth VOC jars, avoiding air spaces, and immediately stored

at 4^oC. (Note: VOC samples are not homogenized, and should be collected prior to that procedure.)

5. If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowel for mixing.

6. Each of the sample locations will be screened using a PID and the results recorded.

7. Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.

8. Verify that a PTFE liner is present in cap and secure the cap tightly.

9. Label the sample bottle with the appropriate label.

10. Place filled containers on ice immediately.

Soil Sample Homogenization

1. Remove the soil from the sampling device and place it in a stainless steel bowl.

2. Remove rocks, twigs, leaves and other debris if they are not considered part of the sample.

3. Thoroughly mix the sample using a stainless steel spoon. The material in the pan should be scraped from the sides and bottom of the pan, rolled to the middle of the pan and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually and then rolled to the center of the container and the entire sample mixed again.

4. Transfer the sample to the appropriate sample containers.

4.9.1.3 Field Observations

At each sampling location, the information presented in Section 5.2, a soil description and the PID readings will be recorded in the field log book.

4.9.2 Surface Sediment/Shallow Water Sampling - Tube Sampler

4.9.2.1 Sampling Equipment

- Stainless steel hand auger or stainless steel scoop
- Roll of polyethylene sheeting
- Stainless steel bowl
- Stainless steel spoon
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.9.2.2 Sampling Procedures

1. Prepare the work area outside the well by placing polyethylene sheeting on the ground to avoid cross-contamination.

2. Clear the area to be sampled of any surface debris such as twigs, rocks, and litter.

3. Gradually force corer into sediment.

4. Remove corer.

5. Remove sediment core from corer and place core on a clean working surface.

6. Discard top of core if any organic material is present.

7. Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media. The VOC organic samples will be collected directly from the sampling device, with no homogenization, tightly packed into two 4 ounce Clear Wide Mouth VOC jars, avoiding air spaces, and immediately stored at 4^{o}C. (Note: VOC samples are not homogenized, and should be collected prior to that procedure.)

8. If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowel for mixing.

9. Repeat sample collection steps to obtain sufficient sample volume.

10. Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.

11. Verify that a PTFE liner is present in cap and secure the cap tightly.

12. Label the sample bottle with the appropriate label.

13. Place filled containers on ice immediately.

Soil Sample Homogenization

1. Remove the soil from the sampling device and place it in a stainless steel bowl.

2. Remove rocks, twigs, leaves and other debris if they are not considered part of the sample.

3. Thoroughly mix the sample using a stainless steel spoon. The material in the pan should be scraped from the sides and bottom of the pan, rolled to the middle of the pan and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually and then rolled to the center of the container and the entire sample mixed again.

4. Transfer the sample to the appropriate sample containers.

4.9.2.3 Field Observations

At each sampling location, the information presented in Section 5.2, a soil description and the PID readings will be recorded in the field log book.

4.9.3 Subsurface Sediment/Shallow Water Sampling - Hand Auger and Tube Sampler

4.9.3.1 Sampling Equipment

- Stainless steel hand auger or stainless steel scoop
- Roll of polyethylene sheeting
- Stainless steel bowl
- Stainless steel spoon
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.9.3.2 Sampling Procedures

1. Prepare the work area by placing polyethylene sheeting on the ground to avoid cross-contamination.

2. Attach the auger bit to a drill rod extension and attach the T handle to the drill rod.

3. Clear the area to be sampled of any surface debris.

4. Begin drilling and periodically remove accumulated sediment. This prevents accidentally brushing loose material into the borehole when removing the auger or adding drill rods.

5. After reaching the desired depth, slowly and carefully remove the auger from boring.

6. Remove auger tip from drill rods and replace with precleaned or decontaminated thin-walled tube sampler. Install proper cutting tip.

7. Carefully lower corer down borehole. Gradually force corer into sediment. Avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring because vibrations may cause the boring wall to collapse.

8. Remove corer and unscrew drill rods.

9. Remove cutting tip and remove core from device.

10. Discard top of core (2.5 cm), which represents any material collected by the corer before penetration of the layer in question.

11. Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media. The VOC organic samples will be collected directly from the sampling device, with no homogenization, tightly packed into two 4 ounce Clear Wide Mouth VOC jars, avoiding air spaces, and immediately stored at 4^{o}C. (Note: VOC samples are not homogenized, and should be collected prior to that procedure.)

12. If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowel for mixing.

13. Repeat sample collection steps to obtain sufficient sample volume.

14. Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.

15. Verify that a PTFE liner is present in cap and secure the cap tightly.

16. Label the sample bottle with the appropriate label.

17. Place filled containers on ice immediately.

Soil Sample Homogenization

1. Remove the soil from the sampling device and place it in a stainless steel bowl.

2. Remove rocks, twigs, leaves and other debris if they are not considered part of the sample.

3. Thoroughly mix the sample using a stainless steel spoon. The material in the pan should be scraped from the sides and bottom of the pan, rolled to the middle of the pan and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually and then rolled to the center of the container and the entire sample mixed again.

4. Transfer the sample to the appropriate sample containers.

4.9.3.3 Field Observations

At each sampling location, the information presented in Section 5.2, a soil description and the PID readings will be recorded in the field log book.

4.9.4 Subsurface Sediment/Shallow Water Sampling - Hand Driven Split Spoon Sampler

4.9.4.1 Sampling Equipment

- Stainless steel hand auger or stainless steel scoop
- Roll of polyethylene sheeting
- Stainless steel bowl
- Stainless steel spoon
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.9.4.2 Sampling Procedures

1. Prepare the work area outside the well by placing polyethylene sheeting on the ground to avoid cross-contamination.

2. Assemble the sampler by aligning both sides of barrel and then screwing the drive shoe on the bottom and the heavier head piece on top.

3. Place the sampler in a perpendicular position on the material to be sampled.

4. Drive the tube utilizing a sledge hammer. Do not drive past the bottom of the head piece as this will result in compression of the sample.

5. Record the length of the tube that penetrated the material being sampled and the number of blows required to obtain this depth.

6. Withdraw the sampler and open by unscrewing drive shoe and head and splitting barrel. If split samples are desired, a decontaminated stainless steel knife should be utilized to split the tube contents in half longitudinally.

7. Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media. The VOC organic samples will be collected directly from the sampling device, with no homogenization, tightly packed into two 4 ounce Clear Wide Mouth VOC jars, avoiding air spaces, and immediately stored at 4^{o}C. (Note: VOC samples are not homogenized, and should be collected prior to that procedure.)

8. If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowel for mixing.

9. Repeat sample collection steps to obtain sufficient sample volume.

10. Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.

11. Verify that a PTFE liner is present in cap and secure the cap tightly.

12. Label the sample bottle with the appropriate label.

13. Place filled containers on ice immediately.

Soil Sample Homogenization

1. Remove the soil from the sampling device and place it in a stainless steel bowl.

2. Remove rocks, twigs, leaves and other debris if they are not considered part of the sample.

3. Thoroughly mix the sample using a stainless steel spoon. The material in the pan should be scraped from the sides and bottom of the pan, rolled to the middle of the pan and initially mixed. The sample should then be quartered and moved to the four corners of the

pan. Each quarter of the sample should be mixed individually and then rolled to the center of the container and the entire sample mixed again.

4. Transfer the sample to the appropriate sample containers.

4.9.4.3 Field Observations

At each sampling location, the information presented in Section 5.2, a soil description and the PID readings will be recorded in the field log book.

Surface sediments/deep water sample collection devices and procedures such as Ponar sampler, Ekman sampler, Smith-Mcintyre sampler, silver bullet sampler, and Vibratory coring devices are not expected to be used based on site conditions at Fort Drum. If these types of deep water collection devices are required, they will be defined in the FSP.

4.9.5 Test Pit Sampling

4.9.5.1 Sampling Equipment

- PID monitoring equipment
- Stainless steel spoon or spatula
- Shovel
- Roll of polyethylene sheeting
- Stainless steel bowl
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.9.5.2 Sampling Procedure

1. The test pits will be excavated by removing the soils in six-inch lifts, moving the bucket at a rate of less than one foot per second.

2. Each bucket removed from the test pit will be screened using a PID and the concentration noted in the field logbook and test pit log.

3. Samples for analysis will be selected based on elevated PID readings and visual observation of stained materials.

4. Excavated soil will be placed on a previously prepared polyethylene-lined area adjacent to the excavation. Prior to returning the soil to the excavation, the test pit shall be

lined with a sheet of polyethylene with holes cut randomly across its length and width in order to mark the limits of excavation.

Soil Sample Collection Procedure

1. A decontaminated shovel will be used to dig a hole approximately six inches to one foot into the soils while the soils are still in the bucket. The purpose of this hole is to allow for the collection of a fresh sample that has not been in contact with the bucket.

2. A stainless steel spoon or spatula will then be used to remove the exposed soil and place it in sample jars.

3. VOC organic samples will be placed directly into two 4 ounce Clear Wide Mouth VOC jars without homogenization. The VOC organic samples should be packed tightly into the sample containers, leaving no air spaces, and immediately placed in a cooler and held at 4^oC.

4. Prior to placement of other samples into jars, the soil will be homogenized as previously.

4.9.5.3 Field Observations

An entry will be made in the field log book for each sample collected. The information will include the information presented in Section 5.2; the approximate depth and location of sample, PID readings, type of waste encountered and visual evidence of contamination.

4.10 SURFACE WATER SAMPLING PROCEDURES

4.10.1 Hand-Held Bottle Sampling

4.10.1.1 Sampling Equipment

- PID monitoring equipment
- Appropriate Bottles
- Roll of polyethylene sheeting
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.10.1.2 Sampling Procedures

1. Spread new polyethylene sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.

2. Submerge the sample container with the cap in place with minimal surface disturbance so that the open end is pointing upstream.

3. Allow the device to fill slowly and continuously using the cap to regulate the speed of water entering the bottle.

4. Retrieve the sample container from the surface water with minimal disturbance..

5. Verify that a PTFE liner is present in the cap and secure the cap tightly.

6. Label the sample bottle with the appropriate sample label, and place on ice immediately.

4.10.1.3 Field Observations

An entry will be made in the field log book for each sample collected. The information will include the information presented in Section 5.2; the approximate depth and location of sample, PID readings, type of waste encountered and visual evidence of contamination.

4.10.2 Dippers and Pond Samplers

4.10.2.1 Sampling Equipment

- PID monitoring equipment
- Appropriate Bottles
- Roll of polyethylene sheeting
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.10.2.2 Sampling Procedures

1. Spread new polyethylene sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.

2. Assemble the dipper or pond sampler. Make sure that the sample container and the bolts and nuts that secure the clamp to the pole are tightened.

3. Collect samples by slowly submerging the precleaned dipper or pond sampler with minimal surface disturbance. Make sure the open end is pointed upstream.

4. Retrieve the dipper or pond sampler from the surface water with minimal disturbance.

5. Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the dipper/samples edge.

6. Empty the sampler slowly, allowing the sample stream to flow gently down the side of the bottle with minimal entry turbulence.

7. Continue delivery of the sample until the bottle is filled.

8. Preserve the sample as necessary and verify that the pH is sufficient for the criteria.

9. Check that the PTFE liner is present in the cap and secure the cap tightly.

10. Label the sample bottle with the appropriate sample label, and place on ice immediately.

4.10.2.3 Field Observations

An entry will be made in the field logbook for each sample collected. The information will include the information presented in Section 5.2, the approximate depth and location of sample, PID readings, type of waste encountered and visual evidence of contamination.

4.10.3 Peristaltic Pump

4.10.3.1 Sampling Equipment

- PID monitoring equipment
- Appropriate Bottles
- Roll of polyethylene sheeting
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.10.3.2 Sampling Procedures

1. Spread new polyethylene sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.

2. Install clean medical-grade silicone tubing in the pump head (as instructed by the manufacturer). Attach the silicon tubing to the glass tubing outlet from the sample bottle.

3. Select the length of suction intake tubing necessary to reach the required sample depth and attach it to the intake side of the sample bottle.

4. If possible, allow several liters of sample to pass through the system before actual sample collection. Collect this purge volume and return it to the source after the sample aliquot has been withdrawn.

5. Fill the necessary sample bottles by allowing pump discharge to flow gently down the side of bottle with minimal entry turbulence. Cap each bottle as filled.

6. Preserve the sample as necessary and verify that the pH is sufficient for the criteria.

7. Check that the PTFE liner is present in the cap and secure the cap tightly.

8. Label the sample bottle with the appropriate sample label, and place on ice immediately.

4.10.3.3 <u>Field Observations</u>

An entry will be made in the field logbook for each sample collected. The information will include the information presented in Section 5.2; the approximate depth and location of sample, PID readings, type of waste encountered and visual evidence of contamination.

4.10.4 Kemmerer Sampler

4.10.4.1 <u>Sampling Equipment</u>

- PID monitoring equipment
- Appropriate Bottles
- Roll of polyethylene sheeting
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.10.4.2 <u>Sampling Procedures</u>

1. Spread new polyethylene sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.

2. Inspect Kemmerer sampler to ensure that sample drain valve is closed (if equipped).

3. Measure and mark sampler line at desired sampling depth.

4. Open bottle by lifting top stopper-trip head assembly.

5. Gradually lower bottle until desired sample depth is reached.

6. Place messenger on sample line and release.

7. Retrieve sampler; hold sampler by center stem to prevent accidental opening of bottom stopper.

8. Rinse or wipe off exterior of sampler body.

9. Recover sample by grasping lower stopper and sampler body with one gloved hand, and transfer sample by either lifting top stopper with other hand and carefully pouring contents into sample bottles or holding drain valve (if present) over sample bottle and opening valve.

10. Allow sample to flow down the side of the sample bottle with minimal disturbance.

11. Preserve the sample as necessary and verify that the pH is sufficient for the criteria.

12. Check that the PTFE liner is present in the cap and secure the cap tightly.

13. Label the sample bottle with the appropriate sample label, and place on ice immediately.

4.10.4.3 <u>Field Observations</u>

An entry will be made in the field log book for each sample collected. The information will include the information presented in Section 5.2; the approximate depth and location of sample, PID readings, type of waste encountered and visual evidence of contamination.

4.10.5 Weighted Bottle Sampler

4.10.5.1 **Sampling Equipment**

- PID monitoring equipment
- Appropriate Bottles
- Roll of polyethylene sheeting
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.10.5.2 **Sampling Procedure**

1. Spread new polyethylene sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.

2. Measure and mark sampler line at desired sampling depth.

3. Lower the sampling device to the predetermined depth.

4. When the sampler is at the required depth, pull out the bottle with a sharp jerk of the sampler line and allow the bottle to fill completely.

5. Retrieve the sampler.

6. Rinse or wipe off exterior of sampler body.

7. Allow sample to flow down the side of the sample bottle with minimal disturbance.

8. Preserve the sample as necessary and verify that the pH is sufficient for the criteria.

9. Check that the PTFE liner is present in the cap and secure the cap tightly.

10. Label the sample bottle with the appropriate sample label, and place on ice immediately.

4.10.5.3 **Field Observations**

An entry will be made in the field log book for each sample collected. The information will include the information presented in Section 5.2; the approximate depth and location of sample, PID readings, type of waste encountered and visual evidence of contamination.

4.10.6 Bacon Bomb Sampler

4.10.6.1 **Sampling Equipment**

- PID monitoring equipment
- Appropriate Bottles
- Roll of polyethylene sheeting
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.10.6.2 Sampling Procedure

1. Spread new polyethylene sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.

2. Measure and mark sampler line at desired sampling depth.

3. Lower the Bacon bomb sampler carefully to the desired sampling depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut.

4. Release the trigger line and retrieve the sampler.

5. Transfer the sample to the sample bottles by pulling on the trigger. Allow sample to flow down the side of the sample bottle with minimal disturbance.

6. Preserve the sample as necessary and verify that the pH is sufficient for the criteria.

7. Check that the PTFE liner is present in the cap and secure the cap tightly.

8. Label the sample bottle with the appropriate sample label, and place on ice immediately.

4.10.6.3 Field Observations

An entry will be made in the field log book for each sample collected. The information will include the information presented in Section 5.2; the approximate depth and location of sample, PID readings, type of waste encountered and visual evidence of contamination.

4.11 POTABLE WATER SAMPLING

4.11.1 Hand-Held Bottle Sampling

4.11.1.1 Sampling Equipment

- PID monitoring equipment
- Appropriate Bottles
- Roll of polyethylene sheeting
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.11.1.2 Sampling Procedure

1. Spread new polyethylene sheeting on the ground surface to prevent cross-contamination of samples.

2. Purge the tap or well until the pH, temperature, and specific conductance are at equilibrium

3. Fill the containers slowly and continuously.

4. Preserve the sample if necessary and verify that the pH is sufficient for the criteria.

5. Verify that a PTFE liner is present in the cap and secure the cap tightly.

6. Label the sample bottle with the appropriate sample label, and place on ice immediately.

4.11.1.3 Field Observations

An entry will be made in the field log book for each sample collected. The information will include the information presented in Section 5.2; the approximate depth and location of sample, PID readings, type of waste encountered and visual evidence of contamination.

4.12 OTHER MATRICES

4.12.1 Non-Aqueous Phase Liquid (NAPL) Sampling

4.12.1.1 Sampling Equipment

- Oil/Water Interface Meter
- Bottom-filling stainless steel or Teflon bailers
- Teflon coated leader
- Bailer retrieval cord
- PID

- Combustible Gas Indicator (CGI)
- Roll of polyethylene sheeting
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.1.2 Sampling Procedure

1. Perforate the center of a piece of polyethylene sheeting and place over the monitoring well. Seal the sheeting to the protective metal casing with duct tape. Cut the sheeting so that it is large enough to accommodate the personnel conducting the sampling as well as the field equipment. Place all sampling equipment on the polyethylene sheeting to avoid contamination.

2. Calibrate all equipment following the procedure(s) described in the manufacturers literature.

3. Remove the well cap and measure the concentration of VOC organic vapors and explosive gases emanating from the well with the PID and CGI.

4. Measure thickness of free product using an oil/water interface meter.

   4.1. Lay the Interface Meter tape into the groove on the periphery of the tape guide. Measurements are read at the apex of the V-notch on the tape guide. A compensation factor is stamped onto the side of the tape guide. Subtract this factor to obtain accurate depth measurements from the top of the casing.

   4.2. Lower probe slowly. If there is no floating product, a single light and intermittent tone will come on. Briefly upon first entering water the steady tone and both lights will activate, but not upon subsequent insertions or removal. If there is a thin film of product, the steady tone and two lights will activate briefly each time the probe enters and exits the liquid. If there is floating product, the steady tone and two lights will activate.

   4.3. Raise and lower the probe gently to determine the exact upper level of any non-conductive floating product. Read the level of the air/product interface off the marked tape.

   4.4. Read the level directly from the tape. Note: Remember to subtract the amount on the tape guide from each measurement.

4.5. Repeat steps 4.3 & 4.4 three times to confirm.

4.6. To determine the thickness of product, subtract reading in step 4.3 from reading in step 4.4.

4.7. If insufficient free product is present in the well, the alternate well may be sampled following the same procedure listed above.

5. Sample free product using a bottom filling Teflon bailer.

5.1. Unwrap laboratory decontaminated dedicated bailer and connect to laboratory decontaminated leader/cable for lowering.

5.2. Lower bailer slowly until it contacts the free product surface.

5.3. Allow bailer to sink with a minimum of surface disturbance. Avoid allowing the bailer to sink to the level of the groundwater.

5.4. Slowly raise the bailer to the surface. Avoid contact of the bailer line to the well casing and/or ground.

5.5. Tip the bailer to allow a slow discharge from the top gently down the side of the sample bottle to minimize turbulence. Fill two 40 ml amber-colored or clear vials. *Note: Amber colored VOC vial will be required to contain the sample and prevent light sensitive compounds from degrading*.

5.6. Repeat steps 5.2-5.5 until an adequate sample volume is acquired.

4.12.1.3 Field Observations

An entry will be made in the field log book for each sample collected. The information will include the information presented in Section 5.2; the approximate depth and location of sample, PID readings, type of waste encountered and visual evidence of contamination.

4.12.2 Concrete Chip Sampling

4.12.2.1 Sampling Equipment

- Pre-measure template or ruler
- Decontaminated chisel and hammer or electric hammer
- Dedicated natural bristle brush

- Decontaminated dust pan
- Decontaminated bucket
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.2.2 Sampling Procedure

1. Measure and mark off the sample location using the template or ruler.

2. When collecting chip samples from a wall, place plastic sheeting directly beneath the collection area.

3. With a decontaminated chisel and hammer, break up the surface to be sampled. An effort should be made to avoid scattering pieces out of the sampling area boundary.

4. The area should be chipped to less than one-quarter inch (preferable 1/8 inch). Record how deep chips were taken.

5. Chips collected from flat surfaces (e.g., floors) shall be collected using a dedicated, decontaminated dust pan and natural bristle brush and transferred directly into the sample bottle. Chips collected from a wall shall be collected in a dedicated, decontaminated bucket held against the wall below the sample location. The chips shall be transferred directly into the sample bottles from the bucket.

4.12.2.3 Field Observations

An entry will be made in the field log book for each sample collected. The information will include the information presented in Section 5.2; the approximate depth and location of sample, PID readings, type of waste encountered and visual evidence of contamination.

4.12.3 Leachate Sampling

4.12.3.1 Sampling Equipment

- pH, temperature and specific conductivity meters
- PID monitoring equipment
- Stainless steel dipper or glass beaker
- Shovel
- Roll of plastic

- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.3.2 Sampling Procedure

1. Leachate samples will be collected as close to the source of the leachate seep as possible.

2. A small depression will be created in the soil with a decontaminated shovel, deep enough to submerge a decontaminated stainless steel dipper or glass beaker.

3. After the depression is created and has filled with leachate, the stainless steel dipper or glass beaker will be used to collect enough leachate to completely fill all necessary sample containers.

4. VOC organic analyses sample containers should be filled slowly to avoid volatilization. No air bubbles should be seen in the containers designated for VOC organics, to minimize loss of volatile compounds from the sample.

5. Any other sample containers should be filled with some headspace in the container.

6. Measure leachate pH, temperature, and specific conductivity. Monitor sampling operations with PID.

4.12.3.3 Field Observations

Data to be recorded in the field logbook includes the information presented in Section 5.2 and PID, pH, temperature and specific conductivity readings.

4.12.4 Sewer Sampling

4.12.4.1 Sampling Equipment

- pH, specific conductivity, temperature meters
- Teflon bailer, pond sampler
- Bailer rope
- Thief, Coliwasa, stratified sample thief
- Combustible gas indicator, PID

- Tools
- "Clam shell" sampler
- Stainless steel spoon
- Stainless steel bowl
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.4.2 Sampling Procedures - Water Samples

1. Prior to conducting sewer sampling, a reading will be taken of the air quality within the drop box. The air quality will be checked by using a combustible gas indicator and a PID. Note the readings in the field note book.

2. All sewer sampling will be conducted in a down gradient to up gradient order. This will limit the effect of interference by any disturbance caused by sampling. Water samples will be collected prior to the collection of sediment samples.

3. Water samples will be collected by means of a bottom check valve bailer or pond sampler. The pond sampler will be used when there is a limited depth of water.

4. The sampling device will be lowered into the drop box and allowed to fill with water.

5. Once filled, the device will be brought to the surface and the sample transferred to sample jars. Sample for VOCs will be collected first. The sampling device shall be handled in such a way as to avoid sample agitation.

6. Monitor pH, specific conductivity, and temperature.

4.12.4.3 Field Observations

Data to be recorded in the field logbook will include the information presented in Section 5.2, odor, pH, temperature, conductivity and PID readings and approximate water depth.

4.12.4.4 Sampling Procedures - Sediment Samples

1. Sediment samples will be collected off the bottom of the storm sewers, drop boxes, or manholes. Sampling will be conducted by means of a "clam shell" sampler (Eckman or Ponar dredge).

2. The "clam shell" sampler will be lowered through the open drop box into the sewer by means of rope, in an open position.

3. Upon reaching the bottom of the sewer the sampler will be worked into the sediment by jerking and lowering the rope.

4. Once sufficient sample is believed to be within the sampler, the rope will slowly be pulled. As the rope is pulled the "clam shells" will close and encapsulate the sample.

5. VOC organic samples shall be collected directly from the sampling device. The remainder of the sample will be placed in a decontaminated stainless steel bowl, homogenized, and transferred to sample jars by means of a stainless steel spoon.

4.12.4.5 Field Observations

Data to be recorded in the field log book will include the information presented in Section 5.2 and a description of the material.

4.12.5 Tank Sampling

4.12.5.1 Sampling Equipment

- pH, specific conductivity, temperature meters
- Electronic oil/water interface probe
- Teflon bailer, disposable polyethylene bailer fitted with bottom-emptying device, pond sampler
- Bailer cord
- Thief, Coliwasa, stratified sample thief
- Combustible gas indicator, PID
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.5.2 Sampling Procedures

1. Upon opening the tank access port, a PID measurement will be taken at the tank opening.

2. The depth to the top of the liquid, and to the bottom of the tank will be measured from a reference point using an interface probe. The interface probe also discerns multiple phases of liquid by detecting changes in density, and will indicate the presence of separate-

phase liquids if present. The interface probe will indicate the presence of separate phases by emitting distinct audible tones when the probe sensor encounters distinct phases.

(Note: Some liquids, for example, waste oil, may adhere to the sensor on the probe and prevent the sensor from detecting a change in phase as it's lowered through the liquid. Various thicknesses of separate phases may be visually estimated).

a. Bailer Method

1. The length of the bailer will be measured.
2. A clear or translucent disposable polyethylene bailer will be slowly lowered into the tank. When the bottom of the bailer reaches the top of the liquid, a mark will be made on the bailer cord at an arbitrary reference point (e.g., the tank access port).
3. The bailer will then be lowered through the liquid, taking care to keep the bailer vertical, until the top of the bailer is level with the top of the liquid. While holding the bailer at this location, another mark will be made on the bailer cord at the reference point. This second mark now represents the depth from the reference point to the bottom of the bailer, when the top of the bailer is at the top of the liquid. The distance from the first mark to the second equals the bailer length, and represents the uppermost vertical sampling interval of the liquid column in the tank.
4. The bailer will be carefully retrieved; the outside will be wiped clean with paper towels or sorbent pads, as appropriate for the known or suspected nature of the liquid.
5. The bailer will then be observed visually to detect separate liquid phases if present. Estimate the relative percentages of distinct phases within this uppermost vertical interval of the liquid column in the tank.
6. Should the appearance of the liquid prevent detection by visual observation of the outside of the bailer (e.g., two liquid phases of similar appearance), the bailer contents will be slowly emptied back into the tank using a bottom-emptying device (a small tube with a ring which releases the check-ball and regulates the flow). Close observation will be made of the liquid(s) discharging from

the bailer. Since the bailer represents a vertical profile of the interval sampled, an estimate of the relative percentages of each phase (within the interval sampled) can be made based on the relative discharge time and relative volume of each phase discharged from the bailer.

7. If the depth from the top of the liquid to the bottom of the tank is greater than the bailer-length, additional marks will be made on the bailer cord. From the second mark on the cord, measure one bailer-length up the cord and mark again. Depending on the depth to the bottom of the tank, additional marks will be made up the cord in this manner.

8. The emptied bailer will be lowered through the liquid again, taking care to keep the bailer vertical, until the <u>third</u> mark on the cord is at the reference point. Repeat the retrieval and observation process described above (steps 1 through 7).

9. Repeat this sampling procedure, sampling from successively lower intervals in the liquid column each time, until the bailer reaches the bottom of the tank.

10. Estimates of the relative percentages of various liquid phases within each vertical interval will then be combined to obtain an estimate for the entire vertical column of the liquid in the tank.

b. <u>Tank Stick Method</u>

1. A dry, incremented measuring stick of sufficient length to reach from the top of the tank to the bottom of the tank, will be smeared on one side with "water paste." Water paste is a green, pasty substance that retains its green color when in contact with non-aqueous-phase liquid (NAPL). When the paste has been in contact with aqueous liquids, the color permanently changes to pink.

2. The stick will carefully be lowered through the tank contents to the bottom of the tank, keeping the stick vertical.

3. The stick will carefully be removed from the tank in a vertical manner, taking care not to smear the water paste.

4. The vertical thickness of the liquid contents of the tank will be determined by noting the liquid mark left on the dry stick. NAPL, if present, will be indicated by water paste that appears wet, but is still green in color. Aqueous liquid, if present, will be indicated by wet paste that has turned pink. The vertical thickness of each liquid phase will be determined by measurements of the indicator color changes of the water paste, and by the wet or dry appearance when the stick is withdrawn from the tank.

3. Single-phase liquids will be sampled using a bailer or a pond sampler, depending on the size of the tank. A pond sampler will be used if there is a limited depth of water. The sampling device will be lowered into the tank and allowed to fill. The device will be retrieved and the sample transferred to the appropriate containers, collecting VOCs first.

4. When separate-phase liquids are present, multiphase sampling will be performed using a disposable bailer, Coliwasa or stratified sample thief, depending on tank size and field conditions. Multiple phases in the tank will be collected either as grab samples of each phase detected, or as one composite sample representing the entire tank contents, according to site-specific objectives. If one multiphase sample is required, care will be taken to estimate relative percentages of each phase in the tank and to fill sample containers with the same percentages of each phase.

5. Tank samples will not be chemically preserved, but will be maintained at 4^0C.

4.12.6 Drum Sampling

4.12.6.1 Sampling Equipment

- PID monitoring equipment
- Non-sparking drum opening tools
- Clear sampling tube, Coliwasa, disposable bailer and/or stratified sample thief
- pH paper
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.6.2 Sampling Procedures

1. The drum opening area will be physically separated by a minimum of 25 feet from drum removal and drum staging operations in order to prevent a possible explosive or

chemical chain reaction. If the contents of the drum are known and no risk of explosive or chemical reaction is present, the spacing may be reduced.

2. The drum bung or lid will be opened using non-sparking tools and removed slowly to allow any built up pressure to be released. The drum should be allowed to equilibrate. The headspace measurement within the drum will then be taken using a PID and the results recorded.

3. A clear sampling tube**,** or transparent disposable bailer will be inserted into the bottom of the drum or top of a solid layer and the liquid material allowed to reach its natural level. The exposed end of the tube will be capped with a stopper or a gloved finger, and the tube removed; or the bailer will be withdrawn.

4. The tube/bailer will be inspected for separate phase liquids and a description written in the field book. If two or more phases are contained within the drum, each phase may be analyzed separately, or may be collected as one composite sample representing the entire drum contents, according to site-specific objectives. If one multiphase sample is required, care will be taken to estimate relative percentages of each phase in the drum and to fill sample containers with the same percentages of each phase.

5. The uncapped end of the sampling tube will then be placed in the precleaned laboratory sample jars. The capped end will be carefully released and the contents allowed to drain.

6. Should leakage problems occur with the open tube sampler due to sample viscosity, a Coliwasa or stratified sample thief will be used to collect representative samples of stratified liquids.

7. Solids, when encountered, will be sampled by means of a dedicated tube. The sample will be obtained by coring the tube into the solid. The tube will then be removed from the drum and the sample extruded into the sample jars.

8. Samples will not be preserved using acids or bases, due to the possibility of chemical reactions.

4.12.6.3 <u>Field Observations</u>

Data to be recorded in the field logbook will include the information presented in Section 5.2 and a description of the drum contents and quantity, pH paper reading, and PID reading.

4.12.7 Wood Chip Sampling

4.12.7.1 Sampling Equipment

- Pre-measure template or ruler
- Decontaminated chisel and hammer or electric hammer
- Dedicated natural bristle brush
- Decontaminated dust pan
- Reciprocating saw or drill with hole saw bit (optional)
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.7.2 Sampling Procedure

1. Measure and mark off the sample location using the template or ruler.

2. With a decontaminated chisel and hammer, break up the surface to be sampled. An effort should be made to avoid scattering pieces out of the sampling area boundary. The area should be chipped to less than one-quarter inch. Record how deep chips were taken.

3. Collect the chipped pieces using a dedicated, decontaminated dust pan and natural bristle brush and transfer the sample directly into the sample bottle.

4.12.7.3 Field Observations

Record the size and depth of the collected chips and the information presented in Section 5.2 in the field logbook.

4.12.8 Wipe Sampling

4.12.8.1 Sampling Equipment

- A ruler, measuring tape or dedicated template to measure out the area being wiped
- Sterile, wrapped gauze pads (3 in. X 3 in.).
- Pesticide-grade solvent (solvent selection dependent on target analytes; i.e., 1:4 acetone/hexane mixture in the case of DDX sampling). To be prepared prior to

sample collection; stored in a 1 liter amber bottle labeled in accordance with OSHA Hazard Communication Standard requirements.

- Nalgene squirt bottle (solvent mixture to be transferred to the squirt bottle during sampling).
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.8.2 Sampling Procedure

1. Choose the sampling location based on a visible inspection of the area.

2. Prior to and during sample collection, wipe blank samples will be collected to determine if any interference's are present in the sample collection materials. These samples will be collected by soaking a gauze pad with the solvent contained in the Nalgene squirt bottle, squeezing excess solvent from the pad and placing the pad in an 8 ounce amber glass sample jar without allowing it to contact any on-site surfaces.

3. Don a new pair of disposable surgical latex gloves (worn over the Edmonton 4H multi-layer gloves) and pre-measure the area to be sampled (i.e. 10 cm X 10 cm).

4. Remove the gauze pad from the box of gauze and its individual wrapper.

5. Using the Nalgene squirt bottle filled with solvent, soak the gauze in 1:4 acetone/hexane mixture; squeeze excess solvent from the gauze pad prior to sample collection.

6. Wipe the entire area measured once in the horizontal direction and once in the vertical direction, applying moderate pressure.

7. Place the gauze in an amber 8 ounce wide mouth sample jar edge-first and replace the container cap.

8. Secure the cap tightly.

9. Label the sample bottle with the appropriate sample label.

10. Place the filled sample container on ice immediately.

4.12.8.3 Field Observations

An entry will be made in the field logbook for each sample collected. The information will include the information presented in Section 5.2; a photograph of the sample area with corresponding placard identification and visual evidence of contamination.

4.12.9 Bulk Dust Sampling

4.12.9.1 Sampling Equipment

- Dedicated natural bristle brush.
- Dust pan lined with aluminum foil.
- Disposable dedicated surgical gloves.
- Dedicated spatula (optional).
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.9.2 Sampling Procedure

1. Choose the sampling location based on a visible inspection of the area. Samples will be collected where sufficient accumulation of dust is present.

2. Prior to and during sample collection, a blank sample will be collected to determine if any interferences are present in the sample collection materials. This sample will consist of an unused and unopened brush, sealed in two “ziplock” bags.

3. Don a new pair of disposable surgical latex gloves.

4. Wrap aluminum foil around the dust pan, covering all surfaces.

5. Remove the plastic cover from the brush and sweep the dust from the entire area of the chosen sampling location into the aluminum-lined dust pan.

6. Place the dust into the sample container using a dedicated spatula.

7. Secure the cap tightly.

8. Label the sample bottle with the appropriate sample label.

9. Place the filled sample container on ice immediately.

4.12.9.3 Field Observations

An entry will be made in the field log book for each sample collected. The information will include the information presented in Section 5.2; a photograph of the sample area with corresponding placard identification and visual evidence of contamination.

4.12.10 Bulk Soil Sampling

4.12.10.1 Sampling Equipment

- Stainless steel shovel/spade, scoop, spoon, hand auger, soil corer
- Roll of polyethylene sheeting
- Stainless steel bowl
- Stainless steel spoon
- PID monitoring equipment.
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.10.2 Sampling Procedures

1. Prepare the work area by placing polyethylene sheeting around the sampling location to avoid cross-contamination. One sample for each required analytical parameter will be collected from approximately each ten cubic yards of soil for representative sampling. If the total bulk volume exceeds approximately ten cubic yards, measure and designate each 10 yd^3 section of the bulk soil; describe location and record in the field logbook.

2. Using a precleaned or decontaminated stainless steel shovel / scoop / trowel / hand auger soil corer (as appropriate based on total bulk soil volume and dimensions), collect a ***grab*** sample aliquot for VOCs analysis first. The grab sample will be collected from one location within the total bulk soil to be sampled, immediately placed in sample containers and placed on ice.

3. Samples for the remaining analytical parameters will be collected from two to five grab locations within the bulk soil, taking care to sample from various areas within the bulk soil to represent the entire volume. The grab samples will then be homogenized in a stainless steel bowl.

4. Transfer the homogenized soil into appropriate sample containers with a stainless steel spoon or equivalent, and place in an iced cooler.

5. Label the sample bottle with the appropriate label, and place sample containers in iced cooler.

Soil Sample Homogenization

1. Remove the soil from the sampling device and place it in a stainless steel bowl.

2. Remove rocks, twigs, leaves and other debris if they are not considered part of the sample.

3. Thoroughly mix the sample using a stainless steel spoon. The material in the pan should be scraped from the sides and bottom of the pan, rolled to the middle of the pan and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually and then rolled to the center of the container and the entire sample mixed again.

4. Transfer the sample to the appropriate sample containers.

4.12.10.3. <u>Field Observations</u>

At each sampling location, the information presented in Section 5.2, a soil description, any observations, and the PID readings will be recorded in the field logbook.

4.12.11 Other Bulk Waste Solids

(Note: Other bulk waste solids may include but are not limited to sludges, oil-soaked rags, various self-contained filters, sorbent material (e.g., speedi-dry, kitty litter); generally requiring characterization for proper disposal. Due to the variety of miscellaneous waste material which may be encountered, it is not possible to describe specific sample collection techniques in this section. Primarily, sampling will be conducted in such a manner to ensure that samples collected adequately represent the entire bulk waste).

4.12.11.1 <u>Sampling Equipment</u>

- Various sample collection equipment, depending on waste matrix
- Roll of polyethylene sheeting

- Stainless steel bowl
- Stainless steel spoon
- Sealable poly bags (e.g., zip-lock bags)
- PID monitoring equipment
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.11.2 Sampling Procedures

1. Prepare the work area by placing polyethylene sheeting on the ground to avoid cross-contamination.

2. Representative sampling will be based on the total volume or quantity of waste to be characterized, the nature of the waste, and any information that is known about the origin or generation of the waste. (For example, a bulk quantity of used filters which are known to be generated from one source/process may be represented by one of the several filters).

3. Using appropriate sampling devices, collect a representative sample of the bulk waste. (For example, if the bulk waste is composed of several filters from different processes, a piece of ***each*** filter should be collected as a composite sample).

4. If appropriate, after VOC sample aliquot is collected, homogenize remainder of sample volume. Place samples in appropriate containers, label sample containers and place in iced cooler.

Soil Sample Homogenization

1. Remove the waste from the sampling device and place it in a stainless steel bowl.

2. Remove rocks, twigs, leaves and other debris if they are not considered part of the sample.

3. Thoroughly mix the sample using a stainless steel spoon. The material in the pan should be scraped from the sides and bottom of the pan, rolled to the middle of the pan and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually and then rolled to the center of the container and the entire sample mixed again.

4. Transfer the sample to the appropriate sample containers.

4.12.11.3 Field Observations

At each sampling location, the information presented in Section 5.2, a bulk waste description and the PID readings will be recorded in the field logbook.

4.12.12 Lead Paint Sampling

4.12.12.1 Sampling Equipment

- PID monitoring equipment
- Stainless steel spoon/spatula
- Hammer and decontaminated chisel
- Core Drill
- Roll of polyethylene sheeting
- Stainless steel bowl
- Sealable poly bags
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.12.2 Sampling Procedure

The nature of the sample collection method is dependent on the sampling rationale. Typically, paint is sampled for lead content for two reasons: renovation, which involves removal of old paint for preparation and recovering; or demolition of entire structure for disposal. In addition, lead paint concentrations are also examined for worker safety issues.

Renovation

1. If renovation is planned, it is only necessary to sample the painted surfaces. Paint will be sampled as several grab samples, collected from all painted surfaces to be renovated. Paint chips will be collected using a variety of hammer and chisel, or scoops/spatulas/scrapers, if loose or peeling paint is available.

2. If demolition and disposal is planned, it will be necessary to include building materials in the sample. Using a core drill, several grab core samples will be collected from throughout the structure, taking care to locate wiring and other infrastructure before drilling. Core samples will be collected such that the entire structure is represented for disposal purposes.

3. Grab samples will then be composited, samples will be placed in the appropriate containers, labeled and placed in an iced cooler.

4.12.12.3 **Field Observations**

An entry will be made in the field log book for each sample collected. The information will include the information presented in Section 5.2; a description of the area or structure sampled, and the approximate location of grab samples.

4.12.13 Air Sampling

4.12.13.1 **Sampling Equipment**

- SUMMA Canister
- Vacuum gage
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.13.2 **Sampling Procedures**

1. Select location of sample (based on specific project needs).

2. Open the valve and allow the evacuated canister to draw an air sample for approximately 40 to 60 seconds.

3. Close the valve after 60 seconds to seal the canister.

4.12.13.3 **Field Observations**

Data to be recorded in the field logbook will include information regarding the sample location and collection process.

4.12.14 Transformer Sampling

Note: This sampling technique applies to inactive transformer units.

4.12.14.1 Outlet Sampling Method

4.12.14.1.1 **Sampling Equipment**

- Clear plastic (Tygon) tubing
- Bucket or pan to catch oil overflow
- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.14.1.2 Sampling Procedures

1. Install a bucket or pan under the electric equipment sampling outlet to catch overflow.

2. Attach one end of the Tygon tubing to the electrical sampling outlet valve and place the other end of the tube in the sample container. The tubing between the transformer and the container should be as short as possible to avoid potential leakage. The tube should be a smaller diameter than the valve ends to ensure that there is no leakage.

3. Drain some oil through the sample valve cock and tubing into the overflow bucket or pan to ensure that there are no contaminants present in the sampling line. Then close the sample valve cock.

4. After draining some oil through the sampling line, place the tubing in the sample container.

5. Open the sample valve cock on the transformer and fill the sample container.

6. When the sample container is completely full of oil, close the transformer valve.

7. Secure the cap tightly.

8. Label the sample and immediately place on ice at 4^0C.

4.12.14.1.3 Field Observations

Data to be recorded in the field logbook will include the information presented in Section 5.2.

4.12.14.2 Glass Thieving Tube Method

4.12.14.2.1 Sampling Equipment

Note: This sampling technique applies to inactive transformer units.

- Glass thieving tube (6 to 16-mm ID) and 1.2 m long

- Disposable gloves (latex or nitrile, depending on site-specific conditions), safety goggles

4.12.14.2.2 Sampling Procedures

1. Remove the cover from the transformer.

2. Insert the glass tubing almost to the bottom of the transformer. Approximately 0.3 m of tubing should extend above the drum.

3. Allow the oil in the transformer to reach a constant level in the tube during the tubes descent.

4. Cap the top of the sampling tube with a tapered stopper , ensuring that the liquid does not come in contact with the stopper.

5. Remove the capped tube from the transformer and insert the uncapped end into the sample container.

6. Release the stopper and allow the oil to drain into the sample container until it is approximately two-thirds full.

7. Remove the tube from the sample container and dispose of the tube properly.

8. Secure the cap tightly.

9. Label the sample and immediately place on ice at 4^0C.

4.12.14.2.3 Field Observations

Data to be recorded in the field logbook will include the information presented in Section 5.2.

4.12.15. VOC Sample Collection Using the En Core® Sampler

4.12.15.1 Sampling Procedure

1. Remove a 5-gram sampler and cap from package and position plunger rod so that the plunger can be moved freely from the top to the bottom of the coring/storage chamber. This is accomplished by pushing the plunger rod down until the small O-ring rests against the tabs. Note: The En Core® sampler is a single-use device.

2. Attach the T-handle to the sampler body by depressing the locking lever on the T-handle, placing the coring body (plunger end first) into the open end of the T-handle,

aligning the slots on the coring body with the locking pins in the T-handle, and twisting the coring body clockwise to lock pins in slots. The plunger should be positioned so that the bottom of the plunger is flush with the bottom of the coring body/storage chamber.

3. Using the T-handle, push the En Core® sampler into the soil in the stainless steel bowl until the coring body/storage chamber is completely full.

4. Verify that the coring/storage chamber is full by looking into the 5 gram viewing hole in the T-handle. The coring body/storage chamber is completely full if the small O-ring on the plunger rod is centered in the T-handle viewing hole.

5. Scrape a decontaminated spatula across the bottom of the coring body/storage chamber so the surface of the soil in the sampler is flush with the opening of the coring body/storage chamber.

6. Quickly wipe the external surface of the coring body/storage chamber with a clean paper towel.

7. After ensuring that the sealing surfaces are clean, cap the coring body/storage chamber while it is still on the T-handle. This is done by gently sliding the cap onto the coring body/storage chamber with a twisting motion.

8. Remove the T-handle from the sampler and lock the plunger into position by rotating the plunger rod.

9. Fill out sample label and attach to the cap of the En Core® sampler.

10. Place sampler in the protective moisture-proof zip-lock bag it came in.

11. Fill out sample information on bag and store bag on ice.

Repeat the above procedure using one more sampler. A total of two En Core® samplers will be collected per six-inch sampling interval

4.12.15.2 Field Observations

Data to be recorded in the field logbook will include the information presented in Section 5.2.

4.13 MISCELLANEOUS

4.13.1 Staff Gauge Readings

Staff gauges that are in the vicinity of a surface water or sediment sample location may require a reading. The staff gauges are graduated in increments of 0.01 feet. The procedure to read the staff gauge will be to read the increments off of the staff gauge and record the information in the field logbook.

4.13.2 Field Test Kits

4.13.2.1 General

Vendor purchased Field Test Kits can provide immediate characterization of the sampling media. As part of the DQO process, the purpose and rationale for using field test kits shall be described in the QAPjP. The following items should be considered when determining the applicability of field test kits for a sampling event:

1. Through the DQO process, identify what field test kit will be used and what useful information will be generated to meet the project goals.
2. If historical information is available, identify the concentration range of the contaminant of concern and identify if the test kit can achieve the concentrations for the investigation.
3. Determine if test kits are commercially available to meet the concentration range of the contaminant.
4. Specify whether or not the use of a test kit will provide accurate information. Determine if interferences may be encountered that would bias the results.

If field test kits are not commercially available, a temporary "on-site" laboratory with equipment/hardware similar to an off-site laboratory may be required.

4.13.2.2 Used Oil and Used Antifreeze Characterization

In order to efficiently evaluate potential contamination with chlorinated solvents, test kits may be used to analyze for total halogens (in used oil) or total organic halogens (in used antifreeze). The test kits manufacturer and procedure is presented in Appendix B.

4.13.3 Global Positioning System (GPS)

The GPS is a satellite-based positioning system, operated and controlled by the U.S. Department of Defense. The GPS includes 24 satellites, and can be used by anyone who has a GPS receiver. The GPS receiver is used for position determination, navigation, and survey tasks on land, sea, and in the air. The method of utilizing GPS varies with each application and the type of GPS equipment used. Operating methods range from low precision, code phase systems to highly accurate, carrier phase systems that facilitate on-the-fly measurements, also known as real-time kinematic surveying (RTK). Generally, the RTK system includes a GPS antenna, a GPS receiver, a radio modem and radio antenna, and a data collector for both the Roving Unit and the Base Station.

For sampling programs that require monitoring, using GPS to accurately sample the same locations should be considered. An SOP for GPS procedure is presented in Appendix B. The QAPjP should identify the system and procedures used if they are other than what is stated in this SOP.

4.14 DECONTAMINATION PROCEDURES / SAMPLE CONTAMINANT SOURCES

This section provides instruction on deciding an appropriate decontamination scheme(s) for the project field sampling equipment in order to prevent or reduce cross-contamination of project samples. The applicability of each step in a decontamination protocol will depend upon the contaminants present onsite, the subsequent analysis to be performed, the composition of the sampling devices, etc. The appropriateness of a decontamination protocol is vital to the eventual validity of the analytical results and decisions made based upon those results. All sampling equipment that has come in contact with a potentially contaminated media must be cleaned prior to the subsequent use of that device. Devices may include bailers, pumps, shovels and scoops, split spoons, tube samplers, augers, etc. Another approach to minimizing the potential for cross-contamination may be to dedicate or use disposable sampling equipment.

4.14.1 Decontamination procedures

Refer to the Table 4-2 for various step-wise decontamination protocols.

4.14.1.1 Reagents

The detergent wash is a non-phosphate detergent solution used with brushing or circulating techniques to remove gross contamination, and/or as a mild neutralizing agent. Tap water is considered a rinse water, preferably from a water system of known chemical composition. Acid rinses are used as the inorganic solubilizing agent, or as a mild neutralizing agent. These rinses are a 10-percent to 1-percent Hydrochloric Acid (HCl) or Nitric Acid (HNO_3) solution prepared from reagent grade acids and deionized water, respectively. Solvent rinses are used as an organic solubilizing agent. Requirements for solvent types vary depending upon the nature of known organic contamination requiring solubilization; and any impurities present within the rinse which may potentially interfere or contribute to the subsequent analysis. All solvent rinses used must be of pesticide grade quality. Finally, the deionized water is organic-free reagent water. Analyte-free water may be used as deemed appropriate.

4.14.1.2 Procedure Clarifications/Exceptions

Refer to Table 4-2 for the general necessary procedures based upon site contaminants and/or subsequent analytical protocols. The detergent wash is used in conjunction with scrubbing for gross contamination removal, followed by the appropriate rinses. For cleaning of pumping equipment or devices with inaccessible internal mechanisms, suggest circulating/flushing the system with the applicable solutions in the order given below. Solvent rinses for pumping equipment should be limited to a 10-percent dilution (vol./vol.) of acetone or isopropyl alcohol in water. Tubing used with peristaltic pumps may be flushing with hexane or dilute HCl, followed by a distilled water rinse depending on contaminants noted onsite. The decontamination of low carbon steel sampling devices should limit the acid rinse to a dilute 1-percent acid solution. All sampling equipment should be allowed to air dry prior to the next use. For this reason it is important to have sufficient sampling devices onsite which may be alternated. This practice will allow a thorough air drying of equipment without increasing sampling downtime. Alternatively, larger equipment (e.g., drill rig components, power augers, etc.) may be cleaned with a portable power washer or a steam cleaning machine in lieu of the protocols outlined above. Finally, depending upon the project, it may be appropriate to contain spent decontamination fluids and arrange for eventual disposal as investigation derived wastes (IDW). In these cases, it is important that these containers be suitable for the eventual disposition of the materials, and therefore comply with any potentially applicable regulations.

Optional procedure for IDW disposal: Decontamination fluids generated during decontamination events can also be disposed of as solid waste in instances where paper towel wipes dampened with Hexane, Isopropyl, and Nitric acid, were used to decontaminate any non-dedicated equipment. Waste paper towels can be discarded as solid waste. The tap and DI water used to rinse the equipment may contain trace levels of solvents and acid; these spent fluids or spent 10% Nitric acid can be neutralized to a pH of 7 and containerized and disposed of by site personnel.

4.14.2 Sample Contaminant Sources and Other Potential Problems.

4.14.2.1 Carryover and Leaching

Contaminant carryover between samples, and/or from leaching of the sampling devices, is very complex and requires special attention. Decisions concerning the appropriateness of the devices material composition must account for these carryover or leaching potentials, and whether these contaminants are of concern on the project. Equipment blanks may be used to assess contamination of this nature.

4.14.2.2 Adsorption

Contaminant adsorption is another problem that must be considered when deciding on an applicable sampling device or the appropriate composition material. This phenomenon is more critical when sampling an aqueous or gaseous media, due to the capability of lower levels of contaminant detection and the fact that the fluid matrix is more apt to potential contaminant transfer. PVC and other plastics are known to sorb organics and to leach plasticizers and phthalate esters. Polypropylene, and other thermoplastics, have been shown to sorb organics and environmental mercury efficiently, and should therefore be avoided in sampling devices, especially tubing. For these reasons, PTFE is commonly chosen over the PVC and plastics when working with organic or mercury contaminants. In addition, some pesticides and halogenated compounds preferentially adsorb to glass surfaces. For this reason, it is recommended that when taking aqueous samples, the sample container NOT be rinsed prior to sample collection; and the same container be rinsed with the extraction solvent after the sample has been quantitatively transferred to an extraction apparatus. Inorganics (metals) adsorption to containers is dependant upon the specific metal element, the concentration, pH, contact time, complexing agents present, and container composition. This is believed to be nominal and proper preservation of samples should prevent this. In deciding appropriate tubing to be used for aqueous sample acquisition, it is important to decide applicable material composition and diameter based upon the contaminant and the purpose of the data. Adsorption is less likely to occur when there is an increase in tubing diameter.

4.15 DECONTAMINATION PROCEDURES

To avoid cross-contamination of samples, equipment used in sampling must be clean and free from the residue of previous samples. Non-dedicated sampling equipment must be cleaned initially and prior to being reused. Initial decontamination shall be performed in accordance with the requirements of Appendix B, NYSDEC, 1990. The following procedure for field decontamination does not apply to heavy equipment or drilling equipment, with the exception of split spoon samplers. Heavy equipment and drilling equipment will be steam cleaned in a pre-designated location prior to use and between locations. Well casings and screens will also be steam cleaned.

- Wash and scrub with low phosphate, laboratory grade detergent,
- Tap water rinse,
- 10% HNO_3, ultrapure (1% for carbon steel) rinse,*
- Tap water rinse,
- Isopropyl alcohol,**
- Thorough rinse with deionized demonstrated analyte-free water,

- Air dry, and
- Wrap in aluminum foil for transport.

*Omit this step if metals are not being analyzed.

**Omit this step if organics are not being analyzed.

Well evacuation tubing and equipment such as submersible pumps and screened augers which are put into the borehole will be decontaminated by thoroughly washing internal and external surfaces with low-phosphate, laboratory grade detergent and rinsing with deionized demonstrated analyte-free water prior to use.

If oil-saturated soils are encountered, sampling equipment will be steam-cleaned prior to performing the decontamination procedures outlined above or be dedicated and disposed of after use.

Field instrumentation should be cleaned according to manufacturer's instructions. Probes, such as those used in pH and conductivity meters, and thermometers must be rinsed prior to and after use with deionized water.

5.0 DOCUMENTATION AND CHAIN OF CUSTODY

5.1 OVERVIEW

Sample custody during the field investigations will be performed in three phases. The first phase encompasses sample collection, pre-laboratory treatment procedures (preservation), packaging, and shipping field custody procedures. The second custody phase involves sample shipment, where mode of shipment, airbill numbers, dates and times are documented. The third phase involves the custody procedures employed by the laboratory.

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

- All samples are uniquely identified;
- The correct samples are tested and are traceable to their source;
- Important sample characteristics are preserved;
- Samples are protected from loss or damage; and
- A record of sample integrity is established and maintained through the entire custody process.

5.2 FIELD DOCUMENTATION

A bound field logbook will be maintained in which to record daily activities. All entries will be made in indelible ink. The field notebook pages shall be prenumbered. Incorrect entries will be corrected by a single stroke through the error and will be verified with the recorder's initials. Entries to the logbook, in addition to the required sampling entries, will include:

- Date;
- Start and finish times;
- Summary of work performed (including samples collected);
- Names of personnel present;
- Names of visitors;

- Weather;
- Level of personal protection used during various activities;
- Calibration of equipment; and
- Observations and remarks.

The following information will be recorded in a field notebook at the time of sampling:

- Sample designation;
- Name of sampler;
- Method of collection;
- Time and date of sampling;
- Type of sample;
- Depth of sample;
- Analyses required and sample container types;
- Field measurements and calibration (if applicable);
- Stratigraphy and/or observed conditions which may impact the chemistry of the sample; and
- Observations and remarks.

5.3 PHOTO DOCUMENTATION

All sampling points should be documented on film. A film record of a sampling event allows positive identification of the sampling point. In some cases, a photograph of the actual sampled collected may be required. Photographs are the most accurate and convenient record of field personnel observations. Photographs taken to document sampling points should include two or more reference points to facilitate relocating the point at a later date. Keeping a record of photographs taken is crucial to their validity as a representation of an existing situation. Photographic documentation is invaluable if the sampling and subsequent analytical data end in litigation, enforcement, or cost recovery actions. In addition to photographs, video coverage of a sampling episode can be equally or even more valuable than photographs because it can be used to prove that samples were taken properly as well as the location at which they were taken. Video coverage can be used as a record of site conditions and can give those who have not been onsite an idea of the circumstances. For each photograph taken, the following items should be noted in the field logbook:

- Date;
- Time;
- Photographer (signature);
- Name of site;
- General direction faced and description of the subject taken;
- Sequential number of the photograph and the roll number; and
- Site photomap.

5.4 FIELD CUSTODY PROCEDURES

5.4.1 Sample Identification

All samples collected from the site must be identified with a sample label in addition to an entry on a chain-of-custody record. Indelible ink will be used to complete sample labels, then labels will be covered with clear plastic waterproof tape.

5.4.1.1 Sample Labels

Sample labels will require the field team to complete the following information for each sample bottle:

1. Site Name.
2. Sample Number.
3. Sample Matrix.
4. Parameters to be Analyzed.
5. Date of Collection.
6. Time of Collection.

7. Preservation Technique Employed.
8. Sampler's Name.

Sample labels will be attached to the sample bottles.

5.4.1.2 Sample Numbering

A unique sample number shall identify each sample. Each QAPjP contains the sample numbering system for the specific sampling project.

5.4.2 Chain-of-Custody Record

The chain-of-custody creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. Chain-of-custody forms will be completed for each sample at the time of collection and will be maintained while shipping the sample to the laboratory. A person is in custody of a sample if the sample is:

- in that person's physical possession;
- in view after being in that person's physical possession;
- placed in a locked repository by that person; or
- placed in a secure, restricted area by that person.

As soon as practical after sample collection, the following information must be entered on the chain-of-custody form. All information is to be recorded in ink.

1. Project number. Enter the alphanumeric designation that uniquely identifies the project site.
2. Project name. Enter the site name.
3. Samplers. Sign the name(s) of the sampler(s).
4. Sample number. Enter the sample number for each sample in the shipment. This number appears on the sample identification label.
5. Date. Enter a six-digit number indicating the month, day and year of sample collection (MMDDYY).

6. Time. Enter a four-digit number indicating the time of collection based on the 24-hour clock; for example, 1354.

7. Sample matrix. Enter the matrix (e.g., soil, aqueous, etc.) of the sample.

8. Parameters for analysis. Enter the analyses to be performed for each sample.

9. Number of containers. For each sample number, enter the number of sample bottles that are contained in the shipment by parameter for analysis.

10. Remarks: Enter any appropriate remarks.

5.5 SAMPLE SHIPMENT

Custody of samples must be maintained through the shipment of samples to the selected laboratory. Samples will be delivered directly to the laboratory by sampling personnel or shipped via the following procedures:

- Use waterproof high-strength plastic ice chests or coolers only.

- After filling out the pertinent information on the sample label and tag, put the sample in the bottle or vial and screw on the lid. For all samples except VOC vials, secure the bottle lid with strapping tape.

- Tape cooler drain shut.

- Place about 3 inches of inert cushioning material such as vermiculite or styrofoam "popcorn" in the bottom of the cooler. Styrofoam packing shall not be used when sampling for volatile organics.

- Enclose the bottles in clear plastic bags through which sample labels are visible, and seal the bag. Place bottles upright in the cooler in such a way that they do not touch and will not touch during shipment.

- Put in additional inert packing material to partially cover sample bottles (more than half-way). Place bags of ice or ice-gel packs around, among, and on top of the sample bottles.

- Fill the remaining space in the cooler with cushioning material.
- If sending the samples by common carrier, sign the chain-of-custody under "Relinquished by," enter the carrier name and airbill number, retain a copy for field records and put the chain-of-custody record in a waterproof plastic "ziplock" bag and tape it with masking tape to the inside lid of the cooler. If

sending the samples by courier or field team shipper, follow the above procedures, but also have the receiving carrier sign under "Received by."

- Apply custody seals to the front and back of the cooler, across the lid.
- Secure lid by taping. Wrap the cooler completely with strapping tape at a minimum of two locations. Do not cover any labels.
- Attach completed shipping label to top of the cooler. The shipping label shall have a return address.
- Ship the cooler by overnight express or courier to the respective laboratory.

Quality Assurance (QA) samples shall be shipped to CEWES-EE-Q at the following address:

US Army Corps of Engineers
Chemical Quality Assurance Branch of WES
420 South 18th Street
Omaha, NE 68102-2586
ATTN: Sample Custodian
Phone (402) 444-4314
Fax (402) 341-5448

The QA laboratory shall be notified of estimated number of samples and analytical parameters a minimum of one week prior to shipment.

5.6 LABORATORY CUSTODY PROCEDURES

When the sample arrives at the laboratory, the sample is received by the sample custodian. The sample label will be identified upon receipt by the laboratory and cross-referenced to the chain-of-custody record. Any inconsistencies will be noted on the custody record. Laboratory personnel will notify the Project QA/QC Coordinator, Site Field Manager or the Project Manager immediately if any inconsistencies exist in the paper work associated with the samples. Laboratory custody procedures are detailed in the Site Specific QAPjPs.

5.7 QA/QC REQUIREMENTS

5.7.1 Field Notebook -Corrections to documentation

All original data recorded in field logbooks and on sample labels, chain of custody records, and receipt for samples forms are written in waterproof ink. If an error is made on an accountable document, corrections should be made simply by crossing out the error and entering the correct information. The erroneous information should not be obliterated. Any error discovered on a document should be corrected by the person who made the entry. All corrections must be initialed and dated.

5.7.2 Photographs.

The photographer should review the photographs or slides when they return from developing and compare them with the photographic log to confirm that the log and photographs match.

5.7.3 Sample labels - Potential problems

Although most sample labels are made with water-resistant paper and are filled out using waterproof ink, inclement weather and general field conditions can affect he legibility of sample labels. It is recommended that after sample labels are filled out and affixed to the sample container, the label should be covered with wide clear tape. This will preserve the label and keep it from becoming illegible. In addition to label protection, chain of custody and analysis request forms should be protected when samples are shipped in iced coolers. Typically, these forms should be placed inside a ziplock bag or similar waterproof protection and taped to the inside lid of the secured shipping container with the samples.

6.0 INSTRUMENT CALIBRATION

6.1 FIELD CALIBRATION PROCEDURES

Measuring and test equipment shall have an initial calibration and shall be recalibrated at scheduled intervals against certified standards that have known and valid traceability to recognized national standards. Calibration intervals for each item shall be, at a minimum, in accordance with manufacturer's recommendations as defined in the equipment manual. Test equipment used for calibration of sensors shall themselves be recalibrated at least once a year or when maintenance or damage indicates a need for recalibration.

Calibration standards shall be maintained and used in an environment with temperature, humidity, and cleanliness controls that are compatible with the accuracy and operating characteristics of the standards. An inspection will be made during the equipment calibration to evaluate the physical condition of the equipment. The purpose of the inspection is to detect any abnormal wear or damage that may affect the operation of the equipment before the next calibration. Equipment found to be out of calibration or in need of maintenance or repair will be identified and removed from service.

The Project QA/QC Coordinator shall be notified if the test equipment is found to be out of tolerance during inspection and calibration. The corrective actions to be taken include evaluating the validity of previous inspection or test results; evaluating the acceptability of the items inspected or tested since the last calibration check; and repeating the original inspections or tests using calibrated equipment when it is necessary to establish the acceptability of previous inspections or tests.

Each item of measuring and test equipment in the calibration program shall be identified in such a way as to show its calibration status and calibration expiration date. Equipment history records for measurement and test equipment shall be used to indicate calibration status and conditions, corrections to be applied, results of in-service checks, and repair history. This will provide a basis for establishing calibration frequencies and for remedial action if the instrument is found out of calibration.

6.2 LABORATORY CALIBRATION PROCEDURES

Laboratory instrumentation calibration procedures, frequency, and standards will be consistent with the requirements of the applicable analytical method. Information regarding laboratory calibration procedures is presented in the QAPjPs.

7.0 ANALYTICAL PROCEDURES

7.1 ROUTINE LABORATORY ANALYSES

The analytical procedures for samples collected at Fort Drum will follow those specified in Tables 7-1 through 7-4. (Tables are presented in Appendix A.) All holding times shall follow the criteria in these tables, which have been stipulated by the NYSDEC. The various laboratories responsible for sample analysis and the proposed analytical methods shall be identified in the Site Specific QAPjPs. Test Methods for Evaluating Solid Waste, USEPA Office of Solid Waste, SW-846, 3rd Edition, Revision No. 2, June 1990; Methods for Chemical Analysis of Water and Wastes, USEPA Office of Research and Development, March 1983; CLP Statement of Work, OLM04.2, October 1999; CLP Statement of Work, ILM04.1, 1994; and American Society for Testing Materials, Annual Book of ASTM Standards are incorporated by reference into this QAPP for the purpose of describing the standard analytical methods. All instrument, method detection limits, and reporting limits specific to each laboratory performing the analysis must be included as an attachment in the QAPjP.

All laboratories providing analytical support at Fort Drum must be certified by the NYSDOH. In the event that the USACE Project Manager requires a laboratory that is USACE validated, the laboratory must maintain both USACE and NYSDOH certifications. If the laboratory selected for a particular project requires USACE validation for some of the project parameters, the Form for the A/E Firm to sponsor validation is identified as “Laboratory Evaluation Request Format” and is presented in Appendix E. (See USACE EM 200-1-1 for further details on USACE validation).

In the event that analytical parameters are not validated by either the NYSDOH and/or the USACE through the performance of proficiency samples and on-site audits, laboratory SOPs will be forwarded to the USACE chemist and NYSDEC personnel for review during the stages of the work plan development (Appendix C references tables from SW-846, which identify various test method procedures for chemical compounds/analytes).

7.2 EXTRACTION EFFICIENCIES

The method chosen for analysis at Fort Drum are the standard analytical methods used within the laboratory industry. The analytical data generated by these standard methods provide information used to make critical decisions at the site. As part of the method, sample preparation or extraction techniques prepare the sample prior to analysis. A way to measure the "integrity" of the method is to introduce known amounts and concentrations of known compounds and subject them to the extraction and analysis procedures outlined in the method. These added compounds are measured after analysis and represent the response of the unknown compounds in the sample. From the results the extraction efficiency for each method is evaluated.

7.3 METHOD DETECTION LIMITS AND QUANTITATION LIMITS

Analyte and associated detection and quantitation limits are presented by method in each Site Specific QAPjP. Actual detection and quantitation limits for specific samples will vary depending on the amounts and types of compounds present in the sample. A significant concentration of one compound may require that the sample be diluted, which increases the detection limits and sample quantitation limits accordingly. In addition, the occurrence of one compound may interfere with the detection of other compounds.

The Method Detection Limit (MDL) is a level at which the analytical procedure referenced is capable of determining with a 99% probability that the constituent is present. The procedure for determining the MDL includes the complete analytical procedure, including any sample preparation such as extractions and digestions. This procedure involves the replicate analysis (seven replicates as a minimum) of a sample with an analyte concentration near, but greater than zero. The standard deviation at this concentration is then calculated.

The Instrument Detection Limit (IDL) establishes the noise level of the instrument under routine operating conditions.

The Practical Quantitation Limit (PQL) establishes a limit with a higher level of precision than associated with the detection limit, but does not represent the lowest achievable detection limit.

Each site specific QAPjP will identify IDLs, MDLs, and PQLs for each method, where applicable.

8.0 DATA REDUCTION, VALIDATION, AND REPORTING

8.1 DATA REDUCTION

8.1.1 Field and Technical Data Reduction

Field personnel will record all field data in bound field notebooks and on standard forms. After checking the validity of the data in the field notes, the Site Field Manager or his designee will reduce the data to tabular form, when possible, by entering the data into data files. Where appropriate, the data files will be set up for direct input into the project database. Subjective data will be filed as hard copies for later review by the Project Manager and incorporation into technical reports, as appropriate.

8.1.2 Laboratory Data Reduction

Data reduction is the process by which raw analytical data generated from laboratory instrument systems is converted into usable concentrations. The raw data, which may take the form of area counts, instrument responses or observations, is processed by the lab and converted into concentrations expressed in the parts-per-million or parts-per-billion range. Raw data from these systems include compound identifications, concentrations, retention times, and data system print-outs. Raw data is usually reported in graphic form, bar-graph form, or tabular form. The laboratories will follow SOPs consistent with the data handling requirements of the applicable methods.

The Laboratory Reporting Limits for all Fort Drum projects must be less than or equal to those stipulated by the NYSDEC. The reporting limits are presented in Appendix D.

8.2 VALIDATION

8.2.1 Field and Technical Data Validation

Validation of objective field and technical data will be performed at two different levels. The first level of data validation will be performed at the time of collection by following standard procedures and quality control checks. The Site Field Manager who will review the data to ensure that the correct codes and units have been included will complete the second level of data validation. After data reduction into tables and arrays is complete, the Field Manager will review data sets for anomalous values. The Project Manager, who will review field reports for reasonableness and completeness, will validate subjective field and technical data. In addition, the Field Manager and/or Site QA/QC Coordinator will make random checks of sampling and field conditions.

8.2.2 Analytical Data Validation

The laboratory shall review data prior to its release from the laboratory. Objectives for review are in accordance with the QA/QC objectives stated in section 3.0 of this document. The laboratory is required to evaluate their ability to meet these objectives. Outlying data shall be flagged in accordance with laboratory SOPs and corrective action shall be taken to rectify the problem.

Decisions made during the RCRA Corrective Action program regarding the release(s) of hazardous constituents, the nature and extent of contamination, and the effectiveness of the corrective measures(s) will depend upon data generated during each phase of the program. That data must be valid in order to support these decisions. Therefore, the validation of field data and data generated by the analytical laboratory is crucial to a project. In order to ensure the validity of analytical data generated by a project, it must be validated by an individual other than the analyst(s) and independent from the project. The QAPjP must address implementation of independent validation.

Data packages generated and received from each laboratory will be validated from one of the following data validation guidelines; each QAPjP must cite the protocol used to evaluate analytical data:

1. Following the “intent” of the National Functional Guidelines for Organic and Inorganic Data Review (the current data validation guidelines can be found on the internet address):
   www.epa.gov/oerrpage/superfund/programs/clp/guidance.htm; or

2. USEPA Region II developed and approved data validation for SW-846 methodologies (current data validation guidelines can be found on the internet address):
   www.epa.gov/region02/smb/sops.htm; or

3. New York State Department of Environmental Conservation Division of Environmental Remediation Guidance for the Development of Data Usability Summary Reports (revision 6/99) located in Appendix F. (NYSDEC contact number (518) 457-3363)

A trained individual who has not been involved in the site sampling or analysis will perform the data assessment. Data will be subject to a data assessment consisting of a review of the following quality controls:

1. Method Blanks: Measure of laboratory contamination. Control limits - detected results should be less than their respective MDL.

2. Field Rinsate Blanks: Measure of field contamination. Control limits - detected results should be less than their respective MDL.

3. Trip Blanks: Measure of field/transport contamination. Control limits - detected results should be less than their respective MDL.

Furthermore, the analytical method performance will be determined by an examination of precision, accuracy, and completeness, as discussed in Section 3.0, by a review of the following quality controls:

1. Laboratory Duplicates: Measure of laboratory precision.

2. Field Duplicates: Measure of field sampling and laboratory precision.

3. Matrix Spikes: Measure of laboratory accuracy and any sample matrix effects.

4. Surrogate Spike Recoveries: Measure of laboratory accuracy.

5. Laboratory Control Samples: Measure of laboratory accuracy.

A narrative describing how the data did or did not meet the validation criteria must be part of the data validation procedure. The validation assessment must describe the overall quality of the data and the data validation report must provide a written statement upon completion of the validation indicating whether or not the data are valid and usable, and shall also include a percent completeness value of usable data.

8.2.3 Data Validation Levels

Data validation for samples collected from Fort Drum will fall into 3 levels, which must be cited in the QAPjP:

Level I – an independent data validation is not performed; a visual check to determine if data make sense.

Level II - minimal data validation effort; some QC indicators, such as blanks to identify laboratory contamination, and surrogates and matrix spikes to evaluate matrix interferences shall be reviewed.

Level III – a comprehensive data validation effort, includes review of all QC and a minimum 10% review of raw data and calculations.

8.3 REPORTING

8.3.1 Field Measurements

Any field analysis results will be recorded in a dedicated field logbook at the time the results are available. The results will be tabulated and plotted in the office as part of the reporting tasks. Reports will also consist of the field logbook, required standard forms, photographic documentation, and Daily Quality Control Reports (DQCRs).

8.3.2 Analytical Data

The content of analytical laboratory data packages designed for work conducted at Fort Drum shall be site specific and shall include the following information:

A. Level I

1. Results only.
2. Reference for analytical methodology used.

3. General discussion including a description of sample types, tests performed, any problems encountered, and any general comments.

4. Data from each discrete sample reported using cross-referencing between normal samples and quality control samples and including all pertinent dates, information, and reporting limits.

5. Copies of chain-of-custody sheets.

B. Level II

1. Pertinent physical data presented in concise, easy to follow formats (i.e., sample number, client, date of sample preparation, date analyzed, percent moisture, etc.).

2. Reference for analytical methodology used.

3. General discussion including a description of sample types, tests performed, any problems encountered, and any general comments.

4. Data from each discrete sample reported using cross-referencing between normal samples and quality control samples and including all pertinent dates, information, and reporting limits.

5. Reported data to include associated quality control samples such as blanks, spikes and spike duplicates, laboratory duplicates, field duplicates, and appropriate check standards.

6. Copies of chain-of-custody sheets.

C. Level III

1. Pertinent physical data presented in concise, easy to follow formats (i.e., sample number, client, date of sample preparation, date analyzed, percent moisture, etc.).

2. Reference for analytical methodology used.

3. General discussion including a description of sample types, tests performed, any problems encountered, and any general comments.

4. Data from each discrete sample reported using cross-referencing between normal samples and quality control samples and including all pertinent dates, information, and reporting limits.

5. Reported data to include associated quality control samples such as blanks, spikes and spike duplicates, laboratory duplicates, field duplicates, and appropriate check standards.

6. Copies of chain-of-custody sheets.

7. Raw data.

8.3.3 Fort Drum Databases

Analytical results may require input in the Fort Drum IRP Database. Appendix H cites the format requirements of this database. Should this format undergo future revisions, the newly established Fort Drum database format shall be included as an attachment in the QAPjP.

Hazardous Waste sampling and characterization is maintained by Fort Drum in the Fort Drum Hazardous Waste Database. This database includes the following information for each sample collected: sample ID; sampling event number; requestor; media state; date sampled; container type; media type; sampling frequency; site location; turn-around-time; chemical analysis; waste code, and other exceedences (i.e., used oil criteria).

9.0 INTERNAL QUALITY CONTROL

9.1 FIELD QUALITY CONTROL

The QC checks employed for field instruments include the following:

QC Method	Purpose	Frequency
Calibration Check	Ensures proper working order of field instrument. Measures accuracy and sensitivity.	Daily
Field Duplicate Sample	Measures instrument precision.	10% (unless stated otherwise in QAPjP)
Field Rinsate Blanks	Measures cross-contamination.	1 per equipment type per decontamination event

9.2 LABORATORY QUALITY CONTROL

All analyses shall include the following QC procedures, where applicable:

Procedure	Frequency
Calibration	As required
Standards	Daily
Method Blanks	Daily
Duplicates	5%
Matrix Spikes	5%
Surrogates	Each sample
QC Check Samples	Daily

9.3 QUALITY CONTROL SAMPLES

The QA/QC samples that will be required for the sampling program shall be identified in the Site Specific QAPjPs. Samples collected for the Hazardous Waste sampling and characterization program do not require QA/QC samples. The types of samples are described below:

Field Sample - The total sample collected at a specific site location. This sample may be any matrix and may be divided to provide material for QA/QC analysis.

Quality Control (QC) Samples - Samples analyzed to help identify potential problems related to sample collection or analysis. QC samples include replicate and split samples, trip blanks, rinsate blanks and filtration blanks.

Quality Assurance (QA) Samples - Split samples sent to Army Corps laboratory for analysis to evaluate the contractor laboratory performance. QA samples represent approximately 10% percent of the field samples.

Matrix Spike/Matrix Spike Duplicates - Aqueous VOC and extractable organic samples collected at three times their standard volume at the frequency of approximately five percent (5%) of the field samples. After sample analysis, the additional sample volume is spiked with a known quantity and reanalyzed. The percent recovery will be used to calculate accuracy. The relative percent difference (RPD) for each component will be used to calculate precision.

Split Samples - Samples collected as a single sample, homogenized, divided into two or more equal parts and placed into separate containers. The sample shall be split in the field prior to delivery to the laboratory. Split samples will be taken at a frequency of approximately 10% per matrix.

Replicate (duplicate, triplicate, etc.) Samples - Multiple grab samples, collected separately, that equally represent a medium at a given time and location. This is the type of co-located sample required for volatile organic analyses and most ground water and surface water samples. Replicate samples will be taken at a frequency of approximately 10% per matrix.

Filtration Blank - When groundwater samples are filtered prior to collection and analysis, a filtration blank is collected. Deionized water is run through a clean filter and submitted as a blank sample to assess the potential for contamination by the filter/filtration process. The filter shall be identical as those used for the field sample filtering.

Trip Blank – Laboratory-prepared containers of organic-free reagent water that are kept with the field sample containers from the time they leave the laboratory until the time they are returned to the laboratory. The purpose of the trip blank is to assess the potential of sample contamination during transit or sample collection. Trip blanks are only required to accompany aqueous VOC samples, and will be analyzed with the associated VOC samples. One trip blank per sample cooler will be sent when sampling for aqueous VOCs.

Field Rinsate Blank - Samples collected from a final rinse of sampling equipment with deionized demonstrated analyte-free water after the decontamination procedure has been performed. The purpose of the field rinsate blank is to determine whether the sampling equipment is causing cross-contamination of samples. The frequency of field blank collection is dependent on the number of decontamination events; i.e., one field blank per decontamination event per equipment type. The number of field blanks should not exceed one per day. Field blanks must be preserved in the same manner as aqueous environmental samples.

Deionized Demonstrated Analyte-Free Water - Deionized demonstrated analyte-free (DI) water is water of a known quality which has been demonstrated through analysis not to possess any contaminants of concern at levels greater than the CLP contract required quantitation limits (CRQLs), as defined in the current CLP Statements of Work (SOW). DI water is used in the final rinse step of decontamination and in the preparation of field rinsate blanks.

10.0 PERFORMANCE AND SYSTEM AUDITS

Audits will include a careful evaluation of both field and laboratory quality control procedures and will be performed before or shortly after systems are operational. The audits will be conducted by an individual who is technically knowledgeable about the operation(s) under review. Systems audits provide a quantitative measure of the quality of the data produced by one section or the entire measurement process. Performance audits are conducted by introducing control samples into the data production process. These control samples may include performance evaluation samples, field samples spiked with known amounts of analyte, and split field samples that are analyzed by two or more analysts within or without the organization. Systems audits are onsite qualitative inspections and reviews of the quality assurance system used by some part of or the entire measurement system. The audits are performed against a set of requirements, which may be a quality assurance project plan or work plan, a standard method, or a project statement of work. The primary objective of the systems audits is to ensure that the QA/QC procedures are being followed.

10.1 FIELD AUDIT PROCEDURES

Field performance audits will be conducted on an ongoing basis during the project as field data are generated, reduced, and analyzed. All numerical manipulations, including manual calculations, will be documented. All records of numerical analyses will be legible, of reproduction-quality, and sufficiently complete to permit logical reconstruction by a qualified individual other than the originator.

Indicators of the level of field performance include the analytical results of the blank and replicate samples. Each blank analysis will be considered an indirect audit of the effectiveness of measures taken in the field to ensure sample integrity (e.g., field decontamination procedures). The results of the field replicate analyses are an indirect audit of the ability of each field team to collect representative sample portions of each matrix type.

System audits of site activities will be accomplished by an inspection of all field site activities. During this audit, the auditor(s) will compare current field practices with standard procedures. The following elements will be evaluated during a field system audit:

1. All activities conducted in accordance with the Work Plan;
2. All procedures and analyses conducted according to procedures outlined in the QAPP;
3. Sample documentation;
4. Working order of instruments and equipment;
5. Level of QA conducted per each field team;
6. Contingency plans in case of equipment failure or other event preventing the planned activity from proceeding;
7. Decontamination procedures;
8. Level of efficiency with which each team conducts planned activities at one site and proceeds to the next; and
9. Sample packaging and shipment.

After completion of the audit, any deficiencies will be discussed with the field staff and corrections identified. If any of these deficiencies could affect the integrity of the samples being collected, the auditor(s) will inform the field staff immediately, so that corrections will be implemented immediately. The audit will be performed by the Project QA/QC Coordinator or the Site Field Manager. The audit form is presented as Figure 10-1 in Appendix G.

10.2 LABORATORY AUDIT PROCEDURES

10.2.1 Systems/Internal Audits

As part of its Quality Assurance Program, the Laboratory Quality Assurance Manager shall conduct periodic checks and audits of the analytical systems. The purpose of these is to ensure that the analytical systems are working properly and that personnel are adhering to established procedures and documenting the required information. These checks and audits will also assist in determining or detecting where problems are occurring.

The Quality Assurance Manager will periodically review laboratory control samples. These samples will check the entire analytical method, the efficiency of the preparation method and the analytical instrument performance. The results of the control samples are reviewed by the Quality Assurance Manager. The Quality Assurance Manager reports the results to the analyst and the Laboratory Manager. When a problem is indicated, the Quality Assurance Manager will assist the analyst and laboratory management in determining the reason and in developing solutions. Rechecking of systems will be conducted by the Quality Assurance Manager as required.

10.2.2 Performance and External Audits

In addition to conducting internal reviews and audits, as part of its established Quality Assurance program, the laboratory is required to take part in regularly scheduled Performance Evaluations and laboratory audits from State and Federal agencies. These are conducted as part of certification processes and to monitor the laboratory performance. These provide an external quality assurance check of the laboratory and provide reviews and information on the management systems, personnel, SOPs, and analytical measurement systems. Acceptable performance on evaluation samples and audits is required for certification and accreditation. The laboratory shall use the information provided from these audits to monitor and assess the quality of its performance. Problems detected in these audits shall be reviewed by the Quality Assurance Manager and laboratory management and corrective action shall be instituted as necessary.

11.0 PREVENTATIVE MAINTENANCE

11.1 INTRODUCTION

A preventative maintenance program is necessary to help prevent delays in project schedules, poor output performance or erroneous results in investigative operations. Preventative maintenance on laboratory analytical equipment used in this program will be performed contractually by qualified personnel. Maintenance of field equipment will be performed routinely for sampling events. More extensive maintenance will be performed based on hours of use, by a qualified servicing organization. Repairs, adjustments and calibrations will be recorded.

11.2 FIELD EQUIPMENT

The three elements of the field equipment maintenance program include normal upkeep of equipment, service and repair (when required), and formalized record-keeping of all work performed on each piece of equipment. This section addresses the normal equipment upkeep element of the maintenance program. For most of the equipment, normal maintenance will consist of cleaning outside surfaces, lubrication of all moving parts, and, if applicable, a battery level check and recharge or replacement as necessary. This program will include the maintenance of all monitoring, measuring, and test equipment returning from use or any equipment used on a daily basis. The frequency of maintenance checks will be dependent on the individual needs and use of each piece of equipment. Maintenance procedures will be only those necessary for keeping an instrument in service or in preparation for everyday use. It is beyond the scope of this document to cover repair procedures for each piece of equipment. Repair problems will be referred to the manufacturer or other qualified servicing organization.

The Project QA/QC Coordinator, or the designated task leader, will be responsible for keeping all maintenance records, making sure all equipment used is maintained properly, informing field team members of any specific maintenance requirements for equipment used at the site and shipping any instrument in need of repair to the correct source.

The field personnel responsibilities include maintaining each piece of equipment located at the site and the maintenance of equipment after use. A record of equipment maintenance and repair will be kept in the field logbook.

11.3 RENTAL EQUIPMENT

Rental equipment used on the project will be obtained only from a certified rental supplier. The equipment will require a pre-receipt to verify accuracy, maintenance and up-keep of the equipment. A receipt indicating that the equipment has been checked upon return will be required as well.

11.4 LABORATORY EQUIPMENT

An important factor in maintaining accuracy and precision, achieving required holding times, and addressing contract schedule is preventive maintenance. As part of the laboratory's standard operating procedures, service contracts are held on critical analytical instruments. Information on the maintenance of the laboratory equipment is provided in the QAPjPs.

12.0 DATA ASSESSMENT PROCEDURES

Data assessment procedures are detailed in Sections 3.0 and 8.0.

13.0 CORRECTIVE ACTION

13.1 INTRODUCTION

Corrective actions are those measures taken to rectify a laboratory or field measurement system that does not comply with this QAPP. The need for corrective action may be identified by system or performance audits or by standard QC procedures. The essential steps in the corrective action system are:

1. Identifying and defining the problem.
2. Assigning of responsibility for investigating the problem.
3. Investigating and determining the cause of the problem.
4. Determining a corrective action to eliminate the problem.
5. Assigning and accepting responsibility for implementing the corrective action.
6. Implementing the corrective action and evaluating its effectiveness.
7. Verifying that the corrective action has eliminated the problem.

A nonconformance is defined as an identified or suspected deficiency in an approved document (e.g., technical report, analysis, calculation, computer program); an item where the quality of the end item itself or subsequent activities using the document or item would be affected by the deficiency; or an activity that is not conducted in accordance with the established plans or procedures. Any staff member engaged in project work who discovers or suspects a nonconformance is responsible for initiating a nonconformance report (see Figure 13-1). The Project QA/QC Coordinator shall evaluate each nonconformance report and shall provide a disposition, which describes the actions to be taken. The Project Manager shall ensure that no further project work dependent on the nonconforming item or activity is performed until approval is obtained and the nonconformance report is closed out. If the nonconformance is related to material, the Project Manager shall be responsible for marking or identifying, with the nonconformance report number, the nonconforming item (if practical) and indicating that it is nonconforming and is not to be used.

Samples that are analyzed prior to the resolution of a nonconforming event will be resampled, and/or reanalyzed once the corrective action has been demonstrated to be effective.

A copy of each closed nonconformance report shall be included in the quality assurance file. Copies of all nonconformance reports shall be maintained by the Project QA/QC Coordinator.

13.2 FIELD CORRECTIVE ACTION

At the end of each sampling day, the sampling team shall report any problems requiring corrective action which were encountered during the day. Corrective action will be undertaken when a non-conforming condition is identified. A non-conforming condition occurs when QA objectives for precision, accuracy, completeness, representativeness or comparability are not met, or when procedural practices or other conditions are not acceptable. A report shall be filed which documents the problems encountered and the corrective action implemented. A stop-work order may be issued by the Project QA/QC Coordinator, upon authorization by the Project Manager, if corrective action does not adequately address a problem, or if no resolution can be reached.

13.3 LABORATORY CORRECTIVE ACTION

If a particular analysis is deemed "out-of control," corrective action will be taken to ensure continued data quality. Actions which may be taken include, but are not limited to:

- Rechecking calculations,
- Checking QC data on other samples,
- Auditing laboratory procedures,
- Reanalyzing the sample if the holding time requirements have not been exceeded,
- Accepting data with the acknowledged level of uncertainty, and

- Discarding data.

The coordinator of the laboratory's analytical section will be responsible for initiating laboratory corrective action when necessary. Recommendations for corrective actions outside the laboratory will be made by the laboratory QA Manager to the Project Manager. Additional information is presented in Site Specific QAPjPs.

14.0 QUALITY ASSURANCE REPORTING

14.1 DAILY QUALITY CONTROL REPORT

A Daily Quality Control Report (DQCR) will be completed for each day of field activities. The report includes the weather during sampling, samples taken, instrument maintenance and calibration, and any field changes, problems or corrective actions. A sample report is presented as Figure 14-1 in Appendix G.

14.2 DATA REPORT TO THE QUALITY ASSURANCE LABORATORY

The raw data will be submitted to the quality assurance (QA) laboratory, when available, for data validation and comparison purposes. The data will include all blank, sample, and internal quality control results such as spike and surrogate recoveries, and replicate analyses.

14.3 QUALITY CONTROL SUMMARY REPORT

A Quality Control Summary Report (QCSR) will be submitted as part of the report of investigation activities. The QCSR may be incorporated into the field investigation report. The QCSR will address:

- Project Scope,
- Project Description,
- Sampling Procedures (planned vs. implemented),
- Field Quality Control Activities (planned vs. implemented),
- Analytical Procedures,
- Significant Problems with Analytical Procedures,

- Data Presentation and Evaluation,
- Quality Control Activities including Discussion of Data Reliability,
- Lessons Learned, and
- DQCR Consolidation.

The report will also discuss any corrective actions implemented in response to problems encountered during the project. Data packages and data assessment reports will be summarized.

15.0 REFERENCES

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EPA 200 Series – Methods for the Determination of Metals in Environmental Samples, EPA/600/4-91/010, June 1991.

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EPA 600 Series – 40 CFR, Part 136, Revised as of July 1, 1005. Appendix A to Part 136 – Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater.

EPA 600 Series – Methods for the Determination of Nonconventional Pesticides in Municipal and Industrial Wastewater – Volume I – EPA-821-R-93-010-A August 1993, Revision 1.

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Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846) – Third Edition, September 1986; Final Update I, July 1992; Final Update IIA, August 1993; Final Update II, September 1994; Final Update IIB, January 1995; Final Update III, December 1996.

USACE, 1994. Requirements for the Preparation of Sampling and Analysis Plans, September 1994.

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USACE, 1998. Monitoring Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Sites (EM 1110-1-4000, 1 Nov 98), page 8-1; and *Malcolm Pirnie* SOP for water level monitoring (appendix A of Gas Alley GW Monitoring Program Work Plan, May 2001).

USEPA, 1999. Contact Laboratory Program Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration, OLM04.2, October 1999.

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USEPA, 1991. User's Guide to the Contract Laboratory Program, January 1991, EPA/540/ P-91/002.

USEPA, 1989. Region II CERCLA Quality Assurance Manual, Final Copy, Revision 1., October, 1989.

USEPA, 1988a. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, October, 1988, EPA/540/G-89/004.

USEPA, 1987b. A Compendium of Superfund Field Operations, December 1987, EPA/540 87/001.

Variability in Protocols – Guy F. Simes, Risk Reduction Engineering Laboratory, Cincinnati, OH, September 1991.

FIGURE 13-1

NONCONFORMANCE AND CORRECTIVE ACTION REPORT

Date ________________

NCR No. ______________

Description of Nonconformance and Cause ____________________________________
____
____
____
____
____

Proposed Disposition ____
____
____
____
____
____

Submitted by: ____________________________ Date: _________________________
Approved by: ____________________________

DISPOSITION (by Project Manager or Designee)

Implementation of Disposition Assigned to: ____________________________________

Actual Disposition ____
____
____
____
____
____

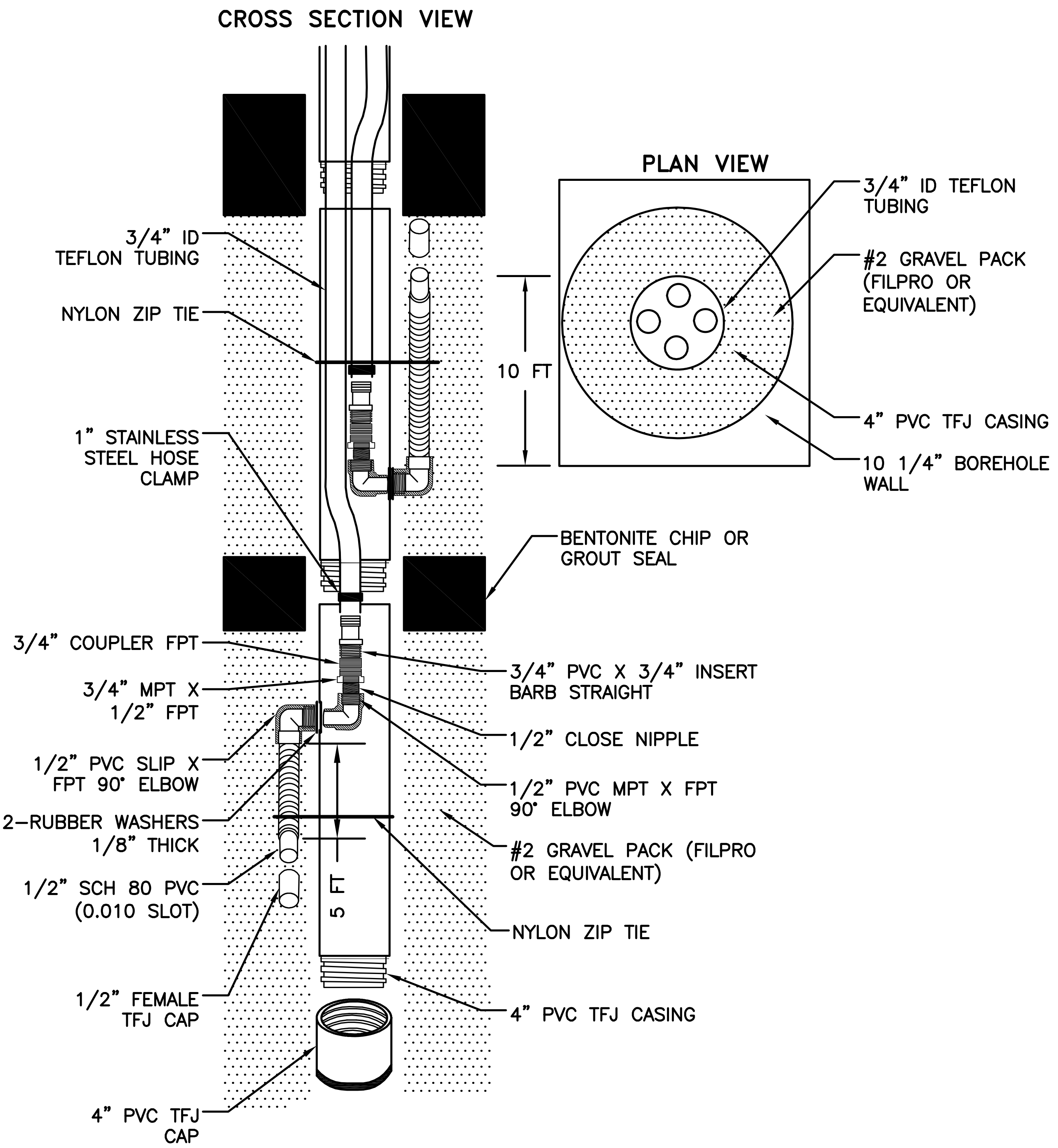
Disposition completed on: _______________________
Date

____
Signature

VERIFICATION
Disposition reviewed and work inspected by: ___________________ on ____________
Disposition verified by: __________________________________ on ______________
(Use additional sheet or memo if necessary)

Appendix C

Well Construction Diagrams



NOTE:
SWISS WELL DESIGNS. PROTECTED BY U.S. PATENT LAW.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY

OASIS FUEL POINT
FORT DRUM, NEW YORK

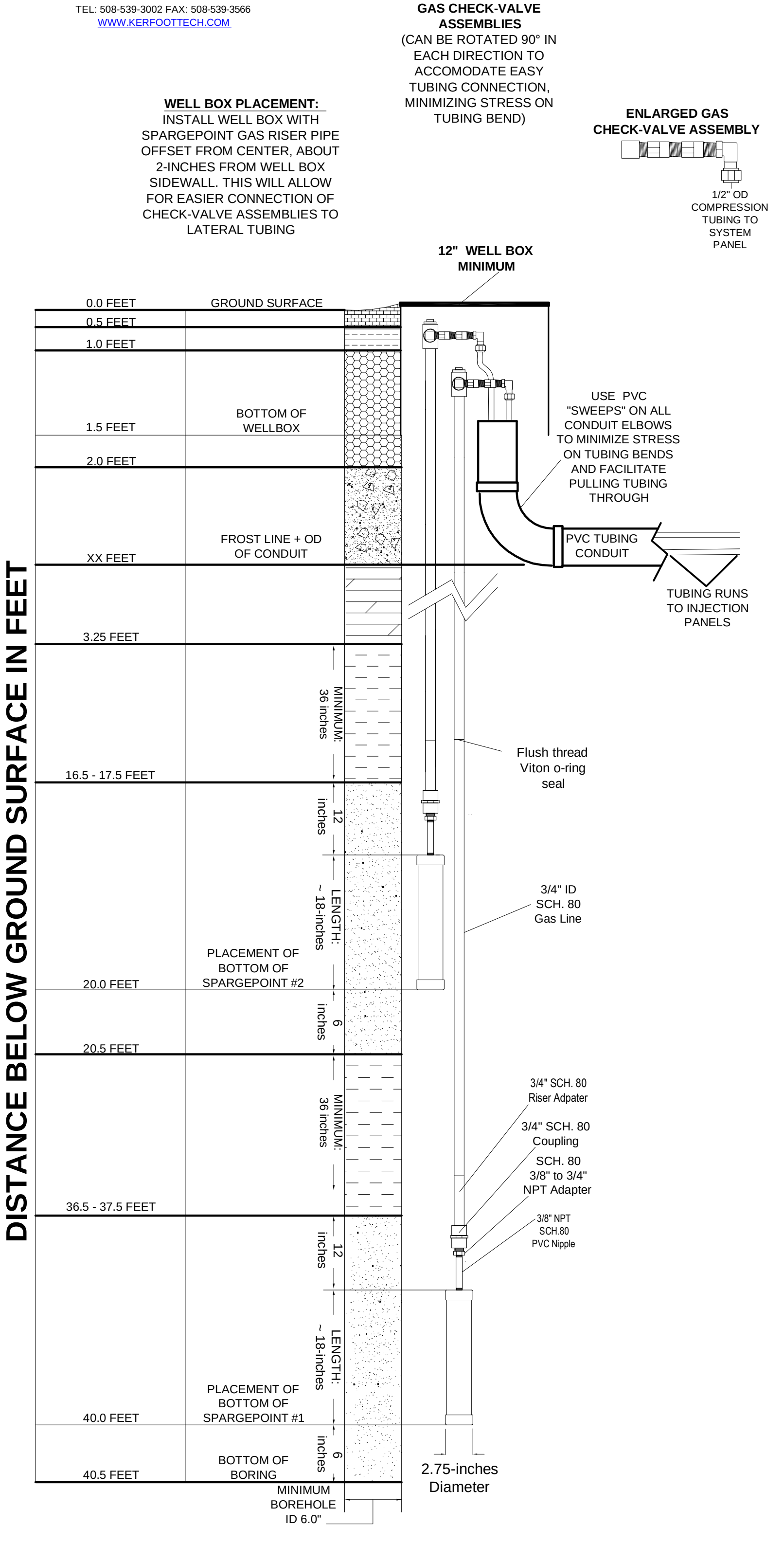
MULTIPORT INTERVAL DETAIL

PROJECT MGR	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	DATE	PROJECT NO	FIGURE
CJS	-	AAS	JH	NO SCALE	OCT 2011	6239301	2

DRAWING NAME: F:\Federal\DOD\Fort Drum\Oasis 2011\wells\Oasis WP Wells.dwg
DATE:10/17/2011 TIME:14:53 DRAWN BY: astreit

DUAL NESTED SPARGEPOINT® INSTALLATION AND CONSTRUCTION DIAGRAM

KERFOOT TECHNOLOGIES, INC.
766B FALMOUTH ROAD, MASHPEE, MA 02649
TEL: 508-539-3002 FAX: 508-539-3566
WWW.KERFOOTTECH.COM



BOREHOLE BACKFILL LEGEND

░	FINE/MEDIUM FILTER "***sugar***" SAND (PASSES GREATER THAN 60 MESH SEIVE)	▨	BACKFILL	▦	CONCRETE
▤	SLOW RELEASE BENTONITE PELLETS (NOT CHIPS)	▩	PEA GRAVEL (FOR DRAINAGE)		
▧	GROUT MIXTURE (20% BENTONITE POWDER AND 80 % PORTLAND CEMENT)	▤	DENSE GRADE ROAD BASE		

CONFIRM BOREHOLE BACKFILL DEPTHS WITH DROP WEIGHT ALWAYS!

MOST IMPORTANT ASPECTS TO ENSURE SUCCESSFUL REMEDIATION

A. 60 Mesh (sugar) sand must be installed around the spargepoint
B. A minimum 3ft of bentonite pellets must be placed between each laminar spargepoint.
C. Use a drop weight to **check** position and depth of spargepoint, sand, and bentonite.
D. A check valve must be placed at the wellhead.

SPARGEPOINT INSTALLATION INSTRUCTIONS

1. Drill a minimum of a **6-inch Inside Diameter** auger boring to desired depth.

2. Lay out spargepoint assembly parts.

3. Place spargepoint into borehole and snugly tighten 5-foot threaded sections of casings onto spargepoint adapter, **making sure** casing thread has a black viton O-ring, while lowering the assembly down the borehole.

4. Overdrill borehoole and tremie sand filter pack to 0.5 ft below to 1ft above each spargepoints with 60 mesh sand (sugar sand). **Do not rush allowing filter sand to settle or bridging and/or breakthrough of grout or bentonite may occur and clog spargepoint.**

5. Tremie bentonite beads a minimum of 3ft in thickness above the sand pack, between the spargepoints.

6. Tremie or back fill grout mixture to bottom of conduit trench (20% Bentonite Beads, 80% Portland Cement). **Make sure the grout mixture is well mixed, avoid any dry nodules. Test the mixture to make sure it is below 110 degrees F when injected. To alleviate some of the heat created from the grout mixture, native sand can be added to the grout mixture.**

7. Complete backfilling with a drainable pea gravel. The Spargepoint casing should be filled with **distilled water** when installation is complete. You can inject/pour it down the gas casing.

   Spargepoints should be enclosed and protected using a road box or well box assembly.

Appendix D

Ozone Calculations and Assumptions

COMMENT WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01
SUBJECT: Oasis - Ozone Loading Rates Calculations
BY: BS CHECKED BY: MH DATE: 11/16/2011

PROBLEM STATEMENT

The expected oxidant demand is the sum of the stoichiometric VOC demand, oxidizable metals demand, and soil demand. A procedure for ozone demand calculations for MTBE, as a primary constituent, was published in the MTBE Remediation Handbook (E.E. Moyer and P.T. Kostecki, eds., Amherst Scientific Publishers, Amherst, MA, 2003). The calculations were performed for the 30-day pilot test. First, the total mass of aqueous and adsorbed fractions are determined for a cone surrounding the proposed dual (double vertical) point system.

ASSUMPTIONS

1. Ozone output: 3 lbs/day = 1,361 gms/day
   For 30 days operation = 40,830 gms O_3

2. Soil type: sandy, medium to fine

3. Vertical depth of contamination: approximately 14.6 m (in the area of MW-16 and MW-28)

4. Porosity: ~0.30

5. Current aqueous VOC mean concentration for pilot study: approximately 500 ug/L
   MTBE 160 µg/L = 0.16 mg/L
   Benzene 190 µg/L = 0.19 mg/L
   Naphthalene 120 µg/L = 0.12 mg/L
   Other 30 µg/L = 0.03 mg/L

6. Liquid volume = VL = (1/3) π r 2 h n (conservatively assumes a parabolic angle of 55 degrees for a medium sand – likely angle will be less than 55 degrees):
   = $(1/3)(3.14)(20.9\text{m})^2$ *14.6m (.30)
   = 2,006 m^3
   = 2,006,560 liters
   Assumed Contaminant Mass
   MTBE = 321 grams
   Benzene = 381 grams
   Naphthalene = 241 grams
   Other = 60 grams

7. Since the liquid/solid ratio is conservatively assumed at 1:1, an equivalent mass exists on the soil, yielding:
   Total MTBE mass = 642 grams
   Total Benzene mass = 762 grams
   Total Naphthalene mass = 482 grams
   Total Other VOC mass = 120 grams

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - Method 1: Ozone Loading Rates

BY: BS CHECKED BY: MH DATE: 11/16/2011

GIVEN Grams ozone per gram contaminant (Karpel vel Leitner, et al., 1994 ; Kerfoot, 2008):

MTBE = 3.0
Benzene = 3.4
Naphthalene = 3.0
Other = 3.9

FIRST Contaminant Oxidative Stoichiometric Demand (SD):

SD = (grams total mass of chemical) x (grams ozone per gram contaminant)

MTBE = 1,926 grams
Benzene = 2,592 grams
Naphthalene = 1,445 grams
Other = 470 grams

Total petroleum hydrocarbon SD = 6,433 grams

SECOND Soil Oxidative Demand (SOD):

No chemical oxidant demand (COD) soil samples have been collected. Formation soils are relatively low in organic content (foc at MW-15 is 0.3%). Atmospheric oxygen in air (20% oxygen) usually is normally sufficient for general oxidative demand. As an conservative approximation for sandy soils, 30% of stoichiometric demand (SD) is used.

SOD = 0.3 x 6,433 grams
SOD = 1,930 grams O_3

THIRD Ferrous Iron Demand:

Commonly, the ferrous iron demand appears filled by oxygen (O_2), but it is conservatively computed since the reaction with ozone is faster.

$O_3 + 2Fe^{2+} = Fe_2O_3$

Previous computation of ferrous iron for assumed conical ROI = 7,424 grams
By stoichiometry, ½ ferrous iron mass would be ozone demand = 3,712 grams

FOURTH Total Oxidant Demand (Total spargewell ozone ROI demand):

= SD + SOD + Ferrous Iron Demand
= 12,075 grams

CALCULATION WORKSHEET

CLIENT:	USACE	JOB NUMBER:	62393.01
SUBJECT:	Oasis - Method 2: Calculation A - Flux of Contaminants into ZOI		
BY:	BS	CHECKED BY: MH	DATE: 11/16/2011

FIRST Total Liquid Content:

Volume = (1/3) π r^2 h

Angle of Cone (From Vertical) = 55 degrees
Depth of Submergence (h) = 48 ft
Porosity = 0.3

Radius (Opposite side) = Adjacent side x Tangent(55)
= 48 ft x tan(55)
= 68.6 ft
= 20.9 m
= 0.96 radians

Volume = 70,861 cubic ft
= 2,006,560 liters
= 2,006,559,759 grams (mL)

SECOND Cross-Sectional Area of Flow:

Area = (1/2) b h ft^2
= 1,645 ft^2
Velocity = 0.66 ft/day
Time = 30 days

Cross-Sectional Area = Velocity x Area x Time
= 32,575 ft^3
= 276,731 L (including 30% porosity)

THIRD Flux Rate of Contaminants into ZOI:

Contaminant	Mass (µg) (Volume x Conc)	Mass (g)	Oxidant Demand Factor	Stoichiometric Demand (g)
MTBE	44,276,885	44.28	3.0	133
Benzene	52,578,801	52.58	3.4	179
Naphthalene	33,207,664	33.21	3.0	100
Other VOCs	8,301,916	8.30	3.9	32

Total stoichiometric demand from 30 days of flux = 444 grams
Total oxidant provided over 30 days (includes auto-decom = 1373 grams
Oxidant:Demand ratio 3.10

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - Method 2: Calculation B - Ozone Degradation

BY: BS CHECKED BY: MH DATE: 11/16/2011

ASSUMPTIONS

Oxidant demand of 1 Liter of groundwater with 500 ug/L total VOCs:	0.0017	ug/L
Oxidant demand of 1 Liter of groundwater with 500 ug/L total VOCs:	1.7099	mg/L
Average ozone bubble velocity (EA internal calculations):	0.0008	m/min
Conversion:	1.33E-05	m/sec
Conversion:	4.37E-05	ft/sec
Conversion:	3.78	ft/day
Hypotenuse distance for a 55 degree cone to water table:	34.3	ft
Travel time for 34.3 ft assuming average ozone bubble velocity:	9.1	days
Half-life of gaseous ozone:	20	hours

FIRST Delivered Ozone Concentrations over Time:

Step	Intial Ozone Concentration (g/L)	Half-life Ozone Concentration (g/L)	Half-life Ozone Concentration (mg/L)	Cumulative Time (hrs)	Cumulative Time (days)
1	5.2000000	2.6000000	2600	20	0.8
2	2.6000000	1.3000000	1300	40	1.7
3	1.3000000	0.6500000	650	60	2.5
4	0.6500000	0.3250000	325	80	3.3
5	0.3250000	0.1625000	163	100	4.2
6	0.1625000	0.0812500	81	120	5.0
7	0.0812500	0.0406250	41	140	5.8
8	0.0406250	0.0203125	20	160	6.7
9	0.0203125	0.0101563	10	180	7.5
10	0.0101563	0.0050781	5.08	200	8.3
11	0.0050781	0.0025391	2.54	220	9.2
12	0.0025391	0.0012695	1.27	240	10.0

SECOND Remaining Mass of Ozone Considering Ozone Auto-Decomposition over Time and Distance:

Days from injection	Mass Injected (g)	Oxidant Mass Remaining (g)	Days from injection	Mass Injected (g)	Oxidant Mass Remaining (g)
30	1361	0.664550781	15	1361	0.664550781
29	1361	0.664550781	14	1361	0.664550781
28	1361	0.664550781	13	1361	0.664550781
27	1361	0.664550781	12	1361	0.664550781
26	1361	0.664550781	11	1361	0.664550781
25	1361	0.664550781	10	1361	1.329101563
24	1361	0.664550781	9	1361	2.658203125
23	1361	0.664550781	8	1361	5.31640625
22	1361	0.664550781	7	1361	10.6328125
21	1361	0.664550781	6	1361	21.265625
20	1361	0.664550781	5	1361	42.53125
19	1361	0.664550781	4	1361	85.0625
18	1361	0.664550781	3	1361	170.125
17	1361	0.664550781	2	1361	340.25
16	1361	0.664550781	1	1361	680.5

Total Oxidant Mass Remaining after 30 Days of Injection (g): **1373**

CALCULATION WORKSHEET

CLIENT:	USACE	JOB NUMBER:	62393.01
SUBJECT:	Oasis - Ozone Injection Pressure		
BY:	JCH CHECKED BY: DFC	DATE:	11/16/2011

GIVEN Sparging depths used for Oasis pilot test.

Shallow point	=	20	ft below the static water table elevation
Deep point	=	40	ft below the static water table elevation
Low air flow rate	=	3	cfm
High air flow rate	=	6	cfm

FIRST Hydrostatic Pressure

Pressure needed to displace the column of water standing in the well pipe.

$P_h = \rho_w g\ (z_s - z_w)$

$P_h = 0.43\ (z_s - z_w)$

P_h = hydrostatic pressure (g cm^{-1} s^{-2})

ρ_w g = density of the water (g/cm) x gravitational acceleration (cm/s)

= 0.43 psi per foot of water column

z_s = depth (cm) to the top of the IAS well screen

z_w = pre-sparging depth (cm) to sparge well free-water surface

SECOND Frictional Losses in Pipe

Head loss due to friction of fluid moving between the well head and the IAS well screen is negligible due to a combination of the low air flows, sparge point and piping diameters, and relatively short distance of piping (i.e., less than 100 ft).

THIRD Filter Pack Air-Entry Pressure

Although a filter pack will not be used due to the nature of the sparge point (which is installed in direct contact with surrounding soil), the backpressure resulting from air flow through the sparge point in a medium sand will be included in the estimation of the injection pressure (using both air flow rates) instead;

Backpressure (psi)	Air Flow (cfm)
3	3
6	6

FOURTH Formation Air-Entry Pressure

Table 2-2 of USACE guidance manual provides the P_e for site soil (fine-medium sand):

P_e = 0.44 psi

Shallow point/lower air flow (20 ft, 3 cfm)

P_e = [20 ft (of water) * 0.43 psi/ft] + 0.44 psi + 3 psi

= **12.04** psi

Deeper point/lower air flow (40 ft, 3 cfm)

P_e = [40 ft (of water) * 0.43 psi/ft] + 0.44 psi + 3 psi

= **20.64** psi

Shallow point/higher air flow (20 ft, 6 cfm)

P_e = [20 ft (of water) * 0.43 psi/ft] + 0.44 psi + 6 psi

= **15.04** psi

Deeper point/higher air flow (40 ft, 6 cfm)

P_e = [40 ft (of water) * 0.43 psi/ft] + 0.44 psi + 6 psi

= **23.64** psi

CALCULATION WORKSHEET

CLIENT: Ft Drum - Oasis JOB NUMBER: 62393.01
SUBJECT: Over Pressure Calculation: **Shallow Sparge Point**
BY: JCH CHECKED BY: DFC DATE: 11/16/2011

Objective:

This calculation estimates the overburden pressure of groundwater and soil at the injection point. Sparging pressures approaching this value could destabilize the formation.

Reference: USACE Engineering Manual EM 1110-1-4005 "Engineering and Design In-Situ Air Sparging", Section 5-3 "Design Guidance - Subsurface" (Equations 5-1 through 5-4)

Relevant Equations:

Equation

$$\textit{pressure}_{\text{soil column}} = (\textit{depth}_{\text{top well screen}})(\textit{s.g.}_{\text{soil}})(1 - \phi)(\textit{s.w.}_{\text{water}}) \quad (5\text{-}1)$$

$$\textit{pressure}_{\text{water column}} = (\textit{depth}_{\text{top well screen}} - \textit{depth}_{\text{water table}})(\textit{s.g.}_{\text{water}})(\phi)(\textit{s.w.}_{\text{water}}) \quad (5\text{-}2)$$

$$\textit{total overburden pressure} = \textit{pressure}_{\text{soil column}} + \textit{pressure}_{\text{water column}} \quad (5\text{-}3)$$

$$\textit{max. injection pressure} = (\text{SF})(\text{total overburden pressure}) \quad (5\text{-}4)$$

(with a minimum safety factor of 35 kPa or 5 psig)

Where:

$\textit{pressure}_{\text{soil column}}$ = Overburden Pressure due to Soil
$\textit{pressure}_{\text{water column}}$ = Overburden Pressure due to Water

			Inputs	
$\textit{depth}_{\text{top well screen}}$	=	Depth to top of well screen below ground surface	80	ft
$\textit{depth}_{\text{water table}}$	=	Depth to water table below ground surface	60	ft
$\textit{s.g.}_{\text{water}}$	=	Specific Gravity of Water	1	
$\textit{s.g.}_{\text{soil}}$	=	Specific Gravity of Soil Formation	2.65	
ϕ	=	Formation Porosity	30	%
$\textit{s.w.}_{\text{water}}$	=	Specific Weight of Water	62.4	lbs/ft^3
SF	=	Safety Factor	70	%

Calculations:

$\textit{pressure}_{\text{soil column}}$ = 9,260 lbs/ft^2

$\textit{pressure}_{\text{water column}}$ = 374 lbs/ft^2

$\textit{total overburden pressure}$ = 9,635 lbs/ft^2 = 66.9 psi

$\textit{max. injection pressure}$ = 6,744 lbs/ft^2 = 46.8 psi

Conclusions:

The design injection pressure of: 15.1 psi (at 6 cfm)
is below the allowable pressure of: 46.8 psi

CALCULATION WORKSHEET

CLIENT: Ft Drum - Oasis JOB NUMBER: 62393.01

SUBJECT: Over Pressure Calculation: **Deep Sparge Point**

BY: JCH CHECKED BY: DFC DATE: 11/16/2011

Objective:

This calculation estimates the overburden pressure of groundwater and soil at the injection point. Sparging pressures approaching this value could destabilize the formation.

Reference: USACE Engineering Manual EM 1110-1-4005 "Engineering and Design In-Situ Air Sparging", Section 5-3 "Design Guidance - Subsurface" (Equations 5-1 through 5-4)

Relevant Equations:

Equation

$pressure_{\text{soil column}} = (depth_{\text{top well screen}})\,(s.g._{\text{soil}})\,(1 - \phi)\,(s.w._{\text{water}})$ (5-1)

$pressure_{\text{water column}} = (depth_{\text{top well screen}} - depth_{\text{water table}})\,(s.g._{\text{water}})\,(\phi)\,(s.w._{\text{water}})$ (5-2)

$\text{total overburden pressure} = pressure_{\text{soil column}} + pressure_{\text{water column}}$ (5-3)

$\text{max. injection pressure} = (SF)\,(\text{total overburden pressure})$ (5-4)

(with a minimum safety factor of 35 kPa or 5 psig)

Where:

$pressure_{\text{soil column}}$ = Overburden Pressure due to Soil

$pressure_{\text{water column}}$ = Overburden Pressure due to Water

Symbol		Description	Inputs	Unit
$depth_{\text{top well screen}}$	=	Depth to top of well screen below ground surface	100	ft
$depth_{\text{water table}}$	=	Depth to water table below ground surface	60	ft
$s.g._{\text{water}}$	=	Specific Gravity of Water	1	
$s.g._{\text{soil}}$	=	Specific Gravity of Soil Formation	2.65	
ϕ	=	Formation Porosity	30	%
$s.w._{\text{water}}$	=	Specific Weight of Water	62.4	lbs/ft^3
SF	=	Safety Factor	70	%

Calculations:

$pressure_{\text{soil column}}$ = 11,575 lbs/ft^2

$pressure_{\text{water column}}$ = 749 lbs/ft^2

total overburden pressure = 12,324 lbs/ft^2 = 85.6 psi

max. injection pressure = 8,627 lbs/ft^2 = 59.9 psi

Conclusions:

The design injection pressure of: 23.8 psi (at 6 cfm)
is below the allowable pressure of: 59.9 psi

Appendix E

Iron Calculations

APPENDIX E
CALCULATING THE POTENTIAL FOR IRON FOULING DURING THE OASIS OZONE PILOT TEST

INTRODUCTION

Based upon the iron concentrations detected in groundwater samples collected at the site, specifically in MW-16 and in the area of the proposed pilot test, a potential for iron precipitation during ozone sparging, of theoretically significant amounts, warranted additional calculation. EA and Kerfoot Technologies, Inc. completed a series of calculations to estimate the potential for iron precipitation over a number of potential radii of influence (ROI), as well as a number of conceptual models for ozone and water flow regimes.

UPDATE TO THE CONCEPTUAL SITE MODEL FOR THE SPARGING SYSTEM

Under the current conceptual model, several flow conditions may exist and should be accounted for when considering the results of the attached iron precipitation calculations (Attachment A). Also, it should be noted that the attached calculations are conservative in nature based upon influent iron concentrations.

1) **Permeability and Zone of Influence—**Horizontal permeability is greater than vertical; therefore, some lateral flow, in addition to vertical flow, of ozone is likely to occur at depth. The current understanding of flow regimes associated with transport of ozone injected using a diffuser involves a percentage of micro-bubble and channel flow both outward and upward from the sparge point. Based upon modeling results presented by K. Reddy and J. Adams[1], anticipated angles for conical zone of influence (ZOI) development range from between approximately 15 and 55 degrees from vertical. This equates to an approximate ROI, as observed at the water table surface, ranging from 12 to 69 ft; respectively (assuming 48 ft of submergence for the deep pilot sparge point).

2) **Horizontal Groundwater Flow—**Natural groundwater flow and the resulting transport of iron, is considered to be predominately horizontal in nature. Also, it is assumed that iron precipitation will occur wherever oxidizing conditions exist, within the ZOI as defined above. As iron enters the ZOI it is oxidized, which decreases the available iron mass within the groundwater over time. Under steady state conditions, the ZOI will have developed to the point that the iron concentration near the injection point will likely be less than the iron concentration upgradient of the ZOI. Therefore, while the maximum observed iron concentrations are applicable to assessing potential formation plugging, they are not directly applicable to small scale estimations of iron precipitation, i.e., immediately adjacent to the sparge point.

3) **Vertical Groundwater Flow—**It is conceivable that during injection, as coalescence of bubbles occurs, upward transport of the larger bubbles will also occur. This upward

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[1] Reddy, K. and Adams, J. 2008. Conceptual Modeling of Air Sparging for Groundwater Remediation, ISEGGSD

transport of bubbles could potentially create a slight upward hydraulic flow gradient drawing some water from beneath the sparge point into the ZOI. However, the likelihood of such an occurrence resulting in significant additional amounts of influent water to the ZOI is considered minimal under the current conceptual model due to the volume of ozone/air planned for injection.

4) **Sparge Point Reflux—**Potential for "reflux" of water within the sparge point exists during pulsed operation due to the compressibility of air versus water. According to Kerfoot Technologies, Inc., this reflux is typically limited to approximately 1 ft of water with the sparge point itself, as long as the check-valve system is operating. Given the entry of groundwater into the sparge point with dissolved ozone the potential for precipitation of iron within the point exists. This potential is more significant if additional water column were present within the point under the scenario where the check valves are not functioning as designed.

IRON PRECIPITATION CALCULATION RESULTS

The method to calculate iron precipitation originated with Kerfoot Technologies, Inc. and was expanded by EA, to include the assumptions as outlined above and general assumptions related to aquifer, iron concentration, and site specific parameters. The calculations assume a conservative scenario for iron precipitation; whereby, saturation of the ZOI with ozone has been achieved. Additionally, influent iron concentrations are assumed to be equal to the maximum observed total iron concentration, which is conservative, as not all iron detected at the site is ferrous and, therefore, would not as readily precipitate with ozone. Only calculation of iron precipitation for the ZOI for the lower sparge point has been completed, as the ZOI for the lower point will likely envelop the ZOI of the upper point.

1) **Formational Plugging—**Two sets of calculations were completed for the lower sparge point. The calculations use the total volume of fluid, converted to mass of fluid, and the maximum detected iron concentration to estimate the mass of precipitate due to oxidation over a given volume of aquifer. This is expressed as a percentage of precipitate mass to pore volume, or mass of water within pore spaces, which can be used as a general indicator of formational plugging. That value is then modified to account for the differential mass of iron to water and is used to generate a volumetric ratio of iron precipitate to water, which is expressed in the calculations as formational plugging. The calculation is then expanded to include the number of groundwater flow through cycles per year and multiplied by the number of years of anticipated operation. The following table summarizes the results of the calculations and data sheets are attached.

Duration of Operation (yrs)	Percent Formational Plugging (15 Degree Conical ZOI)	Percent Formational Plugging (55 Degree Conical ZOI)
1	0.001	0.0002
5	0.006	0.0011
20	0.027	0.0047

While it is not expected that iron precipitation would occur linearly as depicted above, a review of the results above indicates that the anticipated formational plugging is generally not of an order of magnitude where ozone or groundwater flow will be significantly impeded within the duration of operation of the downgradient system.

2) **Sparge Point Plugging—**This set of calculations evaluates the potential for sparge point plugging under the reflux scenario whereby a static water column enters the sparge point during the periodic cessation of injection during pulsing and iron has the potential to precipitate within the sparge point itself. Two sets of calculations were completed for the lower sparge point. The calculations use the total volume of fluid within the sparge point under normal pulsing and then under the scenario where the check valves have failed. Based upon Kerfoot Technologies, Inc. experience and case study data associated with sites with similar geologic properties and iron concentrations, the resultant iron concentrations within the sparge point during pulsed operation would likely be between <0.03 mg/L and 0.20 mg/L, with a mean concentration of approximately 0.11 mg/L. Porosity of the sparge point media is assumed to be approximately 40 percent with an average pore diameter of approximately 200 microns. Porosity of the sparge point media is assumed to be approximately 40 percent with an average pore diameter of approximately 200 microns. Accumulated iron precipitation within the point is assumed to be forced into the sparge point media, cyclically during pulsing, and the resulting percentage decrease in available porosity is calculated temporally. The following table summarizes the results of the calculations and the data sheets are attached.

Duration of Operation (yrs)	Percent Sparge point Plugging (Normal Check Valve Operation)	Percent Sparge point Plugging (Abnormal Check Valve Operation)
1	0.05	0.27
5	0.25	1.37
20	0.99	5.71

While it is not expected that iron precipitation would occur linearly as depicted above, a review of the results above indicates that sparge point plugging is generally not of an order of magnitude where ozone or groundwater flow will be significantly impeded within a year, as long as the check valves continue operating properly. However, it appears that under both check valve scenarios, a potentially significant decrease in porosity may be observed within the 5-year time period.

CONCLUSIONS

Based upon a review of the calculated results, accounting for the assumptions and qualifications identified in this document, the following conclusions can be drawn:

- Formational plugging is unlikely to significantly impact ozone injection capabilities for the anticipated duration of the downgradient ozone barrier system operation

- In the case of reflux occurring within the sparge point itself, the potential for iron plugging does exist; however, the degree of plugging is manageable through routine operations, maintenance, and rehabilitation techniques, as long as correct check valve operation is ensured.

RECOMMENDATIONS

Due to the potential for iron precipitation within the sparge point and the potential interference in operation of the sparging system, EA recommends the following:

- Monitoring of injection pressures and flow rates to check for decreased system performance indicative of potential plugging

- At least an annual inspection of reflux water within the sparge point bottom to check for the presence of iron precipitate

- Bi-annual replacement of the check valves to ensure continued fault-free operation and regular rehabilitation as required by observed decreased system performance, or every 3-5 years as a preventative measure.

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 1Y Formational Plugging 55 Deg Sheet 1 of 2

BY: BS CHECKED BY: MH DATE: 1/11/2012

ASSUMPTIONS Concentration (C): 3.7 mg/L

Total Liquid Content: Volume (V) = (1/3) π r2 h

Angle of Cone (From Vertical) = 55 degrees or 0.9599 radians
Depth of Submergence (h) = 48 ft
Porosity = 0.3

Radius (Opposite side) = Adjacent side x Tangent(55)
= 48 ft x tan(55)
= 68.5 ft
= 20.9 m

Volume = 70,852 cubic ft
= 2,006,294 liters
= 2.006E+09 grams (mL)

Total iron mass in liquid (V*C) = 7,423,289 mg
= 7,423 grams

FIRST Molecular Weight Equivalents

O3 -> = 48 g/mol
2Fe^2+ -> = 112 g/mol
equals = 160 g/mol
H2O -> = 18 g/mol

Therefore if Fe2+ = 7,423 g
Then O3 available = ((g/mol of O3) / (g/mol 2Fe^2+)) * g 2Fe^2+
equals = 3,181 gO3
So Fe2O3 = 10,605 g
Therefore Percent Fe2O3 to H2O = 0.0005286 %

SECOND Residence Time of Cylinder

	Avg Diameter ((2r/2)) (m)	Velocity (m/yr)	Equals	Units
d/v	20.8930	73.4	0.2846	yr
GW Cycle /yr			3.5131	times /yr

	Cycles	Mass per cycle (g)	Equals	Units
Monthly Precipitated Mass	0.2928	10,605	3,104.65	g
Annual Precipitated Mass	3.5131	10,605	37,255.78	g

	Number of years	Annual Precip. Mass	equals	Units
Life-cycle Precipitated Mass	1	37,256	37,255.78	g

THIRD Therefore Percent Fe2O3 to H2O = 0.0018569 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 1Y Formational Plugging 55 Deg Sheet 2 of 2

BY: BS CHECKED BY: MH DATE: 1/11/2012

FOURTH Alternative Calculation:
Accumulation of precipitate per month, accounting for decrease in available porosity

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 1	3,104.65	3104.6485	1.96527E-05
Month 2	3,104.65	6209.2971	3.93054E-05
Month 3	3,104.65	9313.9456	5.89582E-05
Month 4	3,104.65	12418.594	7.86109E-05
Month 5	3,104.65	15523.243	9.82636E-05
Month 6	3,104.65	18627.891	0.000117916
Month 7	3,104.65	21732.54	0.000137569
Month 8	3,104.65	24837.188	0.000157222
Month 9	3,104.65	27941.837	0.000176875
Month 10	3,104.65	31046.485	0.000196527
Month 11	3,104.65	34151.134	0.00021618
Month 12	3,104.65	37255.783	0.000235833

Fomational Plugging:

Therefore Percent Fe2O3 to H2O = 0.0002358 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01
SUBJECT: Oasis - 5Y Formational Plugging 55 Sheet 1 of 3
BY: BS CHECKED BY: MH DATE: 1/11/2012

ASSUMPTIONS Concentration (C): 3.7 mg/L

Total Liquid Content: Volume (V) = (1/3) π r2 h

Angle of Cone (From Vertical) = 55 degrees or 0.9599 radians
Depth of Submergence (h) = 48 ft
Porosity = 0.3

Radius (Opposite side) = Adjacent side x Tangent(55)
= 48 ft x tan(55)
= 68.5 ft
= 20.9 m

Volume = 70,852 cubic ft
= 2,006,294 liters
= 2.006E+09 grams (mL)

Total iron mass in liquid (V*C) = 7,423,289 mg
= 7,423 grams

FIRST Molecular Weight Equivalents

O3 -> = 48 g/mol
2Fe^2+ -> = 112 g/mol
equals = 160 g/mol
H2O -> = 18 g/mol

Therefore if Fe2+ = 7,423 g
Then O3 available = ((g/mol of O3) / (g/mol 2Fe^2+)) * g 2Fe^2+
equals = 3,181 gO3
So Fe2O3 = 10,605 g
Therefore Percent Fe2O3 to H2O = 0.0005286 %

SECOND Residence Time of Cylinder

	Avg Diameter ((2r/2)) (m)	Velocity (m/yr)	Equals	Units
d/v	20.8930	73.4	0.2846	yr
GW Cycle /yr			3.5131	times /yr

	Cycles	Mass per cycle (g)	Equals	Units
Monthly Precipitated Mass	0.2928	10,605	3,104.65	g
Annual Precipitated Mass	3.5131	10,605	37,255.78	g

	Number of years	Annual Precip. Mass	equals	Units
Life-cycle Precipitated Mass	5	37,256	186,278.91	g

THIRD Therefore Percent Fe2O3 to H2O = 0.00928473 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 5Y Formational Plugging 55 Sheet 2 of 3

BY: BS CHECKED BY: MH DATE: 1/11/2012

FOURTH Alternative Calculation:
Accumulation of precipitate per month, accounting for decrease in available porosity

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 1	3,104.65	3104.64855	1.96527E-05
Month 2	3,104.65	6209.2971	3.93054E-05
Month 3	3,104.65	9313.94564	5.89582E-05
Month 4	3,104.65	12418.5942	7.86109E-05
Month 5	3,104.65	15523.2427	9.82636E-05
Month 6	3,104.65	18627.8913	0.000117916
Month 7	3,104.65	21732.5398	0.000137569
Month 8	3,104.65	24837.1884	0.000157222
Month 9	3,104.65	27941.8369	0.000176875
Month 10	3,104.65	31046.4855	0.000196527
Month 11	3,104.65	34151.134	0.00021618
Month 12	3,104.65	37255.7826	0.000235833
Month 13	3,104.65	40360.4311	0.000255486
Month 14	3,104.65	43465.0797	0.000275139
Month 15	3,104.65	46569.7282	0.000294791
Month 16	3,104.65	49674.3768	0.000314444
Month 17	3,104.65	52779.0253	0.000334097
Month 18	3,104.65	55883.6739	0.00035375
Month 19	3,104.65	58988.3224	0.000373403
Month 20	3,104.65	62092.971	0.000393056
Month 21	3,104.65	65197.6195	0.000412709
Month 22	3,104.65	68302.2681	0.000432361
Month 23	3,104.65	71406.9166	0.000452014
Month 24	3,104.65	74511.5652	0.000471667
Month 25	3,104.65	77616.2137	0.00049132
Month 26	3,104.65	80720.8622	0.000510973
Month 27	3,104.65	83825.5108	0.000530626
Month 28	3,104.65	86930.1593	0.000550279
Month 29	3,104.65	90034.8079	0.000569932
Month 30	3,104.65	93139.4564	0.000589585
Month 31	3,104.65	96244.105	0.000609238
Month 32	3,104.65	99348.7535	0.000628891
Month 33	3,104.65	102453.402	0.000648544
Month 34	3,104.65	105558.051	0.000668197
Month 35	3,104.65	108662.699	0.00068785
Month 36	3,104.65	111767.348	0.000707502
Month 37	3,104.65	114871.996	0.000727155
Month 38	3,104.65	117976.645	0.000746808
Month 39	3,104.65	121081.293	0.000766461
Month 40	3,104.65	124185.942	0.000786115
Month 41	3,104.65	127290.59	0.000805768
Month 42	3,104.65	130395.239	0.000825421
Month 43	3,104.65	133499.888	0.000845074

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 5Y Formational Plugging 55 Sheet 3 of 3

BY: BS CHECKED BY: MH DATE: 1/11/2012

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 44	3,104.65	136604.536	0.000864727
Month 45	3,104.65	139709.185	0.00088438
Month 46	3,104.65	142813.833	0.000904033
Month 47	3,104.65	145918.482	0.000923686
Month 48	3,104.65	149023.13	0.000943339
Month 49	3,104.65	152127.779	0.000962992
Month 50	3,104.65	155232.427	0.000982645
Month 51	3,104.65	158337.076	0.001002298
Month 52	3,104.65	161441.724	0.001021951
Month 53	3,104.65	164546.373	0.001041604
Month 54	3,104.65	167651.022	0.001061258
Month 55	3,104.65	170755.67	0.001080911
Month 56	3,104.65	173860.319	0.001100564
Month 57	3,104.65	176964.967	0.001120217
Month 58	3,104.65	180069.616	0.00113987
Month 59	3,104.65	183174.264	0.001159523
Month 60	3,104.65	186278.913	0.001179176

Fomational Plugging:

Therefore Percent Fe_2O_3 to H_2O = 0.00117918 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01
SUBJECT: Oasis - 20Y Formational Plugging 55 Sheet 1 of 7
BY: BS CHECKED BY: MH DATE: 1/11/2012

ASSUMPTIONS Concentration (C): 3.7 mg/L

Total Liquid Content: Volume (V) = (1/3) π r2 h

Angle of Cone (From Vertical) = 55 degrees or 0.9599 radians
Depth of Submergence (h) = 48 ft
Porosity = 0.3

Radius (Opposite side) = Adjacent side x Tangent(55)
= 48 ft x tan(55)
= 68.5 ft
= 20.9 m

Volume = 70,852 cubic ft
= 2,006,294 liters
= 2.006E+09 grams (mL)

Total iron mass in liquid (V*C) = 7,423,289 mg
= 7,423 grams

FIRST Molecular Weight Equivalents

O3 -> = 48 g/mol
2Fe^2+ -> = 112 g/mol
equals = 160 g/mol
H2O -> = 18 g/mol

Therefore if Fe2+ = 7,423 g
Then O3 available = ((g/mol of O3) / (g/mol 2Fe^2+)) * g 2Fe^2+
equals = 3,181 gO3
So Fe2O3 = 10,605 g
Therefore Percent Fe2O3 to H2O = 0.0005286 %

SECOND Residence Time of Cylinder

	Avg Diameter ((2r/2)) (m)	Velocity (m/yr)	Equals	Units
d/v	20.8930	73.4	0.2846	yr
GW Cycle /yr			3.5131	times /yr

	Cycles	Mass per cycle (g)	Equals	Units
Monthly Precipitated Mass	0.2928	10,605	3,104.65	g
Annual Precipitated Mass	3.5131	10,605	37,255.78	g

	Number of years	Annual Precip. Mass	equals	Units
Life-cycle Precipitated Mass	20	37,256	745,115.65	g

THIRD Therefore Percent Fe2O3 to H2O = 0.0371389 %

CALCULATION WORKSHEET

CLIENT:	USACE	JOB NUMBER:	62393.01
SUBJECT:	Oasis - 20Y Formational Plugging 55		Sheet 2 of 7
BY:	BS	CHECKED BY: MH	DATE: 1/11/2012

FOURTH Alternative Calculation:
Accumulation of precipitate per month, accounting for decrease in available porosity

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 1	3,104.65	3104.64855	1.96527E-05
Month 2	3,104.65	6209.2971	3.93054E-05
Month 3	3,104.65	9313.94564	5.89582E-05
Month 4	3,104.65	12418.5942	7.86109E-05
Month 5	3,104.65	15523.2427	9.82636E-05
Month 6	3,104.65	18627.8913	0.000117916
Month 7	3,104.65	21732.5398	0.000137569
Month 8	3,104.65	24837.1884	0.000157222
Month 9	3,104.65	27941.8369	0.000176875
Month 10	3,104.65	31046.4855	0.000196527
Month 11	3,104.65	34151.134	0.00021618
Month 12	3,104.65	37255.7826	0.000235833
Month 13	3,104.65	40360.4311	0.000255486
Month 14	3,104.65	43465.0797	0.000275139
Month 15	3,104.65	46569.7282	0.000294791
Month 16	3,104.65	49674.3768	0.000314444
Month 17	3,104.65	52779.0253	0.000334097
Month 18	3,104.65	55883.6739	0.00035375
Month 19	3,104.65	58988.3224	0.000373403
Month 20	3,104.65	62092.971	0.000393056
Month 21	3,104.65	65197.6195	0.000412709
Month 22	3,104.65	68302.2681	0.000432361
Month 23	3,104.65	71406.9166	0.000452014
Month 24	3,104.65	74511.5652	0.000471667
Month 25	3,104.65	77616.2137	0.00049132
Month 26	3,104.65	80720.8622	0.000510973
Month 27	3,104.65	83825.5108	0.000530626
Month 28	3,104.65	86930.1593	0.000550279
Month 29	3,104.65	90034.8079	0.000569932
Month 30	3,104.65	93139.4564	0.000589585
Month 31	3,104.65	96244.105	0.000609238
Month 32	3,104.65	99348.7535	0.000628891
Month 33	3,104.65	102453.402	0.000648544
Month 34	3,104.65	105558.051	0.000668197
Month 35	3,104.65	108662.699	0.00068785
Month 36	3,104.65	111767.348	0.000707502
Month 37	3,104.65	114871.996	0.000727155
Month 38	3,104.65	117976.645	0.000746808
Month 39	3,104.65	121081.293	0.000766461
Month 40	3,104.65	124185.942	0.000786115
Month 41	3,104.65	127290.59	0.000805768
Month 42	3,104.65	130395.239	0.000825421
Month 43	3,104.65	133499.888	0.000845074

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Formational Plugging 55 Sheet 3 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 44	3,104.65	136604.536	0.000864727
Month 45	3,104.65	139709.185	0.00088438
Month 46	3,104.65	142813.833	0.000904033
Month 47	3,104.65	145918.482	0.000923686
Month 48	3,104.65	149023.13	0.000943339
Month 49	3,104.65	152127.779	0.000962992
Month 50	3,104.65	155232.427	0.000982645
Month 51	3,104.65	158337.076	0.001002298
Month 52	3,104.65	161441.724	0.001021951
Month 53	3,104.65	164546.373	0.001041604
Month 54	3,104.65	167651.022	0.001061258
Month 55	3,104.65	170755.67	0.001080911
Month 56	3,104.65	173860.319	0.001100564
Month 57	3,104.65	176964.967	0.001120217
Month 58	3,104.65	180069.616	0.00113987
Month 59	3,104.65	183174.264	0.001159523
Month 60	3,104.65	186278.913	0.001179176
Month 61	3,104.65	189383.561	0.00119883
Month 62	3,104.65	192488.21	0.001218483
Month 63	3,104.65	195592.859	0.001238136
Month 64	3,104.65	198697.507	0.001257789
Month 65	3,104.65	201802.156	0.001277442
Month 66	3,104.65	204906.804	0.001297096
Month 67	3,104.65	208011.453	0.001316749
Month 68	3,104.65	211116.101	0.001336402
Month 69	3,104.65	214220.75	0.001356055
Month 70	3,104.65	217325.398	0.001375708
Month 71	3,104.65	220430.047	0.001395362
Month 72	3,104.65	223534.695	0.001415015
Month 73	3,104.65	226639.344	0.001434668
Month 74	3,104.65	229743.993	0.001454322
Month 75	3,104.65	232848.641	0.001473975
Month 76	3,104.65	235953.29	0.001493628
Month 77	3,104.65	239057.938	0.001513281
Month 78	3,104.65	242162.587	0.001532935
Month 79	3,104.65	245267.235	0.001552588
Month 80	3,104.65	248371.884	0.001572241
Month 81	3,104.65	251476.532	0.001591895
Month 82	3,104.65	254581.181	0.001611548
Month 83	3,104.65	257685.829	0.001631201
Month 84	3,104.65	260790.478	0.001650855
Month 85	3,104.65	263895.127	0.001670508
Month 86	3,104.65	266999.775	0.001690161
Month 87	3,104.65	270104.424	0.001709815
Month 88	3,104.65	273209.072	0.001729468
Month 89	3,104.65	276313.721	0.001749122

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Formational Plugging 55 Sheet 4 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 90	3,104.65	279418.369	0.001768775
Month 91	3,104.65	282523.018	0.001788428
Month 92	3,104.65	285627.666	0.001808082
Month 93	3,104.65	288732.315	0.001827735
Month 94	3,104.65	291836.964	0.001847389
Month 95	3,104.65	294941.612	0.001867042
Month 96	3,104.65	298046.261	0.001886696
Month 97	3,104.65	301150.909	0.001906349
Month 98	3,104.65	304255.558	0.001926002
Month 99	3,104.65	307360.206	0.001945656
Month 100	3,104.65	310464.855	0.001965309
Month 101	3,104.65	313569.503	0.001984963
Month 102	3,104.65	316674.152	0.002004616
Month 103	3,104.65	319778.8	0.00202427
Month 104	3,104.65	322883.449	0.002043923
Month 105	3,104.65	325988.098	0.002063577
Month 106	3,104.65	329092.746	0.00208323
Month 107	3,104.65	332197.395	0.002102884
Month 108	3,104.65	335302.043	0.002122538
Month 109	3,104.65	338406.692	0.002142191
Month 110	3,104.65	341511.34	0.002161845
Month 111	3,104.65	344615.989	0.002181498
Month 112	3,104.65	347720.637	0.002201152
Month 113	3,104.65	350825.286	0.002220805
Month 114	3,104.65	353929.934	0.002240459
Month 115	3,104.65	357034.583	0.002260113
Month 116	3,104.65	360139.232	0.002279766
Month 117	3,104.65	363243.88	0.00229942
Month 118	3,104.65	366348.529	0.002319073
Month 119	3,104.65	369453.177	0.002338727
Month 120	3,104.65	372557.826	0.002358381
Month 121	3,104.65	375662.474	0.002378034
Month 122	3,104.65	378767.123	0.002397688
Month 123	3,104.65	381871.771	0.002417342
Month 124	3,104.65	384976.42	0.002436995
Month 125	3,104.65	388081.069	0.002456649
Month 126	3,104.65	391185.717	0.002476303
Month 127	3,104.65	394290.366	0.002495956
Month 128	3,104.65	397395.014	0.00251561
Month 129	3,104.65	400499.663	0.002535264
Month 130	3,104.65	403604.311	0.002554917
Month 131	3,104.65	406708.96	0.002574571
Month 132	3,104.65	409813.608	0.002594225
Month 133	3,104.65	412918.257	0.002613879
Month 134	3,104.65	416022.905	0.002633532
Month 135	3,104.65	419127.554	0.002653186
Month 136	3,104.65	422232.203	0.00267284
Month 137	3,104.65	425336.851	0.002692494

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Formational Plugging 55 Sheet 5 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 138	3,104.65	428441.5	0.002712147
Month 139	3,104.65	431546.148	0.002731801
Month 140	3,104.65	434650.797	0.002751455
Month 141	3,104.65	437755.445	0.002771109
Month 142	3,104.65	440860.094	0.002790762
Month 143	3,104.65	443964.742	0.002810416
Month 144	3,104.65	447069.391	0.00283007
Month 145	3,104.65	450174.039	0.002849724
Month 146	3,104.65	453278.688	0.002869378
Month 147	3,104.65	456383.337	0.002889032
Month 148	3,104.65	459487.985	0.002908685
Month 149	3,104.65	462592.634	0.002928339
Month 150	3,104.65	465697.282	0.002947993
Month 151	3,104.65	468801.931	0.002967647
Month 152	3,104.65	471906.579	0.002987301
Month 153	3,104.65	475011.228	0.003006955
Month 154	3,104.65	478115.876	0.003026609
Month 155	3,104.65	481220.525	0.003046263
Month 156	3,104.65	484325.173	0.003065916
Month 157	3,104.65	487429.822	0.00308557
Month 158	3,104.65	490534.471	0.003105224
Month 159	3,104.65	493639.119	0.003124878
Month 160	3,104.65	496743.768	0.003144532
Month 161	3,104.65	499848.416	0.003164186
Month 162	3,104.65	502953.065	0.00318384
Month 163	3,104.65	506057.713	0.003203494
Month 164	3,104.65	509162.362	0.003223148
Month 165	3,104.65	512267.01	0.003242802
Month 166	3,104.65	515371.659	0.003262456
Month 167	3,104.65	518476.308	0.00328211
Month 168	3,104.65	521580.956	0.003301764
Month 169	3,104.65	524685.605	0.003321418
Month 170	3,104.65	527790.253	0.003341072
Month 171	3,104.65	530894.902	0.003360726
Month 172	3,104.65	533999.55	0.00338038
Month 173	3,104.65	537104.199	0.003400034
Month 174	3,104.65	540208.847	0.003419688
Month 175	3,104.65	543313.496	0.003439342
Month 176	3,104.65	546418.144	0.003458996
Month 177	3,104.65	549522.793	0.00347865
Month 178	3,104.65	552627.442	0.003498304
Month 179	3,104.65	555732.09	0.003517959
Month 180	3,104.65	558836.739	0.003537613
Month 181	3,104.65	561941.387	0.003557267
Month 182	3,104.65	565046.036	0.003576921
Month 183	3,104.65	568150.684	0.003596575
Month 184	3,104.65	571255.333	0.003616229
Month 185	3,104.65	574359.981	0.003635883

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Formational Plugging 55 Sheet 6 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 186	3,104.65	577464.63	0.003655537
Month 187	3,104.65	580569.278	0.003675191
Month 188	3,104.65	583673.927	0.003694846
Month 189	3,104.65	586778.576	0.0037145
Month 190	3,104.65	589883.224	0.003734154
Month 191	3,104.65	592987.873	0.003753808
Month 192	3,104.65	596092.521	0.003773462
Month 193	3,104.65	599197.17	0.003793117
Month 194	3,104.65	602301.818	0.003812771
Month 195	3,104.65	605406.467	0.003832425
Month 196	3,104.65	608511.115	0.003852079
Month 197	3,104.65	611615.764	0.003871733
Month 198	3,104.65	614720.413	0.003891388
Month 199	3,104.65	617825.061	0.003911042
Month 200	3,104.65	620929.71	0.003930696
Month 201	3,104.65	624034.358	0.00395035
Month 202	3,104.65	627139.007	0.003970005
Month 203	3,104.65	630243.655	0.003989659
Month 204	3,104.65	633348.304	0.004009313
Month 205	3,104.65	636452.952	0.004028967
Month 206	3,104.65	639557.601	0.004048622
Month 207	3,104.65	642662.249	0.004068276
Month 208	3,104.65	645766.898	0.00408793
Month 209	3,104.65	648871.547	0.004107585
Month 210	3,104.65	651976.195	0.004127239
Month 211	3,104.65	655080.844	0.004146893
Month 212	3,104.65	658185.492	0.004166548
Month 213	3,104.65	661290.141	0.004186202
Month 214	3,104.65	664394.789	0.004205856
Month 215	3,104.65	667499.438	0.004225511
Month 216	3,104.65	670604.086	0.004245165
Month 217	3,104.65	673708.735	0.00426482
Month 218	3,104.65	676813.383	0.004284474
Month 219	3,104.65	679918.032	0.004304128
Month 220	3,104.65	683022.681	0.004323783
Month 221	3,104.65	686127.329	0.004343437
Month 222	3,104.65	689231.978	0.004363092
Month 223	3,104.65	692336.626	0.004382746
Month 224	3,104.65	695441.275	0.0044024
Month 225	3,104.65	698545.923	0.004422055
Month 226	3,104.65	701650.572	0.004441709
Month 227	3,104.65	704755.22	0.004461364
Month 228	3,104.65	707859.869	0.004481018
Month 229	3,104.65	710964.518	0.004500673
Month 230	3,104.65	714069.166	0.004520327
Month 231	3,104.65	717173.815	0.004539982
Month 232	3,104.65	720278.463	0.004559636
Month 233	3,104.65	723383.112	0.004579291

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Formational Plugging 55 Sheet 7 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 234	3,104.65	726487.76	0.004598945
Month 235	3,104.65	729592.409	0.0046186
Month 236	3,104.65	732697.057	0.004638254
Month 237	3,104.65	735801.706	0.004657909
Month 238	3,104.65	738906.354	0.004677563
Month 239	3,104.65	742011.003	0.004697218
Month 240	3,104.65	745115.652	0.004716872

Fomational Plugging:

Therefore Percent Fe_2O_3 to H_2O = 0.00471687 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 1Y Formational Plugging 15 Deg Sheet 1 of 2

BY: BS CHECKED BY: MH DATE: 1/11/2012

ASSUMPTIONS Concentration (C): 3.7 mg/L

Total Liquid Content: Volume (V) = (1/3) π r2 h

Angle of Cone (From Vertical) = 15 degrees or 0.2618 radians
Depth of Submergence (h) = 48 ft
Porosity = 0.3

Radius (Opposite side) = Adjacent side x Tangent(55)
= 48 ft x tan(55)
= 12.9 ft
= 3.9 m

Volume = 2,494 cubic ft
= 70,634 liters
= 7.063E+07 grams (mL)

Total iron mass in liquid (V*C) = 261,345 mg
= 261 grams

FIRST Molecular Weight Equivalents

O3 -> = 48 g/mol
2Fe^2+ -> = 112 g/mol
equals = 160 g/mol
H2O -> = 18 g/mol

Therefore if Fe2+ = 261 g
Then O3 available = ((g/mol of O3) / (g/mol 2Fe^2+)) * g 2Fe^2+
equals = 112 gO3
So Fe2O3 = 373 g
Therefore Percent Fe2O3 to H2O = 0.0005286 %

SECOND Residence Time of Cylinder

	Avg Diameter ((2r/2)) (m)	Velocity (m/yr)	Equals	Units
d/v	3.9202	73.4	0.0534	yr
GW Cycle /yr			18.7235	times /yr

	Cycles	Mass per cycle (g)	Equals	Units
Monthly Precipitated Mass	1.5603	373	582.53	g
Annual Precipitated Mass	18.7235	373	6,990.41	g

	Number of years	Annual Precip. Mass	equals	Units
Life-cycle Precipitated Mass	1	6,990	6,990.41	g

THIRD Therefore Percent Fe2O3 to H2O = 0.0098967 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 1Y Formational Plugging 15 Deg Sheet 2 of 2

BY: BS CHECKED BY: MH DATE: 1/11/2012

FOURTH Alternative Calculation:
Accumulation of precipitate per month, accounting for decrease in available porosity

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 1	582.53	582.53427	0.00010474
Month 2	582.53	1165.0685	0.000209481
Month 3	582.53	1747.6028	0.000314222
Month 4	582.53	2330.1371	0.000418963
Month 5	582.53	2912.6713	0.000523704
Month 6	582.53	3495.2056	0.000628445
Month 7	582.53	4077.7399	0.000733187
Month 8	582.53	4660.2741	0.000837929
Month 9	582.53	5242.8084	0.000942671
Month 10	582.53	5825.3427	0.001047413
Month 11	582.53	6407.8769	0.001152155
Month 12	582.53	6990.4112	0.001256898

Fomational Plugging:

Therefore Percent Fe_2O_3 to H_2O = 0.0012569 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 5Y Formational Plugging 15 Sheet 1 of 3

BY: BS CHECKED BY: MH DATE: 1/11/2012

ASSUMPTIONS Concentration (C): 3.7 mg/L

Total Liquid Content: Volume (V) = (1/3) π r2 h

Angle of Cone (From Vertical) = 15 degrees or 0.2618 radians
Depth of Submergence (h) = 48 ft
Porosity = 0.3

Radius (Opposite side) = Adjacent side x Tangent(55)
= 48 ft x tan(55)
= 12.9 ft
= 3.9 m

Volume = 2,494 cubic ft
= 70,634 liters
= 7.063E+07 grams (mL)

Total iron mass in liquid (V*C) = 261,345 mg
= 261 grams

FIRST Molecular Weight Equivalents

O3 -> = 48 g/mol
2Fe^2+ -> = 112 g/mol
equals = 160 g/mol
H2O -> = 18 g/mol

Therefore if Fe2+ = 261 g
Then O3 available = ((g/mol of O3) / (g/mol 2Fe^2+)) * g 2Fe^2+
equals = 112 gO3
So Fe2O3 = 373 g
Therefore Percent Fe2O3 to H2O = 0.0005286 %

SECOND Residence Time of Cylinder

	Avg Diameter ((2r/2)) (m)	Velocity (m/yr)	Equals	Units
d/v	3.9202	73.4	0.0534	yr
GW Cycle /yr			18.7235	times /yr

	Cycles	Mass per cycle (g)	Equals	Units
Monthly Precipitated Mass	1.5603	373	582.53	g
Annual Precipitated Mass	18.7235	373	6,990.41	g

	Number of years	Annual Precip. Mass	equals	Units
Life-cycle Precipitated Mass	5	6,990	34,952.06	g

THIRD Therefore Percent Fe2O3 to H2O = 0.04948346 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 5Y Formational Plugging 15 Sheet 2 of 3

BY: BS CHECKED BY: MH DATE: 1/11/2012

FOURTH Alternative Calculation:
Accumulation of precipitate per month, accounting for decrease in available porosity

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 1	582.53	582.534268	0.00010474
Month 2	582.53	1165.06854	0.000209481
Month 3	582.53	1747.6028	0.000314222
Month 4	582.53	2330.13707	0.000418963
Month 5	582.53	2912.67134	0.000523704
Month 6	582.53	3495.20561	0.000628445
Month 7	582.53	4077.73988	0.000733187
Month 8	582.53	4660.27414	0.000837929
Month 9	582.53	5242.80841	0.000942671
Month 10	582.53	5825.34268	0.001047413
Month 11	582.53	6407.87695	0.001152155
Month 12	582.53	6990.41122	0.001256898
Month 13	582.53	7572.94548	0.001361641
Month 14	582.53	8155.47975	0.001466384
Month 15	582.53	8738.01402	0.001571128
Month 16	582.53	9320.54829	0.001675871
Month 17	582.53	9903.08256	0.001780615
Month 18	582.53	10485.6168	0.001885359
Month 19	582.53	11068.1511	0.001990103
Month 20	582.53	11650.6854	0.002094848
Month 21	582.53	12233.2196	0.002199592
Month 22	582.53	12815.7539	0.002304337
Month 23	582.53	13398.2882	0.002409082
Month 24	582.53	13980.8224	0.002513828
Month 25	582.53	14563.3567	0.002618573
Month 26	582.53	15145.891	0.002723319
Month 27	582.53	15728.4252	0.002828065
Month 28	582.53	16310.9595	0.002932811
Month 29	582.53	16893.4938	0.003037558
Month 30	582.53	17476.028	0.003142305
Month 31	582.53	18058.5623	0.003247051
Month 32	582.53	18641.0966	0.003351799
Month 33	582.53	19223.6308	0.003456546
Month 34	582.53	19806.1651	0.003561293
Month 35	582.53	20388.6994	0.003666041
Month 36	582.53	20971.2336	0.003770789
Month 37	582.53	21553.7679	0.003875537
Month 38	582.53	22136.3022	0.003980286
Month 39	582.53	22718.8365	0.004085034
Month 40	582.53	23301.3707	0.004189783
Month 41	582.53	23883.905	0.004294532
Month 42	582.53	24466.4393	0.004399282
Month 43	582.53	25048.9735	0.004504031

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 5Y Formational Plugging 15 Sheet 3 of 3

BY: BS CHECKED BY: MH DATE: 1/11/2012

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 44	582.53	25631.5078	0.004608781
Month 45	582.53	26214.0421	0.004713531
Month 46	582.53	26796.5763	0.004818281
Month 47	582.53	27379.1106	0.004923031
Month 48	582.53	27961.6449	0.005027782
Month 49	582.53	28544.1791	0.005132533
Month 50	582.53	29126.7134	0.005237284
Month 51	582.53	29709.2477	0.005342035
Month 52	582.53	30291.7819	0.005446787
Month 53	582.53	30874.3162	0.005551538
Month 54	582.53	31456.8505	0.00565629
Month 55	582.53	32039.3847	0.005761043
Month 56	582.53	32621.919	0.005865795
Month 57	582.53	33204.4533	0.005970547
Month 58	582.53	33786.9875	0.0060753
Month 59	582.53	34369.5218	0.006180053
Month 60	582.53	34952.0561	0.006284807

Fomational Plugging:

Therefore Percent Fe2O3 to H2O = 0.00628481 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Formational Plugging 15 Sheet 1 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

ASSUMPTIONS Concentration (C): 3.7 mg/L

Total Liquid Content: Volume (V) = (1/3) π r2 h

Angle of Cone (From Vertical) = 15 degrees or 0.2618 radians
Depth of Submergence (h) = 48 ft
Porosity = 0.3

Radius (Opposite side) = Adjacent side x Tangent(55)
= 48 ft x tan(55)
= 12.9 ft
= 3.9 m

Volume = 2,494 cubic ft
= 70,634 liters
= 7.063E+07 grams (mL)

Total iron mass in liquid (V*C) = 261,345 mg
= 261 grams

FIRST Molecular Weight Equivalents

O3 -> = 48 g/mol
2Fe^2+ -> = 112 g/mol
equals = 160 g/mol
H2O -> = 18 g/mol

Therefore if Fe2+ = 261 g
Then O3 available = ((g/mol of O3) / (g/mol 2Fe^2+)) * g 2Fe^2+
equals = 112 gO3
So Fe2O3 = 373 g
Therefore Percent Fe2O3 to H2O = 0.0005286 %

SECOND Residence Time of Cylinder

	Avg Diameter ((2r/2)) (m)	Velocity (m/yr)	Equals	Units
d/v	3.9202	73.4	0.0534	yr
GW Cycle /yr			18.7235	times /yr

	Cycles	Mass per cycle (g)	Equals	Units
Monthly Precipitated Mass	1.5603	373	582.53	g
Annual Precipitated Mass	18.7235	373	6,990.41	g

	Number of years	Annual Precip. Mass	equals	Units
Life-cycle Precipitated Mass	20	6,990	139,808.22	g

THIRD Therefore Percent Fe2O3 to H2O = 0.19793383 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Formational Plugging 55 Sheet 2 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

FOURTH Alternative Calculation:
Accumulation of precipitate per month, accounting for decrease in available porosity

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 1	582.53	582.534268	0.00010474
Month 2	582.53	1165.06854	0.000209481
Month 3	582.53	1747.6028	0.000314222
Month 4	582.53	2330.13707	0.000418963
Month 5	582.53	2912.67134	0.000523704
Month 6	582.53	3495.20561	0.000628445
Month 7	582.53	4077.73988	0.000733187
Month 8	582.53	4660.27414	0.000837929
Month 9	582.53	5242.80841	0.000942671
Month 10	582.53	5825.34268	0.001047413
Month 11	582.53	6407.87695	0.001152155
Month 12	582.53	6990.41122	0.001256898
Month 13	582.53	7572.94548	0.001361641
Month 14	582.53	8155.47975	0.001466384
Month 15	582.53	8738.01402	0.001571128
Month 16	582.53	9320.54829	0.001675871
Month 17	582.53	9903.08256	0.001780615
Month 18	582.53	10485.6168	0.001885359
Month 19	582.53	11068.1511	0.001990103
Month 20	582.53	11650.6854	0.002094848
Month 21	582.53	12233.2196	0.002199592
Month 22	582.53	12815.7539	0.002304337
Month 23	582.53	13398.2882	0.002409082
Month 24	582.53	13980.8224	0.002513828
Month 25	582.53	14563.3567	0.002618573
Month 26	582.53	15145.891	0.002723319
Month 27	582.53	15728.4252	0.002828065
Month 28	582.53	16310.9595	0.002932811
Month 29	582.53	16893.4938	0.003037558
Month 30	582.53	17476.028	0.003142305
Month 31	582.53	18058.5623	0.003247051
Month 32	582.53	18641.0966	0.003351799
Month 33	582.53	19223.6308	0.003456546
Month 34	582.53	19806.1651	0.003561293
Month 35	582.53	20388.6994	0.003666041
Month 36	582.53	20971.2336	0.003770789
Month 37	582.53	21553.7679	0.003875537
Month 38	582.53	22136.3022	0.003980286
Month 39	582.53	22718.8365	0.004085034
Month 40	582.53	23301.3707	0.004189783
Month 41	582.53	23883.905	0.004294532
Month 42	582.53	24466.4393	0.004399282
Month 43	582.53	25048.9735	0.004504031

CALCULATION WORKSHEET

CLIENT:	USACE	JOB NUMBER:	62393.01
SUBJECT:	Oasis - 20Y Formational Plugging 55		Sheet 3 of 7
BY:	BS	CHECKED BY: MH	DATE: 1/11/2012

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 44	582.53	25631.5078	0.004608781
Month 45	582.53	26214.0421	0.004713531
Month 46	582.53	26796.5763	0.004818281
Month 47	582.53	27379.1106	0.004923031
Month 48	582.53	27961.6449	0.005027782
Month 49	582.53	28544.1791	0.005132533
Month 50	582.53	29126.7134	0.005237284
Month 51	582.53	29709.2477	0.005342035
Month 52	582.53	30291.7819	0.005446787
Month 53	582.53	30874.3162	0.005551538
Month 54	582.53	31456.8505	0.00565629
Month 55	582.53	32039.3847	0.005761043
Month 56	582.53	32621.919	0.005865795
Month 57	582.53	33204.4533	0.005970547
Month 58	582.53	33786.9875	0.0060753
Month 59	582.53	34369.5218	0.006180053
Month 60	582.53	34952.0561	0.006284807
Month 61	582.53	35534.5903	0.00638956
Month 62	582.53	36117.1246	0.006494314
Month 63	582.53	36699.6589	0.006599068
Month 64	582.53	37282.1932	0.006703822
Month 65	582.53	37864.7274	0.006808576
Month 66	582.53	38447.2617	0.006913331
Month 67	582.53	39029.796	0.007018085
Month 68	582.53	39612.3302	0.00712284
Month 69	582.53	40194.8645	0.007227596
Month 70	582.53	40777.3988	0.007332351
Month 71	582.53	41359.933	0.007437107
Month 72	582.53	41942.4673	0.007541863
Month 73	582.53	42525.0016	0.007646619
Month 74	582.53	43107.5358	0.007751375
Month 75	582.53	43690.0701	0.007856132
Month 76	582.53	44272.6044	0.007960888
Month 77	582.53	44855.1386	0.008065645
Month 78	582.53	45437.6729	0.008170403
Month 79	582.53	46020.2072	0.00827516
Month 80	582.53	46602.7414	0.008379918
Month 81	582.53	47185.2757	0.008484676
Month 82	582.53	47767.81	0.008589434
Month 83	582.53	48350.3442	0.008694192
Month 84	582.53	48932.8785	0.00879895
Month 85	582.53	49515.4128	0.008903709
Month 86	582.53	50097.947	0.009008468
Month 87	582.53	50680.4813	0.009113227
Month 88	582.53	51263.0156	0.009217987
Month 89	582.53	51845.5499	0.009322746

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Formational Plugging 55 Sheet 4 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 90	582.53	52428.0841	0.009427506
Month 91	582.53	53010.6184	0.009532266
Month 92	582.53	53593.1527	0.009637026
Month 93	582.53	54175.6869	0.009741787
Month 94	582.53	54758.2212	0.009846548
Month 95	582.53	55340.7555	0.009951309
Month 96	582.53	55923.2897	0.01005607
Month 97	582.53	56505.824	0.010160831
Month 98	582.53	57088.3583	0.010265593
Month 99	582.53	57670.8925	0.010370354
Month 100	582.53	58253.4268	0.010475117
Month 101	582.53	58835.9611	0.010579879
Month 102	582.53	59418.4953	0.010684641
Month 103	582.53	60001.0296	0.010789404
Month 104	582.53	60583.5639	0.010894167
Month 105	582.53	61166.0981	0.01099893
Month 106	582.53	61748.6324	0.011103693
Month 107	582.53	62331.1667	0.011208457
Month 108	582.53	62913.7009	0.011313221
Month 109	582.53	63496.2352	0.011417985
Month 110	582.53	64078.7695	0.011522749
Month 111	582.53	64661.3037	0.011627513
Month 112	582.53	65243.838	0.011732278
Month 113	582.53	65826.3723	0.011837043
Month 114	582.53	66408.9066	0.011941808
Month 115	582.53	66991.4408	0.012046573
Month 116	582.53	67573.9751	0.012151339
Month 117	582.53	68156.5094	0.012256105
Month 118	582.53	68739.0436	0.012360871
Month 119	582.53	69321.5779	0.012465637
Month 120	582.53	69904.1122	0.012570403
Month 121	582.53	70486.6464	0.01267517
Month 122	582.53	71069.1807	0.012779937
Month 123	582.53	71651.715	0.012884704
Month 124	582.53	72234.2492	0.012989471
Month 125	582.53	72816.7835	0.013094239
Month 126	582.53	73399.3178	0.013199006
Month 127	582.53	73981.852	0.013303774
Month 128	582.53	74564.3863	0.013408542
Month 129	582.53	75146.9206	0.013513311
Month 130	582.53	75729.4548	0.013618079
Month 131	582.53	76311.9891	0.013722848
Month 132	582.53	76894.5234	0.013827617
Month 133	582.53	77477.0576	0.013932387
Month 134	582.53	78059.5919	0.014037156
Month 135	582.53	78642.1262	0.014141926
Month 136	582.53	79224.6605	0.014246696
Month 137	582.53	79807.1947	0.014351466

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Formational Plugging 55 Sheet 5 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 138	582.53	80389.729	0.014456236
Month 139	582.53	80972.2633	0.014561007
Month 140	582.53	81554.7975	0.014665778
Month 141	582.53	82137.3318	0.014770549
Month 142	582.53	82719.8661	0.01487532
Month 143	582.53	83302.4003	0.014980091
Month 144	582.53	83884.9346	0.015084863
Month 145	582.53	84467.4689	0.015189635
Month 146	582.53	85050.0031	0.015294407
Month 147	582.53	85632.5374	0.015399179
Month 148	582.53	86215.0717	0.015503952
Month 149	582.53	86797.6059	0.015608725
Month 150	582.53	87380.1402	0.015713498
Month 151	582.53	87962.6745	0.015818271
Month 152	582.53	88545.2087	0.015923044
Month 153	582.53	89127.743	0.016027818
Month 154	582.53	89710.2773	0.016132592
Month 155	582.53	90292.8115	0.016237366
Month 156	582.53	90875.3458	0.01634214
Month 157	582.53	91457.8801	0.016446915
Month 158	582.53	92040.4143	0.01655169
Month 159	582.53	92622.9486	0.016656465
Month 160	582.53	93205.4829	0.01676124
Month 161	582.53	93788.0172	0.016866015
Month 162	582.53	94370.5514	0.016970791
Month 163	582.53	94953.0857	0.017075567
Month 164	582.53	95535.62	0.017180343
Month 165	582.53	96118.1542	0.017285119
Month 166	582.53	96700.6885	0.017389896
Month 167	582.53	97283.2228	0.017494672
Month 168	582.53	97865.757	0.017599449
Month 169	582.53	98448.2913	0.017704227
Month 170	582.53	99030.8256	0.017809004
Month 171	582.53	99613.3598	0.017913782
Month 172	582.53	100195.894	0.018018559
Month 173	582.53	100778.428	0.018123337
Month 174	582.53	101360.963	0.018228116
Month 175	582.53	101943.497	0.018332894
Month 176	582.53	102526.031	0.018437673
Month 177	582.53	103108.565	0.018542452
Month 178	582.53	103691.1	0.018647231
Month 179	582.53	104273.634	0.01875201
Month 180	582.53	104856.168	0.01885679
Month 181	582.53	105438.703	0.01896157
Month 182	582.53	106021.237	0.01906635
Month 183	582.53	106603.771	0.01917113
Month 184	582.53	107186.305	0.01927591
Month 185	582.53	107768.84	0.019380691

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Formational Plugging 55 Sheet 6 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 186	582.53	108351.374	0.019485472
Month 187	582.53	108933.908	0.019590253
Month 188	582.53	109516.442	0.019695035
Month 189	582.53	110098.977	0.019799816
Month 190	582.53	110681.511	0.019904598
Month 191	582.53	111264.045	0.02000938
Month 192	582.53	111846.579	0.020114162
Month 193	582.53	112429.114	0.020218945
Month 194	582.53	113011.648	0.020323727
Month 195	582.53	113594.182	0.02042851
Month 196	582.53	114176.717	0.020533293
Month 197	582.53	114759.251	0.020638077
Month 198	582.53	115341.785	0.02074286
Month 199	582.53	115924.319	0.020847644
Month 200	582.53	116506.854	0.020952428
Month 201	582.53	117089.388	0.021057212
Month 202	582.53	117671.922	0.021161996
Month 203	582.53	118254.456	0.021266781
Month 204	582.53	118836.991	0.021371566
Month 205	582.53	119419.525	0.021476351
Month 206	582.53	120002.059	0.021581136
Month 207	582.53	120584.593	0.021685922
Month 208	582.53	121167.128	0.021790708
Month 209	582.53	121749.662	0.021895493
Month 210	582.53	122332.196	0.02200028
Month 211	582.53	122914.731	0.022105066
Month 212	582.53	123497.265	0.022209853
Month 213	582.53	124079.799	0.02231464
Month 214	582.53	124662.333	0.022419427
Month 215	582.53	125244.868	0.022524214
Month 216	582.53	125827.402	0.022629001
Month 217	582.53	126409.936	0.022733789
Month 218	582.53	126992.47	0.022838577
Month 219	582.53	127575.005	0.022943365
Month 220	582.53	128157.539	0.023048153
Month 221	582.53	128740.073	0.023152942
Month 222	582.53	129322.607	0.023257731
Month 223	582.53	129905.142	0.02336252
Month 224	582.53	130487.676	0.023467309
Month 225	582.53	131070.21	0.023572099
Month 226	582.53	131652.745	0.023676888
Month 227	582.53	132235.279	0.023781678
Month 228	582.53	132817.813	0.023886468
Month 229	582.53	133400.347	0.023991259
Month 230	582.53	133982.882	0.024096049
Month 231	582.53	134565.416	0.02420084
Month 232	582.53	135147.95	0.024305631
Month 233	582.53	135730.484	0.024410422

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Formational Plugging 55 Sheet 7 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 234	582.53	136313.019	0.024515214
Month 235	582.53	136895.553	0.024620005
Month 236	582.53	137478.087	0.024724797
Month 237	582.53	138060.622	0.024829589
Month 238	582.53	138643.156	0.024934382
Month 239	582.53	139225.69	0.025039174
Month 240	582.53	139808.224	0.025143967
Month 241	582.53	140390.759	0.02524876
Month 242	582.53	140973.293	0.025353553
Month 243	582.53	141555.827	0.025458347
Month 244	582.53	142138.361	0.02556314
Month 245	582.53	142720.896	0.025667934
Month 246	582.53	143303.43	0.025772728
Month 247	582.53	143885.964	0.025877522
Month 248	582.53	144468.498	0.025982317
Month 249	582.53	145051.033	0.026087112
Month 250	582.53	145633.567	0.026191907
Month 251	582.53	146216.101	0.026296702
Month 252	582.53	146798.636	0.026401497
Month 253	582.53	147381.17	0.026506293
Month 254	582.53	147963.704	0.026611089
Month 255	582.53	148546.238	0.026715885
Month 256	582.53	149128.773	0.026820681
Month 257	582.53	149711.307	0.026925478
Month 258	582.53	150293.841	0.027030274
Month 259	582.53	150876.375	0.027135071
Month 260	582.53	151458.91	0.027239868

Fomational Plugging:

Therefore Percent Fe_2O_3 to H_2O = 0.02723987 %

CALCULATION WORKSHEET

CLIENT:	USACE			JOB NUMBER:	62393.01
SUBJECT:	Oasis - 1Y Diffuser Plugging Normal				Sheet 1 of 2
BY:	BS	CHECKED BY:	MH	DATE:	1/11/2012

ASSUMPTIONS Concentration (C): 0.11 mg/L

Volume of Sparge Point

	n	pi	r (m)	h (m)	Equals	
V=n*(pi)*(r^2)*H	1	3.14	0.0254	0.4572	0.00093	m^3
VL					0.9262	liters
					926.197	g (mL)

Total iron mass in liquid

	VL	C	Equals	
VL*C	0.926196857	0.11	0.10188165	mg
			0.00010188	g

Intercalc - Volume of Diffuser Media

	pi	r (m)	h (m)	Equals	
V=(pi)*(r^2)*H	3.14	0.0254	0.4572	0.00093	m^3
VL				0.9262	liters
				926.197	g (mL)

Intercalc - Volume .25" on either side of Diffuser

	pi	r	h	Equals	
V=(pi)*(r^2)*H	3.14	0.034925	0.4572	0.00175	m^3
VL				1.75109	liters
				1751.09	g (mL)

	n	Delta V (m^3)	equals	
V=n*Delta V	0.4	0.0008249	0.00032996	m^3
			0.33	liters
			329.96	grams (mL)

FIRST Molecular Weight Equivalents

O3 -> = 48 g/mol
2Fe^2+ -> = 112 g/mol
equals = 160 g/mol
H2O -> = 18 g/mol

Therefore if Fe2+ = 0.0001019 g
Then O3 available = ((g/mol of O3) / (g/mol 2Fe^2+)) * g 2Fe^2+
equals = 0.0000437 gO3
So Fe2O3 = 0.0001455 g
Therefore Percent Fe2O3 to H2O = 0.0000157 %

SECOND Residence Time of Cylinder

Pulsed Operation	Number of Days	Pulses per Day	Equals	Units
D*P	365	24	8760	Pulses per yr

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 1Y Diffuser Plugging Normal Sheet 2 of 2

BY: BS CHECKED BY: MH DATE: 1/11/2012

	Cycles	Mass per cycle (g)	Equals	Units
Monthly Precipitated Mass	730	0.0001455	0.1062	g
Annual Precipitated Mass	8760	0.0001455	1.2750	g

	Number of years	Annual Precip. Mass	equals	Units
Life-cycle Precipitated Mass	1	1.2750	1.275	g

THIRD Therefore Percent Fe_2O_3 to H_2O = 0.386406 %

FOURTH Alternative Calculation:
Accumulation of precipitate per month, accounting for decrease in available porosity

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 1	0.1062	0.106248	0.004089639
Month 2	0.1062	0.212496	0.008179613
Month 3	0.1062	0.318744	0.012269921
Month 4	0.1062	0.424992	0.016360564
Month 5	0.1062	0.5312401	0.020451541
Month 6	0.1062	0.6374881	0.024542853
Month 7	0.1062	0.7437361	0.0286345
Month 8	0.1062	0.8499841	0.032726481
Month 9	0.1062	0.9562321	0.036818798
Month 10	0.1062	1.0624801	0.040911449
Month 11	0.1062	1.1687281	0.045004435
Month 12	0.1062	1.2749761	0.049097756

Diffuser Plugging:

Therefore Percent Fe_2O_3 to H_2O = 0.0490978 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01
SUBJECT: Oasis - 5Y Diffuser Plugging Normal Sheet 1 of 3
BY: BS CHECKED BY: MH DATE: 1/11/2012

ASSUMPTIONS Concentration (C): 0.11 mg/L

Volume of Sparge Point

	n	pi	r (m)	h (m)	Equals	
V=n*(pi)*(r^2)*H	1	3.14	0.0254	0.4572	0.00093	m^3
VL					0.9262	liters
					926.197	g (mL)

Total iron mass in liquid

	VL	C	Equals	
VL*C	0.926196857	0.11	0.10188165	mg
			0.00010188	g

Intercalc - Volume of Diffuser Media

	pi	r (m)	h (m)	Equals	
V=(pi)*(r^2)*H	3.14	0.0254	0.4572	0.00093	m^3
VL				0.9262	liters
				926.197	g (mL)

Intercalc - Volume .25" on either side of Diffuser

	pi	r	h	Equals	
V=(pi)*(r^2)*H	3.14	0.034925	0.4572	0.00175	m^3
VL				1.75109	liters
				1751.09	g (mL)

	n	Delta V (m^3)	equals	
V=n*Delta V	0.4	0.0008249	0.00032996	m^3
			0.33	liters
			329.96	grams (mL)

FIRST Molecular Weight Equivalents

O3 -> = 48 g/mol
2Fe^2+ -> = 112 g/mol
equals = 160 g/mol
H2O -> = 18 g/mol

Therefore if Fe2+ = 0.0001019 g
Then O3 available = ((g/mol of O3) / (g/mol 2Fe^2+)) * g 2Fe^2+
equals = 0.0000437 gO3
So Fe2O3 = 0.0001455 g
Therefore Percent Fe2O3 to H2O = 0.0000157 %

SECOND Residence Time of Cylinder

Pulsed Operation	Number of Days	Pulses per Day	Equals	Units
D*P	365	24	8760	Pulses per yr

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 5Y Diffuser Plugging Normal Sheet 2 of 3

BY: BS CHECKED BY: MH DATE: 1/11/2012

	Cycles	Mass per cycle (g)	Equals	Units
Monthly Precipitated Mass	730	0.0001455	0.1062	g
Annual Precipitated Mass	8760	0.0001455	1.2750	g

	Number of years	Annual Precip. Mass	equals	Units
Life-cycle Precipitated Mass	5	1.2750	6.375	g

THIRD Therefore Percent Fe_2O_3 to H_2O = 1.9320301 %

FOURTH Alternative Calculation:
Accumulation of precipitate per month, accounting for decrease in available porosity

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 1	0.1062	0.106248	0.004089639
Month 2	0.1062	0.2125	0.008179613
Month 3	0.1062	0.318744	0.012269921
Month 4	0.1062	0.424992	0.016360564
Month 5	0.1062	0.5312401	0.020451541
Month 6	0.1062	0.6374881	0.024542853
Month 7	0.1062	0.7437361	0.0286345
Month 8	0.1062	0.8499841	0.032726481
Month 9	0.1062	0.9562321	0.036818798
Month 10	0.1062	1.0624801	0.040911449
Month 11	0.1062	1.1687281	0.045004435
Month 12	0.1062	1.2749761	0.049097756
Month 13	0.1062	1.3812	0.053191412
Month 14	0.1062	1.4874722	0.057285403
Month 15	0.1062	1.5937202	0.061379729
Month 16	0.1062	1.6999682	0.06547439
Month 17	0.1062	1.8062162	0.069569387
Month 18	0.1062	1.9124642	0.073664718
Month 19	0.1062	2.0187122	0.077760385
Month 20	0.1062	2.1249602	0.081856387
Month 21	0.1062	2.2312082	0.085952724
Month 22	0.1062	2.3374562	0.090049396
Month 23	0.1062	2.4437043	0.094146404
Month 24	0.1062	2.5499523	0.098243748
Month 25	0.1062	2.6562003	0.102341427
Month 26	0.1062	2.7624483	0.106439441
Month 27	0.1062	2.8686963	0.110537791
Month 28	0.1062	2.9749443	0.114636476
Month 29	0.1062	3.0811923	0.118735497

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 5Y Diffuser Plugging Normal Sheet 3 of 3

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 30	0.1062	3.1874403	0.122834854
Month 31	0.1062	3.2936883	0.126934547
Month 32	0.1062	3.3999363	0.131034575
Month 33	0.1062	3.5061844	0.135134939
Month 34	0.1062	3.6124324	0.139235639
Month 35	0.1062	3.7186804	0.143336674
Month 36	0.1062	3.8249284	0.147438046
Month 37	0.1062	3.9311764	0.151539754
Month 38	0.1062	4.0374244	0.155641797
Month 39	0.1062	4.1436724	0.159744177
Month 40	0.1062	4.2499204	0.163846892
Month 41	0.1062	4.3561684	0.167949944
Month 42	0.1062	4.4624165	0.172053332
Month 43	0.1062	4.5686645	0.176157056
Month 44	0.1062	4.6749125	0.180261117
Month 45	0.1062	4.7811605	0.184365514
Month 46	0.1062	4.8874085	0.188470247
Month 47	0.1062	4.9936565	0.192575316
Month 48	0.1062	5.0999045	0.196680722
Month 49	0.1062	5.2061525	0.200786464
Month 50	0.1062	5.3124005	0.204892543
Month 51	0.1062	5.4186486	0.208998958
Month 52	0.1062	5.5248966	0.21310571
Month 53	0.1062	5.6311446	0.217212799
Month 54	0.1062	5.7373926	0.221320224
Month 55	0.1062	5.8436406	0.225427986
Month 56	0.1062	5.9498886	0.229536084
Month 57	0.1062	6.0561366	0.23364452
Month 58	0.1062	6.1623846	0.237753292
Month 59	0.1062	6.2686326	0.241862401
Month 60	0.1062	6.3748807	0.245971847

Diffuser Plugging:

Therefore Percent Fe_2O_3 to H_2O = 0.2459718 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Diffuser Plugging Normal Sheet 1 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

ASSUMPTIONS Concentration (C): 0.11 mg/L

Volume of Sparge Point

	n	pi	r (m)	h (m)	Equals	
V=n*(pi)*(r^2)*H	1	3.14	0.0254	0.4572	0.00093	m^3
VL					0.9262	liters
					926.197	g (mL)

Total iron mass in liquid

	VL	C	Equals	
VL*C	0.926196857	0.11	0.10188165	mg
			0.00010188	g

Intercalc - Volume of Diffuser Media

	pi	r (m)	h (m)	Equals	
V=(pi)*(r^2)*H	3.14	0.0254	0.4572	0.00093	m^3
VL				0.9262	liters
				926.197	g (mL)

Intercalc - Volume .25" on either side of Diffuser

	pi	r	h	Equals	
V=(pi)*(r^2)*H	3.14	0.034925	0.4572	0.00175	m^3
VL				1.75109	liters
				1751.09	g (mL)

	n	Delta V (m^3)	equals	
V=n*Delta V	0.4	0.0008249	0.00032996	m^3
			0.33	liters
			329.96	grams (mL)

FIRST Molecular Weight Equivalents

O3 -> = 48 g/mol
2Fe^2+ -> = 112 g/mol
equals = 160 g/mol
H2O -> = 18 g/mol

Therefore if Fe2+ = 0.0001019 g
Then O3 available = ((g/mol of O3) / (g/mol 2Fe^2+)) * g 2Fe^2+
equals = 0.0000437 gO3
So Fe2O3 = 0.0001455 g
Therefore Percent Fe2O3 to H2O = 0.0000157 %

SECOND Residence Time of Cylinder

Pulsed Operation	Number of Days	Pulses per Day	Equals	Units
D*P	365	24	8760	Pulses per yr

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Diffuser Plugging Normal Sheet 2 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

	Cycles	Mass per cycle (g)	Equals	Units
Monthly Precipitated Mass	730	0.0001455	0.1062	g
Annual Precipitated Mass	8760	0.0001455	1.2750	g

	Number of years	Annual Precip. Mass	equals	Units
Life-cycle Precipitated Mass	20	1.2750	25.500	g

THIRD Therefore Percent Fe2O3 to H2O = 7.7281203 %

FOURTH Alternative Calculation:
Accumulation of precipitate per month, accounting for decrease in available porosity

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 1	0.1062	0.106248	0.004089639
Month 2	0.1062	0.2125	0.008179613
Month 3	0.1062	0.318744	0.012269921
Month 4	0.1062	0.424992	0.016360564
Month 5	0.1062	0.5312401	0.020451541
Month 6	0.1062	0.6374881	0.024542853
Month 7	0.1062	0.7437361	0.0286345
Month 8	0.1062	0.8499841	0.032726481
Month 9	0.1062	0.9562321	0.036818798
Month 10	0.1062	1.0624801	0.040911449
Month 11	0.1062	1.1687281	0.045004435
Month 12	0.1062	1.2749761	0.049097756
Month 13	0.1062	1.3812	0.053191412
Month 14	0.1062	1.4874722	0.057285403
Month 15	0.1062	1.5937202	0.061379729
Month 16	0.1062	1.6999682	0.06547439
Month 17	0.1062	1.8062162	0.069569387
Month 18	0.1062	1.9124642	0.073664718
Month 19	0.1062	2.0187122	0.077760385
Month 20	0.1062	2.1249602	0.081856387
Month 21	0.1062	2.2312082	0.085952724
Month 22	0.1062	2.3374562	0.090049396
Month 23	0.1062	2.4437043	0.094146404
Month 24	0.1062	2.5499523	0.098243748
Month 25	0.1062	2.6562003	0.102341427
Month 26	0.1062	2.7624483	0.106439441
Month 27	0.1062	2.8686963	0.110537791
Month 28	0.1062	2.9749443	0.114636476
Month 29	0.1062	3.0811923	0.118735497

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Diffuser Plugging Normal Sheet 3 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 30	0.1062	3.1874403	0.122834854
Month 31	0.1062	3.2936883	0.126934547
Month 32	0.1062	3.3999363	0.131034575
Month 33	0.1062	3.5061844	0.135134939
Month 34	0.1062	3.6124324	0.139235639
Month 35	0.1062	3.7186804	0.143336674
Month 36	0.1062	3.8249284	0.147438046
Month 37	0.1062	3.9311764	0.151539754
Month 38	0.1062	4.0374244	0.155641797
Month 39	0.1062	4.1436724	0.159744177
Month 40	0.1062	4.2499204	0.163846892
Month 41	0.1062	4.3561684	0.167949944
Month 42	0.1062	4.4624165	0.172053332
Month 43	0.1062	4.5686645	0.176157056
Month 44	0.1062	4.6749125	0.180261117
Month 45	0.1062	4.7811605	0.184365514
Month 46	0.1062	4.8874085	0.188470247
Month 47	0.1062	4.9936565	0.192575316
Month 48	0.1062	5.0999045	0.196680722
Month 49	0.1062	5.2061525	0.200786464
Month 50	0.1062	5.3124005	0.204892543
Month 51	0.1062	5.4186486	0.208998958
Month 52	0.1062	5.5248966	0.21310571
Month 53	0.1062	5.6311446	0.217212799
Month 54	0.1062	5.7373926	0.221320224
Month 55	0.1062	5.8436406	0.225427986
Month 56	0.1062	5.9498886	0.229536084
Month 57	0.1062	6.0561366	0.23364452
Month 58	0.1062	6.1623846	0.237753292
Month 59	0.1062	6.2686326	0.241862401
Month 60	0.1062	6.3748807	0.245971847
Month 61	0.1062	6.4811287	0.25008163
Month 62	0.1062	6.5873767	0.25419175
Month 63	0.1062	6.6936247	0.258302207
Month 64	0.1062	6.7998727	0.262413001
Month 65	0.1062	6.9061207	0.266524132
Month 66	0.1062	7.0123687	0.270635601
Month 67	0.1062	7.1186167	0.274747406
Month 68	0.1062	7.2248647	0.278859549
Month 69	0.1062	7.3311128	0.282972029
Month 70	0.1062	7.4373608	0.287084846
Month 71	0.1062	7.5436088	0.291198001
Month 72	0.1062	7.6498568	0.295311493
Month 73	0.1062	7.7561048	0.299425323
Month 74	0.1062	7.8623528	0.30353949
Month 75	0.1062	7.9686008	0.307653995
Month 76	0.1062	8.0748488	0.311768837
Month 77	0.1062	8.1810968	0.315884017

Month 78	0.1062	8.2873449	0.319999534
Month 79	0.1062	8.3935929	0.324115389
Month 80	0.1062	8.4998409	0.328231582
Month 81	0.1062	8.6060889	0.332348113
Month 82	0.1062	8.7123369	0.336464981
Month 83	0.1062	8.8185849	0.340582188
Month 84	0.1062	8.9248329	0.344699732
Month 85	0.1062	9.0310809	0.348817614
Month 86	0.1062	9.1373289	0.352935834
Month 87	0.1062	9.2435769	0.357054392
Month 88	0.1062	9.349825	0.361173289
Month 89	0.1062	9.456073	0.365292523
Month 90	0.1062	9.562321	0.369412096
Month 91	0.1062	9.668569	0.373532007
Month 92	0.1062	9.774817	0.377652256
Month 93	0.1062	9.881065	0.381772843
Month 94	0.1062	9.987313	0.385893768
Month 95	0.1062	10.093561	0.390015032
Month 96	0.1062	10.199809	0.394136635
Month 97	0.1062	10.306057	0.398258576
Month 98	0.1062	10.412305	0.402380855
Month 99	0.1062	10.518553	0.406503473
Month 100	0.1062	10.624801	0.410626429
Month 101	0.1062	10.731049	0.414749724
Month 102	0.1062	10.837297	0.418873358
Month 103	0.1062	10.943545	0.42299733
Month 104	0.1062	11.049793	0.427121641
Month 105	0.1062	11.156041	0.431246291
Month 106	0.1062	11.262289	0.43537128
Month 107	0.1062	11.368537	0.439496607
Month 108	0.1062	11.474785	0.443622274
Month 109	0.1062	11.581033	0.447748279
Month 110	0.1062	11.687281	0.451874624
Month 111	0.1062	11.793529	0.456001307
Month 112	0.1062	11.899777	0.46012833
Month 113	0.1062	12.006025	0.464255691
Month 114	0.1062	12.112273	0.468383392
Month 115	0.1062	12.218521	0.472511432
Month 116	0.1062	12.324769	0.476639811
Month 117	0.1062	12.431017	0.48076853
Month 118	0.1062	12.537265	0.484897587
Month 119	0.1062	12.643513	0.489026985
Month 120	0.1062	12.749761	0.493156721
Month 121	0.1062	12.856009	0.497286797
Month 122	0.1062	12.962257	0.501417213
Month 123	0.1062	13.068505	0.505547968
Month 124	0.1062	13.174753	0.509679062
Month 125	0.1062	13.281001	0.513810497

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Diffuser Plugging Normal Sheet 5 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 126	0.1062	13.387249	0.517942271
Month 127	0.1062	13.493497	0.522074384
Month 128	0.1062	13.599745	0.526206838
Month 129	0.1062	13.705993	0.530339631
Month 130	0.1062	13.812241	0.534472764
Month 131	0.1062	13.918489	0.538606236
Month 132	0.1062	14.024737	0.542740049
Month 133	0.1062	14.130985	0.546874202
Month 134	0.1062	14.237233	0.551008695
Month 135	0.1062	14.343481	0.555143527
Month 136	0.1062	14.449729	0.5592787
Month 137	0.1062	14.555977	0.563414213
Month 138	0.1062	14.662226	0.567550066
Month 139	0.1062	14.768474	0.571686259
Month 140	0.1062	14.874722	0.575822793
Month 141	0.1062	14.98097	0.579959667
Month 142	0.1062	15.087218	0.584096881
Month 143	0.1062	15.193466	0.588234435
Month 144	0.1062	15.299714	0.59237233
Month 145	0.1062	15.405962	0.596510566
Month 146	0.1062	15.51221	0.600649141
Month 147	0.1062	15.618458	0.604788058
Month 148	0.1062	15.724706	0.608927315
Month 149	0.1062	15.830954	0.613066912
Month 150	0.1062	15.937202	0.617206851
Month 151	0.1062	16.04345	0.62134713
Month 152	0.1062	16.149698	0.625487749
Month 153	0.1062	16.255946	0.62962871
Month 154	0.1062	16.362194	0.633770011
Month 155	0.1062	16.468442	0.637911654
Month 156	0.1062	16.57469	0.642053637
Month 157	0.1062	16.680938	0.646195961
Month 158	0.1062	16.787186	0.650338626
Month 159	0.1062	16.893434	0.654481632
Month 160	0.1062	16.999682	0.658624979
Month 161	0.1062	17.10593	0.662768668
Month 162	0.1062	17.212178	0.666912697
Month 163	0.1062	17.318426	0.671057068
Month 164	0.1062	17.424674	0.67520178
Month 165	0.1062	17.530922	0.679346833
Month 166	0.1062	17.63717	0.683492228
Month 167	0.1062	17.743418	0.687637964
Month 168	0.1062	17.849666	0.691784041
Month 169	0.1062	17.955914	0.69593046
Month 170	0.1062	18.062162	0.700077221
Month 171	0.1062	18.16841	0.704224323
Month 172	0.1062	18.274658	0.708371766
Month 173	0.1062	18.380906	0.712519552

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Diffuser Plugging Normal Sheet 6 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 174	0.1062	18.487154	0.716667678
Month 175	0.1062	18.593402	0.720816147
Month 176	0.1062	18.69965	0.724964957
Month 177	0.1062	18.805898	0.72911411
Month 178	0.1062	18.912146	0.733263604
Month 179	0.1062	19.018394	0.737413439
Month 180	0.1062	19.124642	0.741563617
Month 181	0.1062	19.23089	0.745714137
Month 182	0.1062	19.337138	0.749864999
Month 183	0.1062	19.443386	0.754016203
Month 184	0.1062	19.549634	0.758167749
Month 185	0.1062	19.655882	0.762319637
Month 186	0.1062	19.76213	0.766471867
Month 187	0.1062	19.868378	0.77062444
Month 188	0.1062	19.974626	0.774777354
Month 189	0.1062	20.080874	0.778930611
Month 190	0.1062	20.187122	0.783084211
Month 191	0.1062	20.29337	0.787238153
Month 192	0.1062	20.399618	0.791392437
Month 193	0.1062	20.505866	0.795547064
Month 194	0.1062	20.612114	0.799702033
Month 195	0.1062	20.718362	0.803857345
Month 196	0.1062	20.82461	0.808012999
Month 197	0.1062	20.930858	0.812168996
Month 198	0.1062	21.037106	0.816325336
Month 199	0.1062	21.143354	0.820482019
Month 200	0.1062	21.249602	0.824639044
Month 201	0.1062	21.35585	0.828796412
Month 202	0.1062	21.462098	0.832954123
Month 203	0.1062	21.568346	0.837112177
Month 204	0.1062	21.674594	0.841270574
Month 205	0.1062	21.780842	0.845429314
Month 206	0.1062	21.88709	0.849588396
Month 207	0.1062	21.993338	0.853747822
Month 208	0.1062	22.099586	0.857907591
Month 209	0.1062	22.205834	0.862067703
Month 210	0.1062	22.312082	0.866228159
Month 211	0.1062	22.41833	0.870388958
Month 212	0.1062	22.524578	0.874550099
Month 213	0.1062	22.630826	0.878711585
Month 214	0.1062	22.737074	0.882873413
Month 215	0.1062	22.843322	0.887035585
Month 216	0.1062	22.94957	0.891198101
Month 217	0.1062	23.055818	0.89536096
Month 218	0.1062	23.162066	0.899524162
Month 219	0.1062	23.268314	0.903687708
Month 220	0.1062	23.374562	0.907851598
Month 221	0.1062	23.48081	0.912015832

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Diffuser Plugging Normal Sheet 7 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 222	0.1062	23.587058	0.916180409
Month 223	0.1062	23.693306	0.92034533
Month 224	0.1062	23.799554	0.924510594
Month 225	0.1062	23.905802	0.928676203
Month 226	0.1062	24.01205	0.932842155
Month 227	0.1062	24.118298	0.937008451
Month 228	0.1062	24.224546	0.941175092
Month 229	0.1062	24.330794	0.945342076
Month 230	0.1062	24.437043	0.949509404
Month 231	0.1062	24.543291	0.953677077
Month 232	0.1062	24.649539	0.957845093
Month 233	0.1062	24.755787	0.962013454
Month 234	0.1062	24.862035	0.966182159
Month 235	0.1062	24.968283	0.970351208
Month 236	0.1062	25.074531	0.974520602
Month 237	0.1062	25.180779	0.97869034
Month 238	0.1062	25.287027	0.982860422
Month 239	0.1062	25.393275	0.987030849
Month 240	0.1062	25.499523	0.99120162

Diffuser Plugging:

Therefore Percent Fe_2O_3 to H_2O = 0.9912016 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 1Y Diffuser Plugging Abnormal Sheet 1 of 2

BY: BS CHECKED BY: MH DATE: 1/11/2012

ASSUMPTIONS Concentration (C): 0.11 mg/L

Volume of Sparge Point

	n	pi	r (m)	h (m)	Equals	
V=n*(pi)*(r^2)*H	1	3.14	0.0254	0.4572	0.00093	m^3
VL					0.9262	liters
					926.197	g (mL)

Volume of Sparge Point Piping

	n	pi	r (m)	h (m)	Equals	
V=n*(pi)*(r^2)*H	1	3.14	0.009525	14.6304	0.00417	m^3
VL					4.16789	liters
					4167.89	g (mL)

Total iron mass in liquid

	VLspp+VLsp	C	Equals	
(VLspp+VLsp)*C	5.094082715	0.11	0.5603491	mg
			0.00056035	g

Intercalc - Volume of Diffuser Media

	pi	r (m)	h (m)	Equals	
V=(pi)*(r^2)*H	3.14	0.0254	0.4572	0.00093	m^3
VL				0.9262	liters
				926.197	g (mL)

Intercalc - Volume .25" on either side of Diffuser

	pi	r	h	Equals	
V=(pi)*(r^2)*H	3.14	0.034925	0.4572	0.00175	m^3
VL				1.75109	liters
				1751.09	g (mL)

	n	Delta V (m^3)	equals	
V=n*Delta V	0.4	0.0008249	0.00032996	m^3
			0.33	liters
			329.96	grams (mL)

FIRST Molecular Weight Equivalents

O3 -> = 48 g/mol
2Fe^2+ -> = 112 g/mol
equals = 160 g/mol
H2O -> = 18 g/mol

Therefore if Fe2+ = 0.0005603 g
Then O3 available = ((g/mol of O3) / (g/mol 2Fe^2+)) * g 2Fe^2+
equals = 0.0002401 gO3
So Fe2O3 = 0.0008005 g
Therefore Percent Fe2O3 to H2O = 0.0000864 %

SECOND Residence Time of Cylinder

Pulsed Operation	Number of Days	Pulses per Day	Equals	Units
D*P	365	24	8760	Pulses per yr

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 1Y Diffuser Plugging Abnormal Sheet 2 of 2

BY: BS CHECKED BY: MH DATE: 1/11/2012

	Cycles	Mass per cycle (g)	Equals	Units
Monthly Precipitated Mass	730	0.0008005	0.5844	g
Annual Precipitated Mass	8760	0.0008005	7.0124	g

	Number of years	Annual Precip. Mass	equals	Units
Life-cycle Precipitated Mass	1	7.0124	7.012	g

THIRD Therefore Percent Fe2O3 to H2O = 2.1252331 %

FOURTH Alternative Calculation:
Accumulation of precipitate per month, accounting for decrease in available porosity

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 1	0.5844	0.5843641	0.022497155
Month 2	0.5844	1.1687281	0.045004435
Month 3	0.5844	1.7530922	0.067521847
Month 4	0.5844	2.3374562	0.090049396
Month 5	0.5844	2.9218203	0.112587092
Month 6	0.5844	3.5061844	0.135134939
Month 7	0.5844	4.0905484	0.157692945
Month 8	0.5844	4.6749125	0.180261117
Month 9	0.5844	5.2592765	0.202839462
Month 10	0.5844	5.8436406	0.225427986
Month 11	0.5844	6.4280047	0.248026697
Month 12	0.5844	7.0123687	0.270635601

Diffuser Plugging:

Therefore Percent Fe2O3 to H2O = 0.2706356 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 5Y Diffuser Plugging Abnormal Sheet 1 of 3

BY: BS CHECKED BY: MH DATE: 1/11/2012

ASSUMPTIONS Concentration (C): 0.11 mg/L

Volume of Sparge Point

	n	pi	r (m)	h (m)	Equals	
V=n*(pi)*(r^2)*H	1	3.14	0.0254	0.4572	0.00093	m^3
VL					0.9262	liters
					926.197	g (mL)

Volume of Sparge Point Piping

	n	pi	r (m)	h (m)	Equals	
V=n*(pi)*(r^2)*H	1	3.14	0.009525	14.6304	0.00417	m^3
VL					4.16789	liters
					4167.89	g (mL)

Total iron mass in liquid

	VLspp+VLsp	C	Equals	
(VLspp+VLsp)*C	5.094082715	0.11	0.5603491	mg
			0.00056035	g

Intercalc - Volume of Diffuser Media

	pi	r (m)	h (m)	Equals	
V=(pi)*(r^2)*H	3.14	0.0254	0.4572	0.00093	m^3
VL				0.9262	liters
				926.197	g (mL)

Intercalc - Volume .25" on either side of Diffuser

	pi	r	h	Equals	
V=(pi)*(r^2)*H	3.14	0.034925	0.4572	0.00175	m^3
VL				1.75109	liters
				1751.09	g (mL)

	n	Delta V (m^3)	equals	
V=n*Delta V	0.4	0.0008249	0.00032996	m^3
			0.33	liters
			329.96	grams (mL)

FIRST Molecular Weight Equivalents

O3 -> = 48 g/mol
2Fe^2+ -> = 112 g/mol
equals = 160 g/mol
H2O -> = 18 g/mol

Therefore if Fe2+ = 0.0005603 g
Then O3 available = ((g/mol of O3) / (g/mol 2Fe^2+)) * g 2Fe^2+
equals = 0.0002401 gO3
So Fe2O3 = 0.0008005 g
Therefore Percent Fe2O3 to H2O = 0.0000864 %

SECOND Residence Time of Cylinder

Pulsed Operation	Number of Days	Pulses per Day	Equals	Units
D*P	365	24	8760	Pulses per yr

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 5Y Diffuser Plugging Abnormal Sheet 2 of 3

BY: BS CHECKED BY: MH DATE: 1/11/2012

	Cycles	Mass per cycle (g)	Equals	Units
Monthly Precipitated Mass	730	0.0008005	0.5844	g
Annual Precipitated Mass	8760	0.0008005	7.0124	g

	Number of years	Annual Precip. Mass	equals	Units
Life-cycle Precipitated Mass	5	7.0124	35.062	g

THIRD Therefore Percent Fe2O3 to H2O = 10.626165 %

FOURTH Alternative Calculation:
Accumulation of precipitate per month, accounting for decrease in available porosity

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 1	0.5844	0.5843641	0.022497155
Month 2	0.5844	1.1687281	0.045004435
Month 3	0.5844	1.7530922	0.067521847
Month 4	0.5844	2.3374562	0.090049396
Month 5	0.5844	2.9218203	0.112587092
Month 6	0.5844	3.5061844	0.135134939
Month 7	0.5844	4.0905484	0.157692945
Month 8	0.5844	4.6749125	0.180261117
Month 9	0.5844	5.2592765	0.202839462
Month 10	0.5844	5.8436406	0.225427986
Month 11	0.5844	6.4280047	0.248026697
Month 12	0.5844	7.0123687	0.270635601
Month 13	0.5844	7.5967328	0.293254705
Month 14	0.5844	8.1810968	0.315884017
Month 15	0.5844	8.7654609	0.338523542
Month 16	0.5844	9.349825	0.361173289
Month 17	0.5844	9.934189	0.383833263
Month 18	0.5844	10.518553	0.406503473
Month 19	0.5844	11.102917	0.429183924
Month 20	0.5844	11.687281	0.451874624
Month 21	0.5844	12.271645	0.474575579
Month 22	0.5844	12.856009	0.497286797
Month 23	0.5844	13.440373	0.520008285
Month 24	0.5844	14.024737	0.542740049
Month 25	0.5844	14.609102	0.565482097
Month 26	0.5844	15.193466	0.588234435
Month 27	0.5844	15.77783	0.610997071
Month 28	0.5844	16.362194	0.633770011
Month 29	0.5844	16.946558	0.656553263

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 5Y Diffuser Plugging Abnormal Sheet 3 of 3

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 30	0.5844	17.530922	0.679346833
Month 31	0.5844	18.115286	0.702150729
Month 32	0.5844	18.69965	0.724964957
Month 33	0.5844	19.284014	0.747789525
Month 34	0.5844	19.868378	0.77062444
Month 35	0.5844	20.452742	0.793469707
Month 36	0.5844	21.037106	0.816325336
Month 37	0.5844	21.62147	0.839191332
Month 38	0.5844	22.205834	0.862067703
Month 39	0.5844	22.790198	0.884954456
Month 40	0.5844	23.374562	0.907851598
Month 41	0.5844	23.958926	0.930759136
Month 42	0.5844	24.543291	0.953677077
Month 43	0.5844	25.127655	0.976605428
Month 44	0.5844	25.712019	0.999544196
Month 45	0.5844	26.296383	1.022493388
Month 46	0.5844	26.880747	1.045453012
Month 47	0.5844	27.465111	1.068423075
Month 48	0.5844	28.049475	1.091403583
Month 49	0.5844	28.633839	1.114394544
Month 50	0.5844	29.218203	1.137395965
Month 51	0.5844	29.802567	1.160407853
Month 52	0.5844	30.386931	1.183430215
Month 53	0.5844	30.971295	1.206463058
Month 54	0.5844	31.555659	1.22950639
Month 55	0.5844	32.140023	1.252560218
Month 56	0.5844	32.724387	1.275624549
Month 57	0.5844	33.308751	1.298699389
Month 58	0.5844	33.893115	1.321784747
Month 59	0.5844	34.47748	1.344880629
Month 60	0.5844	35.061844	1.367987043

Diffuser Plugging:

Therefore Percent Fe_2O_3 to H_2O = 1.367987 %

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Diffuser Plugging Abnormal Sheet 1 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

ASSUMPTIONS Concentration (C): 0.11 mg/L

Volume of Sparge Point

	n	pi	r (m)	h (m)	Equals	
V=n*(pi)*(r^2)*H	1	3.14	0.0254	0.4572	0.00093	m^3
VL					0.9262	liters
					926.197	g (mL)

Volume of Sparge Point Piping

	n	pi	r (m)	h (m)	Equals	
V=n*(pi)*(r^2)*H	1	3.14	0.009525	14.6304	0.00417	m^3
VL					4.16789	liters
					4167.89	g (mL)

Total iron mass in liquid

	VLspp+VLsp	C	Equals	
(VLspp+VLsp)*C	5.094082715	0.11	0.5603491	mg
			0.00056035	g

Intercalc - Volume of Diffuser Media

	pi	r (m)	h (m)	Equals	
V=(pi)*(r^2)*H	3.14	0.0254	0.4572	0.00093	m^3
VL				0.9262	liters
				926.197	g (mL)

Intercalc - Volume .25" on either side of Diffuser

	pi	r	h	Equals	
V=(pi)*(r^2)*H	3.14	0.034925	0.4572	0.00175	m^3
VL				1.75109	liters
				1751.09	g (mL)

	n	Delta V (m^3)	equals	
V=n*Delta V	0.4	0.0008249	0.00032996	m^3
			0.33	liters
			329.96	grams (mL)

FIRST Molecular Weight Equivalents

O3 -> = 48 g/mol
2Fe^2+ -> = 112 g/mol
equals = 160 g/mol
H2O -> = 18 g/mol

Therefore if Fe2+ = 0.0005603 g
Then O3 available = ((g/mol of O3) / (g/mol 2Fe^2+)) * g 2Fe^2+
equals = 0.0002401 gO3
So Fe2O3 = 0.0008005 g
Therefore Percent Fe2O3 to H2O = 0.0000864 %

SECOND Residence Time of Cylinder

Pulsed Operation	Number of Days	Pulses per Day	Equals	Units
D*P	365	24	8760	Pulses per yr

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Diffuser Plugging Abnormal Sheet 2 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

	Cycles	Mass per cycle (g)	Equals	Units
Monthly Precipitated Mass	730	0.0008005	0.5844	g
Annual Precipitated Mass	8760	0.0008005	7.0124	g

	Number of years	Annual Precip. Mass	equals	Units
Life-cycle Precipitated Mass	20	7.0124	140.247	g

THIRD Therefore Percent Fe_2O_3 to H_2O = 42.504662 %

FOURTH Alternative Calculation:
Accumulation of precipitate per month, accounting for decrease in available porosity

	Mass	Cumulative Mass	Cumulative Percent Plugging
Month 1	0.5844	0.5843641	0.022497155
Month 2	0.5844	1.1687281	0.045004435
Month 3	0.5844	1.7530922	0.067521847
Month 4	0.5844	2.3374562	0.090049396
Month 5	0.5844	2.9218203	0.112587092
Month 6	0.5844	3.5061844	0.135134939
Month 7	0.5844	4.0905484	0.157692945
Month 8	0.5844	4.6749125	0.180261117
Month 9	0.5844	5.2592765	0.202839462
Month 10	0.5844	5.8436406	0.225427986
Month 11	0.5844	6.4280047	0.248026697
Month 12	0.5844	7.0123687	0.270635601
Month 13	0.5844	7.5967328	0.293254705
Month 14	0.5844	8.1810968	0.315884017
Month 15	0.5844	8.7654609	0.338523542
Month 16	0.5844	9.349825	0.361173289
Month 17	0.5844	9.934189	0.383833263
Month 18	0.5844	10.518553	0.406503473
Month 19	0.5844	11.102917	0.429183924
Month 20	0.5844	11.687281	0.451874624
Month 21	0.5844	12.271645	0.474575579
Month 22	0.5844	12.856009	0.497286797
Month 23	0.5844	13.440373	0.520008285
Month 24	0.5844	14.024737	0.542740049
Month 25	0.5844	14.609102	0.565482097
Month 26	0.5844	15.193466	0.588234435
Month 27	0.5844	15.77783	0.610997071
Month 28	0.5844	16.362194	0.633770011
Month 29	0.5844	16.946558	0.656553263

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Diffuser Plugging Abnormal Sheet 3 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 30	0.5844	17.530922	0.679346833
Month 31	0.5844	18.115286	0.702150729
Month 32	0.5844	18.69965	0.724964957
Month 33	0.5844	19.284014	0.747789525
Month 34	0.5844	19.868378	0.77062444
Month 35	0.5844	20.452742	0.793469707
Month 36	0.5844	21.037106	0.816325336
Month 37	0.5844	21.62147	0.839191332
Month 38	0.5844	22.205834	0.862067703
Month 39	0.5844	22.790198	0.884954456
Month 40	0.5844	23.374562	0.907851598
Month 41	0.5844	23.958926	0.930759136
Month 42	0.5844	24.543291	0.953677077
Month 43	0.5844	25.127655	0.976605428
Month 44	0.5844	25.712019	0.999544196
Month 45	0.5844	26.296383	1.022493388
Month 46	0.5844	26.880747	1.045453012
Month 47	0.5844	27.465111	1.068423075
Month 48	0.5844	28.049475	1.091403583
Month 49	0.5844	28.633839	1.114394544
Month 50	0.5844	29.218203	1.137395965
Month 51	0.5844	29.802567	1.160407853
Month 52	0.5844	30.386931	1.183430215
Month 53	0.5844	30.971295	1.206463058
Month 54	0.5844	31.555659	1.22950639
Month 55	0.5844	32.140023	1.252560218
Month 56	0.5844	32.724387	1.275624549
Month 57	0.5844	33.308751	1.298699389
Month 58	0.5844	33.893115	1.321784747
Month 59	0.5844	34.47748	1.344880629
Month 60	0.5844	35.061844	1.367987043
Month 61	0.5844	35.646208	1.391103996
Month 62	0.5844	36.230572	1.414231495
Month 63	0.5844	36.814936	1.437369547
Month 64	0.5844	37.3993	1.46051816
Month 65	0.5844	37.983664	1.48367734
Month 66	0.5844	38.568028	1.506847095
Month 67	0.5844	39.152392	1.530027432
Month 68	0.5844	39.736756	1.553218359
Month 69	0.5844	40.32112	1.576419883
Month 70	0.5844	40.905484	1.59963201
Month 71	0.5844	41.489848	1.622854749
Month 72	0.5844	42.074212	1.646088106
Month 73	0.5844	42.658576	1.66933209
Month 74	0.5844	43.24294	1.692586706
Month 75	0.5844	43.827305	1.715851962
Month 76	0.5844	44.411669	1.739127867
Month 77	0.5844	44.996033	1.762414426

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Diffuser Plugging Abnormal Sheet 4 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 78	0.5844	45.580397	1.785711648
Month 79	0.5844	46.164761	1.809019539
Month 80	0.5844	46.749125	1.832338107
Month 81	0.5844	47.333489	1.85566736
Month 82	0.5844	47.917853	1.879007304
Month 83	0.5844	48.502217	1.902357947
Month 84	0.5844	49.086581	1.925719297
Month 85	0.5844	49.670945	1.94909136
Month 86	0.5844	50.255309	1.972474145
Month 87	0.5844	50.839673	1.995867658
Month 88	0.5844	51.424037	2.019271907
Month 89	0.5844	52.008401	2.042686899
Month 90	0.5844	52.592765	2.066112642
Month 91	0.5844	53.177129	2.089549143
Month 92	0.5844	53.761494	2.112996409
Month 93	0.5844	54.345858	2.136454448
Month 94	0.5844	54.930222	2.159923268
Month 95	0.5844	55.514586	2.183402875
Month 96	0.5844	56.09895	2.206893278
Month 97	0.5844	56.683314	2.230394483
Month 98	0.5844	57.267678	2.253906498
Month 99	0.5844	57.852042	2.277429331
Month 100	0.5844	58.436406	2.300962989
Month 101	0.5844	59.02077	2.32450748
Month 102	0.5844	59.605134	2.34806281
Month 103	0.5844	60.189498	2.371628988
Month 104	0.5844	60.773862	2.395206021
Month 105	0.5844	61.358226	2.418793916
Month 106	0.5844	61.94259	2.442392682
Month 107	0.5844	62.526954	2.466002325
Month 108	0.5844	63.111318	2.489622853
Month 109	0.5844	63.695683	2.513254273
Month 110	0.5844	64.280047	2.536896593
Month 111	0.5844	64.864411	2.560549822
Month 112	0.5844	65.448775	2.584213965
Month 113	0.5844	66.033139	2.607889031
Month 114	0.5844	66.617503	2.631575027
Month 115	0.5844	67.201867	2.655271962
Month 116	0.5844	67.786231	2.678979841
Month 117	0.5844	68.370595	2.702698674
Month 118	0.5844	68.954959	2.726428467
Month 119	0.5844	69.539323	2.750169229
Month 120	0.5844	70.123687	2.773920966
Month 121	0.5844	70.708051	2.797683687
Month 122	0.5844	71.292415	2.821457399
Month 123	0.5844	71.876779	2.84524211
Month 124	0.5844	72.461143	2.869037826
Month 125	0.5844	73.045508	2.892844557

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Diffuser Plugging Abnormal Sheet 5 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 126	0.5844	73.629872	2.91666231
Month 127	0.5844	74.214236	2.940491092
Month 128	0.5844	74.7986	2.96433091
Month 129	0.5844	75.382964	2.988181774
Month 130	0.5844	75.967328	3.012043689
Month 131	0.5844	76.551692	3.035916665
Month 132	0.5844	77.136056	3.059800708
Month 133	0.5844	77.72042	3.083695827
Month 134	0.5844	78.304784	3.107602028
Month 135	0.5844	78.889148	3.131519321
Month 136	0.5844	79.473512	3.155447712
Month 137	0.5844	80.057876	3.179387209
Month 138	0.5844	80.64224	3.20333782
Month 139	0.5844	81.226604	3.227299553
Month 140	0.5844	81.810968	3.251272415
Month 141	0.5844	82.395332	3.275256415
Month 142	0.5844	82.979697	3.299251559
Month 143	0.5844	83.564061	3.323257856
Month 144	0.5844	84.148425	3.347275314
Month 145	0.5844	84.732789	3.37130394
Month 146	0.5844	85.317153	3.395343742
Month 147	0.5844	85.901517	3.419394728
Month 148	0.5844	86.485881	3.443456905
Month 149	0.5844	87.070245	3.467530282
Month 150	0.5844	87.654609	3.491614867
Month 151	0.5844	88.238973	3.515710667
Month 152	0.5844	88.823337	3.539817689
Month 153	0.5844	89.407701	3.563935943
Month 154	0.5844	89.992065	3.588065435
Month 155	0.5844	90.576429	3.612206173
Month 156	0.5844	91.160793	3.636358167
Month 157	0.5844	91.745157	3.660521422
Month 158	0.5844	92.329521	3.684695947
Month 159	0.5844	92.913886	3.708881751
Month 160	0.5844	93.49825	3.73307884
Month 161	0.5844	94.082614	3.757287224
Month 162	0.5844	94.666978	3.781506909
Month 163	0.5844	95.251342	3.805737904
Month 164	0.5844	95.835706	3.829980216
Month 165	0.5844	96.42007	3.854233854
Month 166	0.5844	97.004434	3.878498825
Month 167	0.5844	97.588798	3.902775138
Month 168	0.5844	98.173162	3.9270628
Month 169	0.5844	98.757526	3.951361819
Month 170	0.5844	99.34189	3.975672204
Month 171	0.5844	99.926254	3.999993962
Month 172	0.5844	100.51062	4.024327101
Month 173	0.5844	101.09498	4.04867163

CALCULATION WORKSHEET

CLIENT: USACE JOB NUMBER: 62393.01

SUBJECT: Oasis - 20Y Diffuser Plugging Abnormal Sheet 6 of 7

BY: BS CHECKED BY: MH DATE: 1/11/2012

Month 174	0.5844	101.67935	4.073027555
Month 175	0.5844	102.26371	4.097394886
Month 176	0.5844	102.84807	4.12177363
Month 177	0.5844	103.43244	4.146163796
Month 178	0.5844	104.0168	4.170565391
Month 179	0.5844	104.60117	4.194978423
Month 180	0.5844	105.18553	4.2194029
Month 181	0.5844	105.76989	4.243838831
Month 182	0.5844	106.35426	4.268286223
Month 183	0.5844	106.93862	4.292745085
Month 184	0.5844	107.52299	4.317215425
Month 185	0.5844	108.10735	4.34169725
Month 186	0.5844	108.69172	4.366190569
Month 187	0.5844	109.27608	4.39069539
Month 188	0.5844	109.86044	4.415211721
Month 189	0.5844	110.44481	4.43973957
Month 190	0.5844	111.02917	4.464278945
Month 191	0.5844	111.61354	4.488829855
Month 192	0.5844	112.1979	4.513392307
Month 193	0.5844	112.78226	4.53796631
Month 194	0.5844	113.36663	4.562551871
Month 195	0.5844	113.95099	4.587149
Month 196	0.5844	114.53536	4.611757704
Month 197	0.5844	115.11972	4.63637799
Month 198	0.5844	115.70408	4.661009869
Month 199	0.5844	116.28845	4.685653347
Month 200	0.5844	116.87281	4.710308432
Month 201	0.5844	117.45718	4.734975134
Month 202	0.5844	118.04154	4.75965346
Month 203	0.5844	118.6259	4.784343419
Month 204	0.5844	119.21027	4.809045018
Month 205	0.5844	119.79463	4.833758266
Month 206	0.5844	120.379	4.858483172
Month 207	0.5844	120.96336	4.883219742
Month 208	0.5844	121.54772	4.907967987
Month 209	0.5844	122.13209	4.932727913
Month 210	0.5844	122.71645	4.95749953
Month 211	0.5844	123.30082	4.982282845
Month 212	0.5844	123.88518	5.007077867
Month 213	0.5844	124.46954	5.031884604
Month 214	0.5844	125.05391	5.056703064
Month 215	0.5844	125.63827	5.081533257
Month 216	0.5844	126.22264	5.106375189
Month 217	0.5844	126.807	5.131228869
Month 218	0.5844	127.39137	5.156094306
Month 219	0.5844	127.97573	5.180971509
Month 220	0.5844	128.56009	5.205860484
Month 221	0.5844	129.14446	5.230761242

Month 222	0.5844	129.72882	5.255673789
Month 223	0.5844	130.31319	5.280598135
Month 224	0.5844	130.89755	5.305534288
Month 225	0.5844	131.48191	5.330482256
Month 226	0.5844	132.06628	5.355442048
Month 227	0.5844	132.65064	5.380413671
Month 228	0.5844	133.23501	5.405397136
Month 229	0.5844	133.81937	5.430392449
Month 230	0.5844	134.40373	5.45539962
Month 231	0.5844	134.9881	5.480418656
Month 232	0.5844	135.57246	5.505449566
Month 233	0.5844	136.15683	5.53049236
Month 234	0.5844	136.74119	5.555547044
Month 235	0.5844	137.32555	5.580613628
Month 236	0.5844	137.90992	5.60569212
Month 237	0.5844	138.49428	5.630782529
Month 238	0.5844	139.07865	5.655884863
Month 239	0.5844	139.66301	5.68099913
Month 240	0.5844	140.24737	5.70612534

Diffuser Plugging:

Therefore Percent Fe_2O_3 to H_2O = 5.7061253 %