C3-006-70596, 8.1

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March 14, 2016

RECEIVED

MAR 16 2016

BUREAU OF
ENVIRONMENTAL REMEDIATION

Ms. Andrea Schiller
Kansas Department of Health and Environment
1000 SW Jackson, Suite 410
Topeka, KS 66612-1367

Re: **Union Pacific Railroad - Double Circle Farm Supply Site**
Fort Scott, Bourbon County, Kansas
KDHE Voluntary Agreement 07VCP003

Dear Ms. Schiller:

On behalf of Union Pacific Railroad, Antea®Group is pleased to provide the Kansas Department of Health and Environment (KDHE) this response to your February 12, 2016 correspondence regarding the review of the November 12, 2015 Voluntary Cleanup (VC) Plan submitted for the above-referenced site.

The following attachment is included for your reference:

- Table 1 – KDHE RSK Standards

This response addresses the following comments from KDHE's correspondence:

1. ***Section 2.2.1***: *The VC Plan indicates "Following remedial activities, KDHE requires that groundwater is monitored and sampled for at least two years or a minimum of four semi-annual events." To clarify, KDHE does not specifically require at least 2 years of monitoring or 4 semi-annual monitoring events following all remedial actions. The policy that appears to be referenced by this sentence in the VC Plan is the general closure criteria that only comes into effect once contaminant concentrations have dropped below cleanup goals. Up to that point, the Voluntary Party could choose a different sampling strategy and would not necessarily be bound by only semi-annual monitoring. In KDHE's experience, it is unlikely that groundwater concentrations will drop below cleanup goals for the first sampling event: therefore, it is likely that monitoring beyond the proposed two years may be necessary.*

   In addition, KDHE does not generally approve to sampling frequency changes or how and when a NFA may be issued in the VC Plan. Both of these issues are result-dependent, which cannot be known at the time of the VC Plan. KDHE would agree, however, to including possible consideration of frequency changes and/or issuing a NFA after a certain monitoring period, to be proposed by the Voluntary Party, in the VC Plan. Please review and revise, as necessary, to clarify this section.

   Response: KDHE's comments regarding sample frequency are acknowledged. The actual frequency and duration of the groundwater monitoring conducted at the site will be determined based on data results following the remedial activities. As outlined in section 3.5 of the report, quarterly sampling is recommended initially to

determine the more immediate effects of the injection. In addition, a potential second injection event with follow up sampling is outlined in the November 12, 2015 plan. Changes in sample frequency will be submitted to KDHE for approval prior to implementation.

2. ***Section 2.2.1, Table & Table 1:*** *Please note that 10 mg/l is the groundwater risk-based cleanup standard (RSK) for nitrate only. There is no RSK or MCL developed for ammonia; however, ammonia is known to move to nitrate quickly. In addition, as TPH-DRO was addressed through the IRMs, it is no longer considered a contaminant of concern for the VC Plan and should be removed from Table 1. Please review and revise the tables, as necessary.*

   Response: The table from Section 2.2.1 of the VC Plan containing the site specific cleanup goals has been revised to include the RSK for nitrate only and is shown below.

Chemical Constituent in Groundwater	***Site-Specific Groundwater Cleanup Goal Residential RSK (mg/L)***
Nitrate	10.0

   In addition, Table 1 from the VC Plan has also been revised. TPH-DRO has been removed from the revised table, and the table includes the RSK values for nitrate only. The revised Table 1 is included as an attachment to this response.

3. ***Section 3.5****: See Comment 1 regarding the proposed frequency changes in monitoring.*

   Response: As stated above, KDHE's comments regarding sample frequency are acknowledged. The actual frequency and duration of the groundwater monitoring conducted at the site will be determined based on data results following the remedial activities. Sample frequencies not currently outlined in the plan would be submitted to KDHE for approval prior to implementation.

4. ***General Comment:*** *KDHE requests a contingency statement be included in the VC Plan, which indicates what is to happen if the proposed VC Plan is not successful in achieving cleanup goals.*

   Response: If the proposed remedial actions and specific contingencies already outlined in the plan are not successful at achieving closure levels, alternatives will be evaluated.

Should you have any questions or require further information, please contact me at 636-442-4777, 800-477-7411 or via email at addie.mette@anteagroup.com.

Sincerely,

Addie J Mette

Addie J. Mette
Sr. Project Manager

Attachment

cc: Mr. Jeffrey D. McDermott, PE – Union Pacific Railroad

TABLE 1
KDHE RSK STANDARDS
UPRR Double Circle Farm Supply Site
Fort Scott, Kansas

Contaminants of Concern (COCs)	Soil				Groundwater
	Vegetation Present		No Vegetation Present		
	0 to 24 inches	Below 24 inches	0 to 8 inches	Below 8 inches	
Nitrate	200 mg/kg	40 mg/kg	85 mg/kg	40 mg/kg	10.0 mg/L

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November 12, 2015

Ms. Andrea Schiller
Kansas Department of Health and Environment
1000 SW Jackson, Suite 400
Topeka, KS 66612-1367

RECEIVED
NOV 13 2015
BUREAU OF
ENVIRONMENTAL REMEDIATION

Re: **Union Pacific Railroad - Double Circle Farm Supply Site**
Fort Scott, Bourbon County, Kansas
KDHE Voluntary Agreement 07VCP003

Dear Mr. Richards:

On behalf of Union Pacific Railroad, Antea Group is submitting this Voluntary Cleanup Plan for the above-referenced site. Should you have any questions regarding the information in this proposal, please contact me at 636-442-4777, 800-477-7411 or via email at addie.mette@anteagroup.com.

Sincerely,

Addie J. Mette

Addie J. Mette
Sr. Project Manager

Cc: Mr. Jeffrey D. McDermott, PE – Union Pacific Railroad

Voluntary Cleanup Plan

Double Circle Farm Supply Site
Fort Scott, Kansas
KDHE Voluntary Agreement 07VCP003

Antea Group Project No. UPR8263A
November 12, 2015

Prepared for:
Union Pacific Railroad
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Voluntary Cleanup Plan

Double Circle Farm Supply Site
Fort Scott, Kansas

1.0 INTRODUCTION

Antea®Group has prepared this Voluntary Cleanup Plan (VCP) on behalf of Union Pacific Railroad (UP) to define remedial activities at the UP property located north of the intersection of Elm Street and National Avenue south of the Marmaton River in Fort Scott, Kansas (hereby the "Site"). The location of the Site is presented on a topographic map, included as **Figure 1**. This VCP has been developed in accordance with the Kansas Department of Health and Environment (KDHE) Voluntary Cleanup and Property Redevelopment Program guidelines. Components of the VCP follow the listings in the Voluntary Cleanup and Property Redevelopment Program, Appendix G: Voluntary Cleanup Plan Scope of Work.

In April 2007, UP filed an Application to participate in the Kansas Voluntary Cleanup and Property Redevelopment Program (VCPRP). UP and KDHE entered into a Voluntary Agreement to address residual impact at the Site under the VCPRP on June 11, 2007. This VCP and subsequent remedial activities are being conducted in accordance with this Voluntary Agreement.

The cleanup action approved by KDHE following submittal of the Voluntary Cleanup Proposal dated June 10, 2015 and further discussed in this VCP, includes the remediation of ammonia and nitrate groundwater concentrations in excess of non-residential Risk-Based Standards of Kansas (RSKs) by in-situ bioremediation and the implementation of Environmental Use Controls (EUC) on the Site.

The in-situ bioremediation alternative was selected as the preferred remedy for ammonia and nitrate in groundwater in the Voluntary Cleanup Proposal dated June 10, 2015, which was approved by KDHE on August 11, 2015. An overview of the remediation evaluation and selection process is further described in **Section 2.0**.

1.1 Property Background

The Site is located on the north side of Fort Scott, in Bourbon County, Kansas. The land-based description of the source area is in the NW quarter of Section 30, T25S, R25E, Fort Scott, Kansas, with center coordinates of N 37.84583 W 94.70808. Bourbon County records show that UP currently owns the property. The property is located north of the intersection of Elm Street and National Avenue, south of the Marmaton River, and covers approximately 6.0 acres. The Marmaton River and thick vegetation border the Site to the west and north. A Site Location Map is included as **Figure 1**.

The Site has been under the ownership of UP since 1889. From 1986 to 1995, Farmland Industries, Inc., leased the Site from UP as the Double Circle Farm Supply for use as a fertilizer warehouse. From 1995 to the present, the Site has existed as a vacant, cleared lot. Land in the vicinity of the Site is utilized as commercial property. The subject property extends from the Marmaton River to the west and north, National Avenue to the east, and approximately 20 feet south of the southern-most railroad tracks on the property. The area south of the property line consists of a concrete-paved driveway owned and used by Westcoat's Auto Body services. Approximately 70 feet south of the southern property line is a retail gasoline service station. A Site Detail Map is included as **Figure 2.**

1.2 Investigation History

The initial Area of Interest (AOI) (an area approximately 100 feet by 150 feet) was determined based on previous investigations performed by KDHE and historical accounts of the ammonia and nitrate release surrounding the former fertilizer warehouse. Previous site investigations suggested that the ammonia and nitrate impact is attributable to a flood event in 1993. A full site investigation to assess environmental impacts has been performed on the accessible portion of the Site. The horizontal and vertical extents of impacted soil were determined through previous investigations conducted through the Voluntary Cleanup Investigations (VCI) performed from October 2007 through November 2008. The results of these investigations are contained in the *Voluntary Cleanup Investigation Report – Double Circle Farm Supply* and the *Voluntary Cleanup Investigation Report Addendum – Double Circle Farm Supply* submitted to KDHE by Foth Infrastructure and Environment, LLC (Foth) on July 30, 2008 and March 16, 2009, respectively.

The Site is heavily vegetated with tall grass and trees; however, two areas of stressed vegetation or bare spots within the area of investigation were historically present as shown on **Figure 2**. Debris piles of concrete, granite and slabs of masonry were also historically present at the Site. The presence of these piles has not been confirmed during recent sampling events due to the overgrown vegetation present at the site. Surface topography in the vicinity of the Site is generally flat to gently sloping towards the North in the direction of the Marmaton River. In the vicinity of the Site, the Marmaton River flows from the west to the east. The Marmaton River is characterized by steep banks and dense vegetation along its boundary with the Site. The Site is located within the Marmaton River 100-year flood plain (FEMA 1998) and is subject to flooding.

A small, abandoned building remains on Site that KDHE described as a former "pump house" (KDHE 2005). Two concrete cradles are present west of the building on the Site, indicating that an above ground storage tank (AST) was once present. Dense vegetation now surrounds the cradles. The outline

of these structures is shown on **Figure 2**. A review of historical Sanborn maps confirms the AST was an anhydrous ammonia tank.

1.2.1 Soil Investigation

VCI activities were conducted from October 2007 through November 2008. Activities included the use of direct push technology (DPT) to collect soil and groundwater samples, excavation of test pits to locate potential subsurface concrete footings, and collection of surface water and sediment samples from the Marmaton River. Five groundwater monitoring wells (MW-1 through MW-5) were installed from August through October 2009 and have been sampled semi-annually.

VCI soil sample concentrations were compared with soil cleanup goals determined from the KDHE RSK manual (KDHE, 2007). Guidelines for ammonia and nitrate were developed to provide non-site specific cleanup goals (KDHE RSK Standards for the COIs) that are generally protective of groundwater and capable of sustaining vegetative growth.

During the VCI, 75 soil samples were collected at various depths for ammonia and nitrate analyses as shown on **Figure 3**. Approximately 91% of the ammonia and nitrate impacted soil above the KDHE RSK standards was present from two to 10 feet bgs (Foth, 2009). This area was defined as the source area. The majority of soil sample locations displayed a decreasing trend in total ammonia and nitrate concentrations with increasing depth. Soil sample FGB-7 had the highest detection (12,914 mg/kg) of total ammonia and nitrate from two to three feet bgs. Soil samples FGB-7 and FGB-14 had detections of total ammonia and nitrate above the KDHE RSK standard from ground surface to 20 feet bgs. Soil sample FGB-8 had the highest detection (45.9 mg/kg) of total ammonia and nitrate at the deepest interval of 45 to 50 feet bgs. KDHE RSK standards are included in **Table 1**.

Twenty-one soil samples were collected at various depths for total petroleum hydrocarbon as diesel range organics (TPH-DRO) analysis as shown on **Figure 3**. None of the soil samples taken from within the initial AOI exceeded the KDHE RSK standard for TPH-DRO. Soil samples FGB-45, FGB-46, and FGB-47, are located south and west of the initial AOI of the Site. These samples exhibited TPH-DRO concentrations exceeding the KDHE RSK standard at various depths up to four feet bgs.

Based on VCI soil sample concentrations, a presumptive shallow soil remedy was proposed to KDHE to address ammonia, nitrate and TPH-DRO in shallow soil. In August 2010, excavation from zero to ten feet bgs was performed as the presumptive remedy as proposed in the *Nitrate Presumptive Remedy Work Plan* (Foth, 2009). The presumptive remedy greatly reduced the leaching of ammonia and nitrate from soil to groundwater. Results of the presumptive remedy were included in the *Nitrate Presumptive Remedy Completion Report* (Foth, 2010).

1.2.2 Groundwater Investigation

Groundwater was not observed in low permeability soil above an approximate depth of 36 feet bgs. Ammonia and nitrate were present in groundwater from 36 to 50 feet bgs.

During the VCI, DPT groundwater samples were collected at nine locations from the Site as shown on **Figure 3**. Groundwater was collected from sample location GW-01 (2007) at an approximate depth of 20 feet bgs and exhibited concentrations of total ammonia and nitrate at 47.35 mg/L. However, it is likely that the groundwater collected from this location was from a perched water zone and is not representative of the aquifer under the Site typically encountered at 42 feet bgs.

Groundwater was collected from sample locations GW-1 (2008), GW-2, GW-3, FGB-8, FGS-13, FGB-41, FGB-57, and FGB 58 as shown on **Figure 3**, at an approximate depth of 42 feet bgs and 50 feet bgs from each sample location. Groundwater sample FGB-8 exceeded the RSK standard with a total ammonia and nitrate concentration of 16.836 mg/L at a depth of 42 feet bgs. Groundwater samples were also analyzed for TPH-DRO. Groundwater sample FGB-41 exceeded the TPH-DRO RSK standard with a concentration of 1.820 mg/L at an approximate depth of 42 feet bgs.

Groundwater monitoring of MW-1 through MW-5 has been conducted semi-annually and reported to KDHE. Following excavation activities, concentrations of TPH-DRO observed in groundwater decreased until they were below RSK standards, therefore approval was obtained from KDHE to discontinue sampling groundwater for TPH-DRO. The July 28, 2015 Groundwater Monitoring Report outlined results through March 2015. Results of gauging and groundwater monitoring through March 2015 are included on **Table 2** and **Table 3.** Groundwater flow direction is toward the north as shown on **Figure 4.**

1.2.3 Surface Water and Sediment Investigation

Five surface water samples and 26 sediment samples were collected from the Marmaton River adjacent to the Site. Sample locations MR-1 and MR-2 are considered upstream sample locations, and sample locations MR-3N, MR-3S, and MR-4 are considered downstream sample locations. Sample locations are shown on **Figure 3**.

The analytical results were compared to the values presented in Tables 1C, 1D, and 1E in the Kansas Surface Water Quality Standards: Numeric Criteria. The highest detection of ammonia and nitrate, 0.229 mg/L, is below applicable concentration criteria for surface water.

Sediment samples corresponding to surface water sample locations were also collected and analyzed for total ammonia and nitrate and did not exceed KDHE RSKs for soil. These sampling results were provided in the *Voluntary Cleanup Investigation Report Addendum* dated March 16, 2009 (Foth).

1.3 Voluntary Cleanup Plan Objectives

The primary objective of the VCP is to reduce groundwater impacts below chemical and media-specific RSKs, as established by KDHE in the RSK Manual, for the protection of human health and the environment. Remedial action at the Site includes in-situ bioremediation to treat approximately 89,000 cubic feet. Groundwater would be monitored to assess the effectiveness of this remedial alternative, including quarterly sampling during the injection year with semi-annual monitoring for approximately one to two years following injection activities. Should concentrations after the first year of quarterly sampling indicate additional remediation is required, a second round of injectate will be applied to the Site. Additional annual monitoring beyond one to two years following the final injection event may be utilized to verify groundwater conditions reach KDHE RSK standards.

Additionally, Environmental Use Controls (EUC) have been applied to the Site. EUC 12-EUC-0004 was approved by KDHE for the site on September 13, 2012. The EUC prohibits residential development, installation of potable wells, and any activity that may uncover or otherwise disturb material(s) that exist at the site above KDHE RSK. These EUC actions have been established at the Site to protect human health and the environment for areas where residual soil impacts are present in excess of residential RSKs.

Three monitoring wells, MW-2, MW-3, and MW-4, continue to exhibit total ammonia + nitrate concentrations above the RSK of 10.0 mg/L. During the March 2015 sampling event, concentrations in MW-2, MW-3, and MW-4 were above the 10 mg/L standard with values 18.73 mg/L, 300.45 mg/L, and 26.06 mg/L respectively. This data is summarized on **Table 3** and the monitoring wells are displayed on **Figure 2**.

Impacted groundwater at the Site will be addressed in two areas, as shown on **Figure 5**:

- Area A – near monitoring well MW-2; and
- Area B – north of former fertilizer warehouse, near monitoring wells MW-3 and MW-4.

2.0 CLEANUP TASKS

Chemical-specific and Site-specific cleanup goals for groundwater are provided in KDHE's Risk-Based Standards for Kansas, RSK Manual (5th Version) dated October 2010 along with the December 1, 2014 Bureau of Environmental Remediation (BER) Policy #BER-RS-047 which was made available online in September 2015. The cleanup goals for groundwater, set forth in this VCP are in accordance with the RSK Manual and BER Policy. The recommended remedy for the site is a typical nitrogen presumptive remedy (NPR) outlined in #BER-RS-047.

2.1 Definition of Cleanup

Remediation of groundwater impacts at the Site will be completed through in-situ bioremediation. Details and specifics pertaining to the nature, extent, concentrations of contamination to be remediated, and the description and nature of remedial implementation are detailed in the Voluntary Cleanup Proposal and are further summarized below. Figures depicting media and chemical-specific concentrations were included in the Voluntary Cleanup Proposal and in the semi-annual groundwater monitoring reports.

2.1.1 Nature and Extent of Soil Contamination

The remediation objectives for impacted soil were substantially met during the presumptive remedial action performed at the Site in August 2010. During this action, soil exceeding KDHE RSK values was excavated to a depth of 10 feet, except as prevented by existing structures that could not be removed. The excavated soil area is included on **Figure 6.**

2.1.2 Nature and Extent of Groundwater Contamination

Historical and recent groundwater monitoring and sampling results have concluded that dissolved-phase ammonia and nitrate are present at the Site above RSK levels. The nature and extent of the dissolved-phase impacts were detailed in the Voluntary Cleanup Proposal. Groundwater analytical data is summarized on **Table 3**.

Groundwater monitoring and reporting have been conducted on a semi-annual basis, with the most recent event conducted in March 2015.

COCs identified in the groundwater media include:

- TPH-DRO;
- Ammonia; and
- Nitrate.

Concentrations of TPH-DRO in all wells sampled have been below the RSK of 500 mg/L. Therefore, monitoring of TPH-DRO was discontinued in 2014 following KDHE's verbal approval in September 2014.

2.2 Cleanup Goals

The KDHE RSK Manual and BER policy describe the process for establishing chemical-specific and Site-specific cleanup goals for groundwater that are protective of human health and the environment. A three-tiered approach is used to determine cleanup levels:

- Tier 1 cleanup objectives are determined only for COCs that are naturally occurring and present in the environment and background. Property background levels can be assessed and used at the site.
- Tier 2 cleanup objectives are risk-based cleanup goals determined by KDHE. These values are based upon risk to human health and the environment and are outlined in the RSK Manual, Summary Table.
- Tier 3 cleanup objectives are property-specific cleanup goals established by performing a site-specific risk analysis with KDHE oversight.

The Tier 2 cleanup objectives were utilized for establishing cleanup goals at the Site. The remediation approach for each impacted media is further defined in the sections below.

Groundwater remediation goals are required to be protective of the residential use. The cleanup goals for soil and groundwater are presented in the BER Policy #BER-RS-047.

2.2.1 Groundwater Cleanup Goals

KDHE's Tier 2 Risk-Based Summary Table specifies that the groundwater remediation goals are derived to be protective of the highest beneficial use, with the assumption that aquifers in Kansas are a source of potable water; therefore, residential RSKs are appropriate for the Site. Following remedial activities, KDHE requires that groundwater is monitored and sampled for at least two years or a minimum of four semi-annual events. Following the monitoring and sampling period, groundwater conditions will be evaluated. An NFA may be attained and no further monitoring may be required if:

- Groundwater analytical results are detected at concentrations below the residential RSKs;
- The plume is determined stable; and
- The dissolve-phase concentrations are decreasing.

Following the two year period, if an NFA is not attained, an annual groundwater monitoring and sampling program will be developed and implemented at the Site, and will be completed annually until an NFA is achieved. Goals for the groundwater media Site-specific COCs are tabulated below:

Chemical Constituent in Groundwater	***Site-Specific Groundwater Cleanup Goal Residential RSK (mg/L)***
Ammonia + Nitrate	10.0

3.0 REMEDIAL ACTION SCOPE OF WORK

As described in **Section 1.3**, the selected remedial action at the Site is in-situ bioremediation to target the groundwater concentrations in excess of residential RSKs. Specific components of the remedial action are detailed in the sections below, and include:

- Completion of applicable permits and applications;
- Underground utility location activities;
- Monitoring Well Installation;
- In-Situ Bioremediation Injection Activities;
- Groundwater Monitoring;
- Surface Water Monitoring;
- Environmental Use Control; and
- Investigative Derived Waste.

Details pertaining to field activities and quality assurance/quality control (QA/QC) methodology and techniques are further detailed in the Quality Assurance Project Plan located in **Appendix A** and the Field Sampling Plan located in **Appendix B**. The Site-specific Health and Safety Plan is presented in **Appendix C.**

3.1 Permits

Permit and application documents are required to be completed prior to the commencement of remediation at the site. An injection permit would be obtained from KDHE to allow for injection of the carbon source.

3.2 Underground Utility Locate

Prior to subsurface activities, monitoring well installation, or injection activities, site utilities will be located and identified by contacting the state public utility locating services and conducting a private locate on the site.

3.3 Monitoring Well Installation

Prior to initiation of the remedial activities, two monitoring wells will be installed at the locations depicted on **Figure 7**. These monitoring wells are located to the north and west of MW-2 to aid in monitoring of the groundwater plume.

3.4 Bioremediation Injection Activities

The remedial activity chosen for this site consists of injecting a food grade carbon source (lecithin) to address residual groundwater impacts of nitrate. The lecithin will be supplied by PeroxyChem, and the specific design parameters were determined by incorporating site information as well as a review of site surface and subsurface conditions. **Appendix D** contains the Emulsified Lecithin Substrate Demand Calculations prepared by PeroxyChem for Treatment Areas A and B.

The approach will consist of direct push application of the carbon source at 89 locations arrayed on 10 foot spacing between points and rows. The direct push application will occur from top down starting at 40 feet bgs and ending at 50 feet bgs (approximately 43 feet below the top of casing to 53 feet below the top of casing) to address the specific saturated zone interval. That interval coincides with the regular groundwater sampling interval and placement of the biotrap previously set at the site to confirm microbial presence. Supplemental injection on a smaller scale may take place approximately one year after initial injection should conditions dictate an additional carbon source is needed.

Injection pressures are expected to be ≤30 psi, and flow rates less than 10 gallons per minutes.

3.4.1 Treatment Area A

Treatment Area A is located near monitoring well MW-2. The injection area is approximately 30 feet by 30 feet with a targeted thickness of 10 feet. Approximately nine injection locations will be placed to treat an area of approximately 9,000 cubic feet.

3.4.2 Treatment Area B

Treatment Area B is located near the former fertilizer warehouse and near monitoring wells MW-3, MW-4, and MW-5. The injection area is approximately 80 feet by 100 feet with a targeted thickness of 10 feet. Approximately 80 injection locations will be placed to treat an area of approximately 80,000 cubic feet.

3.4.3 Reporting

A report will be submitted to KDHE Following completion of the well installation, initial groundwater monitoring event, and injection activities. The report will detail well installation activities including well completion information and analytical results collected prior to injection activities. The report will also detail injection volumes and areas. The report will verify activities were conducted per the plan, or conversely, discuss any difficulties encountered and alterations made to the proposed injection plan based upon site conditions.

3.5 Groundwater Monitoring

Groundwater will be monitored at seven monitoring wells to assess the effectiveness of this remedial alternative, including an initial sampling event prior to injection activities, quarterly sampling for a period of one year following the initial injection with semi-annual monitoring for a maximum of two years following final injection activities. Quarterly sampling will commence approximately 90 days following the first injection event. Post-injection monitoring will be conducted to ensure that this remedial alternative has met the Site closure criteria. EUCs have been implemented to mitigate future risk potentially associated with residual soil impacts. If groundwater concentrations remain in excess of RSKs following the two year monitoring period, an annual groundwater monitoring and sampling program will be developed and implemented at the Site.

Groundwater samples will be collected from the seven site monitoring wells. Prior to sampling the monitoring wells will be gauged for groundwater elevation data. Water quality data will also be collected from each monitoring well using a down-hole multi-parameter meter. The meter will collect pH, temperature, dissolved oxygen, conductivity, and oxidation/reduction potential readings from the groundwater. The pre-injection sampling event will be utilized to verify groundwater temperatures remain above ten degrees Celsius, as a minor decline in biodegradation rates can occur below that temperature. Details pertaining to groundwater compliance monitoring and sampling procedures and protocol are further discussed in the FSP.

3.5.1 Groundwater Monitoring Analytical Parameters

Groundwater samples collected during the monitoring events will be sent to a KDHE certified laboratory for analysis of the following parameters:

- Nitrate as N, Nitrite as N by EPA Method 353.2; and
- Nitrogen, Ammonia by EPA Method 350.1

A site map with groundwater sample locations is provided as **Figure 2**. Groundwater sampling activities and analysis, including QA/QC samples, will be completed in accordance with the Site-specific QAPP and FSP.

3.5.2 Groundwater Monitoring Reporting

Following the groundwater sampling events, semi-annual groundwater monitoring reports will be assembled detailing both field and laboratory analytical data. Each monitoring report will contain the following information, in accordance with KDHE's Voluntary Cleanup and Property Redevelopment Program Manual:

- Details of the monitoring event, property conditions, dates and times, problems, deviations from approved procedures, and general descriptions of monitoring work;
- Tabulated data that include static water levels, analytical results, current and past data;
- Groundwater potentiometric surface maps;
- Contaminant concentration maps;
- Laboratory reports and chain-of-custody forms; and
- A summary of the monitoring results, including a comparison of recent data to past data, a discussion of changes of concentrations or distribution, and other information to demonstrate compliance with the monitoring objectives.

3.6 Surface Water Sampling

Surface water samples will be collected during the groundwater monitoring events from the Marmaton River in three locations. These locations would coincide with previously sampled locations MR-2, MW-3S, and MR-4, shown on **Figure 3**. MR-2 is would be considered the upstream sample location, with MR-3S and MR-4 being the downstream locations. Surface water samples would be analyzed for the same parameters as the groundwater samples, and results would be documented in the semi-annual Groundwater Monitoring Reports.

3.7 Environmental Use Control

An EUC for the site was approved by KDHE on September 12, 2012. The activities restricted by the Site-specific EUC include: residential development, installation of potable wells and any activity that may uncover or otherwise disturb material(s) that exist at the site above KDHE RSK.

3.8 Investigative Derived Waste

Investigative derived waste (IDW) will be generated during the monitoring well installation and well development activities. Soil cuttings and development water will be containerized and sampled for waste characterization of toxicity characteristic leaching procedure (TCLP) for metals by EPA Method 6010, volatile organic compounds (VOCs) by EPA Method 8260, and TPH-DRO by OA-2. In addition, the development water will be analyzed for flashpoint by EPA Method 1010. Following waste characterization, the IDW will be scheduled for off-site disposal, removed from the site by a licensed transporter, and delivered to a permitted disposal facility.

4.0 SCHEDULE

Site activities are anticipated to begin in the first quarter of 2016 with the installation of the two new monitoring wells. Following the completion of the well installation, one pre-injection groundwater and surface water monitoring event will be completed in the second quarter of 2016, immediately before initiation of the bioremediation injection activities. Injection activities are estimated to take approximately four weeks to complete. Quarterly monitoring will be completed for one year following the injection to assess the effectiveness of the remedial alternative. As there will be a microbial acclimation period of one to three months following the injection, the first quarterly event will be scheduled between three and four months following the injection, then quarterly after that. Overall treatment time generally ranges from one to eight months depending upon success of the amendment distribution at the site. A supplemental injection event may be recommended approximately one year after initial injection to polish the treatment area. Semi-annual groundwater monitoring would either follow the quarterly sampling events directly, or begin following the supplemental injection event.

5.0 REFERENCES

Antea Group, July 28, 2015. *Groundwater Monitoring Summary Report.*

Antea Group, June 10, 2015. *Voluntary Cleanup Proposal.*

Foth, July 30, 2008. *Voluntary Cleanup Investigation Report – Double Circle Farm Supply.*

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6.0 LIMITATIONS

The findings contained in this report represent Antea Group's professional opinions based upon the currently available information and are arrived at in accordance with currently acceptable professional standards. For any reports cited that were not generated by Antea USA, Inc., the data from those reports are used "as is" and is assumed to be accurate. Antea USA, Inc. does not guarantee the accuracy of this data for the referenced work performed nor the inferences or conclusions stated in these reports. This report is based upon a specific scope of work requested by the client. The Contract between Antea Group and its client outlines the scope of work, and only those tasks specifically authorized by that contract or outlined in this report were performed. This report is intended only for the use of Antea Group's Client and anyone else specifically listed on this report. Antea Group will not and cannot be liable for unauthorized reliance by any other third party. Other than as contained in this paragraph, Antea Group makes no express or implied warranty as to the contents of this report.

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Meghan Guilford
Project Professional

Reviewed by:

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Tables

Table 1 KDHE RSK Standards
Table 2 Groundwater Elevation Data Summary
Table 3 Groundwater Analytical Data Summary

TABLE 1
KDHE RSK STANDARDS
UPRR Double Circle Farm Supply Site
Fort Scott, Kansas

Contaminants of Concern (COCs)	Soil				Groundwater
	Vegetation Present		No Vegetation Present		
	0 to 24 inches	Below 24 inches	0 to 8 inches	Below 8 inches	
Ammonia/Nitrate: Total	200 mg/kg	40 mg/kg	85 mg/kg	40 mg/kg	10.0 mg/L
TPH-DRO (residential)	3,000 mg/kg	3,000 mg/kg	3,000 mg/kg	3,000 mg/kg	0.500 mg/L

Table 2
Groundwater Elevation Data Summary
Double Circle Farm Supply
Fort Scott, Kansas

Well ID	Total Depth	Length of Screen Interval	Ground Surface Elevation	Top of Casing Elevation (TOC)	Estimated Depth of Screen		Estimated Screen Interval Elevation		Date	Depth to Water from TOC	Ground Water Elevation
					Top	Bottom	Top	Bottom			
MW-1	52.86	10	797.04	799.86	42	52	755.04	745.04	8/11/09	16.19	783.67
									9/4/09	15.64	784.22
									9/11/09	13.71	786.15
									10/9/09	12.01	787.85
									10/16/09	10.90	788.96
									1/19/10	11.11	788.75
									7/29/10	13.96	785.90
									1/20/11	16.03	783.83
									7/26/11	17.05	782.81
									1/26/12	13.59	786.27
									7/18/12	13.82	786.04
									7/17/13	16.84	783.02
									1/22/14	14.30	785.56
									9/29/14	17.35	782.51
									3/11/15	16.43	783.43
MW-2	53.15	10	793.80	796.49	43	53	750.80	740.80	8/11/09	23.54	772.95
									9/4/09	23.32	773.17
									9/11/09	21.31	775.18
									10/9/09	14.19	782.30
									10/16/09	17.75	778.74
									1/19/10	19.31	777.18
									7/29/10	22.08	774.41
									1/20/11	23.61	772.88
									7/26/11	24.20	772.29
									1/26/12	22.51	773.98
									7/18/12	23.07	773.42
									7/17/13	22.38	774.11
									1/22/14	21.79	774.70
									9/29/14	24.58	771.91
									3/11/15	24.01	772.48
MW-3	53.00	10	797.03	799.55	43	53	754.03	744.03	8/11/09	22.32	777.23
									9/4/09	21.33	778.22
									9/11/09	19.65	779.90
									10/9/09	14.15	785.40
									10/16/09	15.35	784.20
									1/19/10	19.10	780.45
									7/29/10	22.60	776.95
									1/20/11	21.67	777.88
									7/26/11	22.51	777.04
									1/26/12	20.45	779.10
									7/18/12	19.64	779.91
									7/17/13	20.91	778.64
									1/22/14	19.83	779.72
									9/29/14	22.37	777.18
									3/11/15	21.65	777.90

Table 2
Groundwater Elevation Data Summary
Double Circle Farm Supply
Fort Scott, Kansas

Well ID	Total Depth	Length of Screen Interval	Ground Surface Elevation	Top of Casing Elevation (TOC)	Estimated Depth of Screen		Estimated Screen Interval Elevation		Date	Depth to Water from TOC	Ground Water Elevation
					Top	Bottom	Top	Bottom			
MW-4	53.05	10	796.93	799.66	43	53	753.93	743.93	8/11/09	19.11	780.55
									9/4/09	18.36	781.30
									9/11/09	16.62	783.04
									10/9/09	14.16	785.50
									10/16/09	13.42	786.24
									1/19/10	14.60	785.06
									7/29/10	17.06	782.60
									1/20/11	17.99	781.67
									7/26/11	19.30	780.36
									1/26/12	15.43	784.23
									7/18/12	15.48	784.18
									7/17/13	18.55	781.11
									1/22/14	16.01	783.65
									9/29/14	18.96	780.70
									3/11/15	18.14	781.52
MW-5	53.05	10	797.42	800.15	43	53	757.15	747.15	10/9/09	17.30	782.85
									10/16/09	19.19	780.96
									1/19/10	19.98	780.17
									7/29/10	22.28	777.87
									1/20/11	24.29	775.86
									7/26/11	25.23	774.92
									1/26/12	21.85	778.30
									7/18/12	23.62	776.53
									7/17/13	24.60	775.55
									1/22/14	23.72	776.43
									9/29/14	25.98	774.17
									3/11/15	25.54	774.61

* All units in feet unless otherwise noted
TOC = Top of Casing

Table 3
Groundwater Analytical Data Summary
Double Circle Farm Supply
Fort Scott, Kansas

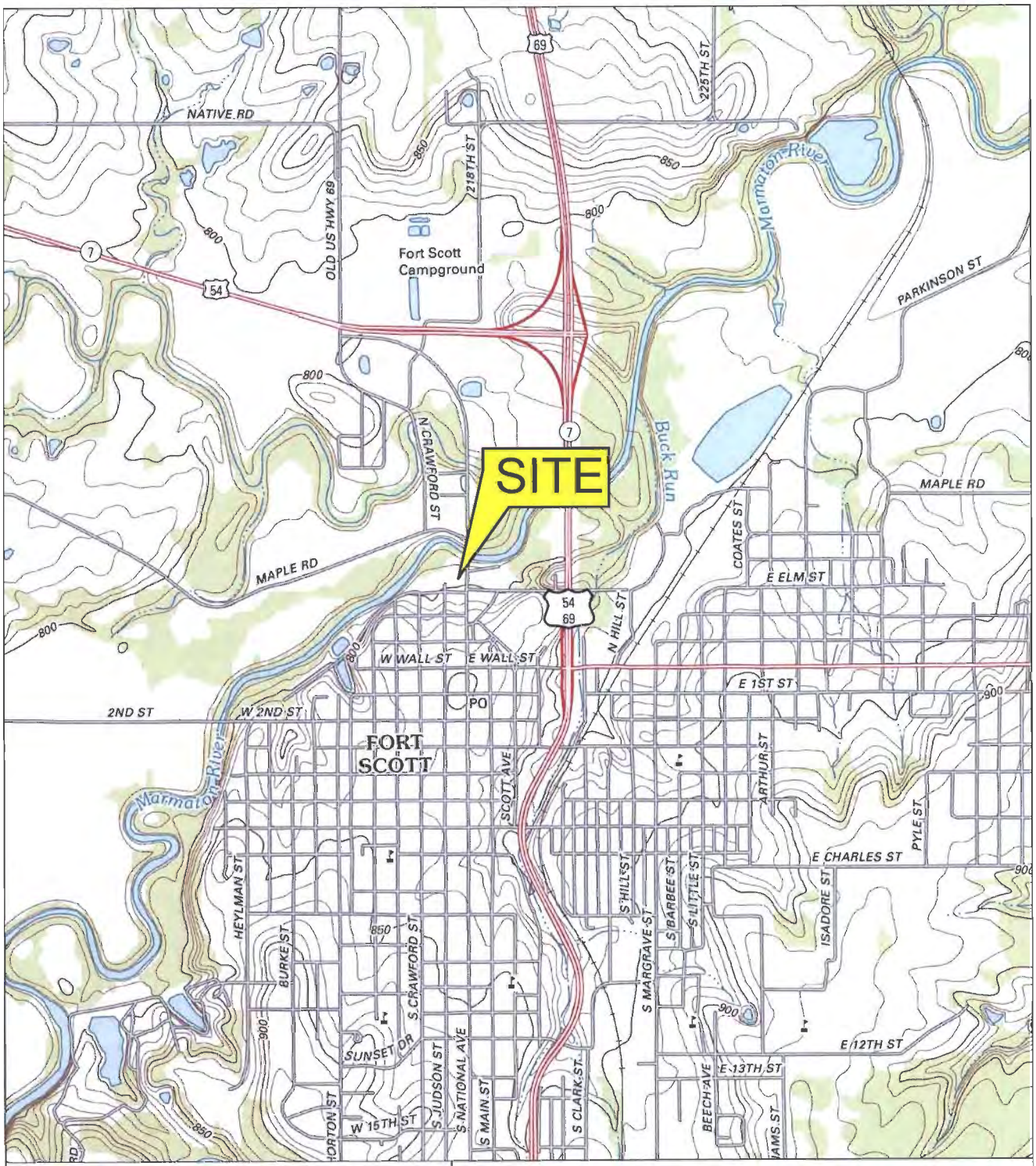
Sample ID	Location ID	Collection Date	Analysis		
			Ammonia	Nitrate	TPH-DRO*
			mg/L	mg/L	mg/L
WG-1475-MW1-090811	MW-1	8/11/2009	3.50	< 0.100	0.0588
WG1475-MW1-100119		1/19/2010	2.91	< 0.100 UJ	< 0.0943
WG-1475-MW1-100729		7/29/2010	0.707	1.94	0.100 J,B
WG-1475-MW1-110120		1/20/2011	2.48	< 0.100	0.0516 J,B
WG-1475-MW1-110726		7/26/2011	2.75	< 0.100	0.0484 J,B
WG-1475-MW1-120126		1/26/2012	1.95	0.744	0.0777 Q3,J
WG-1475-MW1-120718		7/18/2012	1.68	1.14	0.0344 J
WG-1475-MW1-071713		7/17/2013	1.70	0.104	<0.0935
WG-1475-MW1-012214		1/22/2014	1.36 B	0.387	<0.100
WG-1475-MW1-142909		9/29/2014	0.86	0.35	NA
WG-1475-MW1-151103		3/11/2015	1.20	<0.10	NA
WG-1475-MW2-090811	MW-2	8/11/2009	1.67	6.88	0.123
WG-1475-MW2-100119		1/19/2010	**0.608**	**49.0 J**	< 0.0952
WG-1475-MW2-100729		7/29/2010	**0.620**	**12.5**	0.0482 J,B
WG-1475-MW2-110120		1/20/2011	**0.111**	**32.2**	0.0413 J,B
WG-1475-MW2-110726		7/26/2011	**0.404**	**21.8 H2**	0.0412 J,B
WG-1475-MW2-120126		1/26/2012	**0.252**	**55.3 H2**	<0.0485
WG-1475-MW2-120718		7/18/2012	**0.250**	**26.4**	0.0306 J
WG-1475-MW2-071713		7/17/2013	**0.070**	**45.2**	0.120
WG-1475-MW2-012214		1/22/2014	**0.390 B**	**33.3**	<0.0962
WG-1475-MW2-142909		9/29/2014	**<0.10**	**19.7**	NA
WG-1475-MW2-151103		3/11/2015	**0.031 J**	**18.7**	NA
WG-1475-MW3-090811	MW-3	8/11/2009	**2.59**	**111**	0.0416
WG-1475-MW3-090904		9/4/2009	**3.04**	**54.7**	0.0748
WG-1475-MW3-090911		9/11/2009	**2.82 / 2.77**	**96.7 / 145**	0.0322 / 0.0470
WG-1475-MW3-091016		10/16/2009	**2.65**	**85.9**	0.0509
WG-1475-MW3-100119		1/19/2010	**2.30**	**106 J**	< 0.0952
WG-1475-MW3-100729		7/29/2010	**1.84 / 1.56**	**136 / 135**	0.0451 J,B / 0.0511 J,B
WG-1475-MW3-110120		1/20/2011	**0.377 / 0.566**	**111 / 155**	0.0763 J,B / 0.0552 J,B
WG-1475-MW3-110726		7/26/2011	**0.383 / 0.393**	**204 / 211 H2**	0.0379 J,B / 0.0518 J,B
WG-1475-MW3-120126		1/26/2012	**0.975 / 0.884**	**128 H2 / 115 H2**	0.0762 Q3,J / <0.0472
WG-1475-MW3-120718		7/18/2012	**0.390 / 0.723**	**142 / 185**	0.0448 J / 0.0393 J
WG-1475-MW3-071713		7/17/2013	**<0.1 / 0.194**	**114 / 116**	<0.0935 / <0.1
WG-1475-MW3-012214		1/22/2014	**1.67 B / 1.25 B**	**156 / 163**	0.0948 J / <0.0962
WG-1475-MW3-142909		9/29/2014	**<0.1 / <0.1**	**149 / 150**	NA
WG-1475-MW3-151103		3/11/2015	**0.45/0.57**	**300/275**	NA
WG-1475-MW4-090811	MW-4	8/11/2009	**2.69**	**7.89**	0.0396
WG-1475-MW4-090904		9/4/2009	2.24 / 2.64	0.456 / < 0.100	0.124 / 0.0696
WG-1475-MW4-090911		9/11/2009	2.63	0.0730	0.0501
WG-1475-MW4-100119		1/19/2010	1.96	6.11 J	< 0.0952
WG-1475-MW4-100729		7/29/2010	1.22	7.44	0.0621 J,B
WG-1475-MW4-110120		1/20/2011	0.977	8.24	0.0379 J,B
WG-1475-MW4-110726		7/26/2011	1.42	**18.2 H2**	0.0473 J,B
WG-1475-MW4-120126		1/26/2012	**0.711**	**42.8 H2**	<0.0476
WG-1475-MW4-120718		7/18/2012	**0.583**	**26.6**	<0.050
WG-1475-MW4-071713		7/17/2013	<0.1	**12.7**	<0.0935
WG-1475-MW4-012214		1/22/2014	**0.434 B**	**27.8**	<0.0962
WG-1475-MW4-142909		9/29/2014	**<0.1**	**24.2**	NA
WG-1475-MW4-151103		3/11/2015	**0.36**	**25.7**	NA
WG-1475-MW5-091016	MW-5	10/16/2009	0.823	< 0.100	0.0539
WG-1475-MW5-100119		1/19/2010	0.574	< 0.100 UJ	< 0.0971
WG-1475-MW5-100729		7/29/2010	0.337	0.282	0.298 B
WG-1475-MW5-110120		1/20/2011	< 0.100	0.0320 J	0.0390 J,B
WG-1475-MW5-110726		7/26/2011	0.238	< 0.100 H2	< 0.0980
WG-1475-MW5-120126		1/26/2012	**0.141**	**115 H2**	0.042 Q3,QP
WG-1475-MW5-120718		7/18/2012	0.304	0.0330 J	0.0374 J
WG-1475-MW5-071713		7/17/2013	<0.1	0.061	<0.0935
WG-1475-MW5-012214		1/22/2014	0.367 B	0.05 J	0.225
WG-1475-MW5-142909		9/29/2014	<0.1	0.17	NA
WG-1475-MW5-151103		3/11/2015	<0.10	0.23	NA

*: Values have been converted from µg/L to mg/L
Cells with multiple values contain duplicate results
Bold values indicate events exceeding the KDHE RSK standards.
B: Analyte was detected in the associated method blank.
J: Estimated Value
UJ: Non-detect, estimated reporting limit
H2: Initial analysis within holding time. Reanalysis for the required dilution or confirmation was past holding time.
Q3: The chromatographic pattern is not consistent with diesel fuel

KDHE RSK Standards
Ammonia+Nitrate: 10.0 mg/L
TPH-DRO: 0.500 mg/L

Figures

Figure 1	Site Location Map
Figure 2	Site Detail Map
Figure 3	Sample Location Map
Figure 4	Groundwater Flow Map
Figure 5	Proposed Injection Locations
Figure 6	Former Area of Soil Impact
Figure 7	Proposed Monitoring Well Locations



SOURCE: USGS 7.5 MINUTE TOPOGRAPHIC MAP, FT. SCOTT QUADRANGLE (2012)

N

0 2000 FT

SCALE

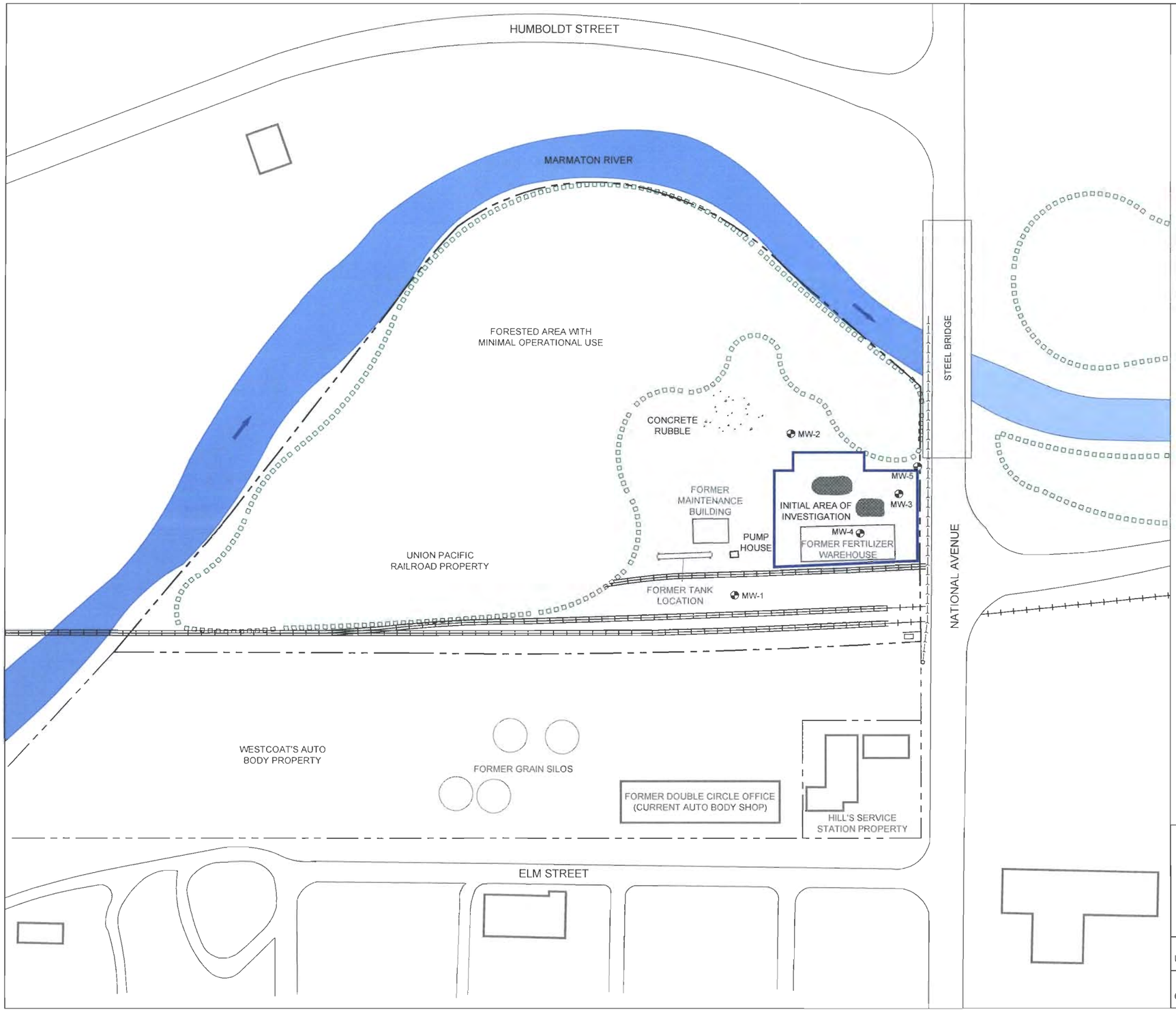
FIGURE 1
SITE LOCATION MAP

DOUBLE CIRCLE FARM SUPPLY SITE

FORT SCOTT, KANSAS

PROJECT NO.	PREPARED BY	DRAWN BY
UPR8263A	LR	JH
DATE	REVIEWED BY	FILE NAME
6/7/13	MP	FtScott

anteagroup



LEGEND:

- UP PROPERTY BOUNDARY
- RAILROAD TRACKS
- ESTIMATED SHRUB AND TREE LINE
- HISTORIC BARE SPOTS
- MONITORING WELL LOCATION

N

0 100 FT

SCALE

ADAPTED FROM A SITE BASE MAP BY FOTH INFRASTRUCTURE & ENVIRONMENT, LLC (2/24/11)

FIGURE 2
SITE DETAIL MAP

DOUBLE CIRCLE FARM SUPPLY SITE

FORT SCOTT, KANSAS

PROJECT NO.	PREPARED BY	DRAWN BY
UPR8263A	LR	JH
DATE	REVIEWED BY	FILE NAME
6/6/13	MP	FtScott

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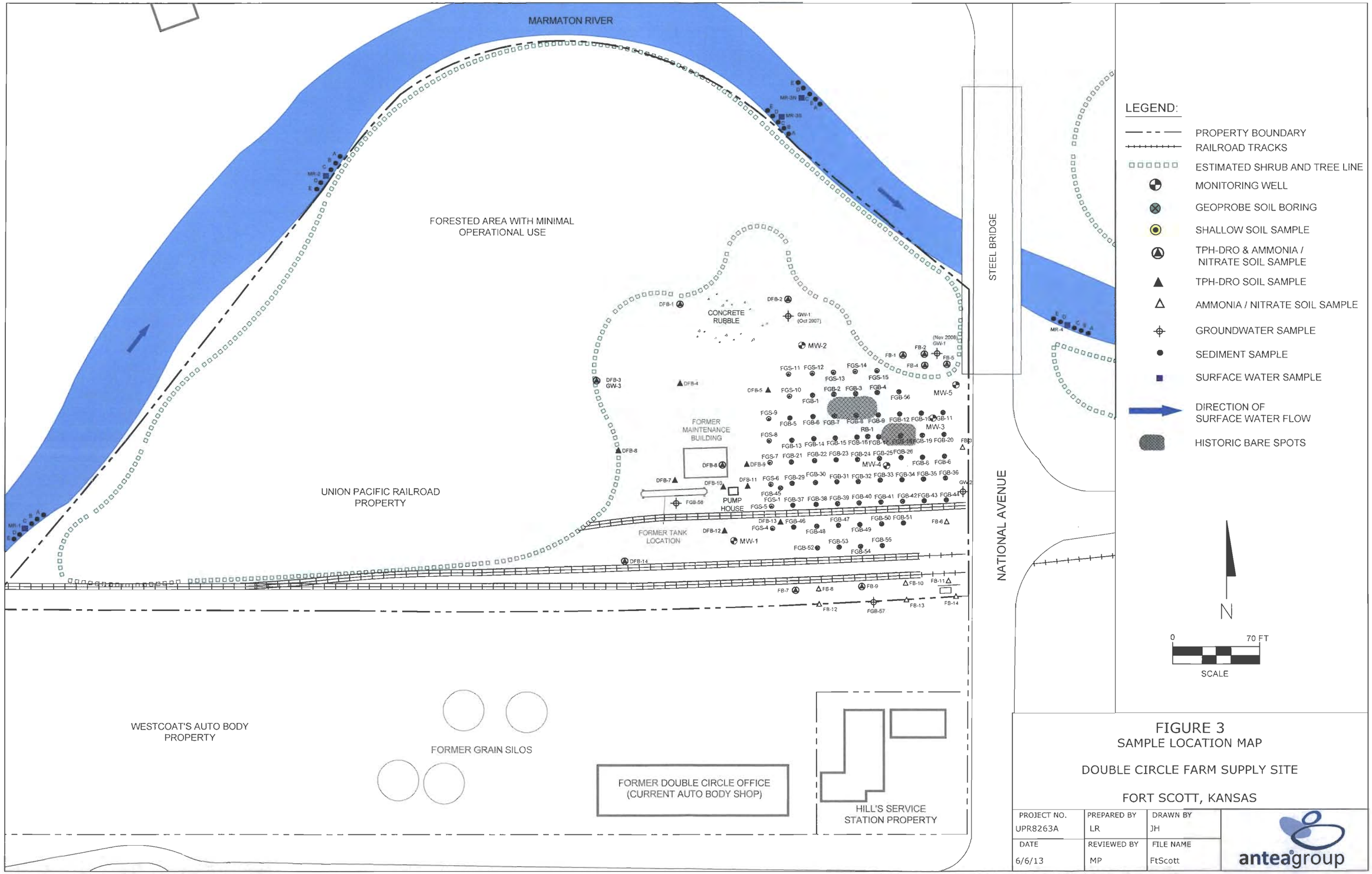

FIGURE 3
SAMPLE LOCATION MAP

DOUBLE CIRCLE FARM SUPPLY SITE

FORT SCOTT, KANSAS

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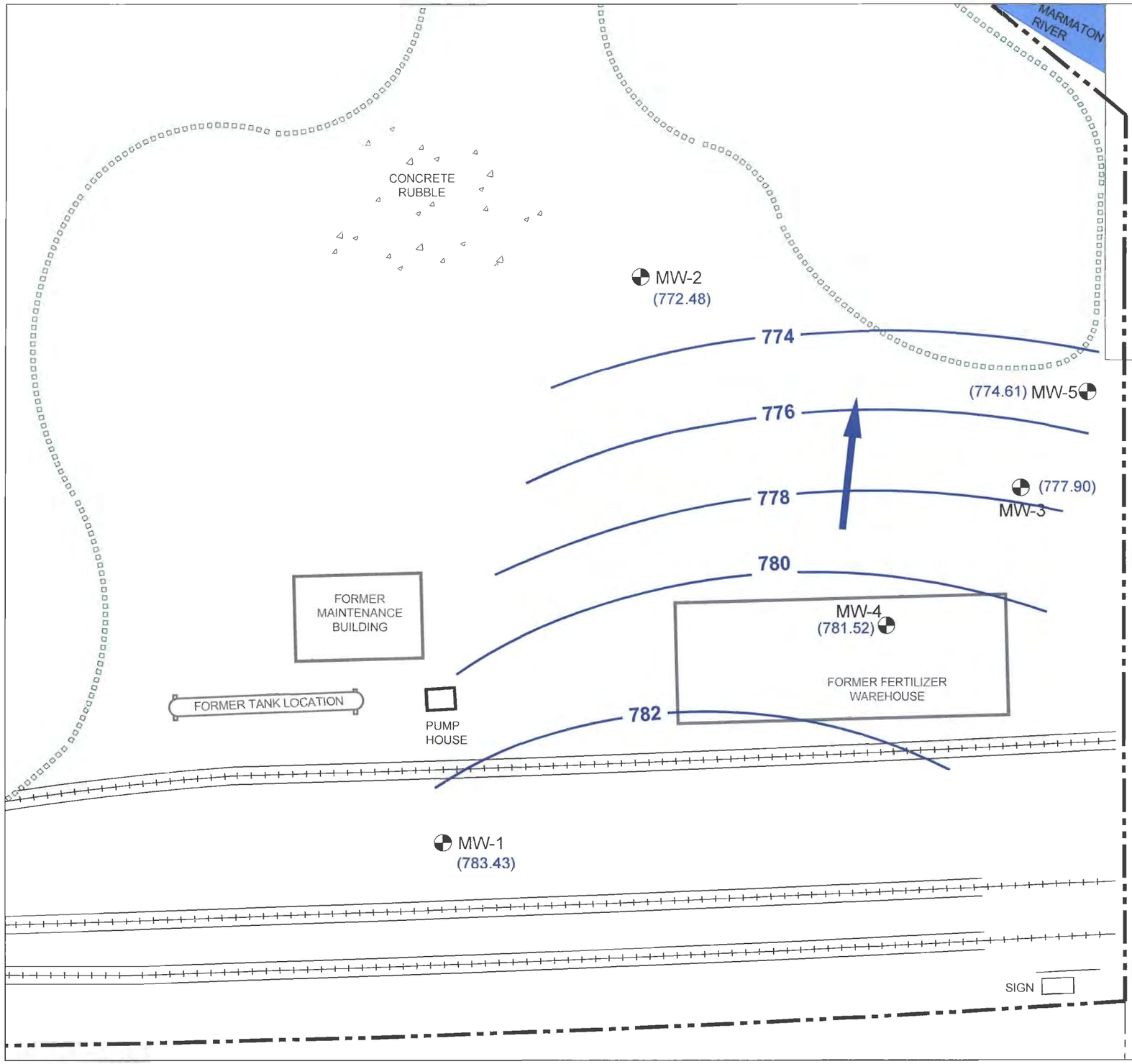
DATE	REVIEWED BY	FILE NAME
6/6/13	MP	FtScott

anteagroup



LEGEND:

- PROPERTY BOUNDARY
- RAILROAD TRACKS
- ESTIMATED SHRUB AND TREE LINE
- MONITORING WELL LOCATION
- (772.48) GROUNDWATER ELEVATION (FT)
- 772 GROUNDWATER ELEVATION CONTOUR (FT) (CONTOUR INTERVAL = 2 FT)
- APPROXIMATE GROUNDWATER FLOW DIRECTION

N

0 30 FT

SCALE

FIGURE 4
GROUNDWATER FLOW MAP
MARCH 11, 2015
DOUBLE CIRCLE FARM SUPPLY SITE

FORT SCOTT, KANSAS

PROJECT NO.	PREPARED BY	DRAWN BY
UPR8263A	DM	JH
DATE	REVIEWED BY	FILE NAME
7/7/15	MP	FtScott

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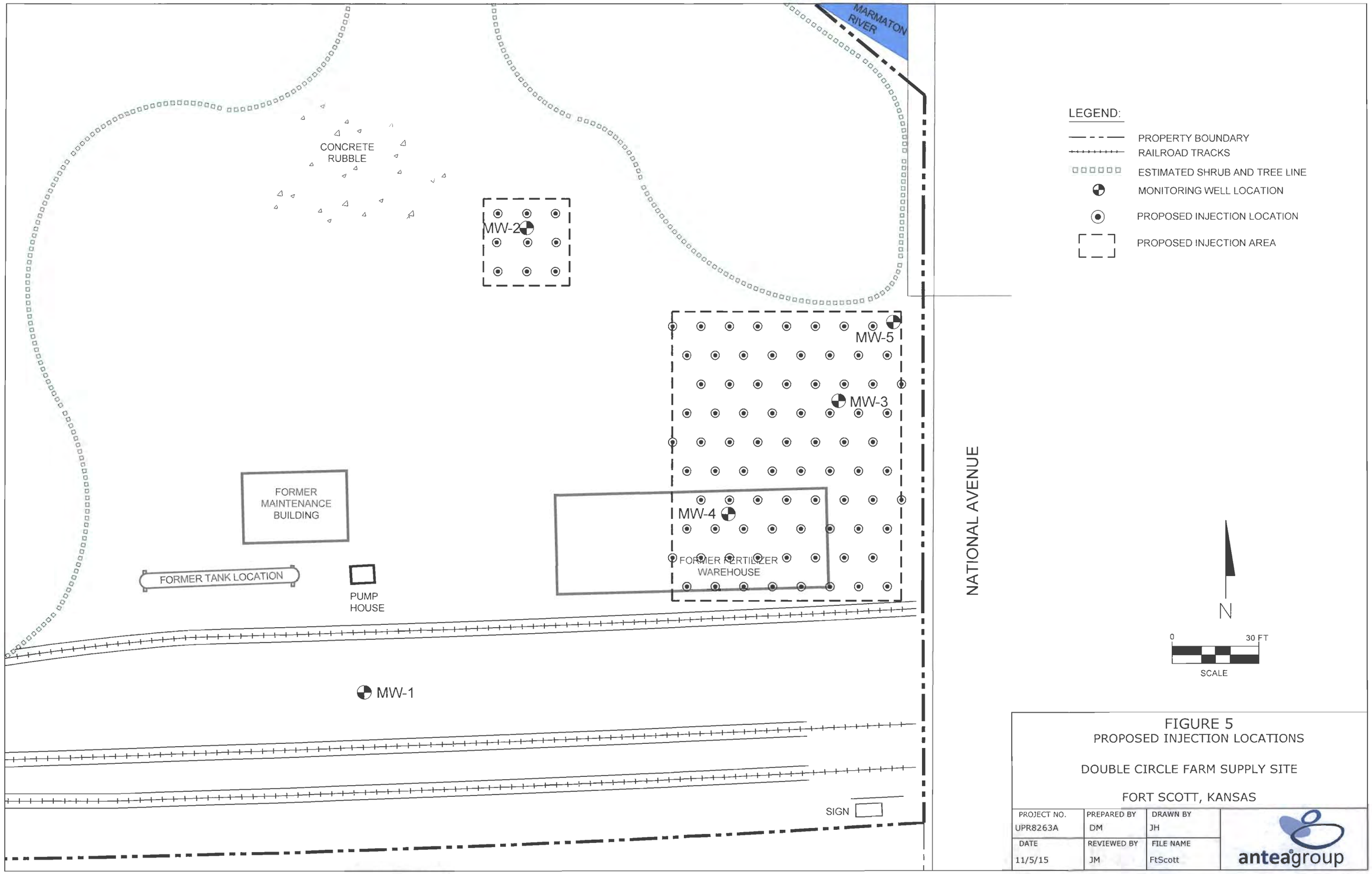

FIGURE 5
PROPOSED INJECTION LOCATIONS

DOUBLE CIRCLE FARM SUPPLY SITE

FORT SCOTT, KANSAS

PROJECT NO.	PREPARED BY	DRAWN BY
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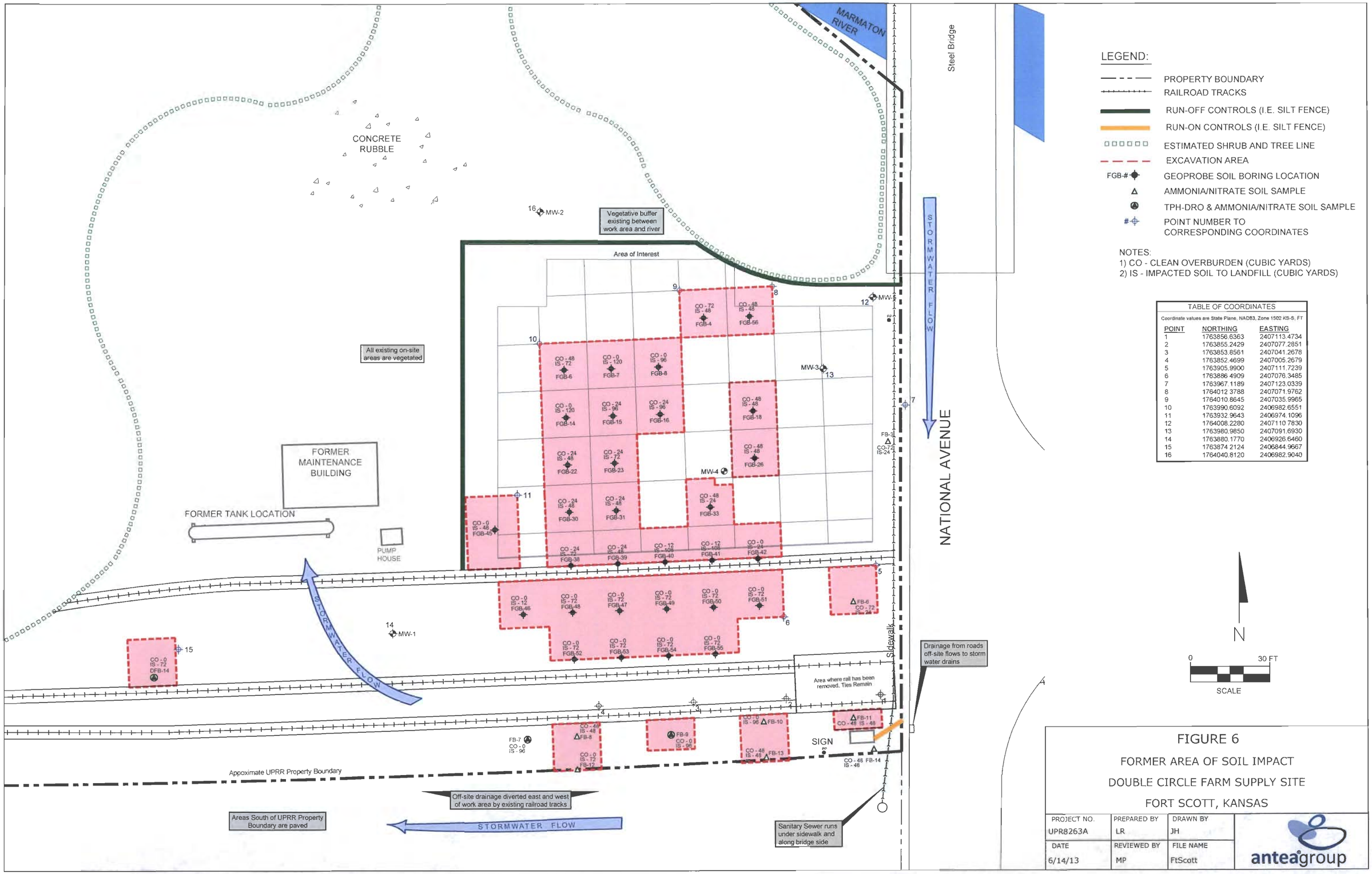
DATE	REVIEWED BY	FILE NAME
11/5/15	JM	FtScott

anteagroup



LEGEND:

- PROPERTY BOUNDARY
- RAILROAD TRACKS
- RUN-OFF CONTROLS (I.E. SILT FENCE)
- RUN-ON CONTROLS (I.E. SILT FENCE)
- ESTIMATED SHRUB AND TREE LINE
- EXCAVATION AREA
- FGB-# GEOPROBE SOIL BORING LOCATION
- AMMONIA/NITRATE SOIL SAMPLE
- TPH-DRO & AMMONIA/NITRATE SOIL SAMPLE
- # POINT NUMBER TO CORRESPONDING COORDINATES

NOTES:
1) CO - CLEAN OVERBURDEN (CUBIC YARDS)
2) IS - IMPACTED SOIL TO LANDFILL (CUBIC YARDS)

TABLE OF COORDINATES

Coordinate values are State Plane, NAD83, Zone 1502 KS-S, FT

POINT	NORTHING	EASTING
1	1763856.6363	2407113.4734
2	1763855.2429	2407077.2851
3	1763853.8561	2407041.2678
4	1763852.4699	2407005.2679
5	1763905.9900	2407111.7239
6	1763886.4909	2407076.3485
7	1763967.1189	2407123.0339
8	1764012.3788	2407071.9762
9	1764010.8645	2407035.9965
10	1763990.6092	2406982.6551
11	1763932.9643	2406974.1096
12	1764008.2280	2407110.7830
13	1763980.9850	2407091.6930
14	1763880.1770	2406926.6460
15	1763874.2124	2406844.9667
16	1764040.8120	2406982.9040

FIGURE 6

FORMER AREA OF SOIL IMPACT

DOUBLE CIRCLE FARM SUPPLY SITE

FORT SCOTT, KANSAS

PROJECT NO.	PREPARED BY	DRAWN BY
UPR8263A	LR	JH
DATE	REVIEWED BY	FILE NAME
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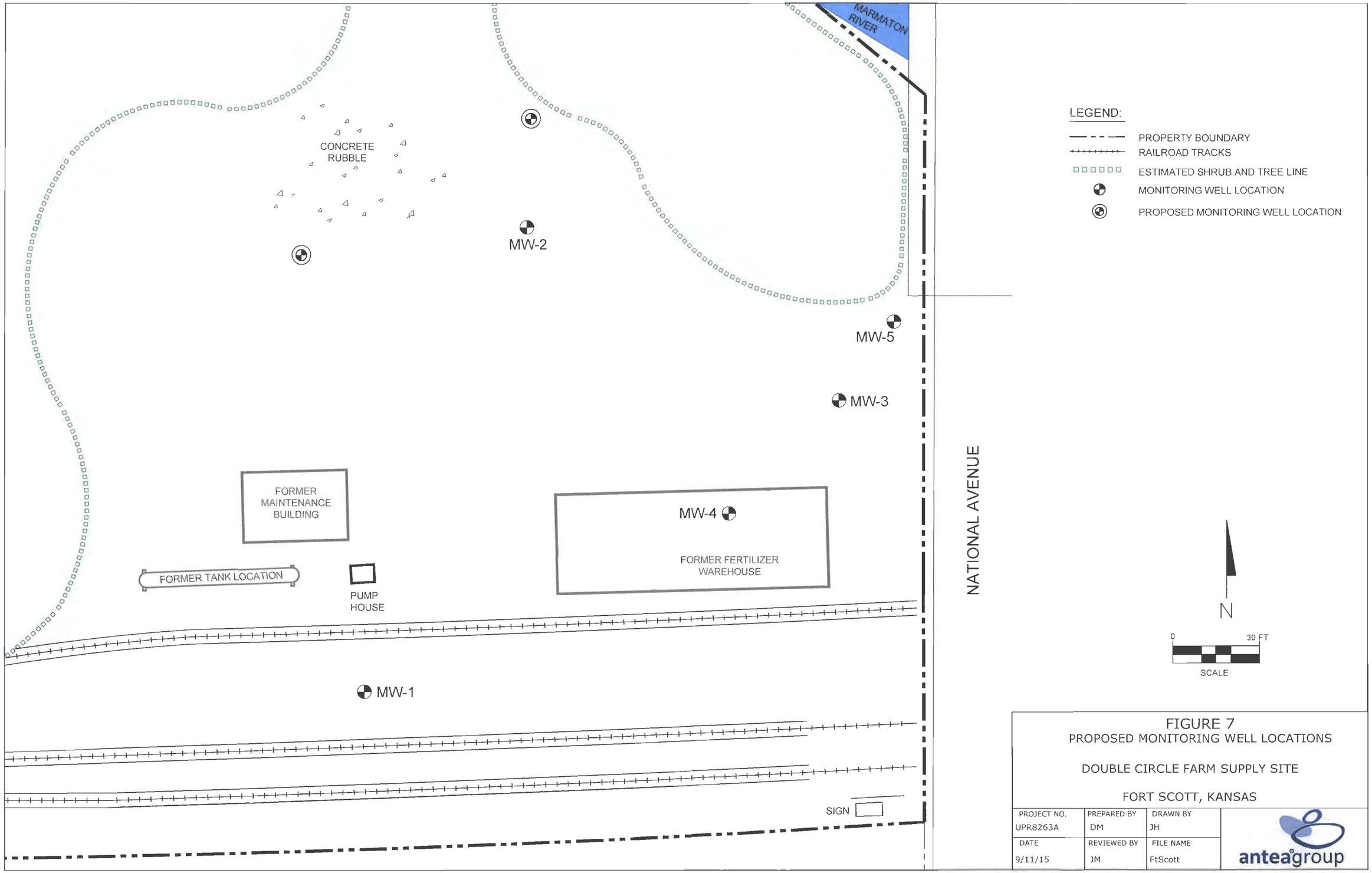

FIGURE 7
PROPOSED MONITORING WELL LOCATIONS

DOUBLE CIRCLE FARM SUPPLY SITE

FORT SCOTT, KANSAS

PROJECT NO.	PREPARED BY	DRAWN BY
UPR8263A	DM	JH
DATE	REVIEWED BY	FILE NAME
9/11/15	JM	FtScott

antea group

Appendix A

Quality Assurance Project Plan

Quality Assurance Project Plan

Double Circle Farm Supply Site
Fort Scott, Kansas
KDHE Voluntary Agreement 07VCP003

Antea Group Project No. UPR8263A
November 12, 2015

Prepared for:
Union Pacific Railroad
1400 Douglas Street, Stop 1030
Omaha, NE 68179

Prepared by:
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150 St. Peters Centre Blvd, Suite C
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Quality Assurance Project Plan

Double Circle Farm Supply Site
Fort Scott, Kansas

1.0 PROJECT OBJECTIVES

The following sections document standard Quality Assurance (QA) and Quality Control (QC) procedures and practices for general soil sampling, groundwater sampling, and field and laboratory activities at the UP property located north of the intersection of Elm Street and National Avenue, south of the Marmaton River in Fort Scott, Kansas (hereby the "Site"). The Data Quality Objective (DQO) is to produce data of known and documented quality. Data generated during the remedial action will be used to determine that groundwater conditions meet regulatory chemical-specific standards, in order to obtain regulatory closure at the Site. Details pertaining to field sampling and applicable procedures are discussed in the Field Sampling Plan (FSP).

This Quality Assurance Project Plan (QAPP) has been produced by Antea®Group on behalf of UP in conjunction with the Voluntary Cleanup Plan (VCP) and FSP. QA and QC procedures, protocols and guidelines presented within are in compliance with KDHE, Antea Group and Kansas certified laboratory's Standard Operating Procedures (SOPs). KDHE specific SOPs are included in **Attachment A**. Applicable Antea Group SOPs and laboratory SOPs are included in **Attachment B** and **C**, respectively.

2.0 PROJECT ORGANIZATION

Antea Group:

- Senior Project Manager – Addie Mette: Responsible for oversight of the Antea Group project team. Ensure that all final information is accurately conveyed to KDHE. Monitors the overall QA/QC operations for the project.
- Project Manager – Jennifer Macdonald: Responsible for ensuring that all information provided to project team (including the internal team, laboratory subcontractors and UP's data management team), and is correctly conveyed to KDHE. Schedules and supervises field staff conducting remediation and sampling activities. Assures that staff are adequately qualified and trained to perform the work, familiar with the required SOPs, including those related to QA/QC, and have the equipment necessary to perform the work. Performs the day to day managerial oversight of the project.

- Project Field Lead – Matthew Cauthon: Prepare and/or implement site-specific sampling plans to collect environmental samples according to SOPs. Conduct sample collection by appropriate methods to provide data of sufficient quality. Prepare and/or implement Health and Safety Plans for remediation. Responsible for ensuring that all field personnel follow guidelines and procedures set forth in this QAPP and other project related documentation. Responsible for ensuring that field data is properly uploaded to UP's database, retained and stored.
- QA/QC Data Analyst – Jennifer Macdonald: Responsible for ensuring that analytical data is properly uploaded, verifies that table creation is completed per SOPs, and performs data validation.
- Data Analyst – Danielle Mattingly: Creates data tables and performs preliminary Quality Control (QC) checks.

Laboratory:

- Project Manager: Responsible for ensuring that appropriate analytical methods, laboratory SOPs, QA/QC procedures, and documentations are implemented. Responsible for ensuring that personnel performing the analytical testing are adequately trained. Provides data to third party data validator and Antea Group.
- Senior Project Manager: Ensures overall validation and final approval of analytical data generated.

Third Party Data Validation:

- Conestoga Rover and Associates (CRA), will provide a third party data validation of field and analytical data, and manage UP's internal database system.

3.0 QUALITY ASSURANCE OBJECTIVES FOR DATA

Sample data collected during remedial action will be utilized in determining if groundwater concentrations are below the chemical-specific regulatory standards (presented in the VCP); therefore, demonstrating that the site meets regulatory closure requirements. Regulatory goals for groundwater will be met when: groundwater concentrations from samples collected from the monitoring wells indicate that onsite chemical concentrations are below residential Risk-based Standards for Kansas (RSK).

When analyzing environmental samples, protocol and processes are required to ensure that the results are reflective of the medium and conditions being measured or analyzed, and in a manner that sampling

and analysis can be duplicated. DQOs are qualitative and quantitative statements that specify the purpose, quality, and/or quantity of the environmental data required to support management and remedial decisions at the Site. DQOs are assessed by evaluating the accuracy, precision, completeness, representativeness, and comparability of all aspects of the data collected.

3.1 Accuracy

Accuracy is a measure of the closeness of an individual measurement or an average of a number of measurements to the true value. Accuracy is calculated in terms of percent recovery (%R) of a known value. The "known" can take the form of USEPA or National Institute of Standards and Technology-traceable standards, laboratory-prepared solutions of target analytes or solutions of surrogate compounds spiked into each sample.

3.2 Precision

Precision is the agreement between a set of replicate measurements without assumption of knowledge of the true value. It is a measure of the variability in repeated measurements of the sample compared to the average value. The precision assessment should represent the variability of sampling, sample handling, preservation, storage, and analysis of the sample data. Precision is reported as relative percent difference (RPD), the difference divided by the average of two positive sample results.

The overall precision is a mixture of sampling and laboratory variability. Laboratory and field duplicate analyses are used to determine precision. Laboratory duplicate RPDs provide a measurement of analytical precision and field duplicate RPDs provide a measure of overall precision.

3.3 Completeness

Completeness is the measure of how the amount of usable (valid) data obtained from a measurement system compares to the expected amount. Completeness is calculated after all analytical data have been reviewed for usability and is expressed as a decimal or percent usable data.

3.4 Representativeness

Representativeness expresses the degree to which data accurately and precisely represents a characteristic of population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness of the data is addressed qualitatively in the VCP and the FSP, and ensures that the the selection of the sampling locations is adequate to account for all Site variations.

3.5 Comparability

Comparability expresses the confidence with which one data set can be compared to another data set. All data collected during remedial action will be internally directly comparable. Whenever possible, data produced will be comparable to other data produced from other similar site investigations using similar techniques and analytical procedures.

3.6 Quality Assurance of Environmental Samples

To assess if environmental measurements are of acceptable quality, the QA measurements discussed above will be examined and compared against KDHE's recommended parameters, KDHE SOPs, and Environmental Protection Agency's (EPA's) SOPs.

Precision and accuracy goals shall be completed in compliance with KDHE's and EPA's appropriate SOPs for laboratory procedures, analysis, precision, and accuracy determinations. Data will only be accepted if the data is reviewed and validated according to Section III of KDHE SOP BER-11 (Evaluation and Validation of Data) and after sampling and chain-of-custody (COCs) SOPs have been substantively followed.

Representativeness will be achieved by collecting samples to accurately reflect the concentrations of the onsite chemical constituents in applicable media. Additionally, representativeness will be achieved by avoiding cross-contamination, using proper chain-of-custody procedures, and in following proper documentation and record keeping procedures.

To ensure comparability, data will be reported as:

- ° Celsius;
- pH units; and
- milligrams/Liter (mg/L) – groundwater and liquids
- millgrams/kilogram (mg/kg) - soil

Additionally, comparability is further addressed by using appropriate field and laboratory methods, consistent with the standards of practice. Comparability will be accomplished by providing enough valid data to support the project objectives. Completeness will take into account sample breakage, laboratory errors, and sample difficulties.

3.7 Quality Assurance / Quality Control Field Samples

The collection of QA/QC data is required to determine precision and accuracy and to demonstrate the absence of interference and/or contamination of sampling equipment, glassware, reagents, etc. All field QC samples will be submitted as blind samples to the laboratory. Specific QC requirements for laboratory analyses will be the responsibility of the project laboratory. Field collected QC samples will include the following:

- **Equipment Rinsate Blanks** are blank samples designed to demonstrate that sampling equipment has been properly prepared and cleaned before field use and that cleaning procedures between samples are sufficient to minimize cross contamination. Rinsate blanks will be collected at a rate of one blank per site, per groundwater sampling event.
- **Field Duplicate** samples consist of a set of two samples collected independently of one another at the same sampling location during the same sampling event. Field duplicates are designed to assess actual field variability as compared to analytical duplicate or MSD analyses which measure laboratory variability. Duplicate samples will be collected at a rate of one for each 10 (groundwater) samples.
- **MS/MSDs** are environmental samples that are spiked, in the laboratory, with a known concentration of a target analyte. The MS/MSDs are used to check sample matrix interferences and evaluate error due to laboratory bias and precision. The project laboratory will perform MS/MSD analyses at a rate of one for each 20 (groundwater) samples.

3.8 Quality Assurance / Quality Control Laboratory Samples

Laboratory calibration and QA/QC sample requirements are defined in the test methods. One laboratory method blank will be analyzed in every analytical batch to assess potential laboratory contaminants. A laboratory control sample (LCS) will be analyzed in every analytical batch to assess the accuracy of the analysis. An MS/MSD will be analyzed at a rate of one per twenty samples to assess the accuracy and precision of the analysis relative to the matrix. The selected Laboratory's Quality Assurance Manual and applicable SOPs are presented in **Attachment C.**

4.0 SPECIAL TRAINING

Sample collectors are required to have successfully completed a 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) site safety course in accordance with 40 CFR Part 311, which references 29 CFR 1910.120. Field personnel are also required to be trained on the site-specific hazards, in compliance with KDHE SOP's BER-21 (Levels of Protection for Field Work) and BER-18 (Field Safety

Protocol), and be familiar with the site-specific HASP, applicable SOPs, this QAPP, the VCP, and the FSP prior to performing sampling activities.

The Contractor completing the remediation work will ensure and provide for the protection of the personnel, safety and health of all their workers onsite. All personnel will comply with applicable worker safety and health laws and regulations.

5.0 DOCUMENTATION AND REPORTING

A complete record of all field activities will be maintained and will including: chain-of-custody documents, field notes, boring logs, analytical data, field map(s), field screening data, data validation documentation, and any QC data. Recording keeping will be completed per Antea Group's SOP PR-751-022, and in compliance with EPA's record keeping requirements. Hard copy documents will be stored at Antea Group's St. Peters, Missouri office and electronically saved on Antea Group's Central File Server.

Field QA/QC documentation must include the following information:

- Date, time, place, and location of samples;
- Onsite personnel and visitors;
- Daily safety discussion and any safety issues;
- Calibration and maintenance records for field instrumentation;
- Documentation of sample collection procedures (e.g. grab sample, composite sample);
- Field parameters and their unit (if applicable);
- Field sample sketch or map;
- Documentation of variances to the FSP, SOPs, or any other guidance documents;
- Copies of chain of custody documents;
- Documentation of decontamination procedures; and,
- Documentation of QA/QC samples (e.g. equipment blanks, duplicate blanks, and trip blanks).

Laboratory QA/QC documentation must include the following:

- QA/QC requirements (where applicable): method/instrument blanks, extraction/digestion blanks, initial calibration information and verification, laboratory fortified blanks/laboratory control samples, duplicate and matrix spikes/matrix spike duplicates; and,
- Instrument performance data (i.e. internal standard and surrogate recovery).

6.0 FIELD SAMPLE ANALYSIS

All instruments and equipment used during sampling and analysis will be operated, calibrated, and maintained according to the manufacturer's guidelines and recommendations and SOPs, as well as criteria set forth in the applicable analytical methodology reference. Operation, calibration, and maintenance will be performed by personnel properly trained in these procedures. Documentation of all routine and special maintenance and calibration information will be maintained in an appropriate logbook or reference file.

The portable photoionization detector (PID) or flame-ionization detector (FID) used for screening soil vapor headspace will be calibrated at the beginning of each day according to the manufacturer's recommended procedure using a laboratory-certified isobutylene gas standard. The PID/FID instrument may also be calibrated during the course of the day. Use of the PID/FID instrument will be in compliance with KDHE's SOPs BER-13 (Headspace Method for Screening Soil Samples for Volatile Organic Compounds) and BER-30 (Operation of the Photoionization Detector).

Water Level, product and well depth measurements will be performed to evaluate groundwater conditions pre- and post-remediation. Additionally, water quality analyzers will be used during well stabilization and groundwater monitoring activities. Use of the field sampling equipment will be performed in compliance with KDHE SOP BER-26 (Use of Water Quality Analyzers for Well Stabilization), BER-30 (Operation of Photoionization Detector), BER-32 (Acquisition of Location Data Using Global Position System (GPS) General Practice for Hand Held Units), and BER-36 (Water Level, Product, and Well Depth Measurements).

7.0 SAMPLE CUSTODY AND HANDLING

The sample collection, custody and handling activities will adhere to applicable KDHE and Antea Group SOPs, and EPA guidelines. Field sampling procedures, methodology, and frequency are further detailed in the FSP.

This section describes sample identification and chain-of-custody (COC) protocols for this project. The purpose of these protocols is to ensure that quality and validity of the samples are maintained through collection, transport, storage and analysis. All sample control and COC protocols will follow EPA's guidance. Chain of custody procedures will be in compliance with KDHE SOP BER-19 (Chain of Custody).

The transportation and handling of samples must be accomplished in a manner that not only protects the integrity of the sample, but also prevents any detrimental effects to sample handlers due to the possible hazardous nature of samples. Regulations for packaging, marking, labeling and shipping hazardous materials are promulgated by DOT in the Code of Federal Regulations, 49 CFR 171 through 177 and/or the International Air Transport Association regulations for Dangerous Goods.

7.1 Sample Containers

The specific methods for sample container size and type, sample preservation requirements and holding times are determined by the contract laboratory chosen for the project. The laboratory will provide the sample containers. Antea Group will verify that the laboratory has supplied the proper containers and that they are pre-cleaned and shipped in sealed coolers.

All samples (with the exception of trip blanks) will be prepared and sealed in the field. Sample collection procedures, locations and protocols will be documented in a bound field notebook.

7.2 Sample Identifiers and Labels

Sample identifiers will be assigned by the sampling team as described in the site-specific FSP. The unique sample identifier will be clearly written on the sample label affixed to each sample container.

Sample labels will be affixed to each sample container in such a way so as to not obscure any QA/QC lot numbers on the containers. Sample information will be printed clearly on each label. Field identification will be sufficient to enable cross-reference with the project field book. Each sample label, regardless of media, will be completed with the sample collection date and time, and the collector's initials. Site-specific nomenclature is further detailed in the FSP.

For COC purposes, all QA/QC samples will be subject to the exact same custodial procedures and documentation as site samples.

7.3 Custody Seals

Custody seals will be used on all coolers and sample shipping containers when samples are shipped to the laboratory. The number of seals per container is dependent upon the nature of each container. Seals will be signed and dated prior to use. Clear strapping tape will be placed over each seal to ensure that seals are not accidentally broken during shipment.

7.4 COC Records/Custody Protocols

The COC will be fully completed in the field and signed by the sample collector. The samples will be entered onto the COC as they are collected. The primary objective of COC protocol is to provide an accurate written record that can trace the possession and handling of a sample from collection to the completion of all required analyses. A sample is in custody if it is in someone's possession, in someone's view, locked up or kept in a secured area that is restricted to authorized personnel only.

7.5 Field Custody Procedures

The following guidance will be used to ensure proper control of samples while in the field:

- As few persons as possible will handle samples.
- Coolers or boxes containing cleaned bottles will be sealed with a custody tape seal during transport to the field or while in storage prior to use. Sample bottles from unsealed coolers or boxes, or bottles that appear to have been tampered with, will not be used.
- The sample collector is personally responsible for the care and custody of samples collected until they are transferred to another person or dispatched properly under COC rules.
- The sample collector will record sample data in the field logbook.
- The site team leader will determine whether proper COC procedures were followed during the fieldwork and decide if additional samples are required.

When transferring custody (i.e., releasing samples to a shipping agent), the following will apply:

- The coolers in which the samples are packed will be sealed and accompanied by COC records. When transferring samples, the individuals relinquishing and receiving them must sign, date and note the time on the COC record. This record documents sample custody transfer.
- Samples will be dispatched to the laboratory for analysis with separate COC records accompanying each shipment. The method of shipment, name of courier and other pertinent information will be entered in the COC record.
- All shipments will be accompanied by COC records identifying their contents. The original record will accompany the shipment. The other copies will be distributed appropriately to the project manager.
- Sent by common carrier, a bill of lading will be used. Freight bills and bills of lading will be retained as part of the permanent documentation.

8.0 DECONTAMINATION PROCEDURES

Equipment that is not directly used for sampling (i.e. drilling steel, excavator bucket, etc.) will be cleaned between each sampling location using a high-pressure water wash. Soil sampling equipment (i.e. hand augers, spoons and scoops) will be cleaned by washing with non-phosphate detergent (e.g. Alconox, Liquinox) and water, rinsing with clean tap water, and rinsing with deionized or distilled water. Water level indicators will be washed with detergent and water and then rinsed with tap water and distilled water before use, between each sampling or measurement location and prior to storage. Equipment decontamination procedures will be completed in accordance with KDHE SOP BER-05 (Decontamination of Equipment) and are further discussed in the FSP.

Disposable nitrile gloves, bailers, HydraSleeves, sample tubing, and any other form of disposable sampling equipment will be discarded after use at each sampling location.

9.0 ANALYTICAL METHODS

The methodologies used for generation of field data, including PID results or FID results, pH, temperature, conductivity, dissolved oxygen and static water level, are summarized in the VCP and the FSP. Field analytical data will be used to augment information generated through laboratory analysis, aid in determining collection of confirmation samples during excavation and landfarm remediation, and to evaluate groundwater conditions following remediation.

Table 1 includes the specific laboratory analytical method for each environmental media, estimated number of samples, sample container type, sample preservation, and associated holding time requirements. The analysis of soil and groundwater will be performed by a Kansas approved and accredited laboratory to perform required analytical methods.

Groundwater samples will be collected during monitoring well installation and post injection activities, and will be analyzed for the identified chemical constituents of concern. The analytical methods will be consistent with previous investigations and include:

Groundwater samples collected as part of the groundwater compliance monitoring will be analyzed for the following parameters:

- Nitrate as N, Nitrite as N by EPA Method 353.2; and
- Nitrogen, Ammonia by EPA Method 350.1.

Water samples collected for waste characterization following monitoring well installation and development activities will be analyzed for the following parameters:

- TCLP for metals by EPA Method 6010;
- VOCs by EPA Method 8260;
- TPH-DRO by Method OA-2
- Flashpoint by EPA Method 1010.

10.0 QUALITY MANAGEMENT

The field lead will perform QA oversight during field activities, and the QA/QC Data Analyst and Laboratory Project Manager will oversee QA of the laboratory analysis and data reporting. These personnel have authority to stop work and/or initiate corrective measures to assure all SOPs are being adequately followed. Any procedures or protocols that may compromise data quality will cease and/or be modified in accordance with the SOPs. All analytical data will be reviewed by the Data Analyst.

11.0 DATA VALIDATION AND REVIEW

All data generated from sampling (both field and laboratory) will be reviewed by comparing calibration, accuracy, and precision to the QC criteria listed in the method description. Data validation will be completed in accordance with KDHE SOP BER-11 (Evaluation and Validation of Data). The validation procedures are generally composed of, but not limited to, the following steps:

- Verifying the correct samples were analyzed and reported in appropriate units.
- Verifying preservation and holding times.
- Verifying that initial and continuing calibrations were performed and met QC criteria.
- Verifying that no analytes were present in the method blanks and that one blank was run every 10 samples.
- Verifying that a duplicate and matrix spike, or matrix spike/matrix spike duplicate (MS/MSD) were run every 20 samples and that QC criteria were met.

11.1 Data Reporting

All laboratory data calculations and reductions will be performed as described in the applicable method references. Raw data, including laboratory worksheets, notebooks, sample tracking records, instrument logs, standard and sample preparation logs, calibration data and associated QC records, should be

retained by the laboratory for a minimum of 10 years and be available for inspection if necessary. While the laboratory data management system may store records electronically, provision should be made for hard copies as necessary to validate results.

Electronic laboratory data will be submitted to GHD will provide third party data evaluation and will provide a validated electronic data deliverable to Antea Group's database team.

Deliverables by the contract laboratory shall be in standard data reporting format. The report shall include the following:

- Cover sheet listing the sample types received and tests performed, and a case narrative describing problems encountered and identifying any analyses not meeting QC criteria, protocol modifications, and/or corrective actions taken, and general comments;
- Laboratory qualifiers and a summary of qualifier definitions;
- Internal standard recovery results and control limits (applicable to VOCs);
- Initial and continuing calibration results and control limits;
- Analytical data reported by sample or by test, containing pertinent information (i.e., field identification number, contract laboratory identification number, date of sample collection, receipt, extracted/digested/analyzed, batch number(s), dilution factors, all analytes and their reporting limits, data qualifiers, matrix units, percent of solids for soil samples, and sample description);
- Analytical information for QC sample spikes, laboratory duplicates, initial and continuing calibration verifications of standards and laboratory blanks, standard procedural blanks, LCS, surrogates, laboratory reference materials, and detection limit check samples;
- Copies of any other forms pertinent to the data review process, including corrective action forms, validation forms, raw data forms, etc.;
- Sample custody records, including original COC forms and cooler receipt forms; and,
- The contract laboratory shall maintain on file all the supporting data and documentation for these samples.

11.2 Data Assessment

The project data assessment procedures are generally composed of but not limited to the following steps:

- Review the COC and verify that all samples were received and analyzed.

- Review laboratory sample delivery group narrative for potential deficiencies in the data.
- Identify and organize the data according to laboratory data packages.
- Apply appropriate data qualifiers to the data.
- Verify the usability of the qualified data.

The Project Manager conducts a critical review of the comments provided in the summary report to determine if they are sufficient to describe and explain any associated problems with the data. If any data gaps are identified in the summary, the project manager resolves them using professional judgment based on the application of the EPA *Functional Guidelines for Data Validation* or EPA *Functional Guidelines for Inorganic Data Review.*

Data qualifiers will be assigned to the data as identified in the summary report. The data qualifiers or flags are assigned by the consultant in accordance with EPA *Functional Guidelines for Data Validation* or EPA *Functional Guidelines for Inorganic Data Review.*

11.3 Corrective Action

Corrective actions are procedures that may be implemented on samples that do not meet QA specifications. The need for corrective action will be based on the limits of acceptability as specified in the appropriate sections of this QAPP. Corrective actions will depend on the problem(s) encountered and, in many cases, may have to be defined as the need arises. Persons responsible for initiating actions and procedures for identifying, documenting and reporting corrective actions include the Project Manager and QA Officer.

11.4 QA/QC Reports

The time and type of corrective action, if needed, will depend on the severity of the problem and relative overall project importance. Corrective actions may include altering procedures in the field, conducting an audit, or modifying laboratory protocol.

In addition to the performance and system audit reports provided to the Project Manager, the post remediation report will contain sections that summarize all relevant data quality information collected during the project.

12.0 LIMITATIONS

The findings contained in this report represent Antea Group's professional opinions based upon the currently available information and are arrived at in accordance with currently acceptable professional standards. For any reports cited that were not generated by Antea USA, Inc., the data from those reports are used "as is" and is assumed to be accurate. Antea USA, Inc. does not guarantee the accuracy of this data for the referenced work performed nor the inferences or conclusions stated in these reports. This report is based upon a specific scope of work requested by the client. The Contract between Antea Group and its client outlines the scope of work, and only those tasks specifically authorized by that contract or outlined in this report were performed. This report is intended only for the use of Antea Group's Client and anyone else specifically listed on this report. Antea Group will not and cannot be liable for unauthorized reliance by any other third party. Other than as contained in this paragraph, Antea Group makes no express or implied warranty as to the contents of this report.

Meghan Guilford — Date: 11-12-2015

Meghan Guilford
Project Professional

Reviewed by:

Addie J. Mette — Date: 11/12/15

Addie J. Mette
Senior Project Manager

Tables

Table 1 Chemical Analytical Methods, Sample Containers, and Holding Times

TABLE 1
Chemical Analytical Methods, Sample Containers, and Holding Times

Analytical Parameter	Sample Matrix	Method	Approximate # of samples	Sample Containers	Number of Containers and Preservation	Holding Time
Nitrate Nitrite	Water	EPA 353.2	7*	250 mL plastic	1 - unpreserved	48 hours
Nitrogen & Ammonia	Water	EPA 350.1	7*	250 mL plastic	1 - Sulfuric Acid	28 days
TPH-DRO	Water	OA-2	1	1L amber glass jar	1 - unpreserved	7 days
Nitrate Nitrite	Soil	EPA 353.2	1	4 oz glass jar	1 - unpreserved	28 days
Nitrogen & Ammonia	Soil	EPA 350.1	1	4 oz glass jar	1 - unpreserved	28 days
TPH-DRO	Soil	OA-2	1	4 oz glass jar	1 - unpreserved	14 days

TPH = Total petroleum hydrocarbons
DRO = Diesel range organics
*Per Sampling Event

Attachment A

KDHE SOPs

STANDARD OPERATING PROCEDURE – BER-01

COLLECTION OF GROUNDWATER SAMPLES AT KNOWN OR SUSPECTED GROUNDWATER CONTAMINATION SITES

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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ATTACHMENT 1 – Pump Information

ATTACHMENT 2 – Example Well Sampling Forms

DISCLAIMER:

This Standard Operating Procedure (SOP) was developed based on a compilation of best available information, knowledge, field experience, and general industry practices to provide guidance to KDHE staff in performing the activities defined herein, in a consistent and standardized manner. This document does not contain regulatory or statutory requirements unless specified.

KDHE has made every attempt to present the information in a clear and concise manner for a variety of users. However, KDHE is not responsible for the misuse or misinterpretation of the information presented herein. Under no circumstances shall KDHE be liable for any actions taken or omissions made by non-KDHE users of this document.

In general, this document should be used as a reference. Differences may exist between the procedures referenced in this document and what is appropriate under site-specific conditions. This document does not represent an endorsement of practitioners or products mentioned in the document.

1.0 INTRODUCTION

The purpose of this Standard Operating Procedure (SOP) is to provide general procedures and guidance for sampling groundwater wells using the well-volume method, the low-flow method, and no-purge methods for common contaminants of concern. Additional guidance is included for specific situations including collection of samples with volatile organic compounds (VOCs) and sites with low-yield wells. The objective of groundwater sampling is to obtain a representative sample by minimizing chemical and biological changes caused by sample collection and handling (USEPA, 2002). This SOP is generally applicable for contaminated sites in Kansas and is intended for wells that have a discrete screen length. Site-specific conditions or circumstances may necessitate the need to deviate from or use methods not outlined in this document subject to unit chief approval.

Each groundwater sampling method has inherent advantages and disadvantages that must be given consideration. An evaluation of site-specific factors is important in determining the appropriate sampling method for a well. These considerations can include, but may not be limited to: hydrogeological conditions, state or federal regulations, analytes of concern, well design, historical data, well development, well hydraulics, well condition, and data quality objectives when selecting appropriate sampling method (ASTM, 2005 and ASTM, 2007). Objectives for a groundwater well sampling program must be clearly defined before field implementation and the appropriate sampling method must be determined on a site-specific basis. The field sampling plan (FSP), quality assurance project plan (QAPP) and health and safety plan (HSP) must be reviewed prior to collection of any samples. Sampling devices selected should be constructed of materials that do not introduce contaminants or alter the target analytes (ASTM, 2007).

2.0 PRE-SAMPLING PROCEDURES

1. Start sampling at the least contaminated well, if known, and work to progressively more contaminated wells. The most contaminated well should be sampled last. If the contamination levels are not known, work from the most downgradient sampling location from the potential source area first, sampling closest to the potential source area last. If the direction of groundwater flow is unknown or uncertain, sampling should be initiated at the farthest distance away while progressively moving closer to the known or suspected source area.

2. Physical contact between sampling equipment and contaminated media should be minimized during well purging and sampling activities to avoid

contaminating the sampling equipment and/or groundwater. For example, bailers and pumps should not come in contact with soil or purge water containers. It may be appropriate to place plastic sheeting around the well to prevent direct contact of sampling equipment with the ground surface. A new pair of sampling gloves must be worn for each well prior to sampling to prevent cross-contamination.

3. Remove well cap to allow the groundwater level in the well to equilibrate with the ambient atmospheric pressure. Record well location, time of day, date, well condition, and other pertinent information in field notebook. Ideally, if more than one well is to be sampled at a site, all wells should be opened and have the depth to water measurements collected before purging and sampling activities begin.

4. When appropriate, screen the head-space of the well with a vapor monitoring instrument immediately after removal of the well cap to determine the presence of organic vapors and record the instrument response in site logbook.

5. Prior to placing any water level measuring device or reusable bailer in a well, care should be exercised to ensure that free floating immiscible product is not present in the well. Only properly decontaminated equipment should be introduced to the well. A disposable bailer may be lowered into the well to determine the approximate depth to water or depth to floating product. If floating product is observed, a groundwater sample should not be collected unless otherwise specified by a site-specific work plan. An interface probe or a partially submerged, clear PVC bailer should be used to measure the floating product thickness and the depth to water in the well. An attempt should be made to describe the type, color, and viscosity of the product.

6. Lower water level measuring device into well until water surface is encountered. Record the depth of the water surface from a specific reference point and record depth to water in field notebook to the nearest one hundredth of a foot. Water level measurement method and measurement reference point should also be recorded. Please refer to BER-36 titled. "Water Level, Product, and Well Depth Measurements."

7. Measure total depth of well and record in site logbook or on log form. Total well depth should not be measured until after the sample is collected when using the no-purge sampling method.

3.0 SAMPLING USING THE WELL-VOLUME METHOD

3.1 DESCRIPTION OF WELL-VOLUME METHOD

The goal of well purging is to remove the stagnant water above the screened interval in order to collect a representative groundwater sample. The well-volume method is a traditional technique where a predetermined volume of water is removed from the well or water is removed from the well until specified parameters have stabilized before sample collection. This SOP outlines general procedures for purging and sampling using a fixed well-volume method. The stabilization well-volume method can be used to determine when a well has been adequately purged, but this specific method is not outlined in this SOP. Stabilization criteria for the stabilization well-volume method are similar to those outlined for low-flow sampling method, but specific stabilization criteria, measurement frequency, and other procedure requirements should be outlined in the site-specific work plan (USEPA, 2002).

Site-specific conditions and objectives should be considered before selecting this method since it may not be appropriate in conditions where there are low-yield wells, wells with higher turbidity, wells in fractured rock settings, wells with a set pump, or wells with separate phases of liquids (such as dense or light non-aqueous phase liquids) (USEPA, 2002). The advantages are that a variety of pumps can be used for purging or sampling and that it does not require chemical parameter measurements to determine when purging is complete. The disadvantages associated with the fixed well-volume method are that there may be an increased cost associated with handling a larger volume of investigative- derived waste (IDW) and that no well-specific analyte indicator or parameter used to determine when the well is adequately purged (ASTM, 2005). It is recommended that the stabilization method is used in most cases as this method commonly provides the most reliable data.

3.2 DETERMINATION OF PURGE VOLUME

A well is typically purged at least three to five well volumes (ASTM, 2007) and a fixed well volume purging is best applied to wells that yield multiple well volumes without fully dewatering the well (ASTM, 2005). The volume of water in the well, depth to water level, inner diameter of the well, the aquifer's recovery rate, accessibility to the well, and the contaminants being sampled have an effect on how a well should be purged and sampled. It is recommended that the same equipment used for purging also be used for sampling, unless the device is inappropriate for target analytes. A pump or bailer can be used to purge a well and it is

preferable that equipment be constructed of an inert material (USEPA, 2002).

The volume of water in the well can be calculated by using information collected in pre-sampling activities (Section 2.0). The depth to water, total well depth, and inner well casing diameter are used in the following formula:

$V = \pi r^2 h(cf)$

where:
V = volume in gallons
π = pi or 3.1416
r = radius of monitoring well (feet); radius in inches/12 = radius in feet
h = height of the water column (feet), which equals the total well depth minus depth to water
cf = conversion factor (7.48 gal/ft^3)

Other variations of the basic formula for a cylinder can also be used to calculate the volume of water in a well. In most cases, it is appropriate to also purge the volume of water contained within a gravel pack and/or well borehole in addition to the well volume to assure that a representative sample is obtained.

For a 2 inch well: Volume = [(total depth – depth to water) * 0.16]
For a 4 inch well: Volume = [(total depth – depth to water) * 0.65]
For a 5 inch well: Volume = [(total depth – depth to water) * 1.03]
For a 6 inch well: Volume = [(total depth – depth to water) * 1.48]

Or calculate the volume using the following formula:
Volume = (total depth – depth to water)(casing inner diameter)^2(0.041)
Note: measurements are in feet

3.3 PURGING PROCEDURES FOR THE WELL-VOLUME METHOD

3.3.1 Purging with a Bailer

Bailers are a simple purging device and generally consist of a rigid length of tube constructed from PVC, stainless steel, or Teflon®, and usually with a ball check-valve at the bottom. A line is used to lower the bailer into the well to retrieve a volume of water. This manual method of purging is best suited for shallow or narrow diameter wells. Generally, bailers should be used if the well has a

low recovery rate or if the amount of water to be purged is minimal (USEPA, 2002).

1. Complete the pre-sampling activities as outlined in Section 2.0.

2. Determine the appropriate purge water volume as described in Section 3.2.

3. Attach the line to the bailer and slowly lower the bailer until it is completely submerged in the water. Only dedicated, disposable, or properly decontaminated purge equipment should be introduced into the well. Over-disturbance of the water column in the well should be avoided. Carefully pull the bailer out to minimize disturbance of the well casing and water, and ensure that the line either falls onto a clean area of plastic sheeting or does not touch the ground. Empty the bailer into a bucket (of a known volume) to measure the volume of water purged.

4. Thereafter, continue with bailing process until desired purge volume has been removed. Record the total volume of water purged in field notebook.

5. Dispose of purged water as specified in the site-specific work plan.

6. If any bailer is being used at more than one well, it should be properly decontaminated prior to sampling the next well. New rope or string must be used at each location.

3.3.2 Purging with a Pump

Pump construction materials (bladders, pump, tubing) should be limited to stainless steel, Teflon, glass or other inert materials. A variety of pumps are available for purging wells. Please make sure that the pump utilized meets the criteria for the depth of water and type of target analytes. A description of common pump types can be found in Pump Information Attachment 1.

1. Complete the pre-sampling procedures as outlined in Section 2.0.

2. Determine the appropriate purge water volume as described in Section 3.2.

3. Assemble pump, hoses and safety cable, and lower the pump into the well at the appropriate depth below the water. Only properly decontaminated purging equipment should be introduced into the well. Care should be taken not to drop the pump in the well and over-disturb the water column. The pump should be placed just below the water level, making sure the pump is deep enough so that purging does not evacuate all the water (running the pump without water may cause damage), but keeping it above the screened interval if possible.

4. Attach a flow meter to the outlet hose to measure the volume of water purged. If a flow meter is not available, a bucket of known volume and stopwatch may be used to measure the volume of water purged and pumping rate.

5. The water level should be monitored during purging to ensure air does not enter the pump, and that the pump is set at an appropriate pump rate. If the pumping rate exceeds the well recharge rate, lower the pump further into the well and continue pumping, or if possible, decrease the pumping rate.

6. Purge the well until the specified volume of water has been evacuated. Record the total volume purged in field notebook. If a fuel powered pump is used, it should be located downwind of the sampling collection point.

7. If any purging equipment is being used at more than one well, it should be properly decontaminated prior to sampling the next well.

3.4 WELL-VOLUME METHOD SAMPLING PROCEDURES

3.4.1 Sampling with a Bailer

Generally, bailers can provide an acceptable sample, as long as sampling personnel use extra care in the collection process. Site-specific conditions or target analytes may necessitate the need to use an alternative sampling method. Bailing a well can disturb the

water when repeatedly lowered into the well introducing bias, especially when sampling for VOCs and metals (USEPA, 2002).

1. Complete the pre-sampling activities as outlined in Section 2.0.

2. Perform the purging method as outlined in Section 3.3.1. The same bailer and line may be used for sampling.

3. Collect samples immediately after purging is complete, but if necessary, allow the well to recharge so a sample can be collected. If a well is purged dry, the well should be sampled within 24 hours and no sooner than 2 hours. See Section 7.2.

4. Lower the bailer slowly and gently into the well, taking care not to shake the casing sides or to splash the bailer into the water. Stop lowering at a point adjacent below the top of the screen.

5. Allow the bailer to fill and then slowly and gently retrieve the bailer from the well, avoiding contact with the casing, so as not to knock flakes of rust or other foreign materials into the bailer or the well.

6. Remove the cap from the pre-labeled sample container(s). Do not place the cap on the ground. Pour water slowly and gently from the bailer or open the stopcock, being careful not to agitate the sample. Care should be taken not to allow the water from one end of the bailer to rush out of the open end of the bailer while pouring water into sample bottles since this can cause agitation.

7. Filter samples, if required by the field sampling plan.

8. Place cap on the sample container tightly, place sample in plastic bag, and place sample container into a cooler.

9. Log all pertinent sampling information in field notebook (date, sample collection time, location, etc.) and fill out chain-of-custody forms.

10. If any sampling equipment is being used at more than one well, it should be properly decontaminated prior to sampling the next well. The use of bailers dedicated to a single well is recommended.

3.4.2 Sampling with a Pump

Selection of a sampling pump should be based on an evaluation of how the pump will affect the target analyte. Some pumps can cause chemical or physical changes such as aeration or volatilization, which could affect the representativeness of the sample.

1. Complete pre-sampling activities as outlined in Section 2.0.

2. Complete purging method as outlined in Section 3.3.2. Only properly decontaminated sampling equipment should be introduced to the well.

3. Samples should be collected immediately after purging is complete without changing the position of the pump or turning it off (if the same pump is used). It may be necessary to allow the well to recharge so a sample can be collected. If a well is purged dry, the well should be sampled within 24 hours and no sooner than 2 hours. See Section 7.2.

4. Remove the cap from the pre-labeled sample container(s). Do not place the cap on the ground. Fill the appropriate sample bottle(s).

5. Filter samples, if required by the field sampling plan.

6. Place cap on the sample container tightly, place sample container in plastic bag, and place sample container in a cooler.

7. Log all pertinent sampling information in field notebook (date, sample collection time, location, etc.) and fill chain-of-custody forms.

8. Upon completion, remove pump and assembly. All pump equipment should be properly decontaminated prior to sampling the next well.

3.5 PURGING AND SAMPLING DOMESTIC AND LAWN AND GARDEN WELLS

Turn on a household fixture (preferably an outside faucet) and allow the well to discharge for a minimum of 5 to 10 minutes. Remember to document the exact amount of time the well was purged. Make certain the discharge point is on the well-side of any water filtering or conditioning device or screen. Do not sample through garden hoses. Collect the sample directly from the faucet, but do not touch the sample container to the faucet. Minimize aeration of discharge during sampling, if possible. If a home has a pressure tank that is used prior to the faucet to be sampled, then it is important to purge enough water to drain the pressure tank prior to sampling so the sample is collected from the well and not water stored in the pressure tank.

If specified by a site-specific work plan, field parameters (dissolved oxygen, specific conductance, pH, temperature, etc.) can be monitored during the evacuation process. When field parameters are within the stabilization criteria described in Section 4.6 for three consecutive measurements, the well is considered purged and a sample can be collected.

4.0 LOW-FLOW SAMPLING METHOD

4.1 DESCRIPTION OF THE LOW-FLOW METHOD

The term "low-flow" refers to the velocity at which water enters the pump intake from the surrounding formation in the immediate vicinity of the well screen. It is assumed that pumping at a low rate within the screened interval of a well will minimize drawdown and the mixing of stagnant water with formation water, which should result in a representative sample of the formation water. Water quality parameters are monitored during the low-flow purging process until sufficient stabilization of water quality parameters has been reached before collection of a sample. References consulted during development of procedures for low-flow sampling include guidance documents from the U. S. Environmental Protection Agency (USEPA 1996, 2001, 2002) and the ASTM International (ASTM 2002).

The low-flow purging and sampling method is best used for situations where the well has a discrete screened interval (10 feet or less) and the aquifer materials are sufficiently permeable to allow drawdown in the well to stabilize during the purging process. This method of purging and sampling should not be used for wells that are screened in low

permeability materials where drawdown cannot achieve stabilization while pumping. In addition, this method of purging and sampling is not intended for wells that contain non-aqueous phase liquids.

Some of the advantages of using the low-flow techniques for purging and sampling can include:

- Improved sample quality by minimizing the disturbance in the well;
- Less mixing of the stagnant casing water with the formation water;
- Samples are more representative of the mobile load of contaminants present in the aquifer reducing the need for filtering the water samples;
- The purging and sampling time is reduced; and
- Purge volumes are smaller resulting in generation of less wastewater.

Some disadvantages for the low-flow method of purging and sampling can include:

- The necessity for more equipment such as variable speed pump with the capability to pump at low rates, a flow-through cell that includes ph, oxidation-reduction potential (ORP), dissolved oxygen (DO), temperature, specific conductance, and a turbidity probe and meter(s);
- Additional cost and time can be incurred since stabilization of water parameters may require relatively longer times;
- Sample results may not be reproducible if the pump is placed at a different depth within the screened interval each time the well is sampled.

4.2 LOW-FLOW SAMPLING EQUIPMENT

NOTE: a majority of this equipment is needed for all types of groundwater sampling.

- well construction information including screened interval, total depth, and well diameter;

- borehole logs;
- well keys;
- map of well locations;
- tools box with necessary tools for opening the well and assembling the pump;
- plastic sheeting to spread around the well;
- low-flow variable speed pump with flow controller;
- tubing that is the appropriate size for the selected pump and made of appropriate material that will not interact with contaminants in the groundwater (e.g. teflon or polyethylene);
- check valve;
- container to collect purge water such as a 55-gallon drum or tank;
- water level measurement device;
- container of known volume and stop watch for measuring flow rate;
- flow-through cell with water-quality indicator meters for ph, specific conductance, dissolved oxygen, oxidation-reduction potential, and temperature;
- nephelometer for measuring turbidity, if desired;
- calibration fluids or standards for water-quality indicator meters and nephelometer;
- barometric pressure for calibrating dissolved oxygen meter, if necessary;
- information such as the inside diameter of the tubing to aid in calculating the total volume of water held by the pumping apparatus (i.e., volume of water held in the tubing, the flow-through cell, and the pump);
- field notebook and field forms for recording measurements and the pumping rate;

- sample bottles, labels, ice, and preservative;
- shipping supplies such as cooler, chain of custody forms, custody seals, tape, shipping forms, plastic sealable bags, and packing materials;
- 0.45 micrometer (μm) filters and other necessary filtering apparatus (if samples will be filtered);
- supplies for decontamination of equipment such as potable water, alconox, deionized water, buckets, spray bottles, brushes;
- work plan and health and safety plan; and
- air monitoring equipment, if required.

4.3 PUMP TYPE AND ASSEMBLY CONSIDERATIONS

A low-flow variable speed pump with a flow controller should be used for low-flow purging and sampling. The pump should be capable of achieving pumping rates that are low enough to allow for stabilization of drawdown in the well; therefore, the permeability of the aquifer at the site should be considered during pump selection. The pump selected should not cause excessive pressure or temperature changes or physical disturbance on the water samples. The types of pumps that may be used include bladder pumps, electrical submersible pumps, gas-powered pumps, and peristaltic pumps. Inertial pumps and grab sampling type of devices such as bailers cannot be used for low-flow sampling techniques because of the disturbance they cause in the well. Another consideration for pump selection is the diameter of the monitoring well casing. Well construction records should be reviewed to identify the diameter of the well casing for all the wells that will be sampled to ensure the correct pump size is selected.

The use of peristaltic pumps will be limited to sites that have shallow depths to water (e.g., less than 20 feet below ground surface). Also, because the peristaltic pump is a suction-lift type of pump, special consideration is needed when samples are to be collected for analysis of VOCs because the suction action can result in degassing of volatiles from the water. If this is the case, the "straw method" can be employed for collection of samples for VOCs. The straw method is described in Section 7.1.

When assembling the pump and tubing, an effort should be made to avoid using an unnecessary amount of extra tubing because excessive tubing at the surface can cause the temperature of the water to change, potentially affecting the water chemistry.

4.4 PUMP PLACEMENT

Once assembled, the pump and/or tubing should be lowered into the well slowly and carefully to minimize disturbing the water column. If lowering the pump into the well casing results in significant disturbance of sediment or particulates, raising the turbidity, it may be necessary to wait to begin pumping until the sediment within the well casing has settled.

If the formation is homogeneous throughout the screened interval, the pump intake should be placed in the middle or slightly above the middle of the screened interval. Placing the pump intake closer to the bottom of the well screen may result in disturbance of sediment that has settled to the bottom of the well. Placing the pump intake too close to the top of the screen may cause the stagnant water in the well casing above the screen to be drawn downward. If the water level intersects the screened interval, the pump should be placed midway between the water level and the bottom of the well, or far enough into the water column so that air does not enter the pump intake while pumping. Well-specific information such as formation heterogeneity within the screened interval or stratification of the contaminants within the screened interval are reasons for placing the pump intake elsewhere within the screened interval to meet site-specific sampling objectives. For example, if the part of the formation that is screened is heterogeneous with respect to hydraulic conductivity, the pump intake should be placed adjacent to the zone that has the highest hydraulic conductivity.

4.5 PUMPING RATE AND WATER LEVEL MEASUREMENT

The pumping rate for the low-flow method will be a function of the permeability of the formation being sampled. Measurement of the water level in the well is used to identify the appropriate pumping rate. The pumping rate should be similar to the recovery rate for the well based on the amount of drawdown measured in the well while purging. Some guidance indicates that drawdown should be no greater than 0.33 feet while performing low-flow purging and sampling; however, well-specific conditions may allow for greater drawdown as long as the drawdown stabilizes. If a well has never been sampled by the low-flow method and the appropriate pumping rate is unknown, the pump should be started at the lowest rate and then increased slowly to determine the highest

pumping rate that can be used while maintaining a stable drawdown. Low-flow rates are typically 0.1 to 0.5 liters per minute (L/min), but it depends on site specific hydrogeology (USEPA 1996). If a formation is very permeable or transmissive, a flow rate of up to 1 L/min can be used as long as the water level can be stabilized while pumping.

The frequency for measurement of water levels will be dependent on the hydraulic conductivity of the formation. Water levels should be measured every 30 seconds to every 5 minutes depending on the situation. More frequent measurement of the water level will be needed when pumping in a well is initiated to assess the level of drawdown. Once the drawdown has stabilized, less frequent measurements are needed. Measurements should be recorded in the field book or on an appropriate field form. An example form is provided in the Attachment 2 and is titled, "Water Well Purging and Sampling Log." It is important to document the pumping rate at which drawdown stabilizes and the depth of pump placement because this information can be utilized for future sampling efforts.

4.6 MEASUREMENT OF WATER-QUALITY INDICATORS AND STABILIZATION CRITERIA

Water quality indicator parameters such as specific conductance, DO, ORP, turbidity, pH, and temperature are measured during the low-flow purging process to determine when the water quality parameters have stabilized for sample collection. Water quality parameters should be measured in a device (flow-through cell) that prevents contact of the purge water with air prior to measurement, especially for DO. The ORP parameter may not be suitable for determining stabilization at all sites, but readings should be recorded if they are available as another check on the oxidation conditions of the water. Turbidity can also be used to help measure stabilization and determine the need for filtering the samples collected for metals analysis. Because sediment particles may collect in the flow-through cell, samples for turbidity measurements should be collected before the water reaches the flow-through cell. If the sample is to be tested for parameters that could be biased by the presence of particulates, such as semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), or metals, it is important to try to reduce the turbidity of the sample to below 10 Nephelometric turbidity units (NTUs). Water samples of this clarity (< 10 NTU) should be more representative of natural colloidal loading in the formation. If the turbidity can be reduced below 10 NTUs, it may not be necessary to filter the samples collected for metals analysis; however, the approved work plan should be reviewed to determine if filtration of samples will be conducted. Note that the BER Policy BER-RS-46 Filtering Water

Samples Collected for Metal Analysis, a water sample should be field filtered if turbidity is greater than 5 NTUs. It may also be appropriate to consider collection of both filtered and unfiltered samples for comparison purposes.

Measurement of the water-quality indicator parameters should be conducted at specific intervals based on the pumping rate and the total volume of water in the pump, tubing, and flow-through cell. The first measurement should be taken after one complete volume of water has passed through the pumping apparatus with subsequent readings being taken as additional volumes of water are pumped out. When three successive readings indicate the water-quality indicator parameters have stabilized within the appropriate criteria, sampling can begin. Stabilization criteria are identified in the table below. If the water-quality indicator parameters do not stabilize even though the low-flow procedures are being followed, then it may be necessary to use a different purge and sample method.

Water-Quality Indicator Parameter	Stabilization Criteria
Specific conductance	+/- 3 % milliSiemens/centimeter (mS/cm)
Dissolved oxygen	+/- 0.3 milligrams per liter (mg/L)
Oxidation-reduction potential*	+/- 10 millivolts (mV)
Turbidity	+/- 10 % when turbidity is greater than 10 NTUs
pH	+/- 0.1 Units
Temperature	None provided; temperature is not a sensitive indicator for purging but should be recorded anyway.

Measurements including water quality parameters, flow rate, volume of water removed should be recorded in the field book or on an appropriate field form. Example forms are included in Attachment 2.

4.7 LOW-FLOW PURGING PROCEDURES

1. Follow pre-sampling procedures as outlined in Section 2.0.

2. Use the water level measurement and well construction information to determine the appropriate depth for the pump intake in the well. Only properly decontaminated equipment should be introduced into the well.

3. Sample labels should be filled out and placed on the bottles prior to starting the purging process.

4. Using the information for the total depth of the well, the well casing diameter and the water level measurement, calculate the volume of water within the well as outlined in Section 3.2 and record the information in the field notebook.

5. Calibrate the water-quality indicator probes/meters with the appropriate calibration solutions according to the manufacturer's instructions. Record all calibration data in the field notebook.

6. Determine the length of tubing needed to place the pump at the predetermined depth within the screened interval. Assemble the pumping apparatus with the tubing. It will be necessary to make sure the pump used has a check valve so that the water within the pumping apparatus does not drain back into the well if the pump is shut off. If a peristaltic pump is used, a check valve should be fitted at the intake end of the tubing.

7. The depth of placement of the pump within the screened interval should be verified by a measurement of a calibrated hose/tubing on the pumping apparatus or by pre-measuring the length of the tubing and pump before placing it in the well. Tubing should be selected to be compatible with target analytes. Slowly and carefully lower the pump and tubing to the predetermined depth in the well. Record the depth of the pump intake in the field notebook.

8. Connect the discharge line of the pump to the flow-through cell containing the water-quality indicator probes/meters. If turbidity measurements will be taken during purging using a separate meter, a "T" connection needs to be added to the tubing prior to reaching the flow-through cell to allow for collection of samples for this parameter.

9. Calculate the volume of water that will be held in the tubing, pump, and flow-through cell. The inside diameter of the tubing will be needed for this calculation.

10. Measure the water level again and record the information. Leave the water level probe in the well.

11. Start the pump at a relatively low pumping rate, (approximately 0.1 to 0.2 L/min) and slowly increase the speed, checking the water levels every 30 seconds initially and comparing this information to previous water levels to determine the amount of drawdown and whether it stabilizes. Exceeding a pumping rate of 1 L/min is not recommended for low-flow purging. If drawdown exceeds 0.33 feet and does not stabilize, reduce the pumping rate. If drawdown stabilizes the frequency of water level measurements can be reduced to every 3 to 5 minutes.

12. Measure the discharge rate of the pump to determine when one volume of the pumping apparatus, tubing, and flow-through cell has been discharged with graduated cylinder and stopwatch. Record the information on form or field notebook. Check the flow-through cell to make sure it fills completely and no air is present in the cell when the water-quality indicators measurements are taken.

13. As each tubing volume is discharged, record the water level, flow rate, volume pumped, and water-quality indicator meter readings and turbidity readings on the field form or in the field book. Continue pumping and recording the information until three successive readings indicate stabilization of the water-quality indicator parameters have been achieved as described in Section 4.5 or in the site-specific QAPP or FSP. Once the stabilization criteria have been achieved, sampling can begin.

14. If drawdown does not stabilize after reducing the pumping rate, it may be necessary to shut off the pump to let the water level recover and then restart the pump at the lowest pumping rate. The pumping apparatus should be equipped with a check valve to prevent water in the tubing from flowing back into the well casing when the pump is turned off. If stabilized drawdown cannot be achieved at the lowest pumping rate available, a different method for sampling should be selected for the well. Another reason for shutting off the pump during purging is if the turbidity of the water increases since this may be an indication that the water column is being disturbed. If reducing the pumping rate does not decrease the turbidity of the water, the pump should be turned off for an appropriate period of time to allow the particulates to settle.

15. Verifying the calibration of water quality parameters and/or recalibration of probes/meters after sampling each well or

sampling at the end of the day may be required in order to document any instrument drift. Perform the instrument calibration verification and/or recalibration if required by site-specific QAPP or FSP. Record data in field notebook.

4.8 LOW-FLOW SAMPLING PROCEDURES

1. Complete low-flow purging procedures as outlined in Section 4.7.

2. Disconnect the tubing from the flow-through cell prior to sampling so that the water does not come in contact with the water-quality indicator meters during sample collection.

3. Sampling can be conducted at the same pumping rate as that used during purging or at a lower rate to minimize turbulence and aeration of the sample when filling the bottles. Fill all sample bottles from the discharge of the tubing. The order of sample collection for different types of analyses is not important unless the samples are to be filtered or if a peristaltic pump is used for purging.

4. If samples are to be filtered, they should be collected towards the end of sample collection process if an in-line filter cartridge will be used. See Section 7.3 for a discussion on filtering.

5. Sample collection for analysis of VOCs can be done at anytime during the sample collection process unless a peristaltic pump is being used to purge the well. If a peristaltic pump is used for low-flow purging and one of the parameters to be analyzed is VOCs, the straw method may be used to fill the samples vials for this parameter to minimize the loss of volatiles and prevent the collection of sample that has come in contact with the silicon tubing in the pump head. The straw method is described in Section 7.1. If adequate volume cannot be obtained to fill all the needed VOA vials with one tubing volume, another type of pump or a different purging and sampling method should be considered. Reinserting the tubing into the well casing to obtain additional sample volume should not be conducted because it will cause disturbance in the well casing and the tubing will pass through the stagnant water column within the casing potentially drawing some of this water into the tubing resulting in collection of an unrepresentative sample.

6. Log all pertinent sampling information in the field notebook (date, sample collection time, location, etc.) and fill out any necessary chain-of-custody forms.

7. Upon completion, remove pump and assembly and properly decontaminate all equipment prior to purging and sampling the next well.

5.0 NO PURGE SAMPLING METHODS

5.1 NO-PURGE METHOD DESCRIPTION

No-purge sampling, also sometimes referred to as passive sampling, is a methodology in which no hydraulic stress or transport is induced on the aquifer. In most wells, groundwater that flows within the well screen is typically in equilibrium with surrounding formation groundwater, so collection of an undisturbed sample of this water is considered representative. There are three main categories of no-purge sampling methods that include grab-type samplers (HydraSleeve™ and Snap Sampler®), diffusion-equilibrium-type samplers (passive diffusion bags made of regenerated-cellulose dialysis membrane samplers or rigid, porous polyethylene samplers) and diffusion-sorption-type samplers (GORE-SORBER™). If applied appropriately, no-purge sampling can produce reliable and accurate data. Note: The Kansas Department of Health and Environment does not endorse any brand or manufacturer.

The main advantages of no-purge sampling are that it can be used in most wells, it is relatively simple and cost effective to use, generates limited volumes of IDW, can be used to collect samples at discrete depth intervals (or used in series to obtain a contaminant profile), does not have a depth limit and generally reduces field sampling variability for highly reproducible results. Some of the disadvantages of no-purge sampling are that the sampling device must be submerged within a screened interval and that the well must be in hydraulic communication with the aquifer, that special consideration is required when free-phase product is present, it requires consideration of contaminant stratification, and it can have limitations on sample volume and analyte.

Switching to a no-purge method at a site where traditional purge-type methods have been previously used may be technically sound and economical. To facilitate this transition in well sampling methods, it may be necessary to complete a comparative study between the selected no-purge sampling method and the current purge-type sampling method. The specific nature of a given no-purge method must be considered when

interpreting and comparing results. Multiple lines of evidence are needed under conditions with high temporal variability where a direct comparison of traditional and no-purge sample results may not be agreeable. In such conditions, data disagreement does not necessarily preclude the use of no-purge sample methodology. (ITRC, 2007).

5.2 GENERAL NO-PURGE SAMPLING GUIDELINES

- When deploying a no-purge device, an appropriate amount of time must pass before sample collection can commence. This waiting period will allow the water within the well screen to re-stabilized with ambient aquifer conditions. The amount of time required for this re-stabilized period is dependent on the relative hydraulic conductivity or transmissivity of the formation the well is screened within. Generally, a shorter amount of time is required for stabilization of water in a higher transmissive aquifer such as sand or gravel (on the order of hours or days) and a longer time is required for stabilization of water in lower transmissive aquifers, such as silt or silty sand (on the order of weeks). The proper stabilization period should be determined on a site-by-site basis. The minimum recommended amount of time between deploying and sampling when using a passive diffusion bag sampler is two weeks.

- The mechanism for no-purge sampling method and device must be understood and applicable to site-specific conditions and appropriate for the target analyte. The manufacturer's directions should be consulted to determine if the target analyte can be collected with the specific no-purge sampler device.

- Device specific procedures developed by the manufacturer should be consulted when developing a site-specific SOP.

- The length of the water column and well screen must be sufficient enough to use a no-purge sampling device. Samples obtained with no-purge devices should only be collected from the screened portion of a well.

- No-purge sampling devices need to remain submerged between sampling events. When long periods of time required for deployment are necessary and/or when water levels fluctuate (temporal changes and adjacent pumping), it may be appropriate to monitor the relative groundwater elevation in the well between sample collection periods.

- Stainless steel weights can be used to hold the no-purge device at the selected sampling interval.

5.3 PROCEDURES FOR NO-PURGE "GRAB" SAMPLING METHOD WITH HYDRASLEEVE™

1. To assemble the Hydrasleeve™, remove the two clips and sleeve from the package and unroll the sleeve. Insert the prongs of the small clip into the hole located on the bottom of the sleeve. Face the clip prongs away from the sample sleeve and then attach the reusable weight to the clip at the bottom of the sleeve.

2. Next, attach the large clip to the top of the sleeve by inserting the prongs into the holes at the top of the sampler.

3. Tie the suspension line to the top clip securely. The sleeve is ready for deployment.

4. If the field sampling plan requires a sleeve series for vertical profiling in a single well, the sleeves can be stacked where the bottom of the top sampler is attached to the top of the bottom sampler. Attach the weight to the bottom sampler in the stack of sleeves. More than one weight may be required if multiple sleeves are used in series. Alternatively, more than one sleeve can be attached to a single tether. Attach the weight to the bottom of the single tether. The top and bottom of each sleeve is then attached to the tether at desired sample intervals. In a case where the water column is shallow, a weight can be added to the top of the sleeve to compress the sleeve in the bottom of the well.

5. To deploy, place Hydrasleeve™ and weight into the well and reel the sleeve down to the desired depth within the well screen. Secure the tether to the outside of the well to prevent losing the sleeve and tether in the bottom of the well.

6. Before sample collection, the aquifer must be allowed to stabilize after the water column has been disturbed due to sleeve deployment. The stabilization period greatly depends on the hydraulic properties of the aquifer where low permeable aquifers may require weeks for stabilization and gravel aquifers require hours to stabilize. The stabilization period should be determined on a site-by-site, well-by-well basis.

7. Once the well has stabilized, the sample can be collected. The Hydrasleeve™ must been moved upward in the well at a rate of one foot per second or faster so that water can pass through the check valve into the sleeve for collection. The check valve of the sampler must move one to two times the total length of the sampler. For example, a 24-inch sampler must be moved for 24 inches, but no greater than 48 inches to fill. Sample collection can either be completed by one continuous pull or by multiple short strokes.

8. Before discharging water from the sleeve, squeeze the full sleeve just below the rigid plastic top ring to expel extra water resting above the check valve. It is recommended to hang the top of the sleeve from a stable point or have another person hold the top of the sleeve during sample collection. Use the short plastic discharge tube included with the sleeve kit to puncture the sleeve at the base of the top ring. Discharge the water into sample containers, being careful not to over agitate the sleeve or water. The sleeve can be raised and lowered to control the flow of water to the sample bottle.

9. If routine monitoring is done at the well, a new Hydrasleeve™ should be assembled and deployed into the well for the next sampling event (Cordry, 2004).

5.4 PROCEDURES FOR NO-PURGE PASSIVE DIFFUSION BAG SAMPLING METHOD

In general, passive diffusion bag samplers consist of a narrow water-filled bag that relies on the diffusion of contaminants in groundwater across the sampler membrane into the bag to reach and maintain equilibrium with the ambient well water. Passive diffusion bag samplers can be made up of different types of materials such as rigid porous polyethylene and regenerated cellulose dialysis membrane. A passive diffusion bag consisting of the proper material must be selected for site-specific contaminants since bag material can limit the diffusion of certain types of contaminants into the bag. The manufacturer's instructions should be consulted to determine if the selected bag material is appropriate for contaminants of concern and to determine the required equilibration time period for specific contaminants.

1. Assemble the passive diffusion bag according to the manufacturer's instructions.

2. Install any necessary weights to the sampler and/or deployment tether. Attach the suspension line to the sampler.

3. Determine the placement of the sampler in the well and lower sampler to the desired depth. Secure tether to the outside of the well to prevent loss of the sampler and tether inside the well.

4. Once sampler is deployed in the well, the sampler must be allowed to equilibrate with ambient well conditions. The proper equilibration period for the sampler and target analytes must be determined on a site-by-site basis. Some samplers have time limits in which the bag can be deployed in the well due to bag integrity issues or biodegradation.

5. Once the equilibrium period is complete, retrieve the sample bag by pulling the tether line until the sampler is retrieved from the well.

6. Before collecting a sample from the bag, it is recommended to suspend the bag sampler from a stationary point. Depending on the sampler style, either puncture the bag with a sampler straw or remove the cap from the sampler and fill sample containers. Take care not to over agitate the bag or water.

7. If well is used for routine monitoring, assemble a new sampler and deploy into the well for the next sampling event.

6.0 POST-SAMPLING PROCEDURES

After all samples are collected and preserved, the reusable sampling equipment should be decontaminated prior to sampling another well. This will prevent cross-contamination of equipment and monitoring wells between locations.

1. Decontaminate all equipment according to SOP No. BER-RS-05 Decontamination of Equipment;

2. Dispose of purge water according to approved procedures in the site-specific work plan and/or consistent with SOP No. BER-RS-08 Characterization and Disposal of IDW;

3. Prepare and transport samples to the laboratory. Check sample documentation and make sure samples are properly packed for shipment to a laboratory consistent with SOP No. BER-RS-19 Chain of Custody.

7.0 SPECIAL CONSIDERATIONS

7.1 VOLATILE ORGANIC COMPOUNDS (VOCS)

VOCs should be collected in a manner that minimizes the volatilization of compounds and minimizes the disturbance of the sample. Sample retrieval systems suitable for the valid collection of volatile organic samples include positive displacement bladder pumps, gear driven submersible pumps, syringe samplers, bailers, passive diffusion bags, the Hydrasleeve™, or snap type of sampler. Suction-lift type of pumps such as peristaltic pumps are generally not recommended for sampling for VOCs because of the potential for degassing of volatiles from the sample; however, under certain conditions these types of pumps may aid in the collection of samples for VOCs as described below.

The following procedures for filling the sample vials for VOC analysis should be followed:

1. Open the vial and fill it slowly to minimize turbulence and aeration of the sample. When collecting duplicates, collect both samples at the same time.

2. Fill the vial to just overflowing. Do not rinse the vial, nor excessively overfill it. There should be a convex meniscus on the top of the vial.

3. Check that the cap has not been contaminated (splashed) and carefully cap the vial. Place the cap directly over the top and screw down firmly. Do not over tighten and break the cap. Placing water sample in the cap and then screwing the cap down on the vial to avoid air bubbles is not recommended.

4. Invert the vial and tap gently. Observe the vial for a few seconds. If an air bubble appears, discard the sample and begin again. If sample containers are pre-preserved then a new sample vial must be used or preservative added to the vial or the sample is collected as a unpreserved sample with appropriate notation on the chain-of-command form. It is imperative that no air bubbles are present in the sample vial.

5. Immediately place the vial in the protective sleeve (if available) and place into the cooler containing ice, oriented so that it is lying on its side, not straight up.

6. The holding time for unpreserved samples is 7 days and 14 days for preserved samples. If possible, samples should be shipped or delivered to the laboratory daily so as not to exceed the holding time. Ensure that the samples remain at 4 -6° C, but do not allow them to freeze.

If a peristaltic pump is used for purging for the purpose of testing for VOCs, the straw method may be used to fill the sample vials to minimize the loss of volatiles. If the straw method will be employed, it should be done after all other sample bottles have been filled by the pump because the straw method requires removing the tubing from the well casing. The straw method is done by filling the tubing by the action of the pump, disconnecting the tubing from the pump while crimping the tubing at the top, withdrawing the tubing from the well, disconnecting the check valve at the bottom of the tubing, and draining the water into the sample vials from the bottom of the tubing. Another method for collection of VOCs using a peristaltic pump is to reverse the direction of the pump and drain the sample into the vials from the bottom of the tubing after removing the check valve. Care should be taken to avoid completely emptying the tubing when filling the sample vials so that water that has come in contact with the silicon tubing in the pump head is not introduced into the sample vials. If adequate volume cannot be obtained to fill all the needed sample vials with one tubing volume, another type of pump or a different purging and sampling method should be considered. Reinserting the tubing into the well casing to obtain additional sample volume should be avoided because it will cause disturbance in the well casing and the tubing will pass through the stagnant water column within the casing potentially drawing some of this water into the tubing resulting in collection of an unrepresentative sample.

7.2 SAMPLING LOW-YIELD WELLS

In situations where a well has low-yield, has limited volume in the casing, and/or recovers slowly in a low hydraulic conductivity formation, procedures for sample collection will be different. One alternative procedure consists of removing stagnant water from above the top of the well screen, to minimize the exposure of the gravel pack and formation to the atmosphere (without lowering the pump into the screened interval), and to then collect a sample. In many cases, purging the well dry cannot be avoided. The well can be purged dry and sampled up to 24 hours after purging activities when the well has recharged a sufficient volume (usually 90% recovery). Sample should be collected no sooner than two hours after purging. Sample collections under these conditions are not

ideal and could result in data that are biased are less representative of aquifer conditions.

The major disadvantage to this method is that evacuation of wells below the top of the well screen or complete dewatering may cause significant alteration of the sample chemistry and representativeness by aeration and agitation of water moving into the well. Data quality objectives should be considered before sampling a well with low-yield in an alternative manner. This method could elevate turbidity levels, affect VOC and metal analytes, and the increase the length of time between purging/dewatering and sample collection. The time interval between dewatering and sampling can be pre-determined on a site-specific basis, but is sometimes left to the discretion of the sampler, which could vary between sampling events and sampling locations. If this technique is used in this circumstance, evacuation times and sampling times should be pre-determined on a site-specific basis. As an alternative to purging a low-yield well dry, it may be advantageous to use either a low-flow sampling method or a no-purge method in order to collect a more representative sample (USEPA, 2002).

7.3 SAMPLE FILTERING

Under some hydrogeological conditions with proper well design, installation and development, sample turbidity cannot be reduced to representative ambient levels. In addition, some analyses require filtration. When collecting samples for metal analysis, it may be appropriate to consider collection of water samples that can be analyzed for total metals (unfiltered) and dissolved metals (filtered). Some reasons for filtering may include the removal of suspended solids for analysis of "dissolved" constituents, determining the percent suspended solids, analysis of "clear" samples for sensitive or delicate laboratory analytical instruments, and removal of any interference by suspended particles (Nielson, 1991). The need for filtering should be determined before field implementation since filtering can alter the geochemical conditions of the sample. Collection of data for turbidity, total suspended solids (TSS), total dissolved solids (TDS), pumping rate, and drawdown is recommended in order to facilitate interpretation of analytical results (USEPA, 2002).

Filtering can be accomplished by three general methods and include vacuum filtration, pressure filtration and in-line filtration. Vacuum ("pulled") and pressure filtration ("pushed") involve transferring the sample from a collection container to the field filtration device, which is then passed through a filter. An in-line filter typically consists of a

cartridge device where an inlet and an outlet connection can be made to enable pressure filtration and is connected directly to the discharge tubing of the groundwater sampling device. An in-line filter is recommended to avoid sample contact with the air and avoid formation of metal precipitates. When selecting a filter method, criteria such as the appropriate filter pore size, speed of filtration, sample volume, sediment loading rate, comparability of filter media with target analytes, field portability, ease of operation and decontamination, field operation reliability, and cost may be considered (Nelson).

The typical filter size is 0.45 microns since this is the commonly accepted demarcation between dissolved and non-dissolved species. A filter may require decontamination or pretreatment prior to use and between uses. If preservation of the sample is necessary, this should be done after filtering. If possible, the first 500 to 1,000 mL of filtered sample should not be collected for analysis (USEPA, 2002).

7.4 SAMPLE PRESERVATION

Complete preservation of samples is practically impossible and preservation techniques only retard the chemical and biological changes which occur after a sample is removed from the source. Therefore, insuring a timely analysis of a sample should be one of the foremost considerations in the sampling plan schedule. The order in which sample containers are filled, method for filling, container type, and preservation method should be outlined in the site-specific work plan. In general, sample container filling should proceed from the most volatile compounds to the least volatile compounds. Preservation methods are generally limited to pH control, controlling exposure to light, chemical addition, refrigeration, and freezing. For groundwater samples, immediate refrigeration to 4-6°C is often the best preservation technique available, but it is not the only measure nor is it applicable in all cases. The requirements for sample volumes, preservation chemicals and temperatures, container types, and number of containers depend on the target analyte and laboratory requirements, so these specifications should be determined in a site-specific work plan. Samples should be collected directly from the sampling device into the appropriate laboratory-cleaned containers unless filtering is required. Complete a field data sheet (if required), a chain of custody form, and record all pertinent data in the site notebook (ASTM, 2007).

8.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site log books.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.
- All samples should be handed in a manner consist with the SOP No.BER-RS-019 Chain of Custody. Chain-of-custody records must be used to record the custody and transfer of samples. These forms must be entirely completed (N/A if not applicable). If directed by the site-specific sampling plan, tamper-proof seals must be placed on either sample containers or shipping coolers. The seal number must be recorded on the chain-of-custody form.
- Decontamination procedures for purging and sampling equipment are outlined in BER SOP # BER-RS-05 Decontamination of Equipment.
- Investigative Derived Waste (IDW) must be managed in a manner consistent with BER SOP #BER-RS-08 Characterization and Disposal of IDW.

9.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow USEPA, Occupational Safety and Health Administration (OSHA) and specific health and safety procedures. More specifically, depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. The site health and safety plan should be reviewed with specific emphasis placed on the protection program planned for the well sampling tasks. Standard safe operating practices should be followed such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and disposable clothing.

For wells with VOCs, one should avoid breathing constituents venting from the well. It may be appropriate to first survey the well head-space with an flame ionization detection/ photoionization detector (FID/PID) prior to sampling. If

monitoring results indicate organic constituents are present, sampling activities may need to be conducted in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.

Physical hazards associated with well sampling include: lifting injuries associated with pump and bailer retrieval and moving equipment; using pocket knives for cutting discharge hose; exposure to heat or cold stresses as a result of exposure to extreme temperatures (may be heightened by protective clothing); the potential for slips, trips, and falls caused by field conditions; traffic injuries in areas next to roads; and restricted mobility due to the wearing of protective clothing.

Additional health and safety information is outlined in BER-18 Field Safety Protocol and BER-21 Levels of Protection for Field Work.

10.0 REFERENCES

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ATTACHMENT 1

PUMP INFORMATION

Suction Lift Pumps

There are three types of suction lift pumps including centrifugal, peristaltic (or rotary peristaltic pump), and direct-line. These pumps are limited in their ability to raise water by the head available from atmospheric pressure and may only be applicable at sites where water is shallow and can only really lift water 25 feet. These pumps may be more appropriately utilized as a well purging device.

Most suction lift pumps draw water through a spiral shaped inlet where pistons or impellers induce a vacuum. Most suction pumps are unacceptable for most sampling purposes because they are usually constructed of materials that are not inert and can expose samples to pump lubricants. They can induce low pressures that can cause degassing of the sample, cavitation, mix air with the sample, and are difficult to clean adequately.

A peristaltic pump is an exception (also known as a rotary peristaltic pump) and is a self-priming, low-volume suction lift pump that moves liquid within the sample tube. No part of the pump contacts the liquid, but degassing can occur. A flexible tubing is placed around the pump rotor and squeezed by rollers during rotation. The rotor movement induces a reduced pressure in the well side tubing and increased pressure in the tube leaving the rotor head, creating lift of the water within the tube. Please note that a peristaltic pump may have limited use in applications with VOCs (ASTM 2007).

Electric Submersible Pumps

Submersible pumps consist of a sealed electric motor that powers a piston, impeller, or helical single thread worm where water is brought to the surface by a discharge tube. Submersible pumps can provide a high discharge rate at depths beyond those of a suction lift pump. Considerable agitation of water can occur, but some pumps are designed specifically for environmental applications. These pumps are generally constructed of plastic, rubber, and metal parts which may affect the analysis of samples for certain trace organics and inorganics. As a consequence, submersible pumps may not be appropriate for investigations requiring analyses of samples for trace contaminants. Many submersible pumps are not appropriate for collecting samples once purging has been performed. VOCs may be removed by aeration by some pumps. Silt and sand can cause damage to the internal pump structures.

Submersible pumps generally use one of two types of power supplies, either electric or compressed gas. Electric pumps can be powered by a 12-volt DC rechargeable battery, or a 110- or 220-volt AC power supply. Those units powered by compressed gas normally use a small electric compressor which also needs 12-volt DC or 110-volt AC power. They may also utilize compressed gas from bottles. Pumps differ according to the depth and diameter of the monitoring wells (ASTM 2007).

Gas-Driven Piston Pumps

Gas driven piston pumps are powered by compressed air where pressurized gas enters the chamber between the pistons. The altering pressurization of the chambers activates the piston that induces water flow during the suction stroke of the piston and brings water to the surface during the pressure stroke. This type of pump can provide continuous sample withdrawal at great depths, but may contribute to trace element detection if trace elements are the target analyte.

Gas-Lift Pumps:

Gas-lift pumps use compressed air to bring water to the surface by forcing water up an educator pipe. The air source can be from a hand pump (for shallower depths), air compressors, and pressurized air cylinders. The use of these pumps can result in considerable sample agitation and mixing within the well and may not be appropriate for sampling of VOCs and other target analytes. The use of these pumps with an air compressor can result in the introduction of oil to the well. This pump type is not recommended for purging or sampling.

Gas Displacement Pumps or Gas Driven Pumps

These pumps force a discrete column of water to the surface through mechanical lift without excessive mixing of the pressurized gas and water as with air-lift equipment. Water first fills the chamber and then a positive pressure is applied to the gas line which closes the sampler check valve. The water is forced up the sample line and the cycle is repeated by removing the pressure. This pump type can offer a reasonable potential for preserving the sample integrity since very little of the driving gas comes in contact with the sample. There is a potential for the loss of dissolved gasses.

Non-Contact Gas Bladder Pumps

To provide the least amount of material interference with the sample, an all stainless-steel and Teflon Middleburg-squeeze bladder pump (e.g., IEA, TIMCO, Well Wizard, Geoguard, and others) is used for the purging procedure. Water comes into contact with the inside of the bladder (Teflon) and the disposable sample tubing. Some wells may have permanently installed bladder pumps (i.e., Well Wizard, Geoguard), that will be used to sample for all parameters.

These pumps are also suitable for shallow (less than 100 feet) wells. They are somewhat difficult to clean, but may be used with dedicated sample tubing to avoid cleaning. These pumps require a power supply and a compressed gas supply (or compressor). They may be operated at variable flow and pressure rates making them ideal for both purging and sampling.

Inertial Lift Pump

Inertial lift pumps consist of a check valve at the end of flexible tubing that are manually operated. The tube and foot valve are placed into the well with one tube at the surface. The tube is moved up and down in a rapid, continuous motion. Water is lifted within the tube with each upward stroke. The downward stroke allows the check valve to open to allow more water to ender the tube.

ATTACHMENT 2

EXAMPLE WELL SAMPLING FORMS

Low-Flow Sample Collection Field Data Sheet

Project Name:				Project Number:		
KDHE Project Manager:				Date:		
Weather Conditions:				Well Tag Removed:		
Well ID:				Well Tag Replaced:		
Well Owner:				Well Type/Size:		
Location:				Site Type:		
Sampled By:	Start Time:			Finish Time:		
Depth to Bottom:	ft BTOC			Purge Method:		
Depth to Water:	ft BTOC			Purge Rate:		
Height of Water Column:	ft			Purge Time:		
Volume:	gal			Actual Purge Volume:		gal
Purge Volume:	gal			Pump Depth:		ft
Well Diameter	0.75"	1"	2"	3"	4"	5"	6"
Volume (gal/ft)	0.023	0.041	0.1632	0.3672	0.6528	1.0199	1.4688

Observations:

Field Parameter Measurements During Purging

Time	Temp	pH	Conductivity	DO	Turbidity	ORP	Other

Field Parameter Measurements on Sample:

Time	Temp	pH	Conductivity	DO	Turbidity	ORP	Other

Types of Samples Collected:

Water	Soil	Air

Notes:

Laboratory:

Water Well Purging and Sampling Log

Project Name:		Project Number:		Well ID:	
Sampled By:			Date:	Well Type:	

Well Data

Well Diameter:		Depth to Product:	
Well Condition:		Depth to Water:	
Notes:		Total Depth:	

Purging Data

Purging Method:		Purging Equipment:	
Pump Intake Depth:		feet below TOC	

WELL VOLUME 1 **WELL VOLUME** = (TOTAL WELL DEPTH – STATIC DEPTH TO WATER) X WELL CAPACITY

Well Volume = (feet – feet) X gallons/foot = gallons

WELL CAPACITY (Gallons Per Foot): **0.75"** = 0.02; **1"** = 0.04; **1.25"** = 0.06; **2"** = 0.16; **3"** = 0.37; **4"** = 0.65; **5"** = 1.02; **6"** = 1.47; **12"** = 5.88

			Purging Start Time:			Purging End Time:			Minimum Purge Volume:	
Time	Water Level	Volume Pumped	DO (%)	DO (mg/L)	Conductivity ( )	pH	ORP (mV)	Temperature	Notes	

Page 1

Stabilization Criteria: DO - +/- 0.3 mg/L; Conductivity - +/- 3%; ORP - +/- 10mV; pH - +/- 0.1 unit

Sample Data

Sample Collection Date & Time:		Sample ID:	
Collection Method:		QC Samples/ID:	
Field Filtered (Yes or No):		Notes:	

Analysis	Containers	# of Bottles	Preservative	Notes

REMARKS:

STANDARD OPERATING PROCEDURE – BER-02

COLLECTION OF SURFACE WATER SAMPLES AT SUSPECTED OR KNOWN CONTAMINATED SITES

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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DISCLAIMER:

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1.0 INTRODUCTION

Surface water samples may be required to establish the existence or extent of contaminant migration. Such data helps investigators identify risks to populations and determine appropriate remedial actions. Comparisons of water chemistry from sampling points upstream to sampling points on-site and downstream from the site are used to evaluate contamination releases. This standard operating procedure (SOP) outlines general considerations and procedures applicable to the collection of a representative surface water sample from a majority of surface waters and impoundments in Kansas. Site-specific circumstances can vary widely from site to site and no universal sampling procedure can be recommended or followed. Techniques and methods must be determined on a site-specific basis (USEPA, 1991). Pertinent surface water sampling SOPs should be outlined in the site-specific quality assurance project plan (QAPP) and the locations and analyses should be outlined in the field sampling plan (FSP).

2.0 EQUIPMENT

The equipment needed for surface water sampling during investigations of contaminated sites is minimal. In most instances, the sample container serves as the sampling device. The use of highly sophisticated or automatic sampling devices is normally not required for routine site investigations. If a more rigorous evaluation of surface water is necessary for a specific site, please refer to the *USGS National Field Manual for the Collection of Water-Quality Data* for additional information.

Several types of sampling devices are available for collecting surface water samples such as the Nansen bottle, DO dunker, Kemmerer sampler and Van Dorn sampler. The sampling method selection depends upon the physical site characteristics and the intended analyses. The following is a general list of equipment used for surface water sampling:

1. Buffer Solutions (pH 4, pH 7 and pH 10)
2. Chain-of-Custody Seals
3. Container Brush
4. Conductivity Meter and calibration solutions
5. Sample containers (with screw caps lined with Teflon)
6. Dissolved Oxygen Indicator (w/probe for field use)

7. Distilled Water

8. Electrical Tape

9. Grease Pencils

10. Hip Boots

11. pH Meter, calibration solutions, and pH Hydrion paper - wide range

12. Plastic Beaker (1000 ml)

13. Polyethylene Bags (8" x 12", 10" x 16", and 12" x 20"

14. Pressure Filtering Apparatus

15. 0.45 micron filters

16. Safety goggles

17. Sample Collection Device (Nansen bottle, DO dunker, Dip Sampler, Discrete Sampler (Kemmerer Sampler and/or Van Dorn Samplers)

18. Tape Measure

19. Global Positioning System Unit (GPS)

3.0 SAMPLING APPROACH

3.1 SELECTION OF SAMPLING LOCATIONS FOR FIELD SAMPLING PLANS

Surface water sampling locations are selected on the basis of their probability for demonstrating contaminant migration. Prior to sampling, surface water drainage in and around a site should be characterized using all available background information, including topographic maps and river basin studies. Air photos may be used to develop drainage maps which can then be confirmed by an initial survey of the surface water adjacent to or on a site. An initial survey of potential sampling points is essential to the development of a work plan. Furthermore, it is possible to anticipate any special equipment or personnel safety requirements which might be necessitated by terrain or other factors. It may also be appropriate to evaluate the temporal presence of surface water under differing seasonal or weather conditions. This initial survey allows field

personnel to identify landmarks which locate sampling points, a crucial step in maintaining documentation of activities for legal actions.

In general, sampling locations may include rivers, creeks, or streams running through or adjacent to a site, including those bodies of water which may receive surface runoff or leachate from a site. Surface water samples may also be collected from lakes, stock watering ponds, or other types of impoundments.

The number of sampling locations is dependent on a variety of factors, including the size of a site and the availability of analytical support. An absolute minimum number would be two locations, one background and one down-stream sample, but three sampling locations are recommended including one background, one at or next to the potential impact area, and one down-stream. Additional locations could be sampled to show concentration changes down-gradient from the source and to provide data to document the extent of impact downstream.

It is essential to establish the quality of water prior to its contact with the site. Surface drainage patterns should be carefully studied to determine background sampling locations. Samples should be collected from each surface water source that is entering the stream between the background and downstream sampling point to identify potential impacts from other drainages. A sample should be collected from each upstream surface water source entering the site just prior to the confluence with the primary stream. For standing bodies of water, a background sample may be collected from a similar water body away from the suspected area of contaminant release.

Ease of access to the sampling location may be an important consideration when the samplers must carry a large amount of equipment to the site. Bridges can sometimes provide good vantage points for sampling when composite samples are being collected. However, the need to sample point sources, such as stream flow from waste dumps, leachate breakouts, or drainage from mined areas may override site selection based on accessibility. Wading for water samples is not recommended in shallow lakes, ponds, and slow-moving rivers and streams because bottom deposits are easily disturbed resulting in increased sediment in the overlying water column. However, wading may be the only practical means for sample collection. Wading procedures should be determined on a site-by-site basis. In slow moving, deep water, a boat is usually required for sampling.

3.2 RIVERS, STREAM, AND CREEKS

In the selection of surface water sampling sites on rivers, streams, and creeks, areas that exhibit the greatest degree of cross-sectional homogeneity should be located. When available, previously collected data may indicate whether potential sampling locations are well mixed or vertically or horizontally stratified. Since mixing is principally governed by turbulence and water velocity, the selection of a site immediately below riffle areas provides good vertical mixing. Horizontal (cross-channel) mixing occurs in constrictions in the channel. When several stations along a stream are to be sampled, they should be strategically located. Selection of sampling sites is often based upon accessibility, stream velocity, location of confluences, intake points for water supplies, and stream geomorphology. It may be necessary to assess the individual contribution of stream or river segments when evaluating a site with multiple drainage pathways.

Actual sample locations will vary with the size of the water body and the amount of turbulence in the stream or river. Generally, with small streams less than about 20 feet wide, a sampling site can be found where the water is well-mixed. In such cases, a single grab sample collected at mid-depth in the center of the channel is adequate to represent the entire cross-section. (A sediment sample can also be collected in the center of the channel, however; the sediment samples should be collected after the surface water sample is obtained). For slightly larger streams, at least one vertical composite should be collected from mid-stream just below the surface, at mid-depth, and just above the bottom. Measurements of pH, temperature and specific conductivity are made and recorded on each aliquot of the vertical composite. Dissolved oxygen is an optional parameter that can be used to determine if a body of water is stratified. Several vertical composites should be collected in rivers. These vertical composites should be located in a manner that is roughly proportional to flow, i.e., they should be closer together toward mid-channel, where most of the flow travels, as opposed to toward the banks, where the proportion of total flow is smaller. The number of vertical composites required and the number of depths sampled for each are determined by the site Field Sampling Plan (FSP). The sample locations and numbers specified in the FSP should be based on a reasonable balance between two considerations:

- The larger the number of subsamples, the more likely the composite sample will represent the water body; however, collecting numerous subsamples is time-consuming and expensive, and can increase the chance of contamination.

If a site is relatively large or complex with respect to surface water, it may be appropriate to design a surface water sampling plan that can be evaluated on a statistical basis.

3.3 LAKES, PONDS, AND IMPOUNDMENTS

Sampling locations may include any adjacent standing bodies of water such as lakes, stock watering ponds, sediment or flood control ponds, marshes, or ox-bow lakes which could receive contaminants. The number of water sampling sites on a lake, pond, or impoundment will vary with the depth, size and shape of the basin. Procedures for collecting samples from impoundments on hazardous waste sites should be evaluated if high concentrations of contaminants are present.

Standing surface waters have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more subsamples be collected. In ponds and small impoundments, a single vertical composite at the deepest point may be sufficient. In naturally formed ponds, the deepest point is usually near the center; in impoundments, the deepest point is usually near the dam. It may be necessary to collect parameters, such as dissolved oxygen, to determine the degree of stratification.

In lakes and larger impoundments, several vertical aliquots may be composited to form a single sample. These aliquots are often taken along a transect or grid. The number of vertical composites and the depths at which samples are collected are outlined in the FSP. If samples will be analyzed for volatile organic compounds (VOCs), only grab samples should be collected for this parameter due to the potential for loss of volatiles while compositing.

Lakes with irregular shapes and with several bays and coves that are protected from the wind may require additional separate composite samples to represent water quality adequately. Similarly, additional samples should be taken where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

3.4 LEACHATES

Leachates can be formed by the mixing of rain water with wastes. A leachate may enter groundwater and/or surface water systems causing deterioration of the water quality. In areas where the ground surface slopes steeply away from the buried wastes, the leachate may "break out"

or emerge on the ground surface. This situation is typically encountered at landfills or at the foot of mine tailings disposal piles. Samples taken from leachate streams may have to be treated as medium or high concentration samples depending upon the field evaluation.

4.0 GENERAL SAMPLING TECHNIQUES

Most surface water samples collected during site investigations are grab samples. Typically, surface water sampling involves immersing the sample container in the body of water; however, the following general suggestions will help ensure that the samples collected are representative of site conditions:

1. The most representative stream samples are collected from mid-channel at 0.6 stream depth in a well-mixed stream;

2. Stagnated areas or pools in a stream or river might contain zones of varying pollutant concentrations, depending upon the physical/chemical properties of the contaminants and the proximity of these stagnated areas to the site;

3. When sampling running water, it is suggested that sampling progress from downstream to upstream to eliminate sediment disturbance in subsequent samples.

4. To sample a pond or other standing body of water, the surface area may be divided into grids. A series of samples taken from each grid is combined into one sample, or several grids may be selected at random;

5. If sample bottles contain preservative or if the sample is collected for VOC analysis, a different clean container should be used to collect the sample and decant the sample into the preserved bottles. If required by site-specific FSP, filtering of samples should be conducted immediately after sample collection.

6. Care should be taken to avoid excessive agitation of the water during transfer from source to bottle. Agitation could result in the loss of volatile constituents;

7. It should be noted that only grab samples should be collected for analysis of VOCs due to the potential for loss of volatiles while compositing. When collecting samples in 40 ml septum vials for VOC analysis, exclude any air space from the top of the bottle and to be sure that the Teflon liner faces in after the bottle is filled and capped. The container should be slowly filled to overflowing, creating a convex meniscus at the

top of the container. After sealing, the bottle should be turned upside down and tapped to check for air bubbles. If air bubbles are present, the bottle should be discarded and a new bottle used to collect the sample;

8. Do not sample at the water surface unless sampling specifically for a constituent which is immiscible and on top of the water. Instead, the sample container should be inverted, lowered to the approximate depth, and held at about a 45-degree angle with the mouth of the bottle facing downstream; and

9. When sampling a small stream, seep, spring, pool, etc., the water may be too shallow or inaccessible to utilize the sample bottle for direct collection of the sample. Instead, a decontaminated stainless steel ladle may be dipped into the water and the water transferred into the sample bottle. Care should be taken to minimize agitation of the sample during transfer.

5.0 SAMPLING METHODS

5.1 DIRECT METHOD

For rivers, streams, creeks, lakes, and other surface waters, the direct sampling method can be used to collect water samples from the surface directly into the sample container. This method should not be used for sampling lagoons or other impoundments where contact with contaminants is a concern (USEPA, 1999).

In the proper sampling attire, access the sampling location by appropriate, safe means. In flowing water the sampler should face upstream with the sampling container upstream of the sampler. Collect the sample under the water surface without disturbing the sediment. For lakes and impoundments, the sample should also be collected under the water surface avoiding surface debris and any boat wakes (USEPA, 1999). For the direct method, pre-preserved bottles should not be used as the collection method because it may dilute the concentration of preservation necessary for a reliable sample result to be obtained. If a sediment sample is also going to be collected, it should be collected after the surface water sample has been obtained.

5.2 DIP SAMPLER

The long handle on the device allows a dip sampler to be used for situations where direct access to the sampling location is limited, such as an outfall pipe or along a lagoon bank (USEPA, 1999). The following procedure should be followed when using a dip sampler:

1. Assemble the device in accordance with the manufacturer's instructions. Device should be properly decontaminated.

2. Extend the device to the sample location and lower the dipper into the water to collect the sample.

3. Retrieve the sampler and transfer the sample in to the appropriate sample container.

5.3 DISCRETE SAMPLERS

Discrete samplers can be useful for collecting discrete samples from a specific depth, and/or collecting sample aliquots to create a vertical composite surface water sample. When multiple sample depths are collected, the sampler should be careful to not disturb the substrate, which can potentially bias the sample (USEPA, 1999).

1. Use a properly decontaminated discrete depth sampling device (e.g. Kemmerer or Van Dorn Bottle), set the device so the sampling end pieces are pulled away from the sampling tube so water will be able to pass through the tube.

2. Lower the sampling device to the predetermined depth. Avoid disturbing the substrate.

3. When the sampling device is at the desired depth, release the messenger, closing the sampling device.

4. Retrieve the sampler and discharge the first 10 to 20 mL to clear any potential contamination on the valve. Transfer the sample to the appropriate sample container.

5. If available, use special attachments created for some discrete samplers to distribute small volumes at low flow rates, especially when collecting certain samples for such analyses such as VOCs (USEPA, 1999).

6.0 REFERENCES

1. US Environmental Protection Agency, (1991) *Compendium of ERT Surface Water and Sediment Sampling Procedures* (EPA/540/P-91/005).

2. US Environmental Protection Agency Region 9 Laboratory, (1999) *Field Sampling Guidance Document #1225 Revision 1: Surface Water Sampling.*

3. U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chapters. A1-A9, available online at http://pubs.water.usgs.gov/twri9A.

STANDARD OPERATING PROCEDURE – BER-03

COLLECTION OF SOIL SAMPLES FOR LABORATORY ANALYSIS

Effective Date: February 5, 2000
Revised Date: January 1, 2011

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ATTACHMENT A Soil Sample Data Form

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1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to establish guidelines for the collection of soil samples for fixed laboratory analysis. Please note that this SOP is not applicable for collection of soil samples for field screening purposes (e.g., immunoassay or colorimetric test kits screening, among others) that may have special container and sample processing requirements (refer to KDHE SOP BER-31, *Field-based Colorimetric Analysis*). This SOP is applicable for collection of soil samples from hand auger samplers, slide-hammer samplers, grab samples from stockpiled or land farmed soils, surface samples, and test pit or excavation confirmation samples, among others. To collect soil samples from split-spoon samplers during drilling, please refer to SOP BER-06, *Installation of Monitoring Wells*. To collect soil samples using direct-push technology (DPT) such as a Geoprobe®, please refer to KDHE SOP BER-07, *KDHE Geoprobe Operations*. Additionally, sampling protocol techniques for U.S. Environmental Protection Agency (EPA) Method 5035, *Closed-System Purge-and-Trap and. Extraction for Volatile Organics in Soil and Water Samples*, are not included in this SOP. Collection of soil samples by Method 5035 should follow the appropriate manufacturer or laboratory-specific protocol.

2.0 METHOD SUMMARY

Soil samples may be collected in either a random or biased manner. Random samples can be based on a grid system or statistical methodology. Biased samples can be collected in areas of visible impact, from locations required to meet regulatory compliance or in suspected source areas, among other locations. Soil samples can be collected at the surface, shallow subsurface, or at depth. Commonly, surface sampling refers to the collection of samples at a depth interval of 0 to 12 inches. When samples are collected at depth, the water content should be noted, since generally "soil sampling" is restricted to the unsaturated zone. Certain regulatory agencies may define the depth interval of a surface sample differently, and this must be defined in the work plan/sampling plan. A detailed description of the sampling locations and proposed methods of sample collection should be included in the work plan/sampling plan.

Similar to sediment sample collection, collection of surface soil samples is most efficiently accomplished with the use of a stainless steel trowel or scoop. However, equipment selection will ultimately be determined by the depth of the sample to be collected, surrounding terrain, and accessibility. For samples at greater depths, a bucket auger, power auger, or slide-hammer may be needed to advance the hole to the point of desired sample collection. To collect samples at depths greater than practical with hand equipment, the use of a drill rig with a split spoon sampler or a DPT rig equipped with a soil coring device may be

necessary. In some situations, such as confirmation sampling of excavation sidewalls or floors, sample locations may be accessed with the use of a backhoe.

3.0 MATERIALS/EQUIPMENT

The following materials and equipment may be required. Please note that this is not an exhaustive list of all materials and equipment potentially necessary for all soil sampling events, but is intended as a guideline for items commonly used. Site-specific sampling requirements may dictate the use of additional items not included in the following list. Ensure that ample time is allowed for obtaining necessary sampling apparatus from the analytical laboratory in advance of mobilizing to the field.

a. An approved work plan/sampling plan which outlines soil sampling requirements.

b. Field notebook, field form(s), Kansas One Call tickets/utility clearance checklist, site maps, chain-of-custody forms, and custody seals.

c. Decontamination supplies (including: non-phosphate, laboratory grade detergent, buckets, nylon scrub brushes, potable water, de-ionized or distilled water, regulatory-required reagents, etc.)

d. Stakes or flags

e. Sampling device (e.g., stainless steel hand auger, slide-hammer soil sampler, stainless steel trowel, etc.). Note: Do not use sampling devices plated with chrome or coatings.

f. Disposable sampling gloves (nitrile, latex, among others).

g. Laboratory-supplied sample containers with labels. If needed, sample liners/sleeves for slide hammer or split-spoon sampler (e.g., brass, stainless steel, acetate), polytetrafluoroethylene (PTFE; Teflon®) tape, and plastic caps.

h. Cooler(s) with double-bagged water ice.

i. Plastic sheeting (minimum 6-mil thickness).

j. Black pen and indelible marker.

k. Zip-lock bags and packing material (e.g., bubble wrap or bubble wrap bags or similar cushioning materials).

l. Tape measure.

m. Paper towels.

n. Clear packing tape.

o. Overnight (express) shipment forms (if needed).

p. Trash bags

q. Global Positioning System (GPS) device

r. Digital Camera

s. Photoionization detector (PID), flame ionization detector (FID), or similar organic vapor measuring instrument.

t. Combustible gas indicator (CGI), if necessary

4.0 DECONTAMINATION

All reusable sampling equipment must be thoroughly cleaned and decontaminated before and after each use according to KDHE SOP, BER-05, *Decontamination of Equipment*. Disposable items such as sampling gloves and plastic sheeting will be changed after each use and discarded in an appropriate manner as general trash.

5.0 PROCEDURE

a. Prior to field sampling activities, determine if utility clearance will be required and, if necessary, perform utility clearance and operation of equipment in accordance with the State of Kansas Underground Utility Damage Prevention Act (Kansas Statutes Annotated [K.S.A.] 66-1801 to 66-1816). Ensure that all access agreements (as required) have been signed and executed prior to mobilizing to the sampling location(s).

b. Use flags or other markers to identify sample locations. If needed, adjust proposed sampling locations based on site access, property boundaries, and surface, subsurface, or overhead utilities or other obstructions.

c. Prior to collecting soil samples, ensure that all sampling equipment has been thoroughly cleaned and decontaminated according to KDHE SOP BER-05 referenced above, and that all equipment is free of mechanical defects and is in working order. Be aware of sampling locations where collection of quality assurance/quality control (QA/QC) samples may require additional soil volume to be collected to fulfill QA/QC sampling requirements.

d. Wearing disposable sampling gloves and using a clean, decontaminated sampling device (e.g., stainless steel hand auger, slide-hammer soil sampler, stainless steel trowel, or shovel, among others), clear surface debris (e.g., rocks, vegetation, trash or other obstructions) from the sample location to expose a fresh soil surface for soil sample collection. For collection of deeper soil samples, a shovel, auger, or mechanical excavator

may be used or required to excavate or retrieve soil from the desired sampling depth.

e. Using disposable gloves and a pre-cleaned, stainless steel spatula, scoop, or spoon for each sample, extract the soil sample from the sampler or collect the sample from the surface, stockpiles, or landfarms. Disposable plastic spoons may also be used.

f. Sample parameters should be collected in the following order, based on volatility:

g. Volatile organic compounds (VOCs)

h. Semi-volatile organic compounds (SVOCs), including pesticides, herbicides, total petroleum hydrocarbons – gasoline range organics (TPH-GRO), TPH-diesel range organics (TPH-DRO), and polychlorinated biphenyls (PCBs).

i. Metals.

j. Place the sample in a laboratory-supplied, pre-cleaned sample container. Soil collected for VOC (EPA SW-846 Method 8260B) analysis should be transferred to sample containers with PTFE-lined lids as quickly as possible to avoid loss of volatile contaminants. When using sample sleeves or liners, PTFE film should be placed between the sample and the end caps. If elevated contamination is suspected in any of the samples collected, it is suggested that these samples be placed in a separate cooler than background or other less contaminated soils to reduce the possibility of cross-contamination.

k. Project-specific requirements may dictate that VOC samples be collected for analysis by EPA SW-846 Method 5035. Collection of samples for EPA SW-846 Method 5035 involves the use of specific sampling apparatus (e.g., TerraCore®, EnCore®) in addition to specific containers and preservatives. Follow the manufacturers' and/or laboratory instructions for sample collection and handling for EPA SW_846 Method 5035. Ensure that sufficient volume of soil for dry weight analysis is included with the aliquot for EPA SW-846 Method 5035 analysis.

l. Label the sample container with appropriate information such as client name, site location, sample identification, date and time of collection, sampler's initials, preservative (if any), and analyses requested. Additional project-specific identifiers and/or labeling may also be required.

m. Specific sample homogenization procedures shall be described in the work plan/sampling plan and approved by KDHE in advance of sampling activities. Samples for VOC analysis will not be homogenized unless required or approved by KDHE. To prepare composite soil samples in the field, equal portions of the sample, either by volume or weight, must be collected from selected sampling locations. Discrete sample aliquots must be placed either on a plastic sheet or in an appropriate container, such as an aluminum or stainless steel pan or bowl, in order to homogenize the sample. If placed on a plastic sheet, the sample will be homogenized by quartering the sample by the repeated diagonal folding of the corners. If placed in a pan or bowl, the sample will be homogenized by mixing with an appropriate tool such as a stainless steel spoon. Alternatively to homogenizing in the field, several discrete samples may be submitted to the laboratory for homogenization.

n. After the sample has been collected (homogenized as appropriate) and put into a container, labeled, and logged in detail, place it in a zip-lock bag and store on ice in a cooler at a temperature between 2° and 6°C for shipment to the laboratory.

o. Complete chain-of-custody form(s), accounting for all samples collected.

p. Soil samples should be delivered to the laboratory as soon as practicable. Check the work plan to determine if any analytes require expedited delivery due to short holding times. If necessary, make advance arrangements with the laboratory for after-hours or Saturday delivery.

q. If field-based analysis or field screening are being performed on the soil samples, follow the appropriate SOP: BER 25, *Mobile Laboratory*; BER 27, *Collection of Solid Samples for XRF Analysis*; BER 13, *Headspace Method for Screening Soil Samples for Volatile Organic Vapors*.

r. The field logbook and appropriate forms should include, but not be limited to the following information: site location, sample location, sample depth, sample identification, date and time collected, sampler's name, method of sample collection, number and type of containers, geologic description of material, description of decontamination procedures, and any other pertinent information. Soil should be described using the Unified Soil Classification System (USCS. A site map should be prepared with exact measurements to each sample location should follow-up sampling be necessary. Additionally, photographs of sampling locations should be taken, and a GPS instrument should be used to document sampling locations.

s. Abandon surface soil sampling locations by backfilling with the removed soil material and/or bentonite chips or pellets. If asphalt or concrete coring is required to access subsurface soil, patch or repair as necessary to match the existing surface materials. Thoroughly decontaminate all reusable sampling equipment. Discard any disposable material or waste generated at the site in an appropriate manner. Manage investigative-derived wastes as prescribed by the approved work plan/sampling plan.

6.0 REFERENCES

U.S. Environmental Protection Agency (EPA), Environmental Response Team (ERT). Soil Sampling, SOP No. 2012, Revision 0.0. February 18, 2000.

EPA, ERT. Superfund Program Representative Sampling Guidance, Volume 1 – Soil. Office of Solid Waste and Emergency Response Directive 9360.4-10EPA 540/R-95/141PB96-963207. December 1995.

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Environmental Standards Inc. March 2009. Standard Operating Procedures for: Soil Sampling for Inorganic Analysis. TVA-KIF-SOP-4. http://www.tva.gov/kingston/sap/TVA-KIF-SOP 04_Soil%20Sampling%20_31%20Mar%2009_.pdf

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EPA Region 9 Laboratory, Richmond, California. Field Sampling Guidance Document #1205, Soil Sampling. Revision. 2. September 1999. http://www.ecy.wa.gov/programs/eap/qa/docs/QAPPtool/Mod7%20EPA%20SOPs/Soil%20Sampling/Region%209%20Soilsample%20GUI.pdf

STANDARD OPERATING PROCEDURE – BER-05

DECONTAMINATION OF EQUIPMENT

Effective Date: August 14, 2000
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1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to establish a consistent process for decontamination of sampling equipment to prevent cross-contamination between sampling locations and events. Preventing cross-contamination in samples is important for reducing the introduction of error into sampling results and for protecting the health and safety of site personnel.

2.0 METHOD SUMMARY

The contamination of equipment requires physical removal by methods such as brushes and high pressure water. This is followed by washing and rinsing the equipment.

3.0 PROCEDURE

1. When applicable, visible contamination should be removed with a metal or nylon brush and/or high pressure water spray.

2. Wash equipment with a non-phosphate detergent solution such as Alconox or an equivalent.

3. Rinse with tap water.

4. Final rinse with deionized/distilled water.

4.0 GENERAL CONSIDERATIONS

1. The use of distilled or deionozed water commonly available from commercial vendors is acceptable for decontamination of sampling equipment. Field blanks may be used to verify the quality of commercially available water.

2. Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

   - Stress work practices that minimize contact with hazardous substances.

   - Use appropriate personal protective equipment (PPE) (e.g. gloves) when handling contaminated equipment; **do not** use contaminated PPE to handle clean equipment.

- Use disposable sampling equipment when appropriate.

3. As part of project planning documentation, develop a decontamination plan before any personnel or equipment enter areas of potential exposure. The equipment decontamination plan may include:

   - The number, location and layout of decontamination stations;
   - Which decontamination apparatuses are required;
   - Methods for disposal of contaminated clothing, disposable equipment and water (can decontamination water be discharged to the ground surface or sanitary sewer, does it need to be treated prior to on-site disposal or disposed off-site).

5.0 SPECIAL CONSIDERATIONS

Sample containers used by KDHE/BER personnel will be decontaminated by the laboratory or vendor from which the containers are obtained.

6.0 GEOPROBE AND DRILL RIG DECONTAMINATION

Specific decontamination procedures are necessary for KDHE's Geoprobe and drill rigs because of the very high frequency of use in KDHE field activities. In general, the following norms apply unless modified by a site-specific work plan. All rods and sampling devices should be visually inspected before use. If visually contaminated, these should not be used. All rods, augers and sampling devices that have been advanced within a contaminated or potentially contaminated site should be decontaminated after use. Decontamination can be done on-site or off-site and should comply with the general instructions above.

Due to the large area required to stage and decontaminate equipment, commercial car washes are frequently utilized for decontamination of Geoprobe rods, drill rig augers and associated sampling devices. Decontamination should be done in a manner compliant with State and local wastewater treatment regulations. The wash facility should be visually inspected before and during decontamination to assure dirt, contaminants, etc. from the facility are not introduced inadvertently during the decontamination process. NOTE: It is important that visible contamination be removed from the probe rods and augers at the site prior decontamination at a car wash. The visible material removed should be treated as Investigative Derived Waste (IDW) in accordance with BER-SOP-08.

If a site is being sampled for constituents frequently occurring in chlorinated water supplies (trichloromethane, trihalomethane compounds, etc.) a rinse blank

sample for volatile organic compounds (VOCs) should be obtained at least once during the decontamination process per site as chlorinated water sources often contain these

constituents, and cross-contamination is a possibility. For sites with other types of contaminants, the site-specific work plan should detail the frequency and type of quality control samples for the decontamination process for Geoprobe and drilling operations.

7.0 REFERENCES

1. United States Environmental Protection Agency (U.S. EPA). Region 4, *Field Equipment Cleaning and Decontamination Operating Procedure.* Document #SESDPROC-205-R1, November 2007.

2. United States Environmental Protection Agency (U.S. EPA) *Sampling Equipment Decontamination,* SOP #2006, August 1994.

STANDARD OPERATING PROCEDURE – BER-06

INSTALLATION OF MONITORING WELLS

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to establish a basic procedure for installation of auger-advanced monitoring wells. Use of this SOP is limited to Kansas Department of Health and Environment (KDHE) and KDHE contractors. Monitoring wells installed as part of groundwater investigations are intended to serve several purposes:

- to indicate the presence, if any, of contaminants of concern (COCs) in groundwater;
- to quantify the concentrations, sources, and vertical distributions of the COCs;
- to serve as a means of obtaining basic hydrogeologic information including static water level of the aquifer of concern, type and thickness of subsurface materials, aquifer characteristics at various depths, depth of the bedrock, etc.

Please note that the intent and requirements of this SOP is to follow all applicable Kansas Regulations pertaining to the installation of monitoring wells, including:

Article 12 – Ground Water Exploration and Protection Act; and
Article 30 – Water Well Contractor's License; Water Well Construction

2.0 METHOD SUMMARY

For wells to be installed with augers, a minimum hollow-stem auger size of 3 3/4" inside diameter or larger should be used to advance monitoring wells. Placement, depth and construction of wells should be conducted under the supervision and direction of a KDHE geologist. Care should be taken to not introduce contamination from the drill rig or surficial area around the well head.

3.0 PROCEDURE

Monitoring wells are generally constructed of polyvinyl chloride (PVC) casing and screen that are placed at depth intervals determined by the project geologist. Typical sizes for the casing are nominal inside diameters of 2 inches, 4 inches, 5 inches, or 6 inches. Deeper wells may require a larger diameter casing or multiple casing strings of progressively smaller diameter casing (such as 4 or 6 inch surface casing with 2 inch inside casing) to exclude shallower zones from the desired screen interval. The PVC pipe and screen is required to be of a minimum thickness depending on the depth of the well. For wells less than 100 feet deep, a minimum of Schedule 40 PVC casing and screen should be utilized. Wells over

100 feet should utilize Schedule 80 or heavier casing. If schedule 40 4-inch PVC casing is used at depths greater than 100 feet, cement grout should be installed in increments of 40 to 50 foot lifts. Clean pipe and screen must be used in all wells. The screen at the bottom of the well should be sealed with a bottom plug. Well development criteria, methods and desired volume are site-specific and should be determined by the KDHE Project Manager on a site-specific basis. Alternate well designs may be developed and approved by KDHE.

Well screen should be constructed of PVC pipe with factory cut slots. The slot size is typically 0.010 inch, although other slot sizes may be used if appropriate for the formation and approved by the supervising geologist. Screen will be installed at the intervals directed by the supervising geologist, based on the requirements of the project and the site conditions. The casing must not be cleaned or cemented with organic solvents or solvent based cements. Suitable fastening methods for those applications are either flush-joint threaded pipe, or slip-joint pipe fastened with stainless steel screws. When a monitoring well is to be used for detection of heavy metals, care must be taken in the choice of tools and supplies to avoid introducing soluble metals into the well.

A gravel pack is used to fill the annulus between the inside of the borehole and the outside of the casing. A minimum of four (4) inches of annulus plus the well casing (6 inches in diameter minimum for a 2 inch casing) is required. The gravel should be of clean silica sand, having a particle size appropriate for the formations in which it is to be used, and the slot size of the screen. The gravel pack material must be selected or approved by the geologist supervising the drilling. The gravel pack should be installed to a minimum of two feet above the screened interval to avoid potential grout penetration into the screen. Centralizers may be required to obtain accurate placement of the gravel pack material. Disinfection of the sand or gravel is not required.

A grout plug consisting of at least 24 inches of bentonite chips, pellets or similar impervious material must be placed above each aquifer. In addition, the top 20 feet of the well must be grouted with bentonite, neat cement, or concrete and the well head must be protected with an apron and locking well cover as described below. Bentonite is preferred as an annular seal and grouting agent. In some cases it will be necessary to install wells which have less than 20 feet of grout. If less than 20 feet of grout is determined for a well, a waiver must be obtained from KDHE's Bureau of Water (BOW).

The casing shall extend at least one foot, but not more than three feet above the ground surface, and have a removable PVC cap, unless a flush mount protective cover has been approved by the project manager and a waiver granted by BOW. The well head shall be surrounded by a concrete apron, at least four inches thick and two to three feet square, centered around the well head above normal ground

level; and sloped to drain away from the well. A locking well cover, constructed of welded steel, and having a suitable hasp will be installed at each well to prevent unauthorized access to the well. The well cover shall be firmly set in the concrete apron. Flush mount well protectors may be substituted for those described above if approved by the project manager. Alternate surface completion designs must be approved by the KDHE project manger with concurrence from BOW.

4.0 GENERAL CONSIDERATIONS

- Well construction details and geologic logs should be recorded by the on-site geologist during the well installation. The appropriate BOW WWC-5 water well construction documentation must be completed within 30 days of well completion.

- Prior to drilling, development, sampling or other activities in connection with construction or use of a monitoring well, all equipment and tools must be cleaned in a suitable fashion. For most circumstances, the procedures outlined in BER-05 should be used.

- Only Schedule 40 or 80 casing and screen will be permitted for small-diameter monitoring wells. No glues, solvents, joint compounds or adhesives will be used. Threaded casing or slip-joint pipe fastened with stainless steel screws will be used.

- Precautions must be taken during all stages of the drilling, installation, and development activities to prevent possible contamination of the well. Grease, fuel, hydraulic fluids, and other foreign materials from the drilling rig and equipment must be isolated from the well. Tools, casing, and drilling fluids must be kept clean and oil free. Clean tap water may be used in situations where heaving conditions are anticipated, however the water source should be sampled for the parameters and constituents of interest to account for water quality of tap water source.

- The well head apron and locking well cover is intended to prevent accidental or intentional introduction of foreign materials into the well. The well cap and locking cover should be installed as soon as practical, and must be locked to prevent tampering with the well. Drainage on the surface in the area of the well should be planned or modified so that there is no standing water in the area of the well, and so that the well will not be subject to runoff or infiltration from known sources of contamination.

- Disposal of cuttings and development/purge water should be performed according to the appropriate KDHE SOP (BER-08).

5.0 SPECIAL CONSIDERATIONS

The driller must be trained to operate the specific rig in use. For non-KDHE drillers, all drillers must be licensed through KDHE's BOW to install wells. Please refer to http://www.kdheks.gov/waterwell/index.html. Safety is a primary concern, and overhead utilities should be checked by the driller to assure that a minimum clearance of 20 feet (vertically and horizontally) exists between the mast in the upright position and any overhead power lines. DigSafe must be called for each location to be drilled. All well placement, logging, and drilling operations must be under the supervision of a Kansas Licensed Professional Geologist within KDHE or its contractors. The KDHE Project Geologist may desire to conduct in-field analysis of cuttings or development water during drilling, and the appropriate KDHE SOP should be consulted for the field analytical procedures to be utilized.

6.0 REFERENCES

ASTM D5092-90(1995) el Standard Practice for the Design and Installation of Ground Water Monitoring Wells in Aquifers.

Groundwater and Wells, 2nd Edition, Driscoll, 2003.

Ground-Water Data-Collection Protocols and Procedures for the National Water-Quality Assessment Program: Selection, Installation, and Documentation of Wells, and Collection of Related Data, US Geological Survey Open-File Report 95-398.

STANDARD OPERATING PROCEDURE – BER-07

KDHE GEOPROBE OPERATIONS

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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In general, this document should be used as a reference. Differences may exist between the procedures referenced in this document and what is appropriate under site-specific conditions. This document does not represent an endorsement of practitioners or products mentioned in the document.

1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to provide minimum operating requirements and recommended techniques for use of Kansas Department of Health and Environment's (KDHE's) Geoprobe units. Procedures which are mandatory, due to safety considerations or to minimum requirements for accuracy, are described in terms of **will** or **must**, while recommendations for good operating technique, efficiency, or enhanced accuracy, are worded as activities that the operators **should** or **may** perform. The procedures assume that two assigned persons will perform all of the necessary activities to operate the equipment, and that they are familiar with the use of the mechanical and analytical equipment and with scientific investigations of contamination sites. These operating procedures are not intended to substitute for training or experience, but to outline the reasonable minimum requirements for performing routine investigations with the equipment. The operators are expected to use their informed and reasonable judgment to interpret and implement the procedures, and to develop means to solve unforeseen problems as they arise.

2.0 SAMPLING PROCEDURES

2.1 PROBE EQUIPMENT OPERATION

2.1.1 Safety Considerations

The probe operator is the primary person to monitor for personnel safety in operating the vehicle and hydraulic probe system. Among the safety considerations are the following:

- A safe working area must be maintained when operating the geoprobe equipment in a street or public traffic area. Traffic cones should be used to close a lane if necessary, and good visibility for drivers and KDHE staff should be maintained around the work area.

- Hands and feet of operators and bystanders must be kept clear of moving parts, such as the probe foot and the drive head. Care must also be taken to prevent damage to the probe or the vehicle in extending and storing the probe. Unauthorized persons are not to be allowed to operate the hydraulic equipment.

- All work sites must be cleared for underground utilities and buried equipment before the probe is driven. 1-800-DIG-

SAFE **must** be called to clear buried utilities. The project manager is responsible for calling utility locates; however, the operator is responsible to making sure that utilities have been cleared and must not operate equipment if utilities have not been properly cleared. The project log book must clearly document that buried utilities have been cleared.

- The probe operator needs to be aware of any overhead power lines and take precautions to prevent hazardous situations by being too close to lines when the probe is extended up.

- The Geoprobe units are much larger and heavier than most personal vehicles, and may handle awkwardly in some situations. Drivers should keep the size and limitations of the units in mind at all times to avoid accidents.

- Steel-toed boots must be worn when assisting or operating a Geoprobe Unit. Hearing protection must be used during hammering operations of the Geoprobe Unit. Safety vest should be worn in areas with high traffic flow. Hard hats may be required at certain sites if specified in the approved Health and Safety Plan or in areas within a facility that may require hard hats.

2.1.2 Routine Equipment Maintenance

The probe operator should perform routine maintenance checks daily and weekly when operating the units. Daily checks should include:

- Check for loose nuts and bolts.

- Check for the wear of threads to prevent lost of tooling down hole.

- Check the hydraulic system for obvious leaks, and maintain the equipment in a clean and serviceable condition. In particular, oil and grease should not be allowed to accumulate where it can contact the probe rods, rod caps, or sampling tools and equipment.

Weekly maintenance checks should also address the following:

- Check the vehicle's motor oil and transmission fluid and refill if necessary.

- Check and refill the hydraulic fluid if necessary.

Watch for damage to mechanical equipment (i.e. rods and hoses.) Hydraulic equipment and hoses must be inspected for cracks or damage to prevent mechanical failure, personnel injury, or down-hole contamination.

2.2 OPERATING PROCEDURES

Personnel safety and equipment operation will be the principle concern of the operator. Both the operator and project manager must ensure that the quality and integrity of all samples are maintained. Principal sources of error in sampling include contamination of tools or sampling equipment, air leaks caused by poorly fitting probe connections or leaky sample tubing, and improper sampling, such as trying to sample an impermeable or water saturated zone for soil gas.

2.2.1 Probe Operating Technique

It is good operator practice to turn off the hydraulic system switch to relieve pressure on the system and save fuel whenever the hydraulic system is not in use. The operator should also turn off the vehicle engine whenever it is not in use to reduce exhaust fumes and noise in the working area. The drive hammer should be operated only when there is weight applied to the probe by the drive head. Use of the hammer without a load on the drive head causes undue wear and possible damage to the hammer and probe equipment. The drive head must not be allowed to lift the foot of the probe off the ground more than six to ten inches. Lifting the foot off the ground too high may lift the rear wheels of the probe vehicle from the ground, causing an unsafe condition that may allow the probe vehicle to fall in any direction, possibly injuring personnel and damaging equipment. When pulling tooling out of the ground, the foot must be placed firmly on the ground. The units should be operated with the hydraulic system switch set at low speed when folding in and out of the vehicle and when advancing the initial probe rod.

2.3 SOIL VAPOR SAMPLING

Soil vapor is collected using the Post-run Tubing (PRT) system. The probe rod is advanced to the desired depth with a PRT point holder and an expendable point attached to the lead rod. The rod train is retracted 0.25" to 3 inches. A PRT point popper, attached to extension rods, is inserted into the rods to force the expendable point out of the point holder. A PRT adapter attached to tubing is inserted down the rod bore and connected to the point holder. Soil vapor sampling is addressed in KDHE SOP BER-37.

2.4 GROUNDWATER SAMPLING

Groundwater samples may be collected directly from the rod string by using either a mill-slotted rod or the Screen Point (SP-15/16) system (drop out screen). After the probe has been driven to the desired sampling depth, an electronic static water level indicator may be used to check for groundwater in the probe rods if a mill-slot has been used. If a SP 15/16 is used the sampler has to be disengaged. Extension rods are lowered to the bottom of the rod string. The extension rods have to extend above the probe rod. The probe rod is retracted four feet while holding the bottom of the screen in place with the extension rod.

A polyethylene tube will be inserted inside the rods with a check valve attached. The tube can act as an inertia pump by physically moving the tube up and down inside the rods. All sample locations should be purged. Once the desired amount of water is purged from the probe, samples may be collected. All water samples other than volatile organic chemical (VOC) samples may be collected by pumping directly into the sample container or into another container such as a cubitainer for heavy metal samples prior to filtering. To collect VOC samples, the tube is pinched off at the top to retain the sample in the tube. The tube is pulled out of the rod with care being taken to avoid the tube touching the ground or any source of contamination. The check valve is removed from the tube. One sampler holds the VOC vial at the bottom end of the tube that had the check valve. A second sampler holds the pinched end of the tube and controls the flow of the sample from the tube to the VOC vial by releasing pressure on the pinched area of the tube and adjusting the height of the tube to allow proper sample flow into the VOC vial. Air pockets within tubing should be purged out prior to and/or during the VOC vial filling process to minimize sample disturbance. Samplers must wear sampling gloves while performing this operation.

Profile samples may be collected using a mill-slotted rod by collecting samples from the top of the water table down or a SP 15/16 sampler by collecting samples from depth to the top of the water table. If groundwater is highly contaminated at the top of the water table, contamination can be carried down with the mill-slot and cross contamination from higher zones may occur. If the geology is such that groundwater is confined, groundwater from lower zones can cross contaminate or dilute samples collected at higher depths when collecting samples with a SP 15/16 sampler going from depth to the top of the groundwater table. Project managers need to take the site geology into account when determining how to sample. At some sites, a discrete hole may be necessary to obtain valid samples for each sample depth.

If the geology is such at the site that groundwater is not easily obtained in the probe rods, a temporary well can be set by removing the probe rods and inserting schedule 80 polyvinyl chloride (PVC) screen and casing. If these temporary wells are not sampled and abandoned immediately, they need to be protected to prevent surface water entering into them. Clean sand can be added until the screen is covered and bentonite added above the sand or a bentonite plug can be placed in the upper 12-inches of the hole.

All samples are to be properly preserved and stored until they reach the laboratory.

2.5 SOIL SAMPLING

KDHE has the capability to collect soil samples using the Large Bore Soil Sampler or the Macro-Core Sampler.

The Large Bore Soil Sampler is a closed piston sampler used for sampling at discrete depths. When collecting soil samples using the Large Bore Soil Sampler, which is a two-foot sampler, the sampler will be pushed in front of the push rods. The Large Bore Soil Sampler can be lined with either an acetate liner or a brass liner. The sampler is pushed to the top of the desired collection depth. The stop pin holding the piston in place is removed through the center of the probe rods using extension rods. The sampler is advanced into the ground an additional two feet. The hammer is activated to start the pushing in order to open the piston so the sample will enter the sampler. After the rods have been pushed the additional two feet, the rods are pulled out of the ground. The liner is removed from the sampler and the sample is transferred to the appropriate sample containers. The brass liner is four six-inch sections held together with heat-shrink tubing that can be snapped apart and used for sample containers if the

laboratory will accept them. If the sample is being analyzed for VOCs, the ends of the sections should be immediately covered with either teflon film or aluminum foil and capped. If the acetate liner is being used to collect samples for VOC analysis, the sample should be transferred to the sample container with as little aeration as possible and the container must be packed as air tight as possible. Using brass liners is the preferred method for the collection of VOCs, because of the loss of VOCs in the plastic and during transferring the sample to a glass container.

The Macro-Core sampler is a continuous core sampler that comes with either a four-foot or a five-foot sample barrel. The four/five-foot sampler can be used as an open tube sampler or a closed-piston sampler. When used as an open tube sampler, a continuous sample is collected in four/five feet sections from the surface to the desired depth. When used as a closed-piston sampler, a sample is collected from the surface to four/five feet depth with the sampler used as an open tube sampler. The piston tip assembly is installed on the sampler. The sampler is driven to a four/five-foot depth, and the piston tip assembly is released to allow soil to enter the sampler while being driven from the four/five-foot depth to an eight/ten-foot depth. The sampler is re-assembled with the piston tip assembly and the process is repeated until the desired depth is reached.

Use of the Macro-Core sampler through undisturbed soil may not be suitable for all geology types and should be evaluated on a case by case basis. A Macro-Core closed piston sampler may be advanced through undisturbed material only if little or no hammering is required. In situations where a soil sample is to be collected at depth, a pilot hole may be necessary or alternative tool options may need to be considered.

2.6 MICRO-WELL INSTALLATION

To install micro-wells using a Geoprobe, refer to KDHE SOP BER-29.

2.7 VAPOR WELL INSTALLATION

To install vapor wells using a Geoprobe, refer to KDHE SOP BER-35.

3.0 DECONTAMINATION PROCEDURES

Please refer to KDHE SOP BER-05 for decontamination procedures.

4.0 REFERENCES

1. Geoprobe® Systems, *Geoprobe Screen Point 15 Groundwater Sampler*, Standard Operating Procedure Technical Bulletin No. 95-1500, Salina, Kansas, October 1995.

2. Geoprobe® Systems, *Geoprobe Screen Point 16 Groundwater Sampler*, Standard Operating Procedure Technical Bulletin No. 93-660, Salina, Kansas, November 2006.

3. Geoprobe® Systems, *Geoprobe AT-600 Series Large Bore Soil Sampler*, Standard Operating Procedure Technical Bulletin No. 95-1500 Salina, Kansas, November 1993.

4. Geoprobe® Systems, *Geoprobe Macro-Core Soil Sampler*, Standard Operating Procedure Technical Bulletin No. 95-8500, Salina, Kansas, revised September 1998.

STANDARD OPERATING PROCEDURE – BER-08

CHARACTERIZATION AND DISPOSAL OF INVESTIGATION-DERIVED WASTE

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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ATTACHMENT 1 **General Solid IDW Disposal Process Flowchart**

ATTACHMENT 2 **General Liquid IDW Disposal Process Flowchart**

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1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to provide general guidelines for management of investigation-derived wastes (IDW) generated during the investigation of potential or actual contaminated sites. These wastes include soil cuttings, drilling muds, purge water, equipment decontamination fluids, disposable personal protective equipment, and other materials. On the basis of project and program requirements, it may be necessary to deviate from the guidelines presented in this SOP. These deviations must be clearly described in associated project planning documentation.

2.0 METHOD SUMMARY

An IDW management strategy or program is a requisite component of project planning documentation. The IDW management strategy must (1) provide safety for on-site personnel, 2) protect human health and the environment, and (3) comply with applicable or relevant and appropriate requirements (ARARs) to the extent practicable. The most important phase of IDW management is planning for waste generation and handling prior to field mobilization. To the extent possible, the IDW management strategy should address IDW minimization, containerization, segregation, characterization, storage, inventory, and identify options for final disposition.

3.0 PROCEDURE

IDW must be characterized at the initial point of generation unless sufficient historical information exists at a particular site or sample location (e.g., a monitoring well where contaminant concentrations have been consistently under applicable threshold levels, etc.). This often necessitates containerization and temporary onsite storage in containers while awaiting sample results. Drums or other containers must be properly labeled (e.g., Waste Awaiting Characterization with contact information provided).

A hazardous waste determination must be made based on the potential listing and toxicity of the IDW. To support waste determinations, IDW samples may be subjected to totals analysis and/or analysis via the toxicity characteristic leaching procedure (TCLP) as per Environmental Protection Agency (EPA) SW-846 Method 1311. The totals analysis results can be used for direct comparison to KDHE's Tier 2 Levels (for solid or liquid IDW), POTW pretreatment standards (for liquid IDW), and maximum concentrations of contaminants for the toxicity characteristic (TCLP threshold levels) as defined in 40 CFR 251.24 (for liquid IDW). Totals analysis for solid IDW can also be used in combination with the Rule of 20 to support comparison to the TCLP threshold levels. The premise behind the Rule of 20 is that during the TCLP analysis, a sample is diluted 20 times. Accordingly, the total concentration results can be compared to the TCLP threshold levels multiplied by 20. If the result is less than 20 times the TCLP

threshold levels for each constituent of concern, then the waste is not a toxicity characteristic hazardous waste. If a solid IDW sample fails the Rule of 20 based on the total waste analysis, it may be a toxicity characteristic hazardous waste and additional samples should be analyzed after TCLP extraction. The TCLP is a leaching procedure that simulates conditions of wastes if they were disposed in a landfill. The TCLP extract is then analyzed by the appropriate methods for the contaminants of concern and those results are compared to the TCLP threshold levels. If it is determined that the IDW is a Resource Conservation and Recovery Act (RCRA) hazardous waste, based on listing or toxicity, RCRA storage, transportation, and disposal requirements become applicable.

The type and frequency of IDW analysis should be discussed in the IDW management strategy on the basis of site-specific information (e.g., amount of waste generated, contaminants of concern, etc.). Use of field analytical technology may be appropriate depending on the contaminants of concern and analytical equipment limitations. If field analysis of IDW is performed, it may also be necessary to submit samples for off-site confirmatory analysis and/or TCLP analysis.

Flow charts depicting the generalized process for managing solid and liquid IDW, including options for disposal, are provided as Attachments 1 and 2. Other options, such as storage of IDW onsite pending implementation of remedial actions, may be appropriate on a site-specific basis.

4.0 GENERAL CONSIDERATIONS

Some general goals for the management of IDW include the following:

- Worker safety;
- Leave the site in no worse condition than existed prior to the investigation;
- Remove wastes that pose an immediate threat to human health or the environment;
- Spread evenly on-site IDW that does not require off-site disposal;
- Minimize the quantity of IDW to the extent practicable;
- Comply with ARARs to the extent practicable; and,
- Consider any potential community concerns regarding on-site disposal of IDW and plan accordingly.

5.0 SPECIAL CONSIDERATIONS

This SOP does not preclude the need for individuals or programs generating wastes to make appropriate waste determinations and to be familiar with relevant federal, state, and local laws, regulations, policies, and guidance, such as *Management of Investigation-Derived Wastes During Site Inspections* (EPA/540/G-91/009) and *Guide to Management of Investigation-Derived Wastes* (EPA Publication 9345.3-03FS). In some cases, it may be necessary to confer with the KDHE-Bureau of Waste Management and/or KDHE-Bureau of Water to determine whether the identified waste management approach will satisfy ARARs.

Note: Sampling of direct-push (Geoprobe or similar units) generates minimal amounts of purge water per sampling location (less than five gallons). Upon approval of the KDHE project manager, purge water not to exceed five gallons per sampling location may be applied on-site from direct push sampling locations only. However, if noticeable contamination (visual or odor) is present in the purge water it should be containerized, characterized, and disposed of in accordance with this policy.

6.0 REFERENCES

1. United States Department of Energy (U.S. DOE), 1999, Memorandum from T. Traceski dated December 20, 1999, Subject – *Management of Remediation Waste Under the Resource Conservation and Recovery Act (RCRA)*, Office of Environmental Policy and Assistance.

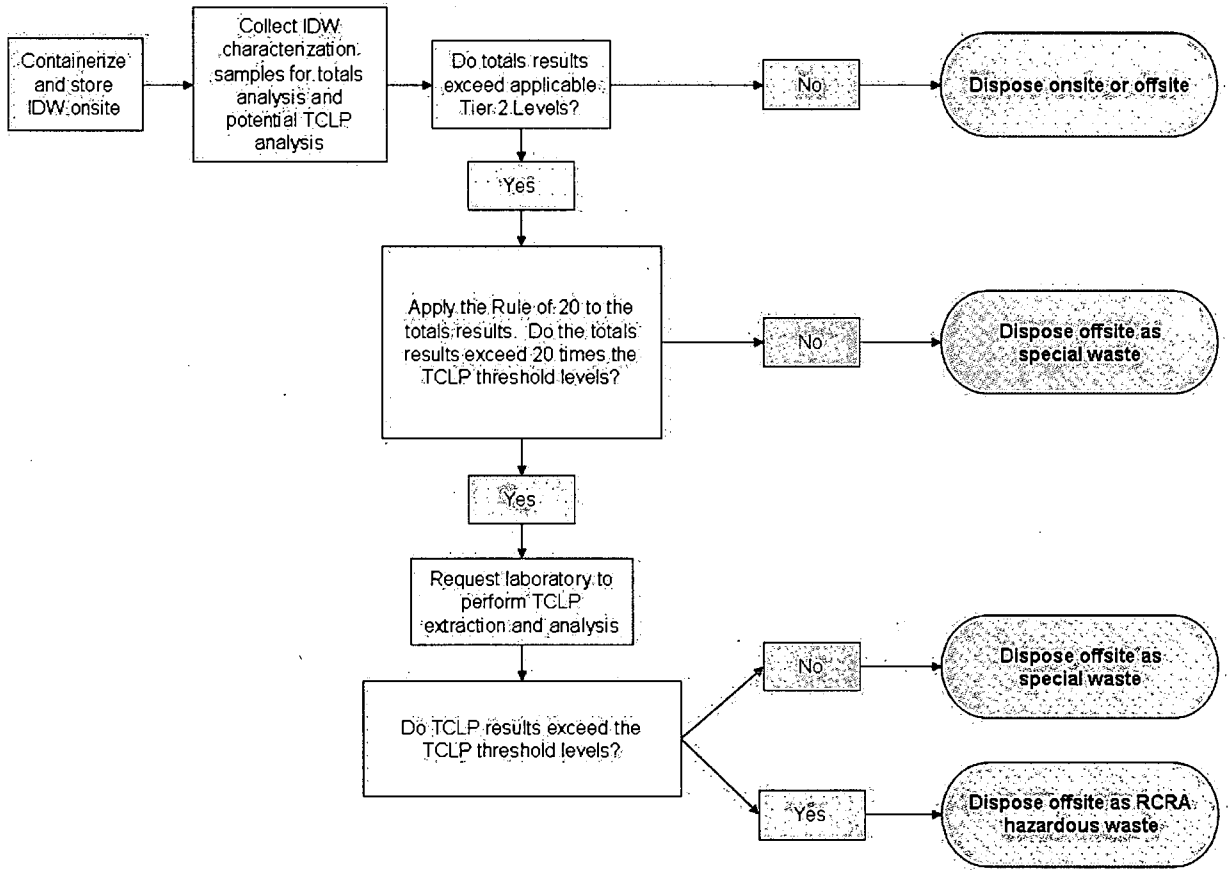
2. United States Environmental Protection Agency (U.S. EPA), 1991, *Management of Investigation-Derived Wastes During Site Inspections* (EPA/540/G-91/009), Office of Emergency and Remedial Response, Washington D.C., May 1991.

3. United States Environmental Protection Agency (U.S. EPA), 1992, *Guide to Management of Investigation-Derived Wastes* (Publication 9345.3-03FS), Office of Solid Waste and Emergency Response, Washington D.C., January 1992.

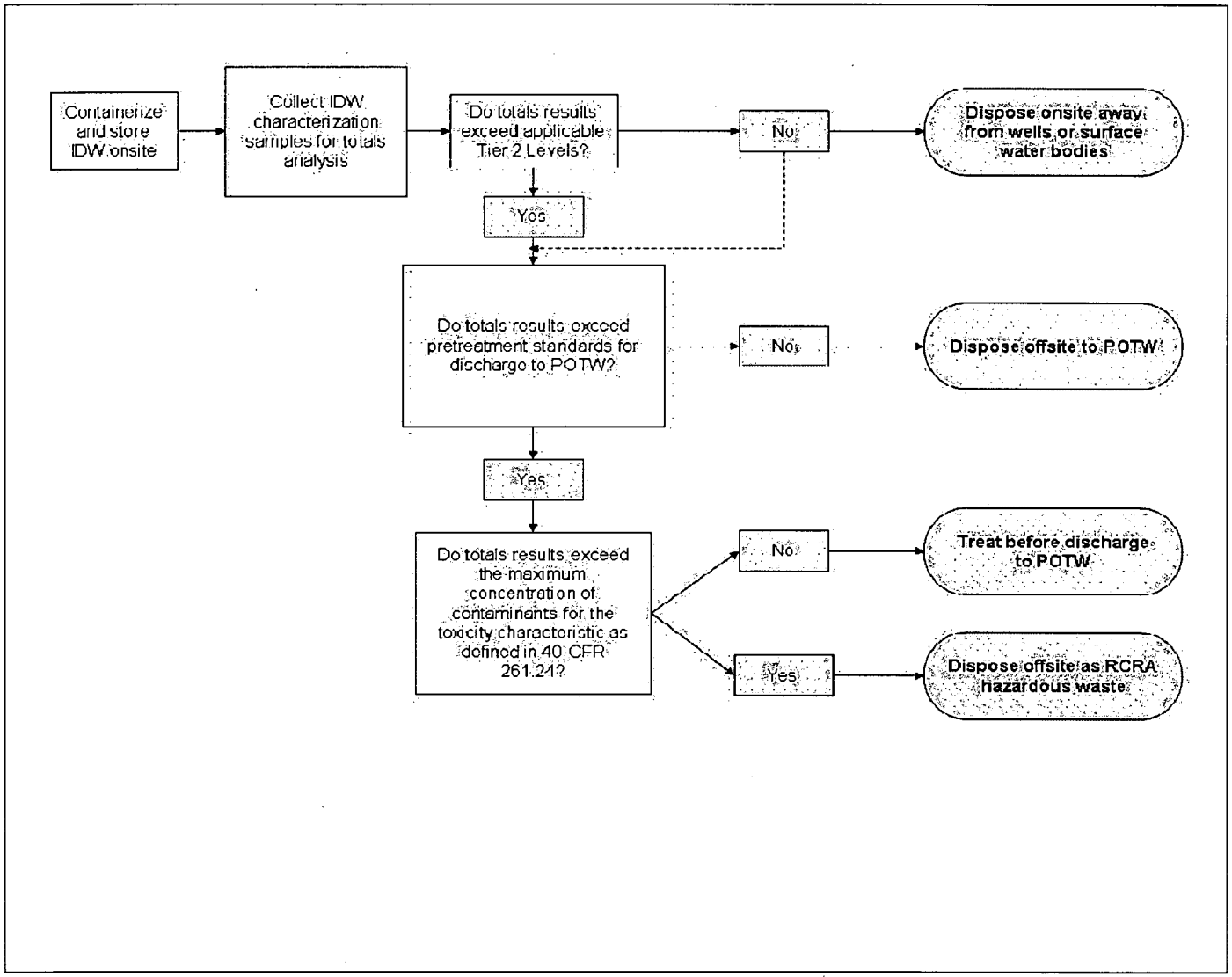
4. United States Environmental Protection Agency (U.S. EPA), 1991, Guide to Discharging Aqueous Wastes to Publicly Owned Treatment Works (Publication 9330.2-13FS), Office of Solid Waste and Emergency Response, Washington D.C., March 1991.

5. Davis, 2001, *Regulated Metals: the Rule of 20*, Pollution Prevention Institute, Small Business Environmental Assistance Program, Kansas State University, Manhattan, Kansas, December 2001.

Attachment 1 – General Strategy for Managing Solid Investigation-Derived Waste



Attachment 2 – General Strategy for Managing Liquid Investigation-Derived Waste



Note: Purge water obtained from direct-push sampling locations only (less than five gallons per location) may be applied on-site at the probe location upon receiving approval from the KDHE project manager. However, if noticeable contamination (visual or odor) is present in the purge water it should be containerized, characterized, and disposed of in accordance with this policy.

STANDARD OPERATING PROCEDURE – BER-11

EVALUATION AND VALIDATION OF DATA

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish the criteria that are followed for documenting and tracking the quality of environmental data generated from field sampling activities. Because valid media-quality data are integral to environmental investigations that characterize site conditions, the quality of the data generated by a field investigation is extremely important to the successful completion of a project. The level of data evaluation and validation required is determined by the project data quality objectives and must be outlined in the site specific or generic Quality Assurance Project Plan (QAPP).

1.2 SCOPE

The environmental investigation process is a three phase cycle that includes: (1) Planning Phase, (2) Implementation Phase, and (3) Assessment Phase. This SOP, which is in the Assessment Phase, is used to evaluate and validate data that was generated during the Implementation Phase. The data is validated based on criteria that are established in the Planning Phase. Data verification is the process for evaluating the completeness, correctness, and conformance / compliance of a specific data set against the method, procedural, or contractual specifications. Data validation is used to determine the quality of a specific data set relative to the end use. It focuses on the project's specifications or needs, designed to meet the needs of the decision makers/data users and should note potentially unacceptable departures from the QA Project Plan.

2.0 DATA EVALUATION AND VALIDATION

The degree of data validation depends on the quality of data needed to meet the data quality objectives for the project, which are specified in the QAPP. Data collected to establish qualitative trends, for example, do not require the same level of validation as data generated to support litigation. Standard data quality attributes that are recognized as important are the Data Quality Indicators. Acceptance criteria placed on the data quality indicators of a given data set are sometimes referred to as measurement quality objectives (MQOs). The Data Quality Indicators (DQIs) are defined in Table 3, EPA Guidance for Quality Assurance Project Plans, EPA QA/G-5. MQOs are usually based on the individual DQIs for each matrix and analyte group or analyte.

2.1 PRECISION

Precision is the degree to which the measurement is reproducible and is to be determined by comparison of laboratory designated duplicates or designated laboratory matrix spike/matrix spike duplicates. Precision will be calculated as the relative percent difference (RPD) of the two measurements. The equation is as follows:

RPD = 100% X [Result 1 - Result 2] / [(Result 1 + Result 2) / 2]

2.2 ACCURACY

Accuracy is the degree of agreement between a measured value and a true or known value. Accuracy is evaluated using matrix spike (MS) recoveries, system monitoring compound spike (surrogate) recoveries, or continuing calibration verification (CCV) recoveries. MS samples are samples into which known concentrations of the target compounds of interest have been added (or "spiked"). Surrogate compounds are compounds that behave in a similar manner as the target compounds but are not target compounds and are added (or "spiked") into each sample prior to extraction and analysis. The samples are analyzed by the appropriate analytical method. The result obtained is compared to the known concentration added and the MS or surrogate percent recovery (%R) is calculated. CCV samples are check standards analyzed at intervals not to exceed 12 hours for organic analyses and every 10 samples for inorganic analyses. When matrix spike samples or surrogate compounds are not possible, CCV sample results are used to determine accuracy. Percent recovery is calculated as follows:

MS %R = 100% X [Spiked Result Conc.- Sample Result Conc.] / Spike Conc.
CCV and surrogate %R = 100% X [Result Conc.) Known/Spiked Conc.]

2.3 METHOD REPORTING LIMITS

Reporting limits will be based upon method quantitation limits. The procedure for determining the method detection limit for a substance is in Appendix B of Part 136 of Title 40 of the Code of Federal Regulations (40 CFR 136 Appendix B). The method quantitation limit is defined as equivalent to the lowest calibration standard analyzed for each analyte or as ten times the method detection limit.

2.4 COMPLETENESS

Completeness is a measure of the amount of valid, usable data obtained from an analytical data set compared to the amount that was planned to be obtained. Completeness takes into account any breakage, laboratory errors, or sampling difficulties.

Completeness = (# of Valid Data Obtained) / (# of Total Planned Data) x 100

2.5 COMPARABILITY

Comparability expresses the confidence with which one data set can be compared to another. Samples from the same media (i.e., soil, water, etc.) will be considered comparable if the procedures for collecting the samples are complied with and consistent, if the units of measurement are the same, and if the reporting limits are comparable. In addition to obtaining samples in accordance with approved procedures and in a consistent manner, comparability is assured through the use of laboratories using established and approved analytical methods and protocols. The laboratory's quality control program is designed to establish consistency in the performance of the analytical process. The program includes traceability of measurements to standardized reference materials to establish comparability with other laboratory results, and internal controls to verify consistency of a given laboratory's performance. Standard reporting units (e.g., mg/kg, µg/L) will be used for reporting the various parameter results. All data will be subjected to strict QA/QC procedures and reported in a consistent manner to allow for comparison across data sets.

2.6 REPRESENTATIVENESS

The representativeness of the data is the degree to which data represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is a function of sample collection and analysis techniques. Data are considered representative if the sampling is performed in accordance with the sampling programs defined in the Field Sampling Plan (FSP) and the analyses meet the requirements outlined in this section and the section on quality control procedures.

3.0 PROCEDURE FOR DATA VALIDATION

The person designated to validate the data for a project will review the data using the criteria established in the QAPP. The degree of validation of the data depends

entirely on the quality of data specified in the QAPP. As a minimum, valid data should be supported with evidence that: (1) all field, laboratory, and other procedures used to collect the data are documented so the work can be reproduced by others skilled in the field; (2) all methods and equipment were working properly when the data was collected; and (3) the methods were capable of producing the values reported and that the precision and accuracy or bias of the data are acceptable for the intended use of the data.

To validate the data for a project, the designated person will:

1. Evaluate the quality assurance objectives using the criteria stated in the QAPP. Both field procedures and laboratory procedures will be evaluated.

2. Evaluate field procedures by examining sample collection procedures and sample handling procedures to determine if the QAPP was followed. To evaluate sample handling procedures, methods of sample collection, chain of custody forms, sample preservation, and handling of the samples until received by the laboratory, will be examined.

3. For laboratory procedures on inorganic compounds, the following may be examined during the validation process:

    - Holding times
    - Instrument calibration, including initial and continuing calibration verification
    - Blank(s)
    - Laboratory control sample(s)
    - Inductively Coupled Plasma (ICP) interference check samples
    - Duplicate sample(s)
    - Matrix spike sample(s)
    - Furnace atomic absorption QC
    - ICP serial dilution(s)
    - Sample result verifications
    - Field duplicates

- General data assessment

4. For laboratory procedures on organic compounds, the following may be examined during the validation process:

   - Holding times
   - Gas Chromatograph/Mass Spectrometer (GC/MS) tuning
   - GC calibration, initial and continuing
   - Blanks
   - Surrogate recoveries
   - Matrix spike/matrix spike duplicates
   - Internal standards performances
   - Target Compounds List (TCL) compound identifications
   - Reported detection limits
   - Tentatively identified compounds (TICs)
   - Overall system performance
   - General data assessment

5. The parameters which do not conform to requirements are listed and the data are qualified according to the guidelines listed in the QAPP. The qualified data package is then reviewed and the project data reviewer, the project geochemist and/or the project manager makes a professional judgment concerning the validity of the data package, and its usability for the project.

6. This SOP only includes general guidelines. Additional data quality evaluation/ validation criteria may be established in a QAPP.

4.0 REFERENCES

1. EPA Guidance for Quality Assurance Project Plans, EPA QA/G-5, (December 2002).

2. EPA Guidance on Data Quality Indicators (EPA/QA G-5i) (EPA, 2002b).

3. EPA Guidance for QA Project Plans (EPA/QA/R-5) (May 2001).

4. EPA Guidance on Environmental Data Verification and Data Validation (EPA QA/G-8) (EPA/240/R-02/004).

5. EPA Data Quality Assessment: A Reviewer's Guide (EPA QA/G-9R) (EPA/240/B-06/002).

STANDARD OPERATING PROCEDURE – BER-12

COLLECTION OF QUALITY CONTROL SAMPLES

Effective Date: August 31, 2000
Revised Date: January 1, 2011

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DISCLAIMER:

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1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to explain the quality control (QC) measures taken to ensure the integrity of the samples collected and to establish the guidelines for the collection of QC samples. The objective of the QC program is to ensure that water-quality data of known and reliable quality are developed.

Documentation of representative data is essential to site investigations; therefore, the data must be validated though the performance of QC sampling. Verification performance sampling is necessary to evaluate and identify contradictory or suspect data. The QC sampling requirements must be determined by the project manager. Data validation measures must be specified as part of all environmental investigations.

The laboratory is responsible for the development and implementation of a laboratory QA/QC program. The collection of field QC samples serves primarily as a check to ensure proper field procedures, but can also serve as a mechanism for the laboratory to perform their QA/QC program (such as collecting sufficient sample for the laboratory to perform matrix spike/matrix spike duplicate samples).

2.0 QUALITY CONTROL SAMPLES

Samples collected for laboratory analysis require the use of quality control samples to monitor sampling activities and laboratory performance. Types of quality control samples may include duplicate and/or duplicate split, trip blank, field equipment blank, matrix spike and matrix spike duplicate, and field matrix spike. A discussion pertaining to each quality control sample follows:

2.1 DUPLICATE AND DUPLICATE SPLIT:

Duplicate sample analysis is performed to evaluate the reproducibility of collection procedures. A duplicate sample is called a split sample when it is collected with or turned over to a second party (e.g., consulting firm) for an independent analysis or submitted to two laboratories for the same analysis. Duplicate samples are two physical samples collected simultaneously from the same location under identical conditions. Duplicate samples may be collected for any media and should be collected in accordance with the sample collection procedures identified in each media specific SOP.

In some cases (not volatile organic compounds), water may have to be accumulated in a common container and then decanted slowly into the

sample bottles. The work plan should be referenced for a description of how duplicate samples are to be collected. Additionally, in the case of wells that recover slowly and produce insufficient water to fill all the replicate sample containers, the containers should be filled incrementally and kept on ice in the cooler between filling periods.

2.2 TRIP BLANK:

A trip blank sample is a sample of distilled or de-ionized water prepared in the laboratory prior to sampling, and travels unopened in a common container with the sample bottles. (Note: USEPA uses the phrase "demonstrated analyte free water") It is later opened in the laboratory and analyzed along with field samples for constituent(s) of interest to ascertain whether cross-contamination has occurred during field handling, shipment, or in the laboratory. Trip blanks are primarily used to identify "artificial" contamination of the sample caused by airborne volatile organic compounds (VOCs) but may also be used to check for "artificial" contamination of the sample by a test substance or other analyte(s). One trip blank should accompany each cooler containing water samples that are being submitted for lab analysis.

2.3 EQUIPMENT BLANK:

An equipment blank sample is collected to evaluate decontamination procedures. It is a sample of analyte-free water which has been used to rinse reusable sampling equipment and is collected after completion of decontamination and prior to sampling. One equipment blank should be incorporated into the sampling program for each day's collection of samples and analyzed for the appropriate chemicals of concern. In some situations one equipment blank will be required for each type of sampling procedure (e.g., bailer, soil sampling equipment, etc.).

2.4 FIELD BLANK:

A field blank may be needed where ambient air quality may be poor. This field blank sample would be taken to determine if airborne contaminants interfere with constituent identification or quantification. This field blank sample is a sample bottle that is filled and sealed with "clean" (e.g., distilled/de-ionized/demonstrated analyte free) water in the analytical laboratory, and travels unopened with the sample bottles. It is opened in the field and exposed to the air at a location(s) to check for potential atmospheric interference(s). The field blank is resealed and shipped to the contract laboratory for analysis.

2.5 MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Spikes of compounds (e.g., standard compound, test substance, etc.) are added to samples in the laboratory to determine if the matrix is interfering with constituent identification or quantification, as well as a check for systematic errors and lack of sensitivity of analytical equipment. Samples for spikes are collected in the identical manner as for standard analysis, and shipped to the laboratory for spiking. Matrix spike duplicate sample collection and laboratory spiking and analysis are performed to evaluate the reproducibility of matrix spike results. Additional sample volume may have to be collected for the laboratory to perform matrix spike/matrix spike duplicate samples.

3.0 PROCEDURE

1. Implement QC sampling as outlined above, depending on the type of QC sample(s) specified in the work plan.

2. Ensure unbiased handling and analysis of duplicate and blank QC samples by concealing their identity by means of coding so that the analytical laboratory cannot determine which samples are included for QC purposes. Attempt to use a code that will not cause confusion if additional samples are collected or additional monitoring wells are installed. For example, if there are three existing monitoring wells (MW-1, 2 and 3), do not label the QC blank MW-4. If an additional monitoring well were installed, confusion could result.

3. Verify that each sample container is properly placed in the cooler, and that the cooler has sufficient ice (wet ice or blue packs) to preserve the samples for transportation to the analytical laboratory. Consult the site work plan to determine if a particular ice is specified as the preservative for transportation (e.g., the USEPA prefers the use of wet ice because they claim that blue ice will not hold the samples at 4E C).

4. Document the QC samples on the appropriate field form and in the field notebook. On the chain-of-custody form, duplicate and blank QC samples will be labeled using codes, and matrix spike and field matrix spike QC samples will be identified as such.

5. The collection of quality control samples will follow KDHE=s various media specific SOPs:

    - SOP BER-01 for the Collection of Ground Water Samples;
    - SOP BER-2 Collection of Surface Water Samples;
    - SOP BER-3 Collection of Soil Samples for Laboratory Analysis
    - SOP BER-4 Collection of Sediment Samples

4.0 REFERENCES

EPA, Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers. USEPA 542-S-02-001, (May 2002)

EPA, Guidance on Environmental Data Verification and Data Validation EPA QA/G-8 (EPA/240/R-02/004) (November 2002)

EPA, Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Region 4, (November 2001)

STANDARD OPERATING PROCEDURE – BER-13

HEADSPACE METHOD FOR SCREENING SOIL SAMPLES FOR VOLATILE ORGANIC COMPOUNDS

Effective Date: October 27, 2000
Revised Date: January 1, 2011

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1.0 INTRODUCTION

The purpose of this standard operating procedure (SOP) is to establish guidelines for screening soil samples for volatile organic vapors using a portable photoionization detector (PID) or colorimetric tubes. This SOP is applicable to soil samples collected from a Geoprobe®, split-spoon samplers during drilling, hand auger samples, and grab samples from stockpiled soils or excavations.

2.0 CONSIDERATIONS

The primary objective of field screening of soil samples is to obtain a qualitative understanding of the distribution of volatile organic compounds (VOCs) in soil. The proper design of an organic vapor screening program requires an understanding of site hydrogeology, potential source areas, and potential contaminants of concern. Sample locations and frequency must be fully defined in the work plan. The work plan should outline the type of lamp to be utilized in the PID based on the ionization potentials and response factors of the constituents of concern or the type of color metric tube. The work plan must also clearly describe the heating or equilibration procedures to be employed if they differ from those described in this SOP. Regardless of the specific equilibration procedure employed, it is imperative that each sample be treated identically to allow the photoionization results from different locations to be comparable. Observations such as moisture, soil composition, and organic content should be noted to facilitate interpretation of the data. Every effort should be made to collect a representative portion of soil from the sampling device.

3.0 MATERIALS/EQUIPMENT

The following material may be used:

- Decontamination supplies (including: non-phosphate laboratory grade detergent, buckets, brushes, potable water, distilled water, plastic sheeting, etc.)
- Field notebook, field form(s), maps, chain-of-custody forms
- Sampling device (split-spoon sampler, stainless steel hand auger, stainless steel trowel, etc.)
- Stainless steel spoons or spatulas
- Disposable plastic spoons
- Plastic sheeting

- Aluminum foil
- Mason jars or driller's jars
- Water bath (hot plate, extension cord, water tray, thermometer)
- Photoionization detector with charging unit or colorimetric tube and pump
- Calibration gases with regulator
- Indelible marker
- Masking tape
- Disposable sampling gloves
- Zip lock bags, approximately 1 quart capacity

4.0 DECONTAMINATION

Where possible, thoroughly pre-cleaned and wrapped sampling equipment should be used and dedicated to individual sampling locations. Disposable items such as sampling gloves, aluminum foil, and sample jars will be discarded after each use in an appropriate manner. If only field screening results are to be obtained then split-spoon samples and hand augers may be cleaned with a soap and water wash and potable water rinse or steam cleaning, and a final distilled water rinse. However, if samples are to be collected concurrently for laboratory analytical results, then all reusable sampling equipment must be thoroughly decontaminated according to SOP BER-05 Decontamination of Field Equipment.

5.0 CALIBRATION

The PID must be calibrated according to the manufacturer's specifications at a minimum frequency of once per day prior to the first sample analyzed each day. A calibration standard gas should be employed which is similar to the compounds of concern expected at the site.

In addition, periodic calibration verifications (e.g., every 2 hours or every ten samples) employing the standard gas must be conducted. The time, date, and calibration procedure must be clearly documented in the field notebook and the calibration log. If at any time the photoionization results appear erratic or inconsistent with field observations, then the unit must be re-calibrated. If calibration is difficult to achieve, then the unit's lamp should be checked for dirt or moisture and cleaned, as necessary. During humid or wet conditions, the unit

should be calibrated on a more frequent basis as determined by field personnel. If colorimetric tubes are used, the brand and type of pumps and tubes must be documented in the field notebook. The expiration date, batch number of the tubes and the methods utilized must be documented.

6.0 PROCEDURE

1. Extract the soil sample from the sampler, quickly measure the recovery, and separate the waste from the true sample by using a dedicated, stainless steel spatula. Where allowed by regulatory agency(ies), disposable plastic spoons may be used.

2. Place the sample in a pre-cleaned glass jar (as quickly as possible to avoid loss of VOCs) filling the jar half full. Place an aluminum foil seal between the glass and metal cap and screw tight. Zip lock bags may be used as an alternative to glass jars for sample containers. The bags should be approximately one quart capacity, and should be filled with approximately equal volumes of soil sample and air space.

3. Label jars or bags with the boring number, depth of sample, date and time of collection. In addition, the field personnel will ensure the following: samples are taken at appropriate depths, unrepresentative portions of the sample are discarded properly; all sampling equipment is decontaminated properly between use; and the driller uses proper methods during sample collection and does not use oil or grease on tools entering the borehole.

4. Log the sample in detail and record sediment characteristics (color, odor, moisture, texture, density, consistency, organic content, and layering).

5. If the ambient temperature during the sampling event exceeds 70° F, the sample may be allowed to equilibrate at ambient temperature for at least five minutes. If the ambient temperature is less than 70° F, the sample temperature should be elevated by placing the sample under gentle heat for at least five minutes. The heater or defroster of a vehicle may be used to heat the sample for the equilibration process. Alternatively, a water bath may be used to heat and stabilize the temperature of the samples. The water bath should bring the temperature of the sample to at least 70° F but no more than 100° F for at least two minutes.

6. If a PID is to be used, ensure that it has been calibrated and that the calibration information is documented in the field book. Pierce the aluminum foil seal with the probe from the PID or colorimetric tube or insert the probe or tube into a small opening in the zip lock bag, and measure the relative concentration of VOCs in the headspace of the soil

sample. The initial (peak) reading must be recorded. The work plan should specify a time period in which the initial peak reading should occur (e.g.: the first 30 seconds).

7. Record the instrument reading in the field notebook, on an appropriate field form, and on the base map, if appropriate.

8. If only field screening results are to be obtained, then reusable sampling devices may be cleaned with a soap and water wash and a potable water rinse. The sampler will then be rinsed with distilled water, assembled and placed on plastic sheeting for reuse. A more rigorous decontamination procedure is required when samples are also being collected for laboratory analysis. Refer to SOP BER-03 for collection of soil samples for laboratory analysis for additional information.

7.0 REFERENCES

Enviro-Equipment, Inc. October 5, 2007. "Accurate Information for Field Soil Screening Procedures, Are your field Soil Screening Procedures Providing You with Practical and Accurate Information?" http://enviroequipment.blogspot.com/2007/10/accurate-information-for-field-soil.html

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Maine Department of Environmental Protection, Bureau of Remediation and Waste Management. March 16, 2009. "Field Screening of Soil Samples Utilizing Photoionization and Flame-Ionization Detectors." *Standard Operating Procedure: DR#011, Revision: 02.* http://www.maine.gov/dep/rwm/hazardouswaste/updatedsops/dr011_2009.doc

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U.S. Environmental Protection Agency. October 6, 1994. "Photoionization Detector (PID) HNU". *SOP: 2114, Rev. 0.0.* http://www.dem.ri.gov/pubs/sops/wmsr2114.pdf

STANDARD OPERATING PROCEDURE BER-17

IMPLEMENTING A SPECIALIZED OCCUPATIONAL HEALTH EXAMINATION PROGRAM

Effective Date: November 11, 2000
Revised Date: January 1, 2011

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1.0 INTRODUCTION

The objective of this SOP is to ensure all BER employees assigned to field investigative tasks requiring the potential use of Level C personal protective equipment (PPE), such as coveralls, gloves, boots, head protection and negative pressure respiratory protection, are physically capable of utilizing the assigned PPE in extreme temperatures and physically demanding work situations. An additional objective is to monitor for potential long term health effects from exposures to common chemicals of interest that may be encountered by field staff.

2.0 PROGRAM SCOPE

It is the general policy of the KDHE/BER to prevent employee exposures to hazardous conditions and agents, where possible, through the use of appropriate engineering controls, work practices, and PPE. The use of certain items of PPE, such as negative pressure respirators, increases physical demands upon employees above those associated with normal agency field investigative work. Of particular concern is the general state of health of the individual assigned to use these devices such that the safety and health of the individual is not compromised nor work function impaired. Positions have been identified throughout the bureau in which the wearing of negative pressure respiratory protective equipment is a necessary requirement. Employees assigned to these positions will be required to complete a baseline health examination. In addition to the baseline examination, the health status of each individual in these positions will be reviewed annually with the employee. Follow-up examinations may be required depending upon the findings of the annual interview.

3.0 PROCEDURES

Employees participating in this program will be scheduled by KDHE/BER for the completion of a baseline or annual examination. This examination will be completed by a designated contractor and may, depending upon the employee's job duties, consist of the following services and procedures as determined by the Supervising Manager:

A. Thorough health and occupational history with special attention to conditions that may affect the capability of the individual to wear a full-face, negative pressure respirator

B. Examination to emphasize cardiovascular, pulmonary, and integumentary systems, including an assessment of vital signs and vision screening

C. Pulmonary function test (spirometry), with forced vital capacity (FVC) and forced expiratory volume (FEV)

D. Electrocardiogram - 12 lead (resting)

E. Blood chemistry profile

F. Urinalysis with microscopic examination

G. Complete blood count (CBC)) with differential

H. Chest roentgenogram (to be included only if considered appropriate by the examining physician based upon the findings of the health and occupational history and spirometry)

I. Heavy metal blood scan

J. Audiology screening (sound booth)

The contracting physician will provide a written report of findings documenting the capability of the individual to use full-face negative pressure respirators and noting any special limitations of the individual (such as the use of prescription eyewear) which should be known to the Department prior to assignment of job tasks requiring the use of full-face respirators.

Employees will have the option of completing a comparable examination with a physician of their choosing; however, such an examination will be at the employee's expense.

4.0 RECORD KEEPING

KDHE/BER will be responsible for the cost of the baseline and annual examinations completed by the selected contractor. The results of detailed health examinations will be maintained on file by the contractor and the summarized written report of findings will be mailed to and maintained on file in the personnel files of the employees examined. Invoices will indicate the names of the individuals receiving examinations and the specific services provided.

5.0 REFERENCE

Title 29 Code of Federal Regulations; Part 1910, Occupational Safety and Health Standards; Subpart H, Hazardous Materials; 1910.120, Hazardous waste operations and emergency response

STANDARD OPERATING PROCEDURE – BER-18

FIELD SAFETY PROTOCOL

Effective Date: October 29, 2000
Revised Date: January 1, 2011

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1.0 INTRODUCTION

This document was developed primarily for unknown hazardous substance sites where a site-specific health and safety plan (HASP) may be required. This document should not be applicable to sites where routine operations such as monitoring, inspecting or overseeing are conducted. A general HASP may be used for these types of operations.

The handling and sampling of contaminated materials (i.e. hazardous substances, hazardous waste, soil, groundwater) always poses a certain degree of hazard. The objective of this document is to serve as a guideline for the safety of Kansas Department of Health and Environment\Bureau of Environmental Remediation (KDHE\BER) personnel while conducting field activities. This document does not replace a generic or site-specific HASP which should be completed for all site investigations. Program Managers may elect to develop a generic site HASP for programs that conduct similar/routine events. This document does not serve as a Standard Operating Procedure (SOP) for emergency response. Emergency response encompasses an enormous amount of variables specific to emergency response situations. Emergency response documents should be consulted for further details.

2.0 REQUIREMENTS FOR FIELD PERSONNEL

Before entering any potentially hazardous waste site or collecting any hazardous samples, BER personnel must have completed a 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) course and be enrolled in a medical monitoring program. Employees are expected to attend a yearly 8-hour HAZWOPER refresher course to maintain their certification.

3.0 RESPONSIBILITY OF PROJECT MANAGER/ ONSITE COORDINATOR

During on-site investigations involving the sampling or handling of hazardous waste, safety precautions must be paramount to all other considerations. Due to the variety of chemicals and their varied toxicities, exposure prevention must be a high priority of the project manager. Despite thorough preparation, a field team may not have adequate knowledge of site conditions. It is impossible to anticipate every hazard that could arise. The project manager or on-site coordinator should consult all available information prior to the field activity to review potential hazards and safety precautions.

In all considerations related to safety, the project manager or on-site coordinator is responsible for overseeing the collection and organization of site data in order to properly assess the hazard potential, and in implementing the generic or site-specific HASP.

4.0 RESPONSIBILITY OF THE SITE SAFETY OFFICER

Some sites will have a separate designated Site Safety Officer (SSO) who will most often generate and supervise the execution of the generic or site-specific HASP. For most sites, the project manager or on-site coordinator will be the SSO. Additional responsibilities may include:

- ensuring all team members are familiar with the site safety plan including the route from the site to the chosen medical facility before any site activities begin;
- conducting site safety briefings and documenting all on-site safety concerns and situations;
- maintaining safety equipment in good condition and proper working order;
- confirming safety equipment is used in accordance with the manufacturer's instructions and bureau SOPs; and
- ensuring team members refrain from activities that would create additional hazards (e.g. smoking, eating on site).

5.0 TYPES OF EXPOSURE TO HAZARDOUS WASTE

In order to ensure the safety of the field team, the project manager and health and safety officer must protect field team staff from exposure to hazardous materials. The purpose of the following information is to provide some basic insight into the manner by which harmful materials may enter the body. The four basic types of exposure are inhalation, skin absorption, ingestion, and eye contact.

5.1 INHALATION

Breathing gas vapor, mist, fumes or dust is a common accidental form of exposure and this route of entry may be a cause of systemic illness. The inhalation hazard depends on a number of factors: the chance that the chemical encountered will leak into the air; the concentration present in the air; the volatility of the chemical at ambient temperature; the inherent toxicity of the chemical; and the length of time the chemical is breathed.

The field team should take the following precautions when entering a site with unknown hazards and/or when sampling from containers, including wells, where the contents pose an inhalation hazard:

- Approach the area, well, or container from an upwind position.
- Sample only in well ventilated areas.
- Use the appropriate respirator based on chemical toxicity and on-site monitoring data.
- When needed, use a suitable air monitoring instrument to screen the well/area for volatile vapors.

5.2 SKIN ABSORPTION

Certain chemicals have the capacity to penetrate unbroken skin (including highly absorbent eye tissue) and are picked up by the blood stream and distributed throughout the body. A combination of gloves, boots, hats, coveralls and proper respirator should be worn to protect against skin exposure and absorption. BER staff must wear personal protective equipment (PPE) and clothing in accordance with SOP-21 to minimize exposure. In addition to donning proper safety clothing and equipment, the following precautions should be used in inspecting sites which may contain materials hazardous by skin absorption:

- Ensure all skin areas are protected during site work.
- Carefully wipe all residue off sample containers after sample collection.
- After completing the investigation, use proper procedures for removing contaminated clothing while still at the site.
- Bag contaminated rags and other disposable items, such as gloves, for proper disposal avoiding skin contact. Gloves should be the last piece of personal protective gear to be removed.
- Wash the hands and facial area before leaving the site or as soon as possible after leaving the site.

The eyes may be harmed by absorbing chemicals in either the liquid or vapor form. Irritant effects vary in degree from mild to severe. Some chemicals have the ability to injure the eye to some degree with surface contact. Eye tissue is also highly absorbent and can not only be damaged but can provide a direct path to the blood stream. The generic or site-specific HASP will describe precautions that should be taken upon entering a site where a contaminant in gas, vapor or liquid form may come into contact with the

eyes.

5.3 INGESTION

Toxic amounts of hazardous material may be transferred to the mouth when drinking or eating. Therefore, these activities should never occur during or after investigations until decontamination procedures have been completed. Furthermore, liquids should not be pipetted or siphoned by mouth under any circumstances.

5.4 INJECTION

BER personnel may be exposed to hazardous chemicals through injection or entry through broken skin. Employees shall be careful to recognize any hazards which may pierce the skin, allowing chemicals to enter the body through a wound. This is of particular concern at abandoned facilities and landfills.

6.0 INITIAL HAZARD ASSESSMENT

In conducting investigations of potential hazardous waste sites a detailed hazard assessment must be done before a site specific safety plan can be generated. The procedures outlined below should be followed to varying degrees for all BER sites where BER personnel will actually be on the site. The hazard assessment will be used to determine whether to enter a potentially hazardous waste site and to determine the appropriate level of protective equipment to be worn when entering the site.

In order to minimize the potential of exposure to a hazardous substance, precautions should be considered in the planning stages and observed during the field activity for any site work. The degree to which these following precautions are executed is dependant on site specific variables including site/contaminant history and potential exposure risk:

- Prior to on-site arrival, a thorough file/historical review must be completed to examine former as well as current practices conducted at the property including information on known or suspected use of chemicals. The review should include information available from outside sources including local libraries, historical societies, and interviews, etc.

- Employees shall review available toxicological information (Condensed Chemical Dictionary, Pesticide Handbook, etc.) to evaluate exposure risks.

- After reviewing the available environmental and toxicological information, protective clothing shall be selected in accordance with BER SOP 21, Levels of Protection for Field Work.

(KDHE/BER employees should not be exposed to Level A or Level B conditions. If unplanned Level A or Level B conditions are encountered in the field, KDHE employees will withdraw immediately and contact a qualified contractor to complete the task.)

An air monitoring program, using a photoionization detector (PID) or similar detector, should be part of all field operations when the potential for atmospheric contamination is present. After a background ambient air measurement is recorded, continual surveillance using direct-reading instruments is needed to detect any changes in air quality. If contaminants are detected above the pre-determined acceptable levels in the HASP, KDHE employees should withdraw immediately and reevaluate the necessary level of respiratory protection.

Before allowing entrance to the site, the project manager should determine if there is an imminent or potential breathing or skin contact hazard and/or risk to health and safety. In such cases, entry is totally unadvisable, and the project manager should withdraw from the area and contact his/her supervisor. If explosivity meter readings exceed 10% of the lower explosive limit (LEL), BER personnel are to withdraw from the site. If warranted, the fire department and supervisor should be notified.

7.0 EMERGENCY TREATMENT

Before entering a site, it is recommended the project manager and field team know the locations and emergency telephone numbers of the nearest medical facility, ambulance service, fire department, police department and poison control centers. (It should be considered during emergency planning that in some remote areas of the state, cell phone service is not reliable.) This information, including a map with the directions to the hospital, shall be included in the HASP. In case of any emergency, appropriate assistance should be called immediately and the appropriate emergency treatment conducted.

KDHE/BER personnel who frequently perform field activities should be trained in basic first aid. A first aid kit with a first aid manual should accompany each KDHE vehicle. The purpose of emergency treatment is to prevent further damage until professional treatment is obtained. Employees will always notify or have someone else notify emergency medical professionals immediately in case of a medical emergency.

First aid procedures for contamination or poisoning by hazardous materials consist of removing, diluting or slowing the movement of the poison. Some knowledge of the hazardous material combined with prompt treatment is essential in reducing the poison's concentration. Accidents such as a fall or heat stroke could also require emergency treatment. For these measures and other emergency information, consult the on-site first aid manual.

8.0 SAFETY EQUIPMENT

Safety equipment may be either associated with the site or assigned to the individual employees.

8.1 FIRST AID KITS

First aid kits should be available on every KDHE site and can be found in each vehicle. The first aid kit should have an accompanying manual. These kits are for basic first aid problems and are not intended to substitute for professional medical care. BER personnel should periodically inspect the kits and restock supplies as needed.

8.2 RESPIRATORY PROTECTION

KDHE will issue respirators to BER employees with a potential for exposure to contaminants through inhalation. Use and care of respirators is described in BER SOP 22, Half/Full-Mask Respirator.

8.3 PERSONAL EQUIPMENT

All field personnel are required to wear steel-toed safety boots on site and be issued a hard hat and safety glasses. The need for a hard hat and safety glasses should be addressed in the site specific safety plan, as well as the need for hearing protection, traffic vests, and other personal items.

9.0 VEHICLE SAFETY

All vehicles used for field activities will be kept in sound/safe mechanical condition and contain the following safety items:

- first aid kit (with manual)
- flashlight
- road hazard kit (emergency flares, triangles, battery jumper cables)

Vehicles should be inspected for the presence of these supplies before departing the

office. While on site, if the vehicle is positioned in such a way as to present a traffic hazard to the vehicle, passing vehicles or persons working around the vehicle, traffic cones will be set to redirect traffic around the work zone.

10.0 REFERENCES

OSHA 29 CFR 1910.120 Hazardous Waste Operations and Emergency Response (HAZWOPER)
(e)(3)(i) - Initial Training
(e)(8) - Refresher Training

EPA 40 CFR 311—WORKER PROTECTION

STANDARD OPERATING PROCEDURE - BER-19

CHAIN OF CUSTODY

Effective Date: October 15, 2000
Revised Date: January 1, 2011

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DISCLAIMER:

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1.0 INTRODUCTION AND OVERVIEW OF CHAIN OF CUSTODY PROCEDURE

This SOP documents the protocol used in the transfer of environmental samples to another person or an analytical laboratory. This SOP is intended to facilitate consistency among staff members, serve as a reference and training tool, and provide a formal written record of the method used to transfer custody of a sample in an environmental monitoring program.

Due to the evidentiary nature of samples collected for investigations, the possession of samples must be traceable from the time the samples are collected until they have been introduced as evidence in legal proceedings. After collecting the samples and labeling the appropriate sample containers, all samples shall be maintained under chain of custody procedures. Each person involved with collecting the samples must know chain of custody procedures.

2.0 CHAIN OF CUSTODY PROCEDURES

To maintain and document sample possession, the following chain of custody procedure should be followed.

2.1 CRITERIA FOR SAMPLE CUSTODY

A sample is under custody if:

1. It is in the sampler's actual possession; or
2. It is in the sampler's view, after being in his/her physical possession; or
3. It was in the sampler's physical possession and then he/she locked it up to prevent tampering; or
4. It is in a designated and identified secured area.

2.2 FIELD CUSTODY CONSIDERATIONS

1. The number of persons handling the samples should be as few as possible.
2. The person who collected the samples in the field is responsible for the care and custody of the samples until they have been transferred or properly relinquished.

2.3 TRANSFER OF CUSTODY AND SHIPMENT

1. Samples must be accompanied by a sample submission form that contains a custody record. Sample submission forms are specific to the laboratory where the samples will be submitted for analysis. Hence, the specified sample submission form for Division of Health and Environmental Laboratory (DHEL) analysis, KDHE outside contractor laboratory analysis, or in-field analysis should be used. The custody record on the sample submission form documents the transfer of custody for the samples from the person collecting the sample to another person or to a permanent laboratory. In transferring the possession of samples, the person relinquishing the samples and the person receiving them will sign and date the sample submission form.

2. All packages containing samples should be accompanied with sample submission forms identifying their contents. The original form should accompany the shipment, and a copy should be retained for permanent documentation by the person currently in custody of the samples.

3. If samples are shipped by a common carrier, a bill of lading should be used. Receipts for bills of lading should be retained for permanent documentation by the person currently in custody of the samples.

STANDARD OPERATING PROCEDURE – BER-21

LEVELS OF PROTECTION FOR FIELD WORK

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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1.0 INTRODUCTION

BER staff must wear personal protective equipment (PPE) when field activities involve known or suspected atmospheric contamination, when vapors, gases, or particulates may be generated, or when direct contact with skin-affecting substances may occur. Respirators can protect lungs, the gastrointestinal tract, and eyes against air toxicants. Chemical resistant clothing can protect the skin from contact with skin destructive and absorbable chemicals. Good personal hygiene can limit or prevent ingestion of material.

Equipment to protect the body against contact with known or anticipated chemical hazards has been divided into four categories according to the degree of protection afforded. All of the clothing or equipment listed for each layer of protection might not be worn all of the time. The specific equipment to be worn for each level will need to be determined by the site safety officer (SSO) and project manager, and will be included in the site Health and Safety Plan (HASP). Examples of equipment used and selection criteria for each level will be given in Section 2. The following are brief descriptions of the levels of protection:

Level A: Should be worn when the highest level of respiratory, skin, and eye protection is needed. KDHE employees should not be exposed to Level A conditions. **If Level A conditions are encountered in the field, KDHE employees will withdraw immediately and contact a qualified contractor to complete the task.**

Level B: Should be selected when the highest level of respiratory protection is needed, but a lesser level of skin protection is required. Level B protection is the minimum level recommended on initial site entries until the hazards have been further defined by on-site studies and appropriate personnel protection utilized. KDHE employees should not be exposed to Level B conditions. **If Level B conditions are encountered in the field, KDHE employees will withdraw immediately and contact a qualified contractor to complete the task.**

Level C: Should be selected when the type(s) of airborne substance(s) is known, the concentration(s) is measured, and the criteria for using air--purifying respirators are met.

Level D: Should not be worn on any site with respiratory or skin hazards. Level D is primarily a work uniform providing minimal protection.

The Level of Protection selected should be based primarily on:

Type(s) and measured concentration(s) of the chemical substance(s) in the ambient atmosphere and its toxicity.

Potential or measured exposure to substances in air, splashes of liquids, or other direct contact with material due to work being performed.

In situations where the type(s) of chemical(s), concentration(s), and possibilities of contact are not known, the appropriate Level of Protection must be selected based on professional experience and judgment until the hazards can be better characterized.

While PPE reduces the potential for contact with harmful substances, ensuring the health and safety of response personnel also requires safe work practices, decontamination, site entry protocols, and other safety considerations.

2.0 LEVELS OF PROTECTION

Each of the four levels of PPE has specific equipment and selection criteria. BER personnel will use the information below when selecting appropriate PPE levels. **Levels A and B are not further discussed in this SOP because if conditions are encountered in the field that would require Levels A or B the KDHE employee is required to withdraw immediately and contact a qualified contractor to complete the task.**

2.1 LEVEL C PROTECTION

Examples of Level C PPE include:

- Full-face or half-face, air-purifying respirator with the appropriate canister or cartridges (MSHA/NIOSH approved)
- Chemical-resistant clothing (coveralls; hooded, two-piece chemical splash suit; chemical-resistant hood and apron; disposable chemical-resistant coveralls)
- Coveralls (cotton)
- Gloves (outer), chemical-resistant
- Gloves (inner), chemical-resistant
- Boots (outer), chemical-resistant, steel toe and shank

- Boots (outer), chemical-resistant (disposable)
- Hard Hat (face shield)
- 2-way radio communications (intrinsically safe)

Level C may be selected if all of the following criteria are met:

- Measured air concentrations of identified substances will be reduced by the respirator to at or below the substance's exposure limit, and the concentration is within the service limit of the canister or cartridges.
- Atmospheric contaminant concentrations do not exceed IDLH levels.
- Atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect the small area of skin left unprotected by chemical-resistant clothing.
- Job functions have been determined not to require self-contained breathing apparatus.
- Total vapor readings register between background and 5 ppm above background on instruments such as a PID or OVA.
- KDHE personnel will periodically monitor concentrations of hazardous constituents in the air to ensure Level C remains appropriate.

2.2 LEVEL D PROTECTION

Examples of Level D PPE include:

- Coveralls
- Gloves
- Boots/shoes, leather or chemical-resistant, steel toe and shank - Boots (outer), chemical-resistant (disposable) - Safety glasses or chemical splash goggles
- Hard hat (face shield)

KDHE personnel may select Level D if the following conditions are met:

- No hazardous air pollutants have been detected.
- Work functions preclude splashes, immersion, or potential for unexpected inhalation of any chemicals.

3.0 PROTECTIVE EQUIPMENT

Provided below are brief descriptions of PPE used by KDHE personnel. This is not a comprehensive index, but rather a list of the more commonly used equipment.

Respirators (half-face or full-face) - use full day, or if breakthrough occurs, or until situation no longer warrants respiratory protection. Respirators should be cleaned according to manufacturer's specifications after each use.

Appropriate canisters or cartridges for respirators should be selected according to need and manufacturer's specifications.

Suits (listing from least protective to most)

Tyvek (uncoated) paper-like suit. Strictly for keeping clean. Properly dispose of after use.

Polyethylene coated tyvek - use while chemical sampling, i.e., solvents, pesticides, etc.

Saran covered tyvek - use for chemical sampling. Somewhat sturdier than the polyethylene coated tyvek.

Heavy duty yellow suit - all uses - clean with soap/water or steam and reuse. Use bleach on boots, suits, shoes, and clothes to remove pesticides.

Gloves (listing from least protective to most)

Disposable nitrile surgical type gloves - for keeping clean or for collecting soil and water samples. May be used as an inner glove for additional protection when using two layers of gloves.

Long green rubber (nitrile) - Use as outer glove. Good chemical resistance.

Thick black, long (neoprene) - good for all uses. Clean and reuse.

Cotton liners - use under gloves when possible.

Visor/Hard Hat - Use during well or tank sampling where there is a danger of splashing.

Goggles & Safety Glasses - Use when eye protection is needed, or when using half face mask. Use common sense approach.

Boots - Rubber/Neoprene. Good for all uses. Use protective covers over boots.

Boot Protective Covers – Disposable rubber, PVC and vinyl protective covers are available to use over Level D footwear.

4.0 DECONTAMINATION AND DISPOSAL

In leaving a contaminated site, appropriate procedures must be carried out for decontamination and for safe packing of protective clothing, safe packing of disposable gear, and transfer of equipment, gear, and samples from the "contaminated" area to the "clean" area. Sequences of these actions will depend on the situation and must be worked out in advance. Disposition of wash water must be determined and planned for in advance.

Reusable protective clothing and equipment should be decontaminated with soap and water at the site and allowed to dry if possible. Face shields, goggles, respirators, rubber gloves (non-disposable), and rubber boots should also be washed between uses. If decontamination cannot be done at the site, the protective clothing and gear should be placed in plastic bags or isolated from "clean" clothing and equipment until it is decontaminated. All disposable items should be sealed in plastic bags and disposed of according to the degree of contamination.

5.0 REFERENCES

Title 29 Code of Federal Regulations Part 1910 – Occupational Safety and Health Standards

STANDARD OPERATING PROCEDURE – BER-26

USE OF WATER QUALITY ANALYZERS FOR WELL STABILIZATION

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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ATTACHMENT A - Sample Collection Field Data Sheet

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1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to provide a method for using Water Quality Analyzers to measure water quality parameters during monitoring well purging to establish well stabilization prior to the collection of environmental samples in accordance with BER SOP-01 Section 4.0, LOW FLOW SAMPLING METHOD. Water quality parameters must be measured in a manner that will ensure the integrity of the data collected. To maintain consistency of the data, the user must consider the tubing diameter, length and material; flow-through cell design, capacity, and sampling set-up; pump operation and plumbing; purge rate; and the specific Water Quality Analyzer(s) and calibration.

Water quality indicator parameters such as Specific Conductance (conductivity), Dissolved Oxygen (DO), Oxidation-Reduction Potential (ORP/Eh), Turbidity, pH, and Temperature are measured during the low-flow purging process to determine when the monitoring well has stabilized for sample collection. Water quality parameters should be measured in a device (flow-through cell) that prevents contact of the purge water with air prior to measurement, especially for DO. The ORP parameter may not be suitable for determining stabilization at all sites, but readings should be recorded if they are available as another check on the oxidation conditions of the water. Turbidity can also be used to help measure stabilization and determine the need for filtering the samples collected for metals analysis. As sediment particles may collect in the flow-through cell, samples for turbidity measurements should be collected before the water reaches the flow-through cell. If the sample is to be tested for parameters that could be biased by the presence of particulates, such as semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), or metals, it is important to try to reduce the turbidity of the sample to below 10 Nephelometric turbidity units (NTUs). Water samples of this clarity (< 10 NTU) should be more representative of natural colloidal loading in the formation. If the turbidity can be reduced below 10 NTUs, it may not be necessary to filter the samples collected for metals analysis; however, the approved work plan should be reviewed to determine if filtration of samples will be conducted. Note that the BER Policy BER-RS-46 Filtering Water Samples Collected for Metal Analysis, a water sample should be field filtered if turbidity is greater than 5 NTUs.

In general, the order of stabilization is pH, temperature, and specific conductance, followed by oxidation-reduction potential, dissolved oxygen and turbidity. Temperature and pH, while commonly used as stabilization indicators, are actually insensitive in distinguishing between formation water and casing water. Nevertheless, these are important parameters for data interpretation and should be measured and recorded.

2.0 PRE-SAMPLING PROCEDURES

Prior to sampling, all Water Quality Analyzers must be calibrated in accordance with the manufacturer's recommendations. The directions for calibration are contained in the owner's manual and should be kept with the Water Quality Analyzer at all times. Calibration solutions must be held at the same temperature of the groundwater as temperature correlation is critical for calculating conductivity, pH, dissolved oxygen and conductivity.

pH

Monitoring for stabilization of pH in groundwater is relatively straightforward and rarely requires serious troubleshooting. When calibrating for pH, do a two-point calibration, at a minimum. The calibration range should bracket the anticipated pH. If the pH is unknown, then a three-point calibration must be made. The temperature of the buffer solutions should be as close to the temperature of the groundwater as possible. If the probe does not calibrate properly, check to make sure that the probe's electrical contact points are dry. As with preventative maintenance of any probe, make sure that the pH probe is rinsed with distilled/deionized water between uses and cleaned periodically per the manufacturer's specifications. Overnight storage generally requires placement of the probe into a 2-molar (M) solution of potassium chloride. This solution may cause an unwanted build up of salt, therefore, frequent rinsing may be necessary.

Temperature

For Water Quality Analyzer instrument probes that rely on the temperature sensor (pH, dissolved oxygen, specific conductance, oxidation-reduction potential), the Water Quality Analyzer temperature sensor must be checked for accuracy against a thermometer that is traceable to the National Institute of Standards and Technology (NIST). The accuracy check should be performed at least once per year, and the results of the accuracy check kept on file.

The accuracy of the instrument must be verified by checking the endpoints of the expected temperature range (0°C-40°C). Place a thermometer that is traceable to the NIST and the temperature probe into a vessel of water and wait for both instruments to stabilize. Compare the two measurements. The instrument's temperature measurement must agree with the NIST reference thermometer within the accuracy of the instrument (±0.15°C). If the measurements do not agree, the instrument's manufacturer should be contacted.

Specific Conductance

Conductivity is used to measure the ability of the water to carry an electrical current. Specific Conductance is the conductivity value corrected to 25°C. Place

the cleaned probes into the Specific Conductivity standard solution, making sure that the probe is fully submerged. The accuracy must be verified by checking the endpoints of the desired conductivity range to ensure linearity. Calibrate the instrument with the high conductivity standard and then check the instrument against the low conductivity standard. Where Specific Conductance is a non-critical measurement, the instrument can be calibrated with one calibration standard.

Turbidity

Turbidity is based upon a comparison of intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a reference solution. Critical to the instrument's operation is that the lens covering the detector unit is kept clean during both calibration and field use. The calibration and post calibration check must be performed before and after sampling.

Dissolved Oxygen

Dissolved oxygen (DO) content in water is measured using a membrane electrode. The DO probe's membrane and electrolyte solution should be inspected for any damage or air bubbles prior to calibration. If air bubbles or damage are present, replace the membrane according to manufacturer suggestions. (After changing the membrane you should wait 12 hours before use to allow the membrane to equilibrate). Calibration of some models requires inputting the current barometric pressure. Do not use barometric pressure directly obtained from meteorology reports as these are usually corrected to sea level.

Place approximately 1/8 inch of water in the bottom of the calibration cup. Place the probe end of the probe into the cup. Engage only 1 or 2 threads of the calibration cup to insure the DO probe is vented to the atmosphere. An alternative is to wrap the probe guard with a wet towel and place the probe into a 5 gallon bucket with 1 inch of water in it. Make sure that the DO and temperature probes are NOT immersed in water and that the calibration cup is not in direct sunlight. Wait approximately 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate.

Oxidation-Reduction Potential

ORP is measuring the difference in potential between two electrodes, one a chemically inert electrode and the other a reference electrode. Though ORP varies greatly with temperature, many ORP instruments do not contain a temperature based correction program installed in the probe or data logger. For the Zobell solution that will be used for this method of calibration, consult the operator's manual for the temperature correction needed. Clean all probes with deionized

water prior to calibration. Place the probes into the Zobell solution and allow the probes to equalize. Look up the millivolt value for the temperature in the operator's manual and enter the corrected value into the instrument.

3.0 SET-UP OF FLOW-THROUGH CELL

Typical flow through cell design is not complicated and almost all on the market today have common shared features. Cells should be transparent in order to "see" the physical condition of the purge water or air bubbles passing through the system. Highly turbid or iron bacteria-laden water can be visually monitored for change as the purge progresses. The cell must be sealed against unwanted exposure to the atmosphere, thus insuring accurate measurement of air-sensitive parameters (dissolved oxygen, pH, etc.). The total capacity of the cell must be small (300-1,000 mL) in order to maintain a desirable turnover rate of water coming into the cell to ensure real-time data integrity. The in-line design must allow for purge water to enter the flow cell from a bottom port and exit at the top. The discharge may be fitted with a check valve. Upon initial pump startup, it is good practice to not connect the pump discharge line to the flow through cell. This will allow the sampler time to monitor drawdown, stabilize the flow rate and prevent fowling of probes by bacteria, sediment, or NAPL. Once drawdown measurements indicate that the flow rate has been controlled and a few minutes (<10) have been allowed to clear any unwanted material, the pump discharge line can then be connected to the cell.

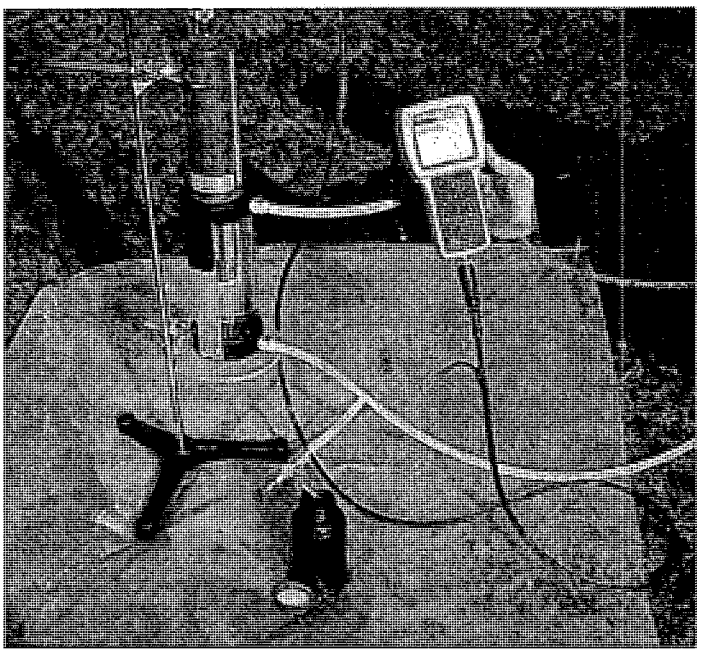

Illustration of Flow Through Cell with stand. (Photograph by J. Schoenleber)

Flow through cell decontamination is important, not only to reduce the potential for cross contamination, but also to ensure data integrity and consistent instrument performance. The cell and probes should be rinsed with distilled/deionized water between each monitor well as accumulation of suspended material may impact probe performance. If they are exposed to contaminants, use a mild detergent. Flow through cell exposure to high levels of contamination may damage probes and require their repair by the manufacturer. The location of the flow through cell or cells in relation to the sample port is critical. Samples for turbidity measurement, general chemistry and laboratory analysis must be collected ahead of the flow through cell. It is also important to locate the flow-through cell as close as possible to the well head in order to minimize the length of tubing needed between the well head and flow through cell. The flow through cell must be protected from ambient conditions and the ground surface.

The inside diameter (ID) of tubing should be no greater than three-eighths of an inch (3/8-in). Quarter-inch (1/4-in) tubing is preferred. Larger tubing diameters reduce flow velocity resulting in a corresponding increase of pump speeds to maintain flow. Increased pump speed will, in turn, elevate the potential for turbulent flow across the screened interval and this may affect the quality of the water being sampled. Conversely, any reduction in flow velocity may allow air to become trapped in the tubing, which may ultimately affect air-sensitive parameters or allow particulates to settle, which may affect turbidity values. The length of tubing, from the top of the well casing to the flow-through chamber, should be the shortest length manageable. Tubing must be completely full of water at all times.

If the sampling plan calls for multiple sample locations within the well screen, sampling should proceed from the top location to the bottom location. This will require that additional tubing be coiled at the surface to allow for pump relocation to the next deeper sampling location. In these instances, the coiled tubing must be protected from ambient conditions and the ground surface, in order to avoid impact to the water quality parameters and sample data. Tubing "reuse" is not recommended when sampling well to well since decontamination of tubing is difficult and time consuming.

4.0 MEASUREMENT OF WATER QUALITY PARAMETERS

Measurement of the water-quality indicator parameters should be conducted at specific intervals based on the pumping rate and the total volume of water in the pump, tubing, and flow-through cell. The first measurement should be taken after one complete volume of water has passed through the pumping apparatus with subsequent readings being taken as additional volumes of water are pumped out. Successive measurements should be completed at 3-5 minute intervals. When three successive readings indicate the water-quality indicator parameters have stabilized within the appropriate criteria, sampling can begin. Stabilization

criteria are identified in the table below. If the water-quality indicator parameters do not stabilize even though the low-flow procedures are being followed, then it may be necessary to use a different purge and sample method.

Water-Quality Indicator Parameter	**Stabilization Criteria**
Specific Conductance	± 3 % milliSiemens/centimeter (mS/cm)
Dissolved Oxygen	± 0.3 milligrams per liter (mg/L) ± 10% (When measured in % saturation)
Oxidation-Reduction Potential	± 10 millivolts (mV)
Turbidity	± 10 % when turbidity is greater than 10 NTUs
pH	± 0.1 Units
Temperature	± 3% Note: Temperature is not a sensitive indicator for stabilization but should be recorded anyway.

Measurements including water quality parameters, flow rate, and volume of water removed should be recorded in the field book or on an appropriate field form. An example field form is included in Attachment A.

In some cases, it may take considerable time to achieve stabilization of the water quality parameters. In other cases, they may never stabilize. However, as provided in USEPA guidance, the following options are available if stability has not been achieved after **FOUR** hours of purging: 1) continue purging until stabilization occurs, no matter how long it takes; 2) discontinue purging, do not collect a sample and document the attempts to reach stabilization; or 3) discontinue purging, collect a sample and document the attempts to reach stabilization. In situations where water quality parameters do not stabilize, the sampler must document that low flow purge sampling could not be performed and document in the report how the samples were collected. While every effort should be taken to assure that all of the water quality parameters stabilize prior to sample collection, one should keep in mind that the stabilization of some water quality parameters may be more difficult to achieve than others. Also, achieving stabilization of some water quality parameters may be more important with respect to some contaminant types (e.g., metals versus VOCs, etc.) than others. For example, total metals concentrations tend to increase with increasing turbidity due to sorption of metals on solids in the water. Similarly, VOC concentrations may be affected by dissolved oxygen (DO) concentrations (i.e., whether the groundwater is aerobic or anaerobic). In addition to providing information on the effectiveness of low-flow sampling, collection of accurate DO data also aids in the evaluation of monitored natural attenuation (MNA) of VOC plumes. Similarly, temperature data can

provide useful information regarding the sampling method. For example, temperature increases resulting from dissipation of heat generated by the submersible pump or from exposure of the tubing to excessive heat at the ground surface can have a significant impact on VOC concentrations in water samples. If, for whatever reason, a water quality parameter is not accurately measured during the monitoring process or a certain water quality parameter does not stabilize, and that particular water quality parameter is not significant with respect to the type of contaminant of concern, sample collection may still proceed. For example, if DO data do not stabilize but all of the other water quality parameters including drawdown and turbidity stabilize and samples will be collected for metals only, then the samples may be collected.

5.0 POST-SAMPLING PROCEDURES

Following sampling, all equipment must be decontaminated in accordance with BER SOP-05.

1. Wash equipment with a non-phosphate detergent solution such as Alconox or an equivalent.

2. Rinse with tap water.

3. Final rinse with deionized/distilled water.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site note books.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

7.0 REFERENCES

1. United States Environmental Protection Agency (U.S. EPA). *Ground Water Issue: Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures.* Document #EPA/540/S-95-504, April, 1996

2. United States Environmental Protection Agency (U.S. EPA) Region IX. *Standard Operating Procedure for Low-Stress (Minimal Drawdown) Ground-Water Sample Collection.* February 2002

3. New Jersey Department of Environmental Protection, Guidance Documents, Field Sampling Procedures Manual, *Chapter 6 – Sample Collection,* http://www.state.nj.us/dep/srp/guidance/fspm/pdf/chapter06_all.pdf, August 2005.

4. United States Environmental Protection Agency (U.S. EPA) Region I. *Standard Operating Procedure for Calibration and Field Measurement Procedures for the YSI Model 6-Series SONDES and Data Logger (Including: Temperature, pH, Specific Conductance, Turbidity, Dissolved Oxygen, Chlorophyll, Rhodamine WT, ORP, and Barometric Pressure),* Revision 7, June 7, 2005.

5. Kansas Department of Health and Environment, Bureau of Environmental Remediation, Quality Management Plan III, Appendix A-Standard Operating Procedures, BER-01 *Collection of Groundwater Samples at Known or Suspected Groundwater Contamination Sites*, August 2010

6. Kansas Department of Health and Environment, Bureau of Environmental Remediation, Quality Management Plan III, Appendix A-Standard Operating Procedures, BER-05 *Decontamination of Equipment*, August 2010

7. United States Geological Survey, *National Field Manual for the Collection of Water Quality Data, Techniques for Water-Resources Investigations, Book 9, Handbook for Water-Resources Investigations, Chapter A6. Field Measurements*, February 2010.

ATTACHMENT A

Sample Collection Field Data Sheet

Project Name:	Project Number:
KDHE Project Manager:	Well Tag Removed:
Weather Conditions:	Well Tag Replaced:
Well ID:	Date:
Well Owner:	Well Type/Size:
Location:	Site Type:

Sampled By:	Start Time:	Finish Time:

Depth to Bottom:	ft BTOC	Purge Method:
Depth to Water:	ft BTOC	Purge Rate:
Height of Water Column:	ft	Purge Time:
Volume:	gal	Actual Purge Volume:
Purge Volume:	gal	

Well Diameter	*0.75"*	*1"*	*2"*	*3"*	*4"*	*6"*
Volume (gal/ft)	*0.023*	*0.041*	*0.1632*	*0.3672*	*0.6528*	*1.4688*

Observations

Field Parameter Measurements During Purging

Time	Temp	pH	Conductivity	Dissolved Oxygen	Visual Turbidity	Other

ATTACHMENT A

Field Parameter Measurements During Purging

Time	Temp	pH	Conductivity	Dissolved Oxygen	Visual Turbidity	Other

Field Parameter Measurements on Sample:

Time	Temp	pH	Conductivity	Dissolved Oxygen	Visual Turbidity	Other

Types of Samples Collected:

Water	Soil	Air

Notes:

Laboratory:

STANDARD OPERATING PROCEDURE – BER-30

OPERATION OF THE PHOTOIONIZATION DETECTOR

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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ATTACHMENT 1 eV Ionization Potentials

DISCLAIMER:

This Standard Operating Procedure (SOP) was developed based on a compilation of best available information, knowledge, field experience, and general industry practices to provide guidance to KDHE staff in performing the activities defined herein, in a consistent and standardized manner. This document does not contain regulatory or statutory requirements unless specified.

KDHE has made every attempt to present the information in a clear and concise manner for a variety of users. However, KDHE is not responsible for the misuse or misinterpretation of the information presented herein. Under no circumstances shall KDHE be liable for any actions taken or omissions made by non-KDHE users of this document.

In general, this document should be used as a reference. Differences may exist between the procedures referenced in this document and what is appropriate under site-specific conditions. This document does not represent an endorsement of practitioners or products mentioned in the document.

1.0 INTRODUCTION

The purpose of this standard operating procedure (SOP) is to describe the procedure for operating a Photoionization Detector (PID) for air monitoring, site entry and field screening. The PID is a portable vapor/gas detector used for a variety of volatile organic and inorganic chemical compounds. The PID measures the total concentration of volatile organic compounds (VOCs). The PID is non-specific and cannot distinguish between individual compounds. The displayed reading represents the total concentration of all detectable VOCs in parts per million (ppm).

2.0 METHOD SUMMARY

The PID is a general survey instrument capable of detecting and measuring real-time concentrations of many organic and inorganic vapors in the air. The PID is similar in application to a flame ionization detector (FID) but the PID is incapable of detecting low molecular weight hydrocarbons such as methane and ethane. The user must select the appropriate instrument capable of detecting the compounds of concern.

The PID employs the principle of photoionization to detect organic and inorganic vapors with ionization potentials less than or equal to the ionization potential provided by the UV lamp. Photoionization occurs when a molecule absorbs a photon of sufficient energy to release an electron and form a positive ion. This will occur when the ionization potential of the molecule is less than the energy provided by the UV lamp. The PID employs a sealed UV light source that emits photons with an energy level high enough to ionize many trace organic and inorganic compounds but not sufficient to ionize the major components of air. Several UV lamps are available for the PID producing different eV ionization potentials. Attachment 1 includes a list of chemicals and their eV ionization potentials. Gases with an ionization potential less than the potential of the UV lamp will be ionized and measured by the PID. Gases with an ionization potential greater than the potential of the lamp will not be detected.

Though the PID can be calibrated to a particular compound, usually isobutylene, the PID cannot distinguish between detectable compounds in a mixture of vapors and indicates an integrated response to the mixture.

3.0 WARNING AND SAFETY CONSIDERATIONS

1. The instrument is intrinsically safe; however, certain procedures such as changing the battery pack and calibration of the instrument must not be preformed in locations where flammable concentrations of gases or vapors may exist.

2. Certain toxic compounds may have ionization potentials greater than the UV lamp and cannot be detected with a PID.

3. The calibration gas is in a compressed gas cylinder and must be handled with care.

4. When calibrating the PID, adequate ventilation must be provided to prevent threshold limit values (TLV) from being exceeded.

5. Exposure of the instrument to prolonged intense sunlight, excessive heat, or excessive moisture may result in erroneous readings.

6. Exposure of the instrument to wet or humid environments may result in erroneous readings.

7. Do not use the instrument where liquids can inadvertently be drawn into the probe.

4.0 EQUIPMENT LIST

1. Spare battery pack (fully charged)
2. Sample tubing
3. In line filters
4. Calibration regulator
5. Calibration gas
6. AC adapter
7. PID

These items are stored in the carrying case, however it is the responsibility of the user to check to make sure that all items are present, and that the batteries are fully charged prior to going to the field.

5.0 CALIBRATION

The instrument is normally calibrated using a calibration gas cylinder of isobutylene at 100 ppm. The instrument can be calibrated with a particular

compound of interest or a response may be programmed into the instrument if the response factor of a compound of interest is known. The instrument can store calibration information for different calibration gases. Refer to the manufacturer's instrument manual for detailed instructions pertaining to calibration using response factors and calibration gases other than isobutylene.

6.0 OPERATION

Once the instrument is calibrated, it is ready to sample. The reading displayed is the total VOCs being detected by the PID. If the power to the instrument is shut off, the instrument will need to be re-calibrated prior to use. The pump can be shut off between readings to extend battery life. The probe assembly of the PID should be positioned close to the area to be monitored as the low sampling rate only allows for localized readings. Under no circumstances should the probe tip be immersed in liquid. The PID survey should be conducted at a moderately slow rate of speed and the intake probe slowly swept from side to side. There may be a three to five second delay in the read-out depending upon the instrument pump and sensitivity to the vapor. During drilling and probing activities, PID monitoring should be performed at regular intervals at the borehole, and breathing zone. The PID should be periodically checked against the calibration standard after approximately 20 samples or at any time readings are suspected to be inaccurate. The PID may provide artificially high readings for a short time following highly contaminated samples. All readings should be recorded in the site logbook. At the end of the day, the outside of the PID should be carefully cleaned of any visible dirt with a damp disposable towel.

Accurate results depend on the operator being completely familiar with the manufacturer's operator's manual. The instructions in the operator's manual should be explicitly followed in order to obtain accurate results. For more detailed instruction and other applications of the PID such as using response factors, data logging, direct printing of data, and downloading data to a computer, refer to the manufacturer's operator's manual.

7.0 MAINTENANCE

7.1 BATTERY CHARGING

A fully charged battery pack powers the instrument for approximately 8 hours. When the low battery indicator is displayed, approximately 30 minutes of operation time is left. The instrument will shut itself off before the battery pack becomes critically low. The battery pack is recharged by either using an AC adapter or an off line charger. To charge the battery pack using the AC adapter, plug the AC adapter into the jack located on the back of the instrument, then plug the AC adapter into an AC outlet. The red LED indicates that the battery is being charged, and the green

LED indicates that the battery is fully charged and ready for use. To charge the battery pack using the off line charger, the battery pack is removed from the instrument and plugged into the charger until the green LED is lit, indicating that the battery is fully charged.

7.2 MAINTENANCE OF THE UV LAMP

1. To replace the UV lamp: turn off the instrument, remove the lamp housing cover with the multi-tool, tilt the instrument slightly, and remove the lamp. **Do not touch the wire grid inside the detector cell. Use a gentle jet of compressed air to blow out any dust or dirt in the detector cell.** Without touching the lamp window, place the new lamp into the lampholder. Replace the old O-ring and lamp spring with the ones supplied with the replacement lamp. Replace the lamp housing cover being careful not to over tighten.

2. To clean the film that builds up on the window of the lamp: Remove the lamp and make sure that it is at room temperature. Dab a cotton swab that has been damped with methanol into the cleaning compound from the cleaning kit. For approximately one minute, gently rub the cleaning compound onto the lamp window using a circular motion. Wipe the window and lamp with a dry, lint free tissue, removing all the cleaning compound and methanol. Replace the lamp into the instrument. Never use methanol to clean the eV Lamp. To clean the e V lamp use the cleaning compound on a dry cotton swab.

7.3 TO REPLACE THE SAMPLE INLET FILTER

Turn off the instrument; unscrew the filter housing from the detector housing, being careful not to lose the O-ring seal; remove the old filter; place the new filter in the filter housing with the polypropylene mesh side facing the instrument; and replace the filter housing.

8.0 REFERENCES

SOP #2114: Photoionization Detector (PID) HNU, U.S. Environmental Protection Agency - Environmental Response Team, 1994

SOP 5: Field Measurements of Organic Vapors, California Department of Toxic Substances Control, 2008

Field Screening Methods Catalog, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, 1988

ATTACHMENT 1: Ionization Potentials (IP eV)

Compound	IP (eV)	GC	PID	FID	Compound	IP (eV)	GC	PID	FID
Acetaldehyde	*10.21*	*X*	*X*	*X*	*3-Bromopropene*	*9.70*	*X*	*X*	*X*
Acetic Acid	*10.37*		*X*	*X*	*2-Bromothiophene*	*8.63*	*X*	*X*	*X*
Acetone	*9.69*	*X*	*X*	*X*	*o-Bromotoluene*	*8.79*	*X*	*X*	*X*
*Acetonitrile**	*12.20*	*X*		*X*	*m-Bromotoluene*	*8.81*	*X*	*X*	*X*
*Acetylene**	*11.41*	*X*	*X*	*X*	*p-Bromotoluene*	*8.67*	*X*	*X*	*X*
Acetylene Dichloride	*9.80*	*X*		*X*	*1,3-Butadene*	*9.07*	*X*	*X*	*X*
Acetylene Tetrabromide	*n.p.*		*X*	*X*	*2,3-Butadione*	*9.23*	*X*	*X*	*X*
Acrolein	*10.10*	*X*	*X*	*X*	*n-Butanal*	*9.83*	*X*	*X*	*X*
Acrylonitrile	*10.91*	*X*	*X*	*X*	*2-Butanal*	*9.73*	*X*	*X*	*X*
Allene	*9.83*	*X*	*X*	*X*	*n-Butane*	*10.63*	*X*	*X*	*X*
Allyl Alcohol	*9.67*	*X*	*X*	*X*	*2-Butanone*	*9.53*	*X*	*X*	*X*
Allyl Chloride	*10.20*	*X*	*X*	*X*	*iso-Butanol*	*10.47*	*X*	*X*	*X*
Aminoethanol	*9.87*	*X*	*X*	*X*	*sec-Butanol*	*10.23*	*X*	*X*	*X*
2-Aminopyridine	*8.34*		*X*	*X*	*tert-Butanol*	*10.25*	*X*	*X*	*X*
Ammonia	*10.15*	*X*	*X*		*1-Butene*	*9.58*	*X*	*X*	*X*
n-Amyl Acetate	*n.p.*	*X*	*X*	*X*	*cis-2-Butene*	*9.13*	*X*	*X*	*X*
sec-Amyl Acetate	*n.p.*	*X*	*X*	*X*	*trans-2-Butene*	*9.13*	*X*	*X*	*X*
Aniline	*7.70*		*X*	*X*	*n-Butyl Acetate*	*10.01*	*X*	*X*	*X*
Arsine	*9.89*	*X*	*X*		*sec-Butyl Acetate*	*9.91*	*X*	*X*	*X*
Benzaldehyde	*9.53*	*X*	*X*	*X*	*t-Butyl Acetate*	*9.90*	*X*	*X*	*X*
Benzene	*9.25*	*X*	*X*	*X*	*n-Butyl Alcohol*	*10.04*	*X*	*X*	*X*
Benzenethiol	*8.33*	*X*	*X*	*X*	*n-Butylmine*	*8.71*		*X*	*X*
Benzyl Chloride	*9.14*	*X*	*X*	*X*	*i-Butylmine*	*8.70*		*X*	*X*
Bromobenzene	*8.98*	*X*	*X*	*X*	*s-Butylamine*	*8.70*		*X*	*X*
1-Bromobutane	*10.13*	*X*	*X*	*X*	*t-Butylamine*	*8.64*		*X*	*X*
2-Bromobutane	*9.98*	*X*	*X*	*X*	*n-Butylbenzene*	*8.69*	*X*	*X*	*X*
1-Bromobuanone	*9.54*	*X*	*X*	*X*	*i-Butylbenzene*	*8.68*	*X*	*X*	*X*
1-Bromo-2-chloroethane	*10.63*	*X*	*X*	*X*	*t-Butylbenzene*	*8.68*	*X*	*X*	*X*
Bromochloromethane	*10.77*	*X*		*X*	*Butyl Cellosolve®*	*8.68*	*X*	*X*	*X*
Bromodichloromethane	*10.59*	*X*	*X*	*X*	*i-Butyl Ethanoate*	*9.95*	*X*	*X*	*X*
1-Bromo-3-chloropropane	*n.p.*	*X*	*X*	*X*	*n-Butyl Mercaptan*	*9.15*	*X*	*X*	*X*
Bromoethane	*10.28*	*X*	*X*	*X*	*t-Butyl Mercaptan*	*9.03*	*X*	*X*	*X*
Bromoethene	*9.80*	*X*	*X*	*X*	*iso-Butyl Mercaptan*	*9.12*	*X*	*X*	*X*
Bromoform	*10.48*	*X*	*X*	*X*	*i-Butyl Methanoate*	*10.46*	*X*	*X*	*X*
1-Bromo-3-hexone	*9.26*	*X*	*X*	*X*	*p-tert-Butyltoluene*	*8.35*	*X*	*X*	*X*
Bromomethane(Methyl Bromide)	*10.53*	*X*	*X*	*X*	*1-Butyne*	*10.18*	*X*	*X*	*X*
Bromomethyl Ethyl Ether	*10.08*	*X*	*X*	*X*	*2-Butyne*	*9.85*	*X*	*X*	*X*
1-Bromo-2-methylpropane	*10.09*	*X*	*X*	*X*	*n-Butyraldehyde*	*9.86*	*X*	*X*	*X*
2-Bromo-2-methylpropane	*9.89*	*X*	*X*	*X*	*Carbon Disulfide*	*10.13*	*X*	*X*	

Compound	IP (eV)	GC	PID	FID	Compound	IP (eV)	GC	PID	FID
1-Bromopentane	*10.10*	*X*	*X*	*X*	*Carbon Tetrachloride**	*11.28*	*X*	*X*	*X*
1-Bromopropane	*10.18*	*X*	*X*	*X*	*Cellosolve Acetate*	*n.p.*	*X*	*X*	*X*
2-Bromopropane	*10.08*	*X*	*X*	*X*	*Chloroacetaldehyde*	*10.16*	*X*	*X*	*X*
1-Bromopropene	*9.30*	*X*	*X*	*X*	*Chlorobenzene*	*9.07*	*X*	*X*	*X*
2-Bromopropene	*10.06*	*X*	*X*	*X*	*Chlorobromomethane*	*10.77*	*X*		*X*
1-Chloro-2-bromoethane	*10.63*	*X*	*X*	*X*	*1,3-Dibromobutane*	*n.p.*	*X*	*X*	*X*
1-Chlorobutane	*10.67*	*X*	*X*	*X*	*1,4-Dibromobutane*	*n.p.*	*X*	*X*	*X*
2-Chlorobutane	*10.65*	*X*	*X*	*X*	*Dibromochloromethane*	*10.59*	*X*	*X*	*X*
1-Chlorobutanone	*9.54*	*X*	*X*	*X*	*Dibromochloropropane*	*n.p.*	*X*	*X*	*X*
1-Chloro-2,3-epoxypropane	*10.60*	*X*	*X*	*X*	*1,1-Dibromoethane*	*10.19*	*X*	*X*	*X*
Chloroethane(Ethyl Chloride)	*10.97*	*X*		*X*	*Dibromomethane*	*10.49*	*X*	*X*	*X*
Chloroethene(Vinyl Chloride)	*10.00*	*X*	*X*	*X*	*1,2-Dibromopropane*	*10.26*	*X*	*X*	*X*
2-Chloroethoxythene	*10.61*	*X*	*X*	*X*	*2,2-Dibromopropane*	*n.p.*	*X*	*X*	*X*
1-Chloro-2-fluorobenzene	*9.16*	*X*	*X*	*X*	*Dibutylamine*	*7.69*		*X*	*X*
1-Chloro-3-fluorobenzene	*9.21*	*X*	*X*	*X*	*1,2-Dichlorobenzene*	*9.07*	*X*	*X*	*X*
cis-1-Chloro-2-fluoroethene	*9.87*	*X*	*X*	*X*	*1,3-Dichlorobutane**	*n.p.*	*X*	*X*	*X*
trans-1-Chloro-2-fluoroethene	*9.87*	*X*	*X*	*X*	*1,4-Dichlorobutane**	*n.p.*	*X*	*X*	*X*
*Chloroform**	*11.37*	*X*	*X*	*X*	*cis-1,4-Dichloro-2-butene*	*n.p.*	*X*	*X*	*X*
o-Chloroiodobenzene	*8.35*	*X*	*X*	*X*	*2,2-Dichlorobutane**	*n.p.*	*X*	*X*	*X*
Chloromethylethyl Ether	*10.08*	*X*	*X*	*X*	*2,3-Dichlorobutane**	*n.p.*	*X*	*X*	*X*
Chloromethylmethyl Ether	*10.25*	*X*	*X*	*X*	*3,4-Dichlorobutane**	*n.p.*	*X*	*X*	*X*
1-Chloro-2-methylpropane	*10.66*	*X*	*X*	*X*	*1,1-Dichloroethane**	*11.06*	*X*	*X*	*X*
Chloroprene	*8.83*	*X*	*X*	*X*	*1,2 Dichloroethane (Ethylene Dichloride)**	*11.04*	*X*	*X*	*X*
*1-Chloropropane**	*10.82*	*X*	*X*	*X*	*cis-1,2-Dichloroethene*	*9.65*	*X*	*X*	*X*
*2-Chloropropane**	*10.78*	*X*	*X*	*X*	*trans-1,2-Dichloroethene*	*9.66*	*X*	*X*	*X*
3-Chloroproene	*10.04*	*X*	*X*	*X*	*1,1-Dichloroethene*	*10.00*	*X*	*X*	*X*
p-Chlorostyrene	*n.p.*	*X*	*X*	*X*	*Dichloroethyl Ether*	*n.p.*	*X*	*X*	*X*
2-Chlorothiophene	*8.68*	*X*	*X*	*X*	*Dichloromethane (Methylene Chloride)**	*11.35*	*X*	*X*	*X*
o-Chlorotoluene	*8.83*	*X*	*X*	*X*	*1,2-Dichloropropane**	*10.87*	*X*	*X*	*X*
m-Chlorotoluene	*8.83*	*X*	*X*	*X*	*1,3-Dichloropropane**	*10.85*	*X*	*X*	*X*
p-Chlorotoluene	*8.70*	*X*	*X*	*X*	*1,1-Dichloropropanone*	*9.71*	*X*	*X*	*X*
o-Cresol	*8.48*		*X*	*X*	*2,3-Dichloropropene*	*9.82*	*X*	*X*	*X*
m-Cresol	*8.48*		*X*	*X*	*Dicyclopentadiene*	*7.74*	*X*	*X*	*X*
p-Cresol	*8.48*		*X*	*X*	*Diethoxymethane*	*9.70*	*X*	*X*	*X*
Cumene (i-Propyl Benzene)	*8.75*	*X*	*X*	*X*	*Diethylamine*	*8.01*		*X*	*X*
Crotonaldehyde	*9.73*	*X*	*X*	*X*	*Diethylaminoethanol*	*8.58*		*X*	*X*
*Cyanoethene**	*10.91*	*X*	*X*	*X*	*Diethyl Ether*	*9.53*	*X*	*X*	*X*
*Cyanogen Bromide**	*10.91*	*X*	*X*		*Diethyl Ketone*	*9.32*	*X*	*X*	*X*

Compound	IP (eV)	GC	PID	FID	Compound	IP (eV)	GC	PID	FID
3-Cyanopropene	*10.39*	*X*	*X*	*X*	*Diethyl Sulfide*	*8.43*	*X*	*X*	*X*
Cyclobutane	*10.50*	*X*	*X*	*X*	*1,2-Difluorobenzene*	*9.31*	*X*	*X*	*X*
Cyclohexane	*9.98*	*X*	*X*	*X*	*1,4-Difluorobenzene*	*9.15*	*X*	*X*	*X*
Cyclohexanol	*10.00*	*X*	*X*	*X*	*Difluorodibromomethane**	*11.18*	*X*		*X*
Cyclohexanone	*9.14*	*X*	*X*	*X*	*Difluoromethylbenzene*	*9.45*	*X*	*X*	*X*
Cyclohexene	*8.95*	*X*	*X*	*X*	*Diiodomethane*	*9.34*	*X*	*X*	*X*
Cyclo-octatetraene	*7.99*	*X*	*X*	*X*	*Diisobutyl Ketone*	*9.04*	*X*	*X*	*X*
Cyclopentadiene	*8.55*	*X*	*X*	*X*	*Diisopropylamine*	*7.73*		*X*	*X*
Cyclopentane	*10.52*	*X*	*X*	*X*	*1,1-Dimethozyethane*	*9.65*	*X*	*X*	*X*
Cyclopentanone	*9.26*	*X*	*X*	*X*	*Dimethozymethane*	*10.00*	*X*	*X*	*X*
Cyclopentene	*9.01*	*X*	*X*	*X*	*Dimethylamine*	*8.24*		*X*	*X*
Cyclopropane	*10.06*	*X*	*X*	*X*	*Dimethylaniline*	*7.13*		*X*	*X*
2-Decanone	*9.40*	*X*	*X*	*X*	*2,3-Dimethylbutadiene*	*8.72*	*X*	*X*	*X*
Diacetone Alcohol	*n.p.*	*X*	*X*	*X*	*2,2-Dimethylbutane*	*10.06*	*X*	*X*	*X*
2,2-Dimethylbutan-3-one	*9.18*	*X*	*X*	*X*	*mono-Fluorobenzene*	*9.20*	*X*	*X*	*X*
2,3-Dimethylbutane	*10.02*	*X*	*X*	*X*	*mono-Fluoroethene*	*10.37*	*X*	*X*	*X*
2,3-Dimethyl-2-butene	*8.30*	*X*	*X*	*X*	*mono-Fluoromethanal*	*11.40*	*X*	*X*	*X*
3,3-Dimethylbutanone	*9.17*	*X*	*X*	*X*	*Fluorotribromomethane*	*10.67*	*X*	*X*	*X*
Dimethyl Disulfide	*8.46*	*X*	*X*	*X*	*o–Fluorotoluene*	*8.92*	*X*	*X*	*X*
Dimethyl Ether	*10.00*	*X*	*X*	*X*	*m-Fluorotoluene*	*8.92*	*X*	*X*	*X*
Dimethylformamide	*9.45*		*X*	*X*	*p-Fluorotoluene*	*8.79*	*X*	*X*	*X*
3,5-Dimethyl-4-heptanone	*9.04*	*X*	*X*	*X*	*Formaldehyde*	*10.88*	*X*		
1,1-Dimethylhydrazine	*8.88*		*X*	*X*	*Freon 11 (Fluorotrichloromethane)*	*11.77*	*X*		*X*
2,2-dimethyl-3-pentanone	*8.98*	*X*	*X*	*X*	*Freon 12 (Dichlorodifluoromethane)*	*12.91*	*X*		*X*
2,2-Dimethylpropane	*10.35*	*X*	*X*	*X*	*Freon 13 (Chlorotrifluoromethane)*	*12.91*	*X*		*X*
Dimethyl Sulfide	*8.69*	*X*	*X*	*X*	*Freon 13 B-1 (Bromotrifluoromethane)*	*12.08*	*X*		*X*
Di-n-propyl Disulfide	*8.27*	*X*	*X*	*X*	*Freon 14 (Carbon Tetrafluoride)*	*16.25*	*X*		*X*
Di-n-propyl Ether	*9.27*	*X*	*X*	*X*	*Freon 21 (Dichlorofluoromethane)*	*12.00*	*X*		*X*
Di-i-propyl Ether	*9.20*	*X*	*X*	*X*	*Freon 22 (Chlorodifluoromethane)*	*12.45*	*X*		*X*
Di-n-propylamine	*7.84*		*X*	*X*	*Freon 113 (1,2-Dichlorotrifluoroethane)*	*11.78*	*X*		*X*
Di-n-propyl Sulfide	*8.30*	*X*	*X*	*X*	*Furan*	*8.89*	*X*	*X*	*X*
1,4-Dioxane	*9.41*	*X*		*X*	*Furfuryl Alcohol*	*n.p.*	*X*	*X*	*X*
Epichlorohydrin	*10.60*	*X*	*X*	*X*	*furfural*	*9.21*	*X*	*X*	*X*
*Ethane**	*11.65*	*X*	*X*	*X*	*n-Heptane*	*10.07*	*X*	*X*	*X*
Ethanol	*10.62*	*X*	*X*	*X*	*2-Heptanone*	*9.33*	*X*	*X*	*X*
Ethanolamine	*9.87*		*X*	*X*	*4-Heptanone*	*9.12*	*X*	*X*	*X*

Compound	IP (eV)	GC	PID	FID	Compound	IP (eV)	GC	PID	FID
Ethanethiol (Ethyl Mercaptan)	*9.29*	*X*	*X*	*X*	*n-Hexane*	*10.18*	*X*	*X*	*X*
Ethene(Ethylene)	*10.52*	*X*	*X*	*X*	*Hexanone*	*n.p.*	*X*	*X*	*X*
Ethyl Acetate	*10.11*	*X*	*X*	*X*	*2-Heanone*	*9.44*	*X*	*X*	*X*
Ethyl Acrylate	*n.p.*	*X*	*X*	*X*	*1-Hexene*	*9.46*	*X*	*X*	*X*
Ethylamine	*8.86*		*X*	*X*	*sec-Hexyl Acetate*	*n.p.*		*X*	*X*
Ethyl Amyl Ketone	*9.10*	*X*	*X*	*X*	*Hydrazine*	*n.p.*	*X*	*X*	*X*
Ethylbenzene	*8.76*	*X*	*X*	*X*	*Hydrogen Selenide*	*9.88*	*X*	*X*	
Ethyl Bromide	*10.29*	*X*	*X*	*X*	*Hydrogen Sulfide*	*10.46*	*X*	*X*	
Ethyl Butyl Ketone	*9.02*	*X*	*X*	*X*	*Hydrogen Telluride*	*9.14*	*X*	*X*	
Ethyl Chloride	*11.01*	*X*		*X*	*Iodobenzene*	*8.73*	*X*	*X*	*X*
Ethyl Chloroacetate	*10.20*	*X*	*X*	*X*	*1-Iodobutane*	*9.21*	*X*	*X*	*X*
Ethyl Ethanoate	*10.10*	*X*	*X*	*X*	*2-Iodobutane*	*9.09*	*X*	*X*	*X*
Ethyl Ether	*9.41*	*X*	*X*	*X*	*Iodoethane (Ethyl Iodide)*	*9.33*	*X*	*X*	*X*
Ethyl Disulfide	*8.27*	*X*	*X*	*X*	*Iodomethane (Methyl Iodide)*	*9.54*	*X*	*X*	*X*
Ethylene Chlorohydrin	*10.90*	*X*	*X*	*X*	*1-Iodo-2-methylpropane*	*9.18*	*X*	*X*	*X*
Ethylene Dibromide (EDB)	*10.37*	*X*	*X*	*X*	*1-Iodo-2-methylpropane*	*9.02*	*X*	*X*	*X*
Ethylene Oxide	*10.56*	*X*	*X*	*X*	*1-Iodopentane*	*9.19*	*X*	*X*	*X*
Ethyl Formate	*10.61*	*X*	*X*	*X*	*1-Iodopropane*	*9.26*	*X*	*X*	*X*
Ethyl Iodide	*9.33*	*X*	*X*	*X*	*2-Iodopropane*	*9.17*	*X*	*X*	*X*
Ethyl Mercaptan	*9.29*	*X*	*X*	*X*	*o-Iodotoluene*	*8.62*		*X*	*X*
Ethyl Methanoate	*10.61*	*X*	*X*	*X*	*m-Iodotoluene*	*8.61*		*X*	*X*
Ethyl Isothiocyanate	*9.14*	*X*	*X*	*X*	*p-Iodotoluene*	*8.50*		*X*	*X*
Ethyl Methyl Sulfide	*8.55*	*X*	*X*	*X*	*Isoamyl Acetate*	*9.90*	*X*	*X*	*X*
Ethyl Propanoate	*10.00*	*X*	*X*	*X*	*Isoamyl Alcohol*	*10.16*	*X*	*X*	*X*
Ethyl Trichloroacetate	*10.44*	*X*	*X*	*X*	*Isobutane*	*10.57*	*X*	*X*	*X*
Isobutylamine	*8.70*		*X*	*X*	*Methyl Isobutyl Ketone(MIBK)*	*9.30*	*X*	*X*	*X*
Isobutyl Acetate	*9.97*	*X*	*X*	*X*	*Methyl Isobutyrate*	*9.98*	*X*	*X*	*X*
Isobutyl Alcohol	*10.47*	*X*	*X*	*X*	*Methyl Isocyanate*	*10.67*		*X*	*X*
Isobutyl Formate	*10.46*	*X*	*X*	*X*	*1-Methyl-4-isopropylbenzene*	*n.p.*	*X*	*X*	*X*
Isobutylene	*9.43*	*X*	*X*	*X*	*Methyl Isopropyl Ketone*	*9.32*	*X*	*X*	*X*
Isobutyraldehyde	*9.74*	*X*	*X*	*X*	*Methyl Mercaptan (Methanethiol)*	*9.44*	*X*	*X*	*X*
Isopentane	*10.32*	*X*	*X*	*X*	*Methyl Methacrylate*	*9.74*	*X*	*X*	*X*
Isoprene	*8.85*	*X*	*X*	*X*	*Methyl Methanoate*	*10.82*	*X*		*X*
Isoprooyl Acetate	*9.99*	*X*	*X*	*X*	*2-Methylpentane*	*10.12*	*X*	*X*	*X*
Isopropyl Alcohol	*10.16*	*X*	*X*	*X*	*3-Methylpentane*	*10.08*	*X*	*X*	*X*
Isopropylamine	*8.72*		*X*	*X*	*2-Methylpropane*	*10.56*	*X*	*X*	*X*
Isopropylbenzene	*8.75*	*X*	*X*	*X*	*2-Methylpropanal*	*9.74*	*X*	*X*	*X*
Isopropyl Ether	*9.20*	*X*	*X*	*X*	*2-Methyl-2-propanol*	*9.70*	*X*	*X*	*X*
Isovaleraldehyde	*9.71*	*X*	*X*	*X*	*2-Methylpropene*	*9.23*	*X*	*X*	*X*

Compound	IP (eV)	GC	PID	FID	Compound	IP (eV)	GC	PID	FID
Ketene	*9.61*	*X*	*X*	*X*	*Methyl n-propyl Ketone*	*9.39*	*X*	*X*	*X*
Mesitylene	*8.40*	*X*	*X*	*X*	*Methyl Styrene*	*8.35*	*X*	*X*	*X*
Mesityl Oxide	*9.08*	*X*	*X*	*X*	*Monomethyl Hydrazine*	*8.00*	*X*	*X*	*X*
Methane	*12.98*	*X*		*X*	*Naphthalene*	*8.10*	*X*	*X*	*X*
*Methanol**	*10.85*	*X*		*X*	*Nitric Oxide*	*9.25*	*X*	*X*	
Methyl Acetate	*10.27*	*X*	*X*	*X*	*Nitrobenzene*	*9.92*		*X*	*X*
Methyl Acrylate	*10.72*	*X*		*X*	*p-Nitrochlorobenzene*	*9.96*		*X*	*X*
Methylamine	*8.87*		*X*	*X*	*n-Nonane*	*10.21*	*X*	*X*	*X*
Methyl Bromide (Bromomethane)	*10.53*	*X*	*X*	*X*	*5-Nonanone*	*9.10*	*X*	*X*	*X*
2-Methyl-1,3-butadiene	*8.85*	*X*	*X*	*X*	*n-Octane*	*10.24*	*X*	*X*	*X*
2-Methylbutanal	*9.71*	*X*	*X*	*X*	*3-Octanone*	*9.19*	*X*	*X*	*X*
2-Methylbutane	*10.31*	*X*	*X*	*X*	*4-Octanone*	*9.10*	*X*	*X*	*X*
2-Methyl-1-butene	*9.12*	*X*	*X*	*X*	*1-Octene*	*9.52*	*X*	*X*	*X*
3-Methyl-1-butene	*9.51*	*X*	*X*	*X*	*n-Pentane*	*10.53*	*X*	*X*	*X*
3-Methyl-2-butene	*8.67*	*X*	*X*	*X*	*cis-1,3-Pentadiene*	*8.59*	*X*	*X*	*X*
Methyl tert-Butyl Ether	*9.41*	*X*	*X*	*X*	*trans-1,3-Pentadiene*	*8.56*	*X*	*X*	*X*
Methyl n-Butyl Ketone	*9.34*	*X*	*X*	*X*	*n-Pentanal*	*9.82*	*X*	*X*	*X*
Methyl Butyrate	*10.07*	*X*	*X*	*X*	*2,4-Pentanedione*	*8.87*	*X*	*X*	*X*
Methyl Cellosolve	*n.p.*	*X*	*X*	*X*	*2-Pentanone*	*9.39*	*X*	*X*	*X*
Methyl Cellosolve Acetate	*n.p.*	*X*	*X*	*X*	*3-Pentanone*	*9.32*	*X*	*X*	*X*
Methyl Chloroacetate	*10.35*	*X*	*X*	*X*	*1-Pentene*	*9.50*	*X*	*X*	*X*
*Methylchloroform (1,1,1-TCA)**	*11.25*	*X*	*X*	*X*	*Perfluoro-2-butene**	*11.25*	*X*		*X*
Methylcyclohexane	*9.85*	*X*	*X*	*X*	*Perfluoro-1-heptene*	*10.48*	*X*	*X*	*X*
Methylcyclohexanol	*9.80*	*X*	*X*	*X*	*n-Perfluoropropyl Iodide*	*10.36*		*X*	*X*
Methlcyclohexanone	*9.05*	*X*	*X*	*X*	*n-Perfluoropropyl-iodomethane*	*9.96*	*X*	*X*	*X*
4-Methylcyclohexene	*8.91*	*X*	*X*	*X*	*n-Perfluoropropyl-methyl Ketone*	*10.58*	*X*	*X*	*X*
Methylcyclopropane	*9.52*	*X*	*X*	*X*	*Phenol*	*8.69*		*X*	*X*
Methyl Dichloroacetate	*10.44*	*X*	*X*	*X*	*Phenyl Ether*	*8.09*	*X*	*X*	*X*
Methyl Ethanoate	*10.27*	*X*	*X*	*X*	*Phenyl Isocyanate*	*8.77*	*X*	*X*	*X*
Methyl Ethyl Ketone (MEK)	*9.53*	*X*	*X*	*X*	*Phosphine*	*9.96*	*X*	*X*	
Methyl Ethyl Sulfide	*8.55*	*X*	*X*	*X*	*Pinene*	*8.07*	*X*	*X*	*X*
2-Methyl Furan	*8.39*	*X*	*X*	*X*	*Propadiene*	*10.19*	*X*	*X*	*X*
Methyl Iodide	*9.54*	*X*	*X*	*X*	*n-Propanal*	*9.95*	*X*	*X*	*X*
*Propane**	*11.07*	*X*	*X*	*X*	*1,2,3-Trichloropropane*	*n.p.*	*X*	*X*	*X*
1-Propanethiol	*9.20*	*X*	*X*	*X*	*Triethylamine*	*7.50*	*X*	*X*	*X*
n-Propanol	*10.51*	*X*	*X*	*X*	*1,2,4-Trifluorobenzene*	*9.37*	*X*	*X*	*X*
Propanone	*9.69*	*X*	*X*	*X*	*1,3,5-Trifluorobenzene*	*9.32*	*X*	*X*	*X*
Propene	*9.73*	*X*	*X*	*X*	*Trifluoroethene*	*10.14*	*X*	*X*	*X*

Compound	IP (eV)	GC	PID	FID	Compound	IP (eV)	GC	PID	FID
Prop-1-ene-2-ol	*8.20*	*X*	*X*	*X*	*1,1,1-Trifluoro-2-iodoethane*	*10.10*	*X*	*X*	*X*
Prop-2-ene-1-ol	*9.67*	*X*	*X*	*X*	*Trifluoroiodomethane*	*10.40*	*X*	*X*	*X*
Propionaldehyde	*9.98*	*X*	*X*	*X*	*Trifluoromethylbenzene*	*9.68*	*X*	*X*	*X*
n-Propyl Acetate	*10.04*	*X*	*X*	*X*	*Trifluoromethylcyclohexane*	*10.46*	*X*	*X*	*X*
n-Propyl Alcohol	*10.20*	*X*	*X*	*X*	*1,1,1-Trifluoropropene*	*10.90*	*X*	*X*	*X*
n-Propylamine	*8.78*		*X*	*X*	*Trimethylamine*	*7.82*	*X*	*X*	*X*
n-Propylbenzene	*8.72*	*X*	*X*	*X*	*2,2,4-Trimethyl Pentane*	*9.86*	*X*	*X*	*X*
Propylene	*9.73*	*X*	*X*	*X*	*2,2,4-Trimethyl-3-pentanone*	*8.82*	*X*	*X*	*X*
Propylene Dichloride	*10.87*	*X*	*X*	*X*	*n-Valeraldehyde*	*9.82*	*X*	*X*	*X*
Propylene Imine	*8.76*	*X*	*X*	*X*	*Vinyl Acetate*	*9.19*	*X*	*X*	*X*
Propylene Oxide	*10.22*	*X*	*X*	*X*	*Vinyl Bromide*	*9.80*	*X*	*X*	*X*
n-Propyl Ether	*9.27*	*X*	*X*	*X*	*Vinyl Chloride (Chloroethene)*	*10.00*	*X*	*X*	*X*
n-Propyl Formate	*10.54*	*X*	*X*	*X*	*4-Vinylcyclohexene*	*8.93*	*X*	*X*	*X*
Propyne	*10.36*	*X*	*X*	*X*	*Vinyl Ethanoate*	*9.19*	*X*	*X*	*X*
Pyridine	*9.32*		*X*	*X*	*Vinyl Fluoride*	*10.37*	*X*	*X*	*X*
Styrene	*8.47*	*X*	*X*	*X*	*Vinylidene Chloride (1,1-DCE)*	*10.00*	*X*	*X*	*X*
Tetrabromoethane	*n.p.*	*X*	*X*	*X*	*Vinyl Methyl Ether*	*8.93*	*X*	*X*	*X*
Tetrachloroethylene (PCE)	*9.32*	*X*	*X*	*X*	*o-Vinyl Toluene*	*8.20*		*X*	*X*
1,1,1,2-Tetrachloropropane	*n.p.*	*X*	*X*	*X*	*o-Xylene*	*8.56*	*X*	*X*	*X*
1,1,2,2-Tetrachloropropane	*11.10*	*X*	*X*	*X*	*m-Xylene*	*8.56*	*X*	*X*	*X*
Tetrafluoroethene	*10.12*	*X*	*X*	*X*	*p-Xylene*	*8.45*	*X*	*X*	*X*
Tetrahydrofuran	*9.54*	*X*	*X*	*X*	*2,4-Xylidine*	*7.65*		*X*	*X*
1,1,1,2-Tetrachloropropane	*n.p.*	*X*	*X*	*X*	*Trichloroethylene (TCE)*	*9.45*	*X*	*X*	*X*
*1,1,2-Trichloroethane**	*11.00*	*X*	*X*	*X*	*Trichloromethyl Ethyl Ether*	*10.08*	*X*	*X*	*X*

** The sensitivity of these compounds are enhanced using an 11 eV lamp instead of the standard 10.6 eV lamp.*

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STANDARD OPERATING PROCEDURE – BER-32

ACQUISITION OF LOCATION DATA USING GLOBAL POSITION SYSTEM (GPS) GENERAL PRACTICE FOR HAND HELD UNITS

Effective Date: August 14, 2000
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ATTACHMENT 1 Available Gps Unit List
ATTACHMENT 2 Data Collection Form

DISCLAIMER:

This Standard Operating Procedure (SOP) was developed based on a compilation of best available information, knowledge, field experience, and general industry practices to provide guidance to KDHE staff in performing the activities defined herein, in a consistent and standardized manner. This document does not contain regulatory or statutory requirements unless specified.

KDHE has made every attempt to present the information in a clear and concise manner for a variety of users. However, KDHE is not responsible for the misuse or misinterpretation of the information presented herein. Under no circumstances shall KDHE be liable for any actions taken or omissions made by non-KDHE users of this document.

In general, this document should be used as a reference. Differences may exist between the procedures referenced in this document and what is appropriate under site-specific conditions. This document does not represent an endorsement of practitioners or products mentioned in the document.

1.0 PURPOSE

This document is to provide the user of handheld global positioning system (GPS) units with the guidance required to collect, edit and report consistent, reliable, and repeatable geospatial data sets (latitude and longitude) for use within the Kansas Department of Health and Environment (KDHE), Bureau of Environmental Remediation (BER). Intended audiences for which this document was prepared include BER staff involved with the planning and conducting of GPS surveys as well as BER staff involved with processing and reporting the collected data sets.

2.0 APPLICABILITY

This document is a general use Standard Operating Procedure (SOP) to be used for handheld GPS units and is not to be used as a SOP for specific brands of GPS models.

3.0 DEFINITIONS AND ACRONYMS

Accuracy: How close a fix comes to the actual position.

Acquisition: The ability to find and lock on to satellite signals for ranging.

Autonomous GPS: A single receiver GPS unit which collects uncorrected positions calculated by the receiver using code measurements.

Average Position Waypoint Collection: A function on most handheld GPS receivers that allows the user to average position samples overtime and save the averaged result as a waypoint. Averaging reduces the effects of position error that results in a more accurate position reading.

Continuously Operated Reference Station (CORS): The National Geodetic Survey (NGS), an office of NOAA's National Ocean Service, coordinates a network of continuously operating reference stations (CORS). Each CORS site provides Global Navigation Satellite System (GNSS - GPS) carrier phase and code range measurements in support of 3-dimensional positioning activities throughout the United States and its territories.

Data Quality Objective (DQO): Qualitative and quantitative statements of the overall level of uncertainty that a decision-maker will accept in results or decisions based on environmental data. They provide the statistical framework for planning and managing environmental data operations consistent with user's needs.

Datum: A datum is a horizontal or vertical reference system for making survey measurements and computations. Improving technology has led to more precise values for the same geographic points over time. To use recently collected data in conjunction with preexisting data, it is necessary to match data and coordinate systems between data sets. Examples of datums are NAD-27, NAD-83 and WGS-84 (North American Datum of 1927, North American Datum of 1983, World Geodetic System 1984).

Differential GPS (DGPS): A technique for reducing the error in GPS-derived positions by using additional data from a reference GPS receiver at a known position. The most common form of DGPS involves determining the combined effects of navigation message ephemeris and satellite clock errors (including the effects of SA) at a reference station and transmitting pseudorange corrections, in real time, to a user's receiver, which applies the corrections in the process of determining its position.

Dilution Of Precision (DOP): A dimensionless number that accounts for the contribution of relative satellite geometry to errors in position determination. DOP has a multiplicative effect on the User Equivalent Range Error (UERE). Generally, the wider the spacing between the satellites being tracked by a GPS receiver, the smaller the error is in position. The most common quantification of DOP is through the Position Dilution Of Precision (PDOP) parameter. PDOP is the number that, when multiplied by the root mean square (rms) UERE, gives the rms position error. Other DOPs include the Geometric Dilution Of Precision (GDOP), Horizontal Dilution Of Precision (HDOP), and Vertical Dilution Of Precision (VDOP).

Federal Geographic Data Committee (FGDC): A committee composed of representatives from Department of Agriculture, Defense, Commerce, Energy and other federal departments and agencies that has a purpose of promoting a coordinated development, sharing, and dissemination of geographic data which in turn improves content, quality, and documentation while reducing duplication of that data.

Global Position System (GPS): GPS is a U.S. spaced based radio navigation system that provides reliable positioning, navigation, and timing services to civilian users and military users on a continuous world wide basis. A constellation of 24 satellites orbit the earth every 12 hours at nominal altitudes of 11,000 miles. GPS satellites emit radio signals that allow GPS receivers to accurately determine locations and times of receiving units at any point on the earth's surface.

Geographical Information Systems (GIS): A computer system designed for storing, manipulating, analyzing, and displaying data in a geographic context.

Horizontal Positional Accuracy: The accuracy of location data on a 2-dimensional surface.

National Standard for Spatial Data Accuracy (NSSDA): This standard is classified as a Data Usability Standard by the Federal Geographic Data Committee (FDGC) Standards Reference Model. A data usability standard describes how to express "the applicability or essence of a data set or data element," and includes, "data quality, assessment, accuracy, and reporting or documentation standards" (FDGC, 1996 p.8).

Post Processing Differential GPS: Using post processing differential GPS data collection techniques, the base station receiver and roving receiver have no data link between them. Each receiver independently records data that allows for differential correction when processed with data from the roving receivers collecting data during the same time period. During the collection period, the two receivers must maintain a lock on the same set of satellites so that the raw data collected from a receiver at a known location can be combined with the raw data from the roving receiver using appropriate software. This results in the location data being more accurate and reliable.

Real-Time Differential GPS: A data collection process whereby a GPS receiver gets real-time correction data from another source in order to filter out sources of error. One way to get correction data is from a GPS receiver called a base unit or base station which remains stationary. This GPS receiver at the known position computes formats and transmits corrections through a data or radio link with a roving GPS receiver. The roving unit receives the correction data from the base station and applies it to its current observations to log more accurate and reliable data. Newer wireless GPS receivers can connect to the internet via a wireless PDA or laptop computer to retrieve information from geostationary satellites, obtain correction information, and apply the correction information in real time.

Selective Availability (SA): The policy and procedure of denying to most nonmilitary GPS users the full accuracy of the system. SA is achieved by dithering the satellite clock (delta-process) and degrading the navigation message ephemeris (epsilon-process). Selective Availability (SA) was an intentional degradation of public GPS signals implemented for national security reasons. At the direction of the President, SA was discontinued in May 2000 to make GPS more responsive to civil and commercial users worldwide.

User Equivalent Range Error (UERE): Any error contributing to the error budget of stand-alone GPS receiver positioning, expressed as an equivalent error in the range between a user's receiver and a satellite.

Waypoint: A destination or point. The coordinates of locations along the desired path as measured in geographic coordinates of longitude and latitude.

Wide Area Augmentation System (WAAS): A system that enhances GPS and is available over a wide geographical area. The WAAS being developed by the Federal Aviation Administration, in concert with other agencies, will provide WADGPS corrections, additional ranging signals from geostationary (GEO) satellites, and integrity data on the GPS and GEO satellites. Because this correction originates from a satellite, it is still subject to some of the errors as non-WAAS satellites.

4.0 QUALIFICATIONS OF OPERATOR

a. The operator shall be familiar with all applicable procedures described in the GPS unit's operators manual.

b. The operator shall be familiar with the basic operations and functions described below.

1. **Give a location:** A GPS unit accurately triangulates your position by receiving data from multiple orbiting satellites. Normally your location is given in coordinates (Latitude and Longitude) or Universal Transverse Mercators (UTMs).

2. **Point to Point Navigation:** A location or destination is called a "waypoint." For example you can establish a starting waypoint at a specific locale by using location function. If you have coordinates for the site you are headed to, a GPS can give you a straight line, point to point bearing and distance to your destination.

3. **Route Navigation:** By combining multiple waypoints in a route, you can move point to point with intermediate bearing and distance guides. Once you reach the first predetermined waypoint the GPS receiver can direct you to the next waypoint or the user can do it manually.

4. **Track:** This function on a GPS unit allows the user to create a track of where the user has been. Typically, the user can configure the GPS unit to drop "trackpoints," intervals of either time or distances. This allows the user to retrace his or her steps and get back to the start point.

c. The operator shall be familiar with this SOP and any other applicable Bureau programs.

d. The operator shall have a clear understanding of datums, coordinate systems, coordinate formats and other terms related to GPS operation.

e. The operator shall understand how to read the information displayed on the GPS unit, such as reading coordinates and their formats. Typically, coordinate formats can be changed through the preferences screen on the GPS unit. The most common formats are described below. ARCmap and Identified Sites List require (ISL) location data to be in the format described in example number 2 below.

1. **DMS (degrees / Minutes / Seconds)**
   Example: N47° 37' 12" W122° 19' 45"

2. **Decimal Degrees (DD):** A decimal equivalent of DMS. This is the format required for input to ARCMap and ISL from an excel spreadsheet or access database. Conversion of DMS to DD is degrees plus minutes divided by 60 plus seconds divided by 3600.
   Example: N47°37'12" W122°19'45", would read N47.62°, W122.3292°

3. **DDM (Degrees, Decimal Minutes):** A decimal version of DMS. In this format, Degrees remain unchanged, the difference is that the seconds are converted to decimal by dividing seconds by 60.
   Example: N47° 37' 12" W122° 19' 45", would read N47°37.2' W122°19.75'

4. **UTM (Universal Transverse Mercator):** A military derived grid system which is not tied to latitude and longitude. It divides the map into a square grid with the grid lines all 1000 meters apart. Most topographic maps have UTM grid lines printed on them. This system is metric based and requires no conversion of minutes and seconds.
   Example: 10T 055368 5274319
   10T identifies the map zone, **0550368** is the east/west or easting, while **5274319** is the north/south or northing.

f. The operator shall have a clear understanding of the importance of accurate data collection and the secondary use of that data.

5.0 PLANNING AND IMPLEMENTING GPS SURVEYS

The following sections outline the basic steps involved in systematic planning and conducting a GPS survey. Several steps must be taken prior to using a GPS receiver to obtain successful GPS data for secondary use.

5.1 DEFINE DATA OBJECTIVES OF GPS SURVEY

Establish the ultimate objective of the survey. Determine level of accuracy required to meet data quality objectives (DQO). Is an autonomous GPS receiver required or a differential GPS (DGPS) receiver required? For autonomous receivers the horizontal accuracy varies dependent upon the quality of the unit being used (autonomous GPS receivers can achieve greater accuracies through post processing of data). For greater horizontal data accuracy requirements, a DGPS unit that operates a roving GPS receiver in conjunction with a base unit receiver may be required. DGPS units are used when location data accuracy is required on a sub meter or even sub centimeter level. This SOP documents the procedure to be used for handheld GPS receivers. The following Categories provide suggested benchmarks for establishing quality control based on intended use of the data collected.

Category I: For enforcement, litigation, direct support of rules and regulations, projects of national significance and highly influential scientific assessment.

Category II: Development of rules and regulations and influential scientific information.

Category III: Validation, general applications and feasibility studies.

Category IV: Screening, exploratory and pure knowledge.

Note: Differential GPS should be employed for Categories I and II or where accuracy measurements on a sub meter level are required.

5.2 DEFINE PROJECT AREA TO BE SURVEYED

Establish overall project area and the limits of the survey to be completed. Utilize all available resources. A 7.5-Minute quadrangle map is ideal when surrounding environments need to be taken into consideration. Use street maps or site maps already available to plan survey accordingly.

5.3 PRE-SURVEY RECONNAISSANCE

Perform a site reconnaissance or walk of the area or features where location data is to be collected. Prepare a sketch of the site with features to be mapped and cross reference the locations to be located with the list developed in the planning stage so that features or facilities to be mapped are not omitted from the survey. If necessary, operator should clear obstructions that may impede or restrict the collection of accurate locational data.

5.4 LIST OF POINTS OR LOCATIONS TO BE SURVEYED

Develop a list of facilities or features targeted for data collection. If possible plot general locations on a field map or site map. If the proposed survey point is on private property care should be taken to pursue appropriate notification and access protocol.

5.5 DEFINE EQUIPMENT NEEDS

Select from a list of equipment currently available for use by BER staff. Selected equipment shall be appropriate for the intended use of the data to be collected. Is a PC and associated software with interface cable, or powered antenna required?

5.6 EQUIPMENT TEST AND SETUP

Prior to departing from office, the user shall check the GPS receiver for proper operation. Check to see if the GPS unit is fully charged and receives good satellite signal in an outdoor environment. If the unit has a self diagnostic program; use the program to check for errors (this should be completed by GSS staff if using their equipment). Check to see if the unit is loaded with the necessary software, map data, and enough storage available to complete survey objectives. Operation manuals provide unit specific procedures which should be referenced to complete system checks on the equipment prior to use in the field (see Attachment 1 for available GPS equipment).

GPS units contain many settings that can serve as quality checks during data acquisition. For instance a minimum number of visible satellites can be specified for data acquisition. The unit will provide a warning signal if less than the minimum specified are available. Four satellites in view are the minimum required, but additional satellites can provide the receiver with stronger signals to select from and perhaps better geometry for calculations. GPS receivers can also calculate a Dilution of Precision (DOP) for Horizontal (HDOP), for Time (TDOP), and general Position

(PDOP) values and is often referenced with lower values leading to more accurate measurements. PDOP values of 6 or less are generally acceptable and limits on PDOP can usually be programmed into the unit or software that interfaces with the receiver.

DOP values in Relation to Quality Categories			
DOP Value	Rating	Description	Suggested for Quality Category
1	Ideal	Highest possible confidence level.	I
2-3	Excellent	Meets all but most demanding needs.	I or II
4-6	Good	Appropriate for most needs.	II, III, or IV
7-8	Moderate	For less demanding uses. Positional measurements could be used for calculations, but the fix quality could still be improved. A more open view of the sky is recommended.	IV
9-20	Fair	Low confidence level. Positional measurements should be discarded or used only to indicate a very rough estimate of the current location.	Not recommended
>20	Poor	Very low confidence level. Measurements are inaccurate by as much of as half a football field and should be discarded.	Not recommended

Note: These Quality Categories in the above table are suggested. Other factors may supersede the information in the table.

5.7 EXECUTION AND COLLECTION OF LOCATION DATA:

GPS location data is collected for multiple points of interest with different data objectives required for the varying Sections within the Bureau of Environmental Remediation. Examples where location data are needed but not limited to are sites on the ISL where contamination has been confirmed or suspected, source facilities, former waste pits or piles, locations where soil, groundwater, or surface water samples were collected for laboratory analysis; monitor well locations; land features such as creeks, streams, or springs; Underground Storage Tanks (UST), Aboveground Storage Tanks (AST), and Leaking Underground Storage Tanks (LUST) locations.

1. Calibrate the unit and ensure all appropriate settings are correct according to the unit's operation manual.

2. Acquire Satellite lock: To provide reliable location information, a GPS receiver must receive good signal strength from a minimum of four satellites. To acquire satellites, the user must turn on the GPS unit and go to the satellite screen.

3. This screen will display the current configuration of the satellites and the strength of signal coming from each one.

4. A clear view of the sky gives the user the best opportunity for an optimal satellite lock. Tree canopies and tall buildings that obscure the view overhead or of the horizon can impede reception.

5. The user must be sure the coordinate system and datum are correctly defined in the GPS unit prior to data collection.

6. Large sites containing multiple source areas or facilities can be identified through collecting location data from each corner of the site in addition to each source area or facility located within that site.

7. Each source facility or area should have GPS data collected at or near its center and should have a specific KDHE project code associated with it.

8. Individual sites or properties that are five acres or less in size should have a single set of location data collected. Most GPS units allow the user to store the locational information in the unit itself as a waypoint and allow the user to label that point with a brief description.

9. When pictures are taken of specific points on a property or site, location data is beneficial to have. Most GPS units allow the user to store the locational information in the unit itself as a waypoint and allow the user to label that point with a brief description.

10. As the user is collecting location data, the user shall record the coordinates along with a label and brief description of the point being surveyed in a site specific log book or data collection form (see Attachment 2). By recording location data in a log book or on a collection form, the user ensures data will not be lost if he or she experiences equipment failure. When recording data using decimal degrees; a minimum of five decimal places is required.

When recording data using degrees decimal minutes, three decimal places are required.

11. If an equipment malfunction is encountered consult the operation manual for guidance on troubleshooting.

12. When the user has completed the survey and has arrived back to the office; download the collected data in the appropriate format and using appropriate software (GSS does this for their equipment).

13. Clear the unit memory for the next operator so that the possibility for the next user to mix data sets is minimized.

5.8 DATA ASSESSMENT AND PROCESSING

Post processing should be conducted after returning from the field to the office where tools for post processing are more easily controlled. Common steps in post processing are transferring the data from the field equipment to the office work stations, conducting the initial stages of processing, computation of the solutions for critical factors, data conversion for use in a GIS, and the final documentation and reporting.

6.0 REFERENCES

El-Rabbany, Ahmed. Introduction to GPS, The Global Positioning System. Norwood: Artech House, 2002.

Federal Geographic Data Committee, *Geospatial Positioning Accuracy Standards, Part 3, National Standard for Spatial Data Accuracy*, FDGC-STD-007.3-1998.

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U.S. Environmental Protection Agency, Office of Environmental Information, *Global Positioning Systems – Technical Implementation Guidance*, EPA/250/R-03/001, September 2003.

U.S. Environmental Protection Agency, *Interim Guidance for Developing Global Positioning System Data Collection Standard Operating Procedures and Quality Assurance Project Plans*, EPA/600/R-08/020, February 2008.

U.S. Environmental Protection Agency, *Terms of Environment: Glossary, Abbreviations, and Acronyms*, EPA/175-B-97-001, December 1997.

Attachment 1

Kansas Department of Health and Environment GPS Equipment List and Configurations NSSDA 95% Confidence Level for Horizontal Accuracy							
No.	Derived Horizontal Accuracy (meters)	Derived Vertical Accuracy (meters)	Reported Accuracy (meters) Horiz /	Verti	Equipment	Type	Date
1	1.95	N/A	2		Thales Mobile Mapper CE/CX	Autonomous (WAAS)	2008
2	1.42	1.58	1	2	Thales Mobile Mapper CE/CX	Differential Post processing - 1 minute	2008
3	1.07	1.10	1	1	Thales Mobile Mapper CE/CX	Differential Post processing 1&5 minute external antennae on bipod	2008
4	2.875	N/A	3		Thales Mobile Mapper Pro	Autonomous (WAAS)	2005 2008
5	1.087	N/A	1	3	Thales Mobile Mapper Pro	Differential Post Processing 1minute	2005 2008
6	16.926		17		Garmin GPS III Plus	Autonomous	2004
7	7.006	N/A	7		Garmin e trex Legend	Autonomous (WAAS)	2004
8	5.373	N/A	5		Delorme GPS/Timble Recon Datalogger	Autonomous (Bluetooth connection between GPS unit, Antennae & Datalogger	2008
9		N/A	7			1:1500 scale - Digital Ortho Photo	2005

Source: *KDHE, GPS Equipment configurations, July 2008.*

Thales MobileMapper CE and CX were found to be equivalent units. Newer technology utilized by the CX made post processing of collected data feasible. Post processing with the CE was unreliable. (In 2007, the manufacturer replaced the CE model with the CX model).

Note: All data were compared to the NGS Independent Source. All post-processing was completed using nearest CORS at 5 second intervals. Post-processing data for 2005 were derived from receivers mounted on a bi-pod. Post-processing data for 2008 were collected on both handheld units and bi-pod mounted units. Autonomous data were collected from handheld receivers.

Attachment 2
DATA COLLECTION FORM

SITE INFORMATION

Today's Date: _____

Brief Description of Weather Conditions: _____

_____

New Site or Existing Site (circle one)? _____New / Existing

Site Name: _____

Site Address: _____

City: _____

County: _____

KDHE Project Code: _____

LOCATION DATA

Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Identifier or Label

GPS Unit Used for Collection of Data: _____

Photographs Taken (circle one)? _____Yes / No

Collectors Name: _____ **Bureau / Section:** _____

STANDARD OPERATING PROCEDURE – BER-36

WATER LEVEL, PRODUCT, AND WELL DEPTH MEASUREMENTS

Effective Date: January 1, 2011

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ATTACHMENT A **Electronic Water Level Indicator**

ATTACHMENT B **Steel Tape**

ATTACHMENT C **Airline**

ATTACHMENT D **Interface Probe**

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1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to establish basic procedures for measuring depth to groundwater, separate chemical phase product levels, and total well depths in monitoring and observation wells. Groundwater level measurements are generally used to construct potentiometric surface maps. Groundwater level data is also used to determine sample purge volumes, hydraulic conductivity, groundwater flow direction, flow velocity, hydraulic gradients, impacts from pumping, or other groundwater stresses.

2.0 METHOD SUMMARY

Prior to field activities, field personnel should have specific information including well identification and location, well casing diameter, casing material, lock number and keys, legal access to the wells, and the length and depth to the well screen. The diameter of the well casing will decide which type of equipment will be used for measuring, purging, and sampling the well or separate chemical phase product.

A surveyed reference point should be marked on the top of the well casing. The reference point, from which all measurements will be taken, should be documented in the field notebook. All field personnel must be made aware of the reference point being used in order to ensure the collection of comparable data.

The well cap must be removed several minutes before measuring begins to allow the water levels in the wells to equilibrate to atmospheric pressure. If possible, water level measurements should proceed from the least to the most contaminated wells. Additionally, the water level measurements of all site wells should be done consecutively before any purging and sampling activities take place. This will ensure the representation of aquifer conditions.

For electric water level indicators, lower the probe into the well until the water surface is reached as indicated by a tone or light on the indicator. Record the distance from the water surface to the reference point. If a separate chemical phase product is present in the well, an interface probe meter is used to measure the product thickness and water level. Continue to lower the probe to the bottom of the well in order to measure the total well depth. All measurements must be made to an accuracy of one-hundredth of a foot (0.01 foot). Remove the electric water level indicator and decontaminate the equipment between all well measurements.

3.0 EQUIPMENT

3.1 WATER LEVEL INDICATORS

3.1.1 Electronic Water Level Indicator

Electronic water level indicators typically consist of dual insulated conductor wires in a flat tape or coaxial cord whose exposed ends are separated by an air gap in a probe and containing a circuit and a source of battery power in the indicator spool. When the probe comes in contact with the water, the circuit is closed and a light and/or audible buzzer attached to the spool will signal contact by lighting up and/or producing an audible tone. Measurements should be made and recorded to the nearest 0.01 foot.

3.1.2 Chalked Steel Tape

Steel tapes are steel bands typically less than an inch wide mounted to a hand-wound reel. A slender weight is attached to the ring at the end of the tape to ensure plumbness. Older tapes may use a lead weight, which presents concerns with water quality. The weight should be either brass or stainless steel. The lower few feet of tape are chalked by pulling the tape across a piece of blue carpenter's chalk. The wet chalk mark identifies the portion of the tape that was submerged. Chalk may result in impacts to groundwater quality analysis.

3.1.3 Airline

Airlines are used in higher capacity industrial and municipal wells. This method involves the installation of a small-diameter pipe or tube (the airline) from the top of the well to a point about 10 feet below the lowest anticipated water level or below the pump intake. Compressed air is used to purge the water from the tube. The pressure, in pounds per square inch (psi), needed to purge the water from the airline is multiplied by 2.31 (feet of water for one psi) which will equal the length in feet of the submerged airline. The depth of water below the center of the pressure gauge can be easily calculated by subtracting the length of the airline below the water surface from the total length of the airline. Airlines can become clogged with mineral deposits or bacterial growth, or develop leaks, and consequently yield false information. A series of airline measurements should be checked periodically by steel tape or an electric water level indicator.

3.2 NON-AQUEOUS PHASE LIQUID MEASURING DEVICE

3.2.1 Interface Probe Meter

Interface probe meters typically consist of dual insulated conductor wires in a flat tape or coaxial cord whose exposed ends are separated by an air gap in a sensor probe and containing an infra-red and conductivity circuit and a source of battery power in the indicator spool. When the sensor probe comes in contact with product, the infra-red circuit detects the product and a light and/or audible buzzer attached to the spool will signal contact by lighting up and/or producing a steady audible tone. When the sensor probe comes in contact with water, the conductivity circuit differentiates between the product (non-conductive) and water (conductive) and a light and/or audible buzzer attached to the spool will signal contact by lighting up and/or producing an intermittent audible tone. Measurements should be made and recorded to the nearest 0.01 foot.

4.0 PROCEDURES

4.1 REFERENCE POINT

Static groundwater levels must be measured from the permanently marked reference point where the top of the well casing was professionally surveyed. The reference point is typically surveyed to establish its position above sea level to an accuracy of 0.01 feet. If no mark is apparent, field personnel should take both water level and total well depth measurements from the north side of the top of the casing and should record this procedure in the field notebook. Monitoring well measurements for water level and total depth should be consistently measured from one reference point in order to properly assess groundwater data. Whenever possible, the inner casing is recommended as reference point, because of the general instability of the outer casings due to frost heaving, vehicular damage, and other activities which could cause movement of the casings.

4.2 MEASURING GROUNDWATER LEVELS

1. Select a water level measuring device based on the site specific conditions.

2. Prior to field work, check the conductivity of the electronic water level indicator by placing the electrode probe into clean water to

close the circuit for testing. A light on the indicator spool should flash and/or an audible buzzer will make a tone that identifies a closed circuit. Note: Do not use distilled water to check the circuit. Electronic water level indicators will not respond to distilled water. Also, check the decontamination condition of the indicator.

3. Start at the least contaminated well, if known.

4. Lay plastic sheeting around the well to minimize the likelihood of contamination of equipment from soil adjacent to the well.

5. Remove the locking well cap and well casing cap. Allow several minutes to pass before measuring begins to allow the water level in the well to equilibrate to atmospheric pressure.

6. Turn on the electronic water level indicator by turning the sensitivity switch on the indicator spool clockwise. The sensitivity switch controls the volume of the audible tone put off by the indicator when the electrode probe comes in contact with water. If using a steel tape, pull the tape across a piece of blue carpenter's chalk.

7. Slowly lower the electrode probe down the well. If utilizing a steel tape, lower the chalked steel tape from the reference point at the top of the well until a short length of tape is submerged. The weight and tape should be lowered into the water slowly to prevent splashing. Submergence of the weighted tape may temporarily cause the water level to rise in small-diameter cased wells.

8. When the electronic water level indicator detects water, check to make sure the electrode probe is not coming into contact with water cascading down the side of the well casing. Raise and lower the tape until the light and/or buzzer goes off and on. This will indicate whether the water level is rising, falling, or is remaining static in the well. For the chalked steel tape, lower the tape into the well until the lower two feet of the tape is submerged.

9. Measure the water level depth relative to the reference point on the top of the monitoring well casing and record the measurement on the tape to the nearest 0.01 foot. Recheck the measurement by taking two to three readings. For the chalked steel tape, the water level depth below the reference point is determined by subtracting the length of the wet tape (indicated by the wet chalk) from the total length of tape lowered into the well. Record the time and date of the water level measurement, the reference point, measurement method, and the water level.

10. Begin rewinding the electrode probe and tape back onto the indicator spool or the steel tape back onto the hand-held spool. Decontaminate the measuring device between each well following KDHE's SOP BER-05 *Decontamination of Equipment*.

4.3 MEASURING NON-AQUEOUS PHASE LIQUID PRODUCT

1. Prior to performing measurements, complete the steps 1-5 as described above in 4.2 Measuring Groundwater Levels.

2. Perform a battery test by turning on the device by pushing the "Start" button on the indicator spool. A brief tone and light will indicate the interface probe meter is functional and a flashing light will indicate the meter is on. Check the decontamination condition of the interface probe prior to field work.

3. Carefully lower the sensor probe into the well.

4. As the sensor probe encounters the product (greater than 1 millimeter thick) a steady audible tone will sound. Measure the NAPL depth relative to the reference point on the top of the monitoring well casing and record the measurement to the nearest 0.01 foot. Recheck the measurement by taking two to three readings.

5. Lower the sensor probe through the NAPL layer very slowly. When passing through the product into water, some product may adhere to the sensor probe. When the water interface is encountered, a second intermittent audible tone is generated. Raise and lower the probe to remove any product from the probe. The water/product interface should be measured as the probe is raised slowly back up. Record the reading to the nearest 0.01 foot and re-check the reading two to three times.

6. To determine if dense non-aqueous phase liquid (DNAPL) is present in the well, continue to lower the sensor probe. If the steady audible tone sounds, determine the top of the heavy product layer by recording the reading to the nearest 0.01 foot and re-check the reading two to three times. Continue lowering the sensor probe until the tape slackens when the bottom of the well has been reached. Again record the depth reading to the nearest 0.01 foot and re-check the reading two to three times. Record the time and date of the water level and product measurements, the reference point, and the water and product level depth measurements.

7. Begin rewinding the sensor probe and tape back onto the indicator spool. Decontaminate the measuring device between each well following KDHE's SOP BER-05 Decontamination of Equipment.

8. Field personnel shall document the description of the product, including thickness of the product layer, color, odor, viscosity, and indicate the type of product suspected.

4.4 MEASURING TOTAL WELL DEPTH

The total depth of the well must be measured at each sampling event to determine any changes in the condition of the well, checking the well casing integrity, or any siltation building up in the well screen. An electronic water level indicator should only be used to measure total well depth if it has been designed to do so. If the indicator has not been designed to measure total water depth, fully submerging the electronic water level indicator probe may cause water to enter the probe, resulting in a possible shorting out of the indicator or leading to a shorter life of the equipment. A weighted steel or fiberglass tape may also be used for measuring. To measure the total depth of a well:

1. Turn off the electronic water level indicator by turning the sensitivity switch on the indicator spool counter-clockwise.

2. Lower the electrode probe or weighted tape down the well casing until the tape becomes slack, indicating the tape has reached the bottom of the well.

3. Pull the tape taut and record the depth reading to the nearest 0.01 foot and re-check the reading two to three times.

4. Begin rewinding the electrode probe and/or tape back onto the indicator spool. Decontaminate the measuring device between each well following KDHE's SOP BER-05 *Decontamination of Equipment*.

5.0 QUALITY CONTROL/QUALITY ASSURANCE

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout, problems, and/or replacement must occur prior to sampling/operation and must be documented.
- To ensure accurate data is collected, repeated measurements should be made within 0.01 feet.
- Decontamination of equipment must take place between well sampling and measurements in accordance with KDHE's SOP BER-05 *Decontamination of Equipment*.

6.0 REFERENCES

1. Illinois United States Geological Survey, Water Science Center, *Introduction to Field Methods for Hydrologic and Environmental Studies*, U.S. Geological Survey Open-File Report 01-50, il.water.usgs.gov/pubs/ofr01_50_chapter4_4.pdf, 2001.

2. United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*, Ground Water Forum Issue Paper, EPA designation EPA/542/S-02/001, May 2002.

3. United States Environmental Protection Agency (Region 4), Science and Ecosystem Support Division, Safety, Health and Environmental Management Program Procedures and Policy, SESD Operating Procedure-Groundwater Level and Well Depth Measurement, SESDPROC-105-R1, November 2007.

4. Kansas Department of Health and Environment, Bureau of Environmental Remediation, Quality Management Plan III, Appendix A-Standard Operating Procedures, BER-01 *Collection of Groundwater Samples at Known or Suspected Groundwater Contamination Sites*, August 2010.

5. Kansas Department of Health and Environment, Bureau of Environmental Remediation, Storage Tank Section, *Petroleum Storage Tank Release Trust Fund Monitoring Request for Proposal,* Revision 5, April 2008.

6. Solinst, Interface Meter Operating Instructions Model 122, http://www.solinst.com/Downloads/Inst/122ins/122ins.pdf, October 2002.

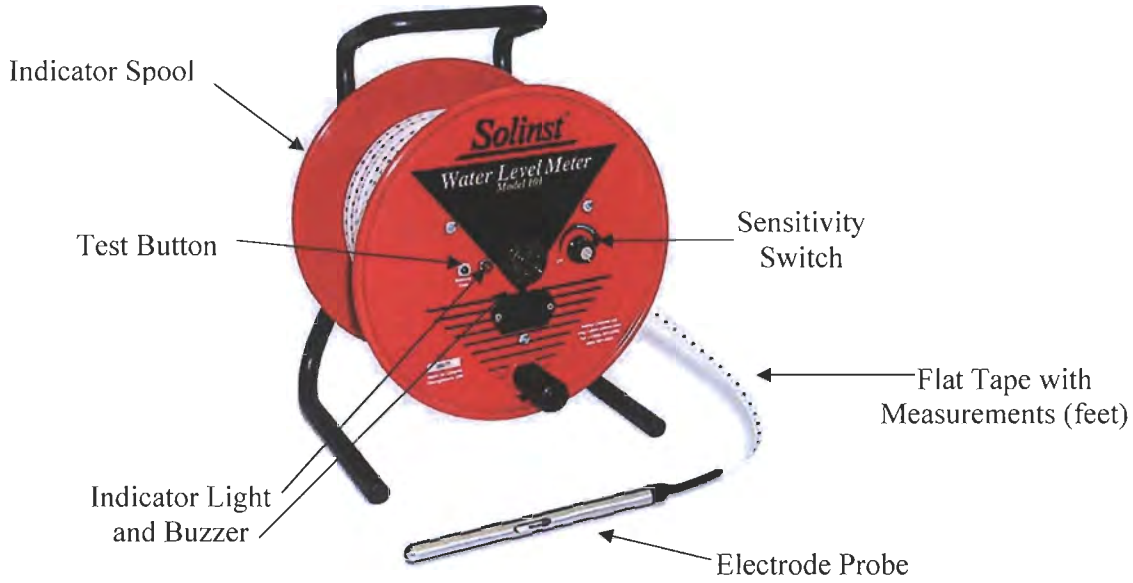
7. Los Alamos National Laboratory, *Environmental Program Directorate Standard Operating Procedure for Manual Groundwater Level Measurements*, SOP-5223, October 2008.

8. New Jersey Department of Environmental Protection, Guidance Documents, Field Sampling Procedures Manual, *Chapter 6 – Sample Collection,* http://www.state.nj.us/dep/srp/guidance/fspm/pdf/chapter06_all.pdf, August 2005.

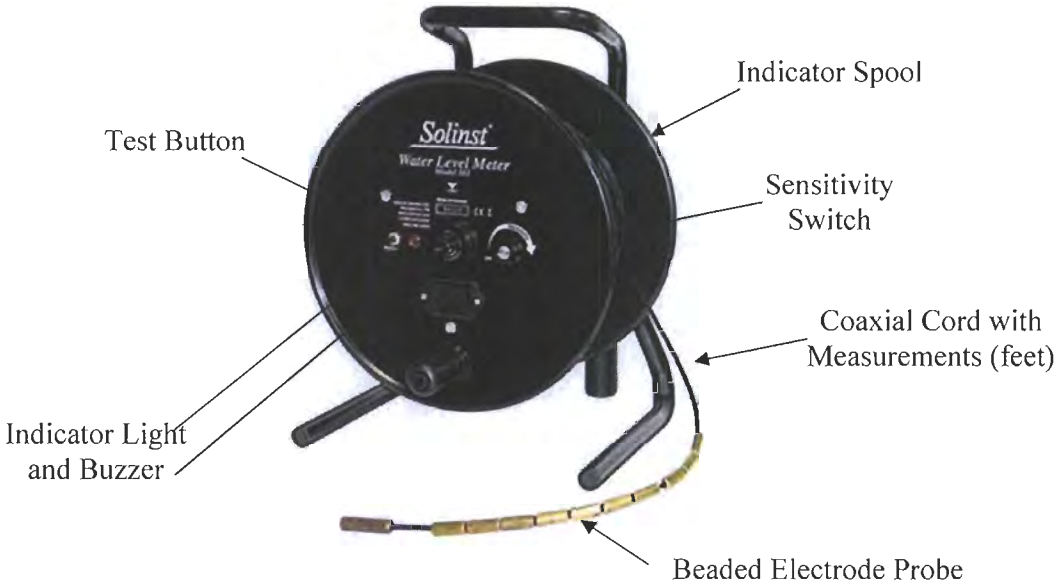
9. RETEC Group, Inc., Standard Operating Procedure (SOP) 231 Water-Level Measurements, April 2002.

ATTACHMENT A

ELECTRONIC WATER LEVEL INDICATOR



Electronic Water Level Indicator for well casing diameters greater than 1 inch.

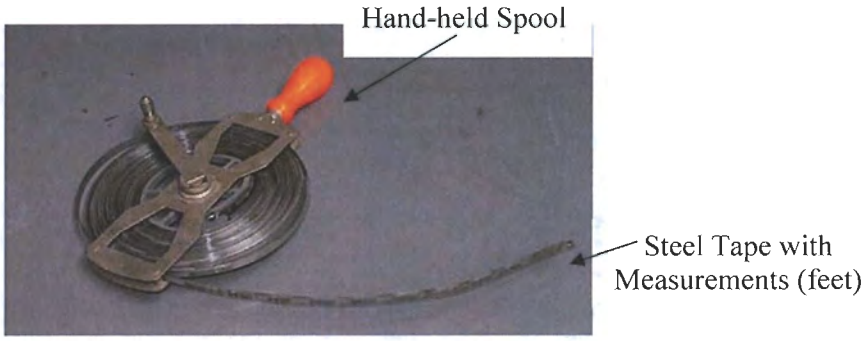


Electronic Water Level Indicator for well casing diameters less than 1 inch.

Note: KDHE does not recommend, endorse, or require specific brands of equipment.

ATTACHMENT B

STEEL TAPE



EXAMPLE OF HAND-HELD STEEL TAPE.

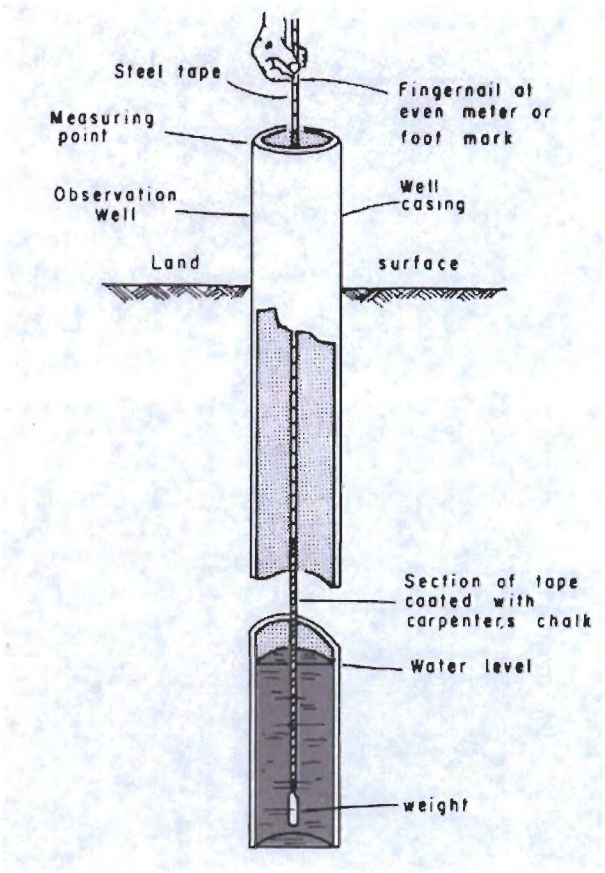


Diagram: Collecting a water level measurement with a weighted and chalked steel tape.

Note: KDHE does not recommend, endorse, or require specific brands of equipment.

ATTACHMENT C

AIRLINE

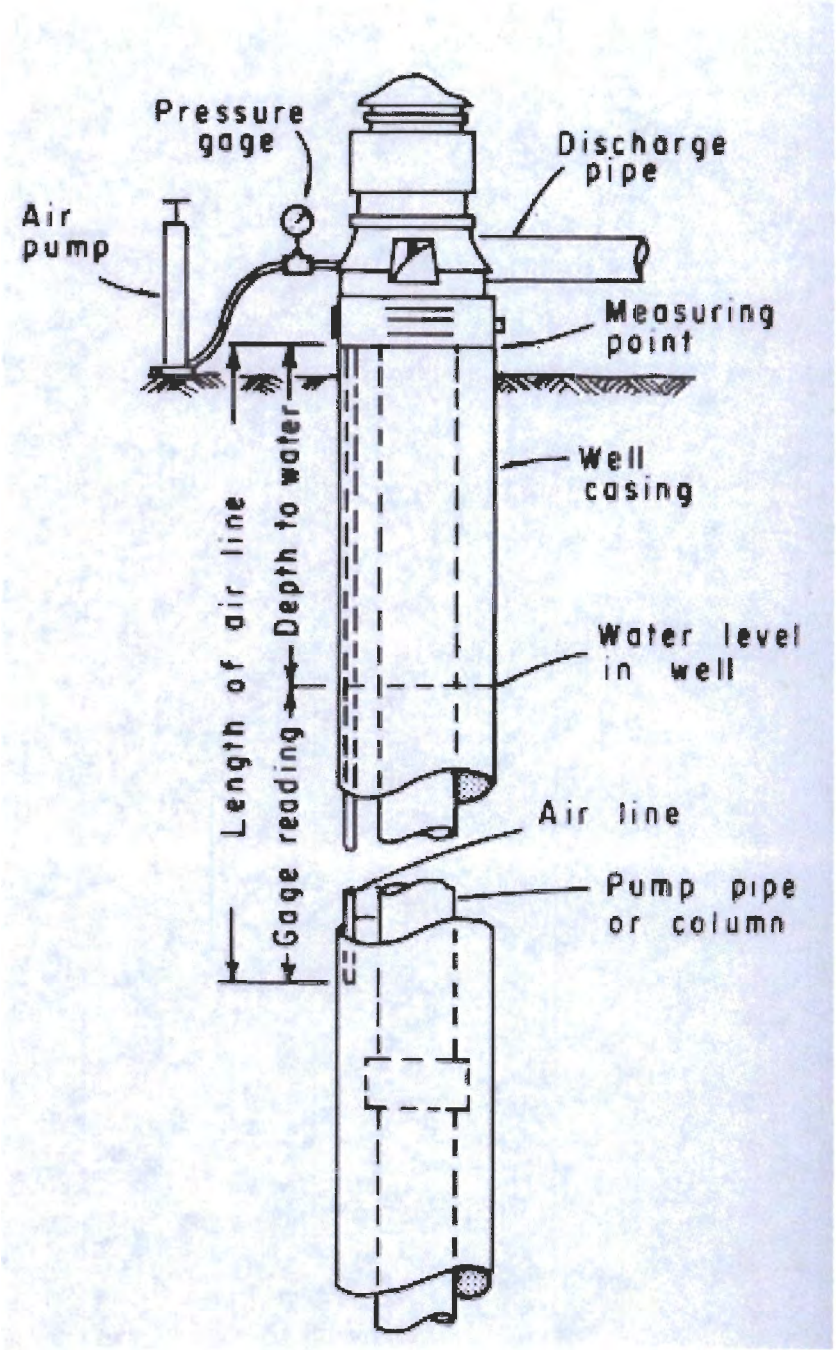
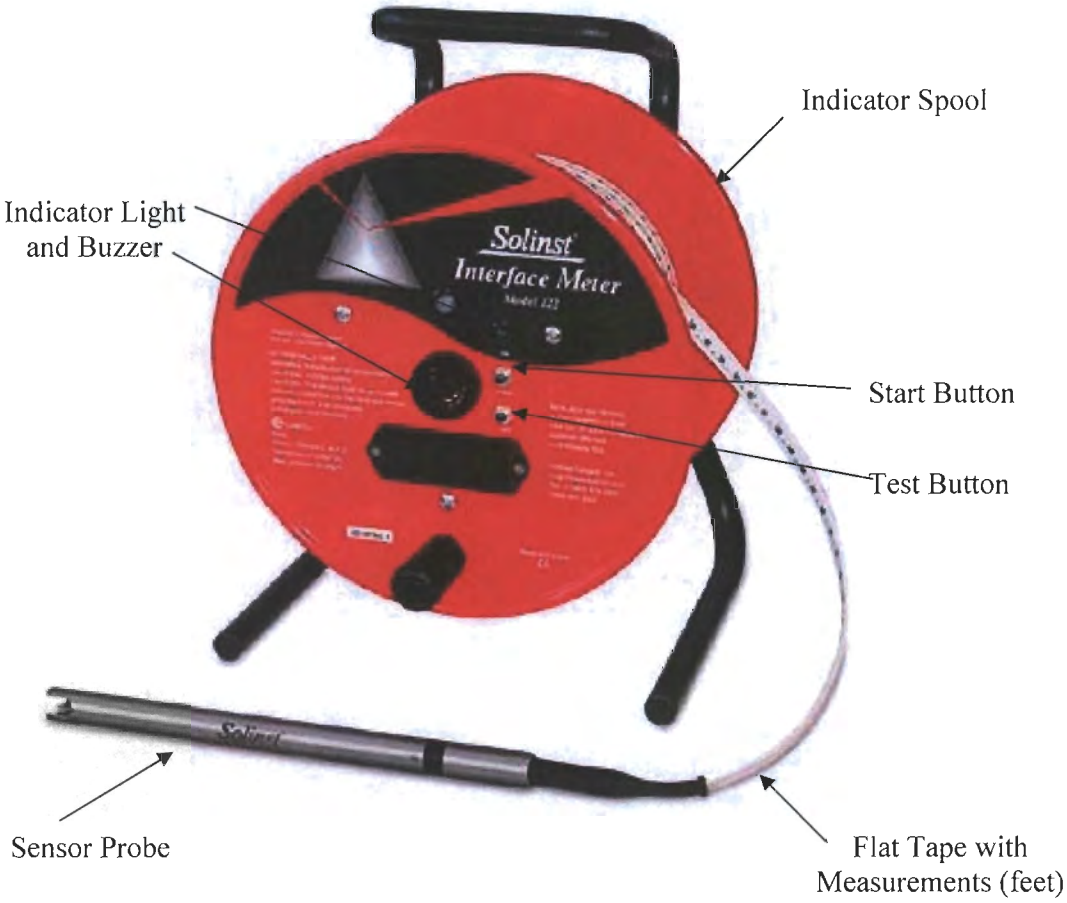


Diagram: Collecting a water level measurement with an airline.

ATTACHMENT D

INTERFACE PROBE



Note: KDHE does not recommend, endorse, or require specific brands of equipment.

Attachment B

Antea Group SOPs

PROCEDURE

Below Ground Utility Survey SOP

Author: John Gobins

Antea Group USA

Approved by: (Signatures on File)

John Gobins Process Owner	March 20, 2012 Date
Rosanna Ouellette QMS Document Control Representative	March 20, 2012 Date
John Gobins QMS Management Representative	March 20, 2012 Date

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Document Change Tracking Form

Version	Revision date	Revisions
0	3/20/2012	Final Document Based upon Previous Team Meetings and Management Approvals in March 2012.

Below Ground Utility Survey SOP

1.0 Scope/Applicability:

This standard operating procedure (SOP) provides guidance for a utility survey.

This procedure is applicable to sites where subsurface intrusive activities are to be conducted.

2.0 Summary:

This procedure entails marking the location of utilities in public property surrounding the project site and determining their entry point onto the project site (assumed private property).

3.0 Definitions:

A list of definitions is provided in Attachment 1 (SOP Definitions).

4.0 Health and Safety:

The Health and Safety considerations for conducting this procedure are described in the following documents:

- Site Health and Safety Plan – H&S Plan Templates (https://anteaintra.anteausainc.com/h&s/plans.htm)
- Job Safety Analysis – Utility Locates (https://anteaintra.anteausainc.com/h&s/files/jsa/Utility_locates_JSA.doc)

Specific health and safety considerations for this procedure include:

- Health and safety considerations associated with this procedure are addressed during the Job Safety Analysis.

5.0 Cautions and Interferences:

Cautions associated with conducting this procedure include:

- Utility locating services (e.g., One Call) typically do not mark utility lines on private property. The subsurface intrusive subcontractor should review all utilities identified at the site boundaries to verify their point of entry onto the site.
- Utility locating services require a minimum of 48 hours notice.

Interferences having the potential to impact the quality of the final product include:

- none

6.0 Personnel Qualifications/Responsibilities:

Personnel performing this procedure are required to have the following qualifications:

- HSSE Training in accordance with Health, Safety, Security, and Environment Practice (https://anteaintra.anteausainc.com/h&s/practices/hsse/HSSE_Practice_Training.pdf).
- Health and Safety training in accordance with Client Required Training (if applicable) (https://anteaintra.anteausainc.com/h&s/training_client_req.htm).
- All field team members engaged in this procedure must have on file a completed Demonstration of Capability for this SOP.

The minimum roles involved and their responsibilities in this procedure include:

- **Project Manager** – Responsible for determining, communicating, and upholding the regulatory, client, and other requirements associated with performing this procedure as part of a project-specific scope of work.
- **Project Professional** – Responsible for creating project-specific scopes of work requiring this procedure in accordance with the identified requirements of this procedure.
- **Staff Professional** – Responsible for implementing project-specific scopes of work requiring this procedure in accordance with this procedure.

7.0 Equipment/Supplies:

The following is the typical list of equipment required for completing this procedure:

- Field Safety Equipment Bag - https://anteaintra.anteausainc.com/h&s/faq_field_bag.htm
- Traffic control devices, as defined in Site Control and Work Zones training - https://anteagroup.adobeconnect.com/sitecontrolworkzones/
- Field logbook and appropriate field form(s)
- Waterproof permanent pens and markers
- Mobile phone - with clock and camera feature
- Spare locks - for buildings, compounds, and well covers (if appropriate)
- Keys - to access existing on-site locks (if appropriate)
- Decontamination supplies/equipment (if appropriate)

Procedure-specific equipment/supplies include:

- Tile probe
- Metal detector or magnetometer, for detecting underground utilities/pipes/drums (1 per sampling team)

8.0 Procedure:

1. Obtain and review copies of facility drawings to identify utility lines that may be located on the property.
2. Call "One Call." Schedule a utility locating session with participating utility companies.
3. Obtain and review copies of map surveys to identify utility easements.
4. Call city or county utilities to identify locations of underground utility lines.
5. Inspect the site for pipeline marker posts.
6. Screen each sample location with a metal detector or magnetometer to verify that no underground pipes or drums exist.
7. Probe boring locations with a tile probe to verify that no non-metallic obstructions exist.
8. Record field observations in accordance with **Fieldwork Documentation SOP**.

9.0 Data and Records Management:

Before finalizing fieldwork documentation:

- Recheck all data inputs to prevent errors.
- Ensure that any repair work needed, issues to be resolved, and/or any uncompleted fieldwork are noted in the fieldwork documentation.

Upon completion of fieldwork, field personnel shall file fieldwork documentation, any electronic field files, the Site Health and Safety Plan, and any associated health and safety forms to the correct project folder, in accordance with **Control of Records SOP**.

10.0 Quality Control:

- All data, observations, calculations must be documented in the field logbook, field forms, and/or any electronic data recording devices (field computers, digital cameras, etc.).
- Any electronic data recording devices must be operated in accordance with manufacturer's operating instructions, unless documented otherwise.
- Monitoring and Measuring Equipment must be calibrated prior to the event and calibration results documented in accordance with **Equipment Calibration and Maintenance SOP**.

11.0 References:

- Superfund Program Standard Operating Procedures
- SOP Definitions (Attachment 1)
- Call Before You Dig 811 - http://www.call811.com/
- American Public Works Association Uniform Color Code Chart - http://www2.apwa.net/documents/About/TechSvcs/One-Call/COLORCC.PDF
- Control of Records SOP
- Fieldwork Documentation SOP
- Equipment Calibration and Maintenance SOP

Attachment 1
SOP Definitions

Attachment 1
SOP Definitions

AS	Air Sparging
ASTM	American Society for Testing and Materials
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CD	Compact Disc
COC	Chain of Custody
COC	Chemical(s) of Concern
CPR	Cardiopulmonary Resuscitation
DNAPL	Dense Non-Aqueous Phase Liquid
DOT	Department of Transportation
DPE	Dual Phase Extraction
DQO	Data Quality Objective
DTB	Depth to bottom (of well)
DTP	Depth to product (in well)
DTW	Depth to water (in well)
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
GAC	Granular Activated Carbon
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSSE	Health, Safety, Security, and Environment
ID	Identification
iEHS	Intelligent Environmental Health and Safety
LNAPL	Light Non-Aqueous Phase Liquid
LPH	Liquid Phase Hydrocarbon
LUST	Leaking Underground Storage Tank
MME	Monitoring and Measuring Equipment
MPE	Multi Phase Extraction
MS/MSD	Matrix Spike/Matrix Spike Duplicate (quality control sample)
MSDS	Material Safety Data Sheet
MW	Monitoring Well
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear Aromatic Hydrocarbon
PDF	Portable Document Format
PID	Photo Ionization Detector
PM	Project Manager
PNA	Polynuclear Aromatic
POTW	Publically Owned Treatment Works
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RBSL	Risk Based Screening Level
RCRA	Resource Conservation Recovery Act
RW	Recovery Well
SB	Soil Boring
SCFM	Standard Cubic Feet per Minute
SHSP	Site Health and Safety Plan (Antea Group)
SOP	Standard Operating Procedure
SSTL	Site Specific Target Level
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TCLP	Toxicity Characteristics Leaching Procedure
TOC	Top of Casing (elevation)
TOC	Total Organic Carbon
TOX	Total Organic Halogen
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound

PROCEDURE

Borehole Clearance SOP

Author: John Gobins

Antea Group USA

Approved by: (Signatures on File)

John Gobins Process Owner	March 20, 2012 Date
Rosanna Ouellette QMS Document Control Representative	March 20, 2012 Date
John Gobins QMS Management Representative	March 20, 2012 Date

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Document Change Tracking Form

Version	Revision date	Revisions
0	3/20/2012	Final Document Based upon Previous Team Meetings and Management Approvals in March 2012.

Borehole Clearance SOP

1.0 Scope/Applicability:

This standard operating procedure (SOP) provides guidance for using airknife technology to clear proposed borehole locations of subsurface utilities and other man-made obstructions prior to drilling in those locations.

The Pre- and Site-Intrusive Work Checklist process shall be initiated during fieldwork planning prior to borehole clearance, and completed during borehole clearance (the form is obtainable at https://anteaintra.anteausainc.com/h&s/files/CK_Predrill_Checklist_single_locality.xls).

This procedure is applicable to all drilling work conducted at project sites.

2.0 Summary:

This procedure entails using airknife equipment to clear a borehole to a desired target depth, prior to drilling in that location. Following the removal of any surface materials (e.g., asphalt or concrete), an airknife connected to a vacuum truck is used to extract soil from the borehole location. The diameter of the borehole created by the air knife should be as least as large as the drill bit diameter. Airknifing is stopped when the desired target depth has been achieved, or when underground structures and/or pea gravel are encountered.

3.0 Definitions:

A list of definitions is provided in Attachment 1 (SOP Definitions).

4.0 Health and Safety:

The Health and Safety considerations for conducting this procedure are described in the following documents:

- Site Health and Safety Plan – H&S Plan Templates (https://anteaintra.anteausainc.com/h&s/plans.htm)
- Job Safety Analysis – (drilling subcontractor shall provide this)
- HSSE Practice – Ground Disturbance (https://anteaintra.anteausainc.com/h&s/practices/hsse/Ground_Disturbance.doc)

Specific health and safety considerations for this procedure include:

- Health and safety considerations associated with this procedure are addressed during the Job Safety Analysis.

5.0 Cautions and Interferences:

Cautions associated with conducting this procedure include:

- As-built diagrams and other maps may not contain all of the subsurface utilities and other man-made features located at a site. Therefore, borehole clearance shall proceed slowly and cautiously to ensure that borehole clearance activities themselves do not damage subsurface utilities and other man-made features.
- Given that existing site information may be incomplete with respect to subsurface utilities and other man-made features, the target depth of borehole clearance shall be established as the depth at which subsurface utilities and other man-made features are not likely to be present at the site.

Interferences having the potential to impact the quality of the final product include:

- Extremely loose soil or shallow groundwater may interfere with the ability to clear and maintain an open borehole to the desired target depth.

6.0 Personnel Qualifications/Responsibilities:

Personnel performing this procedure are required to have the following qualifications:

- HSSE Training in accordance with Health, Safety, Security, and Environment Practice (https://anteaintra.anteausainc.com/h&s/practices/hsse/HSSE_Practice_Training.pdf).
- Health and Safety training in accordance with Client Required Training (if applicable) (https://anteaintra.anteausainc.com/h&s/training_client_req.htm).
- All field team members engaged in this procedure must have on file a completed Demonstration of Capability for this SOP.

The minimum roles involved and their responsibilities in this procedure include:

- **Project Manager** – Responsible for determining, communicating, and upholding the regulatory, client, and other requirements associated with performing this procedure as part of a project-specific scope of work.
- **Project Professional** – Responsible for creating project-specific scopes of work requiring this procedure in accordance with the identified requirements of this procedure.
- **Staff Professional** – Responsible for implementing project-specific scopes of work requiring this procedure in accordance with this procedure.

7.0 Equipment/Supplies:

The following is the typical list of equipment required for completing this procedure:

- Field Safety Equipment Bag - https://anteaintra.anteausainc.com/h&s/faq_field_bag.htm
- Traffic control devices, as defined in Site Control and Work Zones training - https://anteagroup.adobeconnect.com/sitecontrolworkzones/
- Field logbook and appropriate field form(s)
- Waterproof permanent pens and markers
- Mobile phone - with clock and camera feature
- Spare locks - for buildings, compounds, and well covers (if appropriate)
- Keys - to access existing on-site locks (if appropriate)
- Decontamination supplies/equipment (if appropriate)

Procedure-specific equipment/supplies include:

- Site map with proposed boring/well locations
- Measuring wheel/tape
- pH paper

8.0 Procedure:

Airknife

1. Direct the airknife subcontractor regarding which location to airknife first, taking into consideration any special requests the site owner/operator may have had regarding the sequence of airknifing at the site.
2. Inform the airknife subcontractor about the depth of airknifing to be performed at each location. Generally, if drilling is conducted within 10 feet of critical areas at a site (e.g., areas containing underground storage tank (UST) system components), then airknifing shall be conducted to a depth of at least 10 feet below ground surface (bgs). Outside of critical areas, airknifing shall be conducted to a depth of at least 8 feet bgs.
3. If under any condition a drilling location needs to be moved, and/or there are certain restricting conditions at the site, and/or there is a discrepancy between the information in the Work Plan or Site Plan, the Project Manager shall be contacted immediately and verbal authorization received to proceed. If possible, take photos and e-mail those to the Project Manager for discussion.
4. Ensure that the airknifing subcontractor's work area (exclusion zone) is adequately secured at all times with traffic control equipment.
5. Create a boring log for each location and record geological observations in accordance with **Geological Observations SOP**.
6. Ensure the airknife hole is free of underground piping/pea gravel and the hole is approximately the same diameter all the way down to the target depth (does not become narrower with depth). <u>If any underground piping or pea gravel is encountered, STOP airknifing, contact the Project Manager, and await authorization for proceeding to an alternate location</u>.
7. If a drilling location is moved, the new location shall be indicated on the site map with measurements for easy location in the future.
8. Airknife waste shall be properly containerized by the airknifing subcontractor and moved to a pre-approved waste container staging area at the site (see **Waste Management SOP**). Any generated waste drums shall be properly labeled. A Waste Inventory Record shall be completed, and for liquid waste, pH paper shall be used to determine waste pH.
9. Record field observations in the field logbook in accordance with **Fieldwork Documentation SOP**.

While it is possible to clear boreholes by hand augering or post-hole digging, these methods should be avoided as they have numerous limitations, including:

1. Inability to remove rocks that are either too large for the auger bucket or difficult to grab with a post-hole digger;
2. Their smaller diameter as compared with the borehole clearance diameter which is equal to or greater than the drill bit diameter;
3. Depth of clearance which is a function of soil type and field technician experience and strength; and

4. Their physically strenuous nature, which increases the risk of back and other injuries to field technicians performing borehole clearance.

9.0 Data and Records Management:

Before finalizing fieldwork documentation:

- Recheck all data inputs to prevent errors.
- If data were generated from multiple/different sample locations (borings, wells, etc.) at the same site, use appropriate file naming conventions to distinguish one file from another.
- Ensure that any repair work needed, issues to be resolved, and/or any uncompleted fieldwork are noted in the fieldwork documentation.

Upon completion of fieldwork, field personnel shall file fieldwork documentation, any electronic field files, the Site Health and Safety Plan, and any associated health and safety forms to the correct project folder, in accordance with **Control of Records SOP**.

10.0 Quality Control:

- All data, observations, calculations must be documented in the field logbook, field forms, and/or any electronic data recording devices (field computers, digital cameras, etc.).
- Adequate traceability must be ensured between any field notes and complementary field forms.
- Any electronic data recording devices must be operated in accordance with manufacturer's operating instructions, unless documented otherwise.

11.0 References:

- Superfund Program Standard Operating Procedures
- SOP Definitions (Attachment 1)
- Pre- and Site-Intrusive Work Checklist
  https://anteaintra.anteausainc.com/h&s/files/CK_Predrill_Checklist_single_locality.xls
- Geological Observations SOP
- Waste Management SOP
- Fieldwork Documentation SOP
- Control of Records SOP

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SOP Definitions

Attachment 1
SOP Definitions

AS	Air Sparging
ASTM	American Society for Testing and Materials
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CD	Compact Disc
COC	Chain of Custody
COC	Chemical(s) of Concern
CPR	Cardiopulmonary Resuscitation
DNAPL	Dense Non-Aqueous Phase Liquid
DOT	Department of Transportation
DPE	Dual Phase Extraction
DQO	Data Quality Objective
DTB	Depth to bottom (of well)
DTP	Depth to product (in well)
DTW	Depth to water (in well)
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
GAC	Granular Activated Carbon
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSSE	Health, Safety, Security, and Environment
ID	Identification
iEHS	Intelligent Environmental Health and Safety
LNAPL	Light Non-Aqueous Phase Liquid
LPH	Liquid Phase Hydrocarbon
LUST	Leaking Underground Storage Tank
MME	Monitoring and Measuring Equipment
MPE	Multi Phase Extraction
MS/MSD	Matrix Spike/Matrix Spike Duplicate (quality control sample)
MSDS	Material Safety Data Sheet
MW	Monitoring Well
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear Aromatic Hydrocarbon
PDF	Portable Document Format
PID	Photo Ionization Detector
PM	Project Manager
PNA	Polynuclear Aromatic
POTW	Publically Owned Treatment Works
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RBSL	Risk Based Screening Level
RCRA	Resource Conservation Recovery Act
RW	Recovery Well
SB	Soil Boring
SCFM	Standard Cubic Feet per Minute
SHSP	Site Health and Safety Plan (Antea Group)
SOP	Standard Operating Procedure
SSTL	Site Specific Target Level
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TCLP	Toxicity Characteristics Leaching Procedure
TOC	Top of Casing (elevation)
TOC	Total Organic Carbon
TOX	Total Organic Halogen
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound

PROCEDURE

Equipment Decontamination SOP

Author: John Gobins

Antea Group USA

Approved by: (Signatures on File)

John Gobins Process Owner	March 20, 2012 Date
Rosanna Ouellette QMS Document Control Representative	March 20, 2012 Date
John Gobins QMS Management Representative	March 20, 2012 Date

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Equipment Decontamination SOP

1.0 Scope/Applicability:

This standard operating procedure (SOP) provides guidance for preventing, minimizing, or limiting cross-contamination of samples due to inappropriate or inadequate equipment decontamination, and for developing decontamination procedures for sampling equipment to be used during fieldwork activities at contaminated sites. This procedure minimizes the possibility of exposure to field personnel from the handling of improperly decontaminated equipment, but it does not address personnel decontamination.

This procedure is applicable to sampling and non-sampling equipment used at contaminated sites.

2.0 Summary:

This procedure entails removing or neutralizing contaminants from equipment in order to minimize the likelihood of sample cross contamination, reduce or eliminate transfer of contaminants to clean areas, or prevent the mixing of incompatible substances. Gross contamination can be removed by physical decontamination procedures. These abrasive and non-abrasive physical decontamination methods include the use of brushes, air and wet blasting, and high and low pressure water cleaning.

The decontamination procedure may be summarized as follows:

- Initial physical removal.
- A non-phosphate detergent wash.
- A tap-water rinse.
- A distilled/deionized water rinse.
- Optional: A ten (10) percent nitric acid rinse (ONLY used if samples are collected for metals analyses) followed by a distilled/deionized water rinse.
- Optional: A solvent rinse (ONLY used if samples are collected for organics analyses).
- Air dry.
- A distilled/deionized water rinse.
- Air dry.

3.0 Definitions:

A list of definitions is provided in Attachment 1 (SOP Definitions).

4.0 Health and Safety:

The Health and Safety considerations for conducting this procedure are described in the following documents:

- Site Health and Safety Plan – H&S Plan Templates (https://anteaintra.anteausainc.com/h&s/plans.htm)

- Job Safety Analysis – Decontamination (https://anteaintra.anteausainc.com/h&s/files/jsa/Decontamination_JSA.doc)

Specific health and safety considerations for this procedure include:

- For some decontamination procedures, the solvents used (e.g., hydrochloric acid, acetone) raise health and safety, and waste disposal concerns.
- Health and safety considerations associated with this procedure are addressed during the Job Safety Analysis.

5.0 Cautions and Interferences:

Cautions associated with conducting this procedure include:

- The use of distilled/deionized water commonly available from commercial vendors is typically acceptable for decontamination of sampling equipment.
- The use of an untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal or industrial water treatment system.
- If solvents are utilized in decontamination, they raise health and safety, and waste disposal concerns.
- Damage can be incurred by solvent washing of complex and sophisticated sampling equipment.
- Solvent rinses should be applied from individual plastic squeeze bottles, labeled as to content, and not poured/applied directed from the manufacturers container. Use of plastic squeeze bottles minimizes the generation of solvent or acid waste.

Interferences having the potential to impact the quality of the final product include:

- Improperly decontaminated sampling equipment can result in sample cross contamination, and transfer of contaminants to clean areas.

6.0 Personnel Qualifications/Responsibilities:

Personnel performing this procedure are required to have the following qualifications:

- HSSE Training in accordance with Health, Safety, Security, and Environment Practice (https://anteaintra.anteausainc.com/h&s/practices/hsse/HSSE_Practice_Training.pdf).
- Health and Safety training in accordance with Client Required Training (if applicable) (https://anteaintra.anteausainc.com/h&s/training_client_req.htm).
- All field team members engaged in this procedure must have on file a completed Demonstration of Capability for this SOP.

The minimum roles involved and their responsibilities in this procedure include:

- **Project Manager** – Responsible for determining, communicating, and upholding the regulatory, client, and other requirements associated with performing this procedure as part of a project-specific scope of work.
- **Project Professional** – Responsible for creating project-specific scopes of work requiring this procedure in accordance with the identified requirements of this procedure.
- **Staff Professional** – Responsible for implementing project-specific scopes of work requiring this procedure in accordance with this procedure.

7.0 Equipment/Supplies:

The following is the typical list of equipment required for completing this procedure:

- Field Safety Equipment Bag - https://anteaintra.anteausainc.com/h&s/faq_field_bag.htm
- Traffic control devices, as defined in Site Control and Work Zones training - https://anteagroup.adobeconnect.com/sitecontrolworkzones/
- Field logbook and appropriate field form(s)
- Waterproof permanent pens and markers
- Mobile phone - with clock and camera feature
- Spare locks - for buildings, compounds, and well covers (if appropriate)
- Keys - to access existing on-site locks (if appropriate)

Procedure-specific equipment/supplies include:

- Non-phosphate detergent
- Tap water
- Distilled or deionized water
- Solvents for equipment rinses (optional; acetone, hexane, nitric acid, hydrochloric acid)
- Long and short handled brushes
- Bottle brushes
- Drop cloth/plastic sheeting
- Paper towels
- Plastic or galvanized tubs or buckets
- Pressurized sprayers
- Aluminum foil
- Ziploc bags
- Trash bags
- High pressure washer (if necessary)
- Fuel for high pressure washer
- Steam cleaning trough
- 55-gallon drums
- Plywood
- Sump pump
- Landscape timbers, 4 x 4's, or 2 x 4's

8.0 Procedure:

For subcontracted fieldwork, subcontractors shall describe all decontamination of drilling equipment, well construction materials, sampling equipment, tools, etc., in the project work plan. All samples and equipment leaving the contaminated area of a site must be decontaminated to remove any contamination that may have adhered to equipment. This includes casing, drill bits, auger flights, the portions of drill rigs that stand above boreholes, sampling devices, and instruments, such as slugs and sounders. In addition, the subcontractor shall take care to prevent the sample from coming into contact with potentially contaminating substances, such as tape, oil, engine exhaust, corroded surfaces, and dirt.

General

1. Field equipment shall be decontaminated before it is used if the cleanliness of equipment is unknown, and after each use.
2. Before proceeding, obtain the necessary equipment and supplies (see 7.0 Equipment/Supplies). This list provides general guidance and may require modification for project-specific needs. Restock supplies as necessary.
3. Review the sampling plan to determine if equipment blank rinsate (samples) are required. If collection of equipment blanks is required, refer to **QA/QC Sample Collection SOP**.
4. Prepare the decontamination zone in accordance with **Site Preparation and Control SOP**.
5. Don appropriate PPE.

Decontamination Procedures

Decontamination by Rinsing

This is normally performed when contaminant concentrations are negligible or are of a nature where detergents are not necessary. This method is particularly applicable for water soluble compounds or those of an inorganic nature. Contaminants that will not readily adsorb onto the surfaces of equipment and are easily rinsed off the equipment fall into this category.

1. Remove any solid particles from the equipment or material.
2. Triple rinse equipment with analyte-free water.
3. Collect rinsate water and allow to evaporate.
4. If time permits, place equipment on a clean surface and allow to air dry. If equipment is needed immediately for use, ensure that the equipment has been thoroughly rinsed with analyte-free water and wiped with a chemical-free cloth or paper towel to remove excess water.

Decontamination by Hand Washing with Detergent

Hand washing using a detergent such as Alconox is performed when contamination is known or suspected to be present, and particularly when organic constituents are involved. This method applies when triple rinsing is not sufficient to remove contaminants, and steam cleaning is not necessary.

1. Triple rinse with analyte-free water being careful to collect rinsate.
2. Using appropriate brush and detergent, scrub equipment until contaminants have been amply broken down.
3. Triple rinse again with analyte-free water and inspect equipment. Repeat this process as many times as necessary until equipment is visually clean.
4. Allow to air dry for 15 minutes or wipe dry with a clean cloth or paper towel.
5. Properly dispose of all rinsate water (see **Waste Management SOP**) after equipment blanks are collected. Wash or appropriately discard any contaminated PPE. Note: Rinsate containing detergents cannot be discharged to ground or storm drain!

Decontamination by Steam Cleaning

Steam cleaning is performed when equipment is too large to hand wash, or when high-temperature, high-pressure steam is necessary.

1. Steam cleaning troughs shall be clearly marked with signs. All equipment to be decontaminated shall be kept over the troughs during steam cleaning.

2. To ensure the proper use of the steam cleaner, review the manufacturer's instructions (i.e., safety, operation, maintenance, cleanup, etc.).
3. Before proceeding, ensure that troughs have adequate capacity to contain the rinse water.
4. Steam clean all equipment, and ensure that the equipment remains clean until used. Plastic sheeting shall be used beneath equipment stored on the ground. Note: Decontamination water collected in steam cleaning troughs may require sampling prior to disposal; this shall be confirmed with the Project Manager prior to fieldwork activities.

Decontamination of a Portable Pump

1. Rinse pump and discharge line by spraying analyte-free water on the exterior components where contact is made with contaminated well water.
2. Insert the pump into a 55-gallon drum containing analyte-free water and purge the discharge lines for approximately 5 minutes.
3. Collect all rinsate and purge water and properly dispose of (see **Waste Management SOP**).

Decontamination of Drilling Equipment

The following procedure shall be used to decontaminate large pieces of equipment, such as casings, auger flights, pipe and rods, and those portions of the drill rig that may stand directly over a boring or well location or that come into contact with casing, auger flights, pipe, or rods:

1. Deposit the contaminated equipment on the plastic drop cloth/sheet or in a container inside the contamination reduction zone.
2. Place large pieces of equipment (e.g., auger flights) on sawhorses.
3. Use a high-pressure washer and a low-phosphate soap (e.g., Alconox) to remove encrusted material from grossly contaminated equipment. If necessary, use a brush to scrub the equipment until all visible dirt, grime, grease, oil, loose paint, rust flakes, etc., have been removed.
4. Rinse all equipment with potable water.
5. Store the equipment on sawhorses or wrapped in clean plastic sheeting.
6. Decontamination water should be collected and transferred to a 55-gallon drum at the end of the day or whenever significant quantities of water have accumulated. Drums of waste derived from site investigation activities shall be managed in accordance with **Waste Management SOP**.

Decontamination of Sampling Equipment

The following procedure shall be used to decontaminate small sampling equipment such as split spoons, bailers, trowels/spoons and bowls:

1. Scrub the equipment with a solution of potable water and low-phosphate soap (e.g., Alconox).
2. If metals are contaminants of concern, rinse equipment with a 10% acid solution followed by a rinse with deionized water. Use spray bottles to minimize acid waste generation. Collect acid waste in a separate container.

3. If organic constituents are contaminants of concern, rinse the equipment with a pesticide-grade solvent, typically acetone, allow the solvent to evaporate, and then rinse the equipment with deionized water. If acetone is a constituent of concern, substitute methanol as the rinse agent. Collect solvent waste in a separate container and allow to evaporate.
4. Rinse the equipment with copious quantities of distilled or deionized water.
5. Allow the equipment to air dry on a clean surface or rack elevated at least two feet above ground.
6. Wrap the sampling device in aluminum foil or place in Ziploc bags prior to reuse.

At the completion of the decontamination activities, all fluids and solid waste shall be containerized and managed in accordance with **Waste Management SOP**. Document decontamination activities in the field logbook (see **Fieldwork Documentation SOP**).

If a particular contaminant fraction is not present at the site, the sampling equipment decontamination procedure specified above may be modified for site specificity. For example, the solvent rinse may be eliminated if organics are not of concern at a site. Modifications to the standard procedure shall be documented in the site-specific Work Plan or subsequent report.

9.0 Data and Records Management:

Upon completion of fieldwork, field personnel shall file fieldwork documentation, any electronic field files, the Site Health and Safety Plan, and any associated health and safety forms to the correct project folder, in accordance with **Control of Records SOP**.

10.0 Quality Control:

- All data, observations, calculations must be documented in the field logbook, field forms, and/or any electronic data recording devices (field computers, digital cameras, etc.).

11.0 References:

- Superfund Program Standard Operating Procedures
- SOP Definitions (Attachment 1)
- QA/QC Sample Collection SOP
- Site Preparation and Control SOP
- Waste Management SOP
- Fieldwork Documentation SOP
- Control of Records SOP

Attachment 1
SOP Definitions

Attachment 1
SOP Definitions

AS	Air Sparging
ASTM	American Society for Testing and Materials
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CD	Compact Disc
COC	Chain of Custody
COC	Chemical(s) of Concern
CPR	Cardiopulmonary Resuscitation
DNAPL	Dense Non-Aqueous Phase Liquid
DOT	Department of Transportation
DPE	Dual Phase Extraction
DQO	Data Quality Objective
DTB	Depth to bottom (of well)
DTP	Depth to product (in well)
DTW	Depth to water (in well)
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
GAC	Granular Activated Carbon
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSSE	Health, Safety, Security, and Environment
ID	Identification
iEHS	Intelligent Environmental Health and Safety
LNAPL	Light Non-Aqueous Phase Liquid
LPH	Liquid Phase Hydrocarbon
LUST	Leaking Underground Storage Tank
MME	Monitoring and Measuring Equipment
MPE	Multi Phase Extraction
MS/MSD	Matrix Spike/Matrix Spike Duplicate (quality control sample)
MSDS	Material Safety Data Sheet
MW	Monitoring Well
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear Aromatic Hydrocarbon
PDF	Portable Document Format
PID	Photo Ionization Detector
PM	Project Manager
PNA	Polynuclear Aromatic
POTW	Publically Owned Treatment Works
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RBSL	Risk Based Screening Level
RCRA	Resource Conservation Recovery Act
RW	Recovery Well
SB	Soil Boring
SCFM	Standard Cubic Feet per Minute
SHSP	Site Health and Safety Plan (Antea Group)
SOP	Standard Operating Procedure
SSTL	Site Specific Target Level
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TCLP	Toxicity Characteristics Leaching Procedure
TOC	Top of Casing (elevation)
TOC	Total Organic Carbon
TOX	Total Organic Halogen
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound

PROCEDURE

Fieldwork Documentation SOP

Author: John Gobins

Antea Group USA

Approved by: (Signatures on File)

John Gobins Process Owner	March 20, 2012 Date
Rosanna Ouellette QMS Document Control Representative	March 20, 2012 Date
John Gobins QMS Management Representative	March 20, 2012 Date

This is a controlled document with the original located at:

https://anteaintra.anteausainc.com/qms/qms_index.htm

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Document Change Tracking Form

Version	Revision date	Revisions
0	3/20/2012	Final Document Based upon Previous Team Meetings and Management Approvals in March 2012.

Fieldwork Documentation SOP

1.0 Scope/Applicability:

This standard operating procedure (SOP) provides guidance for documenting and reporting fieldwork activities. The objective of the documentation program is to accurately and completely describe all fieldwork activities, thereby demonstrating that all fieldwork activities have been conducted in accordance with the project-specific Work Plan and with applicable regulatory and client technical requirements. Accurate and complete documentation also serves as the first point of reference for tracking projects and efforts expended, recreating field activities, and evaluating new methodologies, and as an integral part of this Quality Management System.

This procedure is applicable to all Antea Group personnel and all fieldwork activities, regardless of whether they are self-performed or performed by subcontractors (overseen in the field by Antea Group).

2.0 Summary:

This procedure entails documenting all aspects of fieldwork, including general field observations, monitoring measurements and sampling data, equipment use, calibrations, and any issues that may impact, or be included in, subsequent site/project reports or correspondence. Documentation media include field logbooks, field data collection forms, health and safety forms, field computers, and digital cameras.

All data entry, observations and calculations for example, whether entered in logbooks or field computers, or on standard forms, can be used during litigation or legal procedures. Therefore, fieldwork documentation, once completed, becomes accountable documentation and must be maintained as part of the official project file.

Language shall be objective, factual, and free of personal opinions or other potentially inappropriate terminology.

3.0 Definitions:

A list of definitions is provided in Attachment 1 (SOP Definitions).

4.0 Health and Safety:

The Health and Safety considerations for conducting this procedure are described in the following documents:

- Site Health and Safety Plan – H&S Plan Templates (https://anteaintra.anteausainc.com/h&s/plans.htm)
- Job Safety Analysis – none

Specific health and safety considerations for this procedure include:

- If possible, field personnel should position themselves in a safe location of the site away from traffic and other site hazards while completing fieldwork documentation, as completion of documentation diverts some awareness away from site surroundings.

5.0 Cautions and Interferences:

Cautions associated with conducting this procedure include:

- Fieldwork documentation is subject to weather conditions during use. Weatherproof paper (e.g., Rite-in-the-Rain) and non-bleeding permanent ink pens must be used to avoid rendering entries useless and unreadable.
- Field computers must be protected from the elements or from accidental damage.
- Electronic data entry is subject to numerous unintentional errors such as incorrect number entry, misplaced decimal points, dyslexic typing, and data entry into the wrong cell, row or column.

Interferences having the potential to impact the quality of the final product include:

- Field personnel data entry errors and/or weather conditions have the ability to impact the quality of documentation obtained during fieldwork activities.

6.0 Personnel Qualifications/Responsibilities:

Personnel performing this procedure are required to have the following qualifications:

- HSSE Training in accordance with Health, Safety, Security, and Environment Practice (https://anteaintra.anteausainc.com/h&s/practices/hsse/HSSE_Practice_Training.pdf).
- Health and Safety training in accordance with Client Required Training (if applicable) (https://anteaintra.anteausainc.com/h&s/training_client_req.htm).
- All field team members engaged in this procedure must have on file a completed Demonstration of Capability for this SOP.

The minimum roles involved and their responsibilities in this procedure include:

- **Project Manager** – Responsible for determining, communicating, and upholding the regulatory, client, and other requirements associated with performing this procedure as part of a project-specific scope of work.
- **Project Professional** – Responsible for creating project-specific scopes of work requiring this procedure in accordance with the identified requirements of this procedure.
- **Staff Professional** – Responsible for implementing project-specific scopes of work requiring this procedure in accordance with this procedure.

7.0 Equipment/Supplies:

The following is the typical list of equipment required for completing this procedure:

- Field Safety Equipment Bag - https://anteaintra.anteausainc.com/h&s/faq_field_bag.htm
- Traffic control devices, as defined in Site Control and Work Zones training - https://anteagroup.adobeconnect.com/sitecontrolworkzones/
- Waterproof permanent pens and markers
- Mobile phone - with clock and camera feature

- Spare locks - for buildings, compounds, and well covers (if appropriate)
- Keys - to access existing on-site locks (if appropriate)
- Decontamination supplies/equipment (if appropriate)

Procedure-specific equipment/supplies include:

- Field logbook (all-weather or water-resistant, e.g. Rite-in-the-Rain)
- Field forms and clipboard
- Field computer (optional)
- Digital camera (if not on mobile phone)

8.0 Procedure:

Field Logbook

All information relating to installation and development of monitoring wells, installation of temporary groundwater sampling points, well development, well purging, groundwater sample collection and all other sampling activities or field work shall be recorded in a field logbook or on field form(s).

Each field logbook shall be uniquely identified, including the Antea Group logo, contact information (e.g. office address and telephone), and the work-site/project number and location/address. The field logbook shall be bound with consecutively numbered pages and be suitable for submission as evidence in legal proceedings. The field logbook shall contain, as a minimum, the following information on the first page for each field event (or day):

- Location, date and time of each activity;
- Weather conditions (changes);
- Activity being performed;
- Identity of the person(s) performing the activity;
- Numerical value and units of any field measurements;
- Identity of, and the calibration results for, each field instrument being used;
- All information required to demonstrate that the work is conducted in accordance with applicable Sampling Plans, Work Plans and SOPs; and
- Visitors to the site.

These entries can be also made on a Fieldwork Daily Log (Attachment 2).

Entries into the field logbook shall be made as follows:

- All entries shall be recorded with non-erasable waterproof ink. Pencil entries are prohibited, as is the use of "white out" or covering tapes.
- If errors are made, a single line shall be drawn through the error and the correct information entered along the side. Corrections must be initialed and dated, preferably by the individual making the error.
- A series of errors (horizontally or vertically) may be initialed/dated once by using 'brackets" to indicate the error series.
- Documentation for each new site visit shall begin on a new left-hand page.
- Number all pages associated with a site event each day as page 1 of 5, 2 of 5, etc.
- Enter the site identification number and date at the top of each page.
- Initial and date the bottom of each page as it is completed.

- This applies to all individuals recording entries on that sheet/page.
- Ideally the number of individuals recording entries should be minimized.
- Draw a diagonal line across and unused space at the bottom of a page.

Where samples are collected, specific information which shall be included for each sample includes:

- Sample type and sampling method;
- Identity of each sample and depth(s) from which it was collected;
- Amount of each sample;
- Sample description (e.g., color, odor, clarity);
- Identification of sampling devices;
- Identification of conditions that might affect the representativeness of a sample (e.g., refueling operations, damaged well casings); and
- All information required to demonstrate that the work is conducted in accordance with applicable Sampling Plans, Work Plans, and SOPs.

Field Forms

Standard field forms are designed to capture activity-specific information and applicable elements as described previously for field logbooks. Forms may be used in conjunction with field logbooks or field computers.

- Data is generally recorded on loose multi-page forms.
- Each page must be identically identified (e.g. with date, location, site/project number etc.).
- It is important to staple/clip/bind all field forms and supporting documents together to prevent loss or misfiling.

Field Computers

The use of field computers to record fieldwork observations is essentially no different than using field forms. Electronic data entry is subject to numerous unintentional errors such as incorrect number entry, misplaced decimal points, dyslexic typing, and data entry into the wrong cell, row or column.

- If discovered in the field, any and all errors can be corrected without notation, prior to any electronic data downloads.
- If discovered after the fact or after an electronic download, all electronic corrections must be documented in both the downloaded electronic file and in any paper file.
- Follow the Antea Group guidelines on making changes to electronic records.
- In general, this will involve using the "tools/track changes" feature in Microsoft Word and the "insert/comment" feature for individual cells in Microsoft Excel.
- Electronic signatures shall be date stamped and unalterable.

Digital Cameras

General guidelines for all types of photos include:

- If possible, use a camera that has a time and/or date stamp. Record the date and time each photo was taken on the photo or with the photo file (as applicable) and in the field logbook.

- Digital camera recording mode (dependent on camera's pixel resolution quality and picture quality mode) shall be set to achieve a minimum pixel resolution of 1600 x 1200 (2 megapixels) or higher.
- Do not use special lenses (i.e., wide-angle lenses) as they can distort the image.
- A brief, accurate description of what the photograph shows, including the name of the site and location, shall be recorded in the field logbook.
- Include the name of the photographer, and witness, as applicable.

When photographs are taken, the record of each frame exposed/recorded shall be kept in the bound field logbook along with the information above required for each photograph. The field investigator shall then enter the required information on a CD using the photographic record from the bound field logbook, to identify each photograph.

9.0 Data and Records Management:

Before finalizing fieldwork documentation:

- Recheck all data inputs to prevent errors.
- If data were generated from multiple/different sample locations (borings, wells, etc.) at the same site, use appropriate file naming conventions to distinguish one file from another.
- Ensure that any repair work needed, issues to be resolved, and/or any uncompleted fieldwork are noted in the fieldwork documentation.

Field Logbooks and Field Forms
These will become part of the project file, and should be kept in the project file at all times when not in the possession of the field team.

Field Computers
Upon return to the office:

- Where paper copies of field data collection forms are required, print out a copy of the field form(s), sign/date each page, staple/clip together with any supporting documents, and file in the correct project folder.
- Where paper copies of field data collection forms are not required, save the field form file(s) to Adobe PDF format, electronically sign/date each page, and file (upload) to the correct project folder along with the original electronic format file(s). As an alternate, electronic files may be printed out, signed/dated, and scanned to Adobe PDF format.

Digital Cameras
Upon return to the office:

- Where paper copies of photographs are required, print out a copy of the photographs, sign/date each photograph, place in a plastic sleeve, and file in the correct project folder, along with the original electronic photograph file(s).
- Where paper copies of photographs are not required, file (upload) the photograph file(s) to the correct project folder.

All fieldwork documentation shall be filed in accordance with **Control of Records SOP**.

10.0 Quality Control:

- All data, observations, calculations must be documented in the field logbook, field forms, and/or any electronic data recording devices (field computers, digital cameras, etc.).
- Adequate traceability must be ensured between any field notes and complementary field forms.
- Any electronic data recording devices must be operated in accordance with manufacturer's operating instructions, unless documented otherwise.

11.0 References:

- Superfund Program Standard Operating Procedures
- SOP Definitions (Attachment 1)
- Fieldwork Daily Log (Attachment 2)
- Control of Records SOP

Attachment 1
SOP Definitions

Attachment 1
SOP Definitions

AS	Air Sparging
ASTM	American Society for Testing and Materials
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CD	Compact Disc
COC	Chain of Custody
COC	Chemical(s) of Concern
CPR	Cardiopulmonary Resuscitation
DNAPL	Dense Non-Aqueous Phase Liquid
DOT	Department of Transportation
DPE	Dual Phase Extraction
DQO	Data Quality Objective
DTB	Depth to bottom (of well)
DTP	Depth to product (in well)
DTW	Depth to water (in well)
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
GAC	Granular Activated Carbon
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSSE	Health, Safety, Security, and Environment
ID	Identification
iEHS	Intelligent Environmental Health and Safety
LNAPL	Light Non-Aqueous Phase Liquid
LPH	Liquid Phase Hydrocarbon
LUST	Leaking Underground Storage Tank
MME	Monitoring and Measuring Equipment
MPE	Multi Phase Extraction
MS/MSD	Matrix Spike/Matrix Spike Duplicate (quality control sample)
MSDS	Material Safety Data Sheet
MW	Monitoring Well
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear Aromatic Hydrocarbon
PDF	Portable Document Format
PID	Photo Ionization Detector
PM	Project Manager
PNA	Polynuclear Aromatic
POTW	Publically Owned Treatment Works
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RBSL	Risk Based Screening Level
RCRA	Resource Conservation Recovery Act
RW	Recovery Well
SB	Soil Boring
SCFM	Standard Cubic Feet per Minute
SHSP	Site Health and Safety Plan (Antea Group)
SOP	Standard Operating Procedure
SSTL	Site Specific Target Level
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TCLP	Toxicity Characteristics Leaching Procedure
TOC	Top of Casing (elevation)
TOC	Total Organic Carbon
TOX	Total Organic Halogen
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound

Attachment 2
Fieldwork Daily Log

anteagroup

(if found, please call 1-800-477-7411)

Site manager telephone number: _____

Check in with site manager (time): _____

Conduct tailgate safety meeting & sign acknowledgement: Y N

Fieldwork Daily Log

Site Name or Number: _____

Project Number: _____

Location (City, State): _____

Date: _____

Page: _____ of _____

Recorded by:

Reviewed by: _____

Fieldwork_Daily_Log.xls

PROCEDURE

Groundwater Sampling Using a Bailer SOP

Author: John Gobins

Antea Group USA

Approved by: (Signatures on File)

John Gobins Process Owner	March 20, 2012 Date
Rosanna Ouellette QMS Document Control Representative	March 20, 2012 Date
John Gobins QMS Management Representative	March 20, 2012 Date

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Document Change Tracking Form

Version	Revision date	Revisions
0	3/20/2012	Final Document Based upon Previous Team Meetings and Management Approvals in March 2012.

Groundwater Sampling Using a Bailer SOP

1.0 Scope/Applicability:

This standard operating procedure (SOP) provides guidance for sampling groundwater using a bailer.

Most contaminated site investigations utilize some form of a groundwater sampling or monitoring program to fully characterize the nature and extent of groundwater contamination. In order to obtain a representative groundwater sample for chemical analysis, it is important to first remove stagnant water in the well before collecting a sample. This may be achieved using a variety of instruments including pumps and bailers. Once purging is completed and the correct laboratory-cleaned sample containers have been prepared, sampling may proceed. Sampling may be conducted with a variety of devices and need not be the same as the device used for purging. During sampling, a field data sheet shall be completed, a Chain-of-Custody form prepared, and all pertinent data recorded in the site logbook.

This procedure is applicable to monitoring wells which are scheduled for sampling at sites where regulatory and/or client requirements call for sampling groundwater from wells with a bailer.

2.0 Summary:

This procedure entails collecting a groundwater sample from a well using a bailer (disposable or reusable). The sampling equipment must be sterile or thoroughly decontaminated prior to sampling in order to prevent cross-contamination of wells. The number and types of sample containers to be filled is based upon the types of analyses to be performed on the sample. For certain types of analyses, samples may need to be filtered in the field prior to being transferred into sample containers. Sample containers are labeled, stored, packaged, and shipped according to pre-defined protocols that are intended to preserve sample integrity from the time the sample is collected until it is received by the analytical laboratory.

3.0 Definitions:

A list of definitions is provided in Attachment 1 (SOP Definitions).

4.0 Health and Safety:

The Health and Safety considerations for conducting this procedure are described in the following documents:

- Site Health and Safety Plan – H&S Plan Templates (https://anteaintra.anteausainc.com/h&s/plans.htm)
- Job Safety Analysis – Well Development and Groundwater Sampling (https://anteaintra.anteausainc.com/h&s/files/jsa/Well_development-GW_sampling_JSA.doc)

Specific health and safety considerations for this procedure include:

- Health and safety considerations associated with this procedure are addressed during the Job Safety Analysis.

5.0 Cautions and Interferences:

Cautions associated with conducting this procedure include:

- Before sampling, monitoring wells shall be allowed to stabilize for a minimum period of 24 hours after development.
- Analysis can be compromised by field personnel in two primary ways: 1) taking an unrepresentative sample, or 2) by incorrect handling of the sample.
- There are numerous ways of introducing foreign contaminants into a sample, and these must be avoided by following strict sampling procedures and utilizing trained field personnel.
- As a general rule, all monitoring wells should be pumped (preferred) or bailed prior to sampling.
- Ideally, sampling equipment should be completely inert, economical to manufacture, easily cleaned, sterilized, reusable, and able to operate at remote sites in the absence of power sources.
- Materials of construction for samplers and evacuation equipment (bladders, pump, bailers, tubing, etc.) should be limited to stainless steel, Teflon, and glass in areas where concentrations are expected to be at or near the detection limit. The tendency of organics to leach into and out of many materials make the selection of materials critical for trace analyses. The use of plastics, such as PVC or polyethylene, should be avoided when analyzing for organics. However, PVC may be used for evacuation equipment as it will not come in contact with the sample, and in highly contaminated wells, disposable equipment (i.e., polypropylene bailers) may be appropriate to avoid cross-contamination.
- Wells should be sampled as soon as possible after purging (certainly no more than 24 hours) and should be sampled in order from least contaminated to most contaminated or from upgradient to downgradient if chemistry is unknown.
- Water levels shall be allowed to recover to 90% of the static water level before sampling.
- All non-dedicated equipment shall be decontaminated in accordance with **Decontamination SOP** prior to use or upon completion of the sampling activities.

Interferences having the potential to impact the quality of the final product include:

- Stagnant water (e.g., the well water above the screened section in confined wells or unconfined wells with submerged screens) may contain foreign material inadvertently or deliberately introduced from the surface resulting in an unrepresentative sample.
- Excessive disruption of water during sample collection from the well or pouring into the bottle can serve to reduce the VOC concentration in samples as a result of volatilization.

6.0 Personnel Qualifications/Responsibilities:

Personnel performing this procedure are required to have the following qualifications:

- HSSE Training in accordance with Health, Safety, Security, and Environment Practice (https://anteaintra.anteausainc.com/h&s/practices/hsse/HSSE_Practice_Training.pdf).

- Health and Safety training in accordance with Client Required Training (if applicable) (https://anteaintra.anteausainc.com/h&s/training_client_req.htm).
- All field team members engaged in this procedure must have on file a completed Demonstration of Capability for this SOP.

The minimum roles involved and their responsibilities in this procedure include:

- **Project Manager** – Responsible for determining, communicating, and upholding the regulatory, client, and other requirements associated with performing this procedure as part of a project-specific scope of work.
- **Project Professional** – Responsible for creating project-specific scopes of work requiring this procedure in accordance with the identified requirements of this procedure.
- **Staff Professional** – Responsible for implementing project-specific scopes of work requiring this procedure in accordance with this procedure.

7.0 Equipment/Supplies:

The following is the typical list of equipment required for completing this procedure:

- Field Safety Equipment Bag - https://anteaintra.anteausainc.com/h&s/faq_field_bag.htm
- Traffic control devices, as defined in Site Control and Work Zones training - https://anteagroup.adobeconnect.com/sitecontrolworkzones/
- Field logbook and appropriate field form(s)
- Waterproof permanent pens and markers
- Mobile phone - with clock and camera feature
- Spare locks - for buildings, compounds, and well covers (if appropriate)
- Keys - to access existing on-site locks (if appropriate)
- Decontamination supplies/equipment (if appropriate)

Procedure-specific equipment/supplies include:

- Sample containers and labels
- Chain-of-Custody forms/Custody seals
- Knife or scissors
- 5-gallon buckets
- Plastic sheeting
- Shipping containers
- Packing materials
- Ziploc-type plastic bags
- Field parameter instruments (multiparameter, turbidimeter, DO meter)
- Calibration standards
- Nylon rope
- Bailers

8.0 Procedure:

1. Prepare for sampling using: **Fieldwork Documentation SOP, VOC Sample Collection SOP, Sample Packaging and Shipping SOP, QA/QC Sample Collection SOP**, and

Groundwater Sampling Form - Purge (Attachment 2) or Groundwater Sampling Form – No Purge (Attachment 3).

2. Water level and liquid levels measurement shall be taken in accordance with **Water and Liquid Level Measurement SOP**.
3. Measurement of field parameters shall be done in accordance with **Measurement of Monitoring Well Field Parameters SOP**.
4. Purge the well in accordance with **Purging a Monitoring Well With a Bailer SOP** or **Purging a Monitoring Well With a Pump SOP**. For no purge wells, skip this step.
5. Allow well to recharge after purging to 90% of the static water level. Variances from this requirement (e.g., for wells in low water yielding deposits) shall be approved by the Project Manager prior to implementation.
6. Assemble and label appropriate sample containers.
7. Attach a new piece of nylon rope to a dedicated bailer, a disposable bailer, or a clean, decontaminated non-dedicated bailer.
8. Lower the bailer slowly and gently into the well, taking care not to shake the casing sides or to splash the bailer into the water. Stop lowering at a point adjacent to the screen.
9. Allow bailer to fill and then slowly and gently retrieve the bailer from the well avoiding contact with the casing, so as not to knock flakes of rust or other foreign material into the bailer.
10. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated or disturbed.
11. Begin pouring slowly from the bailer into the appropriate container. Samples shall be collected in the following order:
    - Volatile organic compounds (VOCs)
    - Semi-volatile organic compounds (SVOCs) and polyaromatic hydrocarbons (PAHs)
    - Inorganic constituents (metals)
    - Mercury
    - Cyanide
    - Total organic carbon (TOC)
    - Total organic halogen (TOX)
    - Samples requiring field filtration
    - Samples for field parameter measurement
    - Samples for nutrient anion determinations
12. Filter and preserve samples as required by the sampling plan.
13. Tightly cap the pre-labeled sample container and place it in a pre-chilled cooler.
14. Label all samples and log all samples on the Groundwater Sampling Form – Purge (Attachment 2) or Groundwater Sampling Form – No Purge (Attachment 3) in accordance with **Fieldwork Documentation SOP**. Complete a Chain-of-Custody record in accordance with **Completing Chain of Custody SOP**.
15. Package samples and complete necessary paperwork in accordance with **Sample Packaging and Shipping SOP**.
16. Transport samples to decontamination zone in preparation for transport to analytical laboratory or to express shipping location.

9.0 Data and Records Management:

Before finalizing fieldwork documentation:

- Recheck all data inputs to prevent errors.
- If data were generated from multiple/different sample locations (borings, wells, etc.) at the same site, use appropriate file naming conventions to distinguish one file from another.
- Ensure that any repair work needed, issues to be resolved, and/or any uncompleted fieldwork are noted in the fieldwork documentation.

Upon completion of fieldwork, field personnel shall file fieldwork documentation, any electronic field files, the Site Health and Safety Plan, and any associated health and safety forms to the correct project folder, in accordance with **Control of Records SOP**.

10.0 Quality Control:

- All data, observations, calculations must be documented in the field logbook, field forms, and/or any electronic data recording devices (field computers, digital cameras, etc.).
- Adequate traceability must be ensured between any field notes and complementary field forms.
- Any electronic data recording devices must be operated in accordance with manufacturer's operating instructions, unless documented otherwise.
- Monitoring and Measuring Equipment must be calibrated prior to the event and calibration results documented in accordance with **Equipment Calibration and Maintenance SOP**.

11.0 References:

- Superfund Program Standard Operating Procedures
- SOP Definitions (Attachment 1)
- Decontamination SOP
- Fieldwork Documentation SOP
- VOC Sample Collection SOP
- Sample Packaging and Shipping SOP
- QA/QC Sample Collection SOP
- Groundwater Sampling Form – Purge (Attachment 2)
- Groundwater Sampling Form – No Purge (Attachment 3)
- Water and Liquid Level Measurement SOP
- Measurement of Monitoring Well Field Parameters SOP
- Purging a Monitoring Well With a Bailer SOP
- Purging a Monitoring Well With a Pump SOP
- Completing Chain of Custody SOP
- Control of Records SOP
- Equipment Calibration and Maintenance SOP

Attachment 1
SOP Definitions

Attachment 1
SOP Definitions

AS	Air Sparging
ASTM	American Society for Testing and Materials
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CD	Compact Disc
COC	Chain of Custody
COC	Chemical(s) of Concern
CPR	Cardiopulmonary Resuscitation
DNAPL	Dense Non-Aqueous Phase Liquid
DOT	Department of Transportation
DPE	Dual Phase Extraction
DQO	Data Quality Objective
DTB	Depth to bottom (of well)
DTP	Depth to product (in well)
DTW	Depth to water (in well)
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
GAC	Granular Activated Carbon
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSSE	Health, Safety, Security, and Environment
ID	Identification
iEHS	Intelligent Environmental Health and Safety
LNAPL	Light Non-Aqueous Phase Liquid
LPH	Liquid Phase Hydrocarbon
LUST	Leaking Underground Storage Tank
MME	Monitoring and Measuring Equipment
MPE	Multi Phase Extraction
MS/MSD	Matrix Spike/Matrix Spike Duplicate (quality control sample)
MSDS	Material Safety Data Sheet
MW	Monitoring Well
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear Aromatic Hydrocarbon
PDF	Portable Document Format
PID	Photo Ionization Detector
PM	Project Manager
PNA	Polynuclear Aromatic
POTW	Publically Owned Treatment Works
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RBSL	Risk Based Screening Level
RCRA	Resource Conservation Recovery Act
RW	Recovery Well
SB	Soil Boring
SCFM	Standard Cubic Feet per Minute
SHSP	Site Health and Safety Plan (Antea Group)
SOP	Standard Operating Procedure
SSTL	Site Specific Target Level
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TCLP	Toxicity Characteristics Leaching Procedure
TOC	Top of Casing (elevation)
TOC	Total Organic Carbon
TOX	Total Organic Halogen
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound

Attachment 2
Groundwater Sampling Form - Purge

anteagroup

(if found, please call 1-800-477-7411)

Groundwater Sampling Form - Purge

Site Name or Number: _____

Project Number: _____

Location (City, State): _____

Date: _____

Page: _____ of _____

WELL ID:			
SAMPLE ID:			
Traffic control set up at well (start time):			
Traffic control set up (end time):			
Casing volume (gal):			
Purged by disposable bailer (Y/N)?		other:	
Measured in 5 gal pail?		other:	
Purge time (from):			

Casing volumes (gal):	T (deg C)	pH	Cond (mS/cm)	DO (mg/L)	ORP	TDS

Start purge time:			
Volume purged (gal):			
Purged dry (Y/N)?:		80% water level	Initial DTW
Pre-sampling depth to water (ft):			
Sampled by disposable bailer (Y/N)?:		other:	
Time/date sampled:			

Sampler container type	No of containers	Preserved by	At what pH	Filter type
40 ml VOA		HCl	<2	none

No of containers:			
Sample color/clarity:			
Duplicate sample number:			
Time collected:			
Samples cooled by Ice (Y/N)?		other:	
Any conditions affecting sample quality (Y/N)?:		describe:	
Ppurge water disposal:			
Well cover secured (time):			
Traffic control removed (end time):			

Sampled by: _____ Reviewed by: _____

Groundwater_Sampling_Form_Purge.xls

Attachment 3
Groundwater Sampling Form – No Purge

anteagroup

(if found, please call 1-800-477-7411)

Groundwater Sampling Form - No Purge

Site Name or Number: _____

Project Number: _____

Location (City, State): _____

Date: _____

Page: _____ of _____

WELL ID:				
SAMPLE ID:				
Traffic control set up at well (start time):				
Traffic control set up (end time):				
Sampled by disposable bailer (Y/N)?		other:		
Time/date sampled:				
	T (deg F)	pH	Cond (mS/cm)	DO (mg/L)
Sample water quality parameters:				
Sampler container type	No of containers	Preserved by	At what pH	Filter type
40 ml VOA		HCl	<2	none
No of containers:				
Sample color/clarity:				
Duplicate sample number:				
Time collected:				
Samples cooled by ice (Y/N)?		other:		
Any conditions affecting sample quality (Y/N)?		describe:		
Well cover secured (time):				
Traffic control removed (end time):				

Sampled by: _____ Reviewed by: _____

Groundwater_Sampling_Form_NoPurge.xls

PROCEDURE

Groundwater Sampling Using Low-Flow Techniques SOP

Author: John Gobins

Antea Group USA

Approved by: (Signatures on File)

John Gobins Process Owner	March 20, 2012 Date
Rosanna Ouellette QMS Document Control Representative	March 20, 2012 Date
John Gobins QMS Management Representative	March 20, 2012 Date

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Groundwater Sampling Using Low-Flow Techniques SOP

1.0 Scope/Applicability:

This standard operating procedure (SOP) provides guidance for sampling groundwater using low-flow techniques. Low-flow methods are typically used in conjunction with micropurging (see **Micro Purging a Monitoring Well SOP**).

Most contaminated site investigations utilize some form of a groundwater sampling or monitoring program to fully characterize the nature and extent of groundwater contamination. In order to obtain a representative groundwater sample for chemical analysis, it is important to first remove stagnant water in the well before collecting a sample. This may be achieved using a variety of instruments including pumps and bailers. Once purging is completed and the correct laboratory-cleaned sample containers have been prepared, sampling may proceed. Sampling may be conducted with a variety of devices and need not be the same as the device used for purging. During sampling, a field data sheet shall be completed, a Chain-of-Custody form prepared, and all pertinent data recorded in the site logbook.

This procedure is applicable to monitoring wells which are scheduled for sampling at sites where regulatory and/or client requirements call for sampling groundwater from wells with low-flow techniques.

2.0 Summary:

This procedure entails collecting a groundwater sample from a well using a low-flow (e.g., peristaltic) pump. The sampling equipment must be thoroughly decontaminated prior to sampling in order to prevent cross-contamination of wells. The number and types of sample containers to be filled is based upon the types of analyses to be performed on the sample. For certain types of analyses, samples may need to be filtered in the field prior to being transferred into sample containers. Sample containers are labeled, stored, packaged, and shipped according to pre-defined protocols that are intended to preserve sample integrity from the time the sample is collected until it is received by the analytical laboratory.

3.0 Definitions:

A list of definitions is provided in Attachment 1 (SOP Definitions).

4.0 Health and Safety:

The Health and Safety considerations for conducting this procedure are described in the following documents:

- Site Health and Safety Plan – H&S Plan Templates (https://anteaintra.anteausainc.com/h&s/plans.htm)

- Job Safety Analysis – Well Development and Groundwater Sampling (https://anteaintra.anteausainc.com/h&s/files/jsa/Well_development-GW_sampling_JSA.doc)

Specific health and safety considerations for this procedure include:

- Health and safety considerations associated with this procedure are addressed during the Job Safety Analysis.

5.0 Cautions and Interferences:

Cautions associated with conducting this procedure include:

- Before sampling, monitoring wells shall be allowed to stabilize for a minimum period of 24 hours after development.
- Analysis can be compromised by field personnel in two primary ways: 1) taking an unrepresentative sample, or 2) by incorrect handling of the sample.
- There are numerous ways of introducing foreign contaminants into a sample, and these must be avoided by following strict sampling procedures and utilizing trained field personnel.
- As a general rule, all monitoring wells should be pumped (preferred) or bailed prior to sampling.
- Ideally, sampling equipment should be completely inert, economical to manufacture, easily cleaned, sterilized, reusable, and able to operate at remote sites in the absence of power sources.
- Materials of construction for samplers and evacuation equipment (bladders, pump, bailers, tubing, etc.) should be limited to stainless steel, Teflon, and glass in areas where concentrations are expected to be at or near the detection limit. The tendency of organics to leach into and out of many materials make the selection of materials critical for trace analyses. The use of plastics, such as PVC or polyethylene, should be avoided when analyzing for organics. However, PVC may be used for evacuation equipment as it will not come in contact with the sample, and in highly contaminated wells, disposable equipment (i.e., polypropylene bailers) may be appropriate to avoid cross-contamination.
- Wells should be sampled as soon as possible after purging (certainly no more than 24 hours) and should be sampled in order from least contaminated to most contaminated or from upgradient to downgradient if chemistry is unknown.
- Water levels shall be allowed to recover to 90% of the static water level before sampling.
- All non-dedicated equipment shall be decontaminated in accordance with **Decontamination SOP** prior to use or upon completion of the sampling activities.

Interferences having the potential to impact the quality of the final product include:

- Stagnant water (e.g., the well water above the screened section in confined wells or unconfined wells with submerged screens) may contain foreign material inadvertently or deliberately introduced from the surface resulting in an unrepresentative sample.
- A non-representative sample can also result from excessive pre-pumping of the monitoring well. Stratification of the leachate concentration in the groundwater formation may occur, or heavier-than-water compounds may sink to the lower portions of the

aquifer. Excessive pumping can dilute or increase the contaminant concentrations from what is representative of the sampling point of interest.

6.0 Personnel Qualifications/Responsibilities:

Personnel performing this procedure are required to have the following qualifications:

- HSSE Training in accordance with Health, Safety, Security, and Environment Practice (https://anteaintra.anteausainc.com/h&s/practices/hsse/HSSE_Practice_Training.pdf).
- Health and Safety training in accordance with Client Required Training (if applicable) (https://anteaintra.anteausainc.com/h&s/training_client_req.htm).
- All field team members engaged in this procedure must have on file a completed Demonstration of Capability for this SOP.

The minimum roles involved and their responsibilities in this procedure include:

- **Project Manager** – Responsible for determining, communicating, and upholding the regulatory, client, and other requirements associated with performing this procedure as part of a project-specific scope of work.
- **Project Professional** – Responsible for creating project-specific scopes of work requiring this procedure in accordance with the identified requirements of this procedure.
- **Staff Professional** – Responsible for implementing project-specific scopes of work requiring this procedure in accordance with this procedure.

7.0 Equipment/Supplies:

The following is the typical list of equipment required for completing this procedure:

- Field Safety Equipment Bag - https://anteaintra.anteausainc.com/h&s/faq_field_bag.htm
- Traffic control devices, as defined in Site Control and Work Zones training - https://anteagroup.adobeconnect.com/sitecontrolworkzones/
- Field logbook and appropriate field form(s)
- Waterproof permanent pens and markers
- Mobile phone - with clock and camera feature
- Spare locks - for buildings, compounds, and well covers (if appropriate)
- Keys - to access existing on-site locks (if appropriate)
- Decontamination supplies/equipment (if appropriate)

Procedure-specific equipment/supplies include:

- Sample containers and labels
- Chain-of-Custody forms/Custody seals
- Knife or scissors
- 5-gallon buckets
- Plastic sheeting
- Shipping containers
- Packing materials
- Ziploc-type plastic bags
- Field parameter instruments (multiparameter, turbidimeter, DO meter)
- Calibration standards

- Generator, if using pump
- Gasoline for generator/air compressor
- Air compressor for bladder pumps
- Pump (peristaltic or bladder)
- Control box
- Discharge tubing for pump
- Appropriate pump fittings (e.g., hose clamps, barbed fittings, etc.)

8.0 Procedure:

1. Prepare for sampling using: **Fieldwork Documentation SOP**, **VOC Sample Collection SOP**, **Sample Packaging and Shipping SOP**, and **QA/QC Sample Collection SOP**, and Groundwater Sampling Form – Low Flow (Attachment 2).
2. Water level and liquid levels measurement shall be taken in accordance with **Water and Liquid Level Measurement SOP**.
3. Measurement of field parameters shall be done in accordance with **Measurement of Monitoring Well Field Parameters SOP**.
4. Purge the well in accordance with **Micro Purging a Monitoring Well SOP**.
5. Allow well to recharge after purging to 90% of the static water level. Variances from this requirement (e.g., for wells in low water yielding deposits) shall be approved by the Project Manager prior to implementation.
6. Disconnect flow-through cells.
7. Assemble and label appropriate sample containers.
8. Set the pump height so that the intake is near the center of the screened interval.
9. Adjust the flow rate of the pump to minimize aeration and bubble formation. A flow rate of <0.5 L/min is typically appropriate. The pump discharge should produce a thin, continuous stream of water when filling the sample container.
10. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated or disturbed.
11. Begin using the pump to fill the appropriate container. Samples shall be collected in the following order:
    - Volatile organic compounds (VOCs)
    - Semi-volatile organic compounds (SVOCs) and polyaromatic hydrocarbons (PAHs)
    - Inorganic constituents (metals)
    - Mercury
    - Cyanide
    - Total organic carbon (TOC)
    - Total organic halogen (TOX)
    - Samples requiring field filtration
    - Samples for field parameter measurement
    - Samples for nutrient anion determinations
12. Filter and preserve samples as required by the sampling plan.
13. Tightly cap the pre-labeled sample container and place it in a pre-chilled cooler.
14. Replace the well cap.

15. Label all samples and log all samples on the Groundwater Sampling Form – Low Flow (Attachment 2) in accordance with **Fieldwork Documentation SOP**. Complete a Chain-of-Custody record in accordance with **Completing Chain of Custody SOP**.
16. Package samples and complete necessary paperwork in accordance with **Sample Packaging and Shipping SOP**.
17. Transport samples to decontamination zone in preparation for transport to analytical laboratory or to express shipping location.

9.0 Data and Records Management:

Before finalizing fieldwork documentation:

- Recheck all data inputs to prevent errors.
- If data were generated from multiple/different sample locations (borings, wells, etc.) at the same site, use appropriate file naming conventions to distinguish one file from another.
- Ensure that any repair work needed, issues to be resolved, and/or any uncompleted fieldwork are noted in the fieldwork documentation.

Upon completion of fieldwork, field personnel shall file fieldwork documentation, any electronic field files, the Site Health and Safety Plan, and any associated health and safety forms to the correct project folder, in accordance with **Control of Records SOP**.

10.0 Quality Control:

- All data, observations, calculations must be documented in the field logbook, field forms, and/or any electronic data recording devices (field computers, digital cameras, etc.).
- Adequate traceability must be ensured between any field notes and complementary field forms.
- Any electronic data recording devices must be operated in accordance with manufacturer's operating instructions, unless documented otherwise.
- Monitoring and Measuring Equipment must be calibrated prior to the event and calibration results documented in accordance with **Equipment Calibration and Maintenance SOP**.

11.0 References:

- Superfund Program Standard Operating Procedures
- Micro Purging a Monitoring Well SOP
- SOP Definitions (Attachment 1)
- Decontamination SOP
- Fieldwork Documentation SOP
- VOC Sample Collection SOP
- Sample Packaging and Shipping SOP
- QA/QC Sample Collection SOP
- Groundwater Sampling Form – Low Flow (Attachment 2)
- Water and Liquid Level Measurement SOP
- Measurement of Monitoring Well Field Parameters SOP

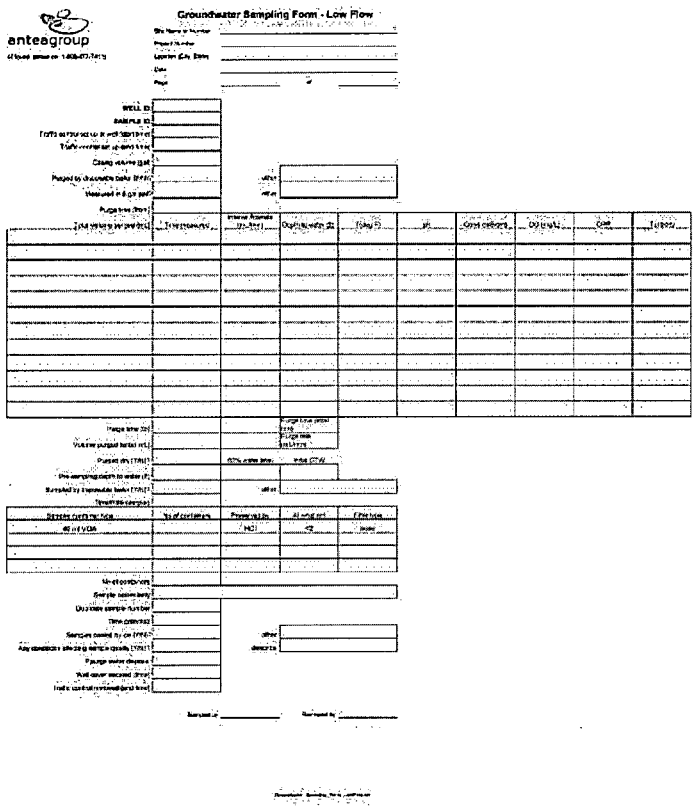
- Completing Chain of Custody SOP
- Control of Records SOP
- Equipment Calibration and Maintenance SOP

Attachment 1
SOP Definitions

Attachment 1
SOP Definitions

AS	Air Sparging
ASTM	American Society for Testing and Materials
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CD	Compact Disc
COC	Chain of Custody
COC	Chemical(s) of Concern
CPR	Cardiopulmonary Resuscitation
DNAPL	Dense Non-Aqueous Phase Liquid
DOT	Department of Transportation
DPE	Dual Phase Extraction
DQO	Data Quality Objective
DTB	Depth to bottom (of well)
DTP	Depth to product (in well)
DTW	Depth to water (in well)
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
GAC	Granular Activated Carbon
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSSE	Health, Safety, Security, and Environment
ID	Identification
iEHS	Intelligent Environmental Health and Safety
LNAPL	Light Non-Aqueous Phase Liquid
LPH	Liquid Phase Hydrocarbon
LUST	Leaking Underground Storage Tank
MME	Monitoring and Measuring Equipment
MPE	Multi Phase Extraction
MS/MSD	Matrix Spike/Matrix Spike Duplicate (quality control sample)
MSDS	Material Safety Data Sheet
MW	Monitoring Well
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear Aromatic Hydrocarbon
PDF	Portable Document Format
PID	Photo Ionization Detector
PM	Project Manager
PNA	Polynuclear Aromatic
POTW	Publically Owned Treatment Works
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RBSL	Risk Based Screening Level
RCRA	Resource Conservation Recovery Act
RW	Recovery Well
SB	Soil Boring
SCFM	Standard Cubic Feet per Minute
SHSP	Site Health and Safety Plan (Antea Group)
SOP	Standard Operating Procedure
SSTL	Site Specific Target Level
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TCLP	Toxicity Characteristics Leaching Procedure
TOC	Top of Casing (elevation)
TOC	Total Organic Carbon
TOX	Total Organic Halogen
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound

Attachment 2
Groundwater Sampling Form – Low Flow



PROCEDURE

Measurement of Monitoring Well Field Parameters SOP

Author: Gordon Hinshalwood

Antea Group USA

Approved by: (Signatures on File)

Gordon Hinshalwood Process Owner	March 20, 2012 Date
Rosanna Ouellette QMS Document Control Representative	March 20, 2012 Date
John Gobins QMS Management Representative	March 20, 2012 Date

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Document Change Tracking Form

Version	Revision date	Revisions
0	3/20/2012	Final Document Based upon Previous Team Meetings and Management Approvals in March 2012.

Measurement of Monitoring Well Field Parameters SOP

1.0 Scope/Applicability:

This standard operating procedure (SOP) provides guidance for measuring groundwater quality field parameters during monitoring well purging.

Field parameters are collected during surface water or groundwater sampling events to identify physical/chemical characteristics of the sample that are representative of field conditions as they exist at the time of sample collection. They are also used to indicate when stagnant water has been removed from the well so that sampling may begin.

This procedure is applicable to sites where regulatory and/or client requirements call for measurement of field parameters during purging of monitoring wells.

2.0 Summary:

This procedure entails pouring a sample of purge water into a small cup following each purged casing volume, and measuring field parameters on the sample. The measurements are performed with field instruments which in some cases require field calibration prior to use. Measurements are compared between casing volumes to determine if purge water is representative of formation water and thus, if the well is ready for sampling.

3.0 Definitions:

A list of definitions is provided in Attachment 1 (SOP Definitions).

4.0 Health and Safety:

The Health and Safety considerations for conducting this procedure are described in the following documents:

- Site Health and Safety Plan – H&S Plan Templates (https://anteaintra.anteausainc.com/h&s/plans.htm)
- Job Safety Analysis – none

Specific health and safety considerations for this procedure include:

- none

5.0 Cautions and Interferences:

Cautions associated with conducting this procedure include:

- Regardless of the brand of meter used, all meters should be properly maintained, calibrated, and operated in accordance with the manufacturer's instructions and with **Equipment Calibration and Maintenance SOP**.

- pH calibration standards include acidic and basic liquids and therefore should be handled with care.

Interferences having the potential to impact the quality of the final product include:

- Water sample turbidity or chemical composition may impact the ability to measure certain field parameters.

6.0 Personnel Qualifications/Responsibilities:

Personnel performing this procedure are required to have the following qualifications:

- HSSE Training in accordance with Health, Safety, Security, and Environment Practice (https://anteaintra.anteausainc.com/h&s/practices/hsse/HSSE_Practice_Training.pdf).
- Health and Safety training in accordance with Client Required Training (if applicable) (https://anteaintra.anteausainc.com/h&s/training_client_req.htm).
- All field team members engaged in this procedure must have on file a completed Demonstration of Capability for this SOP.

The minimum roles involved and their responsibilities in this procedure include:

- **Project Manager** – Responsible for determining, communicating, and upholding the regulatory, client, and other requirements associated with performing this procedure as part of a project-specific scope of work.
- **Project Professional** – Responsible for creating project-specific scopes of work requiring this procedure in accordance with the identified requirements of this procedure.
- **Staff Professional** – Responsible for implementing project-specific scopes of work requiring this procedure in accordance with this procedure.

7.0 Equipment/Supplies:

The following is the typical list of equipment required for completing this procedure:

- Field Safety Equipment Bag - https://anteaintra.anteausainc.com/h&s/faq_field_bag.htm
- Traffic control devices, as defined in Site Control and Work Zones training - https://anteagroup.adobeconnect.com/sitecontrolworkzones/
- Field logbook and appropriate field form(s)
- Waterproof permanent pens and markers
- Mobile phone - with clock and camera feature
- Spare locks - for buildings, compounds, and well covers (if appropriate)
- Keys - to access existing on-site locks (if appropriate)
- Decontamination supplies/equipment (if appropriate)

Procedure-specific equipment/supplies include:

- Field parameter instruments (pH meter, thermometer, conductivity meter, turbidimeter)
- Calibration standards
- Glass bulb thermometer
- Glass measuring or other cup

8.0 Procedure:

Temperature

Temperature is a measure of hotness or coldness on a defined scale as measured using a thermometer. Typical types of thermometers include:

- Digital (thermo-couple) thermistor
- Glass bulb mercury filled
- Bi-metal strip/dial indicator

No matter which type of thermometer is used, it should be calibrated prior to use, if possible. Digital thermometers should be calibrated prior to use by comparison with a mercury bulb thermometer and should agree within +/- 0.5 degrees Celsius (°C). The procedure for measuring temperature is as follows:

1. Clean the probe end with analyte-free water and immerse into sample.
2. Swirl the thermometer in the sample.
3. Allow the thermometer to equilibrate with the sample.
4. Suspend the thermometer away from the sides and bottom to observe the reading.
5. Record the reading in the field logbook or on the appropriate sampling field form in accordance with **Fieldwork Documentation SOP**. Units of temperature are degrees Celsius (°C) and shall be recorded to the nearest tenth (0.1).

pH

The negative decimal log of hydrogen ion concentration (pH) is used to express both acidity and alkalinity on a scale which ranges from 0 to 14, with 7 representing neutrality. The procedure for measuring pH in the field is as follows:

1. Calibrate the instrument in accordance with the manufacturer's specifications.
2. Collect a sample. Measure the temperature prior to measuring the pH.
3. Immerse the probe in the sample, keeping it away from the sides and bottom of the sample container. Allow ample time for the probe to equilibrate with the sample.
4. While suspending the probe away from the sides and bottom of the sample container, record the pH. Units of pH are standard units and should be recorded in tenths (0.1).
5. Rinse the probe with analyte-free water and store it in an analyte-free water filled container until the next sample is ready.
6. Perform a post calibration at the end of the day and record all findings.

Conductivity

Groundwater conductivity is defined as the ability of groundwater to conduct an electrical charge. The procedure for measuring conductivity in the field is as follows:

1. Calibrate the instrument in accordance with the manufacturer's specifications.
2. Collect the sample and check and record its temperature.
3. Correct the conductivity instruments temperature adjustment to the temperature of the sample (if required).
4. Immerse the probe in the sample keeping it away from the sides and bottom of the container. It is important that the entire portion of the probe be wetted by the sample. This will be evident when some of the sample water is seen coming out of the small weep hole.

5. Record the result in the field log book or appropriate sampling field form. Units of conductivity are milli or micro siemens per centimeter (uS or mS/cm) at 25 degrees Celsius. Results shall be reported to the nearest 10 units for readings below 1,000 uS/cm and to the nearest 100 units for readings above 1,000 uS/cm.
6. Rinse probe.

Turbidity

Turbidity is measured using a nephelometer/turbidimeter. The procedure for measuring turbidity is as follows:

1. Rinse the sample cell with analyte-free water.
2. Follow the manufacturer's specifications for collecting a turbidity measurement.
3. Record the reading in the field log book or appropriate sampling field form. The units of turbidity are nephelometric turbidity units or NTUs. Units shall be recorded to the nearest whole unit.

9.0 Data and Records Management:

Before finalizing fieldwork documentation:

- Recheck all data inputs to prevent errors.
- If data were generated from multiple/different sample locations (borings, wells, etc.) at the same site, use appropriate file naming conventions to distinguish one file from another.
- Ensure that any repair work needed, issues to be resolved, and/or any uncompleted fieldwork are noted in the fieldwork documentation.

Upon completion of fieldwork, field personnel shall file fieldwork documentation, any electronic field files, the Site Health and Safety Plan, and any associated health and safety forms to the correct project folder, in accordance with **Control of Records SOP**.

10.0 Quality Control:

- All data, observations, calculations must be documented in the field logbook, field forms, and/or any electronic data recording devices (field computers, digital cameras, etc.).
- Adequate traceability must be ensured between any field notes and complementary field forms.
- Any electronic data recording devices must be operated in accordance with manufacturer's operating instructions, unless documented otherwise.
- Monitoring and Measuring Equipment must be calibrated prior to the event and calibration results documented in accordance with **Equipment Calibration and Maintenance SOP**.

11.0 References:

- Superfund Program Standard Operating Procedures
- SOP Definitions (Attachment 1)
- Fieldwork Documentation SOP
- Control of Records SOP

- Equipment Calibration and Maintenance SOP
- Barcelona & Puls, *Low Flow Ground Water Sampling Proceedures*, 1996 (EPA/540/S-95/504)

Attachment 1
SOP Definitions

Attachment 1
SOP Definitions

AS	Air Sparging
ASTM	American Society for Testing and Materials
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CD	Compact Disc
COC	Chain of Custody
COC	Chemical(s) of Concern
CPR	Cardiopulmonary Resuscitation
DNAPL	Dense Non-Aqueous Phase Liquid
DOT	Department of Transportation
DPE	Dual Phase Extraction
DQO	Data Quality Objective
DTB	Depth to bottom (of well)
DTP	Depth to product (in well)
DTW	Depth to water (in well)
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
GAC	Granular Activated Carbon
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSSE	Health, Safety, Security, and Environment
ID	Identification
iEHS	Intelligent Environmental Health and Safety
LNAPL	Light Non-Aqueous Phase Liquid
LPH	Liquid Phase Hydrocarbon
LUST	Leaking Underground Storage Tank
MME	Monitoring and Measuring Equipment
MPE	Multi Phase Extraction
MS/MSD	Matrix Spike/Matrix Spike Duplicate (quality control sample)
MSDS	Material Safety Data Sheet
MW	Monitoring Well
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear Aromatic Hydrocarbon
PDF	Portable Document Format
PID	Photo Ionization Detector
PM	Project Manager
PNA	Polynuclear Aromatic
POTW	Publically Owned Treatment Works
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RBSL	Risk Based Screening Level
RCRA	Resource Conservation Recovery Act
RW	Recovery Well
SB	Soil Boring
SCFM	Standard Cubic Feet per Minute
SHSP	Site Health and Safety Plan (Antea Group)
SOP	Standard Operating Procedure
SSTL	Site Specific Target Level
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TCLP	Toxicity Characteristics Leaching Procedure
TOC	Top of Casing (elevation)
TOC	Total Organic Carbon
TOX	Total Organic Halogen
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound

PROCEDURE

Monitoring Well Development SOP

Author: John Gobins

Antea Group USA

Approved by: (Signatures on File)

John Gobins Process Owner	March 20, 2012 Date
Rosanna Ouellette QMS Document Control Representative	March 20, 2012 Date
John Gobins QMS Management Representative	March 20, 2012 Date

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Document Change Tracking Form

Version	Revision date	Revisions
0	3/20/2012	Final Document Based upon Previous Team Meetings and Management Approvals in March 2012.

Monitoring Well Development SOP

1.0 Scope/Applicability:

This standard operating procedure (SOP) provides guidance for developing monitoring wells following their installation. The purpose of developing new monitoring wells is to:

- remove residual materials remaining in the wells after installation has been completed;
- establish a good hydraulic communication between the formations in the immediate vicinity of each well and the well which may have been disturbed by well construction;
- ensure long-term stability of the filter pack and surrounding formation adjacent to the well screens; and
- abate any damage done during borehole drilling and casing installation to the surrounding formation that may have impacted localized hydraulic conductivity (e.g. clogging, smearing, bridging, and compaction).

The following development methods are generally used to develop monitoring wells:

- Pumping,
- Compressed air (with the appropriate organic filter system),
- Bailing,
- Surging,
- Backwashing, and
- Jetting.

The appropriate development method will be selected for each project based on the lithology, objectives, and requirements of that project.

This procedure is applicable to monitoring and other wells installed into groundwater.

2.0 Summary:

This procedure entails using a bailer or pump, and alternating this with the use of a surge block, to remove fine-grained deposits from the filter pack and immediate formation following the installation of a monitoring well. The well is considered adequately developed when purge water remains clear and field parameters have stabilized. As a general rule, a minimum of 24 hours after well installation should be allowed prior to conducting well development, in order to provide time for the well filter pack and grouting to stabilize.

3.0 Definitions:

A list of definitions is provided in Attachment 1 (SOP Definitions).

4.0 Health and Safety:

The Health and Safety considerations for conducting this procedure are described in the following documents:

- Site Health and Safety Plan – H&S Plan Templates (https://anteaintra.anteausainc.com/h&s/plans.htm)
- Job Safety Analysis – Well Development and Groundwater Sampling (https://anteaintra.anteausainc.com/h&s/files/jsa/Well_development-GW_sampling_JSA.doc)

Specific health and safety considerations for this procedure include:

- Health and safety considerations associated with this procedure are addressed during the Job Safety Analysis.

5.0 Cautions and Interferences:

Cautions associated with conducting this procedure include:

- A newly completed monitoring well shall not be developed for at least 24 hours after installation. This will allow sufficient time for the well materials to cure before development procedures are initiated.
- When surging the well with a surge block, care shall be taken to not damage the screen of the well while surging.
- Caution shall be used when using high rate pumps and/or large volume air compressors during well development because excessive high rate pumping and high air pressures can damage or destroy the well screen and filter pack.
- Development methods can introduce contaminants to the subsurface. The preferred methods are those that avoid injection of air, foreign water (even if from the same aquifer) and chemicals (dispersants, surfactants, disinfectants, etc.), but site conditions may require the use of the alternate methods. The Project Manager shall define the most appropriate method to use.

Interferences having the potential to impact the quality of the final product include:

- Reused well development equipment, if not properly decontaminated, has the potential for introducing contamination into the aquifer. Contamination is likely to result from: improper storage/transport of equipment, exposure of equipment to on-site sources such as vehicle exhaust, uncovered ground, dirty gloves/clothing, and airborne dust.

6.0 Personnel Qualifications/Responsibilities:

Personnel performing this procedure are required to have the following qualifications:

- HSSE Training in accordance with Health, Safety, Security, and Environment Practice (https://anteaintra.anteausainc.com/h&s/practices/hsse/HSSE_Practice_Training.pdf).
- Health and Safety training in accordance with Client Required Training (if applicable) (https://anteaintra.anteausainc.com/h&s/training_client_req.htm).
- All field team members engaged in this procedure must have on file a completed Demonstration of Capability for this SOP.

The minimum roles involved and their responsibilities in this procedure include:

- **Project Manager** – Responsible for determining, communicating, and upholding the regulatory, client, and other requirements associated with performing this procedure as part of a project-specific scope of work.
- **Project Professional** – Responsible for creating project-specific scopes of work requiring this procedure in accordance with the identified requirements of this procedure.
- **Staff Professional** – Responsible for implementing project-specific scopes of work requiring this procedure in accordance with this procedure.

7.0 Equipment/Supplies:

The following is the typical list of equipment required for completing this procedure:

- Field Safety Equipment Bag - https://anteaintra.anteausainc.com/h&s/faq_field_bag.htm
- Traffic control devices, as defined in Site Control and Work Zones training - https://anteagroup.adobeconnect.com/sitecontrolworkzones/
- Field logbook and appropriate field form(s)
- Waterproof permanent pens and markers
- Mobile phone - with clock and camera feature
- Spare locks - for buildings, compounds, and well covers (if appropriate)
- Keys - to access existing on-site locks (if appropriate)
- Decontamination supplies/equipment (if appropriate)

Procedure-specific equipment/supplies include:

- Water level indicator
- Bailer or pump
- Nylon rope
- Pump controller (if required)
- Generator, if pump is used
- Air compressor, if bladder pump is used
- Gas for generator/air compressor
- Surge block
- Appropriate pump fittings (e.g., hose clamps, barbed fittings, etc.)
- Discharge tubing for pump
- Field parameter instruments (multiparameter meter, turbidimeter, DO meter)
- Drums
- Wrench for opening/sealing drums

8.0 Procedure:

1. All monitoring well development equipment shall be decontaminated in accordance with **Decontamination SOP** before any development activities are initiated.
2. Well development shall be conducted a minimum of 24 hours after the installation of the monitoring well.
3. Collect water level measurements in accordance with **Water and Liquid Level Measurement SOP**.
4. Calculate the well volume in accordance with **Monitoring Well Purging with a Bailer SOP** or **Monitoring Well Purging with a Pump SOP**.

5. Assemble well development equipment in accordance with **Monitoring Well Purging with a Bailer SOP** or **Monitoring Well Purging with a Pump SOP**, depending upon the development method.
6. Begin developing the well using the development method selected.
7. Collect field parameters after each well volume in accordance with **Measurement of Monitoring Well Field Parameters SOP** and record on the Well Development Form (Attachment 2).
8. As purge water clears, place a surge block (or weighted bailer) in the well and lower the surge block until it is near the top of the screen or water surface. Alternately raise and lower the surge block through the vertical distance of one to two feet. The velocity of the surge block motion will depend on the tightness of the formation in which it is installed.
9. After surging the well a few times at a given depth, move the surge block deeper by one or two feet and repeat step 8.
10. Repeat steps 8 and 9 until the surge block has been lowered to the bottom of the screened section of the well.
11. Slowly raise the surge block out of the well.
12. Purge the well of sediment that may have accumulated due to the mechanical surging.
13. Repeat steps 7 through 12 until the purge water remains clear and field parameters have stabilized.
14. If the well is pumped to dryness or near dryness, the water level should be allowed to sufficiently recover (to the static water level) before the next development period is initiated. Continuous purging over a period of several days may be necessary to complete the well development.
15. Development water shall be managed in accordance with **Waste Management SOP**.
16. All field decisions should be documented in the field log book in accordance with **Fieldwork Documentation SOP**.

9.0 Data and Records Management:

Before finalizing fieldwork documentation:

- Recheck all data inputs to prevent errors.
- If data were generated from multiple/different sample locations (borings, wells, etc.) at the same site, use appropriate file naming conventions to distinguish one file from another.
- Ensure that any repair work needed, issues to be resolved, and/or any uncompleted fieldwork are noted in the fieldwork documentation.

Upon completion of fieldwork, field personnel shall file fieldwork documentation, any electronic field files, the Site Health and Safety Plan, and any associated health and safety forms to the correct project folder, in accordance with **Control of Records SOP**.

10.0 Quality Control:

- All data, observations, calculations must be documented in the field logbook, field forms, and/or any electronic data recording devices (field computers, digital cameras, etc.).

- Adequate traceability must be ensured between any field notes and complementary field forms.
- Any electronic data recording devices must be operated in accordance with manufacturer's operating instructions, unless documented otherwise.
- Monitoring and Measuring Equipment must be calibrated prior to the event and calibration results documented in accordance with **Equipment Calibration and Maintenance SOP**.

11.0 References:

- Superfund Program Standard Operating Procedures
- SOP Definitions (Attachment 1)
- Decontamination SOP
- Water and Liquid Level Measurement SOP
- Monitoring Well Purging with a Bailer SOP
- Monitoring Well Purging with a Pump SOP
- Measurement of Monitoring Well Field Parameters SOP
- Well Development Form (Attachment 2)
- Waste Management SOP
- Fieldwork Documentation SOP
- Control of Records SOP
- Equipment Calibration and Maintenance SOP

Attachment 1
SOP Definitions

Attachment 1
SOP Definitions

AS	Air Sparging
ASTM	American Society for Testing and Materials
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CD	Compact Disc
COC	Chain of Custody
COC	Chemical(s) of Concern
CPR	Cardiopulmonary Resuscitation
DNAPL	Dense Non-Aqueous Phase Liquid
DOT	Department of Transportation
DPE	Dual Phase Extraction
DQO	Data Quality Objective
DTB	Depth to bottom (of well)
DTP	Depth to product (in well)
DTW	Depth to water (in well)
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
GAC	Granular Activated Carbon
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSSE	Health, Safety, Security, and Environment
ID	Identification
iEHS	Intelligent Environmental Health and Safety
LNAPL	Light Non-Aqueous Phase Liquid
LPH	Liquid Phase Hydrocarbon
LUST	Leaking Underground Storage Tank
MME	Monitoring and Measuring Equipment
MPE	Multi Phase Extraction
MS/MSD	Matrix Spike/Matrix Spike Duplicate (quality control sample)
MSDS	Material Safety Data Sheet
MW	Monitoring Well
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear Aromatic Hydrocarbon
PDF	Portable Document Format
PID	Photo Ionization Detector
PM	Project Manager
PNA	Polynuclear Aromatic
POTW	Publically Owned Treatment Works
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RBSL	Risk Based Screening Level
RCRA	Resource Conservation Recovery Act
RW	Recovery Well
SB	Soil Boring
SCFM	Standard Cubic Feet per Minute
SHSP	Site Health and Safety Plan (Antea Group)
SOP	Standard Operating Procedure
SSTL	Site Specific Target Level
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TCLP	Toxicity Characteristics Leaching Procedure
TOC	Top of Casing (elevation)
TOC	Total Organic Carbon
TOX	Total Organic Halogen
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound

Attachment 2
Well Development Form

anteagroup

Well Development Form

Site Name or Number: _____

Project Number: _____

Location (City, State): _____

Date: _____

Page _____ of _____

(if found, please call 1-888-477-7411)

Site manager telephone number: _____

Check in with site manager (time): _____

Conduct tailgate safety meeting & sign safety acknowledgement (circle one): Y N

Recorded by: _____

Fieldwork Assignment														
Initial Well Depth (ft)													Final Well Depth (ft)	
Well Diameter (in)													Screen Length (ft)	
Static Water Level (feet)													Total Purged Volume (gal)	
Well Development Method													Well Purged Dry?	
Time	Method	Purging Rate (gpm)	Volume Purged (gal)	Depth to Water (ft bgs)	Temp (°C)	Spec Cond (uS/cm)	pH	Turbidity (NTU)	Other	Comments				

Remaining sample: _____

Equipment used: _____

Reviewed by: _____

PROCEDURE

Monitoring Well Installation and Completion SOP

Author: John Gobins

Antea Group USA

Approved by: (Signatures on File)

John Gobins Process Owner	March 20, 2012 Date
Rosanna Ouellette QMS Document Control Representative	March 20, 2012 Date
John Gobins QMS Management Representative	March 20, 2012 Date

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Document Change Tracking Form

Version	Revision date	Revisions
0	3/20/2012	Final Document Based upon Previous Team Meetings and Management Approvals in March 2012.

Monitoring Well Installation and Completion SOP

1.0 Scope/Applicability:

This standard operating procedure (SOP) provides guidance for the design and installation of permanent monitoring wells in geologic environments. Geologic conditions and project objectives may require several different drilling methods and well installation procedures.

This procedure is applicable to the installation of permanent monitoring wells following the advancement of boreholes using a variety of drilling methods.

2.0 Summary:

This procedure entails installing a permanent monitoring well in a borehole once the borehole has been drilled to the target depth. Once the base of the borehole has been stabilized for well installation, the well materials are assembled and the well lowered into the borehole. The annular space (between the well and the wall of the borehole) is then backfilled. Lastly, a protective well cover is installed over the well.

The design and installation of each permanent monitoring well should ensure the proper functioning of the well for the duration of the monitoring program. When designing monitoring wells, the following shall be considered:

- short-and long-term objectives,
- purpose(s) of the well(s),
- probable duration of the monitoring program,
- contaminants likely to be monitored,
- migration characteristics of the release,
- types of well construction materials to be used,
- surface and subsurface geologic conditions,
- properties of the aquifer(s) to be monitored,
- well screen placement,
- general site conditions, and
- potential site health and safety hazards.

A correctly completed well will ensure that:

- the hydraulic head in the well and the targeted aquifer are the same (for monitoring wells);
- only the targeted aquifer contributes water to the well (for monitoring wells); and
- the well's annular space is not a conduit for contamination or water flows between different aquifers.

3.0 Definitions:

A list of definitions is provided in Attachment 1 (SOP Definitions).

4.0 Health and Safety:

The Health and Safety considerations for conducting this procedure are described in the following documents:

- Site Health and Safety Plan – H&S Plan Templates (https://anteaintra.anteausainc.com/h&s/plans.htm)
- Job Safety Analysis – (drilling subcontractor shall provide this)

Specific health and safety considerations for this procedure include:

- (for wells installed in boreholes drilled with a hollow stem auger drill) US Department of Labor, Safety and Health Information Bulletin "Hazards of Auger Drilling" - http://www.osha.gov/dts/shib/shib041608a.html

5.0 Cautions and Interferences:

Cautions associated with conducting this procedure include:

- Double-cased wells may be required when there is reason to believe that interconnection of two aquifers by well construction may cause cross contamination, and/or when flowing sands make it impossible to install a monitoring well using conventional methods. An outer casing (sometimes called a surface or pilot casing) shall be placed into the borehole and sealed with grout.
- When installing doubled cased wells, the surface casing shall be allowed to set for 24 hours after installation, before completing the installation of the monitoring well.
- Care shall be taken to avoid bridging of the filter pack material.
- Wells shall be allowed to set for 24 hours after installation, before well completions or well development activities are performed.

Interferences having the potential to impact the quality of the final product include:

- Fine-grained formations may be "smeared shut" as a result of hollow stem auger spinning prior to well installation; this "smearing" may significantly restrict the flow of groundwater from the formation to the well.

6.0 Personnel Qualifications/Responsibilities:

Personnel performing this procedure are required to have the following qualifications:

- HSSE Training in accordance with Health, Safety, Security, and Environment Practice (https://anteaintra.anteausainc.com/h&s/practices/hsse/HSSE_Practice_Training.pdf).
- Health and Safety training in accordance with Client Required Training (if applicable) (https://anteaintra.anteausainc.com/h&s/training_client_req.htm).
- All field team members engaged in this procedure must have on file a completed Demonstration of Capability for this SOP.

The minimum roles involved and their responsibilities in this procedure include:

- **Project Manager** – Responsible for determining, communicating, and upholding the regulatory, client, and other requirements associated with performing this procedure as part of a project-specific scope of work.

- **Project Professional** – Responsible for creating project-specific scopes of work requiring this procedure in accordance with the identified requirements of this procedure.
- **Staff Professional** – Responsible for implementing project-specific scopes of work requiring this procedure in accordance with this procedure.

7.0 Equipment/Supplies:

The following is the typical list of equipment required for completing this procedure:

- Field Safety Equipment Bag - https://anteaintra.anteausainc.com/h&s/faq_field_bag.htm
- Traffic control devices, as defined in Site Control and Work Zones training - https://anteagroup.adobeconnect.com/sitecontrolworkzones/
- Field logbook and appropriate field form(s)
- Waterproof permanent pens and markers
- Mobile phone - with clock and camera feature
- Spare locks - for buildings, compounds, and well covers (if appropriate)
- Keys - to access existing on-site locks (if appropriate)
- Decontamination supplies/equipment (if appropriate)

Procedure-specific equipment/supplies include:

- Tape measure
- Threaded end-cap (sump)
- Well casing and screen (e.g., PVC or stainless steel)
- Stainless steel centralizer(s) (if required)
- Steel protective casing or flush-mount well cover, and locking cap
- Filter pack material
- Bentonite powder/pellets
- Portland cement
- Tremie apparatus

8.0 Procedure:

Monitoring Well/Piezometer Installation

When selecting the materials for well construction, the prime concern shall be to select materials that will not contribute foreign constituents, or remove contaminants of concern from the groundwater. All materials selected for monitoring well installation shall be evaluated and approved by an experienced geologist.

Well screen and casing materials used in monitoring well construction in order of preference:

- Rigid PVC meeting NSF Standard 14
- Stainless Steel (304 or 316)
- Other (e.g., black iron, carbon steel, galvanized steel, and fiberglass). These materials are not recommended for long-term monitoring programs at hazardous waste sites due to their low resistance to chemical attack and potential constituent leaching to groundwater.

The length of well screens in permanent monitoring wells shall be long enough to effectively monitor the interval or zone of interest. However, well screens designed for long-term

monitoring purposes should normally not be less than five (5) feet in length. Well screens less that five feet long shall only be used in temporary monitoring wells where groundwater samples are collected for screening purposes. Slot openings for wells screens shall be selected to retain 90 per cent or more of the filter pack material.

The following procedures shall be followed when installing a monitoring well:

1. Advance the borehole to the required depth using the procedure outlined in **Hollow Stem Auger Drilling SOP**.
2. The diameter of the well to be installed will depend on the intended use for the well and possible engineering considerations and needs. A minimum two-inch annular space is required between the borehole and the casing.
3. All well screen and well casing material shall be new and of adequate structural integrity, and shall be made of material that will be compatible with the contaminants present (or anticipated). Screen size shall be determined based on sieve analysis results. Screen length should be adequate to monitor the zone of interest, and in general should not be less than five feet long nor greater than 20 feet.
4. If required, place a threaded sump on the bottom most section of well screen and lower the section into the open borehole. The decision for placing sumps on wells will be made on a site-specific basis.
5. Thread additional lengths of well screen together, as needed, until the appropriate total well screen length is achieved. Do not use cement or glue.
6. Thread solid well casing (in 10-foot lengths) on to the well screen sections to complete the well to a height approximately two to three feet above ground surface. Do not use cement or glue.
7. Centralizers shall be placed on wells greater than 50 feet deep. Monitoring wells less than 50 feet deep generally do not need centralizers. If centralizers are used, they shall be placed below the well screen and above the bentonite pellet seal. Centralizers placed in the wrong locations can cause bridging during material placement.
8. Plumb the well string by the use of centralizers and/or a plumb bob and level. Centralizers can be used to plumb a well, but centralizers should be placed so that the placement of the filter pack, bentonite pellet seal, and annular grout will not be hindered.
9. Install a locking well cap onto the well head. The well cap shall have a small hole drilled to allow for pressure equalization.
10. Place a minimum of 6-inches of filter pack material under the bottom of the well screen or sump to provide a firm footing and an unrestricted flow under the screened area. The filter pack shall extend a minimum of two feet above the top of the well screen, and shall be placed by a tremie pipe where possible. If drilling with hollow-stem augers, the augers shall be lifted as the sand is tremied into the borehole. If it is impracticable to tremie the filter pack, pouring the sand is acceptable in shallow boreholes (less than 50 feet), where the annular space is large enough to prevent bridging. The level of the filter pack materials must be measured at appropriate intervals to ensure no bridging has occurred.
11. Once the filter pack material has been placed, place a seal above the filter pack in the annulus of the borehole to provide a watertight seal. The seal shall be a minimum of two feet thick and shall consist of a minimum of 20 percent solids bentonite. This type of bentonite is available in either powder, pellet, or chip form. The preferred method of placing either bentonite pellets/chips, or a bentonite powder/water mixture, is by tremie

pipe. If this method is not practicable (pellets/chips only), pouring the pellets/chips is acceptable in shallow boreholes (less than 50 feet), where the annular space is large enough to prevent bridging. The pellets/chips must be tamped, and measured at appropriate intervals to ensure they have not bridged. The bentonite seal must be allowed to hydrate for eight hours or the manufacturer's recommended hydration time, whichever is greater. Measure the seal after hydration time to ensure that the required two feet of seal is present.

12. After the bentonite seal has hydrated, grout the remainder of the borehole to prevent surface water infiltration.
13. Prepare the grout mixture for use. The preferred grout to use is a 30% solids bentonite grout with a minimum density of 10 lb/gal. All grouts shall be prepared in accordance with the manufacturer's specifications. Cement grouts shall be mixed using 6.5 to 7 gallons of water per 94-lb bag of Type 1 Portland cement. The addition of bentonite (5 to 10 percent) to the cement grout is generally used to delay the "setting" time and may not be needed in all applications. The specific mixtures and other types of cement and/or grout proposed shall be evaluated by an experienced geologist on a case by case basis. Drilling muds are not acceptable for grouting.
14. Place the grout mixture into the borehole, by the tremie method, from the top of the bentonite seal to within 2-feet of the ground surface or below the frost line, whichever is greater. The tremie tube should have an option of a side discharge port or a bottom discharge port, to minimize damage to the filter pack and/or the bentonite pellet seal, during grout placement.
15. Continue the grouting operation until the grout flowing out of the borehole has achieved a significant density.
16. Place the steel protective casing over the top of the well using with a spacer to keep the protective casing from resting directly on top of the well casing. Ensure that the lower end of the protective casing extends into the grout seal.
17. The outer protective casing shall be installed into the borehole a minimum of 24 hours after the grout has been poured.
18. Allow the grout to cure for a minimum of 24 hours before installing the concrete surface pad or conducting well development activities.
19. Clean and decontaminate all of the equipment used following the procedures outlined in **Decontamination SOP**.
20. Using the standard well installation log form (see Attachment 2, Well Installation Log), document the installation of the well screen and riser, height of the filter pack, installation and thickness of the annular seal, types and quantities of grout material used in the field logbook, recording the type of materials used, the lengths of screen and riser sections, the bottom depth of the boring, the screen slot size, and any sumps or caps placed on the bottom of the well (see **Fieldwork Documentation SOP**).

Surface Completions

Outer Protective Casings

The outer protective casings used over 2-inch well casings shall be 4 inches square by 5 feet long. Similarly, protective casings used over 4-inch well casings shall be 6 inches square and 5 feet long. Round protective casings are also acceptable. All protective casings shall have sufficient clearance around the inner well casings, so that the outer protective casings will not

come into contact with the inner well casings after installation. The protective casings shall have a minimum of two weep holes for drainage. These weep holes shall be a minimum 1/4-inch in diameter and drilled into the protective casings just above the top of the concrete surface pads to prevent water from standing inside of the protective casings. Protective casings made of aluminum or other soft metals are normally not acceptable because they are not strong enough to resist tampering. Aluminum protective casing may be used in very corrosive environments such as coastal areas. After the wells have been installed, the outer protective casing shall be painted with a highly visible enamel paint. The wells shall be permanently marked with the well number, date installed, site name, and elevation on a brass plate to be permanently affixed to the cover or an appropriate place that will not be easily damaged and/or vandalized.

A case-hardened steel lock shall be installed on the locking casing cap to provide well security. This lock shall be covered by some protective measure (i.e., a plastic covering) to prevent corrosion. Lubricants should not be used on the lock as they may contribute to chemical sample alteration. At each site, all locks on the outer protective casings shall be keyed alike. There shall be at least 1 to 2 inches of clearance between the top of the in-place inner well casing cap and the bottom of the protective casing locking cap when in the locked position. The protective casing shall be anchored into the cement surface seal and extend at least 18 inches above the surface of the ground.

Upright completions are the preferred completion method, but if the monitoring wells are installed in a high-traffic area such as a parking lot, in a residential yard, or along the side of a road it may be desirable to finish the wells to the ground surface and install water-tight flush-mounted traffic and/or man-hole covers. Flush-mounted traffic and manhole covers are designed to extend from the ground surface down into the concrete plug around the well casing. Although flush-mounted covers may vary in design, they should have seals that make the unit water-tight when closed and secured. The flush-mounted covers shall be installed as far above grade as practical to minimize standing water and promote runoff. In those regions where winter conditions require snow plowing, the rim of flush-mounted well covers shall be installed no higher than 1/8 inch above the surrounding concrete pad (assumed grade) to minimize the likelihood of damage by snow plowing.

Concrete Surface Pad

A concrete surface pad shall be installed around each well at the same time as the outer protective casing is being installed. The concrete used shall be a reinforced concrete. The surface pad shall be formed around the well casing. Concrete shall be placed into the formed pad and into the borehole (on top of the grout) in one operation making a contiguous unit. The size of the concrete surface pad shall be at least 2 feet x 2 feet x 6 inches with #3 Rebar at 18 inches on center each way. The finished pad shall be sloped 1/8 inch per 2 feet, so that drainage will flow away from the protective casing and off of the pad. In addition, a minimum of 4 inches of the finished pad shall be below grade or ground elevation to prevent washing and undermining by soil erosion.

Surface Protection-Bumper Guards

If the monitoring wells are located in a high traffic area, a minimum of four bumper guards consisting of steel pipes 6 inches in diameter and a minimum 6-foot length shall be installed. These bumper guards shall be installed to a minimum depth of 3 feet below the ground surface in a concrete footing and extend a minimum of 3 feet above ground surface. Concrete shall also be placed into the steel pipe to provide additional strength. Steel rails and/or other steel materials can be used in place of steel pipe but shall be approved by an experienced engineer prior to installation.

Temporary Piezometers

A temporary piezometer is a small diameter cased borehole placed in a direct push borehole. The size of the borehole usually does not allow for filter pack to be placed in the piezometer annulus. The intent of a temporary borehole is to obtain water level data to determine the proper location of monitoring wells. Temporary piezometers differ from permanent piezometers in the following ways:

1. Casing is generally one-inch in diameter or less.
2. Filter pack is not necessary for temporary piezometers.
3. Screen lengths are generally less than five feet.
4. A smaller pad is used to stabilize the top of the piezometer.

Specifications of temporary piezometers may require approval by the local regulatory agency on a site-specific basis.

Surface Casing

When determined necessary by the local regulatory agency, surface casing consists of a watertight pipe which is installed in an excavated or drilled hole, temporarily or permanently, to maintain the hole sidewalls against caving, advance the borehole, and in conjunction with cementing and/or bentonite grouting, to confine the groundwaters to their respective zones of origin, and to prevent surface contaminant filtration.

The drilled hole shall be of sufficient diameter to allow for a minimum 2-inch annular space between the borehole and the casing. The borehole shall be advanced by hollow stem auger or other approved method a minimum 2 feet into the confining zone or other desired depth. The casing shall be assembled and placed into the center of the boring. The casing shall be grouted with cement bentonite grout in such a manner that the desired zone is sealed and no voids remain in the annular space. The cement bentonite grout shall be allowed to cure 24 hours before advancing the boring.

Well Identification

The following guidance applies to standard nomenclature for numbering or identifying monitoring wells in reports and on identification plates installed on the monitoring wells. All monitoring wells (location and elevation) shall be surveyed by a licensed surveyor.

1. Permanent identification marking shall be placed on the well or on the brass monument installed in the protective concrete pad.
2. The identification marking shall contain Well Number, Depth of the Well, Installation Dated, Site Name, Mean Sea Level Elevation.
3. A small key of abbreviations shall be added on the bottom of every table and map.

4. The wells shall be identified as follows:
    - MW-X (e.g., MW-1) - Monitoring well completed in the uppermost saturated zone/aquifer or shallow aquifer, where the "X" represents the well number, in consecutive order of installation. Ideally, at no time should any two wells have the same well number, that is, there should not be a well number MW-3 and RW-3 at the same site.
    - RW-X (e.g., RW-2) - Monitor well used as a recovery well in shallow aquifer.
    - W-X (e.g., W-3) - Monitor well used as an injection well. This includes both wells used for nutrient injection during bio-remediation activities and for re-injection of treated groundwater.
    - PW-X (e.g., PW-4) - Piezometer.

It should be noted that deviation from this well identification guidance may be permissible in those cases where projects have been transitioned from other consultants that have not followed such guidance when numbering wells. For new projects, the Project Manager is responsible for communicating and adhering to this guidance when numbering monitoring wells. Where regulatory or client requirements regarding monitoring well nomenclature exist, those requirements take precedence over this guidance.

9.0 Data and Records Management:

Before finalizing fieldwork documentation:

- Recheck all data inputs to prevent errors.
- If data were generated from multiple/different sample locations (borings, wells, etc.) at the same site, use appropriate file naming conventions to distinguish one file from another.
- Ensure that any repair work needed, issues to be resolved, and/or any uncompleted fieldwork are noted in the fieldwork documentation.

Upon completion of fieldwork, field personnel shall file fieldwork documentation, any electronic field files, the Site Health and Safety Plan, and any associated health and safety forms to the correct project folder, in accordance with **Control of Records SOP**.

10.0 Quality Control:

- All data, observations, calculations must be documented in the field logbook, field forms, and/or any electronic data recording devices (field computers, digital cameras, etc.).
- Adequate traceability must be ensured between any field notes and complementary field forms.
- Any electronic data recording devices must be operated in accordance with manufacturer's operating instructions, unless documented otherwise.

11.0 References:

- Superfund Program Standard Operating Procedures
- SOP Definitions (Attachment 1)

- US Department of Labor, Safety and Health Information Bulletin "Hazards of Auger Drilling" - http://www.osha.gov/dts/shib/shib041608a.html
- Hollow Stem Auger Drilling SOP
- Decontamination SOP
- Well Installation Log (Attachment 2)
- Fieldwork Documentation SOP
- Control of Records SOP

Attachment 1
SOP Definitions

Attachment 1
SOP Definitions

AS	Air Sparging
ASTM	American Society for Testing and Materials
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CD	Compact Disc
COC	Chain of Custody
COC	Chemical(s) of Concern
CPR	Cardiopulmonary Resuscitation
DNAPL	Dense Non-Aqueous Phase Liquid
DOT	Department of Transportation
DPE	Dual Phase Extraction
DQO	Data Quality Objective
DTB	Depth to bottom (of well)
DTP	Depth to product (in well)
DTW	Depth to water (in well)
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
GAC	Granular Activated Carbon
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSSE	Health, Safety, Security, and Environment
ID	Identification
iEHS	Intelligent Environmental Health and Safety
LNAPL	Light Non-Aqueous Phase Liquid
LPH	Liquid Phase Hydrocarbon
LUST	Leaking Underground Storage Tank
MME	Monitoring and Measuring Equipment
MPE	Multi Phase Extraction
MS/MSD	Matrix Spike/Matrix Spike Duplicate (quality control sample)
MSDS	Material Safety Data Sheet
MW	Monitoring Well
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear Aromatic Hydrocarbon
PDF	Portable Document Format
PID	Photo Ionization Detector
PM	Project Manager
PNA	Polynuclear Aromatic
POTW	Publically Owned Treatment Works
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RBSL	Risk Based Screening Level
RCRA	Resource Conservation Recovery Act
RW	Recovery Well
SB	Soil Boring
SCFM	Standard Cubic Feet per Minute
SHSP	Site Health and Safety Plan (Antea Group)
SOP	Standard Operating Procedure
SSTL	Site Specific Target Level
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TCLP	Toxicity Characteristics Leaching Procedure
TOC	Top of Casing (elevation)
TOC	Total Organic Carbon
TOX	Total Organic Halogen
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound

Attachment 2
Well Installation Log (page 1)

anteagroup

WELL INSTALLATION LOG

Client
Project Number
Well No.

Address: Logged By:	Drilling Date(s): Drilling Company: Drilling Method: Boring Depth (ft):	Boring diameter (in.): Sampling Method: Well Depth (ft.): Casing Diameter (in.):	Casing Material: Screen Interval: Screen slot size: Sand Pack:

Depth (ft.)	Water Level	Soil/Rock Graphic	Sampled Interval	Blow Counts (blows/ft)	Recovery (%)	Soil/Rock Visual Description	PID Reading (ppm)	Well Completion	Depth (ft.)
0									0
5									5
10									10
15									15
20									20

Page 1 of ___

Attachment 2 (cont.)
Well Installation Log (page 2)

anteagroup

WELL INSTALLATION LOG

Client
Project Number
Well No:

Address: Logged By:	Drilling Date(s): Drilling Company: Drilling Method: Boring Depth (ft):	Boring diameter (in.): Sampling Method: Well Depth (ft.): Casing Diameter (in.):	Casing Material: Screen Interval: Screen slot size: Sand Pack:

Depth (ft.)	Water Level	Soil/Rock Graphic	Sampled Interval	Blow Counts (blows/ft)	Recovery (%)	Soil/Rock Visual Description	PID Reading (ppm)	Well Completion	Depth (ft.)
0									0
5									5
10									10
15									15
20									20

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PROCEDURE

QA/QC Sample Collection SOP

Author: John Gobins

Antea Group USA

Approved by: (Signatures on File)

John Gobins Process Owner	March 20, 2012 Date
Rosanna Ouellette QMS Document Control Representative	March 20, 2012 Date
John Gobins QMS Management Representative	March 20, 2012 Date

This is a controlled document with the original located at:

https://anteaintra.anteausainc.com/qms/qms_index.htm

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Document Change Tracking Form

Version	Revision date	Revisions
0	3/20/2012	Final Document Based upon Previous Team Meetings and Management Approvals in March 2012.

QA/QC Sample Collection SOP

1.0 Scope/Applicability:

This standard operating procedure (SOP) provides guidance for collecting quality assurance/quality control (QA/QC) samples as part of environmental sampling events.

QA/QC samples are collected to attempt to determine if sample bottle preparation, sample shipment, handling, and storage procedures had an impact on the sample integrity. Data validation is an integral part of the sampling program and consists of reviewing and assessing the quality of data and determining the usability of the data based on previously defined objectives.

This procedure is applicable to all collected environmental samples.

2.0 Summary:

This procedure entails collecting QA/QC samples as part of collecting environmental samples. QA/QC sample collection is defined by the type(s) and quantities of samples being collected, and the analyses being performed. The QA/QC program is defined prior to the sampling event so that the appropriate sample containers can be secured for the QA/QC samples.

3.0 Definitions:

A list of definitions is provided in Attachment 1 (SOP Definitions).

4.0 Health and Safety:

The Health and Safety considerations for conducting this procedure are described in the following documents:

- Site Health and Safety Plan – H&S Plan Templates (https://anteaintra.anteausainc.com/h&s/plans.htm)
- Job Safety Analysis – none

Specific health and safety considerations for this procedure include:

- none

5.0 Cautions and Interferences:

Cautions associated with conducting this procedure include:

- Sample type and frequency shall be selected to match the sampling program, and shall be defined prior to beginning the sampling event.

Interferences having the potential to impact the quality of the final product include:

- The purpose of QA/QC samples is to determine the interferences that are affecting sample quality, and therefore, any interferences than can affect sample quality are considered valid interferences to this procedure.

6.0 Personnel Qualifications/Responsibilities:

Personnel performing this procedure are required to have the following qualifications:

- HSSE Training in accordance with Health, Safety, Security, and Environment Practice (https://anteaintra.anteausainc.com/h&s/practices/hsse/HSSE_Practice_Training.pdf).
- Health and Safety training in accordance with Client Required Training (if applicable) (https://anteaintra.anteausainc.com/h&s/training_client_req.htm).
- All field team members engaged in this procedure must have on file a completed Demonstration of Capability for this SOP.

The minimum roles involved and their responsibilities in this procedure include:

- **Project Manager** – Responsible for determining, communicating, and upholding the regulatory, client, and other requirements associated with performing this procedure as part of a project-specific scope of work.
- **Project Professional** – Responsible for creating project-specific scopes of work requiring this procedure in accordance with the identified requirements of this procedure.
- **Staff Professional** – Responsible for implementing project-specific scopes of work requiring this procedure in accordance with this procedure.

7.0 Equipment/Supplies:

The following is the typical list of equipment required for completing this procedure:

- Field Safety Equipment Bag - https://anteaintra.anteausainc.com/h&s/faq_field_bag.htm
- Traffic control devices, as defined in Site Control and Work Zones training - https://anteagroup.adobeconnect.com/sitecontrolworkzones/
- Field logbook and appropriate field form(s)
- Waterproof permanent pens and markers
- Mobile phone - with clock and camera feature
- Spare locks - for buildings, compounds, and well covers (if appropriate)
- Keys - to access existing on-site locks (if appropriate)
- Decontamination supplies/equipment (if appropriate)

Procedure-specific equipment/supplies include:

- Pre-cleaned sample containers (with preservatives, if required)
- Analyte-free water (distilled or deionized)
- Stainless steel sampling bowl
- Stainless steel sampling spoon
- Other equipment as prescribed for collecting soil or water samples

8.0 Procedure:

Equipment Blanks

Equipment blanks shall be collected using the following procedure:

1. Properly decontaminate the sampling device in accordance with **Equipment Decontamination SOP**. Equipment blanks are not collected on disposable equipment (e.g., disposable bailers).
2. Select the proper sample containers and an appropriate quantity of analyte-free water (deionized or distilled).
3. Complete the sample labels with the appropriate information.
4. Slowly pour the analyte-free water through or over the sampling device until the sample bottle is filled to the appropriate level.
5. Securely tighten the cap on the bottle.
6. Prepare the bottle for shipment in accordance with **Sample Packaging and Shipping SOP**.

Field Blanks

Field blanks shall be collected downwind of possible VOC sources according the following procedure:

1. Select the proper sample containers (VOC vials) for collecting the sample and an appropriate quantity of analyte-free water.
2. Complete the sample labels with the appropriate information.
3. Pour the water into the vial just to overflowing so that there is a meniscus at the top of the vials.
4. Securely tighten the lid on the sample vials.
5. Prepare the sample for shipment in accordance with **Sample Packaging and Shipping SOP**.

Field Duplicate Samples

Duplicate samples shall be collected simultaneously or in immediate succession, using identical recovery techniques, and treated in an identical manner during storage, transportation, and analysis. If possible, collect duplicate samples in areas known to be contaminated to assess the laboratory's ability to measure contamination. Field duplicate samples shall be collected using the following procedure:

1. Select the proper sample containers for collecting a sample and a duplicate sample.
2. Complete the sample labels with the appropriate information.
3. Collect the sample as required.
    a. Groundwater Samples
        i. Collect the sample in accordance with the appropriate sampling SOP.
        ii. Fill the sample bottle half full with the pump or bailer and then fill the duplicate sample bottle half full. Fill the remainder of the sample bottle and then the remainder of the duplicate sample bottle. If a bailer is used, attempt to fill equal quantities from each bailer load into the sample and duplicate bottles.
    b. Soil Samples
        i. Collect the sample in accordance with the appropriate sampling SOP, but collect twice the required sample volume.
        ii. Place the sample material into a stainless steel bowl and homogenize the sample with a stainless steel spoon (see **Soil Sample**

Homogenation SOP). Do not homogenize samples for VOC analysis as the homogenization will cause a release of VOC constituents.

iii. Quarter the sample bowl and set aside two of the sample quarters.
iv. Homogenize the sample again.
v. Fill the appropriate sample jars using the material from the bowl, placing equal portions of sample into the sample bottles.

4. Securely tighten the caps on the sample bottles.
5. Prepare the sample for shipment in accordance with **Sample Packaging and Shipping SOP**.

Field Replicate (Split) Samples

If possible, collect field replicate samples from areas known to be contaminated to assess the laboratory's ability to measure contamination. Field replicate samples shall be collected using the following procedure:

1. Select the proper sample containers for collecting a sample and a replicate sample.
2. Complete the sample labels with the appropriate information.
3. Prepare the sample using the same methods described for Field Duplicate Samples, Step 3.
4. Place the field replicate samples in a separate cooler for shipment to the second laboratory.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Many laboratories can prepare the MS/MSD samples from the submitted sample volume. The sampler is only required to identify the sample for MS/MSD analysis on the Chain-of-Custody Record. If the sampler is required to collect MS/MSD samples, they should be collected as replicate samples but with three sets of samples (one original sample, one matrix spike sample, and one matrix spike duplicate).

Temperature Blank

Temperature blanks are typically prepared by the analytical laboratory and included in the shipment of sample coolers and containers. One temperature blank shall be returned to the laboratory in each sample cooler.

Trip Blank

Trip blanks are usually prepared by the analytical laboratory using analyte-free water and included in the shipment of sample coolers and containers. Trip blanks should only be submitted with samples requiring VOC analysis. One trip blank shall be included in each sample cooler containing samples for VOC analysis. Trip blanks shall be submitted using the following procedure:

1. Prepare the coolers for shipment to the laboratory. If possible, pack all samples for VOC analysis in one cooler so that only one trip blank is required.
2. Identify the trip blank on the Chain-of-Custody Record. If the project will continue for several days, be sure to number trip blanks sequentially so that multiple trip blanks with the same identification number are not submitted to the laboratory.

3. Ensure that VOC analysis (or benzene, toluene, ethylbenzene, and xylenes (BTEX) at Leaking Underground Storage Tank (LUST) sites) is the selected analysis for the trip blank.

QA/QC samples shall be documented, where applicable, on the Chain-of-Custody Record in accordance with the **Completing Chain of Custody SOP**.

9.0 Data and Records Management:

Before finalizing fieldwork documentation:

- Recheck all data inputs to prevent errors.
- If data were generated from multiple/different sample locations (borings, wells, etc.) at the same site, use appropriate file naming conventions to distinguish one file from another.

Upon completion of fieldwork, field personnel shall file fieldwork documentation, any electronic field files, the Site Health and Safety Plan, and any associated health and safety forms to the correct project folder, in accordance with **Control of Records SOP**.

10.0 Quality Control:

- All data, observations, calculations must be documented in the field logbook, field forms, and/or any electronic data recording devices (field computers, digital cameras, etc.).
- Adequate traceability must be ensured between any field notes and complementary field forms.
- Any electronic data recording devices must be operated in accordance with manufacturer's operating instructions, unless documented otherwise.

11.0 References:

- Superfund Program Standard Operating Procedures
- SOP Definitions (Attachment 1)
- Equipment Decontamination SOP
- Sample Packaging and Shipping SOP
- Soil Sample Homogenation SOP
- Completing Chain of Custody SOP
- Antea Group, Chain-of-Custody Record (https://anteaintra.anteausainc.com/marketing/templates/chain_of_custody_record.pdf)
- Control of Records SOP

Attachment 1
SOP Definitions

Attachment 1
SOP Definitions

AS	Air Sparging
ASTM	American Society for Testing and Materials
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CD	Compact Disc
COC	Chain of Custody
COC	Chemical(s) of Concern
CPR	Cardiopulmonary Resuscitation
DNAPL	Dense Non-Aqueous Phase Liquid
DOT	Department of Transportation
DPE	Dual Phase Extraction
DQO	Data Quality Objective
DTB	Depth to bottom (of well)
DTP	Depth to product (in well)
DTW	Depth to water (in well)
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
GAC	Granular Activated Carbon
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSSE	Health, Safety, Security, and Environment
ID	Identification
iEHS	Intelligent Environmental Health and Safety
LNAPL	Light Non-Aqueous Phase Liquid
LPH	Liquid Phase Hydrocarbon
LUST	Leaking Underground Storage Tank
MME	Monitoring and Measuring Equipment
MPE	Multi Phase Extraction
MS/MSD	Matrix Spike/Matrix Spike Duplicate (quality control sample)
MSDS	Material Safety Data Sheet
MW	Monitoring Well
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear Aromatic Hydrocarbon
PDF	Portable Document Format
PID	Photo Ionization Detector
PM	Project Manager
PNA	Polynuclear Aromatic
POTW	Publically Owned Treatment Works
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RBSL	Risk Based Screening Level
RCRA	Resource Conservation Recovery Act
RW	Recovery Well
SB	Soil Boring
SCFM	Standard Cubic Feet per Minute
SHSP	Site Health and Safety Plan (Antea Group)
SOP	Standard Operating Procedure
SSTL	Site Specific Target Level
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
TCLP	Toxicity Characteristics Leaching Procedure
TOC	Top of Casing (elevation)
TOC	Total Organic Carbon
TOX	Total Organic Halogen
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound

PROCEDURE

Sample Labeling SOP

Author: John Gobins

Antea Group USA

Approved by: (Signatures on File)

John Gobins Process Owner	March 20, 2012 Date
Rosanna Ouellette QMS Document Control Representative	March 20, 2012 Date
John Gobins QMS Management Representative	March 20, 2012 Date

This is a controlled document with the original located at:

https://anteaintra.anteausainc.com/qms/qms_index.htm

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Document Change Tracking Form

Version	Revision date	Revisions
0	3/20/2012	Final Document Based upon Previous Team Meetings and Management Approvals in March 2012.

Sample Labeling SOP

1.0 Scope/Applicability:

This standard operating procedure (SOP) provides guidance for labeling of environmental samples.

This procedure is applicable to all collected environmental samples.

2.0 Summary:

This procedure entails properly completing labels to be placed on sample containers. Sample naming convention must be defined prior to sampling activities, and can be based on Antea Group, Client, Analytical Laboratory, or Regulatory Agency standards.

3.0 Definitions:

A list of definitions is provided in Attachment 1 (SOP Definitions).

4.0 Health and Safety:

The Health and Safety considerations for conducting this procedure are described in the following documents:

- Site Health and Safety Plan – H&S Plan Templates (https://anteaintra.anteausainc.com/h&s/plans.htm)
- Job Safety Analysis – none

Specific health and safety considerations for this procedure include:

- none

5.0 Cautions and Interferences:

Cautions associated with conducting this procedure include:

- none

Interferences having the potential to impact the quality of the final product include:

- none

6.0 Personnel Qualifications/Responsibilities:

Personnel performing this procedure are required to have the following qualifications:

- HSSE Training in accordance with Health, Safety, Security, and Environment Practice (https://anteaintra.anteausainc.com/h&s/practices/hsse/HSSE_Practice_Training.pdf).
- Health and Safety training in accordance with Client Required Training (if applicable) (https://anteaintra.anteausainc.com/h&s/training_client_req.htm).

- All field team members engaged in this procedure must have on file a completed Demonstration of Capability for this SOP.

The minimum roles involved and their responsibilities in this procedure include:

- **Project Manager** – Responsible for determining, communicating, and upholding the regulatory, client, and other requirements associated with performing this procedure as part of a project-specific scope of work.
- **Project Professional** – Responsible for creating project-specific scopes of work requiring this procedure in accordance with the identified requirements of this procedure.
- **Staff Professional** – Responsible for implementing project-specific scopes of work requiring this procedure in accordance with this procedure.

7.0 Equipment/Supplies:

The following is the typical list of equipment required for completing this procedure:

- Field Safety Equipment Bag - https://anteaintra.anteausainc.com/h&s/faq_field_bag.htm
- Traffic control devices, as defined in Site Control and Work Zones training - https://anteagroup.adobeconnect.com/sitecontrolworkzones/
- Field logbook and appropriate field form(s)
- Waterproof permanent pens and markers
- Mobile phone - with clock and camera feature
- Spare locks - for buildings, compounds, and well covers (if appropriate)
- Keys - to access existing on-site locks (if appropriate)
- Decontamination supplies/equipment (if appropriate)

Procedure-specific equipment/supplies include:

- Sample container labels

8.0 Procedure:

The sample naming convention to be used on a project can be defined by Antea Group, or the Client, Analytical Laboratory, or Regulatory Agency. Sample naming convention shall be determined by the Project Manager during the project setup stage, and communicated during sample event planning. Extreme care shall be taken to ensure that the sample point location naming for a site is:

- consistent over time,
- identical to that used on any field work order forms, and
- identical to that generated from Antea Group data management systems.

For example, MW-1, MW1, MW_1, MW-01, and MW01 are each a unique sample point location from a database perspective, and therefore data associated with any one of these sample point locations will be uploaded to the corresponding sample point.

Sample labels may be obtained from the analytical laboratory where the samples are to be sent. Field personnel should have a small stock on-hand at all times. Labels are not archived and are destroyed with sample disposal at the laboratory.

Sample Identification

1. Prior to sampling, procedures should be emplaced for unique sample identification and the relation to field identification (i.e., how sample numbers are assigned).
2. Samples shall be uniquely identified, labeled, and documented in the field at the time of collection. Sampling personnel may fill out sample container labels after collecting samples or prior to collecting samples at each location. However, extreme care must be taken to ensure that the container label corresponds to the correct location!
3. Samples collected for laboratory analysis are identified by using standard sample labels which are affixed to the sample containers. Most analytical laboratories will supply the necessary labels.
4. The following information shall be included on the sample label at the time of collection using waterproof, non-erasable ink:
   - Sample ID
   - Project name
   - Sample date - the date when the sample was collected
   - Sample time - military time must be used (e.g., 1:30 pm is recorded as 1330)
   - Samplers' initials - the initials of personnel conducting the sampling
   - Preservation method - any preservative added to the sample should be indicated
   - Comments - any additional information
   - Requested analysis - the type of analysis to be performed on the sample

9.0 Data and Records Management:

Before finalizing fieldwork documentation:

- Recheck all data inputs to prevent errors.
- If data were generated from multiple/different sample locations (borings, wells, etc.) at the same site, use appropriate file naming conventions to distinguish one file from another.

Upon completion of fieldwork, field personnel shall file fieldwork documentation, any electronic field files, the Site Health and Safety Plan, and any associated health and safety forms to the correct project folder, in accordance with **Control of Records SOP**.

10.0 Quality Control:

- All data, observations, calculations must be documented in the field logbook, field forms, and/or any electronic data recording devices (field computers, digital cameras, etc.).
- Adequate traceability must be ensured between any field notes and complementary field forms.
- Any electronic data recording devices must be operated in accordance with manufacturer's operating instructions, unless documented otherwise.

11.0 References:

- Superfund Program Standard Operating Procedures
- SOP Definitions (Attachment 1)

- Control of Records SOP

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SOP Definitions

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PAH	Polynuclear Aromatic Hydrocarbon
PDF	Portable Document Format
PID	Photo Ionization Detector
PM	Project Manager
PNA	Polynuclear Aromatic
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PPE	Personal Protective Equipment
ppm	parts per million
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SSTL	Site Specific Target Level
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TOC	Total Organic Carbon
TOX	Total Organic Halogen
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound

PROCEDURE

Water and Liquid Level Measurement SOP

Author: John Gobins

Antea Group USA

Approved by: (Signatures on File)

John Gobins Process Owner	March 20, 2012 Date
Rosanna Ouellette QMS Document Control Representative	March 20, 2012 Date
John Gobins QMS Management Representative	March 20, 2012 Date

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Document Change Tracking Form

Version	Revision date	Revisions
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Water and Liquid Level Measurement SOP

1.0 Scope/Applicability:

This standard operating procedure (SOP) provides guidance for measuring water and non-aqueous phase liquid (NAPL) levels in a well. An accurate water level measurement is necessary for calculating purge volumes for sampling and for creating water level surface contour maps. Non-aqueous phase liquid level measurements are required for planning, designing, conducting, and monitoring interim and final corrective action measures.

This procedure is applicable to wells that contain water and/or non-aqueous phase liquids.

2.0 Summary:

This procedure entails opening designated wells and gauging the depth to product and depth to water in the well with electronic meters.

3.0 Definitions:

A list of definitions is provided in Attachment 1 (SOP Definitions).

4.0 Health and Safety:

The Health and Safety considerations for conducting this procedure are described in the following documents:

- Site Health and Safety Plan – H&S Plan Templates (https://anteaintra.anteausainc.com/h&s/plans.htm)
- Job Safety Analysis – Well Development and Groundwater Sampling (https://anteaintra.anteausainc.com/h&s/files/jsa/Well_development-GW_sampling_JSA.doc)

Specific health and safety considerations for this procedure include:

- Health and safety considerations associated with this procedure are addressed during the Job Safety Analysis.

5.0 Cautions and Interferences:

Cautions associated with conducting this procedure include:

- Water levels in wells should be measured from the least contaminated to the most contaminated well, or from the most hydraulically upgradient to the most hydraulically downgradient well if site groundwater chemistry is unknown.

Interferences having the potential to impact the quality of the final product include:

- Viscous, weathered non-aqueous phase liquid can adhere to (cloud) the sensor on the product-water interface probe and make it difficult to verify depth to NAPL by alternate raising and lowering of the probe across the depth at which the tone sounds.
- Tightly capped wells in which surrounding formation water level is above the top of well screen may experience a water level rise following removal of the well cap, due to subsequent pressure equilibration inside the well. In this case, adequate time should be allowed before making the final water level measurement.

6.0 Personnel Qualifications/Responsibilities:

Personnel performing this procedure are required to have the following qualifications:

- HSSE Training in accordance with Health, Safety, Security, and Environment Practice (https://anteaintra.anteausainc.com/h&s/practices/hsse/HSSE_Practice_Training.pdf).
- Health and Safety training in accordance with Client Required Training (if applicable) (https://anteaintra.anteausainc.com/h&s/training_client_req.htm).
- All field team members engaged in this procedure must have on file a completed Demonstration of Capability for this SOP.

The minimum roles involved and their responsibilities in this procedure include:

- **Project Manager** – Responsible for determining, communicating, and upholding the regulatory, client, and other requirements associated with performing this procedure as part of a project-specific scope of work.
- **Project Professional** – Responsible for creating project-specific scopes of work requiring this procedure in accordance with the identified requirements of this procedure.
- **Staff Professional** – Responsible for implementing project-specific scopes of work requiring this procedure in accordance with this procedure.

7.0 Equipment/Supplies:

The following is the typical list of equipment required for completing this procedure:

- Field Safety Equipment Bag - https://anteaintra.anteausainc.com/h&s/faq_field_bag.htm
- Traffic control devices, as defined in Site Control and Work Zones training - https://anteagroup.adobeconnect.com/sitecontrolworkzones/
- Field logbook and appropriate field form(s)
- Waterproof permanent pens and markers
- Mobile phone - with clock and camera feature
- Spare locks - for buildings, compounds, and well covers (if appropriate)
- Keys - to access existing on-site locks (if appropriate)
- Decontamination supplies/equipment (if appropriate)

Procedure-specific equipment/supplies include:

- Water level indicator
- Product-water interface probe
- Gasoline and water marking paste
- Metal tape measure
- Photo or Flame Ionization Detector

- Calculator
- Plastic sheeting
- Bolt cutters
- Cotton string
- Clear bailers
- Nylon rope
- Weights

8.0 Procedure:

Water Level Measurement

1. Start at the least contaminated well, if known, or if unknown, at the most hydraulically upgradient well.
2. Inspect the well for signs of tampering or other damage. If tampering is suspected or damage observed (i.e., casing is damaged, lock or cap is missing), then this shall be recorded in the field logbook and on the Water and Liquid Level Measurement Form (Attachment 2), and reported to the Project Manager. Wells that are suspected to have been tampered with shall not be sampled until further guidance from the Project Manager.
3. Lay plastic sheeting around the well to minimize the likelihood of contamination of equipment from soil adjacent to the well.
4. Remove the locking well cap, note location, time of day, and date in field notebook or appropriate log form.
5. Remove the well casing cap.
6. For confined aquifers, wait for water level to equilibrate before measuring water level.
7. Turn on the water level meter.
8. Press the battery check button (if so equipped). A solid tone will be heard if the battery is good.
9. Lower water the level measuring device or equivalent (i.e., permanently installed transducers or airline) into the well, slowly unreeling the measuring tape from the spool of the meter.
10. Continue lowering the probe until a continuous tone is heard. This tone indicates that the probe has come in contact with water.
11. Holding the measuring tape near the measuring reference point, alternately raise and lower the probe across the depth at which the tone sounds. This will ensure that you have an accurate measurement of the depth to water. Record the distance from water surface to the referenced measuring point on well casing in site logbook. Alternatively, if there is no reference point, note that water level measurement is from top of steel casing, top of PVC riser pipe, from ground surface, or some other position on the wellhead, typically on the north edge. Water level measurement shall be recorded to the nearest 0.01 foot.
12. Measure total depth of well (at least twice to confirm measurement) and record on the Water and Liquid Level Measurement Form (Attachment 2). Total depth measurements shall be recorded to the nearest 0.01 foot.
13. If excessive sediment buildup is suspected at the bottom of the well, the measured total depth should be compared with the total depth at the time of drilling (from the boring log). If the sediment thickness exceeds one foot, or is excessively impeding the flow of

groundwater through the well screen, the well shall be redeveloped in accordance with **Monitoring Well Development SOP**.

14. Decontaminate water level probe in accordance with **Decontamination SOP**.

Non-Aqueous Phase Liquid (LNAPL or DNAPL) Level Measurement

Organic liquids may occur in the subsurface of sites as light non-aqueous phase liquids (LNAPL) or dense non-aqueous phase liquids (DNAPL). Where possible, non-aqueous phase liquid levels in wells should be measured using a product-water interface probe. If wells are known or suspected to contain non-aqueous phase liquids, they should be measured last relative to all wells at a site in order to minimize the likelihood of cross contamination of wells by the interface probe. Non-aqueous phase liquid presence and level shall be measured using the following procedure:

1. Start at the least contaminated well or well with smallest non-aqueous phase liquid thickness, if known, or if unknown, at the most hydraulically upgradient well.
2. Inspect the well for signs of tampering or other damage. If tampering is suspected or damage observed (i.e., casing is damaged, lock or cap is missing), then this shall be recorded in the field logbook and on the Water and Liquid Level Measurement Form (Attachment 2), and reported to the Project Manager. Wells that are suspected to have been tampered with shall not be sampled until further guidance from the Project Manager.
3. Lay plastic sheeting around the well to minimize the likelihood of contamination of equipment from soil adjacent to the well.
4. Remove the locking well cap, note location, time of day, and date in field notebook or appropriate log form.
5. Remove the well casing cap.
6. For confined aquifers, wait for water level to equilibrate before measuring water level.
7. Turn on the product-water interface probe.
8. Press the battery check button (if so equipped). A solid tone will be heard if the battery is good.
9. Lower product-water interface probe into well, slowly unreeling the measuring tape from the spool of the meter.
10. Continue lowering the probe until a discontinuous (beeping) tone is heard. This tone indicates that the probe has come in contact with LNAPL. If LNAPL is not present, a solid tone will be heard.
11. Holding the measuring tape near the measuring reference point, alternately raise and lower the probe across the depth at which the tone sounds. This will ensure that you have an accurate measurement of the depth to liquid. Record the distance from liquid surface to the referenced measuring point on well casing on the Water and Liquid Level Measurement Form (Attachment 2). Alternatively, if there is no reference point, note that liquid level measurement is from top of steel casing, top of PVC riser pipe, from ground surface, or some other position on the wellhead, typically on the north edge. Liquid level measurement shall be recorded to the nearest 0.01 foot.
12. Continue lowering the probe until a solid tone is heard. This tone indicates that the probe has come in contact with water.
13. Holding the measuring tape near the measuring reference point, alternately raise and lower the probe across the depth at which the tone sounds. This will ensure that you have

an accurate measurement of the depth to water. Record the distance from water surface to the referenced measuring point on the Water and Liquid Level Measurement Form (Attachment 2). Alternatively, if there is no reference point, note that water level measurement is from top of steel casing, top of PVC riser pipe, from ground surface, or some other position on the wellhead, typically on the north edge. Water level measurement shall be recorded to the nearest 0.01 foot.

14. For sites with DNAPL, steps 12 and 13 will precede steps 10 and 11. Once step 11 has been completed, continue lowering the probe until the bottom of the well is encountered. Measure total depth of well (at least twice to confirm measurement) and record in the site logbook or Water and Liquid Level Measurement Form (Attachment 2). Total depth measurements shall be recorded to the nearest 0.01 foot.
15. Note: For sites with LNAPL, the product-water interface probe should not be used to measure total well depth so as to minimize the likelihood of contaminating additional lengths of the measuring tape.
16. Decontaminate product-water interface probe in accordance with **Decontamination SOP**.

The presence of LNAPL can be confirmed by one of two additional ways:

1. Lowering a clear bailer to just below the top of the groundwater surface, removing the bailer, and observing the contents. The volume of LNAPL recovered can be enhanced through the use of a product cup.
2. For sites where gasoline may have been released to the subsurface, gasoline and water marking paste can be applied to a metal tape measure and the tape measure inserted into the well to just below the top of the groundwater surface. The use of both types of paste will show the interval over which LNAPL is present in the well.

The presence of DNAPL can be confirmed by one of two additional ways:

1. Lowering a weighted bailer to the bottom of the well, removing the bailer and observing the contents for any free product.
2. Lowering a length of weighted cotton string to the bottom of the well, removing the string and observing the string for the DNAPL staining.

The thickness of any non-aqueous phase liquids shall be measured and recorded to the nearest 0.01 ft.

9.0 Data and Records Management:

Before finalizing fieldwork documentation:

- Recheck all data inputs to prevent errors.
- If data were generated from multiple/different sample locations (borings, wells, etc.) at the same site, use appropriate file naming conventions to distinguish one file from another.
- Ensure that any repair work needed, issues to be resolved, and/or any uncompleted fieldwork are noted in the fieldwork documentation.

Upon completion of fieldwork, field personnel shall file fieldwork documentation, any electronic field files, the Site Health and Safety Plan, and any associated health and safety forms to the correct project folder, in accordance with **Control of Records SOP**.

10.0 Quality Control:

- All data, observations, calculations must be documented in the field logbook, field forms, and/or any electronic data recording devices (field computers, digital cameras, etc.).
- Adequate traceability must be ensured between any field notes and complementary field forms.
- Any electronic data recording devices must be operated in accordance with manufacturer's operating instructions, unless documented otherwise.
- Monitoring and Measuring Equipment must be calibrated prior to the event and calibration results documented in accordance with **Equipment Calibration and Maintenance SOP**.

11.0 References:

- Superfund Program Standard Operating Procedures
- SOP Definitions (Attachment 1)
- Water and Liquid Level Measurement Form (Attachment 2)
- Monitoring Well Development SOP
- Decontamination SOP
- Control of Records SOP
- Equipment Calibration and Maintenance SOP

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SOP Definitions

Attachment 1
SOP Definitions

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COC	Chemical(s) of Concern
CPR	Cardiopulmonary Resuscitation
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DPE	Dual Phase Extraction
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EPA	Environmental Protection Agency
FID	Flame Ionization Detector
GAC	Granular Activated Carbon
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NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
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PM	Project Manager
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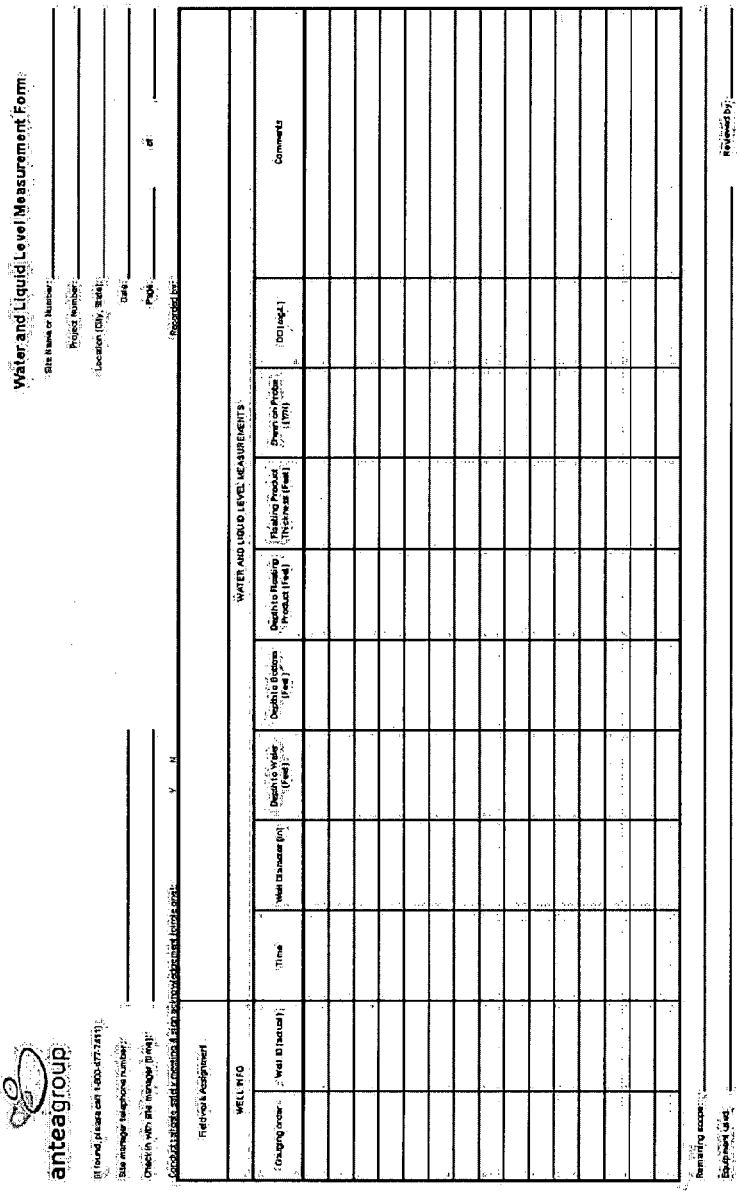
SVOC	Semi-Volatile Organic Compound
TCLP	Toxicity Characteristics Leaching Procedure
TOC	Top of Casing (elevation)
TOC	Total Organic Carbon
TOX	Total Organic Halogen
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound

Attachment 2
Water and Liquid Level Measurement Form



anteagroup

Water and Liquid Level Measurement Form

Site Name or Number:

Project Number:

Location (City, State):

Date: Page of

Recorded by:

Field Work Assignment

Check all boxes and initial if completed. Initials are required.

Y N

WELL INFO

WATER AND LIQUID LEVEL MEASUREMENTS

Changing Order	Well ID (Actual)	Time	Well Diameter (in)	Depth to Water (Feet)	Depth to Bottom (Feet)	Depth to Floating Product (Feet)	Floating Product Thickness (Feet)	Sheen on Probe (Y/N)	DO (mg/L)	Comments

If found, please call 1-800-477-7211

Site manager telephone number:

Check in with site manager (Initial):

Remaining equipment:

Equipment used:

Reviewed by:

Attachment C

Pace Analytical Inc. Quality Assurance Manual and SOPs

QUALITY ASSURANCE MANUAL

Quality Assurance/Quality Control Policies and Procedures

Pace Analytical Services – Kansas

Lenexa Laboratory
9608 Loiret Blvd
Lenexa, KS 66219
913-599-5665

Frontenac Service Center
808 West McKay St
Frontenac, KS 66763
620-235-0003

Corporate Approval

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1800 Elm Street, Suite 200
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10-31-2014
Date

Richard M. Henson
Corporate Director of Quality
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10/31/2014
Date

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1.0. INTRODUCTION AND ORGANIZATIONAL STRUCTURE

"Working together to protect our environment and improve our health"
Pace Analytical Services Inc. - Mission Statement

1.1. Introduction to PASI

1.1.1. Pace Analytical Services, Inc. (PASI) is a privately held, full-service analytical testing firm operating a nationwide system of laboratories. PASI offers extensive services beyond standard analytical testing, including: bioassay for aquatic toxicity, air toxics, dioxins and coplanar PCB's by high resolution mass spectroscopy , radiochemical analyses, product testing, pharmaceutical testing, field services and mobile laboratory capabilities. PASI has implemented a consistent Quality System in each of its laboratories and service centers. In addition, the company utilizes an advanced data management system that is highly efficient and allows for flexible data reporting. Together, these systems ensure data reliability and superior on-time performance. This document defines the Quality System and QA/QC protocols.

1.1.2. Our goal is to combine our expertise in laboratory operations with customized solutions to meet the specific needs of our customers.

1.2. Statement of Purpose

1.2.1. To meet the business needs of our customers for high quality, cost-effective analytical measurements and services.

1.3. Quality Policy Statement and Goals of the Quality System

1.3.1. PASI management is committed to maintaining the highest possible standard of service for our customers by following a documented quality system that is fully compliant with the applicable NELAC or TNI standards. The overall objective of this quality system is to provide reliable data of known quality through adherence to rigorous quality assurance policies and quality control procedures as documented in this Quality Assurance Manual.

1.3.2. All personnel within the PASI network are required to be familiar with all facets of the quality system relevant to their position and implement these policies and procedures in their daily work. This daily focus on quality is applied with initial project planning, continued through all field and laboratory activities, and is ultimately included in the final report generation.

1.3.3. PASI management demonstrates its commitment to quality by providing the resources, including facilities, equipment, and personnel to ensure the adherence to these documented policies and procedures and to promote the continuous improvement of the quality system. All PASI personnel must comply with all current applicable state, federal, and industry standards (2003 NELAC Standard, 2009 TNI Standard, etc.), and are required to perform all tests in accordance with stated methods and customer requirements.

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1.4. Core Values

1.4.1. **Integrity-** Pace personnel are required to abide by the PASI Code of Ethics and all Pace employees must go through Data Integrity/Ethics training upon initial orientation and as an annual refresher.

1.4.2. **Value Employees-** Pace management views employees as our most important asset and communicates to them the relevance and importance of their activities within their job functions and how they contribute to the achievement of the objectives of the quality management system.

1.4.3. **Know Our Customers-** Pace makes every effort to know our customers and address their sampling and analytical needs. More information on this item can be found in section 2.0.

1.4.4. **Honor Commitments-** Pace labs focus on making solid commitments with regards to quality, capacity, and agreed upon turnaround time to our customers.

1.4.5. **Flexible Response To Demand-** Pace labs are equipped with both the material and personnel resources to enable them to be responsive to the demands of customers when situations or projects need change.

1.4.6. **Pursue Opportunities-** Pace is committed to pursuing opportunities for the growth of the company by constantly exploring markets and areas where we can expand.

1.4.7. **Continuously Improve-** Pace has committed much time and effort into establishing a continuous improvement program where company personnel meet on a regular basis to share ideas in cost reduction, production improvement and standardization in order to develop best practices. This information, as well as company financial and production metrics, are tracked, evaluated, and shared with each Pace facility.

1.5. Code of Ethics

1.5.1. PASI's fundamental ethical principles are as follows:

1.5.1.1. Each PASI employee is responsible for the propriety and consequences of his or her actions;

1.5.1.2. Each PASI employee must conduct all aspects of Company business in an ethical and strictly legal manner, and must obey the laws of the United States and of all localities, states and nations where PASI does business or seeks to do business;

1.5.1.3. Each PASI employee must reflect the highest standards of honesty, integrity and fairness on behalf of the Company with customers, suppliers, the public, and one another.

1.5.1.4. Each PASI employee must recognize and understand that our daily activities in environmental laboratories affect public health as well as the environment and that environmental laboratory analysts are a critical part of the system society depends upon to improve and guard our natural resources:

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1.5.2. Strict adherence by each PASI employee to this Code of Ethics and to the Standards of Conduct is essential to the continued vitality of PASI and to continue the pursuit of our common mission to protect our environment and improve our health.

1.5.3. Failure to comply with the Code of Ethics and Standards of Conduct will result in disciplinary action up to and including termination and referral for civil or criminal prosecution where appropriate. An employee will be notified of an infraction and given an opportunity to explain, as prescribed under current disciplinary procedures.

1.5.4. Any Pace employee can contact corporate management to report an ethical concern by calling the anonymous hotline at 612-607-6431.

1.6. Standards of Conduct

1.6.1. **Data Integrity**

1.6.1.1. The accuracy and integrity of the analytical results and its supporting documentation produced at PASI are the cornerstones of the company. Lack of data integrity is an assault on our most basic values putting PASI and its employees at grave financial and legal risk and will not be tolerated. Therefore, employees are to accurately prepare and maintain all technical records, scientific notebooks, calculations, and databases. Employees are prohibited from making false entries or misrepresentations of data for any reason.

1.6.1.2. Managerial staff must make every effort to ensure that personnel are free from any undue pressures that may affect the quality or integrity of their work including commercial, financial, over-scheduling, and working condition pressures.

1.6.2. **Confidentiality**

1.6.2.1. PASI employees must not use or disclose confidential or proprietary information except when in connection with their duties at PASI. This is effective over the course of employment and for an additional period of two years thereafter.

1.6.2.2. Confidential or proprietary information, belonging to either PASI and/or its customers, includes but is not limited to test results, trade secrets, research and development matters, procedures, methods, processes and standards, company-specific techniques and equipment, marketing and customer information, inventions, materials composition, etc.

1.6.3. **Conflict of Interest**

1.6.3.1. PASI employees must avoid situations that might involve a conflict of interest or could appear questionable to others. The employee must be careful in two general areas:

1.6.3.1.1. Participation in activities that conflict or appear to conflict with the employees' PASI responsibilities.

1.6.3.1.2. Offering or accepting anything that might influence the recipient or cause another person to believe that the recipient may be influenced to behave or in a different manner than he would normally. This includes bribes, gifts, kickbacks, or illegal payments.

1.6.3.2. Employees are not to engage in outside business or economic activity relating to a sale or purchase by the Company. Other problematic activities include service on the Board of Directors of a competing or supplier company, significant ownership in a competing or supplier

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company, employment for a competing or supplier company, or participation in any outside business during the employee's work hours.

1.6.4. **Compliance**

1.6.4.1. All employees are required to read, understand, and comply with the various components of the standards listed in this document. As confirmation that they understand their responsibility, each employee is required to sign an acknowledgment form annually that then becomes part of the employee's permanent record. Employees will be held accountable for complying with the Quality Systems as summarized in the Quality Assurance Manual.

1.7. Laboratory Organization

1.7.1. The PASI Corporate Office centralizes company-wide accounting, business development, financial management, human resources development, information systems, marketing, quality, safety, and training activities. PASI's Director of Quality is responsible for assisting the development, implementation and monitoring of quality programs for the company. See Attachment IIB for the Corporate Organizational structure.

1.7.2. Each laboratory within the system operates with local management, but all labs share common systems and receive support from the Corporate Office.

1.7.3. A Senior General Manager (SGM) oversees all laboratories and service centers in their assigned region. Each laboratory or facility in the company is then directly managed by an SGM, a General Manager (GM), an Assistant General Manager (AGM), or an Operations Manager (OM). Quality Managers (QM) or Senior Quality Managers (SQM) at each laboratory report directly to the highest level of local laboratory management, however named, that routinely makes day-to-day decisions regarding that facility's operations. The QMs and SQMs will also receive guidance and direction from the corporate Director of Quality.

1.7.4. The SGM, GM, AGM or OM, or equivalent functionality in each facility, bears the responsibility for the laboratory operations and serves as the final, local authority in all matters. In the absence of these managers, the SQM/QM serves as the next in command, unless the manager in charge has assigned another designee. He or she assumes the responsibilities of the manager, however named, until the manager is available to resume the duties of their position. In the absence of both the manager and the SQM/QM, management responsibility of the laboratory is passed to the Technical Director, provided such a position is identified, and then to the most senior department manager until the return of the lab manager or SQM/QM. The most senior department manager in charge may include the Client Services Manager or the Administrative Business Manager at the discretion of the SGM/GM/AGM/OM.

1.7.5. A Technical Director who is absent for a period of time exceeding 15 consecutive calendar days shall designate another full-time staff member meeting the qualifications of the technical director to temporarily perform this function. The laboratory SGM/GM/AGM/OM or SQM/QM has the authority to make this designation in the event the existing Technical Director is unable to do so. If this absence exceeds 35 consecutive calendar days, the primary accrediting authority shall be notified in writing.

1.7.6. The SQM/QM has the responsibility and authority to ensure the Quality System is implemented and followed at all times. In circumstances where a laboratory is not meeting the established level of

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quality or following the policies set forth in this Quality Assurance Manual, the SQM/QM has the authority to halt laboratory operations should he or she deem such an action necessary. The SQM/QM will immediately communicate the halting of operations to the SGM/GM/AGM/OM and keep them posted on the progress of corrective actions. In the event the SGM/GM/AGM/OM and the SQM/QM are not in agreement as to the need for the suspension, the Chief Operating Officer and Director of Quality will be called in to mediate the situation.

1.7.7. The technical staff of the laboratory is generally organized into the following functional groups:

- Organic Sample Preparation
- Wet Chemistry Analysis
- Metals Analysis
- Volatiles Analysis
- Semi-volatiles Analysis
- Radiochemical Analysis
- Microbiology

1.7.8. Appropriate support groups are present in each laboratory. The actual organizational structure for PASI – Kansas is listed in Attachment IIA. In the event of a change in SGM/GM/AGM/OM, SQM/QM, or any Technical Director, the laboratory will notify its accrediting authorities and revise the organizational chart in the Quality Assurance Manual (QAM) within 30 days. For changes in Department Managers or Supervisors or other laboratory personnel, no notifications will be sent to the laboratory's accrediting agencies; changes to the organizational chart will be updated during or prior to the annual review process. Changes or additions in these key personnel will also be noted by additional signatures on the QAM, as applicable. In any case, the QAM will remain in effect until the next scheduled revision.

1.8. Laboratory Job Descriptions

1.8.1. **Senior General Manager**

- Oversees all functions of all the operations within their designated region;
- Oversees the development of local GMs/AGMs/OMs within their designated region;
- Oversees and authorizes personnel development including staffing, recruiting, training, workload scheduling, employee retention and motivation;
- Oversees the preparation of budgets and staffing plans for all operations within their designated region;
- Ensures compliance with all applicable state, federal and industry standards;
- Works closely with Regional Sales Management.

1.8.2. **General Manager**

- Oversees all functions of their assigned operations;
- Authorizes personnel development including staffing, recruiting, training, workload scheduling, employee retention and motivation;
- Prepares budgets and staffing plans;
- Monitors the Quality Systems of the laboratory and advises the SQM/QM accordingly;
- Ensures compliance with all applicable state, federal and industry standards.

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1.8.3. **Assistant General Manager / Operations Manager**

- In the absence of the SGM/GM, performs all duties as listed above for the SGM or GM;
- Oversees the daily production and quality activities of all departments;
- Manages all departments and works with staff to ensure department objectives are met;
- Works with all departments to ensure capacity and customer expectations are accurately understood and met;
- Works with SGM/GM to prepare appropriate budget and staffing plans for all departments;
- Responsible for prioritizing personnel and production activities within all departments;
- Performs formal and informal performance reviews of departmental staff.

1.8.4. **Senior Quality Manager**

- Provides quality oversight for multiple laboratories where there is not a local quality manager or for labs where there are multiple and separately distinct quality systems in the same facility;
- Responsible for implementing, maintaining and improving the quality system while functioning independently from laboratory operations. Reports directly to the highest level of local laboratory facility management, however named, that routinely makes day-to-day decisions regarding laboratory operations, but receives direction and assistance from the Corporate Director of Quality;
- Ensures that communication takes place at all levels within the lab regarding the effectiveness of the quality system and that all personnel understand their contributions to the quality system;
- Monitors Quality Assurance/Quality Control activities to ensure that the laboratory achieves established standards of quality (as set forth by the Corporate Quality office). The Quality Manager is responsible for reporting the lab's level of compliance to these standards to the Corporate Director of Quality on a quarterly basis;
- Maintains records of quality control data and evaluates data quality;
- Conducts periodic internal audits and coordinates external audits performed by regulatory agencies or customer representatives;
- Reviews and maintains records of proficiency testing results;
- Maintains the document control system;
- Assists in development and implementation of appropriate training programs;
- Provides technical support to laboratory operations regarding methodology and project QA/QC requirements;
- Maintains certifications from federal and state programs;
- Ensures compliance with all applicable state, federal and industry standards;
- Maintains the laboratory training records, including those in the Learning Management System (LMS), and evaluates the effectiveness of training;
- Monitors correctives actions;
- Maintains the currency of the Quality Manual.

1.8.5. **Quality Manager**

- Responsible for implementing, maintaining and improving the quality system while functioning independently from laboratory operations. Reports directly to the highest level of local laboratory facility management, however named, that routinely makes day-to-day

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decisions regarding laboratory operations, but receives direction and assistance from the Corporate Director of Quality. They may also report to a Senior Quality Manager within the same facility;

- Ensures that communication takes place at all levels within the lab regarding the effectiveness of the quality system and that all personnel understand their contributions to the quality system;
- Monitors Quality Assurance/Quality Control activities to ensure that the laboratory achieves established standards of quality (as set forth by the Corporate Quality office). The Quality Manager is responsible for reporting the lab's level of compliance to these standards to the Corporate Director of Quality on a quarterly basis;
- Maintains records of quality control data and evaluates data quality;
- Conducts periodic internal audits and coordinates external audits performed by regulatory agencies or customer representatives;
- Reviews and maintains records of proficiency testing results;
- Maintains the document control system;
- Assists in development and implementation of appropriate training programs;
- Provides technical support to laboratory operations regarding methodology and project QA/QC requirements;
- Maintains certifications from federal and state programs;
- Ensures compliance with all applicable state, federal and industry standards;
- Maintains the laboratory training records, including those in the Learning Management System (LMS), and evaluates the effectiveness of training;
- Monitors correctives actions;
- Maintains the currency of the Quality Manual.

1.8.6. **Quality Assurance Analyst**

- Assists the SQM/QM in the performance of quality department responsibilities as delegated by the SQM/QM;
- Assists in monitoring QA/QC data;
- Assists in internal audits;
- Assists in maintaining training records;
- Assists in maintaining the document control system;

1.8.7. **Technical Director**

- Monitors the standards of performance in quality assurance and quality control data;
- Monitors the validity of analyses performed and data generated;
- Reviews tenders, contracts and QAPPs to ensure the laboratory can meet the data quality objectives for any given project;
- Serves as the manager of the laboratory in the absence of the SGM/GM/AGM/OM and SQM/QM;
- Provides technical guidance in the review, development, and validation of new methodologies.

1.8.8. **Administrative Business Manager**

- Responsible for financial and administrative management for the entire facility;
- Provides input relative to tactical and strategic planning activities;

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- Organizes financial information so that the facility is run as a fiscally responsible business;
- Works with staff to confirm that appropriate processes are put in place to track revenues and expenses;
- Provide ongoing financial information to the SGM/GM/AGM/OM and the management team so they can better manage their business;
- Utilizes historical information and trends to accurately forecast future financial positions;
- Works with management to ensure that key measurements are put in place to be utilized for trend analysis—this will include personnel and supply expenses, and key revenue and expense ratios;
- Works with SGM/GM/AGM/OM to develop accurate budget and track on an ongoing basis;
- Works with entire management team to submit complete and justified capital budget requests and to balance requests across departments;
- Works with project management team and administrative support staff to ensure timely and accurate invoicing.

1.8.9. **Client Services Manager**

- Oversees all the day to day activities of the Client Services Department which includes Project Management and, possibly, Sample Control;
- Responsible for staffing and all personnel management related issues for Client Services;
- Serves as the primary senior consultant to customers on all project related issues such as set up, initiation, execution and closure;
- Performs or is capable of performing all duties listed for that of Project Manager.

1.8.10. **Project Manager**

- Coordinates daily activities including taking orders, reporting data and analytical results;
- Serves as the primary technical and administrative liaison between customers and PASI;
- Communicates with operations staff to update and set project priorities;
- Provides results to customers in the requested format (verbal, hardcopy, electronic, etc.);
- Works with customers, laboratory staff, and other appropriate PASI staff to develop project statements of work or resolve problems of data quality;
- Responsible for solicitation of work requests, assisting with proposal preparation and project initiation with customers and maintain customer records;
- Mediation of project schedules and scope of work through communication with internal resources and management;
- Responsible for preparing routine and non-routine quotations, reports and technical papers;
- Interfaces between customers and management personnel to achieve customer satisfaction;
- Manages large-scale complex projects;
- Supervises less experienced project managers and provide guidance on management of complex projects;
- Arranges bottle orders and shipment of sample kits to customers;
- Verifies login information relative to project requirements and field sample Chains-of-Custody.

1.8.11. **Project Coordinator**

- Responsible for preparation of project specifications and provides technical/project support;

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- Coordinates project needs with other department sections and assists with proposal preparation;
- Prepares routine proposals and invoicing;
- Responsible for scanning, copying, assembling and binding final reports;
- Other duties include filing, maintaining forms, process outgoing mail, maintaining training database and data entry.

1.8.12. **Department Manager/Supervisor**

- Oversees the day-to-day production and quality activities of their assigned department;
- Ensures that quality assurance and quality control criteria of analytical methods and projects are satisfied;
- Assesses data quality and takes corrective action when necessary;
- Approves and releases technical and data management reports;
- Ensures compliance with all applicable state, federal and industry standards.

1.8.13. **Group Supervisor/Leader**

- Trains analysts in laboratory operations and analytical procedures;
- Organizes and schedules analyses with consideration for sample holding times;
- Implements data verification procedures by assigning data verification duties to appropriate personnel;
- Evaluates instrument performance and supervises instrument calibration and preventive maintenance programs;
- Reports non-compliance situations to laboratory management including the SQM/QM.

1.8.14. **Laboratory Analyst**

- Performs detailed preparation and analysis of samples according to published methods and laboratory procedures;
- Processes and evaluates raw data obtained from preparation and analysis steps;
- Generates final results from raw data, performing primary review against method criteria;
- Monitors quality control data associated with analysis and preparation. This includes examination of raw data such as chromatograms as well as an inspection of reduced data, calibration curves, and laboratory notebooks;
- Reports data in LIMS, authorizing for release pending secondary approval;
- Conducts routine and non-routine maintenance of equipment as required;
- Performs or is capable of performing all duties associated with that of Laboratory Technician.

1.8.15. **Laboratory Technician**

- Prepares standards and reagents according to published methods or in house procedures;
- Performs preparation and analytical steps for basic laboratory methods;
- Works under the direction of a Laboratory Analyst on complex methodologies;
- Assists Laboratory Analysts on preparation, analytical or data reduction steps for complex methodologies;
- Monitors quality control data as required or directed. This includes examination of raw data such as chromatograms as well as an inspection of reduced data, calibration curves, and laboratory notebooks.

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1.8.16. **Field Technician**

- Prepares and samples according to published methods, PASI Quality Assurance Manual and/or customer directed sampling objectives;
- Capable of the collection of representative environmental or process related air samples;
- Use computer software to compile, organize, create tables, create graphics and write test reports;
- Reviews project documentation for completeness, method compliance and contract fulfillment;
- Train less experienced environmental technicians and provide guidance on sampling and analysis;
- Responsible for project initiation and contact follow-up;
- Develop sampling plans and prepare test plan documents.

1.8.17. **Field Analyst**

- Analyzes field samples according to published methods, PASI Quality Assurance Manual and/or customer directed sampling objectives,
- Capable of the collection and analysis of representative environmental or process related air samples,
- Proficient in a variety of analytical tests; specifically on-site gas-phase organic and inorganic compounds by extractive fourier transform infrared spectroscopy (FTIR),
- Train less experienced staff and provide guidance on FTIR sampling and analysis,
- Assist in reporting tasks and project management responsibilities, and
- Perform back-up support for manager tasks such as reporting needs and customer concerns.

1.8.18. **Sample Management Personnel**

- Signs for incoming samples and verifies the data entered on the Chain of custody forms;
- Enters the sample information into the Laboratory Information Management System (LIMS) for tracking and reporting;
- Stages samples according to EPA requirements;
- Assists Project Managers and Coordinators in filling bottle orders and sample shipments.

1.8.19. **Systems Administrator or Systems Manager**

- Assists with the creation and maintenance of electronic data deliverables (EDDs);
- Coordinates the installation and use of all hardware, software and operating systems;
- Performs troubleshooting on all aforementioned systems;
- Trains new and existing users on systems and system upgrades;
- Maintains all system security passwords;
- Maintains the electronic backups of all computer systems.

1.8.20. **Safety/Chemical Hygiene Officer**

- Maintains the laboratory Chemical Hygiene Plan;
- Plans and implements safety policies and procedures;
- Maintains safety records;
- Organizes and/or performs safety training;

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- Performs safety inspections and provides corrective/preventative actions;
- Assists personnel with safety issues.

1.8.21. **Program Director/Hazardous Waste Coordinator (or otherwise named)**

- Evaluates waste streams and helps to select appropriate waste transportation and disposal companies;
- Maintains complete records of waste disposal including waste manifests and state reports;
- Assists in training personnel on waste-related issues such as waste handling and storage, waste container labeling, proper satellite accumulation, secondary containment, etc.;
- Conducts a weekly inspection of the waste storage areas of the laboratory.

1.9. Training and Orientation

1.9.1. Training for Pace employees is managed through a web-based Learning Management System. After a new employee has been instructed in matters of human resources, they are given instructional materials for the LMS and a password for access.

1.9.2. A new hire training checklist is provided to the new employee that lists training items for the employee to work through either independently on LMS or with their supervisor or trainer. The training items that can be completed independently include:

- Reading through applicable Standard Operating Procedures;
- Reviewing the Quality Manual and Chemical Hygiene Plan;
- Core training modules such as quality control indicators, basic laboratory skills, etc.;
- Quality Systems training including traceability of measurements, method calibration, calibration verification, accuracy, precision and uncertainty of measurements, corrective actions, documentation, and root cause analysis;
- Data Integrity/Ethics training.

1.9.3. The new employee's Department Supervisor provides the employee with a basic understanding of the role of the laboratory within the structure of PASI and the basic elements of that individual's position. Supervised training uses the following techniques:

- Hands-on training
- Training checklists/worksheets
- Lectures and training sessions
- Method-specific training
- Conferences and seminars
- Short courses
- Specialized training by instrument manufacturers
- Proficiency testing programs.
- On-line courses

1.9.4. Group Supervisors/Leaders are responsible for providing documentation of training and proficiency for each employee under their supervision. The employee's training file indicates what procedures an analyst or a technician is capable of performing, either independently or with supervision. The files also include documentation of continuing capability, which are fully detailed in Section 3.4.

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Training documentation files for each person are maintained by the Quality Office either in hardcopy format or within the LMS.

1.9.5. All procedures and training records are maintained and available for review during laboratory audits. These procedures are reviewed/updated periodically by laboratory management. Additional information can be found in SOP S-ALL-Q-020 **Training and Employee Orientation** or its equivalent revision or replacement.

1.10. Data Integrity System

1.10.1. The data integrity system at PASI provides assurances to management that a highly ethical approach is being applied to all planning, training and implementation of methods. Data integrity is crucial to the success of our company and Pace Analytical is committed to creating and maintaining a culture of quality throughout the organization. To accomplish this goal, PASI has implemented a data integrity system that encompasses the following four requirements:

1.10.1.1. A data integrity training program: standardized training is given to each new employee and a yearly refresher is presented to all employees. Key topics addressed by this training include:

1.10.1.1.1. Need for honesty and transparency in analytical reporting

1.10.1.1.2. Process for reporting data integrity issues

1.10.1.1.3. Specific examples of unethical behavior and improper practices

1.10.1.1.4. Documentation of non-conforming data that is still useful to the data user

1.10.1.1.5. Consequences and punishments for unethical behavior

1.10.1.1.6. Examples of monitoring devices used by management to review data and systems

1.10.1.2. Signed data integrity documentation for all employees: this includes a written quiz following the Ethics training session and written agreement to abide by the Code of Ethics and Standards of Conduct explained in the employee manual.

1.10.1.3. In-depth, periodic monitoring of data integrity including peer data review and validation, internal raw data audits, proficiency testing studies, etc.

1.10.1.4. Documentation of any review or investigation into possible data integrity infractions. This documentation, including any disciplinary actions involved, corrective actions taken, and notifications to customers must be retained for a minimum of five years.

1.10.2. PASI management makes every effort to ensure that personnel are free from any undue pressures that affect the quality of their work including commercial, financial, over scheduling, and working condition pressures.

1.10.3. Corporate management also provides all PASI facilities a mechanism for confidential reporting of data integrity issues that ensures confidentiality and a receptive environment in which all employees are comfortable discussing items of ethical concern. The anonymous message line is monitored by the Corporate Director of Quality who will ensure that all concerns are evaluated and, where necessary, brought to the attention of executive management and investigated. Any Pace employee can contact corporate management to report an ethical concern by calling the anonymous hotline at 612-607-6431.

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1.11. Laboratory Safety

1.11.1. It is the policy of PASI to make safety and health an integral part of daily operations and to ensure that all employees are provided with safe working conditions, personal protective equipment, and requisite training to do their work without injury. Each employee is responsible for his/her own safety as well as those working in the immediate area by complying with established company rules and procedures. These rules and procedures as well as a more detailed description of the employees' responsibilities are contained in the corporate Safety Manual and Chemical Hygiene Plan.

1.12. Security and Confidentiality

1.12.1. Security is maintained by controlled access to laboratory buildings. Exterior doors to laboratory buildings remain either locked or continuously monitored by PASI staff. Posted signs direct visitors to the reception office and mark all other areas as off limits to unauthorized personnel. All visitors, including PASI staff from other facilities, must sign the Visitor's Logbook maintained by the receptionist. A staff member will accompany them during the duration of their stay on the premises unless the SGM/GM/AGM/OM, SQM/QM, or Technical Director specify otherwise. In this instance, the staff member will escort the visitor back to the reception area at the end of his/her visit where he/she signs out. The last staff member to leave their department for the day must ensure that all outside access points to that area are secure.

1.9.1. Additional security is provided where necessary, (e.g., specific secure areas for sample, data, and customer report storage), as requested by customers, or cases where national security is of concern. These areas are lockable within the facilities, or are securely offsite. Access is limited to specific individuals or their designees. Security of sample storage areas is the responsibility of the Client Services Manager. Security of samples and data during analysis and data reduction is the responsibility of Group Supervisors. Security of customer report archives is the responsibility of the Client Services Manager. These secure areas are locked whenever these individuals or their designees are not present in the facility.

1.9.2. Access to designated laboratory sample storage locations is limited to authorized personnel only. Provisions for lock and key access are provided. No samples are to be removed without proper authorization. If requested by customer or contract, samples are not to be removed from secure storage areas without filling out an associated internal chain of custody.

1.9.3. Standard business practices of confidentiality are applied to all documents and information regarding customer analyses. Specific protocols for handling confidential documents are described in PASI SOPs. Additional protocols for sample identification by internal laboratory identification numbers only are implemented as required under contract specific Quality Assurance Project Plans (QAPPs).

1.9.4. All information pertaining to a particular customer, including national security concerns will remain confidential. Data will be released to outside agencies only with written authorization from the customer or where federal or state law requires the company to do so.

1.13. Communications

1.13.1. Management within each lab bears the responsibility of ensuring that appropriate communication processes are established and that communication takes place regarding the effectiveness of the management/quality system. These communication processes may include email, regular staff meetings, senior management meetings, etc.

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1.13.2. Corporate management bears the responsibility of ensuring that appropriate communication processes are established within the network of facilities and that communication takes place at a company-wide level regarding the effectiveness of the management/quality systems of all Pace facilities. These communication processes may include email, quarterly continuous improvement conference calls for all lab departments, and annual continuous improvement meetings for all department supervisors, quality managers, client services managers, and other support positions.

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2.0. SAMPLE CUSTODY

2.1. Sampling Support

2.1.1. Each individual PASI laboratory provides shipping containers, properly preserved sample containers, custody documents, and field quality control samples to support field-sampling events. Guidelines for sample container types, preservatives, and holding times for a variety of methods are listed in Attachment VIII. Note that all analyses listed are not necessarily performed at all PASI laboratories and there may be additional laboratory analyses performed that are not included in these tables. Customers are encouraged to contact their local Pace Project Manager for questions or clarifications regarding sample handling. PASI - Kansas may provide pick-up and delivery services to their customers when needed.

2.2. Field Services

2.2.1. Pace Analytical has a large Field Services Division which is based in their Minneapolis facility as well as limited field service capabilities in some of our other facilities. Field Services provides comprehensive nationwide service offerings including:

- Stack Testing
- Ambient Air
- CEM Certification Testing
- Air Quality Monitoring
- Onsite Analytical Services- FTIR and GC
- Real-time Process Diagnostic/Optimization Testing
- Wastewater, Groundwater and Drinking Water Monitoring
- Storm Water and Surface Water Monitoring
- Soil and Waste Sampling
- Mobile Laboratory Services

2.2.2. Field Services operates under the PASI Corporate Quality System, with applicable and necessary provisions to address the activities, methods, and goals specific to Field Services. All procedures and methods used by Field Services are documented in Standard Operating Procedures and Procedure Manuals.

2.3. Project Initiation

2.3.1. Prior to accepting new work, the laboratory reviews its performance capability. The laboratory confirms that sufficient personnel, equipment capacity, analytical method capability, etc., are available to complete the required work. Customer needs, certification requirements, and data quality objectives are defined and the appropriate sampling and analysis plan is developed to meet the project requirements by project managers or sales representatives. Members of the management staff review current instrument capacity, personnel availability and training, analytical procedures capability, and projected sample load. Management then informs the sales and client services personnel whether or not the laboratory can accept the new project via written correspondence, email, and/or daily operations meetings.

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2.3.2. The laboratory maintains records of all such reviews, including discussions with customers. Routine analytical project documentation of quotes, notes, dates, initials, and/or recordings is maintained in a project folder by project management. Conditions for new and more complex contracts are determined by the SGM/GM/AGM/OM and sales representatives. Quality Management is consulted on technical requirements and operations staff provides input on volume capacities. Evidence of these reviews is maintained in the form of awarded Request for Proposals (RFPs), signed quotes or contracts, and a Customer Relationship Management (CRM) database. If a review identifies a potential mismatch between customer requirements and laboratory capabilities and/or capacities, Pace will specify its level of commitment by listing these exceptions to the requirements within the RFP, quote or contract.

2.3.3. Additional information regarding specific procedures for reviewing new work requests can be found in SOP S-KS-Q-033 **Review of Analytical Requests** or its equivalent revision or replacement.

2.4. Chain of Custody

2.4.1. A chain of custody (COC) provides the legal documentation of samples from time of collection to completion of analysis. PASI has implemented Standard Operating Procedures to ensure that sample custody traceability and responsibility objectives are achieved for every project.

2.4.2. Field personnel or client representatives must complete a chain of custody for all samples that are received by the laboratory. The importance of completeness of COCs is stressed to the samplers and is critical to efficient sample receipt and to insure the requested methods are used to analyze the correct samples.

2.4.3. If sample shipments are not accompanied by the correct documentation, the Sample Receiving department notifies a Project Manager. The Project Manager then obtains the correct documentation/information from the customer in order for analysis of samples to proceed.

2.4.4. The sampler is responsible for providing the following information on the chain of custody form:

- Customer project name
- Project location or number
- Field sample number/identification
- Date and time sampled
- Sample matrix
- Preservative
- Requested analyses
- Sampler signature
- Relinquishing signature
- Date and time relinquished
- Sampler remarks as needed
- Custody Seal Number if present
- Regulatory Program Designation
- The state where the samples were collected to ensure all applicable state requirements are met
- Turnaround time requested
- Purchase order number

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2.4.5. The COC is filled out completely and legibly with indelible ink. Errors are corrected by drawing a single line through the initial entry and initialing and dating the change. All transfers of samples are recorded on the chain of custody in the "relinquished" and "received by" sections. All information except signatures is printed.

2.4.6. Additional information can be found in S-KS-C-001 **Sample Management** or its equivalent revision or replacement.

2.5. Sample Acceptance Policy

2.5.1. In accordance with regulatory guidelines, PASI complies with the following sample acceptance policy for all samples received.

2.5.2. If the samples do not meet the sample receipt acceptance criteria outlined below, the laboratory is required to document all non-compliances, contact the customer, and either reject the samples or fully document any decisions to proceed with analyses of samples which do not meet the criteria. Any results reported from samples not meeting these criteria are appropriately qualified on the final report.

2.5.3. All samples must:

- Have unique customer identification that is clearly marked with indelible ink on durable waterproof labels affixed to the sample containers that match the chain of custody.
- Have clear documentation on the chain of custody related to the location of the sampling site with the time and date of sample collection.
- Have the sampler's name and signature.
- Have all requested analyses clearly designated on the COC.
- Have clear documentation of any special analytical or data reporting requirements.
- Be in appropriate sample containers with clear documentation of the preservatives used.
- Be correctly preserved unless the method allows for laboratory preservation.
- Be received within holding time. Any samples with hold times that are exceeded will not be processed without prior customer approval.
- Have sufficient sample volume to proceed with the analytical testing. If insufficient sample volume is received, analysis will not proceed without customer approval.
- Be received within appropriate temperature ranges - not frozen but ≤6°C (See Note 1), unless program requirements or customer contractual obligations mandate otherwise (see Note 2). The cooler temperature is recorded directly on the COC and the SCUR. Samples that are delivered to the laboratory immediately after collection are considered acceptable if there is evidence that the chilling process has been started. For example, by the arrival of the samples on ice. If samples arrive that are not compliant with these temperature requirements, the customer will be notified. The analysis will NOT proceed unless otherwise directed by the customer. If less than 72 hours remain in the hold time for the analysis, the analysis may be started while the customer is contacted to avoid missing the hold time. Data associated with any deviations from the above sample acceptance policy requirements will be appropriately qualified.

Note 1: Temperature will be read and recorded based on the precision of the measuring device. For example, temperatures obtained from a thermometer graduated to 0.1°C will be read and recorded to

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±0.1°C. Measurements obtained from a thermometer graduate to 0.5°C will be read to ±0.5°C. Measurements read at the specified precision are not to be rounded down to meet the ≤6°C limit

Note 2: Some microbiology methods allow sample receipt temperatures of up to 10°C. Consult the specific method for microbiology samples received above 6°C prior to initiating corrective action for out of temperature preservation conditions.

2.5.4. Upon sample receipt, the following items are also checked and recorded:

- Presence of custody seals or tapes on the shipping containers;
- Sample condition: Intact, broken/leaking, bubbles in VOA samples;
- Sample holding time;
- Sample pH and residual chlorine when required;
- Appropriate containers.

2.5.5. Samples for drinking water analysis that are improperly preserved, or are received past holding time, are rejected at the time of receipt, with the exception of VOA samples that are tested for pH at the time of analysis.

2.5.6. Additional information can be found in S-KS-C-001 **Sample Management** or its equivalent revision or replacement.

2.6. Sample Log-in

2.6.1. After sample inspection, all sample information on the chain of custody is entered into the Laboratory Information Management System (LIMS). This permanent record documents receipt of all sample containers including:

- Customer name and contact
- Customer number
- Pace Analytical project number
- Pace Analytical Project Manager
- Sample descriptions
- Due dates
- List of analyses requested
- Date and time of laboratory receipt
- Field ID code
- Date and time of collection
- Any comments resulting from inspection for sample rejection

2.6.2. All samples received are logged into the LIMS within one working day of receipt. Sample login may be delayed due to customer clarification of analysis needed, corrective actions for sample receipt non-conformance, or other unusual circumstances. If the time collected for any sample is unspecified and Pace is unable to obtain this information from the customer, the laboratory will use 08:00am as the time sampled. All hold times will be based on this sampling time and qualified accordingly if exceeded.

2.6.3. For DoD work, if the time of the sample collection is not provided, the laboratory must assume the most conservative time of day. This is defined as 12:01am.

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2.6.4. The LIMS automatically generates a unique identification number for each sample created in the system. The LIMS sample number follows the general convention of 60XXXXXXYYY. This unique identification number is placed on the sample container as a durable label and becomes the link between the laboratory's sample management system and the customer's field identification; it will be a permanent reference number for all future interactions.

2.6.5. Current division codes are noted below. These division codes are used primarily for accounting purposes and LIMS sample identifications. For smaller facilities, these codes may be used primarily for accounting purposes. More division codes may be added, revised or removed without updating this document.

00 = Corporate
10 = Minnesota/Montana/Virginia MN
12 = Virginia/Duluth MN
20 = New Orleans/Puerto Rico
30 = Pittsburgh
35 = Florida/South Florida
36 = South Florida (accounting only)
40 = Green Bay
50 = Indianapolis/Columbus
51 = Columbus (accounting only)
55/56 = Pace Energy Labs
60 = Kansas
65 = New York (Schenectady)
70 = Long Island
75 = Dallas
92 = Carolinas

2.6.6. Sample labels are printed from the LIMS and affixed to each sample container.

2.6.7. Samples with hold times that are near expiration date/time may be sent directly to the laboratory for analysis at the discretion of the Project Manager and/or SGM/GM/AGM/OM.

2.6.8. Additional information can be found SOP S-KS-C-001 **Sample Management** or its equivalent revision or replacement.

2.7. Sample Storage

2.7.1. Storage Conditions

2.7.1.1. Samples are stored away from all standards, reagents, or other potential sources of contamination. Samples are stored in a manner that prevents cross contamination. Volatile samples are stored separately from other samples. All sample fractions, extracts, leachates, and other sample preparation products are stored in the same manner as actual samples or as specified by the analytical method.

2.7.1.2. Storage blanks, consisting of two 40mL aliquots of reagent water, are stored with volatile samples and are used to measure cross-contamination acquired during storage. If applicable, laboratories must have documented procedures and criteria for evaluating storage blanks, appropriate to the types of samples being stored.

2.7.1.3. Insert specification for ensuring sample temperatures while outside of controlled storage conditions if needed. Additional information can be found in SOP S-KS-Q-042 **Monitoring Temperature Controlled Units.**

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2.7.2. Temperature Monitoring

2.7.2.1. Samples are taken to the appropriate storage location immediately after sample receipt and check-in procedures are completed. All sample storage areas are located in limited access areas and are monitored to ensure sample integrity.

2.7.2.2. The temperature of each refrigerated storage area is maintained at ≤6°C (but above freezing) unless state or program requirements differ. The temperature of each freezer storage area is maintained at <-10°C unless state or program requirements differ. The temperature of each storage area is checked and documented each day of use (each calendar day). If the temperature falls outside the acceptable limits, the following corrective actions are taken and appropriately documented:

- The temperature is rechecked after two hours to verify temperature exceedance. Corrective action is initiated and documented if necessary.
- The SQM/QM and/or laboratory management are notified if the problem persists.
- The samples are relocated to a proper environment if the temperature cannot be maintained after corrective actions are implemented.
- The affected customers are notified.
- Documentation is provided on analytical report.

2.7.2.3. Additional information can be found in SOP S-KS-Q-042 **Monitoring Temperature Controlled Units.**

2.7.3. Hazardous Materials

2.7.3.1. Pure product or potentially heavily contaminated samples must be tagged as "hazardous" or "lab pack" and stored separately from other samples.

2.7.4. Foreign/Quarantined Soils

2.7.4.1. Depending on the soil disposal practices of the laboratory, foreign soils and soils from USDA regulated areas are adequately segregated to enable proper sample disposal. The USDA requires these samples to be incinerated or sterilized by an approved treatment procedure. Additional information regarding USDA regulations and sample handling can be found in applicable local laboratory SOPs.

2.7.4.2. Additional information on sample storage can be found in SOPs S-KS-C-001 **Sample Management** and SOP S-KS-S-002 **Waste Handling and Management** or their equivalent revisions or replacements.

2.8. Sample Protection

2.8.1. PASI laboratory facilities are operated under controlled access protocols to ensure sample and data integrity. Visitors must register at the front desk and be properly escorted at all times.

2.8.2. Samples are removed from storage areas by designated personnel and returned to the storage areas, if necessary, immediately after the required sample quantity has been taken.

2.8.3. Upon customer request, additional and more rigorous chain of custody protocols for samples and data can be implemented. For example, some projects may require internal chain-of-custody protocols.

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2.8.4. Additional information can be found in SOP S-KS-C-001 **Sample Management** or its equivalent revision or replacement.

2.9. Subcontracting Analytical Services

2.9.1. Every effort is made to perform all analyses for PASI customers within the laboratory that receives the samples. When subcontracting to a laboratory other than the receiving laboratory, whether inside or outside the PASI network, becomes necessary, a preliminary verbal communication with that laboratory is undertaken. Customers are notified in writing of the laboratory's intention to subcontract any portion of the testing to another laboratory. Work performed under specific protocols may involve special considerations.

2.9.2. Prior to subcontracting samples to a laboratory outside Pace Analytical, the potential sub-contract laboratory will be pre-qualified by verifying that the subcontractor meets the following criteria:

- All certifications required for the proposed subcontract are in effect,
- Sufficient professional liability and other required insurance coverage is in effect, and
- Is not involved in legal action by any federal, state, or local government agency for data integrity issues and has not been convicted in such investigation at any time during the past 5 years.

2.9.3. The contact and preliminary arrangements are made between the PASI Project Manager and the appropriate subcontract laboratory personnel. The specific terms of the subcontract laboratory agreement include:

- Method of analysis
- Number and type of samples expected
- Project specific QA/QC requirements
- Deliverables required
- Laboratory certification requirement
- Price per analysis
- Turn-around time requirements

2.9.4. Chain-of-custody forms are generated for samples requiring subcontracting to other laboratories. Sample receiving personnel re-package the samples for shipment, create a transfer chain of custody form and record the following information:

- Pace Analytical Laboratory Number
- Matrix
- Requested analysis
- Special instructions regarding turnaround, required detection or reporting limits, or any unusual information known about the samples or analytical procedure.
- Signature in "Relinquished By"

2.9.5. All subcontracted sample data reports are sent to the PASI Project Manager. Pace will provide a copy of the subcontractor's report to the client when requested.

2.9.6. Any Pace Analytical work sent to other labs within the PASI network is handled as subcontracted work and all final reports are labeled clearly with the name of the laboratory performing

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the work. Any non-TNI work is clearly identified. PASI will not be responsible for analytical data if the subcontract laboratory was designated by the customer.

2.9.7. Additional information can be found in SOP S-KS-C-003 **Subcontracting Samples** or its equivalent revision or replacement.

2.9.8. Subcontracted labs used for DoD work must be accredited by DoD or its designated representatives. Subcontracted labs must receive project specific approval from the DoD client before any samples are analyzed. These requirements also apply to the use of any laboratory under the same corporate umbrella, but at a different facility or location.

2.10. Sample Retention and Disposal

2.10.1. Samples, extracts, digestates, and leachates must be retained by the laboratory for the period of time necessary to protect the interests of the laboratory and the customer.

2.10.2. Unused portions of samples are retained by each laboratory based on program or customer requirements for sample retention and storage. The minimum sample retention time is 45 days from receipt of the samples. Samples requiring thermal preservation may be stored at ambient temperature when the hold time is expired, the report has been delivered, and/or allowed by the customer, program, or contract. Samples requiring storage beyond the minimum sample retention time due to special requests or contractual obligations may be stored at ambient temperature unless the laboratory has sufficient capacity and their presence does not compromise the integrity of other samples.

2.10.3. After this period expires, non-hazardous samples are properly disposed of as non-hazardous waste. The preferred method for disposition of hazardous samples is to return the excess sample to the customer. If it is not feasible to return samples, or the customer requires PASI to dispose of excess samples, proper arrangements will be made for disposal by an approved contractor.

2.10.4. Additional information can be found in SOPs S-KS-C-001 **Sample Management** and S-KS-S-002 **Waste Handling and Management** or their equivalent revisions or replacements.

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3.0. ANALYTICAL CAPABILITIES

3.1. Analytical Method Sources

3.1.1. PASI laboratories are capable of analyzing a full range of environmental samples from a variety of matrices, including air, surface water, wastewater, groundwater, soil, sediment, biota, and other waste products. The latest valid editions of methodologies are applied from regulatory and professional sources including EPA, ASTM, USGS, NIOSH, Standard Methods, and State Agencies. Section 11 is a representative listing of general analytical protocol references. PASI discloses in writing to its customers and regulatory agencies any instances in which modified methods are being used in the analysis of samples.

3.1.2. In the event of a customer-specific need, instrumentation constraint or regulatory requirement, PASI laboratories reserve the right to use valid versions of methods that may not be the most recent edition available.

3.2. Analytical Method Documentation

3.2.1. The primary form of PASI laboratory documentation of analytical methods is the Standard Operating Procedure (SOP). SOPs contain pertinent information as to what steps are required by an analyst to successfully perform a procedure. The required contents for the SOPs are specified in SOP S-KS-Q-037 **Preparation of SOPs** or its equivalent revisions or replacements.

3.2.2. The SOPs may be supplemented by other training materials that further detail how methods are specifically performed. This training material will undergo periodic, documented review along with the other Quality System documentation.

3.3. Analytical Method Validation and Instrument Validation

3.3.1. In some situations, PASI develops and validates methodologies that may be more applicable to a specific problem or objective. When non-standard methods are required for specific projects or analytes of interest, or when the laboratory develops or modifies a method, the laboratory validates the method prior to applying it to customer samples. Method validity is established by meeting criteria for precision and accuracy as established by the data quality objectives specified by the end user of the data. The laboratory records the validation procedure, the results obtained and a statement as to the usability of the method. The minimum requirements for method validation include evaluation of sensitivity, quantitation, precision, bias, and selectivity of each analyte of interest.

3.4. Demonstration of Capability (DOC)

3.4.1. Analysts complete an initial demonstration of capability (IDOC) study prior to performing a method or when there is a change in instrument type, personnel, or test method, or at any time that a method has not been performed by the laboratory or analyst in a 12-month period. The mean recovery and standard deviation of each analyte, taken from 4 replicates of a quality control standard is calculated and compared to method criteria (if available) or established laboratory criteria for evaluation of acceptance. Each laboratory maintains copies of all demonstrations of capability, including those that fail acceptance criteria and corresponding raw data for future reference and must document the

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acceptance criteria prior to the analysis of the DOC. Demonstrations of capability are verified on an annual basis.

3.4.2. For Continuing Demonstrations of Capability, the laboratories may use Performance Testing (PT) samples in lieu of the 4-replicate approach listed above. For methods or procedures that do not lend themselves to the "4-replicate" approach, the demonstration of capability requirements will be specified in the applicable SOP. Drinking Water DOCs must be done at or below the MCL.

3.4.3. Additional information can be found in SOP S-ALL-Q-020 **Training and Employee Orientation** or its equivalent revision or replacement.

3.5. Regulatory and Method Compliance

3.5.1. PASI understands that expectations of our customers commonly include the assumption that laboratory data will satisfy specific regulatory requirements. Therefore PASI attempts to ascertain, prior to beginning a project, what applicable regulatory jurisdiction, agency, or protocols apply to that project. This information is also required on the chain of custody submitted with samples.

3.5.2. PASI makes every effort to detect regulatory or project plan inconsistencies, based upon information from the customer, and communicate them immediately to the customer in order to aid in the decision making process. PASI will not be liable if the customer chooses not to follow PASI recommendations.

3.5.3. It is PASI policy to disclose in a forthright manner any detected noncompliance affecting the usability of data produced by our laboratories. The laboratory will notify customers within 30 days of fully characterizing the nature of the nonconformance, the scope of the nonconformance and the impact it may have on data usability.

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4.0. QUALITY CONTROL PROCEDURES

Quality control data is analyzed and where they are found to be outside pre-defined criteria, planned action is taken to correct the problem in order to prevent incorrect results from being reported. Quality control samples are to be processed in the same manner as client samples.

4.1. Method Blank

4.1.1. A method blank is used to evaluate contamination in the preparation/analysis system and is processed through all preparation and analytical steps with its associated samples.

4.1.2. A method blank is processed at a minimum frequency of one per preparation batch (see glossary section of this document for further clarification of the definition of batch). In the case of a method that has no separate preparation step, a method blank is processed with no more than 20 samples of a specific matrix performed by the same analyst, using the same method, standards, and reagents.

4.1.3. The method blank consists of a matrix similar to the associated samples that is known to be free of analytes of interest. Method blanks are not applicable for certain analyses, such as pH, conductivity, flash point and temperature.

4.1.4. Each method blank is evaluated for contamination. The source of any contamination is investigated and documented corrective action is taken when the concentration of any target analyte is detected above the reporting limit and is greater than 1/10 of the amount of that analyte found in any associated sample. Some labs, due to client requirements, etc., may have to evaluate their method blanks down to ½ the reporting limit or down to the method detection limit as opposed to the reporting limit itself. Corrective actions for blank contamination may include the re-preparation and re-analysis of all samples (where possible) and quality control samples. Data qualifiers must be applied to results that are considered affected by contamination in a method blank.

4.1.5. For DoD samples, the method blank will be considered to be contaminated if: 1) The concentration of any target analyte in the blank exceeds 1/2 the reporting limit and is greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit whichever is greater; 2) The concentration of any common laboratory contaminant in the blank exceeds the reporting limit and is greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit whichever is greater or 3) The blank result otherwise affects the sample results as per the test method requirements or the project-specific objectives. If the method blank is contaminated as described above, then the laboratory shall reprocess affected samples in a subsequent preparation batch, except when sample results are below the LOD. If insufficient sample volume remains for reprocessing, the results shall be reported with appropriate data qualifiers.

4.1.6. Deviations made from this policy must be approved by the SQM/QM prior to release of the data.

4.2. Laboratory Control Sample

4.2.1. The Laboratory Control Sample (LCS) is used to evaluate the performance of the entire analytical system including preparation and analysis.

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4.2.2. An LCS is processed at a minimum frequency of one per preparation batch. In the case of a method that has no separate preparation step, an LCS will be processed with no more than 20 samples of a specific matrix performed by the same analyst, using the same method, standards, and reagents.

4.2.3. The LCS consists of a matrix similar to the associated samples that is known to be free of the analytes of interest that is then spiked with known concentrations of target analytes.

4.2.4. The LCS contains **all** analytes specified by a specific method or by the customer or regulatory agency, which may include full list of target compounds, with certain exceptions. These exceptions may include analyzing only specific Aroclors when PCB analysis is requested or not spiking with all EPA Appendix IX compounds when a full Appendix IX list of compounds is requested. However, the lab must ensure that all target components in its scope of accreditation are included in the spike mixture for the LCS over a two (2) year period. In the absence of specified components, the laboratory will spike the LCS with the following compounds:

- For multi-peak analytes (e.g. PCBs, technical chlordane, toxaphene), a representative standard will be processed.
- For methods with long lists of analytes, a representative number of target analytes may be chosen. The following criteria is used to determine the number of LCS compounds used:
  - For methods with 1-10 target compounds, the laboratory will spike with all compounds;
  - For methods with 11-20 target compounds, the laboratory will spike with at least 10 compounds or 80%, whichever is greater;
  - For methods with greater than 20 compounds, the laboratory will spike with at least 16 compounds.

4.2.5. The LCS is evaluated against the method default or laboratory-derived acceptance criteria. For those methods that require laboratory-derived limits, method default control limits may be used until the laboratory has a minimum of 20, but preferably greater than 30, data points from which to derive internal acceptance criteria. Any compound that is outside of these limits is considered to be 'out of control' and must be qualified appropriately. Any associated sample containing an 'out-of-control' compound must either be re-analyzed with a successful LCS or reported with the appropriate data qualifier. When the acceptance criteria for the LCS are exceeded high, and there are associated samples that are non-detects, then those non-detects can be reported with data qualifiers, or when the acceptance criteria are exceeded low, those associated sample results may be reported if they exceed the maximum regulatory limit/decision level with data qualifiers.

4.2.6. For LCSs containing a large number of analytes, it is statistically likely that a few recoveries will be outside of control limits. This does not necessarily mean that the system is out of control, and therefore no corrective action would be necessary (except for proper documentation). TNI has allowed for a minimum number of marginal exceedances, defined as recoveries that are beyond the LCS control limits (3X the standard deviation) but less than the marginal exceedance limits (4X the standard deviation). The number of allowable exceedances depends on the number of compounds in the LCS. If more analyte recoveries exceed the LCS control limits than is allowed (see below) or if any one analyte exceeds the marginal exceedance limits, then the LCS is considered non-compliant and corrective actions are necessary. The number of allowable exceedances is as follows:

- >90 analytes in the LCS- 5 analytes
- 71-90 analytes in the LCS- 4 analytes
- 51-70 analytes in the LCS- 3 analytes

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- 31-50 analytes in the LCS- 2 analytes
- 11-30 analytes in the LCS- 1 analyte
- <11 analytes in the LCS- no analytes allowed out)

4.2.7. A matrix spike (MS) can be used in place of a non-compliant LCS in a batch as long as the MS passes the LCS acceptance criteria (this is a TNI allowance). When this happens, full documentation must be made available to the data user. If this is not allowed by a customer or regulatory body, the associated samples must be rerun with a compliant LCS (if possible) or reported with appropriate data qualifiers.

4.2.8. Deviations made from this policy must be approved by the SQM/QM prior to release of the data.

4.2.9. For Department of Defense projects, the laboratory is not allowed to have any target analytes that exceed DoD LCS control limits. In the case of LCS failures, the laboratory is required to reanalyze the associated samples with an acceptable LCS for all target compounds if there is sufficient sample remaining. The laboratory must make every effort to take the appropriate corrective actions and resolve any anomalies regarding LCSs for Department of Defense projects. All LCS failures must be accounted for in project case narratives. See applicable method SOPs for further corrective action.

4.3. Matrix Spike/Matrix Spike Duplicate (MS/MSD)

4.3.1. A matrix spike (MS) is used to determine the effect of the sample matrix on compound recovery for a particular method. The information from these spikes is sample or matrix specific and is not used to determine the acceptance of an entire batch unless the MS is actually used as the LCS.

4.3.2. A **Matrix Spike/Matrix Spike Duplicate** (MS/MSD) set is processed at a frequency specified in a particular method or as determined by a specific customer request. This frequency will be specified in the applicable method SOP or customer QAPP. In the absence of such requirements, an MS/MSD set is routinely analyzed once per every 20 samples per matrix per method.

4.3.3. The MS and MSD consist of the sample matrix that is then spiked with known concentrations of target analytes. Laboratory personnel spike customer samples that are specifically designated as MS/MSD samples or, when no designated samples are present in a batch, randomly select samples to spike that have adequate sample volume or weight. Spiked samples are prepared and analyzed in the same manner as the original samples and are selected from different customers if possible.

4.3.4. The MS and MSD contain all analytes specified by a specific method or by the customer or regulatory agency. In the absence of specified components, the laboratory will spike the MS/MSD with the same number of compounds as previously discussed in the LCS section. However, the lab must ensure that all targeted components in its scope of accreditation are included in the spike mixture for the MS/MSD over a two (2) year period.

4.3.5. The MS and MSD are evaluated against the method or laboratory derived criteria. Any compound that is outside of these limits is considered to be 'out of control' and must be qualified appropriately. Batch acceptance, however, is based on method blank and LCS performance, not on MS/MSD recoveries. The spike recoveries give the data user a better understanding of the final results based on their site specific information.

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4.3.6. A matrix spike and sample duplicate will be performed instead of a matrix spike and matrix spike duplicate when specified by the customer or method.

4.3.7. Deviations made from this policy must be approved by the SQM/QM prior to release of the data.

4.3.8. For DoD work, each preparation batch of samples must contain an associated MS and MSD (or sample duplicate) using the same matrix collected for the specific DoD project. If adequate sample material is not available, then the lack of MS/MSDs shall be noted in the case narrative. Additional MS/MSDs may be required on a project-specific basis. The MS/MSD must be spiked with all target analytes with the exception of PCB analysis, which is spiked per the method. The concentration of the spiked compounds shall be at or below the midpoint of the calibration range or at the appropriate concentration of concern. Multiple spiked samples may need to be prepared to avoid interferences.

4.3.9. For DoD work, the results of all MS/MSD must be evaluated using the same acceptance criteria used for the LCS.

4.4. Sample Duplicate

4.4.1. A sample duplicate is a second portion of sample that is prepared and analyzed in the laboratory along with the first portion. It is used to measure the precision associated with preparation and analysis. A sample duplicate is processed at a frequency specified by the particular method or as determined by a specific customer.

4.4.2. The sample and duplicate are evaluated against the method or laboratory derived criteria for relative percent difference (RPD). Any duplicate that is outside of these limits is considered to be 'out of control' and must be qualified appropriately.

4.4.3. Deviations made from this policy must be approved by the SQM/QM prior to release of the data.

4.5. Surrogates

4.5.1. Surrogates are compounds that reflect the chemistry of target analytes and are typically added to samples for organic analyses to monitor the effect of the sample matrix on compound recovery.

4.5.2. Surrogates are added to each customer sample (for applicable organics), method blank, LCS, MS, and calibration standard prior to extraction or analysis. The surrogates are evaluated against the method or laboratory derived acceptance criteria or against project-specific acceptance criteria specified by the client, if applicable. Any surrogate compound that is outside of these limits is considered to be 'out of control' and must be qualified appropriately. Samples with surrogate failures are typically re-extracted and/or re-analyzed to confirm that the out-of-control value was caused by the matrix of the sample and not by some other systematic error. An exception to this would be samples that have high surrogate values but no reportable hits for target compounds. These samples would be reported, with a qualifier, because the implied high bias would not affect the final results. For methods with multiple surrogates, documentation regarding acceptance and associated compounds will be found in the individual method SOPs.

4.5.3. Deviations made from this policy must be approved by the SQM/QM prior to release of the data.

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4.6. Internal Standards

4.6.1. Internal Standards are method-specific analytes added to every standard, method blank, laboratory control sample, matrix spike, matrix spike duplicate, sample, and calibration standard at a known concentration, prior to analysis for the purpose of adjusting the response factor used in quantifying target analytes. At a minimum, the laboratory will follow method specific guidelines for the treatment of internal standard recoveries as they are related to the reporting of data.

4.1.1. Deviations made from this policy must be approved by the SQM/QM prior to release of the data.

4.7. Field Blanks

4.7.1. Field blanks are blanks prepared at the sampling site in order to monitor for contamination that may be present in the environment where samples are collected. These field quality control samples are often referenced as field blanks, rinsate blanks, or equipment blanks. The laboratory analyzes these field blanks as normal samples and informs the customer if there are any target compounds detected above the reporting limits.

4.8. Trip Blanks

4.8.1. Trip blanks are blanks that originate from the laboratory as part of the sampling event and are used to monitor for contamination of samples during transport. These blanks accompany the empty sample containers to the field and then accompany the collected samples back to the laboratory. These blanks are routinely analyzed for volatile methods where ambient background contamination is likely to occur.

4.9. Limit of Detection (LOD)

4.9.1. PASI laboratories are required to use a documented procedure to determine a limit of detection for each analyte of concern in each matrix reported. All sample processing steps of the preparation and analytical methods are included in this determination including any clean ups. For any test that does not have a valid LOD, sample results below the limit of quantitation (LOQ) cannot be reported.

4.9.2. The LOD is initially established for the compounds of interest for each method in a clean matrix with no target analytes present and no interferences at a concentration that would impact the results. The LOD is then determined every time there is a change in the test method that affects how the test is performed or when there has been a change in the instrument that affects the sensitivity. If required by customer, method or accreditation body, the LOD will be re-established annually for all applicable methods.

4.9.3. Unless otherwise noted, the method used by PASI laboratories to determine LODs is based on the Method Detection Limit (MDL) procedure outlined in 40 CFR Part 136, Appendix B. Where required by regulatory program or customer, the above referenced procedure will be followed.

4.9.4. Where specifically stated in the published method, LODs or MDLs will be performed at the listed frequency.

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4.9.5. The validity of the LOD must be shown by detection (a value above zero) of the analytes in a QC sample in each quality system matrix. The QC sample must contain the analyte at no more than 3X the LOD for a single analyte test and 4X the LOD for multiple analyte tests. This verification must be performed on each instrument used for sample analysis and reporting of data. The validity of the LOD must be verified as part of the LOD determination process. This verification must be done prior to the use of the LOD for sample analysis.

4.9.6. An LOD study is not required for any analyte for which spiking solutions or quality control samples are not available such as temperature.

4.9.7. The LOD, if required, shall be verified annually for each quality system matrix, technology and analyte. In lieu of performing full LOD (MDL) studies annually, the laboratory can verify the LOD (MDL) on an annual basis, providing this verification is fully documented and does not contradict other customer or program requirements that the laboratory must follow. The requirements of this verification are:

- The spike concentration of the verification must be no more than 3X times the LOD for single analyte tests and 4X the LOD for multiple analyte tests.
- The laboratory must verify the LOD on each instrument used for the reporting of sample data.
- The laboratory must be able to identify all target analytes in the verification standard (distinguishable from noise).

4.9.8. DoD definition for LOD- The smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate is 1%.

4.9.9. Additional information can be found in SOP S-KS-Q-032 **Determination of LOD and LOQ** or its equivalent revision or replacement.

4.10. Limit of Quantitation (LOQ)

4.10.1. A limit of quantitation (LOQ) for every analyte of concern must be determined. For PASI laboratories, this LOQ is referred to as the RL, or Reporting Limit. This RL is based on the lowest calibration standard concentration that is used in each initial calibration. Results below this level are not allowed to be reported without qualification since the results would not be substantiated by a calibration standard. For methods with a determined LOD, results can be reported out below the LOQ but above the LOD if they are properly qualified (e.g., J flag).

4.10.2. The LOQ must be higher than the LOD.

4.10.3. To verify the LOQ, the laboratory will prepare a sample in the same matrix used for the LCS. The sample will be spiked with each target analyte at a concentration equivalent to the RL or 2X the RL. This sample must undergo the routine sample preparation procedure including any routine sample cleanup steps. The sample is then analyzed and the recovery of each target analyte determined. The recovery for each target analyte must meet the laboratories current control limits for an LCS. The annual LOQ verification is not required if the LOD was determined or verified annually on that instrument.

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4.10.4. For DoD approved methods, the LOQ and LOD shall be verified quarterly and valid LOQ must be in place prior to sample analysis.

4.10.5. Additional information can be found in SOP S-KS-Q-032 **Determination of LOD and LOQ** or its equivalent revision or replacement.

4.10.6. Estimate of Analytical Uncertainty

4.10.7. PASI laboratories can provide an estimation of uncertainty for results generated by the laboratory. The estimate quantifies the error associated with any given result at a 95% confidence interval. This estimate does not include bias that may be associated with sampling. The laboratory has a procedure in place for making this estimation. In the absence of a regulatory or customer-specific procedure, PASI laboratories base this estimation on the recovery data obtained from the Laboratory Control Spikes. The uncertainty is a function of the standard deviation of the recoveries multiplied by the appropriate Student's t Factor at 95% confidence. Additional information pertaining to the estimation of uncertainty and the exact manner in which it is derived are contained in the SOP S-KS-Q-022 **Estimation of Measurement Uncertainty** or its equivalent revision or replacement.

4.10.8. The measurement of uncertainty is provided only on request by the customer, as required by specification or regulation and when the result is used to determine conformance within a specification limit.

4.11. Proficiency Testing (PT) Studies

4.11.1. PASI laboratories participate in the TNI defined proficiency testing program. PT samples are obtained from NIST approved providers and analyzed and reported at a minimum of two times per year for the relevant fields of testing per matrix.

4.11.2. The laboratory initiates an investigation whenever PT results are deemed 'unacceptable' by the PT provider. All findings and corrective actions taken are reported to the SQM/QM or their designee. A corrective action plan is initiated and this report is sent to the appropriate state accreditation agencies for their review. Additional PTs will be analyzed and reported as needed for certification purposes.

4.11.3. PT samples are treated as typical customer samples, utilizing the same staff, methods, equipment, facilities, and frequency of analysis. PT samples are included in the laboratory's normal analytical processes and do not receive extraordinary attention due to their nature.

4.11.4. Comparison of analytical results with anyone participating in the same PT study is prohibited prior to the close of the study.

4.11.5. Additional information can be found in SOP S-KS-Q-035 **Proficiency Testing Program** or its equivalent revision or replacement.

4.12. Rounding and Significant Figures

4.12.1. In general, the PASI laboratories report data to no more than three significant digits. Therefore, all measurements made in the analytical process must reflect this level of precision. In the event that a parameter that contributes to the final result has less than three significant figures of precision, the final result must be reported with no more significant figures than that of the parameter in question. The

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rounding rules listed below are descriptive of the LIMS and not necessarily of any supporting program such as Excel.

4.12.2. Data is compared to the reporting limits and MDLs to determine if qualifiers are needed before the rounding step occurs.

4.12.3. **Rounding:** PASI-Kansas follows the odd / even guidelines for rounding numbers:

- If the figure following the one to be retained is less than five, that figure is dropped and the retained ones are not changed (with three significant figures, 2.544 is rounded to 2.54).
- If the figure following the ones to be retained is greater than five, that figure is dropped and the last retained one is rounded up (with three significant figures, 2.546 is rounded to 2.55).
- If the figure following the ones to be retained is five and if there are no figures other than zeros beyond that five, then the five is dropped and the last figure retained is unchanged if it is even and rounded up if it is odd (with three significant figures, 2.525 is rounded to 2.52 and 2.535 is rounded to 2.54).

4.12.4. Significant Digits

4.12.4.1. PASI-Kansas follows the following convention for reporting to a specified number of significant figures. Unless specified by federal, state, or local requirements or on specific request by a customer, the laboratory reports:

Values > 10 – Reported to 3 significant digits
Values ≤ 10 – Reported to 2 significant digits

4.13. Retention Time Windows

4.13.1. When chromatographic conditions are changed, retention times and analytical separations are often affected. As a result, two critical aspects of any chromatographic method are the determination and verification of retention times and analyte separation. Retention time windows must be established for the identification of target analytes. The retention times of all target analytes in all calibration verification standards must fall within the retention time windows. If an analyte falls outside the retention time window in an ICV or CCV, new absolute retention time windows must be calculated, unless instrument maintenance fixes the problem. When a new column is installed, a new retention time window study must be performed.

4.13.2. One process for the production of retention time windows: Make 3 injections of all single component or multi-component analytes over a 72-hour period. Record the retention time in minutes for each analyte and surrogate to 3 decimal places. Calculate the mean and standard deviation of the three absolute retention times for each target analyte and surrogate. For multi-component analytes, choose 3-5 major peaks and calculate the mean and standard deviation for each of the peaks. If the standard deviation of the retention times of a target analyte is 0.000, the lab may use a default standard deviation of 0.01. The width of the retention time window for each analyte and surrogate and major peak in a multi-component analyte is defined as +/- 3 times the standard deviation of the mean absolute retention time established during that 72-hour period or 0.03 minutes, whichever is greater.

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4.13.3. The center of the retention time window is established for each analyte and surrogate by using the absolute retention times from the CCV at the beginning of the analytical shift. For samples run with an initial calibration, use the retention time of the mid-point standard of the initial calibration curve.

4.13.4. For more information, please reference the local facility's analytical SOPs.

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5.0. DOCUMENT MANAGEMENT AND CHANGE CONTROL

5.1. Document Management

5.1.1. Additional information can be found in SOP S-KS-Q-045 **Document Control and Management** or its equivalent revision or replacement. Information on Pace's policy for electronic signatures can also be found in this SOP.

5.1.2. Pace Analytical Services, Inc. has an established procedure for managing documents that are part of the quality system. The list of managed documents includes, but is not limited to, Standard Operating Procedures (both technical and non-technical), Quality Assurance Manuals, quality policy statements, training documents, work-processing documents, charts, posters, memoranda, notices, forms, software, and any other procedures, tables, plans, etc. that have a direct bearing on the quality system (including applicable data records and non-technical documents).

5.1.3. A master list of all managed documents is maintained at each facility identifying the current revision status and distribution of the controlled documents. This establishes that there are no invalid or obsolete documents in use in the facility. All documents are reviewed periodically and revised if necessary. Obsolete documents are systematically discarded or archived for audit or knowledge preservation purposes. Copies of all quality systems documentation provided to DoD for review must be in English.

5.1.4. Each managed document is uniquely identified to include the date of issue, the revision identification, page numbers, the total number of pages and the issuing authorities. For complete information on document numbering, refer to SOP S-ALL-Q-003 **Document Numbering** or its equivalent revision or replacement.

5.1.5. SOPs, specifically, are available to all laboratory staff via the Learning Management System (LMS) which is a secure repository that is accessed through an internet portal. As a local alternative to the hard copy system of controlled documents, secured electronic copies of controlled documents may be maintained on the laboratory's local server. These document files must be read-only for all personnel except the Quality Department and system administrator. Other requirements for this system are as follows:

- Electronic documents must be readily accessible to all facility employees.
- Electronic documents must be locked from printing. All hardcopy SOPs must be obtained from the Quality Department.

5.1.6. **Quality Assurance Manual (QAM):** The Quality Assurance Manual is the company-wide document that describes all aspects of the quality system for PASI. The base QAM template is distributed by the Corporate Quality Department to each of the SQMs/QMs. The local management personnel modify the necessary and permissible sections of the base template and submit those modifications to the Corporate Director of Quality for review. Once approved and signed by both the CEO and the Director of Quality; the SGM/GM/AGM/OM, the SQM/QM, and any Technical Directors sign the Quality Assurance Manual. Each SQM/QM is then in charge of distribution to employees, external customers or regulatory agencies and maintaining a distribution list of controlled document copies. The Quality Assurance Manual template is reviewed on an annual basis by all of the PASI SQMs/QMs and revised accordingly by the Director of Quality.

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5.1.7. **Standard Operating Procedures (SOPs)**

5.1.7.1. SOPs fall into two categories: company-wide documents and facility specific documents. Company-wide SOPs start with the prefix S-ALL- and local SOPs start with the individual facility prefix.

5.1.7.2. The purpose of the company-wide SOPs is to establish policies and procedure that are common and applicable to all PASI facilities. Company-wide SOPs are document-controlled by the corporate quality office and signed copies are distributed to all of the SQMs/QMs. The local management personnel sign the company-wide SOPs. The SQM/QM is then in charge of distribution to employees, external customers, or regulatory agencies and maintaining a distribution list of controlled document copies.

5.1.7.3. Local PASI facilities are responsible for developing facility-specific SOPs applicable to their respective facility. The local facility develops these facility-specific SOPs based on the corporate-wide SOP template. This template is written to incorporate a set of minimum method requirements and PASI best practice requirements. The local facilities may add to or modify the corporate-wide SOP template provided there are no contradictions to the minimum method or best practice requirements. Facility-specific SOPs are controlled by the applicable SQM/QM according to the corporate document management policies.

5.1.7.4. SOPs are reviewed every two years at a minimum although a more frequent review may be required by some state or federal agencies or customers. If no revisions are made based on this review, documentation of the review itself is made by the addition of new signatures on the cover page. If revisions are made, documentation of the revisions is made in the revisions section of each SOP and a new revision number is applied to the SOP. This provides a historical record of all revisions.

5.1.7.5. All copies of superseded SOPs are removed from general use and the original copy of each SOP is archived for audit or knowledge preservation purposes. This ensures that all PASI employees use the most current version of each SOP and provides the SQM/QM with a historical record of each SOP.

5.1.7.6. Additional information can be found in SOP S-KS-Q-037 **Preparation of SOPs** or its equivalent revision or replacement.

5.1.7.7. For DoD approval, all technical SOPs are reviewed for accuracy and adequacy annually and whenever method procedures change and updated as appropriate. All such reviews are documented and made available for assessment. Non-technical SOPs that are not required elements of the quality system are considered administrative SOPs and are not required to be reviewed annually.

5.2. Document Change Control

5.2.1. Changes to managed documents are reviewed and approved in the same manner as the original review. Any revision to a document requires the approval of the applicable signatories. After revisions are approved, a revision number is assigned and the previous version of the document is officially retired. Copies may be kept for audit or knowledge preservation purposes.

5.2.2. All controlled copies of the previous document are replaced with controlled copies of the revised document and the superseded copies are destroyed or archived. All affected personnel are advised that there has been a revision and any necessary training is scheduled.

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5.3. Management of Change

5.3.1. The process for documenting necessary changes within the laboratory network are not typically handled using the corrective or preventive action system as outlined in section 9.0. Management of Change is a proactive approach to dealing with change to minimize the potential negative impact of systematic change in the laboratory and to ensure that each change has a positive desired outcome. This process will primarily be used for the implementation of large scale projects and information system changes as a means to apply consistent systems or procedures within the laboratory network. The request for change is submitted by the initiator and subsequently assigned to an individual or team for development and planning. The final completion of the process culminates in final approval and verification that the procedure was effectively implemented. Additional information can be found in SOP S-KS-Q-034 **Management of Change** or its equivalent revision or replacement.

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6.0. EQUIPMENT AND MEASUREMENT TRACEABILITY

Each PASI facility is equipped with sufficient instrumentation and support equipment to perform the relevant analytical testing or field procedures performed by each facility. Support equipment includes chemical standards, thermometers, balances, disposable and mechanical pipettes, etc. This section details some of the procedures necessary to maintain traceability and to perform proper calibration of instrumentation and support equipment. See Attachment III for a list of equipment currently used at the Kansas PASI facility.

6.1. Standards and Traceability

6.1.1. Each PASI facility retains all pertinent information for standards, reagents, and chemicals to assure traceability to a national standard. This includes documentation of purchase, receipt, preparation, and use.

6.1.2. Upon receipt, all purchased standard reference materials are recorded into a standard logbook or database and assigned a unique identification number. The entries include the facility's unique identification number, the chemical name, manufacturer name, manufacturer's identification numbers, receipt date, and expiration date. Vendor's certificates of analysis for all standards, reagents, or chemicals are retained for future reference.

6.1.3. Subsequent preparations of intermediate or working solutions are also documented in a standard logbook or database. These entries include the stock standard name and lot number, the manufacturer name, the solvents used for preparation, the solvent lot number and manufacturer, the preparation steps, preparation date, expiration dates, preparer's initials, and a unique PASI identification number. This number is used in any applicable sample preparation or analysis logbook so the standard can be traced back to the standard preparation record. This process ensures traceability back to the national standard.

6.1.4. All prepared standard or reagent containers include the PASI identification number, the standard or chemical name, the date of preparation, the date of expiration, the concentration with units, and the preparer's initials. This ensures traceability back to the standard preparation logbook or database.

6.1.5. For containers that are too small to accommodate labels that list all of the above information associated with a standard, the minimum required information will be PASI standard ID, concentration, and expiration date. This assures that no standard will be used past its assigned expiration date.

6.1.6. If a second source standard is required to verify an existing calibration or spiking standard, this standard must be obtained from a different manufacturer or from a different lot unless client specific QAPP requirements state otherwise.

6.1.7. Additional information concerning standards and reagent traceability can be found in the SOP S-KS-Q-043 **Standard and Reagent Management and Traceability** or its equivalent revision or replacement.

6.2. General Analytical Instrument Calibration Procedures (Organic and Inorganic)

6.2.1. All support equipment and instrumentation are calibrated or checked before use to ensure proper functioning and verify that the laboratory's requirements are met. All calibrations are performed by, or

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under the supervision of, an experienced analyst at scheduled intervals against either certified standards traceable to recognized national standards or reference standards whose values have been statistically validated.

6.2.2. Calibration standards for each parameter are chosen to establish the linear range of the instrument and must bracket the concentrations of those parameters measured in the samples. The lowest calibration standard is the lowest concentration for which quantitative data may be reported. Data reported below this level is considered to have less certainty and must be reported using appropriate data qualifiers or explained in a narrative. The highest calibration standard is the highest concentration for which quantitative data may be reported. Data reported above this level is considered to have less certainty and must be reported using appropriate data qualifiers or explained in the narrative. Any specific method requirement for number and type of calibration standards supersedes the general requirement. Instrument and method specific calibration criteria are explained within the specific analytical standard operating procedures for each facility.

6.2.3. Results from all calibration standards analyzed must be included in constructing the calibration curve with the following exceptions:

6.2.3.1. The lowest level calibration standard may be removed from the calibration as long as the remaining number of concentration levels meets the minimum established by the method and standard operating procedure. For multi-parameter methods, this may be done on an individual analyte basis. The reporting limit must be adjusted to the lowest concentration included in the calibration curve;

6.2.3.2. The highest level calibration standard may be removed from the calibration as long as the remaining number of concentration levels meets the minimum established by the method and standard operating procedure. For multi-parameter methods, this may be done an individual analyte basis. The upper limit of quantitation must be adjusted to the highest concentration included in the calibration curve;

6.2.3.3. Multiple points from either the high end or the low end of the calibration curve may be excluded as long as the remaining points are contiguous in nature and the minimum number of levels remains as established by method or standard operating procedure. The reporting limit or quantitation range, whichever is appropriate, must be adjusted accordingly;

6.2.3.4. Results from a concentration level between the lowest and highest calibration levels can only be excluded from an initial calibration curve for a documentable and acceptable cause with approval from the responsible department supervisor and the local SQM/QM or their designee. An acceptable cause is defined as an obvious sample introduction issue that resulted in no response, documentation of an incorrectly prepared standard, or a documented response of a single standard that is greater than 2X the difference from the expected value of that standard. The results for all analytes are to be excluded and the point must be replaced by re-analysis. Re-analysis of this interior standard must occur within the same 12-hour tune time period for GC/MS methodologies and within 8 hours of the initial analysis of that standard for non-GC/MS methodologies. All samples analyzed prior to the re-analyzed calibration curve point must be re-analyzed after the calibration curve is completed and re-processed against the final calibration curve.

6.2.4. Instrumentation or support equipment that cannot be calibrated to specification or is otherwise defective is clearly labeled as out-of-service until it has been repaired and tested to demonstrate it meets the laboratory's specifications. All repair and maintenance activities including service calls are

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documented in the maintenance log. Equipment sent off-site for calibration testing is packed and transported to prevent breakage and is in accordance with the calibration laboratory's recommendations.

6.2.5. In the event that recalibration of a piece of test equipment indicates the equipment may have been malfunctioning during the course of sample analysis, an investigation is performed. The results of the investigation along with a summary of the information reviewed are documented and maintained by the quality manager. Customers must be notified within 30 days after the data investigation is completed and the impact to final results is assessed. This allows for sufficient investigation and review of documentation to determine the impact on the analytical results. Instrumentation found to be consistently out of calibration is either repaired and positively verified or taken out of service and replaced.

6.2.6. Raw data records are retained to document equipment performance. Sufficient raw data is retained to reconstruct the instrument calibration and explicitly connect the continuing calibration verification to the initial calibration.

6.2.7. **General Organic Calibration Procedures**

6.2.7.1. Calibration standards are prepared at a minimum of five concentrations for organic analyses (unless otherwise stipulated in the method).

6.2.7.2. Initial calibration curves are evaluated against appropriate statistical models as required by the analytical methods. Curves that do not meet the appropriate criteria require corrective action that may include re-running the initial calibration curve. Rounding to meet initial calibration criteria is not allowed, that is, 15.3 cannot be rounded down to meet a $\leq$ 15% RSD requirement. This also applies to linear and non-linear fit requirements. All initial calibrations are verified with an initial calibration verification standard (ICV) obtained from a second manufacturer or second lot from the same manufacturer if that lot can be demonstrated as prepared independently from other lots prior to the analysis of samples. Sample results are quantitated from the initial calibration unless otherwise required by regulation, method, or program.

6.2.7.3. The calibration curve is periodically verified by the analysis of a mid-level continuing calibration verification (CCV) standard during the course of sample analysis. This standard is from the same source as the initial calibration unless otherwise specified in the source method to be from an alternate source material. Rounding to meet continuing calibration criteria is not allowed. Continuing calibration verification is performed at the beginning and end of each analytical batch except if an internal standard is used, then only one verification at the beginning of the batch is needed, whenever it is expected that the analytical system may be out of calibration, if the time period for calibration has expired, or for analytical systems that have specific calibration verification requirements. This verification standard must meet acceptance criteria in order for sample analysis to proceed.

6.2.7.4. In the event that the CCV does not meet the acceptance criteria, a second CCV may be injected as part of the diagnostic evaluation and corrective action investigation. If the second CCV is acceptable, the analytical sequence may be continued. If both CCVs fail, the analytical sequence is terminated and corrective action is initiated. Sample analysis cannot begin until after documented corrective action has been completed and either two consecutive passing CCVs have been analyzed or the instrument has successfully passed a new initial calibration. All samples analyzed since the last compliant CCV are re-analyzed for methodologies utilizing external calibration.

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6.2.7.4.1. For DoD labs: the lab must re-analyze CCVs and all samples analyzed since the last successful calibration verification. If re-analysis is not possible, the lab must notify the client prior to reporting data associated with a non-compliant CCV. If these data are reported, the data must be qualified and explained in the case narrative. If the lab routinely analyzes two CCVs, then both CCVs must be evaluated. If either CCV fails, the lab must perform all required corrective actions and re-analyze all samples since the last acceptable calibration verification.

6.2.7.5. When instruments are operating unattended, autosamplers may be programmed to inject consecutive CCVs as a preventative measure against CCV failure with no corrective action. In this case, both CCVs must be evaluated to determine potential impact to the results. A summary of the decision tree and necessary documentation are listed below:

- If both CCVs meet the acceptance criteria, the analytical sequence is allowed to continue without corrective action. The 12 hour clock begins with the injection of the second CCV.
- If the first CCV does not meet the acceptance criteria and the second CCV is acceptable, the analytical sequence is continued and the results are reported.
- If the first CCV meets the acceptance criteria and the second CCV is out of control, the samples after the out of control CCV must be re-analyzed in a compliant analytical sequence.
- If both CCVs are out of control, all samples since the last acceptable CCV must be re-analyzed in a compliant analytical sequence.

6.2.7.6. Some analytical methods require that samples be bracketed by passing CCVs analyzed both before and after the samples. This is specific to each method but, as a general rule, all external calibration methods require bracketing CCVs. Most internal standard calibrations do not require bracketing CCVs.

6.2.7.7. Some analytical methods require verification based on a time interval; some methods require a frequency based on an injection interval. The type and frequency of the calibration verifications is dependent on both the analytical method and possibly on the quality program associated with the samples. The type and frequency of calibration verification will be documented in the method specific SOP employed by each laboratory.

6.2.8. General Inorganic Calibration Procedures

6.2.8.1. The instrument is initially calibrated with standards at multiple concentrations to establish the linearity of the instrument's response. A calibration blank is also included. Initial calibration curves are evaluated against appropriate statistical models as required by the analytical methods. Rounding to meet initial calibration criteria is not allowed. This also applies to linear and non-linear fit requirements. The number of calibration standards used depends on the specific method criteria or customer project requirements, although normally a minimum of three standards is used.

6.2.8.2. The ICP and ICP/MS can be standardized with a zero point and a single point calibration if:

- Prior to analysis, the zero point and the single point calibration are analyzed and a linear range has been established,
- Zero point and single point calibration standards are analyzed with each batch

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- A standard corresponding to the LOQ is analyzed with the batch and meets the established acceptance criteria
- The linearity is verified at the frequency established by the method or manufacturer.

6.2.8.3. All initial calibrations are verified with an initial calibration verification standard (ICV) obtained from a second manufacturer or second lot from the same manufacturer if the lot can be demonstrated as prepared independently from other lots prior to the analysis of samples. Sample results are quantitated from the initial calibration unless otherwise required by regulation, method, or program.

6.2.8.4. During the course of analysis, the calibration curve is periodically verified by the analysis of calibration verification standards (CCV). A calibration verification standard is analyzed within each analytical batch at method/program specific intervals to verify that the initial calibration is still valid. The CCV is also analyzed at the end of the analytical batch.

6.2.8.5. A calibration blank is also run with each calibration verification standard to verify the cleanliness of the system. All reported results must be bracketed by acceptable CCVs. Instrument and method specific calibration acceptance criteria are explained within the specific analytical standard operating procedures for each facility.

6.2.8.6. Interference check standards are also analyzed per method requirements and must meet acceptance criteria for metals analyses.

6.3. Support Equipment Calibration Procedures

6.3.1. All support equipment is calibrated or verified at least annually using NIST traceable references over the entire range of use. The results of calibrations or verifications must be within the specifications required or the equipment will be removed from service until repaired. The laboratory maintains records to demonstrate the correction factors applied to working thermometers.

6.3.2. On each day the equipment is used, balances, ovens, refrigerators (those used to keep samples and standards at required temperatures), freezers, and water baths are checked in the expected use range with NIST traceable references in order to ensure the equipment meets laboratory specifications and these checks are documented appropriately.

6.3.3. **Analytical Balances**

6.3.3.1. Each analytical balance is calibrated or verified at least annually by a qualified service technician. The calibration of each balance is verified each day of use with weights traceable to NIST bracketing the range of use. Calibration weights are ASTM Class 1 or other class weights that have been calibrated against a NIST standard weight and are re-certified every 5 years at a minimum against a NIST traceable reference. Some accrediting agencies may require more frequent checks. If balances are calibrated by an external agency, verification of their weights must be provided. All information pertaining to balance maintenance and calibration is recorded in the individual balance logbook and/or is maintained on file in the Quality department.

6.3.4. **Thermometers**

6.3.4.1. Certified, or reference, thermometers are maintained for checking calibration of working thermometers. Reference thermometers are provided with NIST traceability for initial calibration and are re-certified, at a minimum, every 3 years with equipment directly traceable to NIST.

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6.3.4.2. Working thermometers are compared with the reference thermometers annually according to corporate metrology procedures. Each thermometer is individually numbered and assigned a correction factor based on the NIST reference source. In addition, working thermometers are visually inspected by laboratory personnel prior to use and temperatures are documented.

6.3.4.3. Laboratory thermometer inventory and calibration data are maintained in the Quality department.

6.3.5. **pH/Electrometers**

6.3.5.1. The meter is calibrated before use each day, using fresh buffer solutions.

6.3.6. **Spectrophotometers**

6.3.6.1. During use, spectrophotometer performance is checked at established frequencies in analysis sequences against initial calibration verification (ICV) and continuing calibration verification (CCV) standards.

6.3.7. **Mechanical Volumetric Dispensing Devices**

6.3.7.1. Mechanical volumetric dispensing devices including bottle top dispensers (those that are critical in measuring a required amount of reagent), pipettes, and burettes, excluding Class A volumetric glassware, are checked for accuracy on a quarterly basis.

6.3.7.2. Additional information regarding calibration and maintenance of laboratory support equipment can be found in SOP S-KS-Q-036 **Support Equipment** or its equivalent revision or replacement.

6.4. Instrument/Equipment Maintenance

6.4.1. The objectives of the Pace Analytical maintenance program are twofold: to establish a system of instrument care that maintains instrumentation and equipment at required levels of calibration and sensitivity, and to minimize loss of productivity due to repairs.

6.4.2. The Operations Manager and/or department manager/supervisors are responsible for providing technical leadership to evaluate new equipment, solve equipment problems, and coordinate instrument repair and maintenance. Analysts have the primary responsibility to perform routine maintenance.

6.4.3. To minimize downtime and interruption of analytical work, preventative maintenance is routinely performed on each analytical instrument. Up-to-date instructions on the use and maintenance of equipment are available to staff in the department where the equipment is used.

6.4.4. Department manager/supervisors are responsible for maintaining an adequate inventory of spare parts required to minimize equipment downtime. This inventory includes parts and supplies that are subject to frequent failure, have limited lifetimes, or cannot be obtained in a timely manner should a failure occur.

6.4.5. All major equipment and instrumentation items are uniquely identified to allow for traceability. Equipment/instrumentation is, unless otherwise stated, identified as a system and not as individual pieces. The laboratory maintains equipment records that include the following:

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- The name of the equipment and its software
- The manufacturer's name, type, and serial number
- Approximate date received and date placed into service
- Current location in the laboratory
- Condition when received (new, used, etc.)
- Copy of any manufacturer's manuals or instructions
- Dates and results of calibrations and next scheduled calibration (if known)
- Details of past maintenance activities, both routine and non-routine
- Details of any damage, modification or major repairs

6.4.6. All instrument maintenance is documented in maintenance logbooks that are assigned to each particular instrument or system.

6.4.7. The maintenance log entry must include a summary of the results of that analysis and verification by the analyst that the instrument has been returned to an in-control status. In addition, each entry must include the initials of the analyst making the entry, the dates the maintenance actions were performed, and the date the entry was made in the maintenance logbook, if different from the date(s) of the maintenance.

6.4.8. Any equipment that has been subjected to overloading or mishandling, or that gives suspect results, or has been shown to be defective, is taken out of service and clearly identified. The equipment shall not be used to analyze customer samples until it has been repaired and shown to perform satisfactorily. In the event of instrumentation failure, to avoid hold time issues, the lab may subcontract the necessary samples to another Pace lab or to an outside subcontract lab if possible.

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7.0. CONTROL OF DATA

Analytical results processing, verification, and reporting are procedures employed that result in the delivery of defensible data. These processes include, but are not limited to, calculation of raw data into final concentration values, review of results for accuracy, evaluation of quality control criteria and assembly of technical reports for delivery to the data user.

All analytical data undergo a well-defined, well-documented multi-tier review process prior to being reported to the customer. This section describes procedures used by PASI for translating raw analytical data into accurate final sample reports as well as PASI data storage policies.

7.1. Analytical Results Processing

7.1.1. When analytical, field, or product testing data is generated, it is either recorded in a bound laboratory logbook (e.g., Run log or Instrument log) or copies of computer-generated printouts that are appropriately labeled and filed. These logbooks and other laboratory records are kept in accordance with each facility's Standard Operating Procedure for documentation storage and archival. If the laboratory chooses to minimize or eliminate its paper usage, these records can be kept on electronic media. In this case, the laboratory must ensure that there are sufficient redundant electronic copies so no data is lost due to unforeseen computer issues.

7.1.2. The primary analyst is responsible for initial data reduction and review. This includes confirming compliance with required methodology, verifying calculations, evaluating quality control data, noting non-conformances in logbooks or as footnotes or narratives, and uploading analytical results into the LIMS. The primary analyst must be clearly identified in all applicable logbooks, spreadsheets and LIMS fields.

7.1.3. The primary analyst then compiles the initial data package for verification. This compilation must include sufficient documentation for data review. It may include standard calibrations, chromatograms, manual integration documentation, electronic printouts, chain of custody forms, and logbook copies.

7.1.4. Some agencies or customers require different levels of data reporting. For these special levels, the primary analyst may need to compile additional project information, such as initial calibration data or extensive spectral data, before the data package proceeds to the verification step.

7.2. Data Verification

7.2.1. Data verification is the process of examining data and accepting or rejecting it based on pre-defined criteria. This review step is designed to ensure that reported data are free from calculation and transcription errors, that quality control parameters are evaluated, and that any non-conformances are properly documented.

7.2.2. Analysts performing the analysis and subsequent data reduction have primary responsibility for quality of the data produced. The primary analyst initiates the data verification process by reviewing and accepting the data, provided QC criteria have been met for the samples being reported. Data review checklists, either hardcopy or electronic, are used to document the data review process. The primary analyst is responsible for the initial input of the data into the LIMS. The primary analyst and reviewer must be clearly identified on all applicable data review checklists.

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7.2.3. The completed data package is then sent to a designated qualified reviewer (this cannot be the primary analyst). The following criteria have been established to qualify someone as a data reviewer. To perform secondary data review, the reviewer must:

7.2.3.1. Have a current Demonstration of Capability (DOC) study on file and have an SOP acknowledgement form on file for the method/procedure being reviewed; or, See Note

7.2.3.2. Have a DOC on file for a similar method/technology (i.e., GC/MS) and have an SOP acknowledgment form on file for the method/procedure being reviewed; or, See Note

7.2.3.3. Supervise or manage a Department and have an SOP acknowledgment form on file for the method/procedure being reviewed; or,

7.2.3.4. Have significant background in the department/methods being reviewed through education or experience and have an SOP acknowledgment form on file for the method/procedure being reviewed.

7.2.4. **Note:** Secondary reviewer status must be approved personally by the SQM/QM or SGM/GM/AGM/OM in the event that this person has no prior experience on the specific method or general technology.

7.2.5. This reviewer provides an independent technical assessment of the data package and technical review for accuracy according to methods employed and laboratory protocols. This assessment involves a quality control review for use of the proper methodology and detection limits, compliance to quality control protocol and criteria, presence and completeness of required deliverables, and accuracy of calculations and data quantitation. The reviewer validates the data entered into the LIMS and documents approval of manual integrations.

7.2.6. Once the data have been technically reviewed and approved, authorization for release of the data from the analytical section is indicated by initialing and dating the data review checklist or otherwise initialing and dating the data (or designating the review of data electronically). The Operations or Project Manager examines the report for method appropriateness, detection limits and QC acceptability. Any deviations from the referenced methods are checked for documentation and validity, and QC corrective actions are reviewed for successful resolution. Alternately, final reports can be set to auto email to the client after the analytical results are final and have been run through the Data Checker program for errors. These are set up on a case-by-case basis.

7.2.7. Additional information regarding data review procedures can be found in SOPs S-ALL-Q-005 **Data Reduction, Review and Reporting** and SOP S-KS-Q-041 **Manual Integration** or their equivalent revisions or replacements.

7.2.8. The Data Checker program will process validated data for a given project against a set of pre-determined requirements and known chemistry relationships. The program creates a report that includes a series of warnings and errors for any requirement or condition determined to be suspect or incorrect. These warnings and error counts are displayed on the "Project Inquiry by Client" screen and on the final Data Checker reports. For projects that have any number of warnings or errors, the Data Checker report will provide a message that identifies the source and condition of the error or warning.

7.2.9. Some reports and/or data packages may be reviewed by the QM or SQM or designee based on program requirements (e.g., DoD) or client requirements. In this case a thorough review for completeness and accuracy may include a compilation of raw data and QC summaries in addition to the

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final report to produce a full deliverable package. In the case of DoD, 100% of all packages must have a final administrative review (to confirm that primary and secondary reviews were completed and documented and that data packages are complete) and 10% of all data packages must be reviewed by the Quality Manager for technical completeness/accuracy. This 10% review can be done after the data packages have been submitted to the clients. See SOP S-KS-Q-039 (or equivalent replacement), **Audits and Inspections**, for full Quality department final report and raw data review requirements.

7.3. Data Reporting

7.3.1. Data for each analytical fraction pertaining to a particular PASI project number are delivered to the Project Manager for assembly into the final report. All points mentioned during technical and QC reviews are included in data qualifiers on the final report or in a separate case narrative if there is potential for data to be impacted.

7.3.2. Final reports are prepared according to the level of reporting required by the customer and can be transmitted to the customer via hardcopy or electronic deliverable. A standard PASI final report consists of the following components:

7.3.2.1. A title which designates the report as "Final Report", "Laboratory Results", "Certificate of Results", etc.;

7.3.2.2. Name and address of laboratory (or subcontracted laboratories, if used);

7.3.2.3. Phone number and name of laboratory contact to where questions can be referred;

7.3.2.4. A unique identification number for the report. The pages of the report shall be numbered and a total number of pages shall be indicated;

7.3.2.5. Name and address of customer and name of project;

7.3.2.6. Unique identification of samples analyzed as well as customer sample IDs;

7.3.2.7. Identification of any sample that did not meet acceptable sampling requirements of the relevant governing agency, such as improper sample containers, holding times missed, sample temperature, etc.;

7.3.2.8. Date and time of collection of samples, date of sample receipt by the laboratory, dates of sample preparation and analysis, and times of sample preparation and analysis when the holding time for either is 72 hours or less;

7.3.2.9. Identification of the test methods used;

7.3.2.10. Identification of sampling procedures if sampling was conducted by the laboratory;

7.3.2.11. Deviations from, additions to, or exclusions from the test methods. These can include failed quality control parameters, deviations caused by the matrix of the sample, etc., and can be shown as a case narrative or as defined footnotes to the analytical data;

7.3.2.12. Identification of whether calculations were performed on a dry or wet-weight basis;

7.3.2.13. Reporting limits used;

7.3.2.14. Final results or measurements, supported by appropriate chromatograms, charts, tables, spectra, etc.;

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7.3.2.15. A signature and title, electronic or otherwise, of person accepting responsibility for the content of the report;

7.3.2.16. Date report was issued;

7.3.2.17. A statement clarifying that the results of the report relate only to the samples tested or to the samples as they were received by the laboratory;

7.3.2.18. If necessary, a statement indicating that the report must not be reproduced except in full, without the written approval of the laboratory;

7.3.2.19. Identification of all test results provided by a subcontracted laboratory or other outside source;

7.3.2.20. Identification of results obtained outside of quantitation levels.

In addition to the requirements listed above, final reports shall also contain the following items when necessary for the interpretation of results:

7.3.2.21. Deviations from, additions to, or exclusions from the test method, and information on specific test conditions, such as environmental conditions;

7.3.2.22. Where relevant, a statement of compliance/non-compliance with requirements and/or specifications (e.g., the TNI standard);

7.3.2.23. Where applicable, a statement on the estimated uncertainty of measurement; information on uncertainty is needed in test reports when it is relevant to the validity or application of the test results, when a customer's instruction so requires, or when the uncertainty affects compliance to a specification limit;

7.3.2.24. Where appropriate and needed, opinions and interpretations, which may include opinions on the compliance/non-compliance of the results with requirements, fulfillment of contractual requirements, recommendations on how to use the results, and guidance to be used for improvement;

7.3.3. For DoD labs, in reference to item 7.3.2.8 listed above, both date and time of preparation and analysis are considered essential information, regardless of the length of the holding time, and shall be included as part of the laboratory report.

7.3.4. Any changes made to a final report shall be designated as "Revised" or equivalent wording. The laboratory must keep sufficient archived records of all laboratory reports and revisions. For higher levels of data deliverables, a copy of all supporting raw data is sent to the customer along with a final report of results. When possible, the PASI facility will provide electronic data deliverables (EDD) as required by contracts or upon customer request.

7.3.5. Customer data that requires transmission by telephone, telex, facsimile or other electronic means undergoes appropriate steps to preserve confidentiality.

7.3.6. The following positions are the only approved signatories for PASI final reports:

- Senior General Manager
- General Manager
- Assistant General Manager
- Senior Quality Manager

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- Quality Manager
- Client Services Manager
- Project Manager
- Project Coordinator

7.4. Data Security

7.4.1. All data including electronic files, logbooks, extraction/digestion/distillation worksheets, calculations, project files and reports, and any other information used to produce the technical report are maintained secured and retrievable by the PASI facility.

7.5. Data Archiving

7.5.1. All records compiled by PASI are maintained legible and retrievable and stored secured in a suitable environment to prevent loss, damage, or deterioration by fire, flood, vermin, theft, and/or environmental deterioration. Records are retained for a minimum of five years unless superseded by federal, state, contractual, and/or accreditation requirements. These records may include, but are not limited to, customer data reports, calibration and maintenance of equipment, raw data from instrumentation, quality control documents, observations, calculations, and logbooks. These records are retained in order to provide for possible historical reconstruction including sampling, receipt, preparation, analysis, and personnel involved. TNI-related records will be made readily available to accrediting authorities. Access to archived data is documented and controlled by the SQM/QM or a designated Data Archivist.

7.5.2. Records that are computer generated have either a hard copy or electronic write protected backup copy. Hardware and software necessary for the retrieval of electronic data is maintained with the applicable records. Archived electronic records are stored protected against electronic and/or magnetic sources.

7.5.3. In the event of a change in ownership, accountability or liability, reports of analyses performed pertaining to accreditation will be maintained by the acquiring entity for a minimum of five years. In the event of bankruptcy, laboratory reports and/or records will be transferred to the customer and/or the appropriate regulatory entity upon request.

7.6. Data Disposal

7.6.1. Data that has been archived for the facility's required storage time may be disposed of in a secure manner by shredding, returning to customer, or utilizing some other means that does not jeopardize data confidentiality. Records of data disposal will be archived for a minimum of five years unless superseded by federal, contractual, and/or accreditation requirements. Data disposal includes any preliminary or final reports that are disposed.

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8.0. QUALITY SYSTEM AUDITS AND REVIEWS

8.1. Internal Audits

8.1.1. **Responsibilities**

8.1.1.1. The SQM/QM is responsible for designing and/or conducting internal audits in accordance with a predetermined schedule and procedure. Since internal audits represent an independent assessment of laboratory functions, the auditor must be functionally independent from laboratory operations to ensure objectivity. The auditor must be trained, qualified, and familiar enough with the objectives, principles, and procedures of laboratory operations to be able to perform a thorough and effective evaluation. The SQM/QM evaluates audit observations and verifies the completion of corrective actions. In addition, a periodic corporate audit will be conducted. The corporate audits will focus on the effectiveness of the Quality System as outlined in this manual but may also include other quality programs applicable to an individual laboratory.

8.1.2. Scope and Frequency of Internal Audits

8.1.2.1. The complete internal audit process consists of the following four sections:

- Raw Data Review audits- conducted according to a schedule per local SQM/QM. A certain number of these data review audits are conducted per quarter to accomplish this yearly schedule;
- Quality System audits- considered the traditional internal audit function and includes analyst interviews to help determine whether practice matches method requirements and SOP language;
- Final Report reviews;
- Corrective Action Effectiveness Follow-up.

8.1.2.2. Internal systems audits are conducted yearly at a minimum. The scope of these audits includes evaluation of specific analytical departments or a specific quality related system as applied throughout the laboratory.

8.1.2.3. Where the identification of non-conformities or departures cast doubt on the laboratory's compliance with its own policies and procedures, the lab must ensure that the appropriate areas of activity are audited as soon as possible. Examples of system-wide elements that can be audited include:

- Quality Systems documents, such as Standard Operating Procedures, training documents, Quality Assurance Manual, and all applicable addenda
- Data records and non-technical documents
- Personnel and training files.
- General laboratory safety protocols.
- Chemical handling practices, such as labeling of reagents, solutions, and standards as well as all associated documentation.
- Documentation concerning equipment and instrumentation, calibration/maintenance records, operating manuals.
- Sample receipt and management practices.
- Analytical documentation, including any discrepancies and corrective actions.

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- General procedures for data security, review, documentation, reporting, and archiving.
- Data integrity issues such as proper manual integrations.

8.1.2.4. When the operations of a specific department are evaluated, a number of additional functions are reviewed including:

- Detection limit studies
- Internal chain of custody documentation
- Documentation of standard preparations
- Quality Control limits and Control charts

8.1.2.5. Certain projects may require an internal audit to ensure laboratory conformance to site work plans, sampling and analysis plans, QAPPs, etc.

8.1.2.6. A representative number of data audits are completed annually. Findings from these data audits are handled in the same manner as those from other internal and external audits.

8.1.2.7. The laboratory, as part of their overall internal audit program, ensures that a review is conducted with respect to any evidence of inappropriate actions or vulnerabilities related to data integrity. Discovery and reporting of potential data integrity issues are handled in a confidential manner. All investigations that result in findings of inappropriate activity are fully documented, including the source of the problem, the samples and customers affected the impact on the data, the corrective actions taken by the laboratory, and which final reports had to be re-issued. Customers must be notified within 30 days after the data investigation is completed and the impact to final results is assessed.

8.1.3. Internal Audit Reports and Corrective Action Plans

8.1.3.1. Additional information can be found in SOP S-KS-Q-039 **Internal and External Audits** or its equivalent revision or replacement.

8.1.3.2. A full description of the audit, including the identification of the operation audited, the date(s) on which the audit was conducted, the specific systems examined, and the observations noted are summarized in an internal audit report. Although other personnel may assist with the performance of the audit, the SQM/QM writes and issues the internal audit report identifying which audit observations are deficiencies that require corrective action.

8.1.3.3. When audit findings cast doubt on the effectiveness of the operations or on the correctness of validity of the laboratory's environmental test results, the laboratory will take timely corrective action and notify the customer in writing within three business days, if investigations show that the laboratory results may have been affected.

8.1.3.4. Once completed, the internal audit report is issued jointly to the SGM/GM/AGM/OM and the manager(s)/supervisor(s) of the audited operation at a minimum. The responsible manager(s)/supervisor(s) responds within 14 days with a proposed plan to correct all of the deficiencies cited in the audit report. The SQM/QM may grant additional time for responses to large or complex deficiencies (not to exceed 30 days). Each response must include timetables for completion of all proposed corrective actions.

8.1.3.5. The SQM/QM reviews the audit responses. If the response is accepted, the SQM/QM uses the action plan and timetable as a guideline for verifying completion of the corrective

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action(s). If the SQM/QM determines that the audit response does not adequately address the correction of cited deficiencies, the response will be returned for modification.

8.1.3.6. To complete the audit process, the SQM/QM performs a re-examination of the areas where deficiencies were found to verify that all proposed corrective actions have been implemented. An audit deficiency is considered closed once implementation of the necessary corrective action has been audited and verified. This is usually within 60-90 days after implementation. If corrective action cannot be verified, the associated deficiency remains open until that action is completed.

8.2. External Audits

8.2.1. PASI laboratories are audited regularly by regulatory agencies to maintain laboratory certifications and by customers to maintain appropriate specific protocols.

8.2.2. Audit teams external to the company review the laboratory to assess the effectiveness of systems and degree of technical expertise. The SQM/QM and other QA staff host the audit team and assist in facilitation of the audit process. Generally, the auditors will prepare a formalized audit report listing deficiencies observed and follow-up requirements for the laboratory. In some cases, items of concern are discussed during a debriefing convened at the end of the on-site review process.

8.2.3. The laboratory staff and supervisors develop corrective action plans to address any deficiencies with the guidance of the SQM/QM. The SGM/GM/AGM/OM provides the necessary resources for staff to develop and implement the corrective action plans. The SQM/QM collates this information and provides a written response to the audit team. The response contains the corrective action plan and expected completion dates for each element of the plan. The SQM/QM follows-up with the laboratory staff to ensure corrective actions are implemented and that the corrective action was effective.

8.3. Quarterly Quality Reports

8.3.1. The SQM/QM is responsible for preparing a quarterly report to management summarizing the effectiveness of the laboratory Quality Systems. This status report will include:

- Overview of quality activities for the quarter
- Certification status
- Proficiency Testing study results
- SOP revision activities
- Internal audit (method/system) findings
- Manual integration audit findings (Mintminer)
- Raw Data and Final Report review findings
- MDL activities
- Other significant Quality System items

8.3.2. The Corporate Director of Quality utilizes the information from each laboratory to make decisions impacting the quality program compliance of the company as a whole. Each SGM/GM/AGM/OM utilizes the quarterly report information to make decisions impacting Quality Systems and operational systems at a local level.

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8.3.3. Additional information can be found in SOP S-ALL-Q-014 **Quality System Review** or its equivalent revision or replacement.

8.4. Annual Managerial Review

8.4.1. A managerial review of Management and Quality Systems is performed on an annual basis at a minimum. This allows for assessing program effectiveness and introducing changes and/or improvements.

8.4.2. The managerial review must include the following topics of discussion:

- Suitability of quality management policies and procedures
- Manager/Supervisor reports
- Internal audit results
- Corrective and preventive actions
- External assessment results
- Proficiency testing studies
- Sample capacity and scope of work changes
- Customer feedback, including complaints
- Recommendations for improvement,
- Other relevant factors, such as quality control activities, resources, and staffing.

8.4.3. This managerial review must be documented for future reference by the SQM/QM and copies of the report are distributed to laboratory staff. Results must feed into the laboratory planning system and must include goals, objectives, and action plans for the coming year. The laboratory shall ensure that any actions identified during the review are carried out within an appropriate and agreed upon timescale.

8.5. Customer Service Reviews

8.5.1. As part of the annual managerial review listed previously, the sales staff is responsible for reporting on customer feedback, including complaints. The acquisition of this information is completed by performing surveys.

8.5.2. The sales staff continually receives customer feedback, both positive and negative, and reports this feedback to the laboratory management in order for them to evaluate and improve their management system, testing activities and customer service.

8.5.3. In addition, the labs must be willing to cooperate with customers or their representatives to clarify customer requests and to monitor the laboratory's performance in relation to the work being performed for the customers. This cooperation may include providing the customer reasonable access to relevant areas of the lab for the witnessing of tests being performed; or the preparation of samples or data deliverables to be used for verification purposes.

8.5.4. Customer service is an important aspect to Pace's overall objective of providing a quality product. Good communication should be provided to the customer's throughout projects. The lab should inform the customer of any delay or major deviations in the performance of analytical tests.

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9.0. CORRECTIVE ACTION

Additional information can be found in SOP S-KS-Q-038 **Corrective and Preventive Actions** or its equivalent revision or replacement.

During the process of sample handling, preparation, and analysis, or during review of quality control records, or during reviews of non-technical portions of the lab, certain occurrences may warrant the necessity of corrective actions. These occurrences may take the form of analyst errors, deficiencies in quality control, method deviations, or other unusual circumstances. The Quality System of PASI provides systematic procedures for the documentation, monitoring, completion of corrective actions, and follow-up verification of the effectiveness of these corrective actions. This can be done using PASI's LabTrack system that lists among at a minimum, the deficiency by issue number, the deficiency source, responsible party, root cause, resolution, due date, and date resolved.

9.1. Corrective Action Documentation

9.1.1. The following items are examples of sources of laboratory deviations or non-conformances that warrant some form of documented corrective action:

- Internal Laboratory Non-Conformance Trends
- PE/PT Sample Results
- Internal and External Audits
- Data or Records Review (including non-technical records)
- Client Complaints
- Client Inquiries
- Holding Time violations

9.1.2. Documentation of corrective actions may be in the form of a comment or footnote on the final report that explains the deficiency (e.g., matrix spike recoveries outside of acceptance criteria) or it may be a more formal documentation (either paper system or computerized spreadsheet). This depends on the extent of the deficiency, the impact on the data, and the method or customer requirements for documentation.

9.1.3. The person who discovers the deficiency or non-conformance initiates the corrective action documentation on LabTrack. The documentation must include the affected projects and sample numbers, the name of the applicable Project Manager, the customer name, and the sample matrix involved. The person initiating the corrective action documentation must also list the known causes of the deficiency or non-conformance as well as any corrective/preventative actions that they have taken. Preventive actions must be taken in order to prevent or minimize the occurrence of the situation.

9.1.4. In the event that the laboratory is unable to determine the cause, laboratory personnel and management staff will start a root cause analysis by going through an investigative process. During this process, the following general steps must be taken into account: defining the non-conformance, assigning responsibilities, determining if the condition is significant, and investigating the root cause of the nonconformance. General non-conformance investigative techniques follow the path of the sample through the process looking at each individual step in detail. The root cause must be documented within LabTrack.

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9.1.5. After all the documentation is completed, the routing of the LabTrack will continue from the person initiating the corrective action, to their immediate supervisor or the applicable Project Manager and finally to the SQM/QM, if applicable, who may be responsible for final review and signoff of corrective/preventive actions.

9.1.6. In the event that analytical testing or results do not conform to documented laboratory policies or procedures, customer requirements, or standard specifications, the laboratory shall investigate the significance of the non-conformance and document appropriate corrective actions. The proper level of laboratory management will review any departure from these requirements for technical suitability. These departures are permitted only with the approval of the SGM/GM/AGM/OM or the SQM/QM. Where necessary, Project Management will notify the customer of the situation and will advise of any ramifications to data quality (with the possibility of work being recalled). The procedures for handling non-conforming work are detailed in SOP S-KS-Q-038 **Corrective and Preventive Actions** or its equivalent revision or replacement.

9.1.7. Corrective Action Completion

9.1.8. Internal Laboratory Non-Conformance Trends

9.1.8.1. There are several types of non-conformance trends that may occur in the laboratory that would require the initiation of a corrective action report. Laboratories may choose to initiate a corrective action for all instances of one or more of these categories if they so choose, however the intent is that each of these would be handled according to its severity; one time instances could be handled with a footnote or qualifier whereas a systemic problem with any of these categories may require an official corrective action process. These categories, as defined in the Corrective Action SOP are as follows:

- Login error
- Preparation Error
- Contamination
- Calibration Failure
- Internal Standard Failure
- LCS Failure
- Laboratory accident
- Spike Failure
- Instrument Failure
- Final Reporting error

9.1.9. **PE/PT Sample Results**

9.1.9.1. Any PT result assessed as "not acceptable" requires an investigation and applicable corrective actions. The operational staff is made aware of the PT failures and they are responsible for reviewing the applicable raw data and calibrations and list possible causes for error. The SQM/QM reviews their findings and initiates another external PT sample or an internal PT sample to try and correct the previous failure. Replacement PT results must be monitored by the SQM/QM and reported to the applicable regulatory authorities.

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9.1.10. **Internal and External Audits**

9.1.10.1. The SQM/QM is responsible for documenting all audit findings and their corrective actions. This documentation must include the initial finding, the persons responsible for the corrective action, the due date for responding to the auditing body, the root cause of the finding, and the corrective actions needed for resolution. The SQM/QM is also responsible for providing any back-up documentation used to demonstrate that a corrective action has been completed.

9.1.11. **Data Review**

9.1.11.1. In the course of performing primary and secondary review of data or in the case of raw data reviews (e.g., by the SQM/QM), errors may be found which require corrective actions. Any finding that affects the quality of the data requires some form of corrective action, which may include revising and re-issuing of final reports.

9.1.12. **Client Complaints**

9.1.12.1. Project Managers are responsible for issuing corrective action forms, when warranted, for customer complaints. As with other corrective actions, the possible causes of the problem are listed and the form is passed to the appropriate analyst or supervisor for investigation. After potential corrective actions have been determined, the Project Manager reviews the corrective action form to ensure all customer needs or concerns are being adequately addressed.

9.1.13. **Client Inquiries**

9.1.13.1. When an error on the customer report is discovered, the Project Manager is responsible for initiating a formal corrective action form that describes the failure (e.g., incorrect analysis reported, reporting units are incorrect, or reporting limits do not meet objectives). The Project Manager is also responsible for revising the final report if necessary and submitting it to the customer.

9.1.14. **Holding Time Violations**

9.1.14.1. In the event that a holding time has been missed, the analyst or supervisor must complete a formal corrective action form. The Project Manager and the SQM/QM must be made aware of all holding time violations.

9.1.14.2. The Project Manager must contact the customer in order that appropriate decisions are made regarding the hold time excursion and the ultimate resolution is then documented and included in the customer project file.

9.2. Preventive Action Documentation

9.2.1. Pace laboratories can take advantage of several available information sources in order to identify needed improvements in all of their systems including technical, managerial, and quality. These sources may include:

- Management Continuous Improvement Plan (CIP) metrics which are used by all production departments within Pace. When groups compare performance across the company, ways to improve systems may be discovered. These improvements can be made within a department or laboratory-wide.

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- Annual managerial reviews- part of this TNI-required and NVLAP-required review is to look at all processes and procedures used by the laboratory over the past year and to determine ways to improve these processes in the future.
- Quality systems reviews- any frequent checks of quality systems (monthly logbook reviews, etc.) can uncover issues that can be corrected or adjusted before they become a larger issue.

9.2.2. When improvement opportunities are identified or if preventive action is required, the laboratory can develop, implement, and monitor preventive action plans.

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10.0. GLOSSARY

The source of some of the definitions is indicated previous to the actual definition (e.g., TNI, DoD).

Terms and Definitions	
3P Program	The Pace Analytical continuous improvement program that focuses on Process, Productivity, and Performance. Best Practices are identified that can be used by all PASI labs.
Acceptance Criteria	TNI- Specified limits placed on characteristics of an item, process, or service defined in requirement documents.
Accreditation	TNI- The process by which an agency or organization evaluates and recognizes a laboratory as meeting certain predetermined qualifications or standards, thereby accrediting the laboratory.
Accreditation Body	DoD- Entities recognized in accordance with the DoD-ELAP that are required to operate in accordance with ISO/IEC 17011, *Conformity assessment: General requirements for accreditation bodies accrediting conformity assessment bodies*. The AB must be a signatory, in good standing, to the International Laboratory Accreditation Cooperation (ILAC) mutual recognition arrangement (MRA) that verifies, by evaluation and peer assessment, that its signatory members are in full compliance with ISO/IEC 17011 and that its accredited laboratories comply with ISO/IEC 17025.
Accuracy	TNI- The degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations; a data quality indicator.
Aliquot	DoD- A discrete, measured, representative portion of a sample taken for analysis.
Analysis	DoD- A combination of sample preparation and instrument determination.
Analysis Code (Acode)	All the set parameters of a test, such as Analytes, Method, Detection Limits and Price.
Analysis Sequence	A compilation of all samples, standards and quality control samples run during a specific amount of time on a particular instrument in the order they are analyzed.
Analyst	TNI- The designated individual who performs the "hands-on" analytical methods and associated techniques and who is the one responsible for applying required laboratory practices and other pertinent quality controls to meet the required level of quality.
Analyte	DoD- The specific chemicals or components for which a sample is analyzed; it may be a group of chemicals that belong to the same chemical family and are analyzed together.
Analytical Uncertainty	TNI- A subset of Measurement Uncertainty that includes all laboratory activities performed as part of the analysis.
Assessment	TNI - The evaluation process used to measure or establish the performance, effectiveness, and conformance of an organization and/or its system to defined criteria (to the standards and requirements of laboratory accreditation). DoD- An all-inclusive term used to denote any of the following: audit, performance evaluation, peer review, inspection, or surveillance conducted on-site.

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Atomic Absorption Spectrometer	Instrument used to measure concentration in metals samples.
Atomization	A process in which a sample is converted to free atoms.
Audit	TNI- A systematic and independent examination of facilities, equipment, personnel, training, procedures, record-keeping, data validation, data management, and reporting aspects of a system to determine whether QA/QC and technical activities are being conducted as planned and whether these activities will effectively achieve quality objectives.
Batch	TNI- Environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A **preparation batch** is composed of one to 20 environmental samples of the same quality systems matrix, meeting the above-mentioned criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours. An analytical batch is composed of prepared environmental samples (extracts, digestates or concentrates) which are analyzed together as a group. An analytical batch can include prepared samples originating from various quality system matrices and can exceed 20 samples.
Bias	TNI- The systematic or persistent distortion of a measurement process, which causes errors in one direction (i.e., the expected sample measurement is different from the sample's true value).
Blank	TNI and DoD- A sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results. DoD- Blank samples are negative control samples, which typically include field blank samples (e.g., trip blank, equipment (rinsate) blank, and temperature blank) and laboratory blank samples (e.g., method blank, reagent blank, instrument blank, calibration blank, and storage blank).
Blind Sample	A sub-sample for analysis with a composition known to the submitter. The analyst/laboratory may know the identity of the sample but not its composition. It is used to test the analyst's or laboratory's proficiency in the execution of the measurement process.
BNA (Base Neutral Acid compounds)	A list of semi-volatile compounds typically analyzed by mass spectrometry methods. Named for the way they can be extracted out of environmental samples in an acidic, basic or neutral environment.
BOD (Biochemical Oxygen Demand)	Chemical procedure for determining how fast biological organisms use up oxygen in a body of water.

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Calibration	TNI- A set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards. 1) In calibration of support equipment, the values realized by standards are established through the use of reference standards that are traceable to the International System of Units (SI); 2) In calibration according to test methods, the values realized by standards are typically established through the use of Reference Materials that are either purchased by the laboratory with a certificate of analysis or purity, or prepared by the laboratory using support equipment that has been calibrated or verified to meet specifications.
Calibration Curve	TNI- The mathematical relationship between the known values, such as concentrations, of a series of calibration standards and their instrument response.
Calibration Method	A defined technical procedure for performing a calibration.
Calibration Range	DoD- The range of values (concentrations) between the lowest and highest calibration standards of a multi-level calibration curve. For metals analysis with a single-point calibration, the low-level calibration check standard and the high standard establish the linear calibration range, which lies within the linear dynamic range.
Calibration Standard	TNI- A substance or reference material used for calibration.
Certified Reference Material (CRM)	TNI- Reference material accompanied by a certificate, having a value, measurement uncertainty, and stated metrological traceability chain to a national metrology institute.
Chain of Custody	An unbroken trail of accountability that verifies the physical security of samples, data, and records.
Chain of custody Form (COC)	TNI- Record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and type of containers; the mode of collection, the collector, time of collection; preservation; and requested analyses.
Chemical Oxygen Demand (COD)	A test commonly used to indirectly measure the amount of organic compounds in water.
Client (referred to by ISO as Customer)	Any individual or organization for whom items or services are furnished or work performed in response to defined requirements and expectations.
Code of Federal Regulations (CFR)	A codification of the general and permanent rules published in the Federal Register by agencies of the federal government.
Comparability	An assessment of the confidence with which one data set can be compared to another. Comparable data are produced through the use of standardized procedures and techniques.
Completeness	The percent of valid data obtained from a measurement system compared to the amount of valid data expected under normal conditions. The equation for completeness is: % Completeness = (Valid Data Points/Expected Data Points)*100

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Confirmation	TNI- Verification of the identity of a component through the use of an approach with a different scientific principle from the original method. These may include, but are not limited to: second-column confirmation; alternate wavelength; derivatization; mass spectral interpretation; alternative detectors; or additional cleanup procedures. DoD- Includes verification of the identity and quantity of the analyte being measured by another means (e.g., by another determinative method, technology, or column). Additional cleanup procedures alone are not considered confirmation techniques.
Conformance	An affirmative indication or judgment that a product or service has met the requirements of the relevant specifications, contract, or regulation; also the state of meeting the requirements.
Congener	A member of a class of related chemical compounds (e.g., PCBs, PCDDs).
Consensus Standard	DoD- A standard established by a group representing a cross-section of a particular industry or trade, or a part thereof.
Continuing Calibration Blank (CCB)	A blank sample used to monitor the cleanliness of an analytical system at a frequency determined by the analytical method.
Continuing Calibration Check Compounds (CCC)	Compounds listed in mass spectrometry methods that are used to evaluate an instrument calibration from the standpoint of the integrity of the system. High variability would suggest leaks or active sites on the instrument column.
Continuing Calibration Verification	DoD- The verification of the initial calibration. Required prior to sample analysis and at periodic intervals. Continuing calibration verification applies to both external and internal standard calibration techniques, as well as to linear and non-linear calibration models.
Continuing Calibration Verification (CCV) Standard	Also referred to as a CVS in some methods, it is a standard used to verify the initial calibration of compounds in an analytical method. CCVs are analyzed at a frequency determined by the analytical method.
Continuous Emission Monitor (CEM)	A flue gas analyzer designed for fixed use in checking for environmental pollutants.
Contract Laboratory Program (CLP)	A national network of EPA personnel, commercial labs, and support contractors whose fundamental mission is to provide data of known and documented quality.
Contract Required Detection Limit (CRDL)	Detection limit that is required for EPA Contract Laboratory Program (CLP) contracts.
Contract Required Quantitation Limit (CRQL)	Quantitation limit (reporting limit) that is required for EPA Contract Laboratory Program (CLP) contracts.
Control Chart	A graphic representation of a series of test results, together with limits within which results are expected when the system is in a state of statistical control (see definition for Control Limit)
Control Limit	A range within which specified measurement results must fall to verify that the analytical system is in control. Control limit exceedances may require corrective action or require investigation and flagging of non-conforming data.
Correction	DoD- Action taken to eliminate a detected non-conformity.

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Corrective Action	DoD- The action taken to eliminate the causes of an existing non-conformity, defect, or other undesirable situation in order to prevent recurrence. A root cause analysis may not be necessary in all cases.
Corrective and Preventative Action (CAPA)	The primary management tools for bringing improvements to the quality system, to the management of the quality system's collective processes, and to the products or services delivered which are an output of established systems and processes.
Customer	DoD- Any individual or organization for which products or services are furnished or work performed in response to defined requirements and expectations.
Data Quality Objective (DQO)	Systematic strategic planning tool based on the scientific method that identifies and defines the type, quality, and quantity of data needed to satisfy a specified use or end user.
Data Reduction	TNI- The process of transforming the number of data items by arithmetic or statistical calculation, standard curves, and concentration factors, and collating them into a more usable form.
Definitive Data	DoD- Analytical data of known quantity and quality. The levels of data quality on precision and bias meet the requirements for the decision to be made. Data that is suitable for final decision-making.
Demonstration of Capability	TNI- A procedure to establish the ability of the analyst to generate analytical results of acceptable accuracy and precision. DoD- A procedure to establish the ability of the analyst to generate analytical results by a specific method that meet measurement quality objectives (e.g., for precision and bias).
Detection Limit (DL)	DoD- The smallest analyte concentration that can be demonstrated to be different than zero or a blank concentration at the 99% confidence. At the DL, the false positive rate (Type 1 error) is 1%. A DL may be used as the lowest concentration for reliably reporting a detection of a specific analyte in a specific matrix with a specific method with 99% confidence.
Diesel Range Organics (DRO)	A range of compounds that denote all the characteristic compounds that make up diesel fuel (range can be state or program specific).
Digestion	DoD- A process in which a sample is treated (usually in conjunction with heat and acid) to convert the sample to a more easily measured form.
Document Control	The act of ensuring that documents (and revisions thereto) are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly and controlled to ensure use of the correct version at the location where the prescribed activity is performed.
Documents	DoD- Written components of the laboratory management system (e.g., policies, procedures, and instructions).
Dry Weight	The weight after drying in an oven at a specified temperature.
Duplicate (also known as Replicate or Laboratory Duplicate)	The analyses or measurements of the variable of interest performed identically on two subsamples of the same sample. The results of duplicate analyses are used to evaluate analytical or measurement precision but not the precision of sampling, preservation or storage internal to the laboratory.
Electron Capture Detector (ECD)	Device used in GC methods to detect compounds that absorb electrons (e.g., PCB compounds).
Electronic Data Deliverable (EDD)	A summary of environmental data (usually in spreadsheet form) which clients request for ease of data review and comparison to historical results.

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Eluent	A solvent used to carry the components of a mixture through a stationary phase.
Elute	To extract, specifically, to remove (absorbed material) from an absorbent by means of a solvent.
Elution	A process in which solutes are washed through a stationary phase by movement of a mobile phase.
Environmental Data	DoD- Any measurements or information that describe environmental processes, locations, or conditions; ecological or health effects and consequences; or the performance of environmental technology.
Environmental Monitoring	The process of measuring or collecting environmental data.
Environmental Sample	A representative sample of any material (aqueous, non-aqueous, or multimedia) collected from any source for which determination of composition or contamination is requested or required. Environmental samples can generally be classified as follows: • Non Potable Water (Includes surface water, ground water, effluents, water treatment chemicals, and TCLP leachates or other extracts) • Drinking Water - Delivered (treated or untreated) water designated as potable water • Water/Wastewater - Raw source waters for public drinking water supplies, ground waters, municipal influents/effluents, and industrial influents/effluents • Sludge - Municipal sludges and industrial sludges. • Soil - Predominately inorganic matter ranging in classification from sands to clays. • Waste - Aqueous and non-aqueous liquid wastes, chemical solids, and industrial liquid and solid wastes
Equipment Blank	A sample of analyte-free media used to rinse common sampling equipment to check effectiveness of decontamination procedures.
Facility	A distinct location within the company that has unique certifications, personnel and waste disposal identifications.
False Negative	DoD- A result that fails to identify (detect) an analyte or reporting an analyte to be present at or below a level of interest when the analyte is actually above the level of interest.
False Positive	DoD- A result that erroneously identifies (detects) an analyte or reporting an analyte to be present above a level of interest when the analyte is actually present at or below the level of interest.
Field Blank	A blank sample prepared in the field by filling a clean container with reagent water and appropriate preservative, if any, for the specific sampling activity being undertaken.
Field Measurement	Determination of physical, biological, or radiological properties, or chemical constituents that are measured on-site, close in time and space to the matrices being sampled/measured, following accepted test methods. This testing is performed in the field outside of a fixed-laboratory or outside of an enclosed structure that meets the requirements of a mobile laboratory.
Field of Accreditation	TNI- Those matrix, technology/method, and analyte combinations for which the accreditation body offers accreditation.

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Finding	TNI- An assessment conclusion referenced to a laboratory accreditation standard and supported by objective evidence that identifies a deviation from a laboratory accreditation standard requirement. DoD- An assessment conclusion that identifies a condition having a significant effect on an item or activity. An assessment finding may be positive, negative, or neutral and is normally accompanied by specific examples of the observed condition. The finding must be linked to a specific requirement (e.g., this standard (DoD QSM), ISO requirements, analytical methods, contract specifications, or laboratory management systems requirements).
Flame Atomic Absorption Spectrometer (FAA)	Instrumentation used to measure the concentration of metals in an environmental sample based on the fact that ground state metals absorb light at different wavelengths. Metals in a solution are converted to the atomic state by use of a flame.
Flame Ionization Detector (FID)	A type of gas detector used in GC analysis where samples are passed through a flame which ionizes the sample so that various ions can be measured.
Gas Chromatography (GC)	Instrumentation which utilizes a mobile carrier gas to deliver an environmental sample across a stationary phase with the intent to separate compounds out and measure their retention times.
Gas Chromatograph/ Mass Spectrometry (GC/MS)	In conjunction with a GC, this instrumentation utilizes a mass spectrometer which measures fragments of compounds and determines their identity by their fragmentation patterns (mass spectra).
Gasoline Range Organics (GRO)	A range of compounds that denote all the characteristic compounds that make up gasoline (range can be state or program specific).
Graphite Furnace Atomic Absorption Spectrometry (GFAA)	Instrumentation used to measure the concentration of metals in an environmental sample based on the absorption of light at different wavelengths that are characteristic of different analytes.
High Pressure Liquid Chromatography (HPLC)	Instrumentation used to separate, identify and quantitate compounds based on retention times which are dependent on interactions between a mobile phase and a stationary phase.
Holding Time	TNI- The maximum time that can elapse between two specified activities. 40 CFR Part 136- The maximum time that samples may be held prior to preparation and/or analysis as defined by the method and still be considered valid or not compromised. For sample prep purposes, hold times are calculated using the time of the start of the preparation procedure. DoD- The maximum time that may elapse from the time of sampling to the time of preparation or analysis, or from preparation to analysis, as appropriate.
Homogeneity	The degree to which a property or substance is uniformly distributed throughout a sample.
Homologue	One in a series of organic compounds in which each successive member has one more chemical group in its molecule than the next preceding member. For instance, methanol, ethanol, propanol, butanol, etc., form a homologous series.
Improper Actions	DoD- Intentional or unintentional deviations from contract-specified or method-specified analytical practices that have not been authorized by the customer (e.g., DoD or DOE).

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Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)	Analytical technique used for the detection of trace metals which uses plasma to produce excited atoms that emit radiation of characteristic wavelengths.
Inductively Coupled Plasma- Mass Spectrometry (ICP/MS)	An ICP-AES that is used in conjunction with a mass spectrometer so that the instrument is not only capable of detecting trace amounts of metals and non-metals but is also capable of monitoring isotopic speciation for the ions of choice.
Infrared Spectrometer (IR)	An instrument that uses infrared light to identify compounds of interest.
Initial Calibration (ICAL)	The process of analyzing standards, prepared at specified concentrations, to define the quantitative response relationship of the instrument to the analytes of interest. Initial calibration is performed whenever the results of a calibration verification standard do not conform to the requirements of the method in use or at a frequency specified in the method.
Initial Calibration Blank (ICB)	A blank sample used to monitor the cleanliness of an analytical system at a frequency determined by the analytical method. This blank is specifically run in conjunction with the Initial Calibration Verification (ICV) where applicable.
Initial Calibration Verification (ICV)	DoD- Verifies the initial calibration with a standard obtained or prepared from a source independent of the source of the initial calibration standards to avoid potential bias of the initial calibration.
Instrument Blank	A clean sample (e.g., distilled water) processed through the instrumental steps of the measurement process; used to determine instrument contamination.
Instrument Detection Limits (IDLs)	Limits determined by analyzing a series of reagent blank analyses to obtain a calculated concentration. IDLs are determined by calculating the average of the standard deviations of three runs on three non-consecutive days from the analysis of a reagent blank solution with seven consecutive measurements per day.
Interference, spectral	Occurs when particulate matter from the atomization scatters incident radiation from the source or when the absorption or emission from an interfering species either overlaps or is so close to the analyte wavelength that resolution becomes impossible.
Interference, chemical	Results from the various chemical processes that occur during atomization and later the absorption characteristics of the analyte.
Internal Standards	TNI- A known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method.
Intermediate Standard Solution	Reference solutions prepared by dilution of the stock solutions with an appropriate solvent.
International System of Units (SI)	The coherent system of units adopted and recommended by the General Conference on Weights and Measures.
Ion Chromatography (IC)	Instrumentation or process that allows the separation of ions and molecules based on the charge properties of the molecules.
Isomer	One of two or more compounds, radicals, or ions that contain the same number of atoms of the same element but differ in structural arrangement and properties. For example, hexane (C6H14) could be n-hexane, 2-methylpentane, 3-methylpentane, 2,3-dimethylbutane, 2,2-dimethylbutane.

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Laboratory	A body that calibrates and/or tests.
Laboratory Control Sample (LCS)	TNI- (however named, such as laboratory fortified blank (LFB), spiked blank, or QC check sample): A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes and taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a reference method. It is generally used to establish intra-laboratory or analyst-specific precision and bias or to evaluate the performance of all or a portion of the measurement system.
Laboratory Duplicate	Aliquots of a sample taken from the same container under laboratory conditions and processed and analyzed independently.
Laboratory Information Management System (LIMS)	DoD- The entirety of an electronic data system (including hardware and software) that collects, analyzes, stores, and archives electronic records and documents.
LabTrack	Database used by Pace Analytical to store and track corrective actions and other laboratory issues.
Learning Management System (LMS)	A web-based database used by the laboratories to track and document training activities. The system is administered by the corporate training department and each laboratory's learn centers are maintained by a local administrator.
Legal Chain-of-Custody Protocols	TNI- Procedures employed to record the possession of samples from the time of sampling through the retention time specified by the client or program. These procedures are performed at the special request of the client and include the use of a Chain-of-Custody (COC) Form that documents the collection, transport, and receipt of compliance samples by the laboratory. In addition, these protocols document all handling of the samples within the laboratory.
Limit(s) of Detection (LOD)	TNI- A laboratory's estimate of the minimum amount of an analyte in a given matrix that an analytical process can reliably detect in their facility. DoD- The smallest concentration of a substance that must be present in a sample in order to be detected at the DL with 99% confidence. At the LOD, the false negative rate (Type II error) is 1%. A LOD may be used as the lowest concentration for reliably reporting a non-detect of a specific analyte in a specific matrix with a specific method at 99% confidence.
Limit(s) of Quantitation (LOQ)	TNI- The minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence. DoD- The smallest concentration that produces a quantitative result with known and recorded precision and bias. For DoD/DOE projects, the LOQ shall be set at or above the concentration of the lowest initial calibration standard and within the calibration range.
Linear Dynamic Range	DoD- Concentration range where the instrument provides a linear response.
Liquid chromatography/ tandem mass spectrometry (LC/MS/MS)	Instrumentation that combines the physical separation techniques of liquid chromatography with the mass analysis capabilities of mass spectrometry.
Lot	A quantity of bulk material of similar composition processed or manufactured at the same time.

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Management	Those individuals directly responsible and accountable for planning, implementing, and assessing work.
Management System	System to establish policy and objectives and to achieve those objectives.
Manager (however named)	The individual designated as being responsible for the overall operation, all personnel, and the physical plant of the environmental laboratory. A supervisor may report to the manager. In some cases, the supervisor and the manager may be the same individual.
Matrix	TNI- The substrate of a test sample.
Matrix Duplicate	TNI- A replicate matrix prepared in the laboratory and analyzed to obtain a measure of precision.
Matrix Spike (MS) (spiked sample or fortified sample)	TNI- A sample prepared, taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a referenced method, by adding a known amount of target analyte to a specified amount of sample for which an independent test result of target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency.
Matrix Spike Duplicate (MSD) (spiked sample or fortified sample duplicate)	TNI- A replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.
Measurement Performance Criteria (MPC)	DoD- Criteria that may be general (such as completion of all tests) or specific (such as QC method acceptance limits) that are used by a project to judge whether a laboratory can perform a specified activity to the defined criteria.
Measurement System	TNI and DoD- A test method, as implemented at a particular laboratory, and which includes the equipment used to perform the sample preparation, test and the operator(s).
Measurement Uncertainty	DoD- An estimate of the error in a measurement often stated as a range of values that contain the true value, within a certain confidence level. The uncertainty generally includes many components which may be evaluated from experimental standard deviations based on repeated observations or by standard deviations evaluated from assumed probability distributions based on experience or other information. For DoD/DOE, a laboratory's Analytical Uncertainty (such as use of LCS control limits) can be reported as the minimum uncertainty.
Method	TNI- A body of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, quantification), systematically presented in the order in which they are to be executed.
Method Blank	TNI- A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses.
Method Detection Limit (MDL)	One way to establish a Detection Limit; defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.

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Method of Standard Additions	A set of procedures adding one or more increments of a standard solution to sample aliquots of the same size in order to overcome inherent matrix effects. The procedures encompass the extrapolation back to obtain the sample concentration.
MintMiner	Program used by Pace Analytical to review large amounts of chromatographic data to monitor for errors or data integrity issues.
Mobile Laboratory	TNI- A portable enclosed structure with necessary and appropriate accommodation and environmental conditions for a laboratory, within which testing is performed by analysts. Examples include but are not limited to trailers, vans, and skid-mounted structures configured to house testing equipment and personnel.
National Institute of Standards and Technology (NIST)	TNI- A federal agency of the US Department of Commerce's Technology Administration that is designed as the United States national metrology institute (or NMI).
National Pollutant Discharge Elimination System (NPDES)	A permit program that controls water pollution by regulating point sources that discharge pollutants into U.S. waters.
Negative Control	Measures taken to ensure that a test, its components, or the environment do not cause undesired effects, or produce incorrect test results.
Nitrogen Phosphorus Detector (NPD)	A detector used in GC analyses that utilizes thermal energy to ionize an analyte. With this detector, nitrogen and phosphorus can be selectively detected with a higher sensitivity than carbon.
Nonconformance	An indication or judgment that a product or service has not met the requirement of the relevant specifications, contract, or regulation; also the state of failing to meet the requirements.
Not Detected (ND)	The result reported for a compound when the detected amount of that compound is less than the method reporting limit.
Operator Aid	DoD- A technical posting (such as poster, operating manual, or notepad) that assists workers in performing routine tasks. All operator aids must be controlled documents (i.e., a part of the laboratory management system).
Performance Based Measurement System (PBMS)	An analytical system wherein the data quality needs, mandates or limitations of a program or project are specified and serve as criteria for selecting appropriate test methods to meet those needs in a cost-effective manner.
Photo-ionization Detector (PID)	An ion detector which uses high-energy photons, typically in the ultraviolet range, to break molecules into positively charged ions.
Polychlorinated Biphenyls (PCB)	A class of organic compounds that were used as coolants and insulating fluids for transformers and capacitors. The production of these compounds was banned in the 1970's due to their high toxicity.
Positive Control	Measures taken to ensure that a test and/or its components are working properly and producing correct or expected results from positive test subjects.
Post-Digestion Spike	A sample prepared for metals analyses that has analytes spike added to determine if matrix effects may be a factor in the results.
Power of Hydrogen (pH)	The measure of acidity or alkalinity of a solution.
Practical Quantitation Limit (PQL)	Another term for a method reporting limit. The lowest reportable concentration of a compound based on parameters set up in an analytical method and the laboratory's ability to reproduce those conditions.

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Precision	TNI- The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.
Preservation	TNI and DoD- Any conditions under which a sample must be kept in order to maintain chemical, physical, and/or biological integrity prior to analysis.
Procedure	TNI- A specified way to carry out an activity or process. Procedures can be documented or not.
Proficiency Testing	TNI- A means of evaluating a laboratory's performance under controlled conditions relative to a given set of criteria through analysis of unknown samples provided by an external source.
Proficiency Testing Program	TNI- The aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results and the collective demographics and results summary of all participating laboratories.
Proficiency Testing Sample (PT)	TNI- A sample, the composition of which is unknown to the laboratory and is provided to test whether the laboratory can produce analytical results within the specified acceptance criteria.
Protocol	TNI- A detailed written procedure for field and/or laboratory operation (e.g., sampling, analysis) that must be strictly followed.
Qualitative Analysis	DoD- Analysis designed to identify the components of a substance or mixture.
Quality Assurance (QA)	TNI- An integrated system of management activities involving planning, implementation, assessment, reporting and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client.
Quality Assurance Manual (QAM)	A document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.
Quality Assurance Project Plan (QAPP)	A formal document describing the detailed quality control procedures by which the quality requirements defined for the data and decisions pertaining to a specific project are to be achieved.
Quality Control (QC)	TNI- The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements for quality; also the system of activities and checks used to ensure that measurement systems are maintained within prescribed limits, providing protection against "out of control" conditions and ensuring that the results are of acceptable quality.
Quality Control Sample (QCS)	TNI- A sample used to assess the performance of all or a portion of the measurement system. One of any number of samples, such as Certified Reference Materials, a quality system matrix fortified by spiking, or actual samples fortified by spiking, intended to demonstrate that a measurement system or activity is in control.
Quality Manual	TNI- A document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.

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Quality System	TNI and DoD- A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required quality assurance and quality control activities.
Quality System Matrix	TNI and DoD- These matrix definitions are to be used for purposes of batch and quality control requirements: • **Air and Emissions**: Whole gas or vapor samples including those contained in flexible or rigid wall containers and the extracted concentrated analytes of interest from a gas or vapor that are collected with a sorbent tube, impinger solution, filter, or other device • **Aqueous**: Any aqueous sample excluded from the definition of Drinking Water or Saline/Estuarine. Includes surface water, groundwater effluents, and TCLP or other extracts. • **Biological Tissue**: Any sample of a biological origin such as fish tissue, shellfish or plant material. Such samples shall be grouped according to origin. • **Chemical Waste**: A product or by-product of an industrial process that results in a matrix not previously defined. • **Drinking Water**: Any aqueous sample that has been designated a potable or potentially potable water source. • **Non-aqueous liquid**: Any organic liquid with <15% settleable solids • **Saline/Estuarine**: Any aqueous sample from an ocean or estuary, or other salt water source such as the Great Salt Lake. • **Solids**: Includes soils, sediments, sludges, and other matrices with >15% settleable solids.
Quantitation Range	DoD- The range of values (concentrations) in a calibration curve between the LOQ and the highest successively analyzed initial calibration standard. The quantitation range lies within the calibration range.
Quantitative Analysis	DoD- Analysis designed to determine the amounts or proportions of the components of a substance.
Random Error	The EPA has established that there is a 5% probability that the results obtained for any one analyte will exceed the control limits established for the test due to random error. As the number of compounds measured increases in a given sample, the probability for statistical error also increases.
Raw Data	TNI- The documentation generated during sampling and analysis. This documentation includes, but is not limited to, field notes, electronic data, magnetic tapes, untabulated sample results, QC sample results, print outs of chromatograms, instrument outputs, and handwritten records.
Reagent Blank (method reagent blank)	A sample consisting of reagent(s), without the target analyte or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps.
Reagent Grade	Analytical reagent (AR) grade, ACS reagent grade, and reagent grade are synonymous terms for reagents that conform to the current specifications of the Committee on Analytical Reagents of the American Chemical Society.

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Records	DoD- The output of implementing and following management system documents (e.g., test data in electronic or hand-written forms, files, and logbooks).
Reference Material	TNI- Material or substance one or more of whose property values are sufficiently homogenized and well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials.
Reference Standard	TNI- Standard used for the calibration of working measurement standards in a given organization or at a given location.
Relative Percent Difference (RPD)	A measure of precision defined as the difference between two measurements divided by the average concentration of the two measurements.
Reporting Limit (RL)	The level at which method, permit, regulatory and customer-specific objectives are met. The reporting limit may never be lower than the Limit of Detection (i.e., statistically determined MDL). Reporting limits are corrected for sample amounts, including the dry weight of solids, unless otherwise specified. There must be a sufficient buffer between the Reporting Limit and the MDL. DoD- A customer-specified lowest concentration value that meets project requirements for quantitative data with known precision and bias for a specific analyte in a specific matrix.
Reporting Limit Verification Standard (or otherwise named)	A standard analyzed at the reporting limit for an analysis to verify the laboratory's ability to report to that level.
Representativeness	A quality element related to the ability to collect a sample reflecting the characteristics of the part of the environment to be assessed. Sample representativeness is dependent on the sampling techniques specified in the project work plan.
Requirement	Denotes a mandatory specification; often designated by the term "shall".
Retention Time	The time between sample injection and the appearance of a solute peak at the detector.
Sample	Portion of material collected for analysis, identified by a single, unique alphanumeric code. A sample may consist of portions in multiple containers, if a single sample is submitted for multiple or repetitive analysis.
Sample Condition Upon Receipt Form (SCURF)	Form used by Pace Analytical sample receiving personnel to document the condition of sample containers upon receipt to the laboratory (used in conjunction with a COC).
Sample Delivery Group (SDG)	A unit within a single project that is used to identify a group of samples for delivery. An SDG is a group of 20 or fewer field samples within a project, received over a period of up to 14 calendar days. Data from all samples in an SDG are reported concurrently.
Sample Receipt Form (SRF)	Letter sent to the client upon login to show the tests requested and pricing.
Sample Tracking	Procedures employed to record the possession of the samples from the time of sampling until analysis, reporting and archiving. These procedures include the use of a Chain of custody Form that documents the collection, transport, and receipt of compliance samples to the laboratory. In addition, access to the laboratory is limited and controlled to protect the integrity of the samples.

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Sampling	TNI- Activity related to obtaining a representative sample of the object of conformity assessment, according to a procedure.
Selective Ion Monitoring (SIM)	A mode of analysis in mass spectrometry where the detector is set to scan over a very small mass range, typically one mass unit. The narrower the range, the more sensitive the detector.
Selectivity	TNI- The ability to analyze, distinguish, and determine a specific analyte or parameter from another component that may be a potential interferent or that may behave similarly to the target analyte or parameter within the measurement system.
Sensitivity	TNI- The capability of a method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest.
Serial Dilution	The stepwise dilution of a substance in a solution.
Shall	Denotes a requirement that is mandatory whenever the criterion for conformance with the specification requires that there be no deviation. This does not prohibit the use of alternative approaches or methods for implementing the specification as long as the requirement is fulfilled.
Should	Denotes a guideline or recommendation whenever noncompliance with the specification is permissible.
Signal-to-Noise Ratio (S/N)	DoD- S/N is a measure of signal strength relative to background noise. The average strength of the noise of most measurements is constant and independent of the magnitude of the signal. Thus, as the quantity being measured (producing the signal) decreases in magnitude, S/N decreases and the effect of the noise on the relative error of a measurement increases.
Spike	A known mass of target analyte added to a blank sample or sub-sample; used to determine recovery efficiency or for other quality control purposes.
Standard (Document)	TNI- The document describing the elements of a laboratory accreditation that has been developed and established within the consensus principles of standard setting and meets the approval requirements of standard adoption organizations procedures and policies.
Standard (Chemical)	Standard samples are comprised of a known amount of standard reference material in the matrix undergoing analysis. A standard reference material is a certified reference material produced by US NIST and characterized for absolute content, independent of analytical test method.
Standard Blank (or Reagent Blank)	A calibration standard consisting of the same solvent/reagent matrix used to prepare the calibration standards without the analytes. It is used to construct the calibration curve by establishing instrument background.
Standard Method	A test method issued by an organization generally recognized as competent to do so.
Standard Operating Procedure (SOP)	TNI- A written document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps. SOPs are officially approved as the methods for performing certain routine or repetitive tasks.
Standard Reference Material (SRM)	A certified reference material produced by the US NIST or other equivalent organization and characterized for absolute content, independent of analytical method.
Statement of Qualifications (SOQ)	A document that lists information about a company, typically the qualifications of that company to compete on a bid for services.

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Stock Standard	A concentrated reference solution containing one or more analytes prepared in the laboratory using an assayed reference compound or purchased from a reputable commercial source.
Storage Blank	DoD- A sample of analyte-free media prepared by the laboratory and retained in the sample storage area of the laboratory. A storage blank is used to record contamination attributable to sample storage at the laboratory.
Supervisor	The individual(s) designated as being responsible for a particular area or category of scientific analysis. This responsibility includes direct day-to-day supervision of technical employees, supply and instrument adequacy and upkeep, quality assurance/quality control duties and ascertaining that technical employees have the required balance of education, training and experience to perform the required analyses.
Surrogate	DoD- A substance with properties that mimic the analyte of interest. It is unlikely to be found in environment samples and is added to them for quality control purposes.
Systems Audit	An on-site inspection or assessment of a laboratory's quality system.
Target Analytes	DoD- Analytes or chemicals of primary concern, identified by the customer on a project-specific basis.
Technical Director	Individual(s) who has overall responsibility for the technical operation of the environmental testing laboratory.
Technology	TNI- A specific arrangement of analytical instruments, detection systems, and/or preparation techniques.
Test	A technical operation that consists of the determination of one or more characteristics or performance of a given product, material, equipment, organism, physical phenomenon, process or service according to a specified procedure. The result of a test is normally recorded in a document sometimes called a test report or a test certificate.
Test Method	DoD- A definitive procedure that determines one or more characteristics of a given substance or product.
Test Methods for Evaluating Solid Waste, Physical/ Chemical (SW-846)	EPA Waste's official compendium of analytical and sampling methods that have been evaluated and approved for use in complying with RCRA regulations.
Total Petroleum Hydrocarbons (TPH)	A term used to denote a large family of several hundred chemical compounds that originate from crude oil. Compounds may include gasoline components, jet fuel, volatile organics, etc.
Toxicity Characteristic Leaching Procedure (TCLP)	A solid sample extraction method for chemical analysis employed as an analytical method to simulate leaching of compounds through a landfill.
Traceability	TNI- The ability to trace the history, application, or location of an entity by means of recorded identifications. In a calibration sense, traceability relates measuring equipment to national or international standards, primary standards, basic physical conditions or properties, or reference materials. In a data collection sense, it relates calculations and data generated throughout the project back to the requirements for the quality of the project.

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Training Document	A training resource that provides detailed instructions to execute a specific method or job function.
Trip Blank	This blank sample is used to detect sample contamination from the container and preservative during transport and storage of the sample. A cleaned sample container is filled with laboratory reagent water and the blank is stored, shipped, and analyzed with its associated samples.
Tuning	A check and/or adjustment of instrument performance for mass spectrometry as required by the method.
Ultraviolet Spectrophotometer (UV)	Instrument routinely used in quantitative determination of solutions of transition metal ions and highly conjugated organic compounds.
Uncertainty Measurement	The parameter associated with the result of a measurement that characterized the dispersion of the values that could be reasonably attributed to the measurand (i.e. the concentration of an analyte).
Unethical actions	DoD- Deliberate falsification of analytical or quality control results, where failed method or contractual requirements are made to appear acceptable.
Unregulated Contaminate Monitoring Rule (UCMR)	EPA program to monitor unregulated contaminates in drinking water.
Validation	DoD- The confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled.
Verification	TNI- Confirmation by examination and objective evidence that specified requirements have been met. Note: In connection with the management of measuring equipment, verification provides a means for checking that the deviations between values indicated by a measuring instrument and corresponding known values of a measured quantity are consistently smaller than the maximum allowable error defined in a standard, regulation or specification peculiar to the management of the measuring equipment. The result of verification leads to a decision either to restore in service, to perform adjustment, to repair, to downgrade, or to declare obsolete. In all cases, it is required that a written trace of the verification performed shall be kept on the measuring instrument's individual record.
Whole Effluent Toxicity (WET)	The aggregate toxic effect to aquatic organisms from all pollutants contained in a facility's wastewater (effluent).

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11.0. REFERENCES

11.1. "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act." Federal Register, 40 CFR Part 136.

11.2. "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods." SW-846.

11.3. "Methods for Chemical Analysis of Water and Wastes", EPA 600-4-79-020, 1979 Revised 1983, U.S. EPA.

11.4. U.S. EPA Contract Laboratory Program Statement of Work for Organic Analysis.

11.5. U.S. EPA Contract Laboratory Program Statement of Work for Inorganic Analysis.

11.6. "Standard Methods for the Examination of Water and Wastewater." Current Edition APHA-AWWA-WPCF.

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11.8. "Annual Book of ASTM Standards", Section 11: Water and Environmental Technology, American Society of Testing and Materials.

11.9. "NIOSH Manual of Analytical Methods", Third Edition, 1984, U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health.

11.10. "Methods for the Determination of Organic Compounds in Finished Drinking Water and Raw Source Water", U.S. EPA, Environmental Monitoring and Support Laboratory – Cincinnati (September 1986).

11.11. Quality Assurance of Chemical Measurements, Taylor, John K.; Lewis Publishers, Inc. 1987.

11.12. Methods for Non-conventional Pesticides Chemicals Analysis of Industrial and Municipal Wastewater, Test Methods, EPA-440/1-83/079C.

11.13. Environmental Measurements Laboratory (EML) Procedures Manual, HASL-300, US DOE, February, 1992.

11.14. Requirements for Quality Control of Analytical Data, HAZWRAP, DOE/HWP-65/R1, July, 1990.

11.15. Requirements for Quality Control of Analytical Data for the Environmental Restoration Program, Martin Marietta, ES/ER/TM-16, December, 1992.

11.16. Quality Assurance Manual for Industrial Hygiene Chemistry, AIHA, 1988.

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11.17. National Environmental Laboratory Accreditation Conference, Constitution, Bylaws, and Standards. Most recent version.

11.18. ISO/IEC 17025:2005, General requirements for the competence of testing and calibration laboratories.

11.19. Department of Defense Quality Systems Manual (QSM), version 5.0, March 2013.

11.20. TNI (The NELAC Institute) Standards; most recent version.

11.21. UCMR3 Laboratory Approval Requirements and Information Document, version 2.0, January 2012.

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12.0. REVISIONS

The PASI Corporate Quality Office files both a paper copy and electronic version of a Microsoft Word document with tracked changes detailing all revisions made to the previous version of the Quality Assurance Manual. This document is available upon request. All revisions are summarized in the table below.

Document Number	Reason for Change	Date
Quality Assurance Manual 17.0	Section 2.6.5: Updated facility codes. Section 6.2.3.4: Reworded language regarding calibrations. Section 6.3.7.1: Removed last sentence about syringes. Section 6.4.8: Added sentence about instrumentation failure. Section 7.2.6: Added language regarding auto email function. Section 7.5.1.1: Added red letter section for special data retention requirements. Section 9.2.7.2: Removed sentence regarding hold time reporting by QMs. Section 10: Updated DoD definitions per DoD/DOE QSM, revision 5.0. Also added definitions for LC/MS/MS and UCMR. Section 11: Revised DoD reference and added UCMR3 reference. Attachment VIII: added several drinking water methods and added note 4 regarding hexavalent holding time and preservation.	16April2014

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ATTACHMENT I- QUALITY CONTROL CALCULATIONS

PERCENT RECOVERY (%REC)

$$\%REC = \frac{(MSConc - SampleConc)}{TrueValue} * 100$$

NOTE: The SampleConc is zero (0) for the LCS and Surrogate Calculations

PERCENT DIFFERENCE (%D)

$$\%D = \frac{MeasuredValue - TrueValue}{TrueValue} * 100$$

where:
TrueValue = Amount spiked (can also be the $\overline{CF}$ or $\overline{RF}$ of the ICAL Standards)
Measured Value = Amount measured (can also be the CF or RF of the CCV)

PERCENT DRIFT

$$\%Drift = \frac{CalculatedConcentration - TheoreticalConcentration}{TheoreticalConcentrtion} * 100$$

RELATIVE PERCENT DIFFERENCE (RPD)

$$RPD = \frac{|(R1 - R2)|}{(R1 + R2)/2} * 100$$

where:
R1 = Result Sample 1
R2 = Result Sample 2

CORRELATION COEFFICIENT (R)

$$CorrCoeff = \frac{\sum_{i=1}^{N} W_i * (X_i - \overline{X}) * (Y_i - \overline{Y})}{\sqrt{\left(\sum_{i=1}^{N} W_i * (X_i - \overline{X})^2\right) * \left(\sum_{i=1}^{N} W_i * (Y_i - \overline{Y})^2\right)}}$$

With:		
	N	Number of standard samples involved in the calibration
	i	Index for standard samples
	Wi	Weight factor of the standard sample no. i
	Xi	X-value of the standard sample no. i
	X(bar)	Average value of all x-values
	Yi	Y-value of the standard sample no. i
	Y(bar)	Average value of all y-values

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ATTACHMENT I- QUALITY CONTROL CALCULATIONS (CONTINUED)

STANDARD DEVIATION (S)

$$S = \sqrt{\sum_{i=1}^{n} \frac{(X_i - \overline{X})^2}{(n-1)}}$$

where:
n = number of data points
X_i = individual data point
$\overline{X}$ = average of all data points

AVERAGE ($\overline{X}$)

$$\overline{X} = \frac{\sum_{n=1}^{i} X_i}{n}$$

where:
n = number of data points
X_i = individual data point

RELATIVE STANDARD DEVIATION (RSD)

$$RSD = \frac{S}{\overline{X}} * 100$$

where:
S = Standard Deviation of the data points
$\overline{X}$ = average of all data points

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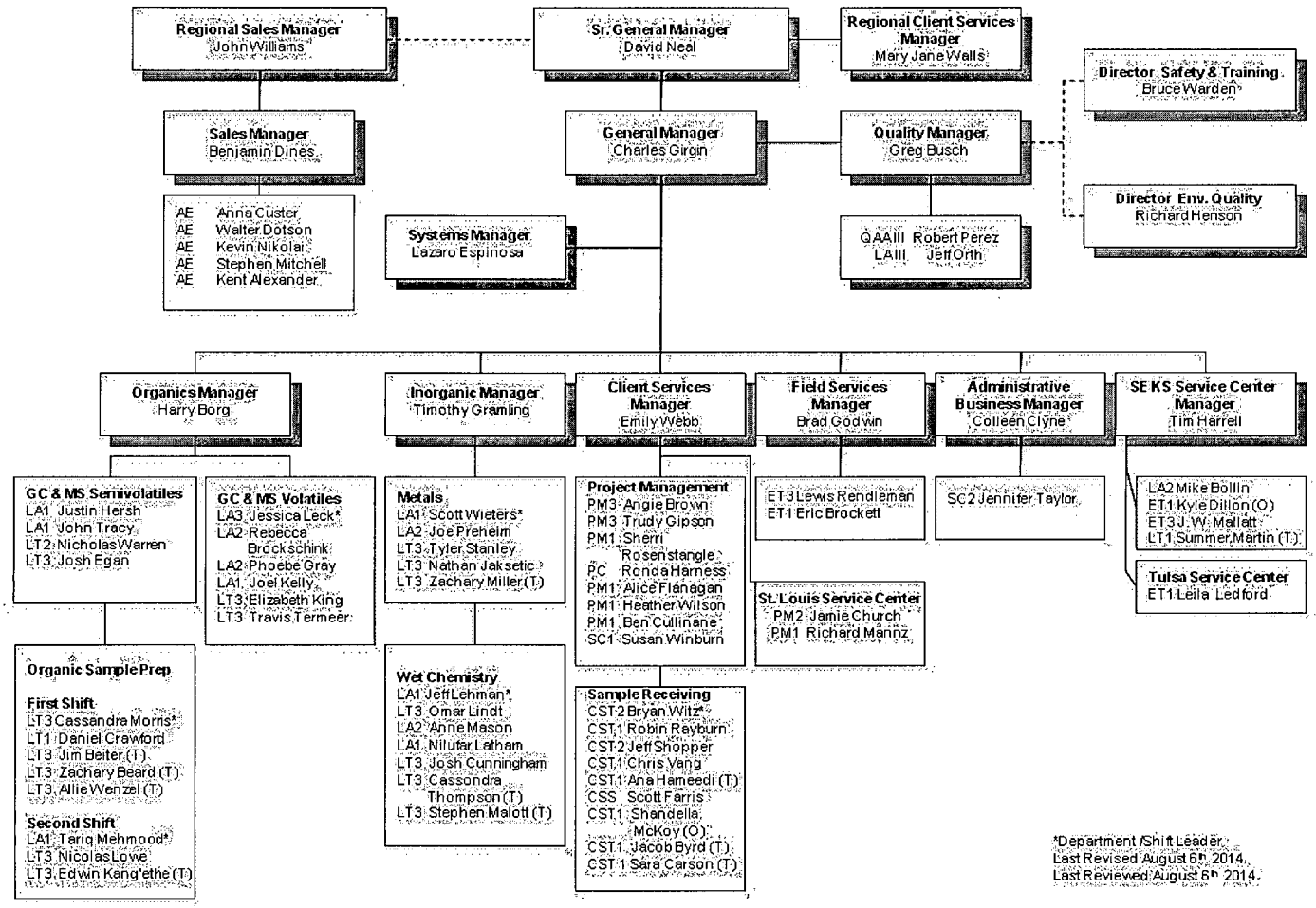
ATTACHMENT II - LABORATORY ORGANIZATIONAL CHART (CURRENT AS OF ISSUE DATE)

Pace Analytical Services, Inc.—Kansas



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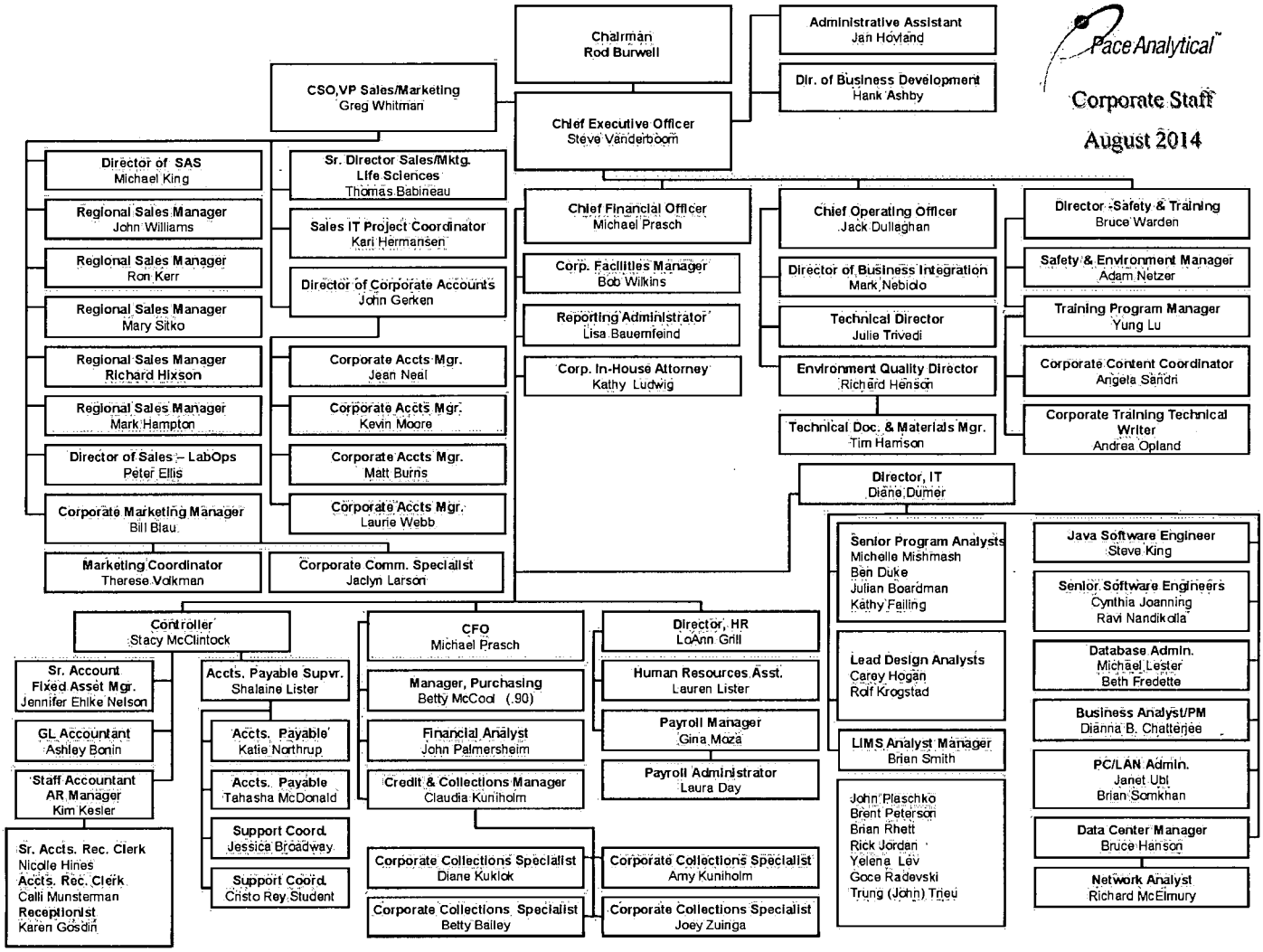
ATTACHMENT III- CORPORATE ORGANIZATIONAL CHART (CURRENT AS OF ISSUE DATE)



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ATTACHMENT IV - LENEXA LABORATORY EQUIPMENT LIST (CURRENT AS OF ISSUE DATE)

Instrument	Age	Manufacturer	Model	Description	Analysis
60FP01	1990	Koehler	K16200	Flashpoint Tester	1010A / ASTM D92
60FP02	2010	Koehler	K16200	Flashpoint Tester	1010A / ASTM D92
60GCS8	2005	Agilent	6890	GC ECD	504.1 / 608 / 8011 / 8082
60GCS9	2008	Agilent	7890A	GC FID	8015 / OA-2 / OKDRO / TCEQ 1005
60GCSA	2009	Agilent	7890A	GC FID	8015 / OA-2 / OKDRO / TCEQ 1005
60GCSF	2013	Agilent	7890A	GC FID	8015 / OA-2 / OKDRO / TCEQ 1005
60GCSG	2013	Agilent	7890B	GC ECD	504.1 / 608 / 8011 / 8082
60GCV2	2012	Agilent	6890	GC FID	8015 / OKGRO
60HG02	2007	Perkin-Elmer	FIMS-400	Mercury Analyzer	245.1 / 7470A / 7471A / 7471B
60HG03	2012	Cetac	M7500	Mercury Analyzer	245.1 / 7470A / 7471A / 7471B
60ICM1	2011	Thermo Sci.	XSeries2	ICP-MS	200.8 / 6020A
60ICP3	2009	Thermo Sci.	iCAP6500	ICP-OES	200.7 / 6010B / 6010C
60ICP4	2011	Thermo Sci.	iCAP6500	ICP-OES	200.7 / 6010B / 6010C
60MARS1	2006	CEM	Mars5	Microwave Extractor	3546
60MARS2	2013	CEM	Mars6	Microwave Extractor	3546
60MSS2	2002	Agilent	6890	GCMS	625 / 8270C / Missouri TPH-DRO/ORO
60MSS3	2008	Agilent	7890A	GCMS	625 / 8270C / Missouri TPH-DRO/ORO
60MSS4	2009	Agilent	7890A	GCMS	625 / 8270C / Missouri TPH-DRO/ORO
60MSS5	2010	Agilent	7890A	GCMS	625 / 8270C / Missouri TPH-DRO/ORO
60MSV1	2009	Agilent	6850	GCMS	624 / OA-1 / 8260B / Missouri TPH-GRO
60MSV2	2007	Agilent	6850	GCMS	624 / OA-1 / 8260B / Missouri TPH-GRO
60MSV5	2002	Agilent	6890	GCMS	624 / OA-1 / 8260B / Missouri TPH-GRO
60MSV8	2007	Agilent	6850	GCMS	624 / OA-1 / 8260B / Missouri TPH-GRO
60MSV9	2008	Agilent	6850	GCMS	624 / OA-1 / 8260B / Missouri TPH-GRO
60MSVA	2010	Agilent	6850	GCMS	624 / OA-1 / 8260B / Missouri TPH-GRO
60MSVB	2010	Agilent	6850	GCMS	624 / OA-1 / 8260B / Missouri TPH-GRO
60WET1	1998	Thermo Sci.	Accumet 150	Dissolved Oxygen Meter	SM 4500-O G
60WET5	1994	Hach	43900	Turbidimeter	180.1
60WET9	1998	Fisher Sci.	09-328	Conductivity Meter	120.1
60WETC	2011	Thermo Sci.	Orion Star LogR	pH Meter	4500-H+ B
60WETD	2013	Fisher Sci.	06-662-61	Conductivity Meter	120.1
60WETE	2013	Oakton	700	pH Meter	4500-H+ B
60WTA0	2009	Lachat	QuikChem 8500	Flow Injection Analyzer	350.1 / 351.2 / / 353.2 / 365.1 / 365.4
60WTA2	2008	Dionex	ICS-2000	Ion Chromatograph	300.0 / 9056A
60WTA8	2006	Unity Sci.	Smartchem200	Discrete Analyzer	351.2 / 420.1 / SM 4500-CN E / 9012A
60WTA9	2008	Shimadzu	UV-1800	UV-Visible Spectrometer	COD / Cl_2 / Fe(II) / Sulfide / Cr(VI)
60WTAA	2010	GE	InnovOx	TOC Analyzer	SM 5310C
60WTAB	2011	Lachat	QuikChem 8500	Flow Injection Analyzer	350.1 / 353.2 / 365.1 / 365.4
60WTAC	2012	Dionex	ICS-1600	Ion Chromatograph	300.0 / 9056A
60WTAD	2012	Dionex	ICS-1500	Ion Chromatograph	300.0 / 9056A
60WTAE	2012	Mantech	PC-1040	Autotitrator	SM2320B
60WTAG	2013	Tekmar	Fusion	TOC Analyzer	SM 5310C

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ATTACHMENT V – FRONTENAC LABORATORY EQUIPMENT LIST (CURRENT AS OF ISSUE DATE)

Instrument	Age	Manufacturer	Model	Analysis
pH Meter	2001	Fisher Sci.	AP61	4500-H+B
Dissolved Oxygen Meter	2006	YSI	550A	4500-O G
Conductivity Meter	2001	Accumet	AB30	120.1
Autoclave	2001	Tutnauer Brinkman	3870E	N/A
Incubator, water bath	2002	Precision	Precision	Microbiology
Incubator, thermal	1995	Equatherm	C1574	Microbiology
Bioassay Water Baths (5 units)	2001	ISO Temp	2100	Bioassay
Balance	1990	Mettler-Toledo	AE-240	N/A
pH, LDO, Conductivity Meter	2011	Hach	HQ40d	4500-H+B, 4500-O G, 120.1
Balance	2014	Mettler-Toledo	XS-105DU	N/A

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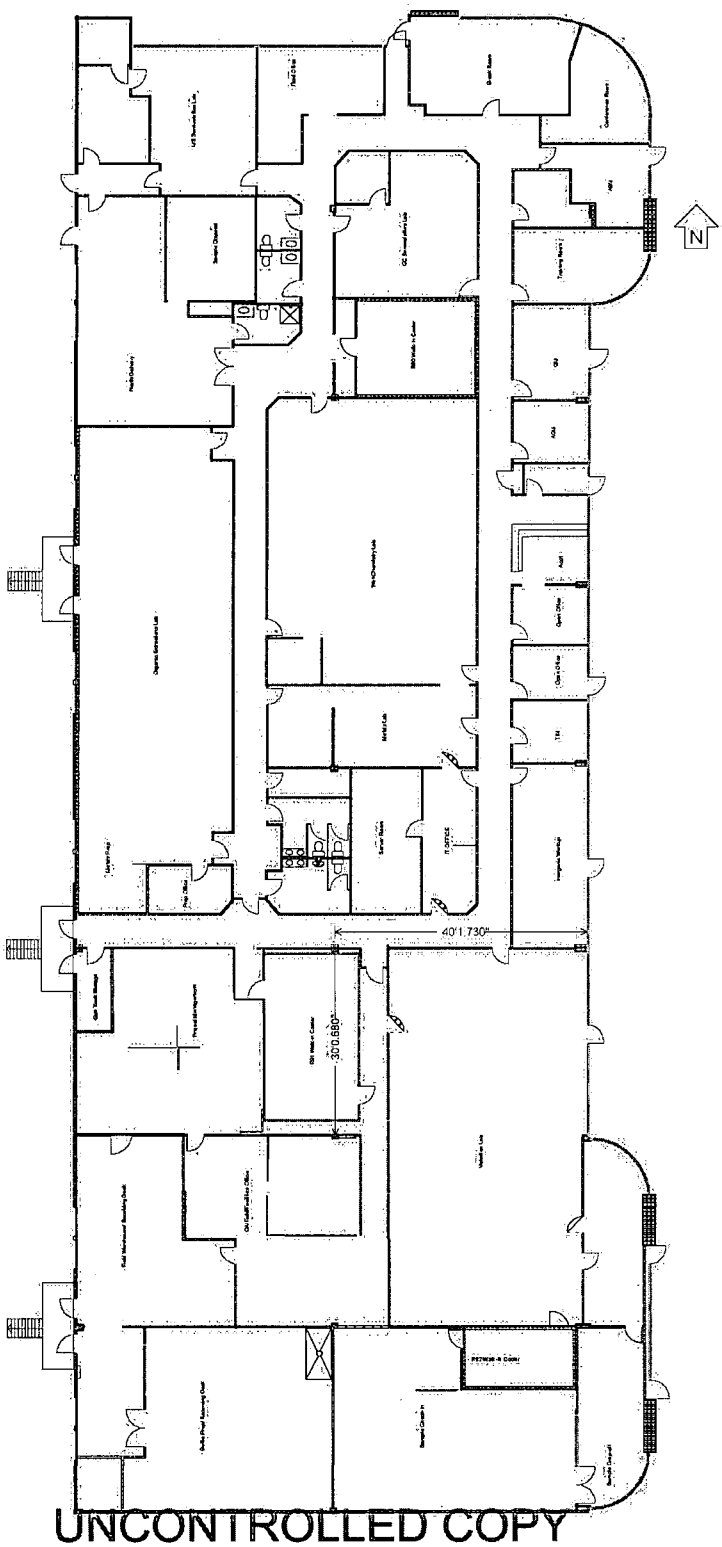
ATTACHMENT VI- LENEXA LABORATORY FLOOR PLAN (CURRENT AS OF ISSUE DATE)



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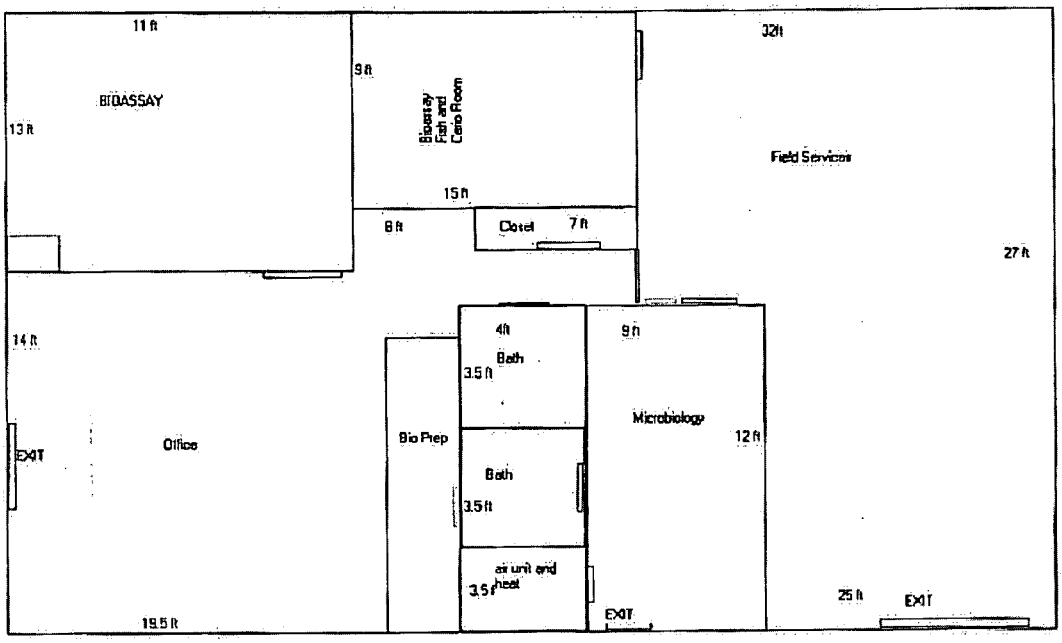
ATTACHMENT VII- FRONTENAC LABORATORY FLOOR PLAN (CURRENT AS OF ISSUE DATE)



All external door do lead to a outside environment

= Door

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SOUTHEAST KANSAS SERVICE CENTER

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ATTACHMENT VIII- LABORATORY SOP LIST (CURRENT AS OF ISSUE DATE)

SOP Number	SOP Title
S-ALL-C-002-rev.4	BOTTLE ORDER DATABASE
S-ALL-C-005-rev.3	PACEPORT CUSTOMER FEEDBACK FORM
S-ALL-O-038-rev.2	TENTATIVELY IDENTIFIED COMPOUNDS
S-ALL-Q-003-rev.9	DOCUMENT NUMBERING
S-ALL-Q-005-rev.7	DATA REDUCTION, REVIEW AND REPORTING
S-ALL-Q-009-rev.6	LABORATORY DOCUMENTATION
S-ALL-Q-014-rev.3	QUALITY SYSTEM REPORTING
S-ALL-Q-014-rev.4	QUALITY SYSTEM REPORTING
S-ALL-Q-015-rev.1	REVIEW OF LABORATORY MANAGEMENT SYSTEM
S-ALL-Q-020-rev.6	TRAINING PROCEDURES
S-ALL-Q-022-rev.4	3P PROGRAM: CONTINUOUS PROCESS IMPROVEMENT
S-ALL-Q-028-rev.4	LABTRACK SYSTEM
S-ALL-Q-029-rev.3	MINTMINER© DATA FILE REVIEW
S-ALL-Q-030-rev.5	EPIC PRO: DATA CHECKER
S-ALL-Q-035-rev.2	DATA RECALL
S-ALL-S-001-rev.4	HAZARD ASSESSMENT
S-COR-Q-034-rev.2	ANONYMOUS HOTLINE PROCEDURE
S-KS-C-001-rev.5	SAMPLE MANAGEMENT
S-KS-C-002-rev.6	ASSEMBLY OF SAMPLE CONTAINER KITS
S-KS-C-003-rev.5	SUBCONTRACTING SAMPLES
S-KS-F-001-rev.4	FIELD MANUAL
S-KS-I-001-rev.8	ACIDITY
S-KS-I-002-rev.12	MANUAL ALKALINITY
S-KS-I-003-rev.10	AMMONIA, NITROGEN BY METHOD 350.1
S-KS-I-004-rev.10	BIOCHEMICAL OXYGEN DEMAND
S-KS-I-005-rev.10	CHEMICAL OXYGEN DEMAND
S-KS-I-007-rev.9	RESIDUAL CHLORINE
S-KS-I-008-rev.12	HEXAVALENT CHROMIUM
S-KS-I-010-rev.8	DISSOLVED OXYGEN
S-KS-I-011-rev.5	FERROUS IRON
S-KS-I-013-rev.5	TKN BY METHOD 351.2
S-KS-I-014-rev.10	OIL AND GREASE/TPH BY METHOD 1664A
S-KS-I-015-rev.4	OIL AND GREASE/TPH BY METHOD 9071B
S-KS-I-016-rev.13	TOTAL ORGANIC CARBON
S-KS-I-017-rev.7	TURBIDITY
S-KS-I-018-rev.9	pH IN WATER, SOIL AND WASTE
S-KS-I-019-rev.9	TOTAL RECOVERABLE PHENOLICS
S-KS-I-020-rev.11	TOTAL SOLIDS
S-KS-I-021-rev.12	TOTAL DISSOLVED SOLIDS
S-KS-I-022-rev.13	TOTAL SUSPENDED SOLIDS
S-KS-I-023-rev.8	SETTLEABLE SOLIDS
S-KS-I-024-rev.9	TOTAL VOLATILE SOLIDS
S-KS-I-025-rev.11	CONDUCTIVITY
S-KS-I-028-rev.8	SULFITE

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SOP Number	SOP Title
S-KS-I-029-rev.10	METHYLENE BLUE ACTIVE SUBSTANCES
S-KS-I-030-rev.9	IGNITABILITY
S-KS-I-032-rev.7	REACTIVITY DISTILLATIONS
S-KS-I-033-rev.7	PAINT FILTER LIQUIDS TEST
S-KS-I-036-rev.9	TOTAL, AMENABLE AND WAD CYANIDE
S-KS-I-037-rev.10	AUTOMATED CHLORIDE
S-KS-I-038-rev.5	ORTHOPHOSPHATE
S-KS-I-039-rev.13	NITRATE/NITRITE BY METHOD 353.2
S-KS-I-040-rev.6	TOTAL PHOSPHORUS
S-KS-I-043-rev.10	ION CHROMATOGRAPHY
S-KS-I-044-rev.4	COLOR ANALYSIS
S-KS-I-045-rev.3	SPECIFIC OXYGEN UPTAKE RATE
S-KS-I-046-rev.2	TOTAL, VOLATILE, AND FIXED SOLIDS IN SLUDGES
S-KS-I-047-rev.1	SULFIDE BY METHYLENE BLUE METHOD (SM4500-$S2^-$ D)
S-KS-I-048-rev.0	SULFIDE BY IODOMETRIC TITRATION (SM 4500-$S2^-$ F)
S-KS-I-049-rev.0	SPECIFIC GRAVITY
S-KS-I-050-rev.1	AUTOMATED ALKALINITY
S-KS-IT-001-rev.4	TARGET DATA BACKUP
S-KS-M-001-rev.3	MICRODIGESTION BY 3010A
S-KS-M-002-rev.12	ACID DIGESTION OF WATERS
S-KS-M-003-rev.9	ACID DIGESTION OF SOILS
S-KS-M-004-rev.4	ACID DIGESTION OF WIPES
S-KS-M-005-rev.16	METALS BY ICP-AES
S-KS-M-006-rev.11	MERCURY PREPARATION AND ANALYSIS
S-KS-M-007-rev.5	CATION EXCHANGE CAPACITY
S-KS-M-008-rev.4	ICP METALS by 6010C
S-KS-M-009-rev.6	METALS BY ICPMS
S-KS-MB-001-rev.8	FECAL COLIFORM
S-KS-MB-003-rev.10	HETEROTROPHIC PLATE COUNT
S-KS-MB-006-rev.7	SUITABILITY TEST
S-KS-MB-007-rev.6	INHIBITORY RESIDUE TEST
S-KS-MB-008-rev.6	ACUTE AQUATIC TOXICITY
S-KS-MB-010-rev.6	CHRONIC AQUATIC TOXICITY
S-KS-MB-013-rev.6	CULTURING BRINE SHRIMP
S-KS-MB-018-rev.6	LIGHT INTENSITY/PHOTOPERIOD
S-KS-MB-019-rev.4	CULTURING C. DUBIA/HATCHING MINNOWS
S-KS-MB-021-rev.3	TOTAL COLIFORM AND E. COLI (COLILERT)
S-KS-MB-022-rev.1	BIOASSAY CHEMICAL TESTS
S-KS-O-001-rev.12	TCLP BY METHOD 1311
S-KS-O-002-rev.3	SPLP BY METHOD 1312
S-KS-O-003-rev.6	ORGANIC EXTRACTION SPIKE VERIFICATION
S-KS-O-004-rev.9	EDB/DBCP BY METHOD 8011
S-KS-O-007-rev.12	PCBs IN WATER AND SOIL
S-KS-O-008-rev.9	PCBs IN OIL AND WIPES
S-KS-O-012-rev.13	VOCs BY METHOD 8260B
S-KS-O-013-rev.12	BNAs BY METHOD 8270C
S-KS-O-014-rev.9	EPH BY METHOD OA-2

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SOP Number	SOP Title
S-KS-O-015-rev.10	EXTRACTABLE HYDROCARBONS BY OKLAHOMA DRO
S-KS-O-016-rev.5	PURGABLE HYDROCARBONS BY OKLAHOMA GRO
S-KS-O-017-rev.8	PERCENT MOISTURE IN SOIL
S-KS-O-018-rev.9	EDB/DBCP BY METHOD 504.1
S-KS-O-020-rev.7	PCBs BY METHOD 608
S-KS-O-022-rev.5	VOCs BY METHOD 624
S-KS-O-023-rev.6	BNAs BY METHOD 625
S-KS-O-024-rev.5	TPH-DRO/ORO BY METHOD 8270C
S-KS-O-025-rev.4	TPH-GRO BY METHOD 8260B
S-KS-O-026-rev.3	TPH-GRO BY METHOD 8015B/C
S-KS-O-027-rev.5	TPH-DRO BY METHOD 8015B/C
S-KS-O-028-rev.8	PAHs BY METHOD 8270C (SIM)
S-KS-O-029-rev.5	SEPARATORY FUNNEL EXTRACTION
S-KS-O-032-rev.4	MICROWAVE SOIL EXTRACTION
S-KS-O-033-rev.3	VPH by METHOD OA-1
S-KS-O-035-rev.1	WASTE DILUTION
S-KS-O-036-rev.1	PCB EXTRACT CLEANUP
S-KS-O-037-rev.2	TPH BY TCEQ METHOD 1005
S-KS-O-038-rev.1	SILICA GEL CLEANUP
S-KS-O-039-rev.1	MICROEXTRACTION OF AQUEOUS SAMPLES
S-KS-Q-001-rev.6	LABORATORY GLASSWARE WASHING
S-KS-Q-006-rev.4	RECEIPT AND STORAGE OF LAB SUPPLIES
S-KS-Q-007-rev.7	LABORATORY SECURITY PROCEDURES
S-KS-Q-011-rev.5	REAGENT WATER QUALITY
S-KS-Q-012-rev.5	SIGNIFICANT FIGURES AND ROUNDING
S-KS-Q-019-rev.5	LAB DATA FILING AND ARCHIVING
S-KS-Q-020-rev.4	USDA REGULATED SOIL
S-KS-Q-022-rev.3	ESTIMATION OF UNCERTAINTY
S-KS-Q-024-rev.2	INSTRUMENT TRANSPORT
S-KS-Q-025-rev.3	A2LA TERMS AND SYMBOLS
S-KS-Q-026-rev.5	PURCHASING OF LAB SUPPLIES
S-KS-Q-027-rev.2	SAMPLE COMPOSITING
S-KS-Q-028-rev.4	CUSTOMER COMPLAINT RESOLUTION
S-KS-Q-029-rev.1	LABORATORY HOUSEKEEPING
S-KS-Q-030-rev.1	MCL VIOLATION REPORTING
S-KS-Q-031-rev.1	SPREADSHEET VALIDATION
S-KS-Q-032-rev.1	LIMIT OF DETECTION
S-KS-Q-033-rev.0	REVIEW OF ANALYTICAL REQUESTS
S-KS-Q-034-rev.0	MANAGEMENT OF CHANGE
S-KS-Q-035-rev.0	PROFICIENCY TESTING PROGRAM
S-KS-Q-036-rev.1	SUPPORT EQUIPMENT
S-KS-Q-037-rev.0	PREPARATION OF SOPS
S-KS-Q-038-rev.1	CORRECTIVE AND PREVENTIVE ACTIONS
S-KS-Q-039-rev.1	INTERNAL AND EXTERNAL AUDITS
S-KS-Q-040-rev.1	VENDOR QUALIFICATION
S-KS-Q-041-rev.1	MANUAL INTEGRATION
S-KS-Q-042-rev.0	MONITORING STORAGE UNITS

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SOP Number	SOP Title
S-KS-Q-043-rev.0	STANDARD/ REAGENT PREPARATION AND TRACEABILITY
S-KS-Q-044-rev.0	CONTROL CHART GENERATION AND ANALYSIS
S-KS-Q-045-rev.0	DOCUMENT MANAGEMENT
S-KS-Q-046-rev.1	SAMPLE HOMOGENIZATION AND SUB-SAMPLING
S-KS-S-002-rev.4	WASTE HANDLING
S-KS-S-003-rev.1	WASTE MGMT TRAINING REQUIREMENTS
S-KS-S-004-rev.2	WORKING ALONE
S-KS-S-005-rev.1	CONTINGENCY PLAN
S-KS-S-006-rev.0	RESPIRATOR USAGE

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ATTACHMENT IX- LABORATORY CERTIFICATION LIST (CURRENT AS OF ISSUE DATE)

SCOPE AND APPLICATION CERTIFICATES ARE MAINTAINED AND FILED IN THE LOCAL QUALITY DEPARTMENT

State	Program	Accrediting Body	Certificate Number	Expiration Date
Arkansas	Hazardous Waste	Department of Environmental Quality	14-019-0	2/2/2015
Arkansas	Wastewater	Department of Environmental Quality	14-019-0	2/2/2015
Illinois	Non Potable Water	Environmental Protection Agency	002885	2/2/2015
Illinois	Solid and Chemical Materials	Environmental Protection Agency	002885	2/4/2015
Iowa	Solid Waste and Contaminated Sites	Department of Natural Resources	118	7/1/2014
Iowa	Underground Storage Tank	Department of Natural Resources	118	7/1/2014
Iowa	Wastewater	Department of Natural Resources	118	7/1/2014
Kansas	Drinking Water	Department of Health & Environment	E-10116	4/30/2015
Kansas	Non Potable Water	Department of Health & Environment	E-10116	4/30/2015
Kansas	Solid / Chemical Waste	Department of Health & Environment	E-10116	4/30/2015
Louisiana	Non Potable Water	Department of Environmental Quality	03055	6/30/2015
Louisiana	Solid Chemical Materials	Department of Environmental Quality	03055	6/30/2015
Minnesota	Clean Water Program	Department of Health	375495	12/31/2014
Nevada	Non Potable Water	Division of Environmental Protection	KS000212015	7/31/2015
Nevada	Solid & Waste Materials	Division of Environmental Protection	KS000212015	7/31/2015
Oklahoma	Non Potable Water	Department of Environmental Quality	2013-027, -028	8/31/2014
Oklahoma	Solids	Department of Environmental Quality	2013-027, -028	8/31/2014
Texas	Non Potable Water	Commission on Environmental Quality	T104704407-11-2	9/30/2014
Texas	Solid & Chemical Material	Commission on Environmental Quality	T104704407-11-2	9/30/2014
Texas	Wastewater	Commission on Environmental Quality	T104704407-11-2	9/30/2014
USDA	Foreign Soil Import	APHIS-PPQ	P330-12-00088	3/30/2015
Utah	Non Potable Water (CWA)	Department of Health	KS000212014-4	5/31/2015
Utah	Non Potable Water (RCRA)	Department of Health	KS000212014-4	5/31/2015
Utah	Solid & Hazardous Material	Department of Health	KS000212014-4	5/31/2015
Wyoming	Storage Tank Program	A2LA	2456.01	7/31/2014

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ATTACHMENT X - PACE CHAIN-OF-CUSTODY (CURRENT AS OF ISSUE DATE)

Pace Analytical™
www.pacelabs.com

CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page: of

Section A Required Client Information:	Section B Required Project Information:	Section C Invoice Information:
Company:	Report To:	Attention:
Address:	Copy To:	Company Name:
		Address:
Email To:	Purchase Order No.:	Pace Quote Reference:
Phone: Fax:	Project Name:	Pace Project Manager:
Requested Due Date/TAT:	Project Number:	Pace Profile #:

REGULATORY AGENCY

☐ NPDES ☐ GROUND WATER ☐ DRINKING WATER
☐ UST ☐ RCRA ☐ OTHER _____

Site Location STATE: _____

Section D Required Client Information

SAMPLE ID (A-Z, 0-9 / ,-) Sample IDs MUST BE UNIQUE

Matrix Codes MATRIX / CODE: Drinking Water DW; Water WT; Waste Water WW; Product P; Soil/Solid SL; Oil OL; Wipe WP; Air AR; Tissue TS; Other OT

ITEM #	SAMPLE ID	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED: COMPOSITE START DATE	COMPOSITE START TIME	COMPOSITE END/GRAB DATE	COMPOSITE END/GRAB TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Preservatives: Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	Analysis Test (Y/N)	Requested Analysis Filtered (Y/N)	Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
1																					
2																					
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					
11																					
12																					

ADDITIONAL COMMENTS:	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS

SAMPLER NAME AND SIGNATURE

PRINT Name of SAMPLER:

SIGNATURE of SAMPLER: DATE Signed (MM/DD/YY):

Temp in °C | Received on Ice (Y/N) | Custody Sealed Cooler (Y/N) | Samples Intact (Y/N)

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ATTACHMENT XI - METHOD HOLD TIME, CONTAINER AND PRESERVATION GUIDE (CURRENT AS OF ISSUE DATE)

THE HOLDING TIME INDICATED IN THE CHART BELOW IS THE MAXIMUM ALLOWABLE TIME FROM COLLECTION TO EXTRACTION AND/OR ANALYSIS PER THE ANALYTICAL METHOD. FOR METHODS THAT REQUIRE PROCESSING PRIOR TO ANALYSIS, THE HOLDING TIME IS DESIGNATED AS 'PREPARATION HOLDING TIME/ANALYSIS HOLDING TIME'.

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Acidity	SM2310B	Water	Plastic/Glass	≤ 6°C	14 Days
Actinides	HASL-300	Water		pH<2 HNO_3	180 Days
Actinides	HASL-300	Solid		None	180 Days
Alkalinity	SM2320B/310.2	Water	Plastic/Glass	≤ 6°C	14 Days
Alkylated PAHs		Water		≤ 6°C; pH<2 1:1 HCl (optional)	14/40 Days preserved; 7/40 Days unpreserved
Alkylated PAHs		Solid		≤ 10°C	1 Year/40 Days
Total Alpha Radium (see note 3)	9315/903.0	Water	Plastic/Glass	pH<2 HNO_3	180 days
Total Alpha Radium (see note 3)	9315	Solid		None	180 days
Anions (Br, Cl, F, NO_2, NO_3, o-Phos, SO_4, bromate, chlorite, chlorate)	300.0/300.1/SM4110B	Water	Plastic/Glass	≤ 6°C; EDA if bromate or chlorite run	All analytes 28 days except: NO_2, NO_3, o-Phos (48 Hours); chlorite (immediately for 300.0; 14 Days for 300.1). NO_2/NO_3 combo 28 days.
Anions (Br, Cl, F, NO_2, NO_3, o-Phos, SO_4, bromate, chlorite, chlorate)	300.0	Solid	Plastic/Glass	≤ 6°C	All analytes 28 days except: NO_2, NO_3, o-Phos (48 hours); chlorite (immediately). NO_2/NO_3 combo 28 days.
Anions (Br, Cl, F, NO_2, NO_3, o-Phos, SO_4	9056	Water/ Solid	Plastic/Glass	≤ 6°C	28 days
Aromatic and Halogenated Volatiles (see note 1)	8021	Solid	5035 vial kit	See note 1	14 days
Aromatic and Halogenated Volatiles	602/8021	Water	40mL vials	pH<2 HCl; ≤ 6°C; $Na_2S_2O_3$ if Cl present	14 Days (7 Days for aromatics if unpreserved)
Acid Volatile Sulfide	Draft EPA 1629	Solid	8oz Glass	≤ 6°C	14 Days
Bacteria, Total Plate Count	SM9221D	Water	Plastic/WK	≤ 6°C; $Na_2S_2O_3$	24 Hours
Base/Neutrals and Acids	8270	Solid	8oz Glass	≤ 6°C	14/40 Days
Base/Neutrals and Acids	625/8270	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
Base/Neutrals, Acids & Pesticides	525.2	Water	1L Amber Glass	pH<2 HCl; ≤ 6°C; Na sulfite if Cl present	14/30 Days
Biomarkers		Water	≤ 6°C; pH<2 1:1 HCl (optional)	14/40 Days preserved; 7/40 Days unpreserved	≤ 6°C; pH<2 1:1 HCl (optional)
Biomarkers		Solid	≤ 10°C	1 Year/40 Days	≤ 10°C

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Parameter	Method	Matrix	Container	Preservative	Max Hold Time
BOD/cBOD	SM5210B	Water	Plastic/Glass	≤ 6°C	48 hours
BTEX/Total Hydrocarbons	TO-3	Air	Summa Canister	None	14 Days
BTEX/Total Hydrocarbons	TO-3	Air	Tedlar Bag or equivalent	None	48 Hours
Carbamates	531.1	Water	Glass	$Na_2S_2O_3$, Monochloroacetic acid pH <3; ≤ 6°C	28 Days
Cation/Anion Balance	SM1030E	Water	Plastic/Glass	None	None
Cation Exchange	9081	Solid	8oz Glass	None	unknown
Chloride	SM4500Cl-C,E	Water	Plastic/Glass	None	28 Days
Chlorine, Residual	SM4500Cl-D,E,G/330.5/Hach 8167	Water	Plastic/Glass	None	15 minutes
Chlorophyll	SM10200H	Water	Opaque bottle or aluminum foil	≤ 6°C	48 Hours to filtration
COD	SM5220C, D/410.4/Hach 8000	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Coliform, Fecal	SM9222D	Water	100mL Plastic	≤ 6°C	8 Hours
Coliform, Fecal	SM9222D	Solid	100mL Plastic	≤ 6°C	8 Hours
Coliform, Fecal	SM9221E	Water	100mL Plastic	≤ 6°C	8 Hours
Coliform, Fecal	SM9221E	Solid	100mL Plastic	≤ 6°C	24 Hours
Coliform, Total	SM9222B	Water	100mL Plastic	≤ 6°C	8 Hours
Coliform, Total	SM9221B	Solid	100mL Plastic	≤ 6°C	8 Hours
Coliform, Total and E. coli	SM9223B	Drinking Water	100mL Plastic	≤ 10°C	30 Hours after collection
Color	SM2120B,E	Water	Covered Plastic/Acid Washed Amber Glass	≤ 6°C	24 Hours
Condensable Particulate Emissions	EPA 202	Air	Solutions	None	180 Days
Cyanide, Reactive	SW846 chap.7	Water	Plastic/Glass	None	28 Days
Cyanide, Reactive	SW846 chap.7	Solid	Plastic/Glass	None	28 Days
Cyanide, Total and Amenable	SM4500CN-A,B,C,D,E,G,I,N/9010/9012/335.4	Water	Plastic/Glass	pH≥12 NaOH; ≤ 6°C; ascorbic acid if Cl present	14 Days (24 Hours if sulfide present- applies to SM4500CN only)
Diesel Range Organics-Alaska DRO	AK102	Solid	8oz Glass	≤ 6°C	14/40 Days
Diesel Range Organics-Alaska DRO	AK102	Water	1L Glass	pH<2 HCl; ≤ 6°C	14/40 Days
Diesel Range Organics-TPH DRO	8015	Solid	8oz Glass Jar	≤ 6°C	14/40 Days
Diesel Range Organics-TPH DRO	8015	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
Diesel Range Organics-TPH DRO	8015	Tissue	1L Amber Glass	≤ - 10°C	1 Year if frozen/40 Days
Diesel Range Organics-NwTPH-Dx	Nw-TPH-Dx	Solid	8oz Glass Jar	≤ 6°C	14/40 Days
Diesel Range Organics-NwTPH-Dx	Nw-TPH-Dx	Water	1L Amber Glass	pH <2 HCl; ≤ 6°C	14/40 Days; 7 Days from collection to extraction if unpreserved
Diesel Range Organics-Wisconsin DRO	WI MOD DRO	Solid	Tared 4oz Glass Jar	≤ 6°C	10/47 Days

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Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Diesel Range Organics-Wisconsin DRO	WI MOD DRO	Water	1L Amber Glass	≤ 6°C; pH <2 HCl	14/40 Days
Dioxins and Furans	1613B	Solid	8oz Glass	≤ 6°C	1 year
Dioxins and Furans	1613B	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	1 year
Dioxins and Furans	1613B	Fish/ Tissue	Aluminum foil	≤ 6°C	1 year
Dioxins and Furans	8290	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	30/45 Days
Dioxins and Furans	8290	Solid	8oz Glass	≤ 6°C	30/45 Days
Dioxins and Furans	8290	Fish/ Tissue	Not specified	< -10°C	30/45 Days
Dioxins and Furans	TO-9	Air	PUF	None	30/45 Days
Diquat/Paraquat	549.2	Water	Amber Plastic	≤ 6°C; $Na_2S_2O_3$	7/21 Days
EDB/DBCP (8011) EDB/DBCP/1,2,3-TCP (504.1)	504.1/8011	Water	40mL vials	≤ 6°C; $Na_2S_2O_3$ if Cl present	14 Days
Endothall	548.1	Water	Amber Glass	≤ 6°C; $Na_2S_2O_3$	7/14 Days
Enterococci	EPA 1600	Water	100mL Plastic	≤ 6°C	8 Hours
Explosives	8330/8332	Water	1L Amber Glass	≤ 6°C	7/40 Days
Explosives	8330/8332	Solid	8oz Glass Jar	≤ 6°C	14/40 Days
Extractable Petroleum Hydrocarbons (aliphatic and aromatic)	MA-EPH	Water	1L Amber Glass	pH<2 HCl; ≤ 6°C	14/40 Days
Extractable Petroleum Hydrocarbons (aliphatic and aromatic)	MA-EPH	Solid	4oz Glass Jar	≤ 6°C	7/40 Days
Fecal Streptococci	SM9230B	Water	100mL Plastic	≤ 6°C	8 Hours
Ferrous Iron	SN3500Fe-D; Hach 8146	Water	Glass	None	Immediate
Flashpoint/Ignitability	1010	Liquid	Plastic/Glass	None	28 Days
Florida PRO	FL PRO DEP (11/1/95)	Liquid	Glass, PTFE lined cap	≤ 6°C; pH <2 H_2SO_4 or HCl	7/40 Days
Fluoride	SM4500Fl-C,D	Water	Plastic	None	28 Days
Gamma Emitting Radionuclides	901.1	Water	Plastic/Glass	pH<2 HNO_3	180 days
Gasoline Range Organics	8015	Water	40mL vials	pH<2 HCl	14 Days
Gasoline Range Organics	8015	Solid	5035 vial kit	See note 1	14 days
Gasoline Range Organics- Alaska GRO	AK101	Solid	5035 vial kit	See 5035 note*	28 Days if GRO only (14 Days with BTEX)
Gasoline Range Organics- Alaska GRO	AK101	Water	40mL vials	pH<2 HCl; ≤ 6°C	14 Days
Gasoline Range Organics- NwTPH-Gx	Nw-TPH-Gx	Water	40mL vials	pH<2 HCl; ≤ 6°C	7 Days unpreserved; 14 Days preserved
Gasoline Range Organics- NwTPH-Gx	Nw-TPH-Gx	Solid	40mL vials	≤ 6°C; packed jars with no headspace	14 Days
Gasoline Range Organics- Wisconsin GRO	WI MOD GRO	Water	40mL vials	pH<2 HCl; ≤ 6°C	14 Days
Gasoline Range Organics- Wisconsin GRO	WI MOD GRO	Solid	40mL MeOH vials	≤ 6°C in MeOH	21 Days

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Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Glyphosate	547	Water	Glass	≤ 6°C; $Na_2S_2O_3$	14 Days (18 Months frozen)
Gross Alpha (NJ 48Hr Method)	NJAC 7:18-6	Water	Plastic/Glass	pH<2 HNO_3	48 Hrs
Gross Alpha and Gross Beta	9310/900.0	Water	Plastic/Glass	pH<2 HNO_3	180 Days
Gross Alpha and Gross Beta	9310	Solid	Glass	None	180 Days
Haloacetic Acids	552.1/552.2	Water	40mL Amber vials	NH_4Cl; ≤ 6°C	14/7 Days if extracts stored ≤ 6°C or 14/14 Days if extracts stored at ≤ -10°C
Hardness, Total ($CaCO_3$)	SM2340B,C/130.1	Water	Plastic/Glass	pH<2 HNO_3	6 Months
Heterotrophic Plate Count (SPC/HPC)	SM9215B	Water	100mL Plastic	≤ 6°C	24 Hours
Heterotrophic Plate Count (SPC/HPC)	SimPlate	Water	100mL Plastic	≤ 6°C	8 Hours
Herbicides, Chlorinated	8151	Solid	8oz Glass Jar	≤ 6°C	14/40 Days
Herbicides, Chlorinated	8151	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
Herbicides, Chlorinated	515.1/515.3	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	14/28 Days
Hexavalent Chromium	7196/218.6/SM3500Cr-B, C, D	Water	Plastic/Glass	≤ 6°C	24 Hours (see note 4)
Hexavalent Chromium	7196/218.6/SM3500Cr-B, C, D	Water	Plastic/Glass	Ammonium Buffer pH 9.3-9.7	28 Days (see note 4)
Hexavalent Chromium	218.6/218.7	Drinking Water	Plastic/Glass	Ammonium Buffer pH >8	14 Days (see note 4)
Hexavalent Chromium	7196 (with 3060A)	Solid		≤ 6°C	24 Hours after extraction
Hydrogen Halide and Halogen Emissions	EPA 26	Air	Solutions	None	6 Months
Ignitability of Solids	1030	Non-liquid Waste	Plastic/Glass	None	28 Days
Lead Emissions	EPA 12	Air	Filter/Solutions	None	6 Months
Lipids	Pace Lipids	Tissue	Plastic/Glass	≤ -10°C	1 Year if frozen
Mercury, Low-Level	1631E	Solid	Glass	None	28 Days
Mercury, Low-Level	1631E	Water	Fluoropolymer bottles (Glass if Hg is only analyte being tested)	12N HCl or BrCl	48 Hours for preservation or analysis; 28 Days to preservation if sample oxidized in bottle; 90 Days for analysis if preserved
Mercury, Low-Level	1631E	Tissue	Plastic/Glass	≤ - 10°C	28 Days if frozen
Mercury	7471	Solid	8oz Glass Jar	≤ 6°C	28 Days
Mercury	7470/245.1/245.2	Water	Plastic/Glass	pH<2 HNO_3	28 Days
Mercury	7471/245.6	Tissue	Plastic/Glass	≤ - 10°C	28 Days if frozen
Metals (GFAA)	7000/200.9	Water	Plastic/Glass	pH<2 HNO_3	180 Days
Metals (ICP)	NIOSH 7300A/7303	Air	Filters	None	180 Days
Metals (ICP/ICPMS)	6010/6020	Solid	8oz Glass Jar	None	180 Days
Metals (ICP/ICPMS)	6010/6020/200.7/200.8	Water	Plastic/Glass	pH<2 HNO_3	180 Days
Metals (ICP/ICPMS)	6020	Tissue	Plastic/Glass	≤ -10°C	180 Days if frozen
Methane, Ethane,	8015 modified	Water	40mL vials	HCl	14 Days

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Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Ethene					
Methane, Ethane, Ethene	RSK-175	Water	40mL vials	HCl	14 Days
Methane, Ethane, Ethene	EPA 3C	Air	Summa Canister	None	14 Days
Methane, Ethane, Ethene	EPA 3C	Air	Tedlar Bag or equivalent	None	48 Hours
Methanol, Ethanol	8015 modified	Water	40mL vials	≤ 6°C	14 Days
Methanol, Ethanol	8015 modified	Solid	2oz Glass	≤ 6°C	14 Days
Nitrogen, Ammonia	SM4500NH3/350.1	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Nitrogen, Kjeldahl (TKN)	351.2	Solid	Plastic/Glass	≤ 6°C	28 Days
Nitrogen, Kjeldahl (TKN)	SM4500-Norg/351.2	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Nitrogen, Nitrate	SM4500-NO3/352.1	Water	Plastic/Glass	≤ 6°C	24 Hours preferred
Nitrogen, Nitrate & Nitrite combination	353.2	Solid	Plastic/Glass	≤ 6°C	28 Days
Nitrogen, Nitrate & Nitrite combination	SM4500-NO3/353.2	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Nitrogen, Nitrite or Nitrate separately	SM4500-NO2/353.2	Water	Plastic/Glass	≤ 6°C	48 Hours
Nitrogen, Organic	SM4500-Norg/351.2	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Non-Methane Organics	EPA 25C	Air	Summa Canister	None	14 Days
Non-Methane Organics	EPA 25C	Air	Tedlar Bag or equivalent	None	48 Hours
Odor	SM2150B	Water	Glass	≤ 6°C	24 Hours
Oil and Grease/HEM	1664A/SM5520B/9070	Water	Glass	pH<2 H_2SO_4 or HCl; ≤ 6°C	28 Days
Oil and Grease/HEM	9071	Solid	Glass	≤ 6°C	28 Days
PBDEs	1614	Water	1L Amber Glass	≤ 6°C	1 Year/1 Year
PBDEs	1614	Solid	Wide Mouth Jar	≤ 6°C	1 Year/1 Year
PBDEs	1614	Tissue	Aluminum Foil	≤ -10°C	1 Year/1 Year
PCBs and Pesticides, Organochlorine (OC)	TO-4/TO-10	Air	PUF	None	7/40 Days
PCBs and Pesticides, Organochlorine (OC)	608	Water	1L Amber Glass		Pest: 7/40 Days; PCB: 1 Year/1 Year
PCBs, Pesticides (OC), Herbicides	508.1	Water	Glass	Na2SO3; pH<2 HCl; ≤ 6°C	14/30 Days
Perchlorate	331	Water	Plastic/Glass	>0-6°C	28 Days
Pesticides, Organochlorine (OC)	8081	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
Pesticides, Organochlorine (OC)	8081	Solid	8oz Glass Jar	≤ 6°C	14/40 Days
Pesticides, Organochlorine (OC)	8081	Tissue	8oz Glass Jar	≤ -10°C	1 Year if frozen/40 Days
Pesticides, Organophosphorous (OP)	8141	Solid	8oz Glass Jar	≤ 6°C	14/40 Days
Pesticides, Organophosphorous (OP)	8141	Water	1L Amber Glass	pH 5-8 with NaOH or H_2SO_4; ≤ 6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
PCBs (Aroclors)	8082	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	1 Year/1 Year
PCBs (Aroclors)	8082	Solid	8oz Glass Jar	≤ 6°C	1 Year/1 Year

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Parameter	Method	Matrix	Container	Preservative	Max Hold Time
PCBs (Aroclors)	8082	Tissue	Plastic/Glass	≤ -10°C	1 Year if frozen/1 Year
PCB Congeners	1668A	Water	1L Amber Glass	≤ 6°C but above freezing	1 Year/1 Year
PCB Congeners	1668A	Solid	4-8oz Glass Jar	≤ 6°C but above freezing	1 Year/1 Year
PCB Congeners	1668A	Tissue	4-8oz Glass Jar	≤ -10°C	1 Year/1 Year
Oil Range Organics-ORO					
Oxygen, Dissolved (Probe)	SM4500-O	Water	Glass	None	15 minutes
Paint Filter Liquid Test	9095	Water	Plastic/Glass	None	N/A
Particulates	PM-10	Air	Filters	None	180 Days
Permanent Gases	EPA 3C	Air	Summa Canister	None	14 Days
Permanent Gases	EPA 3C	Air	Tedlar Bag or equivalent	None	48 Hours
pH	SM4500H+B/9040	Water	Plastic/Glass	None	15 minutes
pH	9045	Solid	Plastic/Glass	None	
Phenol, Total	420.1/420.4/9065/9066	Water	Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Phosphorus, Orthophosphate	SM4500P/365.1/365.3	Water	Plastic	Filter; ≤ 6°C	Filter within 15 minutes, Analyze within 48 Hours
Phosphorus, Total	SM4500P/ 365.1/365.3/365.4	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Phosphorus, Total	365.4	Solid	Plastic/Glass	≤ 6°C	28 Days
Polynuclear Aromatic Hydrocarbons (PAH)	TO-13	Air	PUF	None	7/40 Days
Polynuclear Aromatic Hydrocarbons (PAH)	8270 SIM	Solid	8oz Glass Jar	≤ 6°C	14/40 Days
Polynuclear Aromatic Hydrocarbons (PAH)	8270 SIM	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
Polynuclear Aromatic Hydrocarbons (PAH)	8270 SIM	Tissue	Plastic/Glass	≤ -10°C	1 Year if frozen/40 Days
Radioactive Strontium	905.0	Water	Plastic/Glass	pH<2 HNO_3	180 days
Radium-226	903.0/903.1	Water	Plastic/Glass	pH<2 HNO_3	180 days
Radium-228 (see note 3)	9320/904.0	Water	Plastic/Glass	pH<2 HNO_3	180 days
Radium-228 (see note 3)	9320	Solid			
Residual Range Organics- Alaska RRO	AK103	Solid	8oz Glass	≤ 6°C	14/40 Days
Saturated Hydrocarbons		Water	≤ 6°C; pH<2 1:1 HCl (optional)	14/40 Days preserved; 7/40 Days unpreserved	≤ 6°C; pH<2 1:1 HCl (optional)
Saturated Hydrocarbons		Solid	≤ 10°C	1 Year/40 Days	≤ 10°C
Silica, Dissolved	SM4500Si-D	Water	Plastic	≤ 6°C	28 Days
Solids, Settleable	SM2540F	Water	Glass	≤ 6°C	48 Hours
Solids, Total	SM2540B	Water	Plastic/Glass	≤ 6°C	7 Days
Solids, Total	SM2540G	Solid	Plastic/Glass	≤ 6°C	7 Days
Solids, Total (FOC, OM, Ash)	ASTM D2974	Solid	Plastic/Glass	≤ 6°C	7 Days
Solids, Total Dissolved	SM2540C	Water	Plastic/Glass	≤ 6°C	7 Days
Solids, Total Suspended	SM2540D/USGS I-3765-85	Water	Plastic/Glass	≤ 6°C	7 Days
Solids, Total Volatile	160.4/SM2540E	Water	Plastic/Glass	≤ 6°C	7 Days
Solids, Total Volatile	160.4	Solid	Plastic/Glass	≤ 6°C	7 Days
Specific Conductance	SM2510B/9050/120.1	Water	Plastic/Glass	≤ 6°C	28 Days

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Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Stationary Source Dioxins and Furans	EPA 23	Air	XAD Trap	None	30/45 Days
Stationary Source Mercury	EPA 101	Air	Filters	None	180 Days, 28 Days for Hg
Stationary Source Metals	EPA 29	Air	Filters	None	180 Days, 28 Days for Hg
Stationary Source PM10	EPA 201A	Air	Filters	None	180 Days
Stationary Source Particulates	EPA 5	Air	Filter/Solutions	None	180 Days
Sulfate	SM4500SO4/9036/ 9038/375.2/ASTM D516	Water	Plastic/Glass	$\leq 6°C$	28 Days
Sulfide, Reactive	SW-846 Chap.7	Water	Plastic/Glass	None	28 Days
Sulfide, Reactive	SW-846 Chap.7	Solid	Plastic/Glass	None	28 Days
Sulfide, Total	SM4500S/9030	Water	Plastic/Glass	pH>9 NaOH; ZnOAc; $\leq 6°C$	7 Days
Sulfite	SM4500SO3	Water	Plastic/Glass	None	15 minutes
Surfactants (MBAS)	SM5540C	Water	Plastic/Glass	$\leq 6°C$	48 Hours
Total Organic Carbon (TOC)	SM5310B,C,D/9060	Water	Glass	pH<2 H_2SO_4 or HCl; $\leq 6°C$	28 Days
Total Organic Carbon (TOC)	9060/Walkley Black	Solid	Glass	$\leq 6°C$	14 Days
Total Organic Halogen (TOX)	SM5320/9020/9021	Water	Glass; no headspace	$\leq 6°C$	14 Days
Tritium	906.0	Water	Glass	None	180 days
Turbidity	SM2130B/180.1	Water	Plastic/Glass	$\leq 6°C$	48 Hours
Total Uranium	908.0/ASTM D5174-97	Water	Plastic/Glass	pH<2 HCl	180 days
Volatile Petroleum Hydrocarbons (aliphatic and aromatic)	MA-VPH	Water	40mL vials	pH<2 HCl; $\leq 6°C$	14 Days preserved
Volatile Petroleum Hydrocarbons (aliphatic and aromatic)	MA-VPH	Solid	4-8oz Glass Jar	$\leq 6°C$; packed jars with no headspace	7/28 Days
Volatiles	TO-14	Air	Summa Canister	None	30 Days
Volatiles	TO-14	Air	Tedlar Bag or equivalent	None	48 Hours
Volatiles	TO-15	Air	Summa Canister	None	30 Days
Volatiles	TO-18/8260	Air	Tedlar Bag or equivalent	None	72 Hours
Volatiles	8260	Solid	5035 vial kit	See note 1	14 days
Volatiles	8260	Water	40mL vials	pH<2 HCl; $\leq 6°C$; $Na_2S_2O_3$ if Cl present	14 Days
Volatiles	8260	Conc. Waste	5035 vial kit or 40mL vials	$\leq 6°C$	14 Days
Volatiles	624	Water	40mL vials	pH<2 HCl; $\leq 6°C$; $Na_2S_2O_3$ if Cl present	14 Days (7 Days for aromatics if unpreserved)
Volatiles (see note 2)	524.2	Water	40mL vials (in duplicate)	pH<2 HCl; $\leq 6°C$; Ascorbic acid or $Na_2S_2O_3$ if Cl present[2]	14 Days
UCMR3 Metals	200.8	Water	Plastic or glass	pH<2 HNO_3	28 Days
UCMR3 Hexavalent Chromium	218.7	Water	HDPE or propylene	$Na_2CO_3/NaHCO_3/(NH_4)_2SO_4$; pH>8	14 Days
UCMR3 Chlorate	300.1	Water	Plastic or glass	EDA	28 Days
UCMR3 Hormones	539	Water	Amber glass	$Na_2S_2O_3$, 2-mercaptopyridine-1-	28 Days

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Parameter	Method	Matrix	Container	Preservative	Max Hold Time
				oxide, sodium salt	
UCMR3 Perfluorinated Compounds	537	Water	Polypropylene	Trizma®	14 Days
UCMR3 Volatiles	524.3	Water	40 mL amber glass vials	Ascorbic acid. Maleic acid pH~2	14 Days
UCMR3 1, 4 Dioxane	522	Water	Glass	Na_2SO_3, $NaHSO_4$; pH<4	28 Days
UV254	SM5910B	Water	Glass	$\leq 6°C$	48 Hours

[1] **5035/5035A Note**: 5035 vial kit typically contains 2 vials water, preserved by freezing **or**, 2 vials aqueous sodium bisulfate preserved at 4°C, **and** one vial methanol preserved at $\leq$6°C **and** one container of unpreserved sample stored at $\leq$6°C.

[2] Method 524.2 lists ascorbic acid as the preservative when residual chlorine is suspected, unless gases or Table 7 compounds are NOT compounds of interest and then sodium thiosulfate is the preservative recommended.

[3] Methods 9315 and 9320 both state that if samples are unpreserved, the samples should be brought to the lab within 5 days of collection, preserved in the lab, and then allowed to sit for a minimum of 16 hours before sample preparation/analysis.

[4] The holding time for hexavalent chromium may be extended by the addition of the ammonium buffer listed in EPA 218.6 per the 2012 EPA Method Update Rule. Although Method 218.6 stipulates a different pH range (9.0 to 9.5) for buffering, this method requirement was modified in the Method Update Rule to a pH range of 9.3 to 9.7.For non-potable waters, adjust the pH of the sample to 9.3 to 9.7 during collection with the method required ammonium sulfate buffer to extend the holding time to 28 days. For potable waters, addition of the buffer during collection will extend the holding time for 14 days per EPA 218.7 and the EPA UCMR3 program.

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STANDARD OPERATING PROCEDURE

AMMONIA BY METHOD 350.1

Reference Method: EPA Method 350.1

Local SOP Number:	S-KS-I-003-rev.11
Effective Date:	Date of Final Signature
Supersedes:	S-KS-I-003-rev.10

Approvals

Laboratory General Manager	11-21-14 Date
Laboratory Quality Manager	11-20-14 Date
Laboratory Inorganics Manager	11/20/14 Date

PERIODIC REVIEW

SIGNATURES BELOW INDICATE NO CHANGES HAVE BEEN MADE SINCE PREVIOUS APPROVAL.

Signature	Title	Date
Signature	Title	Date
Signature	Title	Date

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1. Purpose/Identification of Method

The purpose of this SOP is to provide a laboratory specific procedure for determining Ammonia Nitrogen (NH_3–N) by flow injection analysis, in water and soil samples meeting the requirements specified in method EPA 350.1 for waters and modified 350.1 for soils.

2. Summary of Method

Ammonia reacts with alkaline phenol, then with sodium hypochlorite to form indophenol blue. Sodium nitroprusside is added to enhance sensitivity. The absorbance of the reaction product is measured at 630 nm, and is directly proportional to the ammonia concentration in the sample.

3. Scope and Application

3.1. Personnel: The policies and procedures contained in this SOP are applicable to all personnel involved in the analytical method or non-analytical process.

3.2. Parameters: This SOP includes the measurement of ammonia (as nitrogen).

3.3. The procedure converts nitrogen components of biological origin such as amino acids, proteins and peptides to ammonia, but may not convert the nitrogen compounds of some industrial wastes such as amines, nitro compounds, hydrazones, oximes, semicarbazones and some refractory tertiary amines

4. Applicable Matrices

4.1. This method is applicable to drinking, surface and saline waters, domestic and industrial wastes, and soils.

5. Limits of Detection and Quantitation

5.1. The reporting limits (LOQ) for ammonia is 0.1 mg/L and 20 mg/kg as nitrogen. All current MDLs (LOD) are listed in the LIMS and are available by request from the Quality Manager.

6. Interferences

6.1. Calcium and magnesium ions may precipitate if present in sufficient concentration. An EDTA solution is added to samples in-line in order to prevent this problem.

6.2. Turbidity may interfere and is removed by manual filtration.

6.3. Color in the samples that absorbs in the photometric range used for analysis will interfere. Correct by running the sample through the manifold without color formation.

7. Sample Collection, Preservation, Shipment and Storage

Table 7.1 Sample Collection, Preservation, Shipment and Storage

Sample type	Collection per sample	Preservation	Storage	Hold time
Aqueous	Plastic, 250- or 500-mL	H_2SO_4 to pH <2.	≤6°C (not frozen)	28 days

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Sample type	Collection per sample	Preservation	Storage	Hold time
Soil	4- or 8-oz glass jar	None	≤6°C (not frozen)	Extraction: 28 days from collection. Analysis:28 days from extraction

8. Definitions

8.1. Definitions of terms found in this SOP are described in the Pace Analytical Services Quality Manual, Glossary Section.

9. Equipment and Supplies

Table 9.1 – Equipment and Supplies

Supply	Vendor	Model / Version	Comments
Analytical balance	Mettler-Toledo	AE240	Or equivalent
Automated Ion Analyzer	Lachat	QuikChem® 8500	Flow Injection Analysis
Volumetric flasks	Fisher	Class A	1-L, 500- and 100-mL
Centrifuge tubes	Fisher	06-443-19	50-mL

10. Reagents and Standards

Table 10.1 – Standard Storage Conditions

Standard Type	Description	Expiration	Storage
Stock Solutions	▪ Concentrated reference solution purchased directly from approved vendor	▪ Manufacturer's recommended expiration date	▪ Manufacturer's recommended storage conditions
Intermediate and Working Standard Solutions	▪ Reference solutions prepared by dilutions of the stock solution	▪ 3 months from preparation or the expiration date listed for the stock source, whichever is sooner. ▪ Working solutions must be checked frequently and replaced if degradation or evaporation is suspected.	▪ Manufacturer's recommended storage conditions for stock source solution.

Table 10.2 – Reagents and Standards

Reagent/Standard	Concentration/ Description	Vendor/ Item #
Ammonia-Nitrogen Standard	Spex CertiPrep,secondary standard	Fisher / AS-NH3N9-2Y or equivalent
EDTA, disodium salt dihydrate	ACS Reagent grade	Fisher / S311-500
Nitrogen Standard, as Ammonia	Ricca Chemical, primary standard	Fisher / 54554 or equivalent
Reagent water	ASTM Type II	SOP S-KS-Q-011 (latest revision)
Sodium hydroxide	ACS Reagent grade	Fisher / S318-3
Sodium hypochlorite, 6%	Aqua Solutions	Fisher / NC9933706
Sodium nitroferricyanide(III) dihydrate	ACS Reagent grade	/Fisher / S350-100
Sodium phenate solution	Ricca Chemical #7518-1	Fisher / 75181
Sulfuric acid	TraceMetal grade	Fisher / A510-SK-212

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10.1. Sodium Hypochlorite solution: Measure 250 mL of 6% sodium hypochlorite into a 500-mL volumetric flask, dilute to the mark with reagent water and invert to mix.

10.2. EDTA Buffer: Weigh 50.0g EDTA and 9.0g sodium hydroxide into a 1-L volumetric flask, dilute to the mark with reagent water and mix with magnetic stir bar until dissolved.

10.3. Sodium Nitroprusside solution.: Weigh 3.50 g sodium nitroferricyanide(III) dihydrate (sodium nitroprusside) into a 1-L volumetric flask, dilute to the mark with reagent water and invert to mix.

10.4. Carrier/Diluent solution: Add 2.0 mL sulfuric acid to a 1-L volumetric flask containing 900 mL of reagent water, dilute to the mark with reagent water and invert to mix.

10.5. Ammonia Stock solution: Measure 10.0 mL of the primary Ammonia-Nitrogen Standard into a 100-mL volumetric flask, dilute to the mark with reagent water and invert to mix. This will yield a concentration of 100 mg NH_3-N/L.

10.5.1. Prepare a calibration curve by adding the following aliquots of the Ammonia Stock solution to 100-mL volumetric flasks, diluting to the mark with Carrier/Diluent solution and inverting to mix:

Ammonia Stock solution, mL	Concentration, mg NH_3-N/L
0	0.0
0.1	0.1
0.5	0.5
1.0	1.0
2.0	2.0
3.0	3.0
5.0	5.0

10.6. Initial Calibration Verification (ICV) Stock: Measure 10.0 mL of the secondary Nitrogen Standard, as Ammonia into a 100-mL volumetric flask, dilute to the mark with reagent water and invert to mix. This will yield a concentration of 100 mg NH_3-N/L.

10.7. Initial Calibration Verification (ICV) solution: Measure a 3.0-mL aliquot of Initial Calibration Verification Stock into a 100-mL volumetric flask, dilute to the mark with reagent water and invert to mix. This will yield a concentration of 3.0 mg NH_3-N/L. Analyze immediately after each initial calibration.

10.8. Initial Calibration Blank/Continuing Calibration Blank solution (ICB/CCB): Use the Carrier/Diluent solution as the ICB and CCB.

11. Calibration and Standardization

11.1. Calibration Response Factors

11.1.1. Response factors (RF) establish the relationship of the instruments response in comparison with the concentration of any given analyte. To calculate the RF for any given calibration standard (or calibration verification standard), tabulate the detector response against concentration for phenol. Response factors are calculated using the following equation.

$$RF = \frac{C_x}{A_x}$$

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Where:

A_x = Detector response.
C_x = Concentration of the compound being measured (ug/mL).

11.2. Calibration Curve Fit

11.2.1. The calibration curve is a representation of the relationship of the instrument response and analyte concentration. The curve is used to quantitate the concentration of an unknown based on its response and this known relationship.

11.2.2. Linear Regression: The linear regression calibration curve is derived from a least squares regression analysis of the calibration points. A calibration curve based on this technique will have the format of y=ax+b where "a" is the slope of the line and "b" is the y-intercept. In order to use this curve fit technique, a minimum of five calibration points must be available and the origin cannot be included as one of the points. This technique works well for calibrations where the response of the instrument is linear in nature but does not necessarily intercept the y-axis at the origin. However, because the linear regression is not forced through the origin, very low levels of contaminants below the response of the lowest calibration point may generate erroneous reportable results. A calculation of the correlation coefficient "r" is used to determine the acceptability of a linear regressed curve.

11.3. Calibration Verification

11.3.1. Second Source Verification (SSV)

11.3.1.1. In addition to meeting the linearity criteria, any new calibration curve must be assessed for accuracy in the values generated. Accuracy is a function of both the "fit" of the curve to the points used and the accuracy of the standards used to generate the calibration points. By meeting the fit criteria, the accuracy relative to the goodness of fit is addressed. However, because all calibration points are from the same source, it is possible that the calibration points may meet linearity criteria but not be accurately made in terms of their true value.

11.3.1.2. Therefore, to assess the accuracy relative to the purity of the standards, a single standard from a secondary source must be analyzed and the results obtained must be assessed relative to the known true value. This step is referred to as ***Secondary Source Verification*** or, alternatively as ***Initial Calibration Verification***. This secondary source must be from an alternative vendor or, in the event an alternative vendor is not available, from a different lot from the same vendor. The accuracy of the standard is assessed as a percent difference from the true value according to the following equation:

$$\%\text{Drift} = \frac{(\text{Result}_{SSV} - \text{True Value}_{SSV})}{\text{True Value}_{SSV}} \times 100$$

11.3.2. Continuing Calibration Verification (CCV)

11.3.2.1. As part of the analytical process, the instrumentation must be checked periodically to determine if the response has changed significantly since the initial calibration was established. This verification process is known as Continuing Calibration Verification. The validity of the initial calibration is checked at the beginning of every analytical sequence and every 10 samples thereafter for as long as the instrument is analyzing samples and is accomplished by analyzing a midpoint calibration standard (CCV).

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11.3.2.2. The values obtained from the analysis of the CCV are compared to the true values and a percent change calculated. The percent change must meet the method specified criteria for the analysis to proceed for an additional 10 samples.

11.3.2.3. The actual determination of change in instrument response is based on the type of curve fit used for each analyte. Calibration curves based on linear regression are assessed based on the percent drift of the calculated result from the known true value of the standard. The equation for this calculation is as follows:

$$\%\text{Drift} = \frac{(\text{Result}_{CCV} - \text{True Value}_{CCV})}{\text{True Value}_{CCV}} \times 100$$

11.4. Calibration Linearity Problems

11.4.1. The lowest and/or highest level calibration standards may be removed from the calibration as long as the remaining number of concentration levels meets the minimum established by the method and standard operating procedure. For multi-parameter methods, this may be done on an individual analyte basis. The reporting limit must be adjusted to the lowest concentration remaining in the calibration curve and the upper limit of quantitation must be adjusted to the highest concentration remaining in the calibration curve.

11.4.2. Document instrument maintenance.

11.4.3. Complete recalibration of instrument.

11.4.4. Prepare and analyze new ICAL standards.

11.5. Continuing Verification Problems

11.5.1. Reanalyze the original CCV standard to determine instrument consistency.

11.5.2. Prepare and analyze a new CCV standard to determine preparation consistency / standard integrity.

11.5.3. Document instrument maintenance

11.5.4. Reanalyze CCV standard to determine if maintenance was effective in restoring performance.

11.5.5. Complete recalibration of instrument.

11.5.6. If samples were analyzed in spite of verification failures, note the exceptions for addressing those results. Deviations from this requirement must be noted on the injection log with a thorough explanation for the deviation from policy.

Table 11.1 Calibration Criteria

Calibration Metric	Parameter / Frequency	Criteria	Comments
Calibration Curve Fit	Linear Regression	≥ 0.995	If not met, remake standards and recalibrate. Instrument maintenance may be required if problem persists.
Initial Calibration Verification (ICV)	Immediately after each initial calibration	±10% of true value	May be reanalyzed once. A second failure confirms and requires re-preparation of standard and/or recalibration. If problem persists an alternative source standards may need to be obtained.

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Calibration Metric	Parameter / Frequency	Criteria	Comments
Initial Calibration Blank (ICB)	Immediately after each initial calibration verification.	Result should be less than the reporting limit. If results are reported to MDL, the ICB must also be evaluated to the MDL.	May be reanalyzed once. A second failure confirms and requires corrective action (e.g. re-preparation of standard(s) and/or recalibration) Exceptions: If sample results are reported to MDL and ICB is <RL but >MDL, then corrective action is not necessary other than appropriately qualifying the sample results. Unless the customer's QAPP or technical specification instruct to do otherwise. Samples that are <RL may be reported without qualification. (Not applicable to samples reporting down to MDL) Samples >10x ICB may be reported with appropriate qualification.
Continuing Calibration Verification (CCV)	Prior to the analysis of any samples and every 10 samples thereafter. Samples need to be bracketed with CCVs	±10% of true value	May be reanalyzed once. A second failure confirms and requires corrective action (e.g. Re-preparation and/or recalibration). **Exception:** If CCV fails high, then sample(s) that are <RL may be reported with appropriate qualification.
Continuing Calibration Blank (CCB)	Immediately after each continuing calibration verification.	Result should be less than the reporting limit. If results are reported to MDL, the ICB must also be evaluated to the MDL.	May be reanalyzed once. A second failure confirms and requires corrective action (e.g. re-preparation of standard(s) and/or recalibration) Exceptions: If sample results are reported to MDL and CCB is <RL but >MDL, then corrective action is not necessary other than appropriately qualifying the sample results. Unless the customer's QAPP or technical specification instruct to do otherwise. Samples that are <RL may be reported without qualification. (Not applicable to samples reporting down to MDL) Samples >10x ICB may be reported with appropriate qualification.

12. Procedure

12.1. Method Blank (MB)

12.1.1. Water: The water MB is Carrier/Diluent solution.

12.1.2. Soil: Prepare the MB by measuring 5 g of glass beads plus 50 mL of the Carrier/Diluent and place into a 50-mL centrifuge tube.

12.2. Laboratory Control Sample (LCS)

12.2.1. Water: Use an aliquot of ICV solution as the LCS. The true value of the LCS is 2.0 mg NH_3-N/L.

12.2.2. Soil: Prepare the LCS by measuring 5 g of glass beads plus 49 mL of Carrier/Diluent and place into a 50-mL centrifuge tube. Add 1.0 mL of the ICV spiking solution. This will yield a spike concentration of 20 mg NH_3-N/kg.

12.3. Matrix Spike (MS) UNCONTROLLED COPY

12.3.1. Water: Randomly select a sample from the analytical batch for matrix spiking. Place about 40 mL of the selected sample into a 50-mL centrifuge tube, spike with 1.0 mL of the ICV spiking solution, dilute to the mark with sample and invert several times to mix. The true value of the spike added is 2.0 mg NH_3-N/L.

12.3.2. Soil: Randomly select a sample from the analytical batch for matrix spiking. Weigh 5 g of the selected sample into a 50-mL centrifuge tube, spike with 1.0 mL of the ICV spiking solution and fill to the mark with Carrier/Diluent solution. Shake for 20 minutes and centrifuge for 10 minutes. The true value of the spike added is 20 mg NH_3-N/kg.

12.4. Client Samples:

12.4.1. Water: Sample may be diluted if the expected ammonia concentration is higher than the calibration curve.

12.4.2. Soils: Weigh 5 g of the sample into a 50-mL centrifuge tube and fill to the mark with Carrier/Diluent solution. Less sample size may be used if the expected ammonia concentration is higher than the calibration curve.

12.4.2.1. Place the centrifuge tubes on a shaker and shake for 20 minutes.

12.4.2.2. Remove from shaker and centrifuge for 10 minutes.

12.4.2.3. The supernatant liquid is now ready for analysis.

12.5. Analysis

12.5.1. Set up the Lachat to run the Ammonia method following the manufacturer's instructions.

12.5.2. Decant no less than 5 mL of the sample into the autosampler cups for analysis. (Note: if the liquid is turbid or has suspended sediment, filter a portion of the liquid into the autosampler cup).

12.5.3. Arrange the cups on the auto sampler tray in the order they appear on the worklist.

12.5.4. Be certain that the DQM is enabled to run the CCV/CCB prior to cup 1, after each group of ten samples, and at the end of the sequence.

12.5.5. Activate the autodilutor to ensure responses are with range of the initial calibration.

12.6. EPIC Posting

12.6.1. This is a one-step acode.

12.6.2. Export the data file to limslink. From limslink the data is posted to the LIMS and a runlog is created. The runlog is stored in G:/metals/lachat/runlogs/ammonia.

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13. Quality Control

Table 13.1 – Batch Quality Control Criteria

QC Sample	Components	Frequency	Acceptance Criteria	Corrective Action
Method Blank (MB)	Matrix specific; Carrier/Diluent solution or inert solid matrix	One per batch of up to 20 samples	Results should be less than the reporting limit. If results are reported to MDL, the MB must be evaluated to the MDL.	1) Re-analyze blank to confirm failure. 2) Qualify results and / or re-analyze associated samples. **Exceptions:** 1) If sample ND, report sample without qualification. 2) If sample result >10x MB report sample with appropriate qualifier indicating blank contamination. 3) If sample result <10x MB and sample cannot be reanalyzed report sample with appropriate qualifier to indicate an estimated value.
Laboratory Control Sample (LCS)	Matrix specific; Carrier/Diluent solution or inert solid matrix spiked with ammonia.	One per batch of up to 20 samples.	90-110%	1) Reanalyze the LCS to confirm failure 2) Re-prep and reanalyze associated samples. 3) If problem persists, check spike solution **Exceptions:** 1) If LCS > QC limits and these compounds are non-detect in the associated samples, the sample data may be reported with appropriate data qualifiers. 2) If LCS < QC limits and sample cannot be reanalyzed report sample with appropriate qualifier to indicate an estimated value. Client should be alerted to this condition.
Matrix Spike (MS)	Client sample spiked with ammonia.	One per 10 samples or 10% per batch of up to 20 samples.	90-110%	No corrective actions necessary. If LCS recovery is in range, the system is considered valid and the out-of-control MS/MSDs are footnoted appropriately by the analyst.
Duplicate	Sample duplicate	One per batch of up to 20 samples.	RPD limit 20%	No corrective actions necessary. Report outliers with comment.

14. Data Analysis and Calculations

Ammonia, mg/L = A × B

$$\text{Ammonia, mg/kg} = \frac{A \times B \times C}{D}$$

where:
A = concentration of mg NH3-N/L, of the sample read from the instrument.
B = dilution factor
C = final volume, mL.
D = soil aliquot weight, g.

15. Data Assessment and Acceptance Criteria for Quality Control Measures

15.1. See Table 13.1.

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16. Corrective Actions for Out-of-Control Data

16.1. See Tables 11.1 and 13.1.

17. Contingencies for Handling Out-of-Control or Unacceptable Data

17.1. See Tables 11.1 and 13.1. If there is no additional sample volume to perform re-analyses, if the analytical results are due to the customer, and/or if there is no more holding time remaining; then data will be reported as final with applicable qualifiers. If necessary, an official case narrative can be prepared by the Quality Manager or Project Manager.

18. Method Performance

18.1. All applicable personnel must read and understand this SOP with documentation of SOP review maintained in their training files.

18.2. Method Detection Limit (MDL) Study and Verification: An MDL study must be performed every six months for this method.

18.2.1. The MDL study must meet the criteria defined in S-KS-Q-032, Limit of Detection and Limit of Quantitation (or its equivalent revision or replacement).

18.2.2. The calculated MDL must then be verified.

18.2.2.1. Analyze a QC sample containing analytes at no more than 2-3X the MDL for single-analyte tests and 1-4X the MDL for multiple-analyte tests.

18.2.2.2. The QC sample must undergo the applicable sample preparation (e.g., soil extraction).

18.2.2.3. All target compounds must be detected (result greater than 0) to verify the calculated MDL.

18.3. Demonstration of Capability (DOC): Every analyst who performs this method must first document acceptable accuracy and precision by passing a demonstration of capability study (DOC) per S-ALL-Q-020, Training Procedures.

18.3.1. Analysis of four replicates of reagent water spiked with ammonia at a concentration of equivalent to the LCS.

18.3.2. Analysis of four replicates of an inert solid matrix (Ottawa sand, boiling chips, etc.) spiked with ammonia at a concentration of equivalent to the LCS.

18.3.3. If the average recovery meets the matrix-specific LCS criteria and the RSD of the replicates is <20%, system performance is acceptable and analysis of samples may begin. If, however, RSD >20% or average recovery falls outside LCS criteria, system performance is unacceptable. In this event, correct the problem and repeat the test.

19. Method Modifications

19.1. The method has been modified to analyze soil samples.

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19.2. The Linear Calibration Range (LCR) verification listed in method 351.2 has been modified in this SOP. In this SOP, the co-relation coefficient "r" obtained from the linear regression of the calibration is used to verify the LCR daily before sample analysis begins. If the co-relation coefficient "r" is ≥ 0.995, then the linearity of the calibration range is deemed acceptable.

20. Instrument/Equipment Maintenance

20.1. Inspect the sample and reagent lines prior to use, replace as needed. Prior to analysis verify proper flow. Replace lamp as needed. Rinse all lines after use.

21. Troubleshooting

21.1. See instrument manual.

22. Safety

22.1. The toxicity or carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a potential health hazard and exposure should be as low as reasonably achievable. Cautions are included for known extremely hazardous materials.

22.2. Each laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of Material Safety Data Sheets (MSDS) is made available to all personnel involved in the chemical analysis

22.3. MSDS sheets are located in the Quality Assurance Office and should be consulted prior to handling samples and standards.

22.4. Samples should be considered biological contact hazards. Use appropriate protective equipment (lab coat, gloves and lab glasses) and aseptic techniques when handling these samples. Wash hands with soap and water upon completion of the procedure and clean the work surface with a disinfectant.

23. Waste Management

23.1. Procedures for handling waste generated during this analysis are addressed in S-KS-S-002, Waste Handling.

23.2. In order to minimize the amount of waste generated during this procedure, analyst should prepare reagents in an amount which may be used in a reasonable amount of time (e.g., before a reagent expires).

24. Pollution Prevention

24.1. The company wide Chemical Hygiene and Safety Manual contains information on pollution prevention.

25. References

25.1. Pace Quality Assurance Manual - most current version.

25.2. National Environmental Laboratory Accreditation Conference (NELAC), Chapter 5, "Quality Systems"- most current version.

25.3. The NELAC Institute (TNI), Volume 1, Module 2, "Quality Systems"- most current version.

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25.4. Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; Analysis and Sampling Procedures, Federal Register Doc. No: 2012-10210, Final Methods Update Federal Register, Volume 72, Page 11200, Method Update Rule.

25.5. Methods for the Determination of Inorganic Substances in Environmental Samples, EPA/600/R-93/100, Method 350.1, Rev.2.0, August 1993.

25.6. QuickChem Methods Manual. "Ammonia (Phenolate) in Potable Surface Waters', p. 1-14, Method 10-107-06-1G, 12/14/2007.

26. Tables, Diagrams, Flowcharts, and Validation Data

26.1. Attachment 1: Client-Specific Criteria (Internal Use Only)

27. Revisions

Document Number	Reason for Change	Date
KS-I-2302-E	Grammatical/Removal of outdated information.	May 9, 2001
KS-I-2302-F	Grammatical/Removal of outdated information.	July 9, 2003
KS-I-003-rev.6	Grammatical/Removal of outdated information.	September 14, 2005
S-KS-I-003-rev.7	Sec. 9.3: Changed volumetric pipettes to calibrated eppendorf pippeters. Sec. 9.7: Removed degassing with Helium. Sec. 10: Reagents and Standards section – updated vendor and catalog number information. Sec. 10.8: Added calibration spiking soln. Preparation instructions and changed original 10.8 to 10.9. Sec. 10.10: Added instructions on preparation of ICB/CCB soln. Sec. 11.1: Removed Sec. 11.2: Changed wording from working stock solution to calibration spiking soln. Sec. 11.4: Changed wording on printing cal. Graph and procedure if cal. Curve fails. Sec. 11.5: added the word "half" to the phrase CCB must be less than half the PRL. Sec. 11.6: Added instructions on procedure if CCV/CCB set fail. Sec. 12.2.2: Changed wording from Calibration Working soln. To ICV Spiking soln. Sec. 12.4.1: Added SM reference to distillation section. Sec. 13.1-31: Revised QC content to be more specific.	November 8, 2007
S-KS-I-003-rev.8	SOP – Updated to corporate template format. Section 10 – Revised phenolate reagent. Section 11 – Revised for new instrument. Changed calibration point. Section 12 – Removed distillation. Changed spike volume for soil LCS. Section 13 – Added DOC procedure. Added second MS. Section 16 - Revised references	August 26, 2010
S-KS-I-003-rev.9	SOP - Updated to latest prescribed format. Section 14 – Revised water equation. Section 12 – Replaced reagent water with Carrier/Diluent, where appropriate. Section 18 – Inserted MDL procedure. Section 23 - Revised references. Attachment 1 – Inserted client-specific criteria.	February 5, 2013
S-KS-I-003-rev.10	Table 11.1 – Reworded some comments for clarity Section 18.2 – Revised MDL frequency to once every six months Section 19.2 – Added LCR verification by evaluation of co-relation coefficient	August 8, 2013
S-KS-I-003-rev.11	SOP - Updated to latest prescribed format. Added sections for Instrument/Equipment Maintenance and Troubleshooting. Table 10.2 – Revised for standards sourcing. Table 11.1 – Revised for corrective actions. Sectin 12.6 – Added LIMSLINK posting instructions. Table 13.1 – Revised for corrective actions. Sectin 18.2 – Changed MDL frequency to every 6 months. Section 19.2 – Added this section.	November 20, 2014

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Pace Analytical™

STANDARD OPERATING PROCEDURE

NITRATE-NITRITE BY AUTOMATED COLORIMETRY

Reference Methods: EPA Method 353.2

Local SOP Number:	S-KS-I-039-rev.15
Effective Date:	Date of Final Signature
Supersedes:	S-KS-I-039-rev.14

Approvals

Laboratory General Manager	Date: 8-10-15
Laboratory Quality Manager	Date: 8-10-15
Department Manager	Date: 8/10/15

PERIODIC REVIEW

SIGNATURES BELOW INDICATE NO CHANGES HAVE BEEN MADE SINCE PREVIOUS APPROVAL.

Signature	Title	Date

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1. Purpose/Identification of Method

1.1. This Standard Operating Procedure (SOP) documents the procedure for the determination of nitrate and nitrite nitrogen (NO_2-N, NO_3-N) in water samples based on EPA Method 353.2.

2. Summary of Method

2.1. A filtered sample is passed through a column containing granulated copper-cadmium to reduce nitrate to nitrite. The nitrite (that was originally present plus reduced nitrate) is determined by diazotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a highly colored azo dye that is measured colorimetrically at 520 nm.

2.2. Separate, rather than combined nitrate-nitrite, values are readily obtained by carrying out the procedure first with, and then without, the Cu-Cd reduction step.

3. Scope and Application

3.1. Personnel: The policies and procedures contained in this SOP are applicable to all personnel involved in the analytical method or non-analytical process

3.2. Parameters: This SOP applies to measurement of nitrate and nitrite, both singly and combined.

4. Applicable Matrices

4.1. This SOP is applicable to water and most solid samples, regardless of moisture content. Common matrices are ground and surface water, wastewater, aqueous sludge, sediment, soils, and other solid samples. Procedures may need to be adapted to address limits in the method or equipment that might hinder or interference with sample analysis. All adaptations made to address matrix related modifications must be documented within the analytical data.

5. Limits of Detection and Quantitation

5.1. The reporting limit (LOQ) for all analytes is 0.1 mg/L and 1.0 mg/kg for this method. All current MDLs are listed in the LIMS and are available by request from the Quality Manager.

6. Interferences

6.1. Build up of suspended matter in the reduction column will restrict sample flow. Since nitrate and nitrite are found in a soluble state, samples may be pre-filtered.

6.2. Low results might be obtained for samples that contain high concentrations of iron, copper or other metals. EDTA is added to the samples to eliminate this interference.

6.3. Residual chlorine can produce a negative interference by limiting reduction efficiency. Before analysis, samples should be checked and if required, dechlorinated with sodium thiosulfate.

6.4. Samples that contain large concentrations of oil and grease will coat the surface of the cadmium column granules. Pre-extracting the sample with an organic solvent eliminates this interference.

6.5. Method interferences may be caused by contaminants in the reagent water, reagents, glassware, and other sample processing apparatus that bias analyte response.

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7. Sample Collection, Preservation, Shipment and Storage

Sample type	Collection per sample	Preservation	Storage	Hold time
Aqueous NO_2-NO_3 (combined)	Plastic (500-mL)	Acidified w/ 1:1 H_2SO_4 (1-2 drops) to pH<2	≤6°C, but not freezing.	28 days
Aqueous NO_2 or NO_3 (individually)	Plastic (250-mL)	No preservation	≤6°C, but not freezing.	As soon as possible (within 48 hrs)
Solid NO_2 or NO_3 (individually)	Glass (4- or 8-oz)	No preservation	≤6°C	28 days (extraction) 48 hours (analysis)

8. Definitions

8.1. Definitions of terms found in this SOP are described in the Pace Analytical Services Quality Manual, Glossary Section.

9. Equipment and Supplies

Table 9.1 Equipment and Supplies

Supply	Vendor	Model / Version	Comments
Analytical Balance	Mettler-Toledo	AE200	or equivalent
Automated Continuous Flow Analyzer	Lachat Instruments	QuikChem® 8500 Series 2	Including: sampling device, multichannel pump, reaction unit or manifold, autodilutor, colorimetric detector and data recording device.
Volumetric flasks	Various	5, 10, 50,100, 1000, 2000-mL	Class A
Pippettor	Eppendorf	Various	
pH strips	Fisher	0-14 units	

10. Reagents and Standards

Table 10.1 – Stock Reagents and Stock Standards

Reagent/Standard	Concentration/ Description	Vendor/ Item #
Reagent water	ASTM Type II	SOP S-KS-Q-011 (latest revision)
Sodium hydroxide	ACS Reagent Grade	Fisher / S318
Ammonium chloride	ACS Reagent Grade	Fisher / A661-500
Disodium ethylenediamine tetraacetic acid dihydrate	ACS Reagent Grade	Fisher / S311-500
Copper (II) sulfate pentahydrate	≥99%	Fisher / AC19772-2500
Phosphoric acid (85%)	ACS Reagent Grade	Fisher / A242-212
Sulfanilamide	98%	Fisher / AC13285-5000
N-(1-Naphthyl)ethylenediamine dihydrochloride	98+%	Sigma / N-9125
Primary Nitrate Stock Standard	1000 mg/L as NO_3-N	Fisher / 5459-4
Primary Nitrite Stock Standard	1000 mg/L as NO_2-N	Fisher / 5461-4
Secondary Nitrite Stock Standard	1000 mg/L as NO_2-N	SPEX / AS-NO2N9-2Y

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Table 10.2 – Working Reagents

Reagent	Description
Sodium hydroxide solution, 6 N	Add 240 g NaOH very slowly to 750 mL of water. CAUTION: The solution will get very hot! Swirl until dissolved and dilute to 1 liter with reagent water. Cool and store in a plastic bottle.
Ammonium chloride buffer solution, pH 8.5	In a 2-L volumetric flask, dissolve 170.0 g ammonium chloride and 2.0 g disodium ethylenediamine tetraacetic acid dihydrate in approximately 800 mL reagent water. Dilute to the mark and invert to mix. Adjust the pH to 8.5 with 6 N sodium hydroxide solution (approximately 20 mL).
Sulfanilamide color reagent	Add 500 mL reagent water to a 2-L volumetric flask and add the following: 200 mL 85% phosphoric acid, 80 g sulfanilamide, 2.0 g N-(1-naphthyl)ethylenediamine dihydrochloride. Shake to wet and stir for 30 minutes until dissolved. Dilute to the mark and insert stopper. Invert several times to mix. Store in a dark bottle. This solution is stable for one month.
Copper sulfate (2%w/v)	Dissolve 2 grams of copper sulfate ($CuSO_4 \cdot 5H_2O$) in 100 mL reagent water in a volumetric flask. Invert to mix.

Table 10.3 – Standard Storage Conditions

Standard Type	Description	Expiration	Storage
Stock Standards	▪ Concentrated reference solution purchased directly from approved vendor	▪ Manufacturer's recommended expiration date	▪ Manufacturer's recommended storage conditions
Intermediate and Working Standards	▪ Reference solutions prepared by dilutions of the stock solution	▪ Intermediate Standards: 3 months from preparation or the expiration date listed for the stock source, whichever is sooner. ▪ Calibration Standards must be prepared fresh on the same day as the analysis	▪ Manufacturer's recommended storage conditions for stock source solution.

Table 10.4 – Primary Intermediate Standards

Standard	Primary NO_2 Stock Standard (mL)	Primary NO_3 Stock Standard (mL)	Solvent	Final Volume	NO_2-N Concentration	NO_3-N Concentration
Primary Nitrite Intermediate Standard	5.0mL	-	Reagent water	50mL	100mg/L	-
Primary Nitrate Intermediate Standard	-	5.0mL	Reagent water	50mL	-	100mg/L

Table 10.5 – Secondary Intermediate Standard

Standard	Secondary NO_2 Stock Standard	Solvent	Final Volume	NO_2-N Concentration
Secondary Nitrite Intermediate Standard (ICV Intermediate)	5.0mL	Reagent water	50mL	100mg/L

Table 10.6 – Spiking Standard

Standard	Primary NO_2 Stock Standard (mL)	Primary NO_3 Stock Standard (mL)	Solvent	Final Volume	$(NO_3\text{-}N)+(NO_2\text{-}N)$ Concentration	NO_2-N Concentration	NO_3-N Concentration
LCS/MS/MSD Spike Standard	1.0mL	4.0mL	Reagent water	50mL	100mg/L	20mg/L	80mg/L

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Table 10.7 – Primary Working Standards

Standard	Primary NO_2 Int. Standard (mL)	Primary NO_3 Int. Standard	Solvent	Final Volume	NO_2-N Concentration	$(NO_3\text{-}N)+(NO_2\text{-}N)$ Concentration
Calibration Std 1	0	0	Reagent water	50mL	0	0
Calibration Std 2	0.050mL	0	Reagent water	50mL	0.10mg/L	0.10mg/L
Calibration Std 3	0.25mL	0	Reagent water	50mL	0.50mg/L	0.50mg/L
Calibration Std 4	0.50mL	0	Reagent water	50mL	1.0mg/L	1.0mg/L
Calibration Std 5	1.25mL	0	Reagent water	50mL	2.5mg/L	2.5mg/L
Calibration Std 6	2.5mL	0	Reagent water	50mL	5.0mg/L	5.0mg/L
CCV Standard	0.50mL	0.50mL	Reagent water	50mL	1.0mg/L	2.0mg/L
Column Efficiency Check Standard	0	1.0mL	Reagent water	50mL	0	2.0mg/L

Table 10.8 – Secondary Working Standard

Standard	Secondary NO2 Int Standard	Solvent	Final Volume	NO_2-N Concentration	$(NO_3\text{-}N)+(NO_2\text{-}N)$ Concentration
Secondary Nitrite Working Standard (ICV Working)	1.25mL	Reagent water	50mL	2.5mg/L	2.5mg/L

11. Calibration and Standardization

11.1. Initial Calibration (ICAL)

11.1.1. An initial calibration curve using a minimum of five points is analyzed prior to the analysis of any client samples. The lowest spiked standard must be at or below the reporting limit. The lowest spiked calibration point reflects the practical quantitation limit for that compound, a level below which all reported results must be qualified as estimated values.

Table 11.1 – Target Analyte Initial Calibration Concentrations

Analyte	Std 1 (mg/L)	Std 2 (mg/L)	Std 3 (mg/L)	Std 4 (mg/L)	Std 5 (mg/L)	Std 6 (mg/L)
NO_2-N	0	0.10	0.50	1.0	2.5	5.0
NO_3NO_2-N	0	0.10	0.50	1.0	2.5	5.0

11.2. Calibration Response Factors

11.2.1. Response factors (RF) establish the relationship between instruments response and analyte concentration.

11.2.2. To calculate the RF for any given calibration standard (or calibration verification standard), tabulate the area response of the analyte against the concentration using the following equation.

$$RF = \frac{C_x}{A_x}$$

Where:

C_x = Concentration of the compound being measured (mg/L).
A_x = Area of the compound being measured.

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11.3. Calibration Curve Fitting

11.3.1. Linear Regression: The linear regression calibration curve is derived from a least squares regression analysis of the calibration points. A calibration curve based on this technique will have the format of y=ax+b where "a" is the slope of the line and "b" is the y-intercept. In order to use this curve fit technique, a minimum of 5 calibration points must be available and the origin cannot be included as one of the points. This technique works well for calibrations where the response of the instrument is linear in nature but does not necessarily intercept the y-axis at the origin. However, because the linear regression is not forced through the origin, very low levels of contaminants below the response of the lowest calibration point may generate erroneous reportable results. A calculation of the correlation coefficient "r" is used to determine the acceptability of a linear regressed curve .

11.4. Initial Calibration Verification (ICV)

11.4.1. To assess the accuracy relative to the purity of the standards, a single standard from a secondary source must be analyzed and the results obtained must be assessed relative to the known true value. This secondary source must be from an alternative vendor or, in the event an alternative vendor is not available, from a different lot from the same vendor. The accuracy of the standard is assessed as a percent difference from the true value according to the following equation:

$$\%\text{Difference} = \frac{(\text{Result}_{ICV} - \text{True Value}_{ICV})}{\text{True Value}_{ICV}} \times 100$$

11.5. Continuing Calibration Verification (CCV)

11.5.1. The validity of the initial calibration is verified at the start and end of every analytical sequence and after every 10 samples for as long as the instrument is analyzing samples by analysis of a midpoint calibration standard (CCV).

11.5.2. The result of the CCV is compared to the true values and a percent change is calculated. The percent change must meet the method specified criteria for the analysis to proceed.

11.5.3. The actual determination of change in instrument response is based on the type of curve fit used for each analyte. Calibration curves based on a linear or non-linear regression are assessed based on the percent drift of the calculated result from the known true value of the standard. The equation for this calculation is as follows:

$$\%\text{Drift} = \frac{(\text{Result}_{CCV} - \text{True Value}_{CCV})}{\text{True Value}_{CCV}} \times 100$$

11.6. Column Efficiency Check

11.6.1. The reduction efficiency of the cadmium column is verified at the start of every analytical sequence by analyzing the Nitrate Column Efficiency Check Standard. If the reduction efficiency is determined to be less than 90%, the cadmium column must be regenerated or replaced. (See section 12.4 for the column regeneration procedure.) Reduction efficiency is determined by the following equation:

$$\text{Efficiency} = \frac{[NO_3]}{2.0} \times 100$$

Where:

$[NO_3]$ = response of Nitrate Column Efficiency Check Standard

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Table 11.2 – Calibration Criteria

Calibration Metric	Parameter / Frequency	Criteria	Comments
Calibration Curve Fit	Linear Regression/Curve is run daily prior to the ICV	$r \geq 0.995$	If criteria not met, determine the cause and recalibrate.
Initial Calibration Verification Standard (ICV)	Immediately after each calibration	90-110%	May be reanalyzed once. A second failure confirms and requires corrective action and recalibration.
Initial Calibration Verification Blank (ICB)	Immediately after each Initial Calibration Verification Standard	Result should be less than the reporting limit. If results are reported to MDL, the ICB must be evaluated to the MDL.	May be reanalyzed once. A second failure confirms and requires corrective action (e.g. re-preparation of standard(s) and/or recalibration) **Exceptions:** If sample results are reported to MDL and ICB is <RL but >MDL, then corrective action is not necessary other than appropriately qualifying the sample results. Unless the customer's QAPP or technical specification instruct to do otherwise. Samples that are <RL may be reported without qualification. (Not applicable to samples reporting down to MDL) Samples >10x ICB may be reported with appropriate qualification.
Continuing Calibration Verification (CCV)	Prior to the analysis of any samples and every 10 samples thereafter. Samples need to be bracketed with CCVs	90-110%	May be reanalyzed once. A second failure confirms and requires corrective action (e.g. re-preparation and/or recalibration). **Exception:** If CCV fails high, then sample(s) that are <RL may be reported with appropriate qualification.
Continuing Calibration Blank (CCB)	Immediately after each Continuing Calibration Verification Standard	Result should be less than the reporting limit. If results are reported to MDL, the ICB must be evaluated to the MDL.	May be reanalyzed once. A second failure confirms and requires corrective action **Exceptions:** If sample results are reported to MDL and CCB is <RL but >MDL, then corrective action is not necessary other than appropriately qualifying the sample results. Unless the customer's QAPP or technical specification instruct to do otherwise. Samples that are <RL may be reported without qualification. (Not applicable to samples reporting down to MDL) Samples >10x CCB may be reported with appropriate qualification.
Column Efficiency Check	Beginning of each sequence.	Efficiency $\geq$ 90%	Regenerate or replace reduction column and reanalyze affected samples.

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12. Procedure

12.1. Sample Preparation

12.1.1. Method Blank (MB)

12.1.1.1 Water: The water MB is reagent water.

12.1.1.2 Soil: Prepare the MB by measuring 5 g of glass beads plus 50 mL reagent water into a 50-mL centrifuge tube.

12.1.2. Laboratory Control Sample (LCS)

12.1.2.1 Water: Use 1.0 ml of the Spiking Standard per 50mls to prepare the LCS. The true value is 2.0 mg/L NO_3/NO_2, 0.4mg/L NO_2, and 1.6mg/L NO_3.

12.1.2.2 Soil: Prepare the LCS by measuring 5 g of glass beads into a 50-mL centrifuge tube. Spike with 1.0 mL of the Spiking Standard and add 50 mL of reagent water. The final concentration of the LCS is 20 mg/kg NO_3/NO_2, 4.0mg/kg NO_2, and 16mg/kg NO_3.

12.1.3. Matrix Spike (MS)

12.1.3.1 Water: Prepare the MS by adding 0.1 mL of the Spiking Standard to 4.9 mL of the client sample in a test tube. The true value of the MS spike is 2.0 mg/L NO_3/NO_2, 0.4mg/L NO_2, and 1.6mg/L NO_3.

12.1.3.2 Soil: Prepare the MS by measuring 5 g of a client sample into a 50-mL centrifuge tube, spiking with 1.0 mL of the Spiking Standard and adding 50 mL of reagent water. The true value of the MS spike is 20 mg/kg NO_3/NO_2, 4.0mg/kg NO_2, and 16mg/kg NO_3.

12.2. Client Samples:

12.2.1.1 Water: For unpreserved samples verify pH prior to analysis. The must be between 5 and 9. Adjust ph as needed to 5-9.

12.2.1.2 Soil: Weigh 5 g of the sample into a 50-mL centrifuge tube and add 50 mL of reagent water. Place the centrifuge tubes on a shaker and shake for 30 minutes. Remove from shaker and centrifuge for 30 minutes. Verify pH of the supernatant liquid is prior to analysis.

12.3. Analysis

12.3.1. Follow the instructions given in the calibration procedure, Section 11, to set up the Lachat.

12.3.2. Set up the Lachat to run the Nitrate and Nitrite methods simultaneously.

12.3.3. Decant portion of the sample into the autosampler cups for analysis. NOTE: If the liquid is turbid or has suspended sediment filter a portion of the liquid into the autosampler cup.

12.3.4. Arrange the autosampler cups on the autosampler tray in the order they are on the worklist.

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12.3.5. Ensure that the DQM is enabled to run the CCV/CCB first, after each group of 10 samples, at the end of the sequence. Also ensure that the Column Efficiency check standard will be analyzed at the beginning of each sequence.

12.3.6. If the sample absorbance/concentration is greater than the highest standard dilute the extract and re-analyze. The response of the diluted sample should be between the mid and high standards.

12.3.7. Dilutions – Dilutions on aqueous samples must be prepared in volumetric glassware and/or using calibrated pipettors.

12.4. Cadmium Column Regeneration - Spent columns that no longer meet the required 90% reduction efficiency may be regenerated and placed back into service.

12.4.1. Remove endcaps from the spent column to be regenerated.

12.4.2. Attach the supply line from the peristaltic pump to one end of the column and place the column in a beaker to contain the flushing solutions.

12.4.3. Flush the column sequentially, using normal pump tubing and flowrate, with:

12.4.3.1 10 mL reagent water,

12.4.3.2 10 mL 1N HCl. The HCl may cause pitting of the cadmium granules if left in the column. Proceed to the next step immediately.

12.4.3.3 10 mL reagent water,

12.4.3.4 15 mL 2% $CuSO_4$ solution. Precipitated copper may be observed exiting the column (reddish-brown particles). The amount of reddish-brown color should be minimized.

12.4.3.5 Flush with 10 mL ammonium chloride buffer. Stop the pump while leaving the line in the buffer solution. To prevent air from entering the column, cap the exit end, then disconnect the line and cap the second end. Store in a labeled container.

12.4.4. The waste flushing solution in the beaker is hazardous and must be disposed of properly.

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13. Quality Control

Table 13.1 – Batch Quality Control Criteria

QC Sample	Components	Frequency	Acceptance Criteria	Corrective Action
Method Blank (MB)	Matrix-specific; reagent water or glass beads	One per batch of up to 20 samples	Result should be less than the reporting limit. If results are reported to MDL, the MB must be evaluated to the MDL.	1) Re-analyze blank to confirm failure. 2) Qualify results and / or re-analyze associated samples. **Exceptions:** 1) If sample ND, report sample without qualification 2) If sample result >10x MB report sample with appropriate qualifier indicating blank contamination. 3) If sample result <10x MB and sample cannot be reanalyzed report sample with appropriate qualifier to indicate an estimated value. Client should be alerted of this condition.
Laboratory Control Sample (LCS)	Matrix-specific; reagent water or Glass beads spiked with nitrate and nitrite	One per batch of up to 20 samples	$(NO_3\text{-}N)+(NO_2\text{-}N)$: 90-110% $(NO_2\text{-}N)$: 90-110% $(NO_3\text{-}N)$: 85-115%*	1) Reanalyze the LCS to confirm failure 2) Re-prep and reanalyze associated samples. 3) If problem persists, check spike solution **Exceptions:** 1) If LCS > QC limits and these compounds are non-detect in the associated samples, the sample data may be reported with appropriate data qualifiers. 2) If LCS < QC limits and sample cannot be reanalyzed report sample with appropriate qualifier to indicate an estimated value. Client should be alerted to this condition.
Matrix Spike (MS)	Spike standard in client sample(s)	One per 10 samples or 10% per batch of up to 20 samples.	$(NO_3\text{-}N)+(NO_2\text{-}N)$: 90-110% $(NO_2\text{-}N)$: 90-110% $(NO_3\text{-}N)$: 85-115%*	No corrective actions necessary. If LCS recovery is in range, the system is considered valid and the out-of-control MS/MSDs are footnoted appropriately by the analyst.
Duplicate	MS Duplicate *OR (alternative)* Sample Dup	One per batch of up to 20 samples.	Max RPD: 10%	No corrective actions necessary. Report outliers with comment.

*Note: $(NO_3\text{-}N)$ is a calculated analyte. The 85-115% criteria has been set due to the mathematics that is involved (See Attachment I). The analytical system is deemed to be in control if both of the directly measured analytes (NO_3+ NO_2-N and NO_2-N) are within acceptance limits.

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14. Data Analysis and Calculations

14.1. Water

$$NO_3, mg/L = ([NO_3NO_2] - [NO_2]) \times DF$$

$$NO_2, mg/L = [NO_2] \times DF$$

$$NO_3NO_2, mg/L = [NO_3NO_2] \times DF$$

14.2. Soil

$$NO_3, mg/kg = \frac{([NO_3NO_2] - [NO_2]) \times V \times DF}{W}$$

$$NO2, mg/kg = \frac{[NO_2] \times V \times DF}{W}$$

$$NO_3NO_2, mg/kg = \frac{[NO_3NO_2] \times V \times DF}{W}$$

Where:

$[NO_3\ NO_2]$ = concentration of nitrate-nitrite
$[NO_3]$ = concentration of nitrite
$[NO_2]$ = concentration of nitrite
DF = dilution factor made on the sample during the Lachat analysis
V = Volume of sample extract in mL
W = Weight of sample extracted in grams.

15. Data Assessment and Acceptance Criteria for Quality Control Measures

15.1. See Table 13.1.

16. Corrective Actions for Out-of-Control Data

16.1. See Tables 11.2 and 13.1.

17. Contingencies for Handling Out-of-Control or Unacceptable Data

17.1. See Tables 11.2 and 13.1. If there is no additional sample volume to perform re-analyses, if the analytical results are due to the customer, and/or if there is no more holding time remaining; then data will be reported as final with applicable qualifiers. If necessary, an official case narrative can be prepared by the Quality Manager or Project Manager.

18. Method Performance

18.1. All applicable personnel must read and understand this SOP with documentation of SOP review maintained in their training files.

18.2. **Method Detection Limit (MDL) Study and Verification:** An MDL study must be performed at least once every six months for this method. The MDL study must meet the criteria defined in S-KS-Q-032, Limit of Detection and Limit of Quantitation (or its equivalent revision or replacement).

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18.3. **Demonstration of Capability (DOC)**: Every analyst who performs this method must first document acceptable accuracy and precision by passing a demonstration of capability study (DOC) per S-ALL-Q-020, Training Procedures.

18.3.1. Analysis of four replicates of reagent water spiked with all target analytes at a concentration of equivalent to the LCS.

18.3.2. Analysis of four replicates of an inert solid matrix (glass beads) spiked with all target analytes at a concentration of equivalent to the LCS.

18.3.3. If the average recovery is between 90-110% and the RSD of the replicates is <20%, system performance is acceptable and analysis of samples may begin. If, however, RSD >20% or average recovery exceeds 90-110%, system performance is unacceptable. In this event, correct the problem and repeat the test.

19. Method Modifications

19.1. Reduced volume versions of this method that use the same reagents and molar ratios are acceptable provided they meet the quality control and performance requirements stated in the method.

19.2. This method has been modified to incorporate the analysis of soil samples.

19.3. The Linear Calibration Range (LCR) verification listed in method 353.2 has been modified in this SOP. In this SOP, the co-relation coefficient "r" obtained from the linear regression of the calibration is used to verify the LCR daily before sample analysis begins. If the co-relation coefficient "r" is ≥ 0.995, then the linearity of the calibration range is deemed acceptable.

20. Instrument/Equipment Maintenance

20.1 Prior to daily use, visually inspect all sample and reagent lines. Replace pump tubing as needed. Verify that the system is flowing properly. Replace and re-condition Cd columns as needed (column eff parameters). Keep the surface of the instrument clean and dry.

21. Troubleshooting

21.1 Refer to the instrument manual for troubleshooting tips.

22. Safety

22.1. **Standards and Reagents**: The toxicity and carcinogenicity of standards and reagents used in this method have not been fully defined. Each chemical compound should be treated as a potential health hazard. Reduce exposure by the use of gloves, lab coats and safety glasses. Material Safety Data Sheets (MSDSs) are on file in the laboratory and available to all personnel. Standard solutions should be prepared in a hood whenever possible.

22.1.1. The following chemicals in this procedure have the potential to be highly toxic or hazardous, consult MSDS.

- Cadmium
- Phosphoric acid
- Hydrochloric acid
- Sulfuric acid

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22.2. **Samples**: Take precautions when handling samples. Samples should always be treated as potentially hazardous "unknowns". The use of personal protective equipment (gloves, lab coats and safety glasses) is required when handling samples. In the event a sample container must be opened, it is recommended to perform this in a hood whenever possible.

23. Waste Management

23.1. Procedures for handling waste generated during this analysis are addressed in S-KS-S-002, Waste Handling.

23.2. In order to minimize the amount of waste generated during this procedure, analyst should prepare reagents in an amount which may be used in a reasonable amount of time (e.g., before a reagent expires).

24. Pollution Prevention

24.1. The company wide Chemical Hygiene and Safety Manual contains information on pollution prevention.

25. References

25.1. Pace Quality Assurance Manual - most current version.

25.2. National Environmental Laboratory Accreditation Conference (NELAC), Chapter 5, "Quality Systems"- most current version.

25.3. The NELAC Institute (TNI); Volume 1, Module 2, "Quality Systems"- most current version.

25.4. Code of Federal Regulations, Title 40 – Protection of Environment, Part 136 – Guidelines Establishing Test Procedures for the Analysis of Pollutants, Method Update Rule published May 18, 2012.

25.5. Determination of Nitrate-Nitrite Nitrogen by Automated Colorimetry, Method 353.2, Revision 2.0, August 1993.

25.6. Lachat Instruments, Quickchem Method 10-107-04-1-R, April 2008.

26. Tables, Diagrams, Flowcharts, and Validation Data

26.1. Attachment I: Calculation of NO_3 Control Limits

26.2. Attachment II: Client-Specific Criteria (Internal Use Only)

27. Revisions

Document Number	Reason for Change	Date
S-KS-I-039-rev.11	General – Converted SOP to new format Section 10 – Added reagents for column regeneration. Section 11 – Calculate efficiency check based on response. Table 13.1 – Removed CCB which is already in Table 11.2. Removed MSD/DUP which is not applicable to this method. Revised MB and LCS frequency to one per batch of up to 20 samples. Section 18 – Added LOD Verification Attachment I: Added column regeneration procedure.	October 9, 2012

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S-KS-I-039-rev.12	Section 10 – Inserted table for standard storage conditions. Changed calibration and ICV to nitrite only. Inserted standard prep tables. Table 11.2 – Revised column efficiency check frequency. Section 23 – Revised references.	May 3, 2013
S-KS-I-039-rev.13	Revised to most current format. Section 10 – Revised final volume of solutions to 50mL Table 10.2 – Added. Converted prep info into table format. Table 10.6 – Added Spike Solution for LCS/MS/MSD Table 11.2 – Reworded and removed non-linear regression Sections 12.1.2 and 12.1.3 – Revised to use Spike Solution from Table 10.6 Section 12.4 – Was located in section 10 in the previous SOP rev Table 13.1 – Reworded, added Duplicate, and revised NO3 limits to 85-115% Section 17 – Reworded Section 18.2 – Revised MDL frequency to every six months Section 19.3 – Added LCR verification by evaluation of co-relation coefficient Attachment I and II – Added	August 26, 2013
S-KS-I-039-rev.14	Revised to latest prescribed format. Table 10.2 – Revised Ammonium chloride buffer solution preparation.	November 20, 2014
S-KS-I-039-rev.15	Section 12.2.1.1-Added pH check in procedure.	August 10, 2015

Attachment I: Calculation of NO3 Control Limits

LCS NO_2-N True Value Concentration = 0.40mg/L (Directly measured analyte)
LCS NO_2+NO_3-N True Value Concentration = 2.0mg/L (Directly measured analyte)
LCS NO_3-N True Value Concentration = 1.6mg/L (Calculated analyte)

Case #1
NO_2+NO_3-N LCS Result 2.2mg/L = 110%REC = In Control
NO_2-N LCS Result 0.36mg/L = 90%REC = In Control
NO_3 LCS Result = 2.2 – 0.36 = 1.84mg/L = 115%REC

Case #2
NO_2+NO_3-N LCS Result 1.8mg/L = 90%REC = In Control
NO_2-N LCS Result 0.44mg/L = 110%REC = In Control
NO_3 LCS Result = 1.8 – 0.44 = 1.36mg/L = 85%REC

Control of analytical system is to be evaluated based on the analytes that are directly measured (NO_2-N and NO_2+NO_3-N). Therefore, the control limits for the calculated analyte (NO_3-N) will be set at 85-115%REC

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Pace Analytical™

STANDARD OPERATING PROCEDURE

DETERMINATION OF EXTRACTABLE PETROLEUM HYDROCARBONS BY METHOD OA-2

Reference Methods: OA-2

Local SOP Number:	S-KS-O-014-rev.10
Effective Date:	Date of Final Signature
Supersedes:	S-KS-O-014-rev.9

Approvals

Laboratory General Manager — Date: 3-5-15

Laboratory Quality Manager — Date: 3-5-15

Department Manager — Date: 3-5-15

PERIODIC REVIEW

SIGNATURES BELOW INDICATE NO CHANGES HAVE BEEN MADE SINCE PREVIOUS APPROVAL.

Signature	Title	Date

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1. Purpose/Identification of Method

1.1. This Standard Operating Procedure (SOP) documents the procedures used by PASI – Kansas to determine the concentration of Extractable Petroleum Hydrocarbons (EPH) in environmental samples. The laboratory utilizes GC/FID and bases these documented procedures on those listed in Method OA-2, Revision 7/27/93.

2. Summary of Method

2.1. Sample extracts are prepared for analysis by an appropriate sample preparation method. The Extractable Petroleum Hydrocarbons are introduced into the gas chromatograph (GC) by injecting an aliquot of the sample extract. The GC conditions are programmed to separate the analytes. The GC effluent is directly introduced to a Flame Ionization Detector (FID) for both identification and quantification of analytes. Analytes are identified by comparing the peak pattern ("fingerprint") seen on the sample chromatogram with those of authentic standards. Analytes are quantified by comparing the total area response within a retention time range to an external standard.

3. Scope and Application

3.1. This method covers the determination of low volatility petroleum products and organic compounds that are soluble in moderate to low polarity organic solvents and are amenable to gas chromatography.

3.2. The method includes the determination of compounds listed in section 5 in a liquid or solid matrix.

3.3. This procedure is restricted to use by, or under the supervision of, analysts experienced in the use of semi-volatile configured GC systems and interpretation of extractable petroleum hydrocarbon data. Each analyst must demonstrate the capability to generate acceptable results with this method to be considered qualified to report sample results.

3.4. The policies and procedures contained in this SOP are applicable to all personnel involved in the analytical method or non-analytical process.

4. Applicable Matrices

4.1. This method is applicable to most water and solid samples, regardless of moisture content. Common matrices are ground and surface water, wastewater, aqueous sludge, sediment, soils, and other solid samples. Procedures may need to be adapted to address limits in the method or equipment that might hinder or interference with sample analysis. All adaptations made to address matrix-related modifications must be documented within the analytical data.

5. Limits of Detection and Quantitation

5.1. The reporting limit (LOQ) for all analytes is listed in the table below for this method. All current MDLs (LOD) are listed in the LIMS and are available by request from the Quality Manager.

Analyte	Water PRL (mg/L)	Soil PRL (mg/kg)
Diesel Fuel	0.399	10
Fuel Oil	0.399	10
Gasoline	0.399	10
Hydraulic Fluid	0.399	10
Jet Fuel	0.399	10
Kerosene	0.399	10
Mineral Spirits	0.399	10

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Analyte	Water PRL (mg/L)	Soil PRL (mg/kg)
Motor Oil	0.399	10
TEH as Diesel No. 2	0.399	10
TPH	0.399	10
Transformer Oil	0.399	10
Waste Oil	0.399	10

5.2. PRL's are subject to change based on current analytical system performance and actual sample matrices.

6. Interferences

6.1. Method interferences may be caused by contaminants in solvents, reagents, glassware, and other sample processing hardware that lead to discrete artifacts and/or elevated baselines in chromatograms. All of these materials must be routinely demonstrated to be free from interferences under the conditions of the analysis by running laboratory reagent blanks.

6.2. Interferences by phthalate esters can pose a major problem in all analyses. Common flexible plastics contain varying amounts of phthalates. These phthalates are easily extracted or leached from such materials during laboratory operations. Cross-contamination of clean glassware occurs when plastics and samples are handled by personnel. Interferences from phthalates can best be minimized by avoiding the use of plastics in the laboratory. Exhaustive cleanup of reagents and glassware may be required to eliminate background phthalate contamination.

6.3. Matrix interferences may be caused by high concentration contaminants that are co-extracted from the sample. The extent of matrix interferences will vary considerably from source to source, depending upon the nature and diversity of the site being sampled.

6.4. Contamination by carryover can occur whenever high-concentration and low-concentration samples are sequentially analyzed. To reduce carryover, the sample syringe must be rinsed with solvent (methylene chloride) between sample injections. When a concentrated sample is injected, a solvent blank should follow to ensure there is no carryover.

7. Sample Collection, Preservation, Shipment and Storage

Sample type	Collection per sample	Preservation	Storage	Holding time
Liquid	Amber glass bottle with Teflon-lined lid (minimum 100 mL)	N/A	≤6°C (not freezing)	Extract within 7 days of collection. Analyze within 40 days of extraction.
Solid	Clear or amber glass jar (minimum 2 oz.)	N/A	≤6°C (not freezing)	Extract within 14 days of collection. Analyze within 40 days of extraction.

8. Definitions

8.1. Definitions of terms found in this SOP are described in the Pace Analytical Services Quality Manual, Glossary Section.

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9. Equipment and Supplies

Supply	Vendor	Model / Version	Comments
Gas Chromatograph	Agilent	5890 Series II	or equivalent
Flame Ionization Detector	Agilent	5890	
Data System	Thruput Systems, Inc.	Target, version 3.4	
Autosampler	Agilent	7673	or equivalent
Analytical Column	Restek	Rtx®-5 (10254)	30m x 0.32mm, 1.0 µm df
Ferrules	CRS	213108	0.8 mm id, Vespel/Graphite
Ferrules	CRS	213168	0.8 mm id, Vespel/Graphite
Septa	CRS	236115	7/16"
Volumetric Flasks	Various	5-, 10-, 50-, 100-mL	Class A
Glass Storage Vials	Fisher	14-959-25A	12mL, with Teflon-lined screw caps
Glass Autosampler Vials	Fisher	03-375-2S	2mL, amber or clear
Extraction Vials	Fisher	12-100-103	40-mL, amber or clear
Gas tight syringes	Hamilton	1700 Series	10-, 25-, 100-, 500-, 1000-uL
Microdispensers	Fisher	21-176E	100-uL
Replacement Bores	Fisher	21-169-F	100-/200-uL
Analytical Balance	Ohaus	SP-202	Capable of weighing 0.01g
Glass pipettes	Fisher	13-678-6A	5.75"

10. Reagents and Standards

Table 10.1 – Standard Storage Conditions

Standard Type	Description	Expiration	Storage
Stock Solutions	▪ Concentrated reference solution purchased directly from approved vendor	▪ Manufacturer's recommended expiration date for unopened ampulated standards. ▪ Stock standards must be replaced six months after ampule is opened or on expiration date, whichever is sooner.	▪ Manufacturer's recommended storage conditions ▪ When standard is opened, record all information in the standard logbook.
Intermediate and Working Standard Solutions	▪ Reference solutions prepared by dilutions of the stock solution	▪ 6 months from preparation or the expiration date listed for the stock source, whichever is sooner. ▪ Working solutions must be checked frequently and replaced if degradation or evaporation is suspected.	▪ Store in amber vials with Teflon-lined screw caps at ≤6°C

Table 10.2 – Reagents and Stock Standards

Reagent/Standard	Concentration/ Description	Requirements/ Vendor/ Item #
Organic-free water	ASTM Type II	SOP S-KS-Q-011 (latest revision)
p-terphenyl	Neat (99+%)	Arcos Organics / 13792
n-tetracosane	Neat (99+%)	Alfa Aesar/ 42462
Diesel Fuel #2 Composite Standard	50 mg/mL; Primary stock standard	Restek / 31259
Diesel Fuel Standard	40 mg/mL; Secondary stock standard	Accustandard / FU-009-40X

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Reagent/Standard	Concentration/ Description	Requirements/ Vendor/ Item #
Unleaded Gasoline Composite Standard	50 mg/mL	Restek / 30206
Motor Oil Composite Standard	50 mg/mL	Restek / 31464
Kerosene Composite Standard	50 mg/mL	Restek / 31257
Fuel Oil #6 Standard	50 mg/mL	Restek / 31248
Mineral Spirits Standard	50 mg/mL	Restek / 31261
Hydraulic Oil (Fluid) Standard	50 mg/mL	Restek / 31839
PCB-Free Transformer Oil	Exxon® Univolt® N-61	Restek / 32424
Acetone	Pesticide grade or equivalent	Fisher / A929
Methylene chloride	Pesticide grade or equivalent	Fisher / D151
CT ETPH Alkane Standard	1.0 mg/mL (each) C9, C10-C36 (even alkanes)	Accustandard / DRH-009S
TPH n-Alkane Standard	200 ug/mL (each) C6, C12, C28, C35	Restek / 31698

Table 10.3 – Intermediate Standards

Standard	Stock Standard	Standard Amount	Solvent	Final Total Volume	Final Concentration
n-Tetracosane Intermediate Standard	Neat n-Tetracosane	1.00g	Hexane	100mL	10,000 ug/mL
p-Terphenyl Intermediate Standard	Neat p-Terphenyl	1.00g	MeCl2	100mL	10,000 ug/mL
Diesel Intermediate Standard	Primary Stock Standard (50mg/mL)	12.5mL	MeCl2	25mL	25,000 ug/mL

Table 10.4 – Working Spike Standards

Standard	Diesel Primary Stock Standard	Tetracosane Intermediate Standard	Terphenyl Intermediate Standard	Solvent	Final Volume	Diesel Final Concentration	Surrogate Final Concentration
OA2 Surrogate Spike Standard	-	7.5mL	7.5mL	Acetone	1000mL	-	75 ug/mL
OA2 Diesel Spike Standard	10mL	-	-	Acetone	200mL	2500 ug/mL	-
OA2 Surrogate RV Spike Standard	-	1.5mL	1.5mL	Acetone	1000mL	-	1.5 ug/mL
OA2 Diesel RV Spike Standard	2.0mL	-	-	Acetone	200mL	500 ug/mL	-

Table 10.5 – Retention Time Marker (RTM) Working Standard

Standard	CT ETPH Alkane Stock Standard	TPH Alkane Stock Standard	Solvent	Final Volume	Final Concentration
RTM Working Standard	0.5mL	0.5mL	CH_2Cl_2	25mL	20 ug/mL and 4.0 ug/mL

Table 10.6 – Instrument Blank Working Standard

Standard	Diesel Standard	Tetracosane Intermediate Standard	Terphenyl Intermediate Standard	Solvent	Final Volume	Diesel Final Concentration	Surrogate Final Concentration
Instrument Blank Working Standard	-	2.4mL	2.4mL	CH_2Cl_2	400mL	-	60 ug/mL

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Table 10.7 – Diesel Calibration Working Standards

Working Standard	Source Standard	Amount of Source Standard	Tetracosane Intermediate Standard	Terphenyl Intermediate Standard	Solvent	Final Volume	Diesel Final Concentration	Surrogate Final Concentration
DSL-8	Diesel Intermediate Standard	5.0mL	1.25mL	1.25mL	CH_2Cl_2	50mL	2500 ug/mL	250 ug/mL
DSL-7	Diesel Intermediate Standard	4.0mL	1.0mL	1.0mL	CH_2Cl_2	50mL	2000 ug/mL	200 ug/mL
DSL-6	Diesel Intermediate Standard	4.0mL	1.0mL	1.0mL	CH_2Cl_2	100mL	1000 ug/mL	100 ug/mL
DSL-5	DSL-8	5.0mL	-	-	CH_2Cl_2	25mL	500 ug/mL	50 ug/mL
DSL-4	DSL-5	2.5mL	-	-	CH_2Cl_2	25mL	50 ug/mL	5.0 ug/mL
DSL-3	DSL-4	12.5mL	-	-	CH_2Cl_2	25mL	25 ug/mL	2.5 ug/mL
DSL-2	DSL-3	10mL	-	-	CH_2Cl_2	25mL	10 ug/mL	1.0 ug/mL
DSL-1	DSL-2	12.5mL	-	-	CH_2Cl_2	25mL	5 ug/mL	0.5 ug/mL

Table 10.8 – Diesel Second Source (ICV) Working Standard

Working Standard	Source Standard	Amount of Source Standard	Tetracosane Intermediate Standard	Terphenyl Intermediate Standard	Solvent	Final Volume	Diesel Final Concentration	Surrogate Final Concentration
ICV	Secondary Stock Standard	1.0mL	0.20mL	0.20mL	CH_2Cl_2	20mL	1000 ug/mL	100 ug/mL

Table 10.9 – Gasoline Calibration Working Standards

Working Standard	Source Standard	Amount of Source Standard	Tetracosane Intermediate Standard	Terphenyl Intermediate Standard	Solvent	Final Volume	Gasoline Final Concentration	Surrogate Final Concentration
GAS-6	Gasoline Stock Standard	2.5mL	-	-	CH_2Cl_2	50mL	2500 ug/mL	-
GAS-5	Gasoline Stock Standard	1.0mL	-	-	CH_2Cl_2	50mL	1000 ug/mL	-
GAS-4	Gasoline Stock Standard	0.50mL	-	-	CH_2Cl_2	50mL	500 ug/mL	-
GAS-3	GAS-4	12.5mL	-	-	CH_2Cl_2	25mL	250 ug/mL	-
GAS-2	GAS-3	5.0mL	-	-	CH_2Cl_2	25mL	50 ug/mL	-
GAS-1	GAS-2	12.5mL	-	-	CH_2Cl_2	25mL	25 ug/mL	-

Table 10.10 – Motor Oil Calibration Working Standards

Working Standard	Source Standard	Amount of Source Standard	Tetracosane Intermediate Standard	Terphenyl Intermediate Standard	Solvent	Final Volume	Motor Oil Final Concentration	Surrogate Final Concentration
MOIL-6	Motor Oil Stock Standard	1.25mL	-	-	CH_2Cl_2	25mL	2500 ug/mL	-
MOIL-5	Motor Oil Stock Standard	1.0mL	-	-	CH_2Cl_2	25mL	2000 ug/mL	-
MOIL-4	Motor Oil Stock Standard	1.0mL	-	-	CH_2Cl_2	50mL	1000 ug/mL	-
MOIL-3	Motor Oil Stock Standard	0.75mL	-	-	CH_2Cl_2	50mL	750 ug/mL	-
MOIL-2	MOIL-4	12.5mL	-	-	CH_2Cl_2	25mL	500 ug/mL	-
MOIL-1	MOIL-2	12.5mL	-	-	CH_2Cl_2	25mL	250 ug/mL	-

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Table 10.11 – Product Identification Working Standards

Working Standard	Source Standard	Amount of Source Standard	Tetracosane Intermediate Standard	Terphenyl Intermediate Standard	Solvent	Final Volume	Final Concentration	Surrogate Final Concentration
Mineral Spirits	Mineral Spirits Stock Standard	1.0mL	0.50mL	0.50mL	CH_2Cl_2	50mL	1000 ug/mL	100 ug/mL
Fuel Oil	Fuel Oil Stock Standard	1.0mL	0.50mL	0.50mL	CH_2Cl_2	50mL	1000 ug/mL	100 ug/mL
Hydraulic Oil	Hydraulic Oil Stock Standard	1.0mL	0.50mL	0.50mL	CH_2Cl_2	50mL	1000 ug/mL	100 ug/mL
Jet Fuel	Jet Fuel Stock Standard	1.0mL	0.50mL	0.50mL	CH_2Cl_2	50mL	1000 ug/mL	100 ug/mL
Kerosene	Kerosene Stock Standard	1.0mL	0.50mL	0.50mL	CH_2Cl_2	50mL	1000 ug/mL	100 ug/mL
Transformer Oil Intermediate	Transformer Oil (Neat)	1.0g	-	-	CH_2Cl_2	100mL	10000 ug/mL	-
Transformer Oil Working	Transformer Oil Intermediate	5.0mL	0.50mL	0.50mL	CH_2Cl_2	50mL	1000 ug/mL	100 ug/mL

11. Calibration and Standardization

11.1. Initial Calibration (ICAL)

11.1.1. Analysis of Standards - An initial calibration consisting of a minimum of three concentration levels is analyzed prior to analyzing client samples. (Typically an eight-point curve is used for diesel fuel, a six-point curve for gasoline, and a six-point curve for motor oil is used.) The lowest calibration point reflects the practical quantitation limit for that compound, a level below which all reported results must be qualified as estimated values.

11.1.2. The Product Identification Standards (Mineral Spirits, Fuel Oil, Hydraulic Oil, Jet Fuel, Kerosene, and Transformer Oil) are analyzed at least annually on each system and the resulting chromatograms kept for reference.

11.1.2.1 **Note:** If any of these product identification standards are being quantitated and reported, then there must be a minimum of a three point calibration or the concentrations reported must be qualified as estimated.

11.1.3. The Retention Time Marker (RTM) Standard C6 to C36 is used as a reference marker, but the OA2 Diesel, Gasoline and motor Oil ranges are defined as follows:

11.1.3.1 Diesel fuel – all chromatographic peaks eluting from 0.01 minutes prior to the first Diesel Standard peank to 0.01 minutes past the last Diesle Standard peak.

11.1.3.2 Gasoline – all chromatographic peaks eluting between the first peak of the Gasoline standard (after the solvent front) to 0.01 minutes past the last Gasoline Standard peak.

11.1.3.3 Motor Oil – all chromatographic peaks eluting from 0.01 minuts prior to the first Motor Oil Standard peak to 0.01 minutes past the last Motor Oil Standard peak.

All other petroleum products will be quantitated using the 0.01 minutes before and after the first and last chromatographic peaks respectively.

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11.1.4. Calibration Response Factors - Response factors (RF) establish the relationship of the instruments response in comparison with the concentration of any given analyte. To calculate the RF for any given calibration standard (or calibration verification standard), tabulate the area response of the analyte peak (or total area) against concentration for each compound. Response factors are calculated using the following equation. Most, if not all modern chromatography data systems are capable of calculating this factor and using it to quantify analyte concentrations.

$$RF = \frac{C_x}{A_x}$$

Where:
A_x = Area of the total ion chromatogram for the retention time window.
C_x = Concentration of the compound being measured (ug/mL).

11.1.5. Calibration Curve Fit - The calibration curve is a representation of the relationship of the instrument response and analyte concentration. The curve is used to quantitate the concentration of an unknown based on its response and this known relationship. The curve is produced in several ways depending on the nature of the "goodness of fit". The average response factor is also used to diagnose the integrity of the chromatography system as it relates to calibration linearity. The %RSD is compared to the method criteria and if exceeds the criteria, the system needs to be inspected for potential sources of errors and recalibrated.

11.1.6. **Average Response Factor ($\overline{RF}$):** The average response factor is determined by averaging the response factors calculated for each calibration level for each target analyte. The average RF can be used to calculate the concentration of target analytes in samples provided the criteria are met for consistency in the RFs for any given analyte. An average response factor is the default curve fitting option for calibrations. It is in the most basic sense, a linear regression that is forced through zero at the origin. Because of its simplicity and the interception of the y-axis at the origin, this is the preferred technique for curve fitting. A calculation of the percent relative standard deviation (%RSD) is used to determine the acceptability of the use of the $\overline{RF}$. (See Table 11.1)

The % RSD is calculated as follows: $\%RSD = \frac{SD \times 100}{\overline{RF}}$

Where:
SD = Standard deviation of the averaged RFs for a given compound

11.1.7. **Linear Regression:** The linear regression calibration curve is derived from a least squares regression analysis of the calibration points. A calibration curve based on this technique will have the format of y = ax+b where "a" is the slope of the line and "b" is the y-intercept. In order to use this curve fit technique, a minimum of 5 calibration points must be available and the origin cannot be included as one of the points. This technique works well for calibrations where the response of the instrument is linear in nature, but does not necessarily intercept the y-axis at the origin. However, because the linear regression is not forced through the origin, very low levels of contaminants below the response of the lowest calibration point may generate erroneous reportable results. A calculation of the correlation coefficient "r" is used to determine the acceptability of a linear regressed curve (see Table 11.1).

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11.1.8. **Non-linear Regression:** The non-linear regression calibration curve is derived from a least squares regression analysis of the calibration points. A calibration curve based on this technique will have the format of $y= ax^2+bx+c$. In order to use this curve fit technique, a minimum of 6 calibration points must be available and the origin cannot be included as one of the points. This technique works well for calibrations where the response of the instrument gradually decreases with increasing concentrations. Using this technique, an analyst may be able to generate calibration curves with correlation coefficients very close or equivalent to 1.000. However, because the non-linear regression is not forced through the origin, very low levels of contaminants below the response of the lowest calibration point may generate erroneous reportable results. Likewise, high levels of contamination may not be able to be calculated due to regression equations with multiple intercepts of either axis on the calibration plot. A calculation of the coefficient of determination (COD) is used to determine the acceptability of a non-linear regressed curve (see Table 11.1).

11.2. Calibration Verification

11.2.1. Second Source Verification (SSV)

In addition to meeting the linearity criteria, any new calibration curve must be assessed for accuracy in the values generated. Accuracy is a function of both the "fit" of the curve to the points used and the accuracy of the standards used to generate the calibration points. By meeting the fit criteria, the accuracy relative to the goodness of fit is addressed. However, because all calibration points are from the same source, it is possible that the calibration points may meet linearity criteria, but not be accurately made in terms of their true value.

Therefore, to assess the accuracy relative to the purity of the standards, a single standard from a secondary source must be analyzed and the results obtained must be assessed relative to the known true value. This step is referred to as ***Secondary Source Verification*** or, alternatively as ***Initial Calibration Verification***. This secondary source must be from an alternative vendor or, in the event an alternative vendor is not available, from a different lot from the same vendor. The accuracy of the standard is assessed as a percent difference from the true value according to the following equation:

$$\%\text{Difference} = \frac{\left(RF_{SSV} - \overline{RF}\right)}{\overline{RF}} \times 100 \text{ (curves based on } \overline{RF}\text{)}$$

$$\%\text{Drift} = \frac{\left(\text{Result}_{SSV} - \text{True Value}_{SSV}\right)}{\text{True Value}_{SSV}} \times 100 \text{ (curves based on linear or non-linear regression)}$$

11.2.2. Continuing Calibration Verification (CCV)

As part of the analytical process, the instrumentation must be checked periodically to determine if the response has changed significantly since the initial calibration was established. This verification process is known as ***Continuing Calibration Verification***. The validity of the initial calibration is checked at the beginning of every daily analytical sequence for as long as the instrument is analyzing samples and is accomplished by analyzing a midpoint calibration standard (CCV). The values obtained from the analysis of the CCV are compared to the true values and a percent change calculated. The percent change must meet the method-specified criteria for the analysis to proceed for an additional twenty injections. Calibration curves based on an average response factor are assessed based on the percent difference of the RF calculated for the CCV from the average RF established in the initial calibration. The equations for this calculation is as follows:

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$$\%\text{Difference} = \frac{\left(RF_{CCV} - \overline{RF}\right)}{\overline{RF}} \times 100 \text{ (curves based on } \overline{RF}\text{)}$$

$$\%\text{Drift} = \frac{\left(\text{Result}_{CCV} - \text{True Value}_{CCV}\right)}{\text{True Value}_{CCV}} \times 100 \text{ (curves based on linear or non-linear regression)}$$

11.2.3. The absolute retention times in all continuing calibration standards must be within the retention time windows established at the beginning of the analytical shift. Catastrophic retention time shifting indicates potential chromatographic problems, and the system may require maintenance. A new initial calibration sequence is required prior to resuming analysis of samples.

Table 11.1 – Calibration Acceptance and Verification Criteria

Calibration Metric	Parameter / Frequency	Criteria	Comments
Calibration Curve Fit	Average Response Factor	%RSD ≤ 20%	If not met, try linear regression fit
	Linear Regression	r ≥ 0.99	If not met, try non-linear regression fit
	Non-linear Regression	COD ≥ 0.99	If not met, remake standards and recalibrate. Instrument maintenance may be required if problem persists.
Second Source Verification Standard	Immediately after each initial calibration	% Diff ± 25% % Drift ± 25% OR As specified per client QAPP	May be reanalyzed once. A second failure confirms and requires re-preparation of standard and/or recalibration. If problem persists an alternative source standard may need to be obtained.
Continuing Calibration Verification	Prior to the analysis of any samples, every twenty injections thereafter, and at the end of the analytical sequence. OR As specified per client QAPP	% Diff ± 20% % Drift ± 20%	May be reanalyzed once. A second failure confirms and requires corrective action (e.g. re-preparation and/or recalibration). **Exception:** If CCV fails high, then sample(s) that are <RL may be reported with appropriate qualification.
	Surrogate/Standard Peak RT	Within RTW	Use RT of the daily calibration standard (or midpoint of initial calibration, if analyzed that day) ± 0.03 minutes as the retention time window.
Instrument Blanks	Immediately following any standard that precedes a client or QC sample.	a) Surrogate recoveries should fall within 50-150%. b) Surrogate peaks must fall within sequence RTW. c) Target analytes should be less than the reporting limit. d) If sample results are reported to MDL, the IB must also be evaluated to the MDL.	May be reanalyzed once. A second failure confirms and requires corrective action (e.g. re-preparation of standard(s) and/or recalibration) **Exceptions:** If sample results are reported to MDL and IB is <RL but >MDL, then corrective action is not necessary other than appropriately qualifying the sample results. Unless the customer's QAPP or technical specification instruct to do otherwise. Samples that are <RL may be reported without qualification. (Not applicable to samples reporting down to MDL) Samples >10x IB may be reported with appropriate qualification.

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11.3. Calibration Linearity Problems

11.3.1. The lowest and/or highest level calibration standards may be removed from the calibration as long as the remaining number of concentration levels meets the minimum 3 calibration point requirement for OA2. The reporting limit must be adjusted to the lowest concentration remaining in the calibration curve and the upper limit of quantitation must be adjusted to the highest concentration remaining in the calibration curve.

11.3.2. Results from a concentration level between the lowest and highest calibration levels (interior point) can only be excluded from an initial calibration curve for a documentable and acceptable cause with approval from the responsible department supervisor and the local Quality Manager or his designee.

11.3.2.1 An acceptable cause is defined as an obvious sample introduction issue that resulted in no response, documentation of an incorrectly prepared standard, or a documented response of a single standard that is greater than 2X difference from the expected value of that standard.

11.3.2.2 The results for all analytes in the calibration point are to be excluded and the point must be replaced by re-analysis. Re-analysis of this interior standard must occur within the within 8 hours of the initial analysis of that standard for GC methodologies.

11.3.2.3 All samples analyzed prior to the re-analyzed calibration curve point must be reanalyzed and processed against the final calibration curve.

11.3.3. Perform and document instrument maintenance.

11.3.4. Complete recalibration of instrument.

11.3.5. Prepare and analyze new ICAL standards.

11.4. Continuing Verification Problems

11.4.1. Reanalyze the original CCV standard to determine instrument consistency.

11.4.2. Prepare and analyze a new CCV standard to determine preparation consistency / standard integrity.

11.4.3. Perform and document instrument maintenance

11.4.4. Reanalyze CCV standard to determine if maintenance was effective in restoring performance.

11.4.5. Complete recalibration of instrument.

11.4.6. If samples were analyzed in spite of verification failures, note the exception below for addressing those results. Deviations from this requirement must be noted on the injection log with a thorough explanation for the deviation from policy.

11.4.7. *Exception:* If calibration verification is above the upper control limit, samples non-detected for those analytes may be reported without reanalysis.

12. Procedure

12.1. GC System Preparation

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12.1.1. Configure the GC system to match the following operating parameters based on instrument configuration. The parameters themselves are saved as a method on the chromatography data system. By loading the last method used, the instrument will auto-configure to match the parameters from the last time the system was operated under that method. Verify that the settings in the software match the appropriate configuration.

Table 12.1 –Instrument Operating Parameters

Component	Settings and Consumables		
Gas Chromatograph	Column: Aglient DB-5 10M x 0.32mm x 0.5um, LTM P/N 123-500 ELTM (or equivalent) Inlet Liner: Restek P/N 23300.5 (or equivalent) Inlet Seal: Restek #21306 (not required on Aglient MMI injection systems) Column Ferrules: SGE analytical science P/N 072608 (or equivalent)	Column Flow: 5ml/min (Hydrogen) (constant flow) This should give ~8psi injection port head pressure <u>Column Setup:</u> Initial Temperature: 50°C Initial Hold : 0.5 min Ramp: 120°C/min Final Temperature: 340°C Final Hold: 1.96 min Total Run Time: 4.88 min	Oven Temperature: 290°C (constant) Injector Temperature: 290 °C Detector (FID) Temperature: 300 °C Detector Hydrogen Flow:30 ml/min Detector Air Flow : 300 ml/min Make up gas Nitrogen (constant mode) 20 ml/min
Autosampler	Sample Washes: 0 Sample Pump: 2 Injection Volume 1.0 uL Syringe Size: 10 uL	PostInj Solvent A Washes: 3 PostInj Solvent B Washes: 2 Viscosity Delay: 0 sec. Plunger Speed: Fast PreInjection Dwell: 0 min PostInjection Dwell: 0 min	

12.2. Calibration Verification

12.2.1. Prior to sample analysis, the instrument must undergo calibration verification. If it has already been determined that the instrument needs to be recalibrated, follow the procedures listed in Section 11 (Calibration). Otherwise, analyze a Continuing Calibration Verification Standard to determine the current calibration status.

12.2.2. If the CCV meets control criteria, the system is deemed to be in control and analysis of samples may commence. If the CCV does not meet control criteria, follow the corrective action procedures listed Section 11.5 (Continuing Verification Problems).

12.2.3. A CCV must be injected every twenty injections and at the end of the analytical sequence.

12.2.4. When instruments are operating unattended, autosamplers may be programmed to inject consecutive CCVs as a preventative measure against CCV failure with no corrective action. In this case, both CCVs must be evaluated to determine potential impact to the results. A summary of the decision tree and necessary documentation are listed below:

12.2.4.1 If both CCVs meet the acceptance criteria, the analytical sequence is allowed to continue without corrective action.

12.2.4.2 If the first CCV does not meet the acceptance criteria and the second CCV is acceptable, the analytical sequence is continued and the results are reported.

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12.2.4.3 If the first CCV meets the acceptance criteria and the second CCV is out of control, the samples after the out of control CCV must be re-analyzed in a compliant analytical sequence.

12.2.4.4 If both CCVs are out of control, all samples since the last acceptable CCV must be re-analyzed in a compliant analytical sequence.

12.3. Soil/Waste Preparation

12.3.1. Refer to the most current revision of SOP S-KS-O-032, *Microwave Extraction by EPA 3546*, for preparation of soil/solid samples.

12.3.2. Refer to the most current revision of SOP S-KS-O-035, *Waste Dilution*, for wastes and products miscible with organic solvents.

12.4. Water Sample Preparation

12.4.1. Refer to the most current revision of SOP S-KS-O-029, *Separatory Funnel Extraction*, or SOP S-KS-O-040, *Separatory Funnel Extraction (Reduced Volume)* for preparation of aqueous samples.

12.5. Dilutions

12.5.1. Dilutions on sample extracts must be prepared in a volumetric fashion. Sample aliquots should be taken in volumetric syringes and brought to volume by the addition of solvent via an appropriate syringe.

12.5.2. In the event a dilution is made to bring a target analyte into calibration range, the analyst should make a dilution such that the target analyte is roughly the equivalent of the mid calibration point whenever possible. Record the lot number of the diluent in the analysis sequence logbook.

12.6. Data Reduction

12.6.1. Qualitative Analysis

12.6.1.1 Verification of the identity of the contaminant must be established by comparison of sample chromatograms with high-quality commercial products used as standards.

12.6.1.2 Petroleum products are complex mixtures of compounds derived from crude petroleum, and different products may have overlapping boiling ranges and chromatograms; care must be taken to distinguish closely related products and to account for possible degradation in the environment.

12.6.1.3 Identification of the contaminant is established by comparison of sample chromatograms with the commercial products used as standards. The standard most nearly matching the sample chromatogram(s) is selected and used for sample quantitation.

12.6.1.4 In the event that a contaminant cannot be matched to a standard, the detector response will be quantitated and reported as TEH as Diesel No 2 or as Total Petroleum Hydrocarbons (TPH), depending on clients' requirements.

12.6.2. Quantitative Analysis

12.6.2.1 Quantitation is based on the peak area within the standard range (first peak to last peak)

12.6.2.1.1 Petroleum products that may be reported but not limited to are:

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Diesel Fuel
Gasoline
Mineral spirits
Kerosene
Jet fuel
Fuel oil
Motor oil
Hydraulic fluid

12.6.2.2 The data system will calculate the concentration of each analyte in the sample extract. If supplied with the preparation parameters, the system may be able to calculate the results back to the original matrix.

13. Quality Control

13.1. Table 13.1 – Batch Quality Control Criteria

QA Sample	Components	Frequency	Acceptance Criteria	Corrective Action
Method Blank (MB)	Matrix-specific; Reagent water or Ottawa sand	One per batch of up to 20 samples	1) Target analytes should be less than the reporting limit. 2) If results are reported to MDL, the MB must also be evaluated to the MDL	1) Re-analyze blank to confirm failure. 2) Qualify results and / or re-extract associated samples. ***Exceptions:*** 1) If sample ND, report sample without qualification 2) If sample result >10x MB detects and sample cannot be reanalyzed, report sample with appropriate qualifier indicating blank contamination. 3) If sample result <10x MB detects, report sample with appropriate qualifier to indicate an estimated value. Client must be alerted and authorize this condition. 4) If sample results are reported to MDL and MB is <RL but >MDL, then corrective action is not necessary other than appropriately qualifying the sample results. Unless the customer's QAPP or technical specification instruct to do otherwise.
Laboratory Control Sample (LCS)	Matrix-specific; Reagent water or Ottawa sand spiked with diesel fuel	One per batch of up to 20 samples	Laboratory-derived recovery limits, not to exceed ± 40%.	1) Reanalyze the LCS to confirm failure 2) Re-extract samples where possible 3) If problem persists, check spike solution ***Exceptions:*** 1) LCS > QC limits and these compounds are non-detect in the associated samples, the sample data may be reported with appropriate data qualifiers. 2) If LCS < QC limits and sample cannot be reanalyzed report sample with appropriate qualifier to indicate an estimated value. Client should be alerted to this condition.

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QA Sample	Components	Frequency	Acceptance Criteria	Corrective Action
Matrix Spike (MS)	Matrix-specific; Client Sample spiked with diesel fuel	One per batch of up to 20 samples	Laboratory-derived recovery limits, not to exceed ± 40%, except for a demonstrated matrix effect.	1) No corrective actions necessary. If LCS recovery is in range, the system is considered valid and the out-of-control MS/MSDs are footnoted appropriately indicating matrix interferences.
Matrix Spike Duplicate (MSD)	MS Duplicate	One per batch of up to 20 samples.	Laboratory-derived RPD limit.	1) No corrective actions necessary. Report results with an appropriate footnote.

13.2. **Table 13.2 – Sample Quality Control**

QA Sample	Components	Frequency	Acceptance Criteria	Corrective Action
Surrogate Standards	n-Tetracosane p-Terphenyl	Added to all samples, spikes, control samples and method blanks prior to analysis	Laboratory-derived recovery limits Surrogate retention time must fall within sequence RTW.	1) Re-analyze extract to confirm failure 2) Assess impact of sample matrix 3) In the absence of obvious matrix interference to recovery (high background, extremely dark extract), re-extract sample. ***Exceptions:*** 1) Surr. Rec. above criteria and target compounds < RL, result may be reported with appropriate footnote. 2) Surr. Rec. out of control due to obvious sample matrix interference (i.e. co-elution), report results with appropriate footnote.

14. Data Analysis and Calculations

14.1. Aqueous sample:

$$\text{Concentration (mg/L)} = \frac{(C_x)(V_v)(DF)}{(V_s)}$$

where:
Cx = Concentration in extract (ug/mL).
Vv = Volume of final extract (mL).
DF= Dilution factor.
Vs = Volume of water sample extracted (mL).

14.2. Soil/Solid sample:

$$\text{Concentration (mg/kg)} = \frac{(C_x)(V_v)(DF)}{(W_s)}$$

where:
C_x = Concentration in extract (ug/mL).
V_v = Volume of final extract (mL).
DF= Dilution factor.
W_s= Weight of soil sample extracted (g).

15. Data Assessment and Acceptance Criteria for Quality Control Measures

15.1. See tables in section 13.

16. Corrective Actions for Out-of-Control Data

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16.1. See tables in sections 11 and 13.

17. Contingencies for Handling Out-of-Control or Unacceptable Data

17.1. See tables in sections 11 and 13. If there is no additional sample volume to perform re-analyses, if the analytical results are due to the customer, and/or if there is no more holding time remaining; then data will be reported as final with applicable qualifiers. If necessary, an official case narrative can be prepared by the Quality Manager or Project Manager.

18. Method Performance

18.1. All applicable personnel must read and understand this SOP with documentation of SOP review maintained in their training files.

18.2. **Method Detection Limit (MDL) Study**: An MDL study must be conducted annually (per the method) per S-ALL-Q-004, Method Detection Limit Studies for each matrix per instrument.

18.3. **Demonstration of Capability (DOC)**: Every analyst who performs this method must first document acceptable accuracy and precision by passing a demonstration of capability study (DOC) per S-ALL-Q-020, Training Procedures.

18.3.1. Analysis of 4 replicates of reagent water spiked with 1 mL of the OA-2 Spiking Standard solution at a concentration of 5000 ug/L or equivalent to the LCS.

18.3.2. Analysis of 4 replicates of Ottawa sand spiked with 1 mL of OA-2 Spiking Standard solution at a concentration of 500 mg/kg or equivalent to the LCS.

18.3.3. Using the results of each set of four analyses, compute the average percent recovery (X) and the relative standard deviation (RSD) of the recoveries for diesel fuel.

18.3.4. If X is with the matrix-specific LCS acceptance criteria and the RSD is <30%, system performance is acceptable and analysis of samples may begin.

18.3.5. If, however, either RSD exceeds the precision limit or X falls outside the range for recovery, system performance is unacceptable. In this event, correct the problem and repeat the test.

19. Method Modifications

19.1. For this SOP, the lab has chosen to allow sample volumes >100 mL instead of the method-specified 1000 mL.

19.2. For this SOP, the retention time maker is used for reference purposes only..

20. Instrument/Equipment Maintenance

20.1. Perform the following daily, prior to the analytical sequence:

20.1.1. replace inlet liner, o-ring, seal, and septum,

20.1.2. clean inlet with $MeCl_2$-moistened swab,

20.1.3. remove approximately 5cm from front of column.

21. Troubleshooting

21.1 See instrument manual.

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22. Safety

22.1. **Standards and Reagents**: The toxicity and carcinogenicity of standards and reagents used in this method have not been fully defined. Each chemical compound should be treated as a potential health hazard. Reduce exposure by the use of gloves, lab coats and safety glasses. Material Safety Data Sheets (MSDSs) are on file in the laboratory and available to all personnel. Standard solutions should be prepared in a hood whenever possible.

22.2. **Samples**: Take precautions when handling samples. Samples should always be treated as potentially hazardous "unknowns". The use of personal protective equipment (gloves, lab coats and safety glasses) is required when handling samples. In the event a sample container must be opened, it is recommended to perform this in a hood whenever possible.

22.3. **Equipment**

22.3.1. Portions of the analytical instrumentation operate at high temperature. Instruments should be turned off or the heated zone temperatures lowered to reduce the risk of thermal burns. Allow adequate time for the equipment to cool prior to working on these specific zones.

22.3.2. The instrument also uses gas under high pressure. These high pressures introduce the risk of injury due to flying objects should a vessel or line rupture. Safety glasses are mandatory at all times when working in, on or around these pieces of equipment. Even instrumentation that is not operating may contain portions of the system under pressure.

22.3.3. When using hydrogen (H_2) as the carrier gas or fuel gas, be aware that hydrogen gas can flow into the GC oven and create an explosion hazard. Therefore, be sure that the supply is turned off until all connections are made and ensure that the inlet and detector column fittings are either connected to a column or capped at all times when hydrogen gas is supplied to the instrument. Hydrogen is flammable. Leaks, when confined in an enclosed space, may create a fire or explosion hazard. In any application using hydrogen, leak test all connections, lines, and valves before operating the instrument. Always turn off the hydrogen supply at its source before working on the instrument.

23. Waste Management

23.1. Procedures for handling waste generated during this analysis are addressed in S-ALL-S-002, Waste Handling.

23.2. In order to minimize the amount of waste generated during this procedure, analyst should prepare reagents in an amount which may be used in a reasonable amount of time (e.g., before a reagent expires).

24. Pollution Prevention

24.1. The company wide Chemical Hygiene and Safety Manual contains information on pollution prevention.

25. References

25.1. Method OA-2, "Method for Determination of Extractable Petroleum Products (And Related Low Volatility Organic Compounds)," revision 7/27/93.

25.2. Pace Quality Assurance Manual- most current version.

25.3. National Environmental Laboratory Accreditation Conference (NELAC), Chapter 5, "Quality Systems," most current version.

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25.4. The NELAC Institute (TNI); Volume 1, Module 2, "Quality Systems"- most current version.

26. Tables, Diagrams, Flowcharts, and Validation Data

26.1. Attachment I: Client-Specific Criteria (Internal Use Only)

26.2. Attachment II: Client-Specific Criteria (Internal Use Only)

27. Revisions

Document Number	Reason for Change	Date
KS-O-6320-C	Grammatical/Removal of outdated information.	March 23, 2001
KS-O-6320-D	Grammatical/Removal of outdated information.	February 11, 2003
KS-O-014-rev.5	Grammatical/Removal of outdated information.	June 2, 2005
S-KS-O-014-rev.6	Overall conversion to template format. Changes required based on conversion are not explicitly noted unless change represents a significant policy change. Section 10 - Added surrogates to all standards.	December 18, 2007
S-KS-O-014-rev.7	Section 10 – Replaced standard solvent with methylene chloride. Changed standard preparation. Section 12 – Changed extraction weights and volumes. Section 14 – Changed RSD criteria for DOC. Section 17 – Changed Motor Oil PQLs.	June 10, 2009
S-KS-O-014-rev.8	SOP – Updated to new SOP template format. Section 5 – Updated PQLs. Section 10 – Added sixth level to diesel curve. Section 12 - Added 60GCS9.	July 12, 2012
S-KS-O-014-rev.9	Section 5 – Revised Soil LOQs to 10mg/kg Section 10 – Reorganized and converted info into table format. Added secondary source prep info. Added RTM standard prep info. Revised number of diesel cal stds to 8. Revised number of gas and m.oil cal stds to 6. Section 11.1.2 – Added product identification standards analyzed annually Section 11.1.3 – Added RTM standard Section 11.1.5 – Reworded for clarity Table 11.1 – Reworded and revised ICV and CCV frequency. Revised ICV acceptance criteria. Section 11.3 – Reworded and added some corrective actions Table 12.1 – Revised GC settings and consumables Section 12.2 – Reworded Section 12.3 – Changed soil extraction procedure to EPA 3546 (microwave) Section 12.5 – Reworded Section 12.6 – Added RTM standard Table 13.1 – Reworded corrective actions for clarity Section 17 – Reworded Section 19 – Added RTM as a method mod Attachments I and II – Added	December 4, 2013
S-KS-O-014-rev.10	Revised to latest prescribed format Section 11.1.3 Changed definitions of Gasoline, Diesel and Motor Oil peaks. Section 12.6.2 Changed analyte reporting list and range. Section 19.2 – Retention Time Marker for reference only Attachment I: Added a disclaimer Attachement II: Added a disclaimer	March 5, 2015

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Appendix B

Field Sampling Plan

Voluntary Cleanup Plan
Field Sampling Plan

Double Circle Farm Supply Site
Fort Scott, Kansas
KDHE Voluntary Agreement 07VCP003

Antea Group Project No. UPR8263A
November 12, 2015

Prepared for:
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Voluntary Cleanup Plan

Field Sampling Plan

Double Circle Farm Supply Site
Fort Scott, Kansas

1.0 INTRODUCTION

Antea®Group, on behalf of Union Pacific Railroad (UP), has prepared this Field Sampling Plan (FSP) to summarize field activities and procedures associated with the remedial action implementation at the UP property located north of the intersection of Elm Street and National Avenue, south of the Marmaton River in Fort Scott, Kansas (hereby the "Site"). The FSP describes the procedures for sample positioning, sample collection, processing, identification, documentation, equipment decontamination, and sample handling for the remedial field activities, and was developed in conjunction with the Voluntary Cleanup Plan (VCP) and associated Quality Assurance Project Plan (QAPP). This document was completed in compliance with Kansas Department of Health and Environment's (KDHE) Voluntary Cleanup and Property Redevelopment Program Manual.

Standard operating procedures (SOPs) for tasks discussed in this document will govern all aspects of field measurement, methodology, sample collection, and documentation efforts to ensure that samples collected are representative of conditions in the field. Rationale for the FSP scope of work and remedial activities are discussed in the VCP. KDHE's SOPs are presented as an Attachment in the QAPP.

Sampling activities proposed as part of the VCP, included in this FSP include the following project tasks:

- Groundwater Monitoring Well Installation: Prior to the start of remediation activities, two additional groundwater monitoring wells will be installed to aid in monitoring of the groundwater plume.

- Pre-Remediation Sampling: One round of groundwater and surface water samples will be collected prior to remediation activities.

- Post Remediation Sampling: Groundwater and surface water sampling will be performed for a minimum of two (2) years following the remediation activities. Data collected from the

groundwater sampling events will provide post remediation dissolved-phase concentrations at the Site.

2.0 FIELD ACTIVITIES

This section pertains to the proposed field activities to be completed as part of the remediation activities at the Site. Prior to subsurface activities, the state one call, UP-specific locates, and UP facility personnel will be notified of the proposed work and to locate and identify subsurface utilities within the proposed disturbed area(s).

2.1 Monitoring Well Design, Installation and Construction

Monitoring wells will be installed and constructed by a Kansas licensed driller at the locations determined in the VCP. Monitoring wells will be constructed in compliance with KDHE SOP BER-06, Installation of Monitoring Wells.

During monitoring well installation activities, well construction details and geologic logs will be recorded by the onsite personnel, in accordance with KDHE SOP BER-06, Installation of Monitoring Wells.

Following the installation of the groundwater monitoring wells, each well will be developed by surging and pumping. The purpose of the development activities is to set the sand pack and to remove fine-grained material from the sand pack and casing. This is done to enable the collection of groundwater samples with a low turbidity.

An electronic water level meter will be used to measure depth to water in the well, as measured from the top of the surveyed well casing. Additionally, the total depth of each well will be measured with the water level meter. The water depth and total well depth measurements will be used to calculate the thickness of the water column (height of standing water in the well). The well depth obtained by the water level meter should be compared to the well completion data obtained during well construction. Significant differences between these values may indicate silt buildup in the well. Use of the water level meter or product level meter will be performed in compliance with SOP BER-36, Water Level, Product, and Well Depth Measurements.

Each monitoring well will be surged and pumped to remove the fine-grained material. Surging and pumping will continue until a noticeable decrease in suspended solids is observed. Well construction and design equipment will be supplied by the contractor in accordance with EPA and KDHE regulations and SOPs. Well development equipment is discussed in Section 3.2.3.

2.2 Groundwater Sampling

Proper sampling protocol must be followed to ensure that representative samples of groundwater are provided for analysis and that the act of sampling does not contribute to further impact at the site or cross-contamination of samples. Techniques employed shall be thoroughly documented.

Groundwater samples will be collected in accordance with KDHE SOP BER-01 (Collection of Groundwater Samples at Known or Suspected Groundwater Contaminated Sites). Groundwater samples will be collected from on-site monitoring wells for laboratory analysis in accordance with the VCP and QAPP.

2.2.1 Groundwater Elevation Monitoring

Static groundwater elevation will be measured using an electronic water level meter. Use of the water level meter will be completed in accordance with KDHE SOP BER-36, Water Level, Product, and Well Depth Measurements.

2.2.2 Water Quality Data

Water quality data will be collected from each monitoring well using a down-hole multi-parameter meter. The meter will collect pH, temperature, dissolved oxygen, conductivity, and oxidation/reduction potential readings from the groundwater. Use of the multi-meter will be completed in accordance with the KDHE SOP BER-26, Use of Water Quality Analyzers for Well Stabilization.

2.2.3 Groundwater Sample Designation

Groundwater samples collected from proposed or existing monitoring wells will be labeled according to the monitoring well ID and the date of collection. Sample identification will be designated with the media type (WG for Groundwater), the UP facility ID number, Monitoring well ID (MW-1), and date (month/day/year). The date and time of collection will be recorded in the field logbook and on the COC. Sample names will follow the below format:

WG-1475-MW-1-050115

2.2.4 Groundwater Sampling Equipment

Equipment and material that will be used to collect groundwater samples are listed below:

Nitrile gloves	FedEx shipping labels
Nylon rope	Sharpie pen
Distilled water	Field notebook, site map
HydraSleeve	Quart size freezer Ziploc bags
Paper Towels	Hand tools
Alconox or Liquinox	Laboratory supplied sample jars, COCs, labels
GPS unit	Decontamination equipment
Calculator	5-gallon buckets
Coolers	Multi-parameter meters
Ice	Peristaltic pump and tubing
Disposable bailers	

2.3 Surface Water Sampling

Surface water samples will be collected in accordance with KDHE SOP BER-02 (Collection of Surface Water Samples at Suspected or Known Contaminated Sites). Surface water samples will be collected from three locations in the Marmaton River, both upstream and downstream, for laboratory analysis in accordance with the VCP and QAPP.

2.3.1 Surface Water Sample Designation

Surface water samples collected from the Marmaton River will be labeled according to the sample location ID and the date of collection. Sample identification will be designated with the media type (WS for surface water), the UP facility ID number, location ID (MR-1), and date (month/day/year). The date and time of collection will be recorded in the field logbook and on the COC. Sample names will follow the below format:

WS-1475-MR-1-050115

2.3.2 Groundwater Sampling Equipment

Equipment and material that will be used to collect surface water samples are listed below:

Nitrile gloves	FedEx shipping labels
Coolers	Sharpie pen
Distilled water	Field notebook, site map
Dip Sampler	Quart size freezer Ziploc bags
Paper Towels	Ice
Alconox or Liquinox	Laboratory supplied sample jars, COCs, labels
GPS unit	
Calculator	

2.4 Quality Control and Quality Assurance Samples

Quality Assurance/Quality Control (QA/QC) samples, such as field duplicate samples collected during sampling activities, will be labeled with unique sample identifiers and the date at which the sample was collected. A record of the QA/QC samples collected will be kept in the field notebook along with the chain of custody (COC). The following sample naming format will be followed for QA/QC samples that may be collected:

Equipment Blanks - WQ-1475-EB–1-050115
Trip Blanks - WQ-1475-TB–1-050115
Field Blanks - WQ-1475-FB–1-050115
Duplicate Samples - WG-1475-DUP-1-050115

3.0 DECONTAMINATION OF EQUIPMENT

Equipment used during field activities will be decontaminated prior to use and during sampling to reduce the potential for the introduction of contamination and cross-contamination in accordance with the guidelines and procedures set forth in this document. These procedures are necessary to ensure quality control in decontamination of field equipment. Equipment decontamination will be completed in accordance with KDHE SOP BER-05 (Decontamination of Equipment).

3.1 Decontamination Procedures

Decontamination of all non-disposable field sampling equipment, field instruments and sample containers will be conducted in a thorough and step-wise manner as described below. Decontamination

will be conducted in the designated decontamination area. Decontamination procedures shall be documented in the field notebook.

3.1.1 Exploration and Drilling Equipment Procedure

Prior to use, between locations, upon arriving at the site and when leaving the site, push probes, augers, and other non-sampling equipment shall be certified clean or decontaminated in accordance with the following procedures:

- Move equipment to designated decontamination area;
- Clean thoroughly (inside and outside) with a high-pressure steam cleaning unit (water at 200° F and 1,500 psi);
- Allow to air dry; and
- Store in a clean area on plastic sheeting

3.1.2 Sampling Equipment Decontamination Procedure

All non-disposable sampling equipment used for soil and groundwater sampling will be decontaminated between each sample. The decontamination procedure is provided as follows:

- Rinse thoroughly with potable water
- Scrub with non-phosphate cleaning solution such as Liquinox or Alconox to remove any visible dirt or contamination
- Rinse thoroughly with potable water
- Rinse with distilled water

Sampling equipment shall be stored in the same manner as non-sampling equipment described above.

3.1.3 Sample Containers

Sample containers will be laboratory-cleaned and will be supplied by the analytical lab performing the analytical analyses.

3.1.4 Equipment for Decontamination of Equipment

Equipment and material that will be used to decontaminate sampling equipment are listed below:

Distilled water	Long handled bottle brushes
Potable water	Trash receptacles
5-gallon buckets	Plastic sheeting
Scrub brushes	Liquinox or Alconox

4.0 HANDLING OF ENVIRONMENTAL SAMPLES

Numerous samples from various environmental media shall be collected at the Site. It is imperative that proper sample identification, handling, storage and shipping procedures be followed to ensure that samples can be properly traced and that data obtained is of known quality. This section specifies general methods for handling storage and shipping of samples collected during the remedial action. Additional sample handling and shipping information can be found in the QAPP.

4.1 Procedures

Sampling personnel will be equipped with a bound field notebook during performance of remediation activities. All data regarding sample collection will be recorded in this field notebook. The chain-of-custody (COC) program will allow for the tracking, possession and handling of individual samples from the time of field collection through laboratory analysis. The COC form will be used by personnel responsible for ensuring the integrity of the samples and will be maintained in the project files as documentation of sample handling procedures.

4.2 Sample Container Preparation

All containers used in the sampling of groundwater shall be laboratory cleaned as specified in the QAPP. The container type and preservative requirements shall follow the specifications of the QAPP.

4.3 Procedures to Prevent Cross-Contamination

Personnel collecting soil and groundwater samples will take the following precautions to minimize sample contamination or cross-contamination between samples:

- New nitrile gloves will be used while collecting all samples and will be disposed of after equipment has been decontaminated.
- Sampling personnel will not touch the inside of the sampling container.
- Only equipment that has been properly decontaminated according to the procedures specified in **Section 4.0**, Decontamination of Equipment, will be used for environmental sample collection.

4.4 Sample Chain-of-Custody Record Form

The primary objective of the chain of custody procedures is to provide an accurate written or computerized record that can be used to trace the possession and handling of a sample from collection to completion of all required analysis. Details of the chain of custody procedures are outlined in the QAPP.

5.0 LIMITATIONS

The findings contained in this report represent Antea Group's professional opinions based upon the currently available information and are arrived at in accordance with currently acceptable professional standards. For any reports cited that were not generated by Antea USA, Inc., the data from those reports are used "as is" and is assumed to be accurate. Antea USA, Inc. does not guarantee the accuracy of this data for the referenced work performed nor the inferences or conclusions stated in these reports. This report is based upon a specific scope of work requested by the client. The Contract between Antea Group and its client outlines the scope of work, and only those tasks specifically authorized by that contract or outlined in this report were performed. This report is intended only for the use of Antea Group's Client and anyone else specifically listed on this report. Antea Group will not and cannot be liable for unauthorized reliance by any other third party. Other than as contained in this paragraph, Antea Group makes no express or implied warranty as to the contents of this report.

Meghan Guilford — Date: 11-12-2015

Meghan Guilford
Project Professional

Reviewed by:

Addie J Mette — Date: 11/12/15

Addie J. Mette
Senior Project Manager

Attachment A

KDHE – Standard Operating Procedures

STANDARD OPERATING PROCEDURE – BER-01

COLLECTION OF GROUNDWATER SAMPLES AT KNOWN OR SUSPECTED GROUNDWATER CONTAMINATION SITES

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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ATTACHMENT 1 – Pump Information

ATTACHMENT 2 – Example Well Sampling Forms

DISCLAIMER:

This Standard Operating Procedure (SOP) was developed based on a compilation of best available information, knowledge, field experience, and general industry practices to provide guidance to KDHE staff in performing the activities defined herein, in a consistent and standardized manner. This document does not contain regulatory or statutory requirements unless specified.

KDHE has made every attempt to present the information in a clear and concise manner for a variety of users. However, KDHE is not responsible for the misuse or misinterpretation of the information presented herein. Under no circumstances shall KDHE be liable for any actions taken or omissions made by non-KDHE users of this document.

In general, this document should be used as a reference. Differences may exist between the procedures referenced in this document and what is appropriate under site-specific conditions. This document does not represent an endorsement of practitioners or products mentioned in the document.

1.0 INTRODUCTION

The purpose of this Standard Operating Procedure (SOP) is to provide general procedures and guidance for sampling groundwater wells using the well-volume method, the low-flow method, and no-purge methods for common contaminants of concern. Additional guidance is included for specific situations including collection of samples with volatile organic compounds (VOCs) and sites with low-yield wells. The objective of groundwater sampling is to obtain a representative sample by minimizing chemical and biological changes caused by sample collection and handling (USEPA, 2002). This SOP is generally applicable for contaminated sites in Kansas and is intended for wells that have a discrete screen length. Site-specific conditions or circumstances may necessitate the need to deviate from or use methods not outlined in this document subject to unit chief approval.

Each groundwater sampling method has inherent advantages and disadvantages that must be given consideration. An evaluation of site-specific factors is important in determining the appropriate sampling method for a well. These considerations can include, but may not be limited to: hydrogeological conditions, state or federal regulations, analytes of concern, well design, historical data, well development, well hydraulics, well condition, and data quality objectives when selecting appropriate sampling method (ASTM, 2005 and ASTM, 2007). Objectives for a groundwater well sampling program must be clearly defined before field implementation and the appropriate sampling method must be determined on a site-specific basis. The field sampling plan (FSP), quality assurance project plan (QAPP) and health and safety plan (HSP) must be reviewed prior to collection of any samples. Sampling devices selected should be constructed of materials that do not introduce contaminants or alter the target analytes (ASTM, 2007).

2.0 PRE-SAMPLING PROCEDURES

1. Start sampling at the least contaminated well, if known, and work to progressively more contaminated wells. The most contaminated well should be sampled last. If the contamination levels are not known, work from the most downgradient sampling location from the potential source area first, sampling closest to the potential source area last. If the direction of groundwater flow is unknown or uncertain, sampling should be initiated at the farthest distance away while progressively moving closer to the known or suspected source area.

2. Physical contact between sampling equipment and contaminated media should be minimized during well purging and sampling activities to avoid

contaminating the sampling equipment and/or groundwater. For example, bailers and pumps should not come in contact with soil or purge water containers. It may be appropriate to place plastic sheeting around the well to prevent direct contact of sampling equipment with the ground surface. A new pair of sampling gloves must be worn for each well prior to sampling to prevent cross-contamination.

3. Remove well cap to allow the groundwater level in the well to equilibrate with the ambient atmospheric pressure. Record well location, time of day, date, well condition, and other pertinent information in field notebook. Ideally, if more than one well is to be sampled at a site, all wells should be opened and have the depth to water measurements collected before purging and sampling activities begin.

4. When appropriate, screen the head-space of the well with a vapor monitoring instrument immediately after removal of the well cap to determine the presence of organic vapors and record the instrument response in site logbook.

5. Prior to placing any water level measuring device or reusable bailer in a well, care should be exercised to ensure that free floating immiscible product is not present in the well. Only properly decontaminated equipment should be introduced to the well. A disposable bailer may be lowered into the well to determine the approximate depth to water or depth to floating product. If floating product is observed, a groundwater sample should not be collected unless otherwise specified by a site-specific work plan. An interface probe or a partially submerged, clear PVC bailer should be used to measure the floating product thickness and the depth to water in the well. An attempt should be made to describe the type, color, and viscosity of the product.

6. Lower water level measuring device into well until water surface is encountered. Record the depth of the water surface from a specific reference point and record depth to water in field notebook to the nearest one hundredth of a foot. Water level measurement method and measurement reference point should also be recorded. Please refer to BER-36 titled. "Water Level, Product, and Well Depth Measurements."

7. Measure total depth of well and record in site logbook or on log form. Total well depth should not be measured until after the sample is collected when using the no-purge sampling method.

3.0 SAMPLING USING THE WELL-VOLUME METHOD

3.1 DESCRIPTION OF WELL-VOLUME METHOD

The goal of well purging is to remove the stagnant water above the screened interval in order to collect a representative groundwater sample. The well-volume method is a traditional technique where a predetermined volume of water is removed from the well or water is removed from the well until specified parameters have stabilized before sample collection. This SOP outlines general procedures for purging and sampling using a fixed well-volume method. The stabilization well-volume method can be used to determine when a well has been adequately purged, but this specific method is not outlined in this SOP. Stabilization criteria for the stabilization well-volume method are similar to those outlined for low-flow sampling method, but specific stabilization criteria, measurement frequency, and other procedure requirements should be outlined in the site-specific work plan (USEPA, 2002).

Site-specific conditions and objectives should be considered before selecting this method since it may not be appropriate in conditions where there are low-yield wells, wells with higher turbidity, wells in fractured rock settings, wells with a set pump, or wells with separate phases of liquids (such as dense or light non-aqueous phase liquids) (USEPA, 2002). The advantages are that a variety of pumps can be used for purging or sampling and that it does not require chemical parameter measurements to determine when purging is complete. The disadvantages associated with the fixed well-volume method are that there may be an increased cost associated with handling a larger volume of investigative- derived waste (IDW) and that no well-specific analyte indicator or parameter used to determine when the well is adequately purged (ASTM, 2005). It is recommended that the stabilization method is used in most cases as this method commonly provides the most reliable data.

3.2 DETERMINATION OF PURGE VOLUME

A well is typically purged at least three to five well volumes (ASTM, 2007) and a fixed well volume purging is best applied to wells that yield multiple well volumes without fully dewatering the well (ASTM, 2005). The volume of water in the well, depth to water level, inner diameter of the well, the aquifer's recovery rate, accessibility to the well, and the contaminants being sampled have an effect on how a well should be purged and sampled. It is recommended that the same equipment used for purging also be used for sampling, unless the device is inappropriate for target analytes. A pump or bailer can be used to purge a well and it is

preferable that equipment be constructed of an inert material (USEPA, 2002).

The volume of water in the well can be calculated by using information collected in pre-sampling activities (Section 2.0). The depth to water, total well depth, and inner well casing diameter are used in the following formula:

$V = \pi r^2 h(cf)$

where:
V = volume in gallons
π = pi or 3.1416
r = radius of monitoring well (feet); radius in inches/12 = radius in feet
h = height of the water column (feet), which equals the total well depth minus depth to water
cf = conversion factor (7.48 gal/ft^3)

Other variations of the basic formula for a cylinder can also be used to calculate the volume of water in a well. In most cases, it is appropriate to also purge the volume of water contained within a gravel pack and/or well borehole in addition to the well volume to assure that a representative sample is obtained.

For a 2 inch well: Volume = [(total depth – depth to water) * 0.16]
For a 4 inch well: Volume = [(total depth – depth to water) * 0.65]
For a 5 inch well: Volume = [(total depth – depth to water) * 1.03]
For a 6 inch well: Volume = [(total depth – depth to water) * 1.48]

Or calculate the volume using the following formula:
Volume = (total depth – depth to water)(casing inner diameter)^2(0.041)
Note: measurements are in feet

3.3 PURGING PROCEDURES FOR THE WELL-VOLUME METHOD

3.3.1 Purging with a Bailer

Bailers are a simple purging device and generally consist of a rigid length of tube constructed from PVC, stainless steel, or Teflon®, and usually with a ball check-valve at the bottom. A line is used to lower the bailer into the well to retrieve a volume of water. This manual method of purging is best suited for shallow or narrow diameter wells. Generally, bailers should be used if the well has a

low recovery rate or if the amount of water to be purged is minimal (USEPA, 2002).

1. Complete the pre-sampling activities as outlined in Section 2.0.

2. Determine the appropriate purge water volume as described in Section 3.2.

3. Attach the line to the bailer and slowly lower the bailer until it is completely submerged in the water. Only dedicated, disposable, or properly decontaminated purge equipment should be introduced into the well. Over-disturbance of the water column in the well should be avoided. Carefully pull the bailer out to minimize disturbance of the well casing and water, and ensure that the line either falls onto a clean area of plastic sheeting or does not touch the ground. Empty the bailer into a bucket (of a known volume) to measure the volume of water purged.

4. Thereafter, continue with bailing process until desired purge volume has been removed. Record the total volume of water purged in field notebook.

5. Dispose of purged water as specified in the site-specific work plan.

6. If any bailer is being used at more than one well, it should be properly decontaminated prior to sampling the next well. New rope or string must be used at each location.

3.3.2 Purging with a Pump

Pump construction materials (bladders, pump, tubing) should be limited to stainless steel, Teflon, glass or other inert materials. A variety of pumps are available for purging wells. Please make sure that the pump utilized meets the criteria for the depth of water and type of target analytes. A description of common pump types can be found in Pump Information Attachment 1.

1. Complete the pre-sampling procedures as outlined in Section 2.0.

2. Determine the appropriate purge water volume as described in Section 3.2.

3. Assemble pump, hoses and safety cable, and lower the pump into the well at the appropriate depth below the water. Only properly decontaminated purging equipment should be introduced into the well. Care should be taken not to drop the pump in the well and over-disturb the water column. The pump should be placed just below the water level, making sure the pump is deep enough so that purging does not evacuate all the water (running the pump without water may cause damage), but keeping it above the screened interval if possible.

4. Attach a flow meter to the outlet hose to measure the volume of water purged. If a flow meter is not available, a bucket of known volume and stopwatch may be used to measure the volume of water purged and pumping rate.

5. The water level should be monitored during purging to ensure air does not enter the pump, and that the pump is set at an appropriate pump rate. If the pumping rate exceeds the well recharge rate, lower the pump further into the well and continue pumping, or if possible, decrease the pumping rate.

6. Purge the well until the specified volume of water has been evacuated. Record the total volume purged in field notebook. If a fuel powered pump is used, it should be located downwind of the sampling collection point.

7. If any purging equipment is being used at more than one well, it should be properly decontaminated prior to sampling the next well.

3.4 WELL-VOLUME METHOD SAMPLING PROCEDURES

3.4.1 Sampling with a Bailer

Generally, bailers can provide an acceptable sample, as long as sampling personnel use extra care in the collection process. Site-specific conditions or target analytes may necessitate the need to use an alternative sampling method. Bailing a well can disturb the

water when repeatedly lowered into the well introducing bias, especially when sampling for VOCs and metals (USEPA, 2002).

1. Complete the pre-sampling activities as outlined in Section 2.0.

2. Perform the purging method as outlined in Section 3.3.1. The same bailer and line may be used for sampling.

3. Collect samples immediately after purging is complete, but if necessary, allow the well to recharge so a sample can be collected. If a well is purged dry, the well should be sampled within 24 hours and no sooner than 2 hours. See Section 7.2.

4. Lower the bailer slowly and gently into the well, taking care not to shake the casing sides or to splash the bailer into the water. Stop lowering at a point adjacent below the top of the screen.

5. Allow the bailer to fill and then slowly and gently retrieve the bailer from the well, avoiding contact with the casing, so as not to knock flakes of rust or other foreign materials into the bailer or the well.

6. Remove the cap from the pre-labeled sample container(s). Do not place the cap on the ground. Pour water slowly and gently from the bailer or open the stopcock, being careful not to agitate the sample. Care should be taken not to allow the water from one end of the bailer to rush out of the open end of the bailer while pouring water into sample bottles since this can cause agitation.

7. Filter samples, if required by the field sampling plan.

8. Place cap on the sample container tightly, place sample in plastic bag, and place sample container into a cooler.

9. Log all pertinent sampling information in field notebook (date, sample collection time, location, etc.) and fill out chain-of-custody forms.

10. If any sampling equipment is being used at more than one well, it should be properly decontaminated prior to sampling the next well. The use of bailers dedicated to a single well is recommended.

3.4.2 Sampling with a Pump

Selection of a sampling pump should be based on an evaluation of how the pump will affect the target analyte. Some pumps can cause chemical or physical changes such as aeration or volatilization, which could affect the representativeness of the sample.

1. Complete pre-sampling activities as outlined in Section 2.0.

2. Complete purging method as outlined in Section 3.3.2. Only properly decontaminated sampling equipment should be introduced to the well.

3. Samples should be collected immediately after purging is complete without changing the position of the pump or turning it off (if the same pump is used). It may be necessary to allow the well to recharge so a sample can be collected. If a well is purged dry, the well should be sampled within 24 hours and no sooner than 2 hours. See Section 7.2.

4. Remove the cap from the pre-labeled sample container(s). Do not place the cap on the ground. Fill the appropriate sample bottle(s).

5. Filter samples, if required by the field sampling plan.

6. Place cap on the sample container tightly, place sample container in plastic bag, and place sample container in a cooler.

7. Log all pertinent sampling information in field notebook (date, sample collection time, location, etc.) and fill chain-of-custody forms.

8. Upon completion, remove pump and assembly. All pump equipment should be properly decontaminated prior to sampling the next well.

3.5 PURGING AND SAMPLING DOMESTIC AND LAWN AND GARDEN WELLS

Turn on a household fixture (preferably an outside faucet) and allow the well to discharge for a minimum of 5 to 10 minutes. Remember to document the exact amount of time the well was purged. Make certain the discharge point is on the well-side of any water filtering or conditioning device or screen. Do not sample through garden hoses. Collect the sample directly from the faucet, but do not touch the sample container to the faucet. Minimize aeration of discharge during sampling, if possible. If a home has a pressure tank that is used prior to the faucet to be sampled, then it is important to purge enough water to drain the pressure tank prior to sampling so the sample is collected from the well and not water stored in the pressure tank.

If specified by a site-specific work plan, field parameters (dissolved oxygen, specific conductance, pH, temperature, etc.) can be monitored during the evacuation process. When field parameters are within the stabilization criteria described in Section 4.6 for three consecutive measurements, the well is considered purged and a sample can be collected.

4.0 LOW-FLOW SAMPLING METHOD

4.1 DESCRIPTION OF THE LOW-FLOW METHOD

The term "low-flow" refers to the velocity at which water enters the pump intake from the surrounding formation in the immediate vicinity of the well screen. It is assumed that pumping at a low rate within the screened interval of a well will minimize drawdown and the mixing of stagnant water with formation water, which should result in a representative sample of the formation water. Water quality parameters are monitored during the low-flow purging process until sufficient stabilization of water quality parameters has been reached before collection of a sample. References consulted during development of procedures for low-flow sampling include guidance documents from the U. S. Environmental Protection Agency (USEPA 1996, 2001, 2002) and the ASTM International (ASTM 2002).

The low-flow purging and sampling method is best used for situations where the well has a discrete screened interval (10 feet or less) and the aquifer materials are sufficiently permeable to allow drawdown in the well to stabilize during the purging process. This method of purging and sampling should not be used for wells that are screened in low

permeability materials where drawdown cannot achieve stabilization while pumping. In addition, this method of purging and sampling is not intended for wells that contain non-aqueous phase liquids.

Some of the advantages of using the low-flow techniques for purging and sampling can include:

- Improved sample quality by minimizing the disturbance in the well;
- Less mixing of the stagnant casing water with the formation water;
- Samples are more representative of the mobile load of contaminants present in the aquifer reducing the need for filtering the water samples;
- The purging and sampling time is reduced; and
- Purge volumes are smaller resulting in generation of less wastewater.

Some disadvantages for the low-flow method of purging and sampling can include:

- The necessity for more equipment such as variable speed pump with the capability to pump at low rates, a flow-through cell that includes ph, oxidation-reduction potential (ORP), dissolved oxygen (DO), temperature, specific conductance, and a turbidity probe and meter(s);
- Additional cost and time can be incurred since stabilization of water parameters may require relatively longer times;
- Sample results may not be reproducible if the pump is placed at a different depth within the screened interval each time the well is sampled.

4.2 LOW-FLOW SAMPLING EQUIPMENT

NOTE: a majority of this equipment is needed for all types of groundwater sampling.

- well construction information including screened interval, total depth, and well diameter;

- borehole logs;
- well keys;
- map of well locations;
- tools box with necessary tools for opening the well and assembling the pump;
- plastic sheeting to spread around the well;
- low-flow variable speed pump with flow controller;
- tubing that is the appropriate size for the selected pump and made of appropriate material that will not interact with contaminants in the groundwater (e.g. teflon or polyethylene);
- check valve;
- container to collect purge water such as a 55-gallon drum or tank;
- water level measurement device;
- container of known volume and stop watch for measuring flow rate;
- flow-through cell with water-quality indicator meters for ph, specific conductance, dissolved oxygen, oxidation-reduction potential, and temperature;
- nephelometer for measuring turbidity, if desired;
- calibration fluids or standards for water-quality indicator meters and nephelometer;
- barometric pressure for calibrating dissolved oxygen meter, if necessary;
- information such as the inside diameter of the tubing to aid in calculating the total volume of water held by the pumping apparatus (i.e., volume of water held in the tubing, the flow-through cell, and the pump);
- field notebook and field forms for recording measurements and the pumping rate;

- sample bottles, labels, ice, and preservative;
- shipping supplies such as cooler, chain of custody forms, custody seals, tape, shipping forms, plastic sealable bags, and packing materials;
- 0.45 micrometer (μm) filters and other necessary filtering apparatus (if samples will be filtered);
- supplies for decontamination of equipment such as potable water, alconox, deionized water, buckets, spray bottles, brushes;
- work plan and health and safety plan; and
- air monitoring equipment, if required.

4.3 PUMP TYPE AND ASSEMBLY CONSIDERATIONS

A low-flow variable speed pump with a flow controller should be used for low-flow purging and sampling. The pump should be capable of achieving pumping rates that are low enough to allow for stabilization of drawdown in the well; therefore, the permeability of the aquifer at the site should be considered during pump selection. The pump selected should not cause excessive pressure or temperature changes or physical disturbance on the water samples. The types of pumps that may be used include bladder pumps, electrical submersible pumps, gas-powered pumps, and peristaltic pumps. Inertial pumps and grab sampling type of devices such as bailers cannot be used for low-flow sampling techniques because of the disturbance they cause in the well. Another consideration for pump selection is the diameter of the monitoring well casing. Well construction records should be reviewed to identify the diameter of the well casing for all the wells that will be sampled to ensure the correct pump size is selected.

The use of peristaltic pumps will be limited to sites that have shallow depths to water (e.g., less than 20 feet below ground surface). Also, because the peristaltic pump is a suction-lift type of pump, special consideration is needed when samples are to be collected for analysis of VOCs because the suction action can result in degassing of volatiles from the water. If this is the case, the "straw method" can be employed for collection of samples for VOCs. The straw method is described in Section 7.1.

When assembling the pump and tubing, an effort should be made to avoid using an unnecessary amount of extra tubing because excessive tubing at the surface can cause the temperature of the water to change, potentially affecting the water chemistry.

4.4 PUMP PLACEMENT

Once assembled, the pump and/or tubing should be lowered into the well slowly and carefully to minimize disturbing the water column. If lowering the pump into the well casing results in significant disturbance of sediment or particulates, raising the turbidity, it may be necessary to wait to begin pumping until the sediment within the well casing has settled.

If the formation is homogeneous throughout the screened interval, the pump intake should be placed in the middle or slightly above the middle of the screened interval. Placing the pump intake closer to the bottom of the well screen may result in disturbance of sediment that has settled to the bottom of the well. Placing the pump intake too close to the top of the screen may cause the stagnant water in the well casing above the screen to be drawn downward. If the water level intersects the screened interval, the pump should be placed midway between the water level and the bottom of the well, or far enough into the water column so that air does not enter the pump intake while pumping. Well-specific information such as formation heterogeneity within the screened interval or stratification of the contaminants within the screened interval are reasons for placing the pump intake elsewhere within the screened interval to meet site-specific sampling objectives. For example, if the part of the formation that is screened is heterogeneous with respect to hydraulic conductivity, the pump intake should be placed adjacent to the zone that has the highest hydraulic conductivity.

4.5 PUMPING RATE AND WATER LEVEL MEASUREMENT

The pumping rate for the low-flow method will be a function of the permeability of the formation being sampled. Measurement of the water level in the well is used to identify the appropriate pumping rate. The pumping rate should be similar to the recovery rate for the well based on the amount of drawdown measured in the well while purging. Some guidance indicates that drawdown should be no greater than 0.33 feet while performing low-flow purging and sampling; however, well-specific conditions may allow for greater drawdown as long as the drawdown stabilizes. If a well has never been sampled by the low-flow method and the appropriate pumping rate is unknown, the pump should be started at the lowest rate and then increased slowly to determine the highest

pumping rate that can be used while maintaining a stable drawdown. Low-flow rates are typically 0.1 to 0.5 liters per minute (L/min), but it depends on site specific hydrogeology (USEPA 1996). If a formation is very permeable or transmissive, a flow rate of up to 1 L/min can be used as long as the water level can be stabilized while pumping.

The frequency for measurement of water levels will be dependent on the hydraulic conductivity of the formation. Water levels should be measured every 30 seconds to every 5 minutes depending on the situation. More frequent measurement of the water level will be needed when pumping in a well is initiated to assess the level of drawdown. Once the drawdown has stabilized, less frequent measurements are needed. Measurements should be recorded in the field book or on an appropriate field form. An example form is provided in the Attachment 2 and is titled, "Water Well Purging and Sampling Log." It is important to document the pumping rate at which drawdown stabilizes and the depth of pump placement because this information can be utilized for future sampling efforts.

4.6 MEASUREMENT OF WATER-QUALITY INDICATORS AND STABILIZATION CRITERIA

Water quality indicator parameters such as specific conductance, DO, ORP, turbidity, pH, and temperature are measured during the low-flow purging process to determine when the water quality parameters have stabilized for sample collection. Water quality parameters should be measured in a device (flow-through cell) that prevents contact of the purge water with air prior to measurement, especially for DO. The ORP parameter may not be suitable for determining stabilization at all sites, but readings should be recorded if they are available as another check on the oxidation conditions of the water. Turbidity can also be used to help measure stabilization and determine the need for filtering the samples collected for metals analysis. Because sediment particles may collect in the flow-through cell, samples for turbidity measurements should be collected before the water reaches the flow-through cell. If the sample is to be tested for parameters that could be biased by the presence of particulates, such as semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), or metals, it is important to try to reduce the turbidity of the sample to below 10 Nephelometric turbidity units (NTUs). Water samples of this clarity (< 10 NTU) should be more representative of natural colloidal loading in the formation. If the turbidity can be reduced below 10 NTUs, it may not be necessary to filter the samples collected for metals analysis; however, the approved work plan should be reviewed to determine if filtration of samples will be conducted. Note that the BER Policy BER-RS-46 Filtering Water

Samples Collected for Metal Analysis, a water sample should be field filtered if turbidity is greater than 5 NTUs. It may also be appropriate to consider collection of both filtered and unfiltered samples for comparison purposes.

Measurement of the water-quality indicator parameters should be conducted at specific intervals based on the pumping rate and the total volume of water in the pump, tubing, and flow-through cell. The first measurement should be taken after one complete volume of water has passed through the pumping apparatus with subsequent readings being taken as additional volumes of water are pumped out. When three successive readings indicate the water-quality indicator parameters have stabilized within the appropriate criteria, sampling can begin. Stabilization criteria are identified in the table below. If the water-quality indicator parameters do not stabilize even though the low-flow procedures are being followed, then it may be necessary to use a different purge and sample method.

Water-Quality Indicator Parameter	Stabilization Criteria
Specific conductance	+/- 3 % milliSiemens/centimeter (mS/cm)
Dissolved oxygen	+/- 0.3 milligrams per liter (mg/L)
Oxidation-reduction potential*	+/- 10 millivolts (mV)
Turbidity	+/- 10 % when turbidity is greater than 10 NTUs
pH	+/- 0.1 Units
Temperature	None provided; temperature is not a sensitive indicator for purging but should be recorded anyway.

Measurements including water quality parameters, flow rate, volume of water removed should be recorded in the field book or on an appropriate field form. Example forms are included in Attachment 2.

4.7 LOW-FLOW PURGING PROCEDURES

1. Follow pre-sampling procedures as outlined in Section 2.0.

2. Use the water level measurement and well construction information to determine the appropriate depth for the pump intake in the well. Only properly decontaminated equipment should be introduced into the well.

3. Sample labels should be filled out and placed on the bottles prior to starting the purging process.

4. Using the information for the total depth of the well, the well casing diameter and the water level measurement, calculate the volume of water within the well as outlined in Section 3.2 and record the information in the field notebook.

5. Calibrate the water-quality indicator probes/meters with the appropriate calibration solutions according to the manufacturer's instructions. Record all calibration data in the field notebook.

6. Determine the length of tubing needed to place the pump at the predetermined depth within the screened interval. Assemble the pumping apparatus with the tubing. It will be necessary to make sure the pump used has a check valve so that the water within the pumping apparatus does not drain back into the well if the pump is shut off. If a peristaltic pump is used, a check valve should be fitted at the intake end of the tubing.

7. The depth of placement of the pump within the screened interval should be verified by a measurement of a calibrated hose/tubing on the pumping apparatus or by pre-measuring the length of the tubing and pump before placing it in the well. Tubing should be selected to be compatible with target analytes. Slowly and carefully lower the pump and tubing to the predetermined depth in the well. Record the depth of the pump intake in the field notebook.

8. Connect the discharge line of the pump to the flow-through cell containing the water-quality indicator probes/meters. If turbidity measurements will be taken during purging using a separate meter, a "T" connection needs to be added to the tubing prior to reaching the flow-through cell to allow for collection of samples for this parameter.

9. Calculate the volume of water that will be held in the tubing, pump, and flow-through cell. The inside diameter of the tubing will be needed for this calculation.

10. Measure the water level again and record the information. Leave the water level probe in the well.

11. Start the pump at a relatively low pumping rate, (approximately 0.1 to 0.2 L/min) and slowly increase the speed, checking the water levels every 30 seconds initially and comparing this information to previous water levels to determine the amount of drawdown and whether it stabilizes. Exceeding a pumping rate of 1 L/min is not recommended for low-flow purging. If drawdown exceeds 0.33 feet and does not stabilize, reduce the pumping rate. If drawdown stabilizes the frequency of water level measurements can be reduced to every 3 to 5 minutes.

12. Measure the discharge rate of the pump to determine when one volume of the pumping apparatus, tubing, and flow-through cell has been discharged with graduated cylinder and stopwatch. Record the information on form or field notebook. Check the flow-through cell to make sure it fills completely and no air is present in the cell when the water-quality indicators measurements are taken.

13. As each tubing volume is discharged, record the water level, flow rate, volume pumped, and water-quality indicator meter readings and turbidity readings on the field form or in the field book. Continue pumping and recording the information until three successive readings indicate stabilization of the water-quality indicator parameters have been achieved as described in Section 4.5 or in the site-specific QAPP or FSP. Once the stabilization criteria have been achieved, sampling can begin.

14. If drawdown does not stabilize after reducing the pumping rate, it may be necessary to shut off the pump to let the water level recover and then restart the pump at the lowest pumping rate. The pumping apparatus should be equipped with a check valve to prevent water in the tubing from flowing back into the well casing when the pump is turned off. If stabilized drawdown cannot be achieved at the lowest pumping rate available, a different method for sampling should be selected for the well. Another reason for shutting off the pump during purging is if the turbidity of the water increases since this may be an indication that the water column is being disturbed. If reducing the pumping rate does not decrease the turbidity of the water, the pump should be turned off for an appropriate period of time to allow the particulates to settle.

15. Verifying the calibration of water quality parameters and/or recalibration of probes/meters after sampling each well or

sampling at the end of the day may be required in order to document any instrument drift. Perform the instrument calibration verification and/or recalibration if required by site-specific QAPP or FSP. Record data in field notebook.

4.8 LOW-FLOW SAMPLING PROCEDURES

1. Complete low-flow purging procedures as outlined in Section 4.7.

2. Disconnect the tubing from the flow-through cell prior to sampling so that the water does not come in contact with the water-quality indicator meters during sample collection.

3. Sampling can be conducted at the same pumping rate as that used during purging or at a lower rate to minimize turbulence and aeration of the sample when filling the bottles. Fill all sample bottles from the discharge of the tubing. The order of sample collection for different types of analyses is not important unless the samples are to be filtered or if a peristaltic pump is used for purging.

4. If samples are to be filtered, they should be collected towards the end of sample collection process if an in-line filter cartridge will be used. See Section 7.3 for a discussion on filtering.

5. Sample collection for analysis of VOCs can be done at anytime during the sample collection process unless a peristaltic pump is being used to purge the well. If a peristaltic pump is used for low-flow purging and one of the parameters to be analyzed is VOCs, the straw method may be used to fill the samples vials for this parameter to minimize the loss of volatiles and prevent the collection of sample that has come in contact with the silicon tubing in the pump head. The straw method is described in Section 7.1. If adequate volume cannot be obtained to fill all the needed VOA vials with one tubing volume, another type of pump or a different purging and sampling method should be considered. Reinserting the tubing into the well casing to obtain additional sample volume should not be conducted because it will cause disturbance in the well casing and the tubing will pass through the stagnant water column within the casing potentially drawing some of this water into the tubing resulting in collection of an unrepresentative sample.

6. Log all pertinent sampling information in the field notebook (date, sample collection time, location, etc.) and fill out any necessary chain-of-custody forms.

7. Upon completion, remove pump and assembly and properly decontaminate all equipment prior to purging and sampling the next well.

5.0 NO PURGE SAMPLING METHODS

5.1 NO-PURGE METHOD DESCRIPTION

No-purge sampling, also sometimes referred to as passive sampling, is a methodology in which no hydraulic stress or transport is induced on the aquifer. In most wells, groundwater that flows within the well screen is typically in equilibrium with surrounding formation groundwater, so collection of an undisturbed sample of this water is considered representative. There are three main categories of no-purge sampling methods that include grab-type samplers (HydraSleeve™ and Snap Sampler®), diffusion-equilibrium-type samplers (passive diffusion bags made of regenerated-cellulose dialysis membrane samplers or rigid, porous polyethylene samplers) and diffusion-sorption-type samplers (GORE-SORBER™). If applied appropriately, no-purge sampling can produce reliable and accurate data. Note: The Kansas Department of Health and Environment does not endorse any brand or manufacturer.

The main advantages of no-purge sampling are that it can be used in most wells, it is relatively simple and cost effective to use, generates limited volumes of IDW, can be used to collect samples at discrete depth intervals (or used in series to obtain a contaminant profile), does not have a depth limit and generally reduces field sampling variability for highly reproducible results. Some of the disadvantages of no-purge sampling are that the sampling device must be submerged within a screened interval and that the well must be in hydraulic communication with the aquifer, that special consideration is required when free-phase product is present, it requires consideration of contaminant stratification, and it can have limitations on sample volume and analyte.

Switching to a no-purge method at a site where traditional purge-type methods have been previously used may be technically sound and economical. To facilitate this transition in well sampling methods, it may be necessary to complete a comparative study between the selected no-purge sampling method and the current purge-type sampling method. The specific nature of a given no-purge method must be considered when

interpreting and comparing results. Multiple lines of evidence are needed under conditions with high temporal variability where a direct comparison of traditional and no-purge sample results may not be agreeable. In such conditions, data disagreement does not necessarily preclude the use of no-purge sample methodology. (ITRC, 2007).

5.2 GENERAL NO-PURGE SAMPLING GUIDELINES

- When deploying a no-purge device, an appropriate amount of time must pass before sample collection can commence. This waiting period will allow the water within the well screen to re-stabilized with ambient aquifer conditions. The amount of time required for this re-stabilized period is dependent on the relative hydraulic conductivity or transmissivity of the formation the well is screened within. Generally, a shorter amount of time is required for stabilization of water in a higher transmissive aquifer such as sand or gravel (on the order of hours or days) and a longer time is required for stabilization of water in lower transmissive aquifers, such as silt or silty sand (on the order of weeks). The proper stabilization period should be determined on a site-by-site basis. The minimum recommended amount of time between deploying and sampling when using a passive diffusion bag sampler is two weeks.

- The mechanism for no-purge sampling method and device must be understood and applicable to site-specific conditions and appropriate for the target analyte. The manufacturer's directions should be consulted to determine if the target analyte can be collected with the specific no-purge sampler device.

- Device specific procedures developed by the manufacturer should be consulted when developing a site-specific SOP.

- The length of the water column and well screen must be sufficient enough to use a no-purge sampling device. Samples obtained with no-purge devices should only be collected from the screened portion of a well.

- No-purge sampling devices need to remain submerged between sampling events. When long periods of time required for deployment are necessary and/or when water levels fluctuate (temporal changes and adjacent pumping), it may be appropriate to monitor the relative groundwater elevation in the well between sample collection periods.

- Stainless steel weights can be used to hold the no-purge device at the selected sampling interval.

5.3 PROCEDURES FOR NO-PURGE "GRAB" SAMPLING METHOD WITH HYDRASLEEVE™

1. To assemble the Hydrasleeve™, remove the two clips and sleeve from the package and unroll the sleeve. Insert the prongs of the small clip into the hole located on the bottom of the sleeve. Face the clip prongs away from the sample sleeve and then attach the reusable weight to the clip at the bottom of the sleeve.

2. Next, attach the large clip to the top of the sleeve by inserting the prongs into the holes at the top of the sampler.

3. Tie the suspension line to the top clip securely. The sleeve is ready for deployment.

4. If the field sampling plan requires a sleeve series for vertical profiling in a single well, the sleeves can be stacked where the bottom of the top sampler is attached to the top of the bottom sampler. Attach the weight to the bottom sampler in the stack of sleeves. More than one weight may be required if multiple sleeves are used in series. Alternatively, more than one sleeve can be attached to a single tether. Attach the weight to the bottom of the single tether. The top and bottom of each sleeve is then attached to the tether at desired sample intervals. In a case where the water column is shallow, a weight can be added to the top of the sleeve to compress the sleeve in the bottom of the well.

5. To deploy, place Hydrasleeve™ and weight into the well and reel the sleeve down to the desired depth within the well screen. Secure the tether to the outside of the well to prevent losing the sleeve and tether in the bottom of the well.

6. Before sample collection, the aquifer must be allowed to stabilize after the water column has been disturbed due to sleeve deployment. The stabilization period greatly depends on the hydraulic properties of the aquifer where low permeable aquifers may require weeks for stabilization and gravel aquifers require hours to stabilize. The stabilization period should be determined on a site-by-site, well-by-well basis.

7. Once the well has stabilized, the sample can be collected. The Hydrasleeve™ must been moved upward in the well at a rate of one foot per second or faster so that water can pass through the check valve into the sleeve for collection. The check valve of the sampler must move one to two times the total length of the sampler. For example, a 24-inch sampler must be moved for 24 inches, but no greater than 48 inches to fill. Sample collection can either be completed by one continuous pull or by multiple short strokes.

8. Before discharging water from the sleeve, squeeze the full sleeve just below the rigid plastic top ring to expel extra water resting above the check valve. It is recommended to hang the top of the sleeve from a stable point or have another person hold the top of the sleeve during sample collection. Use the short plastic discharge tube included with the sleeve kit to puncture the sleeve at the base of the top ring. Discharge the water into sample containers, being careful not to over agitate the sleeve or water. The sleeve can be raised and lowered to control the flow of water to the sample bottle.

9. If routine monitoring is done at the well, a new Hydrasleeve™ should be assembled and deployed into the well for the next sampling event (Cordry, 2004).

5.4 PROCEDURES FOR NO-PURGE PASSIVE DIFFUSION BAG SAMPLING METHOD

In general, passive diffusion bag samplers consist of a narrow water-filled bag that relies on the diffusion of contaminants in groundwater across the sampler membrane into the bag to reach and maintain equilibrium with the ambient well water. Passive diffusion bag samplers can be made up of different types of materials such as rigid porous polyethylene and regenerated cellulose dialysis membrane. A passive diffusion bag consisting of the proper material must be selected for site-specific contaminants since bag material can limit the diffusion of certain types of contaminants into the bag. The manufacturer's instructions should be consulted to determine if the selected bag material is appropriate for contaminants of concern and to determine the required equilibration time period for specific contaminants.

1. Assemble the passive diffusion bag according to the manufacturer's instructions.

2. Install any necessary weights to the sampler and/or deployment tether. Attach the suspension line to the sampler.

3. Determine the placement of the sampler in the well and lower sampler to the desired depth. Secure tether to the outside of the well to prevent loss of the sampler and tether inside the well.

4. Once sampler is deployed in the well, the sampler must be allowed to equilibrate with ambient well conditions. The proper equilibration period for the sampler and target analytes must be determined on a site-by-site basis. Some samplers have time limits in which the bag can be deployed in the well due to bag integrity issues or biodegradation.

5. Once the equilibrium period is complete, retrieve the sample bag by pulling the tether line until the sampler is retrieved from the well.

6. Before collecting a sample from the bag, it is recommended to suspend the bag sampler from a stationary point. Depending on the sampler style, either puncture the bag with a sampler straw or remove the cap from the sampler and fill sample containers. Take care not to over agitate the bag or water.

7. If well is used for routine monitoring, assemble a new sampler and deploy into the well for the next sampling event.

6.0 POST-SAMPLING PROCEDURES

After all samples are collected and preserved, the reusable sampling equipment should be decontaminated prior to sampling another well. This will prevent cross-contamination of equipment and monitoring wells between locations.

1. Decontaminate all equipment according to SOP No. BER-RS-05 Decontamination of Equipment;

2. Dispose of purge water according to approved procedures in the site-specific work plan and/or consistent with SOP No. BER-RS-08 Characterization and Disposal of IDW;

3. Prepare and transport samples to the laboratory. Check sample documentation and make sure samples are properly packed for shipment to a laboratory consistent with SOP No. BER-RS-19 Chain of Custody.

7.0 SPECIAL CONSIDERATIONS

7.1 VOLATILE ORGANIC COMPOUNDS (VOCS)

VOCs should be collected in a manner that minimizes the volatilization of compounds and minimizes the disturbance of the sample. Sample retrieval systems suitable for the valid collection of volatile organic samples include positive displacement bladder pumps, gear driven submersible pumps, syringe samplers, bailers, passive diffusion bags, the Hydrasleeve™, or snap type of sampler. Suction-lift type of pumps such as peristaltic pumps are generally not recommended for sampling for VOCs because of the potential for degassing of volatiles from the sample; however, under certain conditions these types of pumps may aid in the collection of samples for VOCs as described below.

The following procedures for filling the sample vials for VOC analysis should be followed:

1. Open the vial and fill it slowly to minimize turbulence and aeration of the sample. When collecting duplicates, collect both samples at the same time.

2. Fill the vial to just overflowing. Do not rinse the vial, nor excessively overfill it. There should be a convex meniscus on the top of the vial.

3. Check that the cap has not been contaminated (splashed) and carefully cap the vial. Place the cap directly over the top and screw down firmly. Do not over tighten and break the cap. Placing water sample in the cap and then screwing the cap down on the vial to avoid air bubbles is not recommended.

4. Invert the vial and tap gently. Observe the vial for a few seconds. If an air bubble appears, discard the sample and begin again. If sample containers are pre-preserved then a new sample vial must be used or preservative added to the vial or the sample is collected as a unpreserved sample with appropriate notation on the chain-of-command form. It is imperative that no air bubbles are present in the sample vial.

5. Immediately place the vial in the protective sleeve (if available) and place into the cooler containing ice, oriented so that it is lying on its side, not straight up.

6. The holding time for unpreserved samples is 7 days and 14 days for preserved samples. If possible, samples should be shipped or delivered to the laboratory daily so as not to exceed the holding time. Ensure that the samples remain at 4 -6° C, but do not allow them to freeze.

If a peristaltic pump is used for purging for the purpose of testing for VOCs, the straw method may be used to fill the sample vials to minimize the loss of volatiles. If the straw method will be employed, it should be done after all other sample bottles have been filled by the pump because the straw method requires removing the tubing from the well casing. The straw method is done by filling the tubing by the action of the pump, disconnecting the tubing from the pump while crimping the tubing at the top, withdrawing the tubing from the well, disconnecting the check valve at the bottom of the tubing, and draining the water into the sample vials from the bottom of the tubing. Another method for collection of VOCs using a peristaltic pump is to reverse the direction of the pump and drain the sample into the vials from the bottom of the tubing after removing the check valve. Care should be taken to avoid completely emptying the tubing when filling the sample vials so that water that has come in contact with the silicon tubing in the pump head is not introduced into the sample vials. If adequate volume cannot be obtained to fill all the needed sample vials with one tubing volume, another type of pump or a different purging and sampling method should be considered. Reinserting the tubing into the well casing to obtain additional sample volume should be avoided because it will cause disturbance in the well casing and the tubing will pass through the stagnant water column within the casing potentially drawing some of this water into the tubing resulting in collection of an unrepresentative sample.

7.2 SAMPLING LOW-YIELD WELLS

In situations where a well has low-yield, has limited volume in the casing, and/or recovers slowly in a low hydraulic conductivity formation, procedures for sample collection will be different. One alternative procedure consists of removing stagnant water from above the top of the well screen, to minimize the exposure of the gravel pack and formation to the atmosphere (without lowering the pump into the screened interval), and to then collect a sample. In many cases, purging the well dry cannot be avoided. The well can be purged dry and sampled up to 24 hours after purging activities when the well has recharged a sufficient volume (usually 90% recovery). Sample should be collected no sooner than two hours after purging. Sample collections under these conditions are not

ideal and could result in data that are biased are less representative of aquifer conditions.

The major disadvantage to this method is that evacuation of wells below the top of the well screen or complete dewatering may cause significant alteration of the sample chemistry and representativeness by aeration and agitation of water moving into the well. Data quality objectives should be considered before sampling a well with low-yield in an alternative manner. This method could elevate turbidity levels, affect VOC and metal analytes, and the increase the length of time between purging/dewatering and sample collection. The time interval between dewatering and sampling can be pre-determined on a site-specific basis, but is sometimes left to the discretion of the sampler, which could vary between sampling events and sampling locations. If this technique is used in this circumstance, evacuation times and sampling times should be pre-determined on a site-specific basis. As an alternative to purging a low-yield well dry, it may be advantageous to use either a low-flow sampling method or a no-purge method in order to collect a more representative sample (USEPA, 2002).

7.3 SAMPLE FILTERING

Under some hydrogeological conditions with proper well design, installation and development, sample turbidity cannot be reduced to representative ambient levels. In addition, some analyses require filtration. When collecting samples for metal analysis, it may be appropriate to consider collection of water samples that can be analyzed for total metals (unfiltered) and dissolved metals (filtered). Some reasons for filtering may include the removal of suspended solids for analysis of "dissolved" constituents, determining the percent suspended solids, analysis of "clear" samples for sensitive or delicate laboratory analytical instruments, and removal of any interference by suspended particles (Nielson, 1991). The need for filtering should be determined before field implementation since filtering can alter the geochemical conditions of the sample. Collection of data for turbidity, total suspended solids (TSS), total dissolved solids (TDS), pumping rate, and drawdown is recommended in order to facilitate interpretation of analytical results (USEPA, 2002).

Filtering can be accomplished by three general methods and include vacuum filtration, pressure filtration and in-line filtration. Vacuum ("pulled") and pressure filtration ("pushed") involve transferring the sample from a collection container to the field filtration device, which is then passed through a filter. An in-line filter typically consists of a

cartridge device where an inlet and an outlet connection can be made to enable pressure filtration and is connected directly to the discharge tubing of the groundwater sampling device. An in-line filter is recommended to avoid sample contact with the air and avoid formation of metal precipitates. When selecting a filter method, criteria such as the appropriate filter pore size, speed of filtration, sample volume, sediment loading rate, comparability of filter media with target analytes, field portability, ease of operation and decontamination, field operation reliability, and cost may be considered (Nelson).

The typical filter size is 0.45 microns since this is the commonly accepted demarcation between dissolved and non-dissolved species. A filter may require decontamination or pretreatment prior to use and between uses. If preservation of the sample is necessary, this should be done after filtering. If possible, the first 500 to 1,000 mL of filtered sample should not be collected for analysis (USEPA, 2002).

7.4 SAMPLE PRESERVATION

Complete preservation of samples is practically impossible and preservation techniques only retard the chemical and biological changes which occur after a sample is removed from the source. Therefore, insuring a timely analysis of a sample should be one of the foremost considerations in the sampling plan schedule. The order in which sample containers are filled, method for filling, container type, and preservation method should be outlined in the site-specific work plan. In general, sample container filling should proceed from the most volatile compounds to the least volatile compounds. Preservation methods are generally limited to pH control, controlling exposure to light, chemical addition, refrigeration, and freezing. For groundwater samples, immediate refrigeration to 4-6°C is often the best preservation technique available, but it is not the only measure nor is it applicable in all cases. The requirements for sample volumes, preservation chemicals and temperatures, container types, and number of containers depend on the target analyte and laboratory requirements, so these specifications should be determined in a site-specific work plan. Samples should be collected directly from the sampling device into the appropriate laboratory-cleaned containers unless filtering is required. Complete a field data sheet (if required), a chain of custody form, and record all pertinent data in the site notebook (ASTM, 2007).

8.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site log books.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.
- All samples should be handed in a manner consist with the SOP No.BER-RS-019 Chain of Custody. Chain-of-custody records must be used to record the custody and transfer of samples. These forms must be entirely completed (N/A if not applicable). If directed by the site-specific sampling plan, tamper-proof seals must be placed on either sample containers or shipping coolers. The seal number must be recorded on the chain-of-custody form.
- Decontamination procedures for purging and sampling equipment are outlined in BER SOP # BER-RS-05 Decontamination of Equipment.
- Investigative Derived Waste (IDW) must be managed in a manner consistent with BER SOP #BER-RS-08 Characterization and Disposal of IDW.

9.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow USEPA, Occupational Safety and Health Administration (OSHA) and specific health and safety procedures. More specifically, depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. The site health and safety plan should be reviewed with specific emphasis placed on the protection program planned for the well sampling tasks. Standard safe operating practices should be followed such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and disposable clothing.

For wells with VOCs, one should avoid breathing constituents venting from the well. It may be appropriate to first survey the well head-space with an flame ionization detection/ photoionization detector (FID/PID) prior to sampling. If

monitoring results indicate organic constituents are present, sampling activities may need to be conducted in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.

Physical hazards associated with well sampling include: lifting injuries associated with pump and bailer retrieval and moving equipment; using pocket knives for cutting discharge hose; exposure to heat or cold stresses as a result of exposure to extreme temperatures (may be heightened by protective clothing); the potential for slips, trips, and falls caused by field conditions; traffic injuries in areas next to roads; and restricted mobility due to the wearing of protective clothing.

Additional health and safety information is outlined in BER-18 Field Safety Protocol and BER-21 Levels of Protection for Field Work.

10.0 REFERENCES

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ATTACHMENT 1

PUMP INFORMATION

Suction Lift Pumps

There are three types of suction lift pumps including centrifugal, peristaltic (or rotary peristaltic pump), and direct-line. These pumps are limited in their ability to raise water by the head available from atmospheric pressure and may only be applicable at sites where water is shallow and can only really lift water 25 feet. These pumps may be more appropriately utilized as a well purging device.

Most suction lift pumps draw water through a spiral shaped inlet where pistons or impellers induce a vacuum. Most suction pumps are unacceptable for most sampling purposes because they are usually constructed of materials that are not inert and can expose samples to pump lubricants. They can induce low pressures that can cause degassing of the sample, cavitation, mix air with the sample, and are difficult to clean adequately.

A peristaltic pump is an exception (also known as a rotary peristaltic pump) and is a self-priming, low-volume suction lift pump that moves liquid within the sample tube. No part of the pump contacts the liquid, but degassing can occur. A flexible tubing is placed around the pump rotor and squeezed by rollers during rotation. The rotor movement induces a reduced pressure in the well side tubing and increased pressure in the tube leaving the rotor head, creating lift of the water within the tube. Please note that a peristaltic pump may have limited use in applications with VOCs (ASTM 2007).

Electric Submersible Pumps

Submersible pumps consist of a sealed electric motor that powers a piston, impeller, or helical single thread worm where water is brought to the surface by a discharge tube. Submersible pumps can provide a high discharge rate at depths beyond those of a suction lift pump. Considerable agitation of water can occur, but some pumps are designed specifically for environmental applications. These pumps are generally constructed of plastic, rubber, and metal parts which may affect the analysis of samples for certain trace organics and inorganics. As a consequence, submersible pumps may not be appropriate for investigations requiring analyses of samples for trace contaminants. Many submersible pumps are not appropriate for collecting samples once purging has been performed. VOCs may be removed by aeration by some pumps. Silt and sand can cause damage to the internal pump structures.

Submersible pumps generally use one of two types of power supplies, either electric or compressed gas. Electric pumps can be powered by a 12-volt DC rechargeable battery, or a 110- or 220-volt AC power supply. Those units powered by compressed gas normally use a small electric compressor which also needs 12-volt DC or 110-volt AC power. They may also utilize compressed gas from bottles. Pumps differ according to the depth and diameter of the monitoring wells (ASTM 2007).

Gas-Driven Piston Pumps

Gas driven piston pumps are powered by compressed air where pressurized gas enters the chamber between the pistons. The altering pressurization of the chambers activates the piston that induces water flow during the suction stroke of the piston and brings water to the surface during the pressure stroke. This type of pump can provide continuous sample withdrawal at great depths, but may contribute to trace element detection if trace elements are the target analyte.

Gas-Lift Pumps:

Gas-lift pumps use compressed air to bring water to the surface by forcing water up an educator pipe. The air source can be from a hand pump (for shallower depths), air compressors, and pressurized air cylinders. The use of these pumps can result in considerable sample agitation and mixing within the well and may not be appropriate for sampling of VOCs and other target analytes. The use of these pumps with an air compressor can result in the introduction of oil to the well. This pump type is not recommended for purging or sampling.

Gas Displacement Pumps or Gas Driven Pumps

These pumps force a discrete column of water to the surface through mechanical lift without excessive mixing of the pressurized gas and water as with air-lift equipment. Water first fills the chamber and then a positive pressure is applied to the gas line which closes the sampler check valve. The water is forced up the sample line and the cycle is repeated by removing the pressure. This pump type can offer a reasonable potential for preserving the sample integrity since very little of the driving gas comes in contact with the sample. There is a potential for the loss of dissolved gasses.

Non-Contact Gas Bladder Pumps

To provide the least amount of material interference with the sample, an all stainless-steel and Teflon Middleburg-squeeze bladder pump (e.g., IEA, TIMCO, Well Wizard, Geoguard, and others) is used for the purging procedure. Water comes into contact with the inside of the bladder (Teflon) and the disposable sample tubing. Some wells may have permanently installed bladder pumps (i.e., Well Wizard, Geoguard), that will be used to sample for all parameters.

These pumps are also suitable for shallow (less than 100 feet) wells. They are somewhat difficult to clean, but may be used with dedicated sample tubing to avoid cleaning. These pumps require a power supply and a compressed gas supply (or compressor). They may be operated at variable flow and pressure rates making them ideal for both purging and sampling.

Inertial Lift Pump

Inertial lift pumps consist of a check valve at the end of flexible tubing that are manually operated. The tube and foot valve are placed into the well with one tube at the surface. The tube is moved up and down in a rapid, continuous motion. Water is lifted within the tube with each upward stroke. The downward stroke allows the check valve to open to allow more water to ender the tube.

ATTACHMENT 2

EXAMPLE WELL SAMPLING FORMS

Low-Flow Sample Collection Field Data Sheet

Project Name:	Project Number:
KDHE Project Manager:	Date:
Weather Conditions:	Well Tag Removed:
Well ID:	Well Tag Replaced:
Well Owner:	Well Type/Size:
Location:	Site Type:

Sampled By:	Start Time:	Finish Time:

Depth to Bottom:	ft BTOC	Purge Method:	
Depth to Water:	ft BTOC	Purge Rate:	
Height of Water Column:	ft	Purge Time:	
Volume:	gal	Actual Purge Volume:	gal
Purge Volume:	gal	Pump Depth:	ft

Well Diameter	0.75"	1"	2"	3"	4"	5"	6"
Volume (gal/ft)	0.023	0.041	0.1632	0.3672	0.6528	1.0199	1.4688

Observations:

Field Parameter Measurements During Purging

Time	Temp	pH	Conductivity	DO	Turbidity	ORP	Other

Field Parameter Measurements on Sample:

Time	Temp	pH	Conductivity	DO	Turbidity	ORP	Other

Types of Samples Collected:

Water	Soil	Air

Notes:

Laboratory:

Water Well Purging and Sampling Log

Project Name:		Project Number:		Well ID:	
Sampled By:			Date:	Well Type:	

Well Data

Well Diameter:		Depth to Product:	
Well Condition:		Depth to Water:	
Notes:		Total Depth:	

Purging Data

Purging Method:		Purging Equipment:	
Pump Intake Depth:	feet below TOC		

WELL VOLUME 1 WELL VOLUME = (TOTAL WELL DEPTH – STATIC DEPTH TO WATER) X WELL CAPACITY

Well Volume = (feet – feet) X gallons/foot = gallons

WELL CAPACITY (Gallons Per Foot): **0.75" = 0.02; 1" = 0.04; 1.25" = 0.06; 2" = 0.16; 3" = 0.37; 4" = 0.65; 5" = 1.02; 6" = 1.47; 12" = 5.88**

			Purging Start Time:			Purging End Time:			Minimum Purge Volume:
Time	Water Level	Volume Pumped	DO (%)	DO (mg/L)	Conductivity ( )	pH	ORP (mV)	Temperature	Notes

Page 1

Stabilization Criteria: DO - +/- 0.3 mg/L; Conductivity - +/- 3%; ORP - +/- 10mV; pH - +/- 0.1 unit

Sample Data

Sample Collection Date & Time:		Sample ID:	
Collection Method:		QC Samples/ID:	
Field Filtered (Yes or No):		Notes:	

Analysis	Containers	# of Bottles	Preservative	Notes

REMARKS:

STANDARD OPERATING PROCEDURE – BER-02

COLLECTION OF SURFACE WATER SAMPLES AT SUSPECTED OR KNOWN CONTAMINATED SITES

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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DISCLAIMER:

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In general, this document should be used as a reference. Differences may exist between the procedures referenced in this document and what is appropriate under site-specific conditions. This document does not represent an endorsement of practitioners or products mentioned in the document.

1.0 INTRODUCTION

Surface water samples may be required to establish the existence or extent of contaminant migration. Such data helps investigators identify risks to populations and determine appropriate remedial actions. Comparisons of water chemistry from sampling points upstream to sampling points on-site and downstream from the site are used to evaluate contamination releases. This standard operating procedure (SOP) outlines general considerations and procedures applicable to the collection of a representative surface water sample from a majority of surface waters and impoundments in Kansas. Site-specific circumstances can vary widely from site to site and no universal sampling procedure can be recommended or followed. Techniques and methods must be determined on a site-specific basis (USEPA, 1991). Pertinent surface water sampling SOPs should be outlined in the site-specific quality assurance project plan (QAPP) and the locations and analyses should be outlined in the field sampling plan (FSP).

2.0 EQUIPMENT

The equipment needed for surface water sampling during investigations of contaminated sites is minimal. In most instances, the sample container serves as the sampling device. The use of highly sophisticated or automatic sampling devices is normally not required for routine site investigations. If a more rigorous evaluation of surface water is necessary for a specific site, please refer to the *USGS National Field Manual for the Collection of Water-Quality Data* for additional information.

Several types of sampling devices are available for collecting surface water samples such as the Nansen bottle, DO dunker, Kemmerer sampler and Van Dorn sampler. The sampling method selection depends upon the physical site characteristics and the intended analyses. The following is a general list of equipment used for surface water sampling:

1. Buffer Solutions (pH 4, pH 7 and pH 10)
2. Chain-of-Custody Seals
3. Container Brush
4. Conductivity Meter and calibration solutions
5. Sample containers (with screw caps lined with Teflon)
6. Dissolved Oxygen Indicator (w/probe for field use)

7. Distilled Water

8. Electrical Tape

9. Grease Pencils

10. Hip Boots

11. pH Meter, calibration solutions, and pH Hydrion paper - wide range

12. Plastic Beaker (1000 ml)

13. Polyethylene Bags (8" x 12", 10" x 16", and 12" x 20"

14. Pressure Filtering Apparatus

15. 0.45 micron filters

16. Safety goggles

17. Sample Collection Device (Nansen bottle, DO dunker, Dip Sampler, Discrete Sampler (Kemmerer Sampler and/or Van Dorn Samplers)

18. Tape Measure

19. Global Positioning System Unit (GPS)

3.0 SAMPLING APPROACH

3.1 SELECTION OF SAMPLING LOCATIONS FOR FIELD SAMPLING PLANS

Surface water sampling locations are selected on the basis of their probability for demonstrating contaminant migration. Prior to sampling, surface water drainage in and around a site should be characterized using all available background information, including topographic maps and river basin studies. Air photos may be used to develop drainage maps which can then be confirmed by an initial survey of the surface water adjacent to or on a site. An initial survey of potential sampling points is essential to the development of a work plan. Furthermore, it is possible to anticipate any special equipment or personnel safety requirements which might be necessitated by terrain or other factors. It may also be appropriate to evaluate the temporal presence of surface water under differing seasonal or weather conditions. This initial survey allows field

personnel to identify landmarks which locate sampling points, a crucial step in maintaining documentation of activities for legal actions.

In general, sampling locations may include rivers, creeks, or streams running through or adjacent to a site, including those bodies of water which may receive surface runoff or leachate from a site. Surface water samples may also be collected from lakes, stock watering ponds, or other types of impoundments.

The number of sampling locations is dependent on a variety of factors, including the size of a site and the availability of analytical support. An absolute minimum number would be two locations, one background and one down-stream sample, but three sampling locations are recommended including one background, one at or next to the potential impact area, and one down-stream. Additional locations could be sampled to show concentration changes down-gradient from the source and to provide data to document the extent of impact downstream.

It is essential to establish the quality of water prior to its contact with the site. Surface drainage patterns should be carefully studied to determine background sampling locations. Samples should be collected from each surface water source that is entering the stream between the background and downstream sampling point to identify potential impacts from other drainages. A sample should be collected from each upstream surface water source entering the site just prior to the confluence with the primary stream. For standing bodies of water, a background sample may be collected from a similar water body away from the suspected area of contaminant release.

Ease of access to the sampling location may be an important consideration when the samplers must carry a large amount of equipment to the site. Bridges can sometimes provide good vantage points for sampling when composite samples are being collected. However, the need to sample point sources, such as stream flow from waste dumps, leachate breakouts, or drainage from mined areas may override site selection based on accessibility. Wading for water samples is not recommended in shallow lakes, ponds, and slow-moving rivers and streams because bottom deposits are easily disturbed resulting in increased sediment in the overlying water column. However, wading may be the only practical means for sample collection. Wading procedures should be determined on a site-by-site basis. In slow moving, deep water, a boat is usually required for sampling.

3.2 RIVERS, STREAM, AND CREEKS

In the selection of surface water sampling sites on rivers, streams, and creeks, areas that exhibit the greatest degree of cross-sectional homogeneity should be located. When available, previously collected data may indicate whether potential sampling locations are well mixed or vertically or horizontally stratified. Since mixing is principally governed by turbulence and water velocity, the selection of a site immediately below riffle areas provides good vertical mixing. Horizontal (cross-channel) mixing occurs in constrictions in the channel. When several stations along a stream are to be sampled, they should be strategically located. Selection of sampling sites is often based upon accessibility, stream velocity, location of confluences, intake points for water supplies, and stream geomorphology. It may be necessary to assess the individual contribution of stream or river segments when evaluating a site with multiple drainage pathways.

Actual sample locations will vary with the size of the water body and the amount of turbulence in the stream or river. Generally, with small streams less than about 20 feet wide, a sampling site can be found where the water is well-mixed. In such cases, a single grab sample collected at mid-depth in the center of the channel is adequate to represent the entire cross-section. (A sediment sample can also be collected in the center of the channel, however; the sediment samples should be collected after the surface water sample is obtained). For slightly larger streams, at least one vertical composite should be collected from mid-stream just below the surface, at mid-depth, and just above the bottom. Measurements of pH, temperature and specific conductivity are made and recorded on each aliquot of the vertical composite. Dissolved oxygen is an optional parameter that can be used to determine if a body of water is stratified. Several vertical composites should be collected in rivers. These vertical composites should be located in a manner that is roughly proportional to flow, i.e., they should be closer together toward mid-channel, where most of the flow travels, as opposed to toward the banks, where the proportion of total flow is smaller. The number of vertical composites required and the number of depths sampled for each are determined by the site Field Sampling Plan (FSP). The sample locations and numbers specified in the FSP should be based on a reasonable balance between two considerations:

- The larger the number of subsamples, the more likely the composite sample will represent the water body; however, collecting numerous subsamples is time-consuming and expensive, and can increase the chance of contamination.

If a site is relatively large or complex with respect to surface water, it may be appropriate to design a surface water sampling plan that can be evaluated on a statistical basis.

3.3 LAKES, PONDS, AND IMPOUNDMENTS

Sampling locations may include any adjacent standing bodies of water such as lakes, stock watering ponds, sediment or flood control ponds, marshes, or ox-bow lakes which could receive contaminants. The number of water sampling sites on a lake, pond, or impoundment will vary with the depth, size and shape of the basin. Procedures for collecting samples from impoundments on hazardous waste sites should be evaluated if high concentrations of contaminants are present.

Standing surface waters have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more subsamples be collected. In ponds and small impoundments, a single vertical composite at the deepest point may be sufficient. In naturally formed ponds, the deepest point is usually near the center; in impoundments, the deepest point is usually near the dam. It may be necessary to collect parameters, such as dissolved oxygen, to determine the degree of stratification.

In lakes and larger impoundments, several vertical aliquots may be composited to form a single sample. These aliquots are often taken along a transect or grid. The number of vertical composites and the depths at which samples are collected are outlined in the FSP. If samples will be analyzed for volatile organic compounds (VOCs), only grab samples should be collected for this parameter due to the potential for loss of volatiles while compositing.

Lakes with irregular shapes and with several bays and coves that are protected from the wind may require additional separate composite samples to represent water quality adequately. Similarly, additional samples should be taken where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

3.4 LEACHATES

Leachates can be formed by the mixing of rain water with wastes. A leachate may enter groundwater and/or surface water systems causing deterioration of the water quality. In areas where the ground surface slopes steeply away from the buried wastes, the leachate may "break out"

or emerge on the ground surface. This situation is typically encountered at landfills or at the foot of mine tailings disposal piles. Samples taken from leachate streams may have to be treated as medium or high concentration samples depending upon the field evaluation.

4.0 GENERAL SAMPLING TECHNIQUES

Most surface water samples collected during site investigations are grab samples. Typically, surface water sampling involves immersing the sample container in the body of water; however, the following general suggestions will help ensure that the samples collected are representative of site conditions:

1. The most representative stream samples are collected from mid-channel at 0.6 stream depth in a well-mixed stream;

2. Stagnated areas or pools in a stream or river might contain zones of varying pollutant concentrations, depending upon the physical/chemical properties of the contaminants and the proximity of these stagnated areas to the site;

3. When sampling running water, it is suggested that sampling progress from downstream to upstream to eliminate sediment disturbance in subsequent samples.

4. To sample a pond or other standing body of water, the surface area may be divided into grids. A series of samples taken from each grid is combined into one sample, or several grids may be selected at random;

5. If sample bottles contain preservative or if the sample is collected for VOC analysis, a different clean container should be used to collect the sample and decant the sample into the preserved bottles. If required by site-specific FSP, filtering of samples should be conducted immediately after sample collection.

6. Care should be taken to avoid excessive agitation of the water during transfer from source to bottle. Agitation could result in the loss of volatile constituents;

7. It should be noted that only grab samples should be collected for analysis of VOCs due to the potential for loss of volatiles while compositing. When collecting samples in 40 ml septum vials for VOC analysis, exclude any air space from the top of the bottle and to be sure that the Teflon liner faces in after the bottle is filled and capped. The container should be slowly filled to overflowing, creating a convex meniscus at the

top of the container. After sealing, the bottle should be turned upside down and tapped to check for air bubbles. If air bubbles are present, the bottle should be discarded and a new bottle used to collect the sample;

8. Do not sample at the water surface unless sampling specifically for a constituent which is immiscible and on top of the water. Instead, the sample container should be inverted, lowered to the approximate depth, and held at about a 45-degree angle with the mouth of the bottle facing downstream; and

9. When sampling a small stream, seep, spring, pool, etc., the water may be too shallow or inaccessible to utilize the sample bottle for direct collection of the sample. Instead, a decontaminated stainless steel ladle may be dipped into the water and the water transferred into the sample bottle. Care should be taken to minimize agitation of the sample during transfer.

5.0 SAMPLING METHODS

5.1 DIRECT METHOD

For rivers, streams, creeks, lakes, and other surface waters, the direct sampling method can be used to collect water samples from the surface directly into the sample container. This method should not be used for sampling lagoons or other impoundments where contact with contaminants is a concern (USEPA, 1999).

In the proper sampling attire, access the sampling location by appropriate, safe means. In flowing water the sampler should face upstream with the sampling container upstream of the sampler. Collect the sample under the water surface without disturbing the sediment. For lakes and impoundments, the sample should also be collected under the water surface avoiding surface debris and any boat wakes (USEPA, 1999). For the direct method, pre-preserved bottles should not be used as the collection method because it may dilute the concentration of preservation necessary for a reliable sample result to be obtained. If a sediment sample is also going to be collected, it should be collected after the surface water sample has been obtained.

5.2 DIP SAMPLER

The long handle on the device allows a dip sampler to be used for situations where direct access to the sampling location is limited, such as an outfall pipe or along a lagoon bank (USEPA, 1999). The following procedure should be followed when using a dip sampler:

1. Assemble the device in accordance with the manufacturer's instructions. Device should be properly decontaminated.

2. Extend the device to the sample location and lower the dipper into the water to collect the sample.

3. Retrieve the sampler and transfer the sample in to the appropriate sample container.

5.3 DISCRETE SAMPLERS

Discrete samplers can be useful for collecting discrete samples from a specific depth, and/or collecting sample aliquots to create a vertical composite surface water sample. When multiple sample depths are collected, the sampler should be careful to not disturb the substrate, which can potentially bias the sample (USEPA, 1999).

1. Use a properly decontaminated discrete depth sampling device (e.g. Kemmerer or Van Dorn Bottle), set the device so the sampling end pieces are pulled away from the sampling tube so water will be able to pass through the tube.

2. Lower the sampling device to the predetermined depth. Avoid disturbing the substrate.

3. When the sampling device is at the desired depth, release the messenger, closing the sampling device.

4. Retrieve the sampler and discharge the first 10 to 20 mL to clear any potential contamination on the valve. Transfer the sample to the appropriate sample container.

5. If available, use special attachments created for some discrete samplers to distribute small volumes at low flow rates, especially when collecting certain samples for such analyses such as VOCs (USEPA, 1999).

6.0 REFERENCES

1. US Environmental Protection Agency, (1991) *Compendium of ERT Surface Water and Sediment Sampling Procedures* (EPA/540/P-91/005).

2. US Environmental Protection Agency Region 9 Laboratory, (1999) *Field Sampling Guidance Document #1225 Revision 1: Surface Water Sampling.*

3. U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chapters. A1-A9, available online at http://pubs.water.usgs.gov/twri9A.

STANDARD OPERATING PROCEDURE – BER-03

COLLECTION OF SOIL SAMPLES FOR LABORATORY ANALYSIS

Effective Date: February 5, 2000
Revised Date: January 1, 2011

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ATTACHMENT A Soil Sample Data Form

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1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to establish guidelines for the collection of soil samples for fixed laboratory analysis. Please note that this SOP is not applicable for collection of soil samples for field screening purposes (e.g., immunoassay or colorimetric test kits screening, among others) that may have special container and sample processing requirements (refer to KDHE SOP BER-31, *Field-based Colorimetric Analysis*). This SOP is applicable for collection of soil samples from hand auger samplers, slide-hammer samplers, grab samples from stockpiled or land farmed soils, surface samples, and test pit or excavation confirmation samples, among others. To collect soil samples from split-spoon samplers during drilling, please refer to SOP BER-06, *Installation of Monitoring Wells*. To collect soil samples using direct-push technology (DPT) such as a Geoprobe®, please refer to KDHE SOP BER-07, *KDHE Geoprobe Operations*. Additionally, sampling protocol techniques for U.S. Environmental Protection Agency (EPA) Method 5035, *Closed-System Purge-and-Trap and. Extraction for Volatile Organics in Soil and Water Samples*, are not included in this SOP. Collection of soil samples by Method 5035 should follow the appropriate manufacturer or laboratory-specific protocol.

2.0 METHOD SUMMARY

Soil samples may be collected in either a random or biased manner. Random samples can be based on a grid system or statistical methodology. Biased samples can be collected in areas of visible impact, from locations required to meet regulatory compliance or in suspected source areas, among other locations. Soil samples can be collected at the surface, shallow subsurface, or at depth. Commonly, surface sampling refers to the collection of samples at a depth interval of 0 to 12 inches. When samples are collected at depth, the water content should be noted, since generally "soil sampling" is restricted to the unsaturated zone. Certain regulatory agencies may define the depth interval of a surface sample differently, and this must be defined in the work plan/sampling plan. A detailed description of the sampling locations and proposed methods of sample collection should be included in the work plan/sampling plan.

Similar to sediment sample collection, collection of surface soil samples is most efficiently accomplished with the use of a stainless steel trowel or scoop. However, equipment selection will ultimately be determined by the depth of the sample to be collected, surrounding terrain, and accessibility. For samples at greater depths, a bucket auger, power auger, or slide-hammer may be needed to advance the hole to the point of desired sample collection. To collect samples at depths greater than practical with hand equipment, the use of a drill rig with a split spoon sampler or a DPT rig equipped with a soil coring device may be

necessary. In some situations, such as confirmation sampling of excavation sidewalls or floors, sample locations may be accessed with the use of a backhoe.

3.0 MATERIALS/EQUIPMENT

The following materials and equipment may be required. Please note that this is not an exhaustive list of all materials and equipment potentially necessary for all soil sampling events, but is intended as a guideline for items commonly used. Site-specific sampling requirements may dictate the use of additional items not included in the following list. Ensure that ample time is allowed for obtaining necessary sampling apparatus from the analytical laboratory in advance of mobilizing to the field.

a. An approved work plan/sampling plan which outlines soil sampling requirements.

b. Field notebook, field form(s), Kansas One Call tickets/utility clearance checklist, site maps, chain-of-custody forms, and custody seals.

c. Decontamination supplies (including: non-phosphate, laboratory grade detergent, buckets, nylon scrub brushes, potable water, de-ionized or distilled water, regulatory-required reagents, etc.)

d. Stakes or flags

e. Sampling device (e.g., stainless steel hand auger, slide-hammer soil sampler, stainless steel trowel, etc.). Note: Do not use sampling devices plated with chrome or coatings.

f. Disposable sampling gloves (nitrile, latex, among others).

g. Laboratory-supplied sample containers with labels. If needed, sample liners/sleeves for slide hammer or split-spoon sampler (e.g., brass, stainless steel, acetate), polytetrafluoroethylene (PTFE; Teflon®) tape, and plastic caps.

h. Cooler(s) with double-bagged water ice.

i. Plastic sheeting (minimum 6-mil thickness).

j. Black pen and indelible marker.

k. Zip-lock bags and packing material (e.g., bubble wrap or bubble wrap bags or similar cushioning materials).

l. Tape measure.

m. Paper towels.

n. Clear packing tape.

o. Overnight (express) shipment forms (if needed).

p. Trash bags

q. Global Positioning System (GPS) device

r. Digital Camera

s. Photoionization detector (PID), flame ionization detector (FID), or similar organic vapor measuring instrument.

t. Combustible gas indicator (CGI), if necessary

4.0 DECONTAMINATION

All reusable sampling equipment must be thoroughly cleaned and decontaminated before and after each use according to KDHE SOP, BER-05, *Decontamination of Equipment*. Disposable items such as sampling gloves and plastic sheeting will be changed after each use and discarded in an appropriate manner as general trash.

5.0 PROCEDURE

a. Prior to field sampling activities, determine if utility clearance will be required and, if necessary, perform utility clearance and operation of equipment in accordance with the State of Kansas Underground Utility Damage Prevention Act (Kansas Statutes Annotated [K.S.A.] 66-1801 to 66-1816). Ensure that all access agreements (as required) have been signed and executed prior to mobilizing to the sampling location(s).

b. Use flags or other markers to identify sample locations. If needed, adjust proposed sampling locations based on site access, property boundaries, and surface, subsurface, or overhead utilities or other obstructions.

c. Prior to collecting soil samples, ensure that all sampling equipment has been thoroughly cleaned and decontaminated according to KDHE SOP BER-05 referenced above, and that all equipment is free of mechanical defects and is in working order. Be aware of sampling locations where collection of quality assurance/quality control (QA/QC) samples may require additional soil volume to be collected to fulfill QA/QC sampling requirements.

d. Wearing disposable sampling gloves and using a clean, decontaminated sampling device (e.g., stainless steel hand auger, slide-hammer soil sampler, stainless steel trowel, or shovel, among others), clear surface debris (e.g., rocks, vegetation, trash or other obstructions) from the sample location to expose a fresh soil surface for soil sample collection. For collection of deeper soil samples, a shovel, auger, or mechanical excavator

may be used or required to excavate or retrieve soil from the desired sampling depth.

e. Using disposable gloves and a pre-cleaned, stainless steel spatula, scoop, or spoon for each sample, extract the soil sample from the sampler or collect the sample from the surface, stockpiles, or landfarms. Disposable plastic spoons may also be used.

f. Sample parameters should be collected in the following order, based on volatility:

g. Volatile organic compounds (VOCs)

h. Semi-volatile organic compounds (SVOCs), including pesticides, herbicides, total petroleum hydrocarbons – gasoline range organics (TPH-GRO), TPH-diesel range organics (TPH-DRO), and polychlorinated biphenyls (PCBs).

i. Metals.

j. Place the sample in a laboratory-supplied, pre-cleaned sample container. Soil collected for VOC (EPA SW-846 Method 8260B) analysis should be transferred to sample containers with PTFE-lined lids as quickly as possible to avoid loss of volatile contaminants. When using sample sleeves or liners, PTFE film should be placed between the sample and the end caps. If elevated contamination is suspected in any of the samples collected, it is suggested that these samples be placed in a separate cooler than background or other less contaminated soils to reduce the possibility of cross-contamination.

k. Project-specific requirements may dictate that VOC samples be collected for analysis by EPA SW-846 Method 5035. Collection of samples for EPA SW-846 Method 5035 involves the use of specific sampling apparatus (e.g., TerraCore®, EnCore®) in addition to specific containers and preservatives. Follow the manufacturers' and/or laboratory instructions for sample collection and handling for EPA SW_846 Method 5035. Ensure that sufficient volume of soil for dry weight analysis is included with the aliquot for EPA SW-846 Method 5035 analysis.

l. Label the sample container with appropriate information such as client name, site location, sample identification, date and time of collection, sampler's initials, preservative (if any), and analyses requested. Additional project-specific identifiers and/or labeling may also be required.

m. Specific sample homogenization procedures shall be described in the work plan/sampling plan and approved by KDHE in advance of sampling activities. Samples for VOC analysis will not be homogenized unless required or approved by KDHE. To prepare composite soil samples in the field, equal portions of the sample, either by volume or weight, must be collected from selected sampling locations. Discrete sample aliquots must be placed either on a plastic sheet or in an appropriate container, such as an aluminum or stainless steel pan or bowl, in order to homogenize the sample. If placed on a plastic sheet, the sample will be homogenized by quartering the sample by the repeated diagonal folding of the corners. If placed in a pan or bowl, the sample will be homogenized by mixing with an appropriate tool such as a stainless steel spoon. Alternatively to homogenizing in the field, several discrete samples may be submitted to the laboratory for homogenization.

n. After the sample has been collected (homogenized as appropriate) and put into a container, labeled, and logged in detail, place it in a zip-lock bag and store on ice in a cooler at a temperature between 2° and 6°C for shipment to the laboratory.

o. Complete chain-of-custody form(s), accounting for all samples collected.

p. Soil samples should be delivered to the laboratory as soon as practicable. Check the work plan to determine if any analytes require expedited delivery due to short holding times. If necessary, make advance arrangements with the laboratory for after-hours or Saturday delivery.

q. If field-based analysis or field screening are being performed on the soil samples, follow the appropriate SOP: BER 25, *Mobile Laboratory*; BER 27, *Collection of Solid Samples for XRF Analysis*; BER 13, *Headspace Method for Screening Soil Samples for Volatile Organic Vapors*.

r. The field logbook and appropriate forms should include, but not be limited to the following information: site location, sample location, sample depth, sample identification, date and time collected, sampler's name, method of sample collection, number and type of containers, geologic description of material, description of decontamination procedures, and any other pertinent information. Soil should be described using the Unified Soil Classification System (USCS. A site map should be prepared with exact measurements to each sample location should follow-up sampling be necessary. Additionally, photographs of sampling locations should be taken, and a GPS instrument should be used to document sampling locations.

s. Abandon surface soil sampling locations by backfilling with the removed soil material and/or bentonite chips or pellets. If asphalt or concrete coring is required to access subsurface soil, patch or repair as necessary to match the existing surface materials. Thoroughly decontaminate all reusable sampling equipment. Discard any disposable material or waste generated at the site in an appropriate manner. Manage investigative-derived wastes as prescribed by the approved work plan/sampling plan.

6.0 REFERENCES

U.S. Environmental Protection Agency (EPA), Environmental Response Team (ERT). Soil Sampling, SOP No. 2012, Revision 0.0. February 18, 2000.

EPA, ERT. Superfund Program Representative Sampling Guidance, Volume 1 – Soil. Office of Solid Waste and Emergency Response Directive 9360.4-10EPA 540/R-95/141PB96-963207. December 1995.

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Environmental Standards Inc. March 2009. Standard Operating Procedures for: Soil Sampling for Inorganic Analysis. TVA-KIF-SOP-4. http://www.tva.gov/kingston/sap/TVA-KIF-SOP 04_Soil%20Sampling%20_31%20Mar%2009_.pdf

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EPA Region 9 Laboratory, Richmond, California. Field Sampling Guidance Document #1205, Soil Sampling. Revision. 2. September 1999. http://www.ecy.wa.gov/programs/eap/qa/docs/QAPPtool/Mod7%20EPA%20SOPs/Soil%20Sampling/Region%209%20Soilsample%20GUI.pdf

STANDARD OPERATING PROCEDURE – BER-05

DECONTAMINATION OF EQUIPMENT

Effective Date: August 14, 2000
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1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to establish a consistent process for decontamination of sampling equipment to prevent cross-contamination between sampling locations and events. Preventing cross-contamination in samples is important for reducing the introduction of error into sampling results and for protecting the health and safety of site personnel.

2.0 METHOD SUMMARY

The contamination of equipment requires physical removal by methods such as brushes and high pressure water. This is followed by washing and rinsing the equipment.

3.0 PROCEDURE

1. When applicable, visible contamination should be removed with a metal or nylon brush and/or high pressure water spray.

2. Wash equipment with a non-phosphate detergent solution such as Alconox or an equivalent.

3. Rinse with tap water.

4. Final rinse with deionized/distilled water.

4.0 GENERAL CONSIDERATIONS

1. The use of distilled or deionozed water commonly available from commercial vendors is acceptable for decontamination of sampling equipment. Field blanks may be used to verify the quality of commercially available water.

2. Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

   - Stress work practices that minimize contact with hazardous substances.

   - Use appropriate personal protective equipment (PPE) (e.g. gloves) when handling contaminated equipment; **do not** use contaminated PPE to handle clean equipment.

- Use disposable sampling equipment when appropriate.

3. As part of project planning documentation, develop a decontamination plan before any personnel or equipment enter areas of potential exposure. The equipment decontamination plan may include:

   - The number, location and layout of decontamination stations;
   - Which decontamination apparatuses are required;
   - Methods for disposal of contaminated clothing, disposable equipment and water (can decontamination water be discharged to the ground surface or sanitary sewer, does it need to be treated prior to on-site disposal or disposed off-site).

5.0 SPECIAL CONSIDERATIONS

Sample containers used by KDHE/BER personnel will be decontaminated by the laboratory or vendor from which the containers are obtained.

6.0 GEOPROBE AND DRILL RIG DECONTAMINATION

Specific decontamination procedures are necessary for KDHE's Geoprobe and drill rigs because of the very high frequency of use in KDHE field activities. In general, the following norms apply unless modified by a site-specific work plan. All rods and sampling devices should be visually inspected before use. If visually contaminated, these should not be used. All rods, augers and sampling devices that have been advanced within a contaminated or potentially contaminated site should be decontaminated after use. Decontamination can be done on-site or off-site and should comply with the general instructions above.

Due to the large area required to stage and decontaminate equipment, commercial car washes are frequently utilized for decontamination of Geoprobe rods, drill rig augers and associated sampling devices. Decontamination should be done in a manner compliant with State and local wastewater treatment regulations. The wash facility should be visually inspected before and during decontamination to assure dirt, contaminants, etc. from the facility are not introduced inadvertently during the decontamination process. NOTE: It is important that visible contamination be removed from the probe rods and augers at the site prior decontamination at a car wash. The visible material removed should be treated as Investigative Derived Waste (IDW) in accordance with BER-SOP-08.

If a site is being sampled for constituents frequently occurring in chlorinated water supplies (trichloromethane, trihalomethane compounds, etc.) a rinse blank

sample for volatile organic compounds (VOCs) should be obtained at least once during the decontamination process per site as chlorinated water sources often contain these

constituents, and cross-contamination is a possibility. For sites with other types of contaminants, the site-specific work plan should detail the frequency and type of quality control samples for the decontamination process for Geoprobe and drilling operations.

7.0 REFERENCES

1. United States Environmental Protection Agency (U.S. EPA). Region 4, *Field Equipment Cleaning and Decontamination Operating Procedure.* Document #SESDPROC-205-R1, November 2007.

2. United States Environmental Protection Agency (U.S. EPA) *Sampling Equipment Decontamination,* SOP #2006, August 1994.

STANDARD OPERATING PROCEDURE – BER-06

INSTALLATION OF MONITORING WELLS

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to establish a basic procedure for installation of auger-advanced monitoring wells. Use of this SOP is limited to Kansas Department of Health and Environment (KDHE) and KDHE contractors. Monitoring wells installed as part of groundwater investigations are intended to serve several purposes:

- to indicate the presence, if any, of contaminants of concern (COCs) in groundwater;
- to quantify the concentrations, sources, and vertical distributions of the COCs;
- to serve as a means of obtaining basic hydrogeologic information including static water level of the aquifer of concern, type and thickness of subsurface materials, aquifer characteristics at various depths, depth of the bedrock, etc.

Please note that the intent and requirements of this SOP is to follow all applicable Kansas Regulations pertaining to the installation of monitoring wells, including:

Article 12 – Ground Water Exploration and Protection Act; and
Article 30 – Water Well Contractor's License; Water Well Construction

2.0 METHOD SUMMARY

For wells to be installed with augers, a minimum hollow-stem auger size of 3 3/4" inside diameter or larger should be used to advance monitoring wells. Placement, depth and construction of wells should be conducted under the supervision and direction of a KDHE geologist. Care should be taken to not introduce contamination from the drill rig or surficial area around the well head.

3.0 PROCEDURE

Monitoring wells are generally constructed of polyvinyl chloride (PVC) casing and screen that are placed at depth intervals determined by the project geologist. Typical sizes for the casing are nominal inside diameters of 2 inches, 4 inches, 5 inches, or 6 inches. Deeper wells may require a larger diameter casing or multiple casing strings of progressively smaller diameter casing (such as 4 or 6 inch surface casing with 2 inch inside casing) to exclude shallower zones from the desired screen interval. The PVC pipe and screen is required to be of a minimum thickness depending on the depth of the well. For wells less than 100 feet deep, a minimum of Schedule 40 PVC casing and screen should be utilized. Wells over

100 feet should utilize Schedule 80 or heavier casing. If schedule 40 4-inch PVC casing is used at depths greater than 100 feet, cement grout should be installed in increments of 40 to 50 foot lifts. Clean pipe and screen must be used in all wells. The screen at the bottom of the well should be sealed with a bottom plug. Well development criteria, methods and desired volume are site-specific and should be determined by the KDHE Project Manager on a site-specific basis. Alternate well designs may be developed and approved by KDHE.

Well screen should be constructed of PVC pipe with factory cut slots. The slot size is typically 0.010 inch, although other slot sizes may be used if appropriate for the formation and approved by the supervising geologist. Screen will be installed at the intervals directed by the supervising geologist, based on the requirements of the project and the site conditions. The casing must not be cleaned or cemented with organic solvents or solvent based cements. Suitable fastening methods for those applications are either flush-joint threaded pipe, or slip-joint pipe fastened with stainless steel screws. When a monitoring well is to be used for detection of heavy metals, care must be taken in the choice of tools and supplies to avoid introducing soluble metals into the well.

A gravel pack is used to fill the annulus between the inside of the borehole and the outside of the casing. A minimum of four (4) inches of annulus plus the well casing (6 inches in diameter minimum for a 2 inch casing) is required. The gravel should be of clean silica sand, having a particle size appropriate for the formations in which it is to be used, and the slot size of the screen. The gravel pack material must be selected or approved by the geologist supervising the drilling. The gravel pack should be installed to a minimum of two feet above the screened interval to avoid potential grout penetration into the screen. Centralizers may be required to obtain accurate placement of the gravel pack material. Disinfection of the sand or gravel is not required.

A grout plug consisting of at least 24 inches of bentonite chips, pellets or similar impervious material must be placed above each aquifer. In addition, the top 20 feet of the well must be grouted with bentonite, neat cement, or concrete and the well head must be protected with an apron and locking well cover as described below. Bentonite is preferred as an annular seal and grouting agent. In some cases it will be necessary to install wells which have less than 20 feet of grout. If less than 20 feet of grout is determined for a well, a waiver must be obtained from KDHE's Bureau of Water (BOW).

The casing shall extend at least one foot, but not more than three feet above the ground surface, and have a removable PVC cap, unless a flush mount protective cover has been approved by the project manager and a waiver granted by BOW. The well head shall be surrounded by a concrete apron, at least four inches thick and two to three feet square, centered around the well head above normal ground

level, and sloped to drain away from the well. A locking well cover, constructed of welded steel, and having a suitable hasp will be installed at each well to prevent unauthorized access to the well. The well cover shall be firmly set in the concrete apron. Flush mount well protectors may be substituted for those described above if approved by the project manager. Alternate surface completion designs must be approved by the KDHE project manger with concurrence from BOW.

4.0 GENERAL CONSIDERATIONS

- Well construction details and geologic logs should be recorded by the on-site geologist during the well installation. The appropriate BOW WWC-5 water well construction documentation must be completed within 30 days of well completion.

- Prior to drilling, development, sampling or other activities in connection with construction or use of a monitoring well, all equipment and tools must be cleaned in a suitable fashion. For most circumstances, the procedures outlined in BER-05 should be used.

- Only Schedule 40 or 80 casing and screen will be permitted for small-diameter monitoring wells. No glues, solvents, joint compounds or adhesives will be used. Threaded casing or slip-joint pipe fastened with stainless steel screws will be used.

- Precautions must be taken during all stages of the drilling, installation, and development activities to prevent possible contamination of the well. Grease, fuel, hydraulic fluids, and other foreign materials from the drilling rig and equipment must be isolated from the well. Tools, casing, and drilling fluids must be kept clean and oil free. Clean tap water may be used in situations where heaving conditions are anticipated, however the water source should be sampled for the parameters and constituents of interest to account for water quality of tap water source.

- The well head apron and locking well cover is intended to prevent accidental or intentional introduction of foreign materials into the well. The well cap and locking cover should be installed as soon as practical, and must be locked to prevent tampering with the well. Drainage on the surface in the area of the well should be planned or modified so that there is no standing water in the area of the well, and so that the well will not be subject to runoff or infiltration from known sources of contamination.

- Disposal of cuttings and development/purge water should be performed according to the appropriate KDHE SOP (BER-08).

5.0 SPECIAL CONSIDERATIONS

The driller must be trained to operate the specific rig in use. For non-KDHE drillers, all drillers must be licensed through KDHE's BOW to install wells. Please refer to http://www.kdheks.gov/waterwell/index.html. Safety is a primary concern, and overhead utilities should be checked by the driller to assure that a minimum clearance of 20 feet (vertically and horizontally) exists between the mast in the upright position and any overhead power lines. DigSafe must be called for each location to be drilled. All well placement, logging, and drilling operations must be under the supervision of a Kansas Licensed Professional Geologist within KDHE or its contractors. The KDHE Project Geologist may desire to conduct in-field analysis of cuttings or development water during drilling, and the appropriate KDHE SOP should be consulted for the field analytical procedures to be utilized.

6.0 REFERENCES

ASTM D5092-90(1995) el Standard Practice for the Design and Installation of Ground Water Monitoring Wells in Aquifers.

Groundwater and Wells, 2nd Edition, Driscoll, 2003.

Ground-Water Data-Collection Protocols and Procedures for the National Water-Quality Assessment Program: Selection, Installation, and Documentation of Wells, and Collection of Related Data, US Geological Survey Open-File Report 95-398.

STANDARD OPERATING PROCEDURE – BER-07

KDHE GEOPROBE OPERATIONS

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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In general, this document should be used as a reference. Differences may exist between the procedures referenced in this document and what is appropriate under site-specific conditions. This document does not represent an endorsement of practitioners or products mentioned in the document.

1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to provide minimum operating requirements and recommended techniques for use of Kansas Department of Health and Environment's (KDHE's) Geoprobe units. Procedures which are mandatory, due to safety considerations or to minimum requirements for accuracy, are described in terms of **will** or **must**, while recommendations for good operating technique, efficiency, or enhanced accuracy, are worded as activities that the operators **should** or **may** perform. The procedures assume that two assigned persons will perform all of the necessary activities to operate the equipment, and that they are familiar with the use of the mechanical and analytical equipment and with scientific investigations of contamination sites. These operating procedures are not intended to substitute for training or experience, but to outline the reasonable minimum requirements for performing routine investigations with the equipment. The operators are expected to use their informed and reasonable judgment to interpret and implement the procedures, and to develop means to solve unforeseen problems as they arise.

2.0 SAMPLING PROCEDURES

2.1 PROBE EQUIPMENT OPERATION

2.1.1 Safety Considerations

The probe operator is the primary person to monitor for personnel safety in operating the vehicle and hydraulic probe system. Among the safety considerations are the following:

- A safe working area must be maintained when operating the geoprobe equipment in a street or public traffic area. Traffic cones should be used to close a lane if necessary, and good visibility for drivers and KDHE staff should be maintained around the work area.

- Hands and feet of operators and bystanders must be kept clear of moving parts, such as the probe foot and the drive head. Care must also be taken to prevent damage to the probe or the vehicle in extending and storing the probe. Unauthorized persons are not to be allowed to operate the hydraulic equipment.

- All work sites must be cleared for underground utilities and buried equipment before the probe is driven. 1-800-DIG-

SAFE **must** be called to clear buried utilities. The project manager is responsible for calling utility locates; however, the operator is responsible to making sure that utilities have been cleared and must not operate equipment if utilities have not been properly cleared. The project log book must clearly document that buried utilities have been cleared.

- The probe operator needs to be aware of any overhead power lines and take precautions to prevent hazardous situations by being too close to lines when the probe is extended up.

- The Geoprobe units are much larger and heavier than most personal vehicles, and may handle awkwardly in some situations. Drivers should keep the size and limitations of the units in mind at all times to avoid accidents.

- Steel-toed boots must be worn when assisting or operating a Geoprobe Unit. Hearing protection must be used during hammering operations of the Geoprobe Unit. Safety vest should be worn in areas with high traffic flow. Hard hats may be required at certain sites if specified in the approved Health and Safety Plan or in areas within a facility that may require hard hats.

2.1.2 Routine Equipment Maintenance

The probe operator should perform routine maintenance checks daily and weekly when operating the units. Daily checks should include:

- Check for loose nuts and bolts.

- Check for the wear of threads to prevent lost of tooling down hole.

- Check the hydraulic system for obvious leaks, and maintain the equipment in a clean and serviceable condition. In particular, oil and grease should not be allowed to accumulate where it can contact the probe rods, rod caps, or sampling tools and equipment.

Weekly maintenance checks should also address the following:

- Check the vehicle's motor oil and transmission fluid and refill if necessary.

- Check and refill the hydraulic fluid if necessary.

Watch for damage to mechanical equipment (i.e. rods and hoses.) Hydraulic equipment and hoses must be inspected for cracks or damage to prevent mechanical failure, personnel injury, or down-hole contamination.

2.2 OPERATING PROCEDURES

Personnel safety and equipment operation will be the principle concern of the operator. Both the operator and project manager must ensure that the quality and integrity of all samples are maintained. Principal sources of error in sampling include contamination of tools or sampling equipment, air leaks caused by poorly fitting probe connections or leaky sample tubing, and improper sampling, such as trying to sample an impermeable or water saturated zone for soil gas.

2.2.1 Probe Operating Technique

It is good operator practice to turn off the hydraulic system switch to relieve pressure on the system and save fuel whenever the hydraulic system is not in use. The operator should also turn off the vehicle engine whenever it is not in use to reduce exhaust fumes and noise in the working area. The drive hammer should be operated only when there is weight applied to the probe by the drive head. Use of the hammer without a load on the drive head causes undue wear and possible damage to the hammer and probe equipment. The drive head must not be allowed to lift the foot of the probe off the ground more than six to ten inches. Lifting the foot off the ground too high may lift the rear wheels of the probe vehicle from the ground, causing an unsafe condition that may allow the probe vehicle to fall in any direction, possibly injuring personnel and damaging equipment. When pulling tooling out of the ground, the foot must be placed firmly on the ground. The units should be operated with the hydraulic system switch set at low speed when folding in and out of the vehicle and when advancing the initial probe rod.

2.3 SOIL VAPOR SAMPLING

Soil vapor is collected using the Post-run Tubing (PRT) system. The probe rod is advanced to the desired depth with a PRT point holder and an expendable point attached to the lead rod. The rod train is retracted 0.25" to 3 inches. A PRT point popper, attached to extension rods, is inserted into the rods to force the expendable point out of the point holder. A PRT adapter attached to tubing is inserted down the rod bore and connected to the point holder. Soil vapor sampling is addressed in KDHE SOP BER-37.

2.4 GROUNDWATER SAMPLING

Groundwater samples may be collected directly from the rod string by using either a mill-slotted rod or the Screen Point (SP-15/16) system (drop out screen). After the probe has been driven to the desired sampling depth, an electronic static water level indicator may be used to check for groundwater in the probe rods if a mill-slot has been used. If a SP 15/16 is used the sampler has to be disengaged. Extension rods are lowered to the bottom of the rod string. The extension rods have to extend above the probe rod. The probe rod is retracted four feet while holding the bottom of the screen in place with the extension rod.

A polyethylene tube will be inserted inside the rods with a check valve attached. The tube can act as an inertia pump by physically moving the tube up and down inside the rods. All sample locations should be purged. Once the desired amount of water is purged from the probe, samples may be collected. All water samples other than volatile organic chemical (VOC) samples may be collected by pumping directly into the sample container or into another container such as a cubitainer for heavy metal samples prior to filtering. To collect VOC samples, the tube is pinched off at the top to retain the sample in the tube. The tube is pulled out of the rod with care being taken to avoid the tube touching the ground or any source of contamination. The check valve is removed from the tube. One sampler holds the VOC vial at the bottom end of the tube that had the check valve. A second sampler holds the pinched end of the tube and controls the flow of the sample from the tube to the VOC vial by releasing pressure on the pinched area of the tube and adjusting the height of the tube to allow proper sample flow into the VOC vial. Air pockets within tubing should be purged out prior to and/or during the VOC vial filling process to minimize sample disturbance. Samplers must wear sampling gloves while performing this operation.

Profile samples may be collected using a mill-slotted rod by collecting samples from the top of the water table down or a SP 15/16 sampler by collecting samples from depth to the top of the water table. If groundwater is highly contaminated at the top of the water table, contamination can be carried down with the mill-slot and cross contamination from higher zones may occur. If the geology is such that groundwater is confined, groundwater from lower zones can cross contaminate or dilute samples collected at higher depths when collecting samples with a SP 15/16 sampler going from depth to the top of the groundwater table. Project managers need to take the site geology into account when determining how to sample. At some sites, a discrete hole may be necessary to obtain valid samples for each sample depth.

If the geology is such at the site that groundwater is not easily obtained in the probe rods, a temporary well can be set by removing the probe rods and inserting schedule 80 polyvinyl chloride (PVC) screen and casing. If these temporary wells are not sampled and abandoned immediately, they need to be protected to prevent surface water entering into them. Clean sand can be added until the screen is covered and bentonite added above the sand or a bentonite plug can be placed in the upper 12-inches of the hole.

All samples are to be properly preserved and stored until they reach the laboratory.

2.5 SOIL SAMPLING

KDHE has the capability to collect soil samples using the Large Bore Soil Sampler or the Macro-Core Sampler.

The Large Bore Soil Sampler is a closed piston sampler used for sampling at discrete depths. When collecting soil samples using the Large Bore Soil Sampler, which is a two-foot sampler, the sampler will be pushed in front of the push rods. The Large Bore Soil Sampler can be lined with either an acetate liner or a brass liner. The sampler is pushed to the top of the desired collection depth. The stop pin holding the piston in place is removed through the center of the probe rods using extension rods. The sampler is advanced into the ground an additional two feet. The hammer is activated to start the pushing in order to open the piston so the sample will enter the sampler. After the rods have been pushed the additional two feet, the rods are pulled out of the ground. The liner is removed from the sampler and the sample is transferred to the appropriate sample containers. The brass liner is four six-inch sections held together with heat-shrink tubing that can be snapped apart and used for sample containers if the

laboratory will accept them. If the sample is being analyzed for VOCs, the ends of the sections should be immediately covered with either teflon film or aluminum foil and capped. If the acetate liner is being used to collect samples for VOC analysis, the sample should be transferred to the sample container with as little aeration as possible and the container must be packed as air tight as possible. Using brass liners is the preferred method for the collection of VOCs, because of the loss of VOCs in the plastic and during transferring the sample to a glass container.

The Macro-Core sampler is a continuous core sampler that comes with either a four-foot or a five-foot sample barrel. The four/five-foot sampler can be used as an open tube sampler or a closed-piston sampler. When used as an open tube sampler, a continuous sample is collected in four/five feet sections from the surface to the desired depth. When used as a closed-piston sampler, a sample is collected from the surface to four/five feet depth with the sampler used as an open tube sampler. The piston tip assembly is installed on the sampler. The sampler is driven to a four/five-foot depth, and the piston tip assembly is released to allow soil to enter the sampler while being driven from the four/five-foot depth to an eight/ten-foot depth. The sampler is re-assembled with the piston tip assembly and the process is repeated until the desired depth is reached.

Use of the Macro-Core sampler through undisturbed soil may not be suitable for all geology types and should be evaluated on a case by case basis. A Macro-Core closed piston sampler may be advanced through undisturbed material only if little or no hammering is required. In situations where a soil sample is to be collected at depth, a pilot hole may be necessary or alternative tool options may need to be considered.

2.6 MICRO-WELL INSTALLATION

To install micro-wells using a Geoprobe, refer to KDHE SOP BER-29.

2.7 VAPOR WELL INSTALLATION

To install vapor wells using a Geoprobe, refer to KDHE SOP BER-35.

3.0 DECONTAMINATION PROCEDURES

Please refer to KDHE SOP BER-05 for decontamination procedures.

4.0 REFERENCES

1. Geoprobe® Systems, *Geoprobe Screen Point 15 Groundwater Sampler*, Standard Operating Procedure Technical Bulletin No. 95-1500, Salina, Kansas, October 1995.

2. Geoprobe® Systems, *Geoprobe Screen Point 16 Groundwater Sampler*, Standard Operating Procedure Technical Bulletin No. 93-660, Salina, Kansas, November 2006.

3. Geoprobe® Systems, *Geoprobe AT-600 Series Large Bore Soil Sampler*, Standard Operating Procedure Technical Bulletin No. 95-1500 Salina, Kansas, November 1993.

4. Geoprobe® Systems, *Geoprobe Macro-Core Soil Sampler*, Standard Operating Procedure Technical Bulletin No. 95-8500, Salina, Kansas, revised September 1998.

STANDARD OPERATING PROCEDURE – BER-08

CHARACTERIZATION AND DISPOSAL OF INVESTIGATION-DERIVED WASTE

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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ATTACHMENT 1 **General Solid IDW Disposal Process Flowchart**

ATTACHMENT 2 **General Liquid IDW Disposal Process Flowchart**

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1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to provide general guidelines for management of investigation-derived wastes (IDW) generated during the investigation of potential or actual contaminated sites. These wastes include soil cuttings, drilling muds, purge water, equipment decontamination fluids, disposable personal protective equipment, and other materials. On the basis of project and program requirements, it may be necessary to deviate from the guidelines presented in this SOP. These deviations must be clearly described in associated project planning documentation.

2.0 METHOD SUMMARY

An IDW management strategy or program is a requisite component of project planning documentation. The IDW management strategy must (1) provide safety for on-site personnel, 2) protect human health and the environment, and (3) comply with applicable or relevant and appropriate requirements (ARARs) to the extent practicable. The most important phase of IDW management is planning for waste generation and handling prior to field mobilization. To the extent possible, the IDW management strategy should address IDW minimization, containerization, segregation, characterization, storage, inventory, and identify options for final disposition.

3.0 PROCEDURE

IDW must be characterized at the initial point of generation unless sufficient historical information exists at a particular site or sample location (e.g., a monitoring well where contaminant concentrations have been consistently under applicable threshold levels, etc.). This often necessitates containerization and temporary onsite storage in containers while awaiting sample results. Drums or other containers must be properly labeled (e.g., Waste Awaiting Characterization with contact information provided).

A hazardous waste determination must be made based on the potential listing and toxicity of the IDW. To support waste determinations, IDW samples may be subjected to totals analysis and/or analysis via the toxicity characteristic leaching procedure (TCLP) as per Environmental Protection Agency (EPA) SW-846 Method 1311. The totals analysis results can be used for direct comparison to KDHE's Tier 2 Levels (for solid or liquid IDW), POTW pretreatment standards (for liquid IDW), and maximum concentrations of contaminants for the toxicity characteristic (TCLP threshold levels) as defined in 40 CFR 251.24 (for liquid IDW). Totals analysis for solid IDW can also be used in combination with the Rule of 20 to support comparison to the TCLP threshold levels. The premise behind the Rule of 20 is that during the TCLP analysis, a sample is diluted 20 times. Accordingly, the total concentration results can be compared to the TCLP threshold levels multiplied by 20. If the result is less than 20 times the TCLP

threshold levels for each constituent of concern, then the waste is not a toxicity characteristic hazardous waste. If a solid IDW sample fails the Rule of 20 based on the total waste analysis, it may be a toxicity characteristic hazardous waste and additional samples should be analyzed after TCLP extraction. The TCLP is a leaching procedure that simulates conditions of wastes if they were disposed in a landfill. The TCLP extract is then analyzed by the appropriate methods for the contaminants of concern and those results are compared to the TCLP threshold levels. If it is determined that the IDW is a Resource Conservation and Recovery Act (RCRA) hazardous waste, based on listing or toxicity, RCRA storage, transportation, and disposal requirements become applicable.

The type and frequency of IDW analysis should be discussed in the IDW management strategy on the basis of site-specific information (e.g., amount of waste generated, contaminants of concern, etc.). Use of field analytical technology may be appropriate depending on the contaminants of concern and analytical equipment limitations. If field analysis of IDW is performed, it may also be necessary to submit samples for off-site confirmatory analysis and/or TCLP analysis.

Flow charts depicting the generalized process for managing solid and liquid IDW, including options for disposal, are provided as Attachments 1 and 2. Other options, such as storage of IDW onsite pending implementation of remedial actions, may be appropriate on a site-specific basis.

4.0 GENERAL CONSIDERATIONS

Some general goals for the management of IDW include the following:

- Worker safety;
- Leave the site in no worse condition than existed prior to the investigation;
- Remove wastes that pose an immediate threat to human health or the environment;
- Spread evenly on-site IDW that does not require off-site disposal;
- Minimize the quantity of IDW to the extent practicable;
- Comply with ARARs to the extent practicable; and,
- Consider any potential community concerns regarding on-site disposal of IDW and plan accordingly.

5.0 SPECIAL CONSIDERATIONS

This SOP does not preclude the need for individuals or programs generating wastes to make appropriate waste determinations and to be familiar with relevant federal, state, and local laws, regulations, policies, and guidance, such as *Management of Investigation-Derived Wastes During Site Inspections* (EPA/540/G-91/009) and *Guide to Management of Investigation-Derived Wastes* (EPA Publication 9345.3-03FS). In some cases, it may be necessary to confer with the KDHE-Bureau of Waste Management and/or KDHE-Bureau of Water to determine whether the identified waste management approach will satisfy ARARs.

Note: Sampling of direct-push (Geoprobe or similar units) generates minimal amounts of purge water per sampling location (less than five gallons). Upon approval of the KDHE project manager, purge water not to exceed five gallons per sampling location may be applied on-site from direct push sampling locations only. However, if noticeable contamination (visual or odor) is present in the purge water it should be containerized, characterized, and disposed of in accordance with this policy.

6.0 REFERENCES

1. United States Department of Energy (U.S. DOE), 1999, Memorandum from T. Traceski dated December 20, 1999, Subject – *Management of Remediation Waste Under the Resource Conservation and Recovery Act (RCRA)*, Office of Environmental Policy and Assistance.

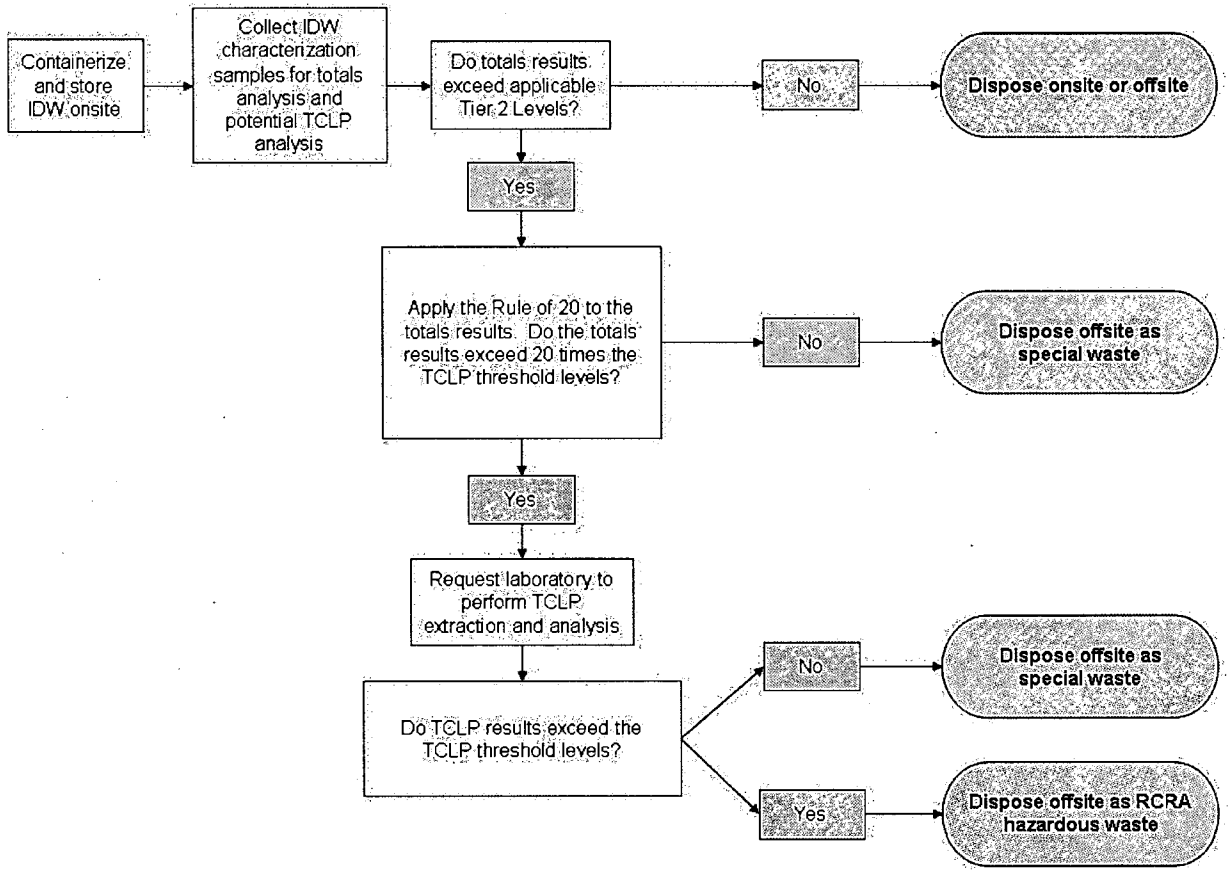
2. United States Environmental Protection Agency (U.S. EPA), 1991, *Management of Investigation-Derived Wastes During Site Inspections* (EPA/540/G-91/009), Office of Emergency and Remedial Response, Washington D.C., May 1991.

3. United States Environmental Protection Agency (U.S. EPA), 1992, *Guide to Management of Investigation-Derived Wastes* (Publication 9345.3-03FS), Office of Solid Waste and Emergency Response, Washington D.C., January 1992.

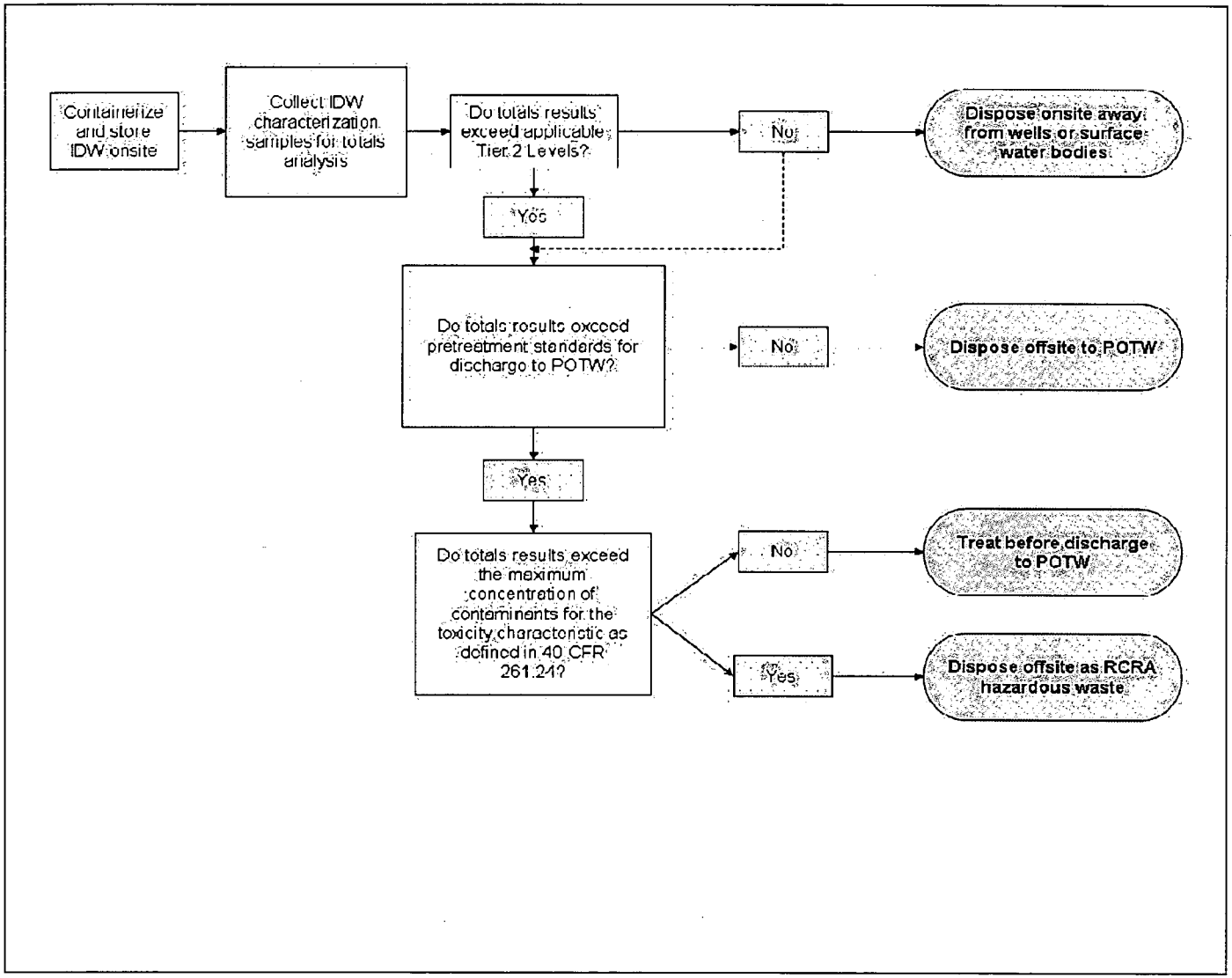
4. United States Environmental Protection Agency (U.S. EPA), 1991, Guide to Discharging Aqueous Wastes to Publicly Owned Treatment Works (Publication 9330.2-13FS), Office of Solid Waste and Emergency Response, Washington D.C., March 1991.

5. Davis, 2001, *Regulated Metals: the Rule of 20*, Pollution Prevention Institute, Small Business Environmental Assistance Program, Kansas State University, Manhattan, Kansas, December 2001.

Attachment 1 – General Strategy for Managing Solid Investigation-Derived Waste



Attachment 2 – General Strategy for Managing Liquid Investigation-Derived Waste



Note: Purge water obtained from direct-push sampling locations only (less than five gallons per location) may be applied on-site at the probe location upon receiving approval from the KDHE project manager. However, if noticeable contamination (visual or odor) is present in the purge water it should be containerized, characterized, and disposed of in accordance with this policy.

STANDARD OPERATING PROCEDURE – BER-11

EVALUATION AND VALIDATION OF DATA

Effective Date: August 14, 2000
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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish the criteria that are followed for documenting and tracking the quality of environmental data generated from field sampling activities. Because valid media-quality data are integral to environmental investigations that characterize site conditions, the quality of the data generated by a field investigation is extremely important to the successful completion of a project. The level of data evaluation and validation required is determined by the project data quality objectives and must be outlined in the site specific or generic Quality Assurance Project Plan (QAPP).

1.2 SCOPE

The environmental investigation process is a three phase cycle that includes: (1) Planning Phase, (2) Implementation Phase, and (3) Assessment Phase. This SOP, which is in the Assessment Phase, is used to evaluate and validate data that was generated during the Implementation Phase. The data is validated based on criteria that are established in the Planning Phase. Data verification is the process for evaluating the completeness, correctness, and conformance / compliance of a specific data set against the method, procedural, or contractual specifications. Data validation is used to determine the quality of a specific data set relative to the end use. It focuses on the project's specifications or needs, designed to meet the needs of the decision makers/data users and should note potentially unacceptable departures from the QA Project Plan.

2.0 DATA EVALUATION AND VALIDATION

The degree of data validation depends on the quality of data needed to meet the data quality objectives for the project, which are specified in the QAPP. Data collected to establish qualitative trends, for example, do not require the same level of validation as data generated to support litigation. Standard data quality attributes that are recognized as important are the Data Quality Indicators. Acceptance criteria placed on the data quality indicators of a given data set are sometimes referred to as measurement quality objectives (MQOs). The Data Quality Indicators (DQIs) are defined in Table 3, EPA Guidance for Quality Assurance Project Plans, EPA QA/G-5. MQOs are usually based on the individual DQIs for each matrix and analyte group or analyte.

2.1 PRECISION

Precision is the degree to which the measurement is reproducible and is to be determined by comparison of laboratory designated duplicates or designated laboratory matrix spike/matrix spike duplicates. Precision will be calculated as the relative percent difference (RPD) of the two measurements. The equation is as follows:

RPD = 100% X [Result 1 - Result 2] / [(Result 1 + Result 2) / 2]

2.2 ACCURACY

Accuracy is the degree of agreement between a measured value and a true or known value. Accuracy is evaluated using matrix spike (MS) recoveries, system monitoring compound spike (surrogate) recoveries, or continuing calibration verification (CCV) recoveries. MS samples are samples into which known concentrations of the target compounds of interest have been added (or "spiked"). Surrogate compounds are compounds that behave in a similar manner as the target compounds but are not target compounds and are added (or "spiked") into each sample prior to extraction and analysis. The samples are analyzed by the appropriate analytical method. The result obtained is compared to the known concentration added and the MS or surrogate percent recovery (%R) is calculated. CCV samples are check standards analyzed at intervals not to exceed 12 hours for organic analyses and every 10 samples for inorganic analyses. When matrix spike samples or surrogate compounds are not possible, CCV sample results are used to determine accuracy. Percent recovery is calculated as follows:

MS %R = 100% X [Spiked Result Conc.- Sample Result Conc.] / Spike Conc.
CCV and surrogate %R = 100% X [Result Conc.) Known/Spiked Conc.]

2.3 METHOD REPORTING LIMITS

Reporting limits will be based upon method quantitation limits. The procedure for determining the method detection limit for a substance is in Appendix B of Part 136 of Title 40 of the Code of Federal Regulations (40 CFR 136 Appendix B). The method quantitation limit is defined as equivalent to the lowest calibration standard analyzed for each analyte or as ten times the method detection limit.

2.4 COMPLETENESS

Completeness is a measure of the amount of valid, usable data obtained from an analytical data set compared to the amount that was planned to be obtained. Completeness takes into account any breakage, laboratory errors, or sampling difficulties.

Completeness = (# of Valid Data Obtained) / (# of Total Planned Data) x 100

2.5 COMPARABILITY

Comparability expresses the confidence with which one data set can be compared to another. Samples from the same media (i.e., soil, water, etc.) will be considered comparable if the procedures for collecting the samples are complied with and consistent, if the units of measurement are the same, and if the reporting limits are comparable. In addition to obtaining samples in accordance with approved procedures and in a consistent manner, comparability is assured through the use of laboratories using established and approved analytical methods and protocols. The laboratory's quality control program is designed to establish consistency in the performance of the analytical process. The program includes traceability of measurements to standardized reference materials to establish comparability with other laboratory results, and internal controls to verify consistency of a given laboratory's performance. Standard reporting units (e.g., mg/kg, µg/L) will be used for reporting the various parameter results. All data will be subjected to strict QA/QC procedures and reported in a consistent manner to allow for comparison across data sets.

2.6 REPRESENTATIVENESS

The representativeness of the data is the degree to which data represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is a function of sample collection and analysis techniques. Data are considered representative if the sampling is performed in accordance with the sampling programs defined in the Field Sampling Plan (FSP) and the analyses meet the requirements outlined in this section and the section on quality control procedures.

3.0 PROCEDURE FOR DATA VALIDATION

The person designated to validate the data for a project will review the data using the criteria established in the QAPP. The degree of validation of the data depends

entirely on the quality of data specified in the QAPP. As a minimum, valid data should be supported with evidence that: (1) all field, laboratory, and other procedures used to collect the data are documented so the work can be reproduced by others skilled in the field; (2) all methods and equipment were working properly when the data was collected; and (3) the methods were capable of producing the values reported and that the precision and accuracy or bias of the data are acceptable for the intended use of the data.

To validate the data for a project, the designated person will:

1. Evaluate the quality assurance objectives using the criteria stated in the QAPP. Both field procedures and laboratory procedures will be evaluated.

2. Evaluate field procedures by examining sample collection procedures and sample handling procedures to determine if the QAPP was followed. To evaluate sample handling procedures, methods of sample collection, chain of custody forms, sample preservation, and handling of the samples until received by the laboratory, will be examined.

3. For laboratory procedures on inorganic compounds, the following may be examined during the validation process:

    - Holding times
    - Instrument calibration, including initial and continuing calibration verification
    - Blank(s)
    - Laboratory control sample(s)
    - Inductively Coupled Plasma (ICP) interference check samples
    - Duplicate sample(s)
    - Matrix spike sample(s)
    - Furnace atomic absorption QC
    - ICP serial dilution(s)
    - Sample result verifications
    - Field duplicates

- General data assessment

4. For laboratory procedures on organic compounds, the following may be examined during the validation process:

   - Holding times
   - Gas Chromatograph/Mass Spectrometer (GC/MS) tuning
   - GC calibration, initial and continuing
   - Blanks
   - Surrogate recoveries
   - Matrix spike/matrix spike duplicates
   - Internal standards performances
   - Target Compounds List (TCL) compound identifications
   - Reported detection limits
   - Tentatively identified compounds (TICs)
   - Overall system performance
   - General data assessment

5. The parameters which do not conform to requirements are listed and the data are qualified according to the guidelines listed in the QAPP. The qualified data package is then reviewed and the project data reviewer, the project geochemist and/or the project manager makes a professional judgment concerning the validity of the data package, and its usability for the project.

6. This SOP only includes general guidelines. Additional data quality evaluation/ validation criteria may be established in a QAPP.

4.0 REFERENCES

1. EPA Guidance for Quality Assurance Project Plans, EPA QA/G-5, (December 2002).

2. EPA Guidance on Data Quality Indicators (EPA/QA G-5i) (EPA, 2002b).

3. EPA Guidance for QA Project Plans (EPA/QA/R-5) (May 2001).

4. EPA Guidance on Environmental Data Verification and Data Validation (EPA QA/G-8) (EPA/240/R-02/004).

5. EPA Data Quality Assessment: A Reviewer's Guide (EPA QA/G-9R) (EPA/240/B-06/002).

STANDARD OPERATING PROCEDURE – BER-12

COLLECTION OF QUALITY CONTROL SAMPLES

Effective Date: August 31, 2000
Revised Date: January 1, 2011

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DISCLAIMER:

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1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to explain the quality control (QC) measures taken to ensure the integrity of the samples collected and to establish the guidelines for the collection of QC samples. The objective of the QC program is to ensure that water-quality data of known and reliable quality are developed.

Documentation of representative data is essential to site investigations; therefore, the data must be validated though the performance of QC sampling. Verification performance sampling is necessary to evaluate and identify contradictory or suspect data. The QC sampling requirements must be determined by the project manager. Data validation measures must be specified as part of all environmental investigations.

The laboratory is responsible for the development and implementation of a laboratory QA/QC program. The collection of field QC samples serves primarily as a check to ensure proper field procedures, but can also serve as a mechanism for the laboratory to perform their QA/QC program (such as collecting sufficient sample for the laboratory to perform matrix spike/matrix spike duplicate samples).

2.0 QUALITY CONTROL SAMPLES

Samples collected for laboratory analysis require the use of quality control samples to monitor sampling activities and laboratory performance. Types of quality control samples may include duplicate and/or duplicate split, trip blank, field equipment blank, matrix spike and matrix spike duplicate, and field matrix spike. A discussion pertaining to each quality control sample follows:

2.1 DUPLICATE AND DUPLICATE SPLIT:

Duplicate sample analysis is performed to evaluate the reproducibility of collection procedures. A duplicate sample is called a split sample when it is collected with or turned over to a second party (e.g., consulting firm) for an independent analysis or submitted to two laboratories for the same analysis. Duplicate samples are two physical samples collected simultaneously from the same location under identical conditions. Duplicate samples may be collected for any media and should be collected in accordance with the sample collection procedures identified in each media specific SOP.

In some cases (not volatile organic compounds), water may have to be accumulated in a common container and then decanted slowly into the

sample bottles. The work plan should be referenced for a description of how duplicate samples are to be collected. Additionally, in the case of wells that recover slowly and produce insufficient water to fill all the replicate sample containers, the containers should be filled incrementally and kept on ice in the cooler between filling periods.

2.2 TRIP BLANK:

A trip blank sample is a sample of distilled or de-ionized water prepared in the laboratory prior to sampling, and travels unopened in a common container with the sample bottles. (Note: USEPA uses the phrase "demonstrated analyte free water") It is later opened in the laboratory and analyzed along with field samples for constituent(s) of interest to ascertain whether cross-contamination has occurred during field handling, shipment, or in the laboratory. Trip blanks are primarily used to identify "artificial" contamination of the sample caused by airborne volatile organic compounds (VOCs) but may also be used to check for "artificial" contamination of the sample by a test substance or other analyte(s). One trip blank should accompany each cooler containing water samples that are being submitted for lab analysis.

2.3 EQUIPMENT BLANK:

An equipment blank sample is collected to evaluate decontamination procedures. It is a sample of analyte-free water which has been used to rinse reusable sampling equipment and is collected after completion of decontamination and prior to sampling. One equipment blank should be incorporated into the sampling program for each day's collection of samples and analyzed for the appropriate chemicals of concern. In some situations one equipment blank will be required for each type of sampling procedure (e.g., bailer, soil sampling equipment, etc.).

2.4 FIELD BLANK:

A field blank may be needed where ambient air quality may be poor. This field blank sample would be taken to determine if airborne contaminants interfere with constituent identification or quantification. This field blank sample is a sample bottle that is filled and sealed with "clean" (e.g., distilled/de-ionized/demonstrated analyte free) water in the analytical laboratory, and travels unopened with the sample bottles. It is opened in the field and exposed to the air at a location(s) to check for potential atmospheric interference(s). The field blank is resealed and shipped to the contract laboratory for analysis.

2.5 MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Spikes of compounds (e.g., standard compound, test substance, etc.) are added to samples in the laboratory to determine if the matrix is interfering with constituent identification or quantification, as well as a check for systematic errors and lack of sensitivity of analytical equipment. Samples for spikes are collected in the identical manner as for standard analysis, and shipped to the laboratory for spiking. Matrix spike duplicate sample collection and laboratory spiking and analysis are performed to evaluate the reproducibility of matrix spike results. Additional sample volume may have to be collected for the laboratory to perform matrix spike/matrix spike duplicate samples.

3.0 PROCEDURE

1. Implement QC sampling as outlined above, depending on the type of QC sample(s) specified in the work plan.

2. Ensure unbiased handling and analysis of duplicate and blank QC samples by concealing their identity by means of coding so that the analytical laboratory cannot determine which samples are included for QC purposes. Attempt to use a code that will not cause confusion if additional samples are collected or additional monitoring wells are installed. For example, if there are three existing monitoring wells (MW-1, 2 and 3), do not label the QC blank MW-4. If an additional monitoring well were installed, confusion could result.

3. Verify that each sample container is properly placed in the cooler, and that the cooler has sufficient ice (wet ice or blue packs) to preserve the samples for transportation to the analytical laboratory. Consult the site work plan to determine if a particular ice is specified as the preservative for transportation (e.g., the USEPA prefers the use of wet ice because they claim that blue ice will not hold the samples at 4E C).

4. Document the QC samples on the appropriate field form and in the field notebook. On the chain-of-custody form, duplicate and blank QC samples will be labeled using codes, and matrix spike and field matrix spike QC samples will be identified as such.

5. The collection of quality control samples will follow KDHE=s various media specific SOPs:

   - SOP BER-01 for the Collection of Ground Water Samples;
   - SOP BER-2 Collection of Surface Water Samples;
   - SOP BER-3 Collection of Soil Samples for Laboratory Analysis
   - SOP BER-4 Collection of Sediment Samples

4.0 REFERENCES

EPA, Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers. USEPA 542-S-02-001, (May 2002)

EPA, Guidance on Environmental Data Verification and Data Validation EPA QA/G-8 (EPA/240/R-02/004) (November 2002)

EPA, Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Region 4, (November 2001)

STANDARD OPERATING PROCEDURE – BER-13

HEADSPACE METHOD FOR SCREENING SOIL SAMPLES FOR VOLATILE ORGANIC COMPOUNDS

Effective Date: October 27, 2000
Revised Date: January 1, 2011

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1.0 INTRODUCTION

The purpose of this standard operating procedure (SOP) is to establish guidelines for screening soil samples for volatile organic vapors using a portable photoionization detector (PID) or colorimetric tubes. This SOP is applicable to soil samples collected from a Geoprobe®, split-spoon samplers during drilling, hand auger samples, and grab samples from stockpiled soils or excavations.

2.0 CONSIDERATIONS

The primary objective of field screening of soil samples is to obtain a qualitative understanding of the distribution of volatile organic compounds (VOCs) in soil. The proper design of an organic vapor screening program requires an understanding of site hydrogeology, potential source areas, and potential contaminants of concern. Sample locations and frequency must be fully defined in the work plan. The work plan should outline the type of lamp to be utilized in the PID based on the ionization potentials and response factors of the constituents of concern or the type of color metric tube. The work plan must also clearly describe the heating or equilibration procedures to be employed if they differ from those described in this SOP. Regardless of the specific equilibration procedure employed, it is imperative that each sample be treated identically to allow the photoionization results from different locations to be comparable. Observations such as moisture, soil composition, and organic content should be noted to facilitate interpretation of the data. Every effort should be made to collect a representative portion of soil from the sampling device.

3.0 MATERIALS/EQUIPMENT

The following material may be used:

- Decontamination supplies (including: non-phosphate laboratory grade detergent, buckets, brushes, potable water, distilled water, plastic sheeting, etc.)
- Field notebook, field form(s), maps, chain-of-custody forms
- Sampling device (split-spoon sampler, stainless steel hand auger, stainless steel trowel, etc.)
- Stainless steel spoons or spatulas
- Disposable plastic spoons
- Plastic sheeting

- Aluminum foil
- Mason jars or driller's jars
- Water bath (hot plate, extension cord, water tray, thermometer)
- Photoionization detector with charging unit or colorimetric tube and pump
- Calibration gases with regulator
- Indelible marker
- Masking tape
- Disposable sampling gloves
- Zip lock bags, approximately 1 quart capacity

4.0 DECONTAMINATION

Where possible, thoroughly pre-cleaned and wrapped sampling equipment should be used and dedicated to individual sampling locations. Disposable items such as sampling gloves, aluminum foil, and sample jars will be discarded after each use in an appropriate manner. If only field screening results are to be obtained then split-spoon samples and hand augers may be cleaned with a soap and water wash and potable water rinse or steam cleaning, and a final distilled water rinse. However, if samples are to be collected concurrently for laboratory analytical results, then all reusable sampling equipment must be thoroughly decontaminated according to SOP BER-05 Decontamination of Field Equipment.

5.0 CALIBRATION

The PID must be calibrated according to the manufacturer's specifications at a minimum frequency of once per day prior to the first sample analyzed each day. A calibration standard gas should be employed which is similar to the compounds of concern expected at the site.

In addition, periodic calibration verifications (e.g., every 2 hours or every ten samples) employing the standard gas must be conducted. The time, date, and calibration procedure must be clearly documented in the field notebook and the calibration log. If at any time the photoionization results appear erratic or inconsistent with field observations, then the unit must be re-calibrated. If calibration is difficult to achieve, then the unit's lamp should be checked for dirt or moisture and cleaned, as necessary. During humid or wet conditions, the unit

should be calibrated on a more frequent basis as determined by field personnel. If colorimetric tubes are used, the brand and type of pumps and tubes must be documented in the field notebook. The expiration date, batch number of the tubes and the methods utilized must be documented.

6.0 PROCEDURE

1. Extract the soil sample from the sampler, quickly measure the recovery, and separate the waste from the true sample by using a dedicated, stainless steel spatula. Where allowed by regulatory agency(ies), disposable plastic spoons may be used.

2. Place the sample in a pre-cleaned glass jar (as quickly as possible to avoid loss of VOCs) filling the jar half full. Place an aluminum foil seal between the glass and metal cap and screw tight. Zip lock bags may be used as an alternative to glass jars for sample containers. The bags should be approximately one quart capacity, and should be filled with approximately equal volumes of soil sample and air space.

3. Label jars or bags with the boring number, depth of sample, date and time of collection. In addition, the field personnel will ensure the following: samples are taken at appropriate depths, unrepresentative portions of the sample are discarded properly; all sampling equipment is decontaminated properly between use; and the driller uses proper methods during sample collection and does not use oil or grease on tools entering the borehole.

4. Log the sample in detail and record sediment characteristics (color, odor, moisture, texture, density, consistency, organic content, and layering).

5. If the ambient temperature during the sampling event exceeds 70° F, the sample may be allowed to equilibrate at ambient temperature for at least five minutes. If the ambient temperature is less than 70° F, the sample temperature should be elevated by placing the sample under gentle heat for at least five minutes. The heater or defroster of a vehicle may be used to heat the sample for the equilibration process. Alternatively, a water bath may be used to heat and stabilize the temperature of the samples. The water bath should bring the temperature of the sample to at least 70° F but no more than 100° F for at least two minutes.

6. If a PID is to be used, ensure that it has been calibrated and that the calibration information is documented in the field book. Pierce the aluminum foil seal with the probe from the PID or colorimetric tube or insert the probe or tube into a small opening in the zip lock bag, and measure the relative concentration of VOCs in the headspace of the soil

sample. The initial (peak) reading must be recorded. The work plan should specify a time period in which the initial peak reading should occur (e.g.: the first 30 seconds).

7. Record the instrument reading in the field notebook, on an appropriate field form, and on the base map, if appropriate.

8. If only field screening results are to be obtained, then reusable sampling devices may be cleaned with a soap and water wash and a potable water rinse. The sampler will then be rinsed with distilled water, assembled and placed on plastic sheeting for reuse. A more rigorous decontamination procedure is required when samples are also being collected for laboratory analysis. Refer to SOP BER-03 for collection of soil samples for laboratory analysis for additional information.

7.0 REFERENCES

Enviro-Equipment, Inc. October 5, 2007. "Accurate Information for Field Soil Screening Procedures, Are your field Soil Screening Procedures Providing You with Practical and Accurate Information?" http://enviroequipment.blogspot.com/2007/10/accurate-information-for-field-soil.html

Los Alamos National Laboratory. September 13, 2004. "Risk Reduction and Environmental Stewardship - Environmental Characterization and Remediation, Standard Operating Procedure for Headspace Vapor Screening with a Photoionization Detector." *SOP-06.33, Revision: 0*, Document Catalog Number: ER2004-0438. http://www.lanl.gov/environment/all/docs/qa/er/SOP-06.33.pdf

Maine Department of Environmental Protection, Bureau of Remediation and Waste Management. March 16, 2009. "Field Screening of Soil Samples Utilizing Photoionization and Flame-Ionization Detectors." *Standard Operating Procedure: DR#011, Revision: 02.* http://www.maine.gov/dep/rwm/hazardouswaste/updatedsops/dr011_2009.doc

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U.S. Environmental Protection Agency. October 6, 1994. "Photoionization Detector (PID) HNU". *SOP: 2114, Rev. 0.0.* http://www.dem.ri.gov/pubs/sops/wmsr2114.pdf

STANDARD OPERATING PROCEDURE BER-17

IMPLEMENTING A SPECIALIZED OCCUPATIONAL HEALTH EXAMINATION PROGRAM

Effective Date: November 11, 2000
Revised Date: January 1, 2011

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1.0 INTRODUCTION

The objective of this SOP is to ensure all BER employees assigned to field investigative tasks requiring the potential use of Level C personal protective equipment (PPE), such as coveralls, gloves, boots, head protection and negative pressure respiratory protection, are physically capable of utilizing the assigned PPE in extreme temperatures and physically demanding work situations. An additional objective is to monitor for potential long term health effects from exposures to common chemicals of interest that may be encountered by field staff.

2.0 PROGRAM SCOPE

It is the general policy of the KDHE/BER to prevent employee exposures to hazardous conditions and agents, where possible, through the use of appropriate engineering controls, work practices, and PPE. The use of certain items of PPE, such as negative pressure respirators, increases physical demands upon employees above those associated with normal agency field investigative work. Of particular concern is the general state of health of the individual assigned to use these devices such that the safety and health of the individual is not compromised nor work function impaired. Positions have been identified throughout the bureau in which the wearing of negative pressure respiratory protective equipment is a necessary requirement. Employees assigned to these positions will be required to complete a baseline health examination. In addition to the baseline examination, the health status of each individual in these positions will be reviewed annually with the employee. Follow-up examinations may be required depending upon the findings of the annual interview.

3.0 PROCEDURES

Employees participating in this program will be scheduled by KDHE/BER for the completion of a baseline or annual examination. This examination will be completed by a designated contractor and <u>may, depending upon the employee's job duties,</u> consist of the following services and procedures as determined by the Supervising Manager:

A. Thorough health and occupational history with special attention to conditions that may affect the capability of the individual to wear a full-face, negative pressure respirator

B. Examination to emphasize cardiovascular, pulmonary, and integumentary systems, including an assessment of vital signs and vision screening

C. Pulmonary function test (spirometry), with forced vital capacity (FVC) and forced expiratory volume (FEV)

D. Electrocardiogram - 12 lead (resting)

E. Blood chemistry profile

F. Urinalysis with microscopic examination

G. Complete blood count (CBC)) with differential

H. Chest roentgenogram (to be included only if considered appropriate by the examining physician based upon the findings of the health and occupational history and spirometry)

I. Heavy metal blood scan

J. Audiology screening (sound booth)

The contracting physician will provide a written report of findings documenting the capability of the individual to use full-face negative pressure respirators and noting any special limitations of the individual (such as the use of prescription eyewear) which should be known to the Department prior to assignment of job tasks requiring the use of full-face respirators.

Employees will have the option of completing a comparable examination with a physician of their choosing; however, such an examination will be at the employee's expense.

4.0 RECORD KEEPING

KDHE/BER will be responsible for the cost of the baseline and annual examinations completed by the selected contractor. The results of detailed health examinations will be maintained on file by the contractor and the summarized written report of findings will be mailed to and maintained on file in the personnel files of the employees examined. Invoices will indicate the names of the individuals receiving examinations and the specific services provided.

5.0 REFERENCE

Title 29 Code of Federal Regulations; Part 1910, Occupational Safety and Health Standards; Subpart H, Hazardous Materials; 1910.120, Hazardous waste operations and emergency response

STANDARD OPERATING PROCEDURE – BER-18

FIELD SAFETY PROTOCOL

Effective Date: October 29, 2000
Revised Date: January 1, 2011

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1.0 INTRODUCTION

This document was developed primarily for unknown hazardous substance sites where a site-specific health and safety plan (HASP) may be required. This document should not be applicable to sites where routine operations such as monitoring, inspecting or overseeing are conducted. A general HASP may be used for these types of operations.

The handling and sampling of contaminated materials (i.e. hazardous substances, hazardous waste, soil, groundwater) always poses a certain degree of hazard. The objective of this document is to serve as a guideline for the safety of Kansas Department of Health and Environment\Bureau of Environmental Remediation (KDHE\BER) personnel while conducting field activities. This document does not replace a generic or site-specific HASP which should be completed for all site investigations. Program Managers may elect to develop a generic site HASP for programs that conduct similar/routine events. This document does not serve as a Standard Operating Procedure (SOP) for emergency response. Emergency response encompasses an enormous amount of variables specific to emergency response situations. Emergency response documents should be consulted for further details.

2.0 REQUIREMENTS FOR FIELD PERSONNEL

Before entering any potentially hazardous waste site or collecting any hazardous samples, BER personnel must have completed a 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) course and be enrolled in a medical monitoring program. Employees are expected to attend a yearly 8-hour HAZWOPER refresher course to maintain their certification.

3.0 RESPONSIBILITY OF PROJECT MANAGER/ ONSITE COORDINATOR

During on-site investigations involving the sampling or handling of hazardous waste, safety precautions must be paramount to all other considerations. Due to the variety of chemicals and their varied toxicities, exposure prevention must be a high priority of the project manager. Despite thorough preparation, a field team may not have adequate knowledge of site conditions. It is impossible to anticipate every hazard that could arise. The project manager or on-site coordinator should consult all available information prior to the field activity to review potential hazards and safety precautions.

In all considerations related to safety, the project manager or on-site coordinator is responsible for overseeing the collection and organization of site data in order to properly assess the hazard potential, and in implementing the generic or site-specific HASP.

4.0 RESPONSIBILITY OF THE SITE SAFETY OFFICER

Some sites will have a separate designated Site Safety Officer (SSO) who will most often generate and supervise the execution of the generic or site-specific HASP. For most sites, the project manager or on-site coordinator will be the SSO. Additional responsibilities may include:

- ensuring all team members are familiar with the site safety plan including the route from the site to the chosen medical facility before any site activities begin;
- conducting site safety briefings and documenting all on-site safety concerns and situations;
- maintaining safety equipment in good condition and proper working order;
- confirming safety equipment is used in accordance with the manufacturer's instructions and bureau SOPs; and
- ensuring team members refrain from activities that would create additional hazards (e.g. smoking, eating on site).

5.0 TYPES OF EXPOSURE TO HAZARDOUS WASTE

In order to ensure the safety of the field team, the project manager and health and safety officer must protect field team staff from exposure to hazardous materials. The purpose of the following information is to provide some basic insight into the manner by which harmful materials may enter the body. The four basic types of exposure are inhalation, skin absorption, ingestion, and eye contact.

5.1 INHALATION

Breathing gas vapor, mist, fumes or dust is a common accidental form of exposure and this route of entry may be a cause of systemic illness. The inhalation hazard depends on a number of factors: the chance that the chemical encountered will leak into the air; the concentration present in the air; the volatility of the chemical at ambient temperature; the inherent toxicity of the chemical; and the length of time the chemical is breathed.

The field team should take the following precautions when entering a site with unknown hazards and/or when sampling from containers, including wells, where the contents pose an inhalation hazard:

- Approach the area, well, or container from an upwind position.
- Sample only in well ventilated areas.
- Use the appropriate respirator based on chemical toxicity and on-site monitoring data.
- When needed, use a suitable air monitoring instrument to screen the well/area for volatile vapors.

5.2 SKIN ABSORPTION

Certain chemicals have the capacity to penetrate unbroken skin (including highly absorbent eye tissue) and are picked up by the blood stream and distributed throughout the body. A combination of gloves, boots, hats, coveralls and proper respirator should be worn to protect against skin exposure and absorption. BER staff must wear personal protective equipment (PPE) and clothing in accordance with SOP-21 to minimize exposure. In addition to donning proper safety clothing and equipment, the following precautions should be used in inspecting sites which may contain materials hazardous by skin absorption:

- Ensure all skin areas are protected during site work.
- Carefully wipe all residue off sample containers after sample collection.
- After completing the investigation, use proper procedures for removing contaminated clothing while still at the site.
- Bag contaminated rags and other disposable items, such as gloves, for proper disposal avoiding skin contact. Gloves should be the last piece of personal protective gear to be removed.
- Wash the hands and facial area before leaving the site or as soon as possible after leaving the site.

The eyes may be harmed by absorbing chemicals in either the liquid or vapor form. Irritant effects vary in degree from mild to severe. Some chemicals have the ability to injure the eye to some degree with surface contact. Eye tissue is also highly absorbent and can not only be damaged but can provide a direct path to the blood stream. The generic or site-specific HASP will describe precautions that should be taken upon entering a site where a contaminant in gas, vapor or liquid form may come into contact with the

eyes.

5.3 INGESTION

Toxic amounts of hazardous material may be transferred to the mouth when drinking or eating. Therefore, these activities should never occur during or after investigations until decontamination procedures have been completed. Furthermore, liquids should not be pipetted or siphoned by mouth under any circumstances.

5.4 INJECTION

BER personnel may be exposed to hazardous chemicals through injection or entry through broken skin. Employees shall be careful to recognize any hazards which may pierce the skin, allowing chemicals to enter the body through a wound. This is of particular concern at abandoned facilities and landfills.

6.0 INITIAL HAZARD ASSESSMENT

In conducting investigations of potential hazardous waste sites a detailed hazard assessment must be done before a site specific safety plan can be generated. The procedures outlined below should be followed to varying degrees for all BER sites where BER personnel will actually be on the site. The hazard assessment will be used to determine whether to enter a potentially hazardous waste site and to determine the appropriate level of protective equipment to be worn when entering the site.

In order to minimize the potential of exposure to a hazardous substance, precautions should be considered in the planning stages and observed during the field activity for any site work. The degree to which these following precautions are executed is dependant on site specific variables including site/contaminant history and potential exposure risk:

- Prior to on-site arrival, a thorough file/historical review must be completed to examine former as well as current practices conducted at the property including information on known or suspected use of chemicals. The review should include information available from outside sources including local libraries, historical societies, and interviews, etc.

- Employees shall review available toxicological information (Condensed Chemical Dictionary, Pesticide Handbook, etc.) to evaluate exposure risks.

- After reviewing the available environmental and toxicological information, protective clothing shall be selected in accordance with BER SOP 21, Levels of Protection for Field Work.

(KDHE/BER employees should not be exposed to Level A or Level B conditions. If unplanned Level A or Level B conditions are encountered in the field, KDHE employees will withdraw immediately and contact a qualified contractor to complete the task.)

An air monitoring program, using a photoionization detector (PID) or similar detector, should be part of all field operations when the potential for atmospheric contamination is present. After a background ambient air measurement is recorded, continual surveillance using direct-reading instruments is needed to detect any changes in air quality. If contaminants are detected above the pre-determined acceptable levels in the HASP, KDHE employees should withdraw immediately and reevaluate the necessary level of respiratory protection.

Before allowing entrance to the site, the project manager should determine if there is an imminent or potential breathing or skin contact hazard and/or risk to health and safety. In such cases, entry is totally unadvisable, and the project manager should withdraw from the area and contact his/her supervisor. If explosivity meter readings exceed 10% of the lower explosive limit (LEL), BER personnel are to withdraw from the site. If warranted, the fire department and supervisor should be notified.

7.0 EMERGENCY TREATMENT

Before entering a site, it is recommended the project manager and field team know the locations and emergency telephone numbers of the nearest medical facility, ambulance service, fire department, police department and poison control centers. (It should be considered during emergency planning that in some remote areas of the state, cell phone service is not reliable.) This information, including a map with the directions to the hospital, shall be included in the HASP. In case of any emergency, appropriate assistance should be called immediately and the appropriate emergency treatment conducted.

KDHE/BER personnel who frequently perform field activities should be trained in basic first aid. A first aid kit with a first aid manual should accompany each KDHE vehicle. The purpose of emergency treatment is to prevent further damage until professional treatment is obtained. Employees will always notify or have someone else notify emergency medical professionals immediately in case of a medical emergency.

First aid procedures for contamination or poisoning by hazardous materials consist of removing, diluting or slowing the movement of the poison. Some knowledge of the hazardous material combined with prompt treatment is essential in reducing the poison's concentration. Accidents such as a fall or heat stroke could also require emergency treatment. For these measures and other emergency information, consult the on-site first aid manual.

8.0 SAFETY EQUIPMENT

Safety equipment may be either associated with the site or assigned to the individual employees.

8.1 FIRST AID KITS

First aid kits should be available on every KDHE site and can be found in each vehicle. The first aid kit should have an accompanying manual. These kits are for basic first aid problems and are not intended to substitute for professional medical care. BER personnel should periodically inspect the kits and restock supplies as needed.

8.2 RESPIRATORY PROTECTION

KDHE will issue respirators to BER employees with a potential for exposure to contaminants through inhalation. Use and care of respirators is described in BER SOP 22, Half/Full-Mask Respirator.

8.3 PERSONAL EQUIPMENT

All field personnel are required to wear steel-toed safety boots on site and be issued a hard hat and safety glasses. The need for a hard hat and safety glasses should be addressed in the site specific safety plan, as well as the need for hearing protection, traffic vests, and other personal items.

9.0 VEHICLE SAFETY

All vehicles used for field activities will be kept in sound/safe mechanical condition and contain the following safety items:

- first aid kit (with manual)
- flashlight
- road hazard kit (emergency flares, triangles, battery jumper cables)

Vehicles should be inspected for the presence of these supplies before departing the

office. While on site, if the vehicle is positioned in such a way as to present a traffic hazard to the vehicle, passing vehicles or persons working around the vehicle, traffic cones will be set to redirect traffic around the work zone.

10.0 REFERENCES

OSHA 29 CFR 1910.120 Hazardous Waste Operations and Emergency Response (HAZWOPER)
(e)(3)(i) - Initial Training
(e)(8) - Refresher Training

EPA 40 CFR 311—WORKER PROTECTION

STANDARD OPERATING PROCEDURE - BER-19

CHAIN OF CUSTODY

Effective Date: October 15, 2000
Revised Date: January 1, 2011

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DISCLAIMER:

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1.0 INTRODUCTION AND OVERVIEW OF CHAIN OF CUSTODY PROCEDURE

This SOP documents the protocol used in the transfer of environmental samples to another person or an analytical laboratory. This SOP is intended to facilitate consistency among staff members, serve as a reference and training tool, and provide a formal written record of the method used to transfer custody of a sample in an environmental monitoring program.

Due to the evidentiary nature of samples collected for investigations, the possession of samples must be traceable from the time the samples are collected until they have been introduced as evidence in legal proceedings. After collecting the samples and labeling the appropriate sample containers, all samples shall be maintained under chain of custody procedures. Each person involved with collecting the samples must know chain of custody procedures.

2.0 CHAIN OF CUSTODY PROCEDURES

To maintain and document sample possession, the following chain of custody procedure should be followed.

2.1 CRITERIA FOR SAMPLE CUSTODY

A sample is under custody if:

1. It is in the sampler's actual possession; or
2. It is in the sampler's view, after being in his/her physical possession; or
3. It was in the sampler's physical possession and then he/she locked it up to prevent tampering; or
4. It is in a designated and identified secured area.

2.2 FIELD CUSTODY CONSIDERATIONS

1. The number of persons handling the samples should be as few as possible.
2. The person who collected the samples in the field is responsible for the care and custody of the samples until they have been transferred or properly relinquished.

2.3 TRANSFER OF CUSTODY AND SHIPMENT

1. Samples must be accompanied by a sample submission form that contains a custody record. Sample submission forms are specific to the laboratory where the samples will be submitted for analysis. Hence, the specified sample submission form for Division of Health and Environmental Laboratory (DHEL) analysis, KDHE outside contractor laboratory analysis, or in-field analysis should be used. The custody record on the sample submission form documents the transfer of custody for the samples from the person collecting the sample to another person or to a permanent laboratory. In transferring the possession of samples, the person relinquishing the samples and the person receiving them will sign and date the sample submission form.

2. All packages containing samples should be accompanied with sample submission forms identifying their contents. The original form should accompany the shipment, and a copy should be retained for permanent documentation by the person currently in custody of the samples.

3. If samples are shipped by a common carrier, a bill of lading should be used. Receipts for bills of lading should be retained for permanent documentation by the person currently in custody of the samples.

STANDARD OPERATING PROCEDURE – BER-21

LEVELS OF PROTECTION FOR FIELD WORK

Effective Date: August 14, 2000
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1.0 INTRODUCTION

BER staff must wear personal protective equipment (PPE) when field activities involve known or suspected atmospheric contamination, when vapors, gases, or particulates may be generated, or when direct contact with skin-affecting substances may occur. Respirators can protect lungs, the gastrointestinal tract, and eyes against air toxicants. Chemical resistant clothing can protect the skin from contact with skin destructive and absorbable chemicals. Good personal hygiene can limit or prevent ingestion of material.

Equipment to protect the body against contact with known or anticipated chemical hazards has been divided into four categories according to the degree of protection afforded. All of the clothing or equipment listed for each layer of protection might not be worn all of the time. The specific equipment to be worn for each level will need to be determined by the site safety officer (SSO) and project manager, and will be included in the site Health and Safety Plan (HASP). Examples of equipment used and selection criteria for each level will be given in Section 2. The following are brief descriptions of the levels of protection:

Level A: Should be worn when the highest level of respiratory, skin, and eye protection is needed. KDHE employees should not be exposed to Level A conditions. **If Level A conditions are encountered in the field, KDHE employees will withdraw immediately and contact a qualified contractor to complete the task.**

Level B: Should be selected when the highest level of respiratory protection is needed, but a lesser level of skin protection is required. Level B protection is the minimum level recommended on initial site entries until the hazards have been further defined by on-site studies and appropriate personnel protection utilized. KDHE employees should not be exposed to Level B conditions. **If Level B conditions are encountered in the field, KDHE employees will withdraw immediately and contact a qualified contractor to complete the task.**

Level C: Should be selected when the type(s) of airborne substance(s) is known, the concentration(s) is measured, and the criteria for using air--purifying respirators are met.

Level D: Should not be worn on any site with respiratory or skin hazards. Level D is primarily a work uniform providing minimal protection.

The Level of Protection selected should be based primarily on:

Type(s) and measured concentration(s) of the chemical substance(s) in the ambient atmosphere and its toxicity.

Potential or measured exposure to substances in air, splashes of liquids, or other direct contact with material due to work being performed.

In situations where the type(s) of chemical(s), concentration(s), and possibilities of contact are not known, the appropriate Level of Protection must be selected based on professional experience and judgment until the hazards can be better characterized.

While PPE reduces the potential for contact with harmful substances, ensuring the health and safety of response personnel also requires safe work practices, decontamination, site entry protocols, and other safety considerations.

2.0 LEVELS OF PROTECTION

Each of the four levels of PPE has specific equipment and selection criteria. BER personnel will use the information below when selecting appropriate PPE levels. **Levels A and B are not further discussed in this SOP because if conditions are encountered in the field that would require Levels A or B the KDHE employee is required to withdraw immediately and contact a qualified contractor to complete the task.**

2.1 LEVEL C PROTECTION

Examples of Level C PPE include:

- Full-face or half-face, air-purifying respirator with the appropriate canister or cartridges (MSHA/NIOSH approved)
- Chemical-resistant clothing (coveralls; hooded, two-piece chemical splash suit; chemical-resistant hood and apron; disposable chemical-resistant coveralls)
- Coveralls (cotton)
- Gloves (outer), chemical-resistant
- Gloves (inner), chemical-resistant
- Boots (outer), chemical-resistant, steel toe and shank

- Boots (outer), chemical-resistant (disposable)
- Hard Hat (face shield)
- 2-way radio communications (intrinsically safe)

Level C may be selected if all of the following criteria are met:

- Measured air concentrations of identified substances will be reduced by the respirator to at or below the substance's exposure limit, and the concentration is within the service limit of the canister or cartridges.
- Atmospheric contaminant concentrations do not exceed IDLH levels.
- Atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect the small area of skin left unprotected by chemical-resistant clothing.
- Job functions have been determined not to require self-contained breathing apparatus.
- Total vapor readings register between background and 5 ppm above background on instruments such as a PID or OVA.
- KDHE personnel will periodically monitor concentrations of hazardous constituents in the air to ensure Level C remains appropriate.

2.2 LEVEL D PROTECTION

Examples of Level D PPE include:

- Coveralls
- Gloves
- Boots/shoes, leather or chemical-resistant, steel toe and shank - Boots (outer), chemical-resistant (disposable) - Safety glasses or chemical splash goggles
- Hard hat (face shield)

KDHE personnel may select Level D if the following conditions are met:

- No hazardous air pollutants have been detected.
- Work functions preclude splashes, immersion, or potential for unexpected inhalation of any chemicals.

3.0 PROTECTIVE EQUIPMENT

Provided below are brief descriptions of PPE used by KDHE personnel. This is not a comprehensive index, but rather a list of the more commonly used equipment.

Respirators (half-face or full-face) - use full day, or if breakthrough occurs, or until situation no longer warrants respiratory protection. Respirators should be cleaned according to manufacturer's specifications after each use.

Appropriate canisters or cartridges for respirators should be selected according to need and manufacturer's specifications.

Suits (listing from least protective to most)

Tyvek (uncoated) paper-like suit. Strictly for keeping clean. Properly dispose of after use.

Polyethylene coated tyvek - use while chemical sampling, i.e., solvents, pesticides, etc.

Saran covered tyvek - use for chemical sampling. Somewhat sturdier than the polyethylene coated tyvek.

Heavy duty yellow suit - all uses - clean with soap/water or steam and reuse. Use bleach on boots, suits, shoes, and clothes to remove pesticides.

Gloves (listing from least protective to most)

Disposable nitrile surgical type gloves - for keeping clean or for collecting soil and water samples. May be used as an inner glove for additional protection when using two layers of gloves.

Long green rubber (nitrile) - Use as outer glove. Good chemical resistance.

Thick black, long (neoprene) - good for all uses. Clean and reuse.

Cotton liners - use under gloves when possible.

Visor/Hard Hat - Use during well or tank sampling where there is a danger of splashing.

Goggles & Safety Glasses - Use when eye protection is needed, or when using half face mask. Use common sense approach.

Boots - Rubber/Neoprene. Good for all uses. Use protective covers over boots.

Boot Protective Covers – Disposable rubber, PVC and vinyl protective covers are available to use over Level D footwear.

4.0 DECONTAMINATION AND DISPOSAL

In leaving a contaminated site, appropriate procedures must be carried out for decontamination and for safe packing of protective clothing, safe packing of disposable gear, and transfer of equipment, gear, and samples from the "contaminated" area to the "clean" area. Sequences of these actions will depend on the situation and must be worked out in advance. Disposition of wash water must be determined and planned for in advance.

Reusable protective clothing and equipment should be decontaminated with soap and water at the site and allowed to dry if possible. Face shields, goggles, respirators, rubber gloves (non-disposable), and rubber boots should also be washed between uses. If decontamination cannot be done at the site, the protective clothing and gear should be placed in plastic bags or isolated from "clean" clothing and equipment until it is decontaminated. All disposable items should be sealed in plastic bags and disposed of according to the degree of contamination.

5.0 REFERENCES

Title 29 Code of Federal Regulations Part 1910 – Occupational Safety and Health Standards

STANDARD OPERATING PROCEDURE – BER-26

USE OF WATER QUALITY ANALYZERS FOR WELL STABILIZATION

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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ATTACHMENT A - Sample Collection Field Data Sheet

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1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to provide a method for using Water Quality Analyzers to measure water quality parameters during monitoring well purging to establish well stabilization prior to the collection of environmental samples in accordance with BER SOP-01 Section 4.0, LOW FLOW SAMPLING METHOD. Water quality parameters must be measured in a manner that will ensure the integrity of the data collected. To maintain consistency of the data, the user must consider the tubing diameter, length and material; flow-through cell design, capacity, and sampling set-up; pump operation and plumbing; purge rate; and the specific Water Quality Analyzer(s) and calibration.

Water quality indicator parameters such as Specific Conductance (conductivity), Dissolved Oxygen (DO), Oxidation-Reduction Potential (ORP/Eh), Turbidity, pH, and Temperature are measured during the low-flow purging process to determine when the monitoring well has stabilized for sample collection. Water quality parameters should be measured in a device (flow-through cell) that prevents contact of the purge water with air prior to measurement, especially for DO. The ORP parameter may not be suitable for determining stabilization at all sites, but readings should be recorded if they are available as another check on the oxidation conditions of the water. Turbidity can also be used to help measure stabilization and determine the need for filtering the samples collected for metals analysis. As sediment particles may collect in the flow-through cell, samples for turbidity measurements should be collected before the water reaches the flow-through cell. If the sample is to be tested for parameters that could be biased by the presence of particulates, such as semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), or metals, it is important to try to reduce the turbidity of the sample to below 10 Nephelometric turbidity units (NTUs). Water samples of this clarity (< 10 NTU) should be more representative of natural colloidal loading in the formation. If the turbidity can be reduced below 10 NTUs, it may not be necessary to filter the samples collected for metals analysis; however, the approved work plan should be reviewed to determine if filtration of samples will be conducted. Note that the BER Policy BER-RS-46 Filtering Water Samples Collected for Metal Analysis, a water sample should be field filtered if turbidity is greater than 5 NTUs.

In general, the order of stabilization is pH, temperature, and specific conductance, followed by oxidation-reduction potential, dissolved oxygen and turbidity. Temperature and pH, while commonly used as stabilization indicators, are actually insensitive in distinguishing between formation water and casing water. Nevertheless, these are important parameters for data interpretation and should be measured and recorded.

2.0 PRE-SAMPLING PROCEDURES

Prior to sampling, all Water Quality Analyzers must be calibrated in accordance with the manufacturer's recommendations. The directions for calibration are contained in the owner's manual and should be kept with the Water Quality Analyzer at all times. Calibration solutions must be held at the same temperature of the groundwater as temperature correlation is critical for calculating conductivity, pH, dissolved oxygen and conductivity.

pH

Monitoring for stabilization of pH in groundwater is relatively straightforward and rarely requires serious troubleshooting. When calibrating for pH, do a two-point calibration, at a minimum. The calibration range should bracket the anticipated pH. If the pH is unknown, then a three-point calibration must be made. The temperature of the buffer solutions should be as close to the temperature of the groundwater as possible. If the probe does not calibrate properly, check to make sure that the probe's electrical contact points are dry. As with preventative maintenance of any probe, make sure that the pH probe is rinsed with distilled/deionized water between uses and cleaned periodically per the manufacturer's specifications. Overnight storage generally requires placement of the probe into a 2-molar (M) solution of potassium chloride. This solution may cause an unwanted build up of salt, therefore, frequent rinsing may be necessary.

Temperature

For Water Quality Analyzer instrument probes that rely on the temperature sensor (pH, dissolved oxygen, specific conductance, oxidation-reduction potential), the Water Quality Analyzer temperature sensor must be checked for accuracy against a thermometer that is traceable to the National Institute of Standards and Technology (NIST). The accuracy check should be performed at least once per year, and the results of the accuracy check kept on file.

The accuracy of the instrument must be verified by checking the endpoints of the expected temperature range (0°C-40°C). Place a thermometer that is traceable to the NIST and the temperature probe into a vessel of water and wait for both instruments to stabilize. Compare the two measurements. The instrument's temperature measurement must agree with the NIST reference thermometer within the accuracy of the instrument (±0.15°C). If the measurements do not agree, the instrument's manufacturer should be contacted.

Specific Conductance

Conductivity is used to measure the ability of the water to carry an electrical current. Specific Conductance is the conductivity value corrected to 25°C. Place

the cleaned probes into the Specific Conductivity standard solution, making sure that the probe is fully submerged. The accuracy must be verified by checking the endpoints of the desired conductivity range to ensure linearity. Calibrate the instrument with the high conductivity standard and then check the instrument against the low conductivity standard. Where Specific Conductance is a non-critical measurement, the instrument can be calibrated with one calibration standard.

Turbidity

Turbidity is based upon a comparison of intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a reference solution. Critical to the instrument's operation is that the lens covering the detector unit is kept clean during both calibration and field use. The calibration and post calibration check must be performed before and after sampling.

Dissolved Oxygen

Dissolved oxygen (DO) content in water is measured using a membrane electrode. The DO probe's membrane and electrolyte solution should be inspected for any damage or air bubbles prior to calibration. If air bubbles or damage are present, replace the membrane according to manufacturer suggestions. (After changing the membrane you should wait 12 hours before use to allow the membrane to equilibrate). Calibration of some models requires inputting the current barometric pressure. Do not use barometric pressure directly obtained from meteorology reports as these are usually corrected to sea level.

Place approximately 1/8 inch of water in the bottom of the calibration cup. Place the probe end of the probe into the cup. Engage only 1 or 2 threads of the calibration cup to insure the DO probe is vented to the atmosphere. An alternative is to wrap the probe guard with a wet towel and place the probe into a 5 gallon bucket with 1 inch of water in it. Make sure that the DO and temperature probes are NOT immersed in water and that the calibration cup is not in direct sunlight. Wait approximately 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate.

Oxidation-Reduction Potential

ORP is measuring the difference in potential between two electrodes, one a chemically inert electrode and the other a reference electrode. Though ORP varies greatly with temperature, many ORP instruments do not contain a temperature based correction program installed in the probe or data logger. For the Zobell solution that will be used for this method of calibration, consult the operator's manual for the temperature correction needed. Clean all probes with deionized

water prior to calibration. Place the probes into the Zobell solution and allow the probes to equalize. Look up the millivolt value for the temperature in the operator's manual and enter the corrected value into the instrument.

3.0 SET-UP OF FLOW-THROUGH CELL

Typical flow through cell design is not complicated and almost all on the market today have common shared features. Cells should be transparent in order to "see" the physical condition of the purge water or air bubbles passing through the system. Highly turbid or iron bacteria-laden water can be visually monitored for change as the purge progresses. The cell must be sealed against unwanted exposure to the atmosphere, thus insuring accurate measurement of air-sensitive parameters (dissolved oxygen, pH, etc.). The total capacity of the cell must be small (300-1,000 mL) in order to maintain a desirable turnover rate of water coming into the cell to ensure real-time data integrity. The in-line design must allow for purge water to enter the flow cell from a bottom port and exit at the top. The discharge may be fitted with a check valve. Upon initial pump startup, it is good practice to not connect the pump discharge line to the flow through cell. This will allow the sampler time to monitor drawdown, stabilize the flow rate and prevent fowling of probes by bacteria, sediment, or NAPL. Once drawdown measurements indicate that the flow rate has been controlled and a few minutes (<10) have been allowed to clear any unwanted material, the pump discharge line can then be connected to the cell.

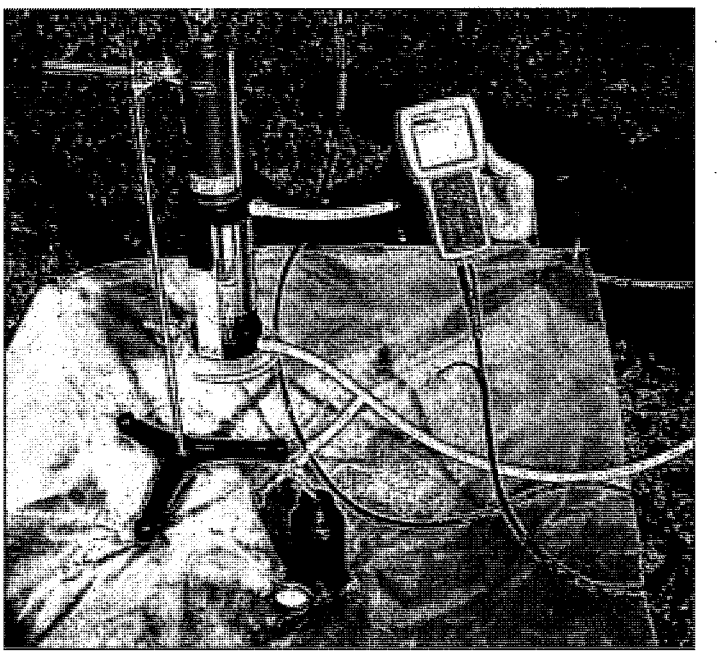

Illustration of Flow Through Cell with stand. (Photograph by J. Schoenleber)

Flow through cell decontamination is important, not only to reduce the potential for cross contamination, but also to ensure data integrity and consistent instrument performance. The cell and probes should be rinsed with distilled/deionized water between each monitor well as accumulation of suspended material may impact probe performance. If they are exposed to contaminants, use a mild detergent. Flow through cell exposure to high levels of contamination may damage probes and require their repair by the manufacturer. The location of the flow through cell or cells in relation to the sample port is critical. Samples for turbidity measurement, general chemistry and laboratory analysis must be collected ahead of the flow through cell. It is also important to locate the flow-through cell as close as possible to the well head in order to minimize the length of tubing needed between the well head and flow through cell. The flow through cell must be protected from ambient conditions and the ground surface.

The inside diameter (ID) of tubing should be no greater than three-eighths of an inch (3/8-in). Quarter-inch (1/4-in) tubing is preferred. Larger tubing diameters reduce flow velocity resulting in a corresponding increase of pump speeds to maintain flow. Increased pump speed will, in turn, elevate the potential for turbulent flow across the screened interval and this may affect the quality of the water being sampled. Conversely, any reduction in flow velocity may allow air to become trapped in the tubing, which may ultimately affect air-sensitive parameters or allow particulates to settle, which may affect turbidity values. The length of tubing, from the top of the well casing to the flow-through chamber, should be the shortest length manageable. Tubing must be completely full of water at all times.

If the sampling plan calls for multiple sample locations within the well screen, sampling should proceed from the top location to the bottom location. This will require that additional tubing be coiled at the surface to allow for pump relocation to the next deeper sampling location. In these instances, the coiled tubing must be protected from ambient conditions and the ground surface, in order to avoid impact to the water quality parameters and sample data. Tubing "reuse" is not recommended when sampling well to well since decontamination of tubing is difficult and time consuming.

4.0 MEASUREMENT OF WATER QUALITY PARAMETERS

Measurement of the water-quality indicator parameters should be conducted at specific intervals based on the pumping rate and the total volume of water in the pump, tubing, and flow-through cell. The first measurement should be taken after one complete volume of water has passed through the pumping apparatus with subsequent readings being taken as additional volumes of water are pumped out. Successive measurements should be completed at 3-5 minute intervals. When three successive readings indicate the water-quality indicator parameters have stabilized within the appropriate criteria, sampling can begin. Stabilization

criteria are identified in the table below. If the water-quality indicator parameters do not stabilize even though the low-flow procedures are being followed, then it may be necessary to use a different purge and sample method.

Water-Quality Indicator Parameter	**Stabilization Criteria**
Specific Conductance	± 3 % milliSiemens/centimeter (mS/cm)
Dissolved Oxygen	± 0.3 milligrams per liter (mg/L) ± 10% (When measured in % saturation)
Oxidation-Reduction Potential	± 10 millivolts (mV)
Turbidity	± 10 % when turbidity is greater than 10 NTUs
pH	± 0.1 Units
Temperature	± 3% Note: Temperature is not a sensitive indicator for stabilization but should be recorded anyway.

Measurements including water quality parameters, flow rate, and volume of water removed should be recorded in the field book or on an appropriate field form. An example field form is included in Attachment A.

In some cases, it may take considerable time to achieve stabilization of the water quality parameters. In other cases, they may never stabilize. However, as provided in USEPA guidance, the following options are available if stability has not been achieved after **FOUR** hours of purging: 1) continue purging until stabilization occurs, no matter how long it takes; 2) discontinue purging, do not collect a sample and document the attempts to reach stabilization; or 3) discontinue purging, collect a sample and document the attempts to reach stabilization. In situations where water quality parameters do not stabilize, the sampler must document that low flow purge sampling could not be performed and document in the report how the samples were collected. While every effort should be taken to assure that all of the water quality parameters stabilize prior to sample collection, one should keep in mind that the stabilization of some water quality parameters may be more difficult to achieve than others. Also, achieving stabilization of some water quality parameters may be more important with respect to some contaminant types (e.g., metals versus VOCs, etc.) than others. For example, total metals concentrations tend to increase with increasing turbidity due to sorption of metals on solids in the water. Similarly, VOC concentrations may be affected by dissolved oxygen (DO) concentrations (i.e., whether the groundwater is aerobic or anaerobic). In addition to providing information on the effectiveness of low-flow sampling, collection of accurate DO data also aids in the evaluation of monitored natural attenuation (MNA) of VOC plumes. Similarly, temperature data can

provide useful information regarding the sampling method. For example, temperature increases resulting from dissipation of heat generated by the submersible pump or from exposure of the tubing to excessive heat at the ground surface can have a significant impact on VOC concentrations in water samples. If, for whatever reason, a water quality parameter is not accurately measured during the monitoring process or a certain water quality parameter does not stabilize, and that particular water quality parameter is not significant with respect to the type of contaminant of concern, sample collection may still proceed. For example, if DO data do not stabilize but all of the other water quality parameters including drawdown and turbidity stabilize and samples will be collected for metals only, then the samples may be collected.

5.0 POST-SAMPLING PROCEDURES

Following sampling, all equipment must be decontaminated in accordance with BER SOP-05.

1. Wash equipment with a non-phosphate detergent solution such as Alconox or an equivalent.

2. Rinse with tap water.

3. Final rinse with deionized/distilled water.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site note books.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

7.0 REFERENCES

1. United States Environmental Protection Agency (U.S. EPA). *Ground Water Issue: Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures.* Document #EPA/540/S-95-504, April, 1996

2. United States Environmental Protection Agency (U.S. EPA) Region IX. *Standard Operating Procedure for Low-Stress (Minimal Drawdown) Ground-Water Sample Collection.* February 2002

3. New Jersey Department of Environmental Protection, Guidance Documents, Field Sampling Procedures Manual, *Chapter 6 – Sample Collection,* http://www.state.nj.us/dep/srp/guidance/fspm/pdf/chapter06_all.pdf, August 2005.

4. United States Environmental Protection Agency (U.S. EPA) Region I. *Standard Operating Procedure for Calibration and Field Measurement Procedures for the YSI Model 6-Series SONDES and Data Logger (Including: Temperature, pH, Specific Conductance, Turbidity, Dissolved Oxygen, Chlorophyll, Rhodamine WT, ORP, and Barometric Pressure),* Revision 7, June 7, 2005.

5. Kansas Department of Health and Environment, Bureau of Environmental Remediation, Quality Management Plan III, Appendix A-Standard Operating Procedures, BER-01 *Collection of Groundwater Samples at Known or Suspected Groundwater Contamination Sites*, August 2010

6. Kansas Department of Health and Environment, Bureau of Environmental Remediation, Quality Management Plan III, Appendix A-Standard Operating Procedures, BER-05 *Decontamination of Equipment*, August 2010

7. United States Geological Survey, *National Field Manual for the Collection of Water Quality Data, Techniques for Water-Resources Investigations, Book 9, Handbook for Water-Resources Investigations, Chapter A6. Field Measurements*, February 2010.

ATTACHMENT A

Sample Collection Field Data Sheet

Project Name:	Project Number:
KDHE Project Manager:	Well Tag Removed:
Weather Conditions:	Well Tag Replaced:
Well ID:	Date:
Well Owner:	Well Type/Size:
Location:	Site Type:

Sampled By:	Start Time:	Finish Time:

Depth to Bottom:	ft BTOC	Purge Method:
Depth to Water:	ft BTOC	Purge Rate:
Height of Water Column:	ft	Purge Time:
Volume:	gal	Actual Purge Volume:
Purge Volume:	gal	

Well Diameter	*0.75"*	*1"*	*2"*	*3"*	*4"*	*6"*
Volume (gal/ft)	*0.023*	*0.041*	*0.1632*	*0.3672*	*0.6528*	*1.4688*

Observations

Field Parameter Measurements During Purging

Time	Temp	pH	Conductivity	Dissolved Oxygen	Visual Turbidity	Other

ATTACHMENT A

Field Parameter Measurements During Purging						
Time	Temp	pH	Conductivity	Dissolved Oxygen	Visual Turbidity	Other

Field Parameter Measurements on Sample:						
Time	Temp	pH	Conductivity	Dissolved Oxygen	Visual Turbidity	Other

Types of Samples Collected:		
Water	Soil	Air

Notes:

Laboratory:

STANDARD OPERATING PROCEDURE – BER-30

OPERATION OF THE PHOTOIONIZATION DETECTOR

Effective Date: August 14, 2000
Revised Date: January 1, 2011

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ATTACHMENT 1 eV Ionization Potentials

DISCLAIMER:

This Standard Operating Procedure (SOP) was developed based on a compilation of best available information, knowledge, field experience, and general industry practices to provide guidance to KDHE staff in performing the activities defined herein, in a consistent and standardized manner. This document does not contain regulatory or statutory requirements unless specified.

KDHE has made every attempt to present the information in a clear and concise manner for a variety of users. However, KDHE is not responsible for the misuse or misinterpretation of the information presented herein. Under no circumstances shall KDHE be liable for any actions taken or omissions made by non-KDHE users of this document.

In general, this document should be used as a reference. Differences may exist between the procedures referenced in this document and what is appropriate under site-specific conditions. This document does not represent an endorsement of practitioners or products mentioned in the document.

1.0 INTRODUCTION

The purpose of this standard operating procedure (SOP) is to describe the procedure for operating a Photoionization Detector (PID) for air monitoring, site entry and field screening. The PID is a portable vapor/gas detector used for a variety of volatile organic and inorganic chemical compounds. The PID measures the total concentration of volatile organic compounds (VOCs). The PID is non-specific and cannot distinguish between individual compounds. The displayed reading represents the total concentration of all detectable VOCs in parts per million (ppm).

2.0 METHOD SUMMARY

The PID is a general survey instrument capable of detecting and measuring real-time concentrations of many organic and inorganic vapors in the air. The PID is similar in application to a flame ionization detector (FID) but the PID is incapable of detecting low molecular weight hydrocarbons such as methane and ethane. The user must select the appropriate instrument capable of detecting the compounds of concern.

The PID employs the principle of photoionization to detect organic and inorganic vapors with ionization potentials less than or equal to the ionization potential provided by the UV lamp. Photoionization occurs when a molecule absorbs a photon of sufficient energy to release an electron and form a positive ion. This will occur when the ionization potential of the molecule is less than the energy provided by the UV lamp. The PID employs a sealed UV light source that emits photons with an energy level high enough to ionize many trace organic and inorganic compounds but not sufficient to ionize the major components of air. Several UV lamps are available for the PID producing different eV ionization potentials. Attachment 1 includes a list of chemicals and their eV ionization potentials. Gases with an ionization potential less than the potential of the UV lamp will be ionized and measured by the PID. Gases with an ionization potential greater than the potential of the lamp will not be detected.

Though the PID can be calibrated to a particular compound, usually isobutylene, the PID cannot distinguish between detectable compounds in a mixture of vapors and indicates an integrated response to the mixture.

3.0 WARNING AND SAFETY CONSIDERATIONS

1. The instrument is intrinsically safe; however, certain procedures such as changing the battery pack and calibration of the instrument must not be preformed in locations where flammable concentrations of gases or vapors may exist.

2. Certain toxic compounds may have ionization potentials greater than the UV lamp and cannot be detected with a PID.

3. The calibration gas is in a compressed gas cylinder and must be handled with care.

4. When calibrating the PID, adequate ventilation must be provided to prevent threshold limit values (TLV) from being exceeded.

5. Exposure of the instrument to prolonged intense sunlight, excessive heat, or excessive moisture may result in erroneous readings.

6. Exposure of the instrument to wet or humid environments may result in erroneous readings.

7. Do not use the instrument where liquids can inadvertently be drawn into the probe.

4.0 EQUIPMENT LIST

1. Spare battery pack (fully charged)

2. Sample tubing

3. In line filters

4. Calibration regulator

5. Calibration gas

6. AC adapter

7. PID

These items are stored in the carrying case, however it is the responsibility of the user to check to make sure that all items are present, and that the batteries are fully charged prior to going to the field.

5.0 CALIBRATION

The instrument is normally calibrated using a calibration gas cylinder of isobutylene at 100 ppm. The instrument can be calibrated with a particular

compound of interest or a response may be programmed into the instrument if the response factor of a compound of interest is known. The instrument can store calibration information for different calibration gases. Refer to the manufacturer's instrument manual for detailed instructions pertaining to calibration using response factors and calibration gases other than isobutylene.

6.0 OPERATION

Once the instrument is calibrated, it is ready to sample. The reading displayed is the total VOCs being detected by the PID. If the power to the instrument is shut off, the instrument will need to be re-calibrated prior to use. The pump can be shut off between readings to extend battery life. The probe assembly of the PID should be positioned close to the area to be monitored as the low sampling rate only allows for localized readings. Under no circumstances should the probe tip be immersed in liquid. The PID survey should be conducted at a moderately slow rate of speed and the intake probe slowly swept from side to side. There may be a three to five second delay in the read-out depending upon the instrument pump and sensitivity to the vapor. During drilling and probing activities, PID monitoring should be performed at regular intervals at the borehole, and breathing zone. The PID should be periodically checked against the calibration standard after approximately 20 samples or at any time readings are suspected to be inaccurate. The PID may provide artificially high readings for a short time following highly contaminated samples. All readings should be recorded in the site logbook. At the end of the day, the outside of the PID should be carefully cleaned of any visible dirt with a damp disposable towel.

Accurate results depend on the operator being completely familiar with the manufacturer's operator's manual. The instructions in the operator's manual should be explicitly followed in order to obtain accurate results. For more detailed instruction and other applications of the PID such as using response factors, data logging, direct printing of data, and downloading data to a computer, refer to the manufacturer's operator's manual.

7.0 MAINTENANCE

7.1 BATTERY CHARGING

A fully charged battery pack powers the instrument for approximately 8 hours. When the low battery indicator is displayed, approximately 30 minutes of operation time is left. The instrument will shut itself off before the battery pack becomes critically low. The battery pack is recharged by either using an AC adapter or an off line charger. To charge the battery pack using the AC adapter, plug the AC adapter into the jack located on the back of the instrument, then plug the AC adapter into an AC outlet. The red LED indicates that the battery is being charged, and the green

LED indicates that the battery is fully charged and ready for use. To charge the battery pack using the off line charger, the battery pack is removed from the instrument and plugged into the charger until the green LED is lit, indicating that the battery is fully charged.

7.2 MAINTENANCE OF THE UV LAMP

1. To replace the UV lamp: turn off the instrument, remove the lamp housing cover with the multi-tool, tilt the instrument slightly, and remove the lamp. **Do not touch the wire grid inside the detector cell. Use a gentle jet of compressed air to blow out any dust or dirt in the detector cell.** Without touching the lamp window, place the new lamp into the lampholder. Replace the old O-ring and lamp spring with the ones supplied with the replacement lamp. Replace the lamp housing cover being careful not to over tighten.

2. To clean the film that builds up on the window of the lamp: Remove the lamp and make sure that it is at room temperature. Dab a cotton swab that has been damped with methanol into the cleaning compound from the cleaning kit. For approximately one minute, gently rub the cleaning compound onto the lamp window using a circular motion. Wipe the window and lamp with a dry, lint free tissue, removing all the cleaning compound and methanol. Replace the lamp into the instrument. Never use methanol to clean the eV Lamp. To clean the e V lamp use the cleaning compound on a dry cotton swab.

7.3 TO REPLACE THE SAMPLE INLET FILTER

Turn off the instrument; unscrew the filter housing from the detector housing, being careful not to lose the O-ring seal; remove the old filter; place the new filter in the filter housing with the polypropylene mesh side facing the instrument; and replace the filter housing.

8.0 REFERENCES

SOP #2114: Photoionization Detector (PID) HNU, U.S. Environmental Protection Agency - Environmental Response Team, 1994

SOP 5: Field Measurements of Organic Vapors, California Department of Toxic Substances Control, 2008

Field Screening Methods Catalog, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, 1988

ATTACHMENT 1: Ionization Potentials (IP eV)

Compound	IP (eV)	GC	PID	FID	Compound	IP (eV)	GC	PID	FID
Acetaldehyde	*10.21*	*X*	*X*	*X*	*3-Bromopropene*	*9.70*	*X*	*X*	*X*
Acetic Acid	*10.37*		*X*	*X*	*2-Bromothiophene*	*8.63*	*X*	*X*	*X*
Acetone	*9.69*	*X*	*X*	*X*	*o-Bromotoluene*	*8.79*	*X*	*X*	*X*
*Acetonitrile**	*12.20*	*X*		*X*	*m-Bromotoluene*	*8.81*	*X*	*X*	*X*
*Acetylene**	*11.41*	*X*	*X*	*X*	*p-Bromotoluene*	*8.67*	*X*	*X*	*X*
Acetylene Dichloride	*9.80*	*X*		*X*	*1,3-Butadene*	*9.07*	*X*	*X*	*X*
Acetylene Tetrabromide	*n.p.*		*X*	*X*	*2,3-Butadione*	*9.23*	*X*	*X*	*X*
Acrolein	*10.10*	*X*	*X*	*X*	*n-Butanal*	*9.83*	*X*	*X*	*X*
Acrylonitrile	*10.91*	*X*	*X*	*X*	*2-Butanal*	*9.73*	*X*	*X*	*X*
Allene	*9.83*	*X*	*X*	*X*	*n-Butane*	*10.63*	*X*	*X*	*X*
Allyl Alcohol	*9.67*	*X*	*X*	*X*	*2-Butanone*	*9.53*	*X*	*X*	*X*
Allyl Chloride	*10.20*	*X*	*X*	*X*	*iso-Butanol*	*10.47*	*X*	*X*	*X*
Aminoethanol	*9.87*	*X*	*X*	*X*	*sec-Butanol*	*10.23*	*X*	*X*	*X*
2-Aminopyridine	*8.34*		*X*	*X*	*tert-Butanol*	*10.25*	*X*	*X*	*X*
Ammonia	*10.15*	*X*	*X*		*1-Butene*	*9.58*	*X*	*X*	*X*
n-Amyl Acetate	*n.p.*	*X*	*X*	*X*	*cis-2-Butene*	*9.13*	*X*	*X*	*X*
sec-Amyl Acetate	*n.p.*	*X*	*X*	*X*	*trans-2-Butene*	*9.13*	*X*	*X*	*X*
Aniline	*7.70*		*X*	*X*	*n-Butyl Acetate*	*10.01*	*X*	*X*	*X*
Arsine	*9.89*	*X*	*X*		*sec-Butyl Acetate*	*9.91*	*X*	*X*	*X*
Benzaldehyde	*9.53*	*X*	*X*	*X*	*t-Butyl Acetate*	*9.90*	*X*	*X*	*X*
Benzene	*9.25*	*X*	*X*	*X*	*n-Butyl Alcohol*	*10.04*	*X*	*X*	*X*
Benzenethiol	*8.33*	*X*	*X*	*X*	*n-Butylmine*	*8.71*		*X*	*X*
Benzyl Chloride	*9.14*	*X*	*X*	*X*	*i-Butylmine*	*8.70*		*X*	*X*
Bromobenzene	*8.98*	*X*	*X*	*X*	*s-Butylamine*	*8.70*		*X*	*X*
1-Bromobutane	*10.13*	*X*	*X*	*X*	*t-Butylamine*	*8.64*		*X*	*X*
2-Bromobutane	*9.98*	*X*	*X*	*X*	*n-Butylbenzene*	*8.69*	*X*	*X*	*X*
1-Bromobuanone	*9.54*	*X*	*X*	*X*	*i-Butylbenzene*	*8.68*	*X*	*X*	*X*
1-Bromo-2-chloroethane	*10.63*	*X*	*X*	*X*	*t-Butylbenzene*	*8.68*	*X*	*X*	*X*
Bromochloromethane	*10.77*	*X*		*X*	*Butyl Cellosolve®*	*8.68*	*X*	*X*	*X*
Bromodichloromethane	*10.59*	*X*	*X*	*X*	*i-Butyl Ethanoate*	*9.95*	*X*	*X*	*X*
1-Bromo-3-chloropropane	*n.p.*	*X*	*X*	*X*	*n-Butyl Mercaptan*	*9.15*	*X*	*X*	*X*
Bromoethane	*10.28*	*X*	*X*	*X*	*t-Butyl Mercaptan*	*9.03*	*X*	*X*	*X*
Bromoethene	*9.80*	*X*	*X*	*X*	*iso-Butyl Mercaptan*	*9.12*	*X*	*X*	*X*
Bromoform	*10.48*	*X*	*X*	*X*	*i-Butyl Methanoate*	*10.46*	*X*	*X*	*X*
1-Bromo-3-hexone	*9.26*	*X*	*X*	*X*	*p-tert-Butyltoluene*	*8.35*	*X*	*X*	*X*
Bromomethane(Methyl Bromide)	*10.53*	*X*	*X*	*X*	*1-Butyne*	*10.18*	*X*	*X*	*X*
Bromomethyl Ethyl Ether	*10.08*	*X*	*X*	*X*	*2-Butyne*	*9.85*	*X*	*X*	*X*
1-Bromo-2-methylpropane	*10.09*	*X*	*X*	*X*	*n-Butyraldehyde*	*9.86*	*X*	*X*	*X*
2-Bromo-2-methylpropane	*9.89*	*X*	*X*	*X*	*Carbon Disulfide*	*10.13*	*X*	*X*	

Compound	IP (eV)	GC	PID	FID	Compound	IP (eV)	GC	PID	FID
1-Bromopentane	*10.10*	*X*	*X*	*X*	*Carbon Tetrachloride**	*11.28*	*X*	*X*	*X*
1-Bromopropane	*10.18*	*X*	*X*	*X*	*Cellosolve Acetate*	*n.p.*	*X*	*X*	*X*
2-Bromopropane	*10.08*	*X*	*X*	*X*	*Chloroacetaldehyde*	*10.16*	*X*	*X*	*X*
1-Bromopropene	*9.30*	*X*	*X*	*X*	*Chlorobenzene*	*9.07*	*X*	*X*	*X*
2-Bromopropene	*10.06*	*X*	*X*	*X*	*Chlorobromomethane*	*10.77*	*X*		*X*
1-Chloro-2-bromoethane	*10.63*	*X*	*X*	*X*	*1,3-Dibromobutane*	*n.p.*	*X*	*X*	*X*
1-Chlorobutane	*10.67*	*X*	*X*	*X*	*1,4-Dibromobutane*	*n.p.*	*X*	*X*	*X*
2-Chlorobutane	*10.65*	*X*	*X*	*X*	*Dibromochloromethane*	*10.59*	*X*	*X*	*X*
1-Chlorobutanone	*9.54*	*X*	*X*	*X*	*Dibromochloropropane*	*n.p.*	*X*	*X*	*X*
1-Chloro-2,3-epoxypropane	*10.60*	*X*	*X*	*X*	*1,1-Dibromoethane*	*10.19*	*X*	*X*	*X*
Chloroethane(Ethyl Chloride)	*10.97*	*X*		*X*	*Dibromomethane*	*10.49*	*X*	*X*	*X*
Chloroethene(Vinyl Chloride)	*10.00*	*X*	*X*	*X*	*1,2-Dibromopropane*	*10.26*	*X*	*X*	*X*
2-Chloroethoxythene	*10.61*	*X*	*X*	*X*	*2,2-Dibromopropane*	*n.p.*	*X*	*X*	*X*
1-Chloro-2-fluorobenzene	*9.16*	*X*	*X*	*X*	*Dibutylamine*	*7.69*		*X*	*X*
1-Chloro-3-fluorobenzene	*9.21*	*X*	*X*	*X*	*1,2-Dichlorobenzene*	*9.07*	*X*	*X*	*X*
cis-1-Chloro-2-fluoroethene	*9.87*	*X*	*X*	*X*	*1,3-Dichlorobutane**	*n.p.*	*X*	*X*	*X*
trans-1-Chloro-2-fluoroethene	*9.87*	*X*	*X*	*X*	*1,4-Dichlorobutane**	*n.p.*	*X*	*X*	*X*
*Chloroform**	*11.37*	*X*	*X*	*X*	*cis-1,4-Dichloro-2-butene*	*n.p.*	*X*	*X*	*X*
o-Chloroiodobenzene	*8.35*	*X*	*X*	*X*	*2,2-Dichlorobutane**	*n.p.*	*X*	*X*	*X*
Chloromethylethyl Ether	*10.08*	*X*	*X*	*X*	*2,3-Dichlorobutane**	*n.p.*	*X*	*X*	*X*
Chloromethylmethyl Ether	*10.25*	*X*	*X*	*X*	*3,4-Dichlorobutane**	*n.p.*	*X*	*X*	*X*
1-Chloro-2-methylpropane	*10.66*	*X*	*X*	*X*	*1,1-Dichloroethane**	*11.06*	*X*	*X*	*X*
Chloroprene	*8.83*	*X*	*X*	*X*	*1,2 Dichloroethane (Ethylene Dichloride)**	*11.04*	*X*	*X*	*X*
*1-Chloropropane**	*10.82*	*X*	*X*	*X*	*cis-1,2-Dichloroethene*	*9.65*	*X*	*X*	*X*
*2-Chloropropane**	*10.78*	*X*	*X*	*X*	*trans-1,2-Dichloroethene*	*9.66*	*X*	*X*	*X*
3-Chloroproene	*10.04*	*X*	*X*	*X*	*1,1-Dichloroethene*	*10.00*	*X*	*X*	*X*
p-Chlorostyrene	*n.p.*	*X*	*X*	*X*	*Dichloroethyl Ether*	*n.p.*	*X*	*X*	*X*
2-Chlorothiophene	*8.68*	*X*	*X*	*X*	*Dichloromethane (Methylene Chloride)**	*11.35*	*X*	*X*	*X*
o-Chlorotoluene	*8.83*	*X*	*X*	*X*	*1,2-Dichloropropane**	*10.87*	*X*	*X*	*X*
m-Chlorotoluene	*8.83*	*X*	*X*	*X*	*1,3-Dichloropropane**	*10.85*	*X*	*X*	*X*
p-Chlorotoluene	*8.70*	*X*	*X*	*X*	*1,1-Dichloropropanone*	*9.71*	*X*	*X*	*X*
o-Cresol	*8.48*		*X*	*X*	*2,3-Dichloropropene*	*9.82*	*X*	*X*	*X*
m-Cresol	*8.48*		*X*	*X*	*Dicyclopentadiene*	*7.74*	*X*	*X*	*X*
p-Cresol	*8.48*		*X*	*X*	*Diethoxymethane*	*9.70*	*X*	*X*	*X*
Cumene (i-Propyl Benzene)	*8.75*	*X*	*X*	*X*	*Diethylamine*	*8.01*		*X*	*X*
Crotonaldehyde	*9.73*	*X*	*X*	*X*	*Diethylaminoethanol*	*8.58*		*X*	*X*
*Cyanoethene**	*10.91*	*X*	*X*	*X*	*Diethyl Ether*	*9.53*	*X*	*X*	*X*
*Cyanogen Bromide**	*10.91*	*X*	*X*		*Diethyl Ketone*	*9.32*	*X*	*X*	*X*

Compound	IP (eV)	GC	PID	FID	Compound	IP (eV)	GC	PID	FID
3-Cyanopropene	*10.39*	*X*	*X*	*X*	*Diethyl Sulfide*	*8.43*	*X*	*X*	*X*
Cyclobutane	*10.50*	*X*	*X*	*X*	*1,2-Difluorobenzene*	*9.31*	*X*	*X*	*X*
Cyclohexane	*9.98*	*X*	*X*	*X*	*1,4-Difluorobenzene*	*9.15*	*X*	*X*	*X*
Cyclohexanol	*10.00*	*X*	*X*	*X*	*Difluorodibromomethane**	*11.18*	*X*		*X*
Cyclohexanone	*9.14*	*X*	*X*	*X*	*Difluoromethylbenzene*	*9.45*	*X*	*X*	*X*
Cyclohexene	*8.95*	*X*	*X*	*X*	*Diiodomethane*	*9.34*	*X*	*X*	*X*
Cyclo-octatetraene	*7.99*	*X*	*X*	*X*	*Diisobutyl Ketone*	*9.04*	*X*	*X*	*X*
Cyclopentadiene	*8.55*	*X*	*X*	*X*	*Diisopropylamine*	*7.73*		*X*	*X*
Cyclopentane	*10.52*	*X*	*X*	*X*	*1,1-Dimethozyethane*	*9.65*	*X*	*X*	*X*
Cyclopentanone	*9.26*	*X*	*X*	*X*	*Dimethozymethane*	*10.00*	*X*	*X*	*X*
Cyclopentene	*9.01*	*X*	*X*	*X*	*Dimethylamine*	*8.24*		*X*	*X*
Cyclopropane	*10.06*	*X*	*X*	*X*	*Dimethylaniline*	*7.13*		*X*	*X*
2-Decanone	*9.40*	*X*	*X*	*X*	*2,3-Dimethylbutadiene*	*8.72*	*X*	*X*	*X*
Diacetone Alcohol	*n.p.*	*X*	*X*	*X*	*2,2-Dimethylbutane*	*10.06*	*X*	*X*	*X*
2,2-Dimethylbutan-3-one	*9.18*	*X*	*X*	*X*	*mono-Fluorobenzene*	*9.20*	*X*	*X*	*X*
2,3-Dimethylbutane	*10.02*	*X*	*X*	*X*	*mono-Fluoroethene*	*10.37*	*X*	*X*	*X*
2,3-Dimethyl-2-butene	*8.30*	*X*	*X*	*X*	*mono-Fluoromethanal*	*11.40*	*X*	*X*	*X*
3,3-Dimethylbutanone	*9.17*	*X*	*X*	*X*	*Fluorotribromomethane*	*10.67*	*X*	*X*	*X*
Dimethyl Disulfide	*8.46*	*X*	*X*	*X*	*o–Fluorotoluene*	*8.92*	*X*	*X*	*X*
Dimethyl Ether	*10.00*	*X*	*X*	*X*	*m-Fluorotoluene*	*8.92*	*X*	*X*	*X*
Dimethylformamide	*9.45*		*X*	*X*	*p-Fluorotoluene*	*8.79*	*X*	*X*	*X*
3,5-Dimethyl-4-heptanone	*9.04*	*X*	*X*	*X*	*Formaldehyde*	*10.88*	*X*		
1,1-Dimethylhydrazine	*8.88*		*X*	*X*	*Freon 11 (Fluorotrichloromethane)*	*11.77*	*X*		*X*
2,2-dimethyl-3-pentanone	*8.98*	*X*	*X*	*X*	*Freon 12 (Dichlorodifluoromethane)*	*12.91*	*X*		*X*
2,2-Dimethylpropane	*10.35*	*X*	*X*	*X*	*Freon 13 (Chlorotrifluoromethane)*	*12.91*	*X*		*X*
Dimethyl Sulfide	*8.69*	*X*	*X*	*X*	*Freon 13 B-1 (Bromotrifluoromethane)*	*12.08*	*X*		*X*
Di-n-propyl Disulfide	*8.27*	*X*	*X*	*X*	*Freon 14 (Carbon Tetrafluoride)*	*16.25*	*X*		*X*
Di-n-propyl Ether	*9.27*	*X*	*X*	*X*	*Freon 21 (Dichlorofluoromethane)*	*12.00*	*X*		*X*
Di-i-propyl Ether	*9.20*	*X*	*X*	*X*	*Freon 22 (Chlorodifluoromethane)*	*12.45*	*X*		*X*
Di-n-propylamine	*7.84*		*X*	*X*	*Freon 113 (1,2-Dichlorotrifluoroethane)*	*11.78*	*X*		*X*
Di-n-propyl Sulfide	*8.30*	*X*	*X*	*X*	*Furan*	*8.89*	*X*	*X*	*X*
1,4-Dioxane	*9.41*	*X*		*X*	*Furfuryl Alcohol*	*n.p.*	*X*	*X*	*X*
Epichlorohydrin	*10.60*	*X*	*X*	*X*	*furfural*	*9.21*	*X*	*X*	*X*
*Ethane**	*11.65*	*X*	*X*	*X*	*n-Heptane*	*10.07*	*X*	*X*	*X*
Ethanol	*10.62*	*X*	*X*	*X*	*2-Heptanone*	*9.33*	*X*	*X*	*X*
Ethanolamine	*9.87*		*X*	*X*	*4-Heptanone*	*9.12*	*X*	*X*	*X*

Compound	IP (eV)	GC	PID	FID	Compound	IP (eV)	GC	PID	FID
Ethanethiol (Ethyl Mercaptan)	*9.29*	*X*	*X*	*X*	*n-Hexane*	*10.18*	*X*	*X*	*X*
Ethene(Ethylene)	*10.52*	*X*	*X*	*X*	*Hexanone*	*n.p.*	*X*	*X*	*X*
Ethyl Acetate	*10.11*	*X*	*X*	*X*	*2-Heanone*	*9.44*	*X*	*X*	*X*
Ethyl Acrylate	*n.p.*	*X*	*X*	*X*	*1-Hexene*	*9.46*	*X*	*X*	*X*
Ethylamine	*8.86*		*X*	*X*	*sec-Hexyl Acetate*	*n.p.*		*X*	*X*
Ethyl Amyl Ketone	*9.10*	*X*	*X*	*X*	*Hydrazine*	*n.p.*	*X*	*X*	*X*
Ethylbenzene	*8.76*	*X*	*X*	*X*	*Hydrogen Selenide*	*9.88*	*X*	*X*	
Ethyl Bromide	*10.29*	*X*	*X*	*X*	*Hydrogen Sulfide*	*10.46*	*X*	*X*	
Ethyl Butyl Ketone	*9.02*	*X*	*X*	*X*	*Hydrogen Telluride*	*9.14*	*X*	*X*	
Ethyl Chloride	*11.01*	*X*		*X*	*Iodobenzene*	*8.73*	*X*	*X*	*X*
Ethyl Chloroacetate	*10.20*	*X*	*X*	*X*	*1-Iodobutane*	*9.21*	*X*	*X*	*X*
Ethyl Ethanoate	*10.10*	*X*	*X*	*X*	*2-Iodobutane*	*9.09*	*X*	*X*	*X*
Ethyl Ether	*9.41*	*X*	*X*	*X*	*Iodoethane (Ethyl Iodide)*	*9.33*	*X*	*X*	*X*
Ethyl Disulfide	*8.27*	*X*	*X*	*X*	*Iodomethane (Methyl Iodide)*	*9.54*	*X*	*X*	*X*
Ethylene Chlorohydrin	*10.90*	*X*	*X*	*X*	*1-Iodo-2-methylpropane*	*9.18*	*X*	*X*	*X*
Ethylene Dibromide (EDB)	*10.37*	*X*	*X*	*X*	*1-Iodo-2-methylpropane*	*9.02*	*X*	*X*	*X*
Ethylene Oxide	*10.56*	*X*	*X*	*X*	*1-Iodopentane*	*9.19*	*X*	*X*	*X*
Ethyl Formate	*10.61*	*X*	*X*	*X*	*1-Iodopropane*	*9.26*	*X*	*X*	*X*
Ethyl Iodide	*9.33*	*X*	*X*	*X*	*2-Iodopropane*	*9.17*	*X*	*X*	*X*
Ethyl Mercaptan	*9.29*	*X*	*X*	*X*	*o-Iodotoluene*	*8.62*		*X*	*X*
Ethyl Methanoate	*10.61*	*X*	*X*	*X*	*m-Iodotoluene*	*8.61*		*X*	*X*
Ethyl Isothiocyanate	*9.14*	*X*	*X*	*X*	*p-Iodotoluene*	*8.50*		*X*	*X*
Ethyl Methyl Sulfide	*8.55*	*X*	*X*	*X*	*Isoamyl Acetate*	*9.90*	*X*	*X*	*X*
Ethyl Propanoate	*10.00*	*X*	*X*	*X*	*Isoamyl Alcohol*	*10.16*	*X*	*X*	*X*
Ethyl Trichloroacetate	*10.44*	*X*	*X*	*X*	*Isobutane*	*10.57*	*X*	*X*	*X*
Isobutylamine	*8.70*		*X*	*X*	*Methyl Isobutyl Ketone(MIBK)*	*9.30*	*X*	*X*	*X*
Isobutyl Acetate	*9.97*	*X*	*X*	*X*	*Methyl Isobutyrate*	*9.98*	*X*	*X*	*X*
Isobutyl Alcohol	*10.47*	*X*	*X*	*X*	*Methyl Isocyanate*	*10.67*		*X*	*X*
Isobutyl Formate	*10.46*	*X*	*X*	*X*	*1-Methyl-4-isopropylbenzene*	*n.p.*	*X*	*X*	*X*
Isobutylene	*9.43*	*X*	*X*	*X*	*Methyl Isopropyl Ketone*	*9.32*	*X*	*X*	*X*
Isobutyraldehyde	*9.74*	*X*	*X*	*X*	*Methyl Mercaptan (Methanethiol)*	*9.44*	*X*	*X*	*X*
Isopentane	*10.32*	*X*	*X*	*X*	*Methyl Methacrylate*	*9.74*	*X*	*X*	*X*
Isoprene	*8.85*	*X*	*X*	*X*	*Methyl Methanoate*	*10.82*	*X*		*X*
Isoprooyl Acetate	*9.99*	*X*	*X*	*X*	*2-Methylpentane*	*10.12*	*X*	*X*	*X*
Isopropyl Alcohol	*10.16*	*X*	*X*	*X*	*3-Methylpentane*	*10.08*	*X*	*X*	*X*
Isopropylamine	*8.72*		*X*	*X*	*2-Methylpropane*	*10.56*	*X*	*X*	*X*
Isopropylbenzene	*8.75*	*X*	*X*	*X*	*2-Methylpropanal*	*9.74*	*X*	*X*	*X*
Isopropyl Ether	*9.20*	*X*	*X*	*X*	*2-Methyl-2-propanol*	*9.70*	*X*	*X*	*X*
Isovaleraldehyde	*9.71*	*X*	*X*	*X*	*2-Methylpropene*	*9.23*	*X*	*X*	*X*

Compound	IP (eV)	GC	PID	FID	Compound	IP (eV)	GC	PID	FID
Ketene	*9.61*	*X*	*X*	*X*	*Methyl n-propyl Ketone*	*9.39*	*X*	*X*	*X*
Mesitylene	*8.40*	*X*	*X*	*X*	*Methyl Styrene*	*8.35*	*X*	*X*	*X*
Mesityl Oxide	*9.08*	*X*	*X*	*X*	*Monomethyl Hydrazine*	*8.00*	*X*	*X*	*X*
Methane	*12.98*	*X*		*X*	*Naphthalene*	*8.10*	*X*	*X*	*X*
*Methanol**	*10.85*	*X*		*X*	*Nitric Oxide*	*9.25*	*X*	*X*	
Methyl Acetate	*10.27*	*X*	*X*	*X*	*Nitrobenzene*	*9.92*		*X*	*X*
Methyl Acrylate	*10.72*	*X*		*X*	*p-Nitrochlorobenzene*	*9.96*		*X*	*X*
Methylamine	*8.87*		*X*	*X*	*n-Nonane*	*10.21*	*X*	*X*	*X*
Methyl Bromide (Bromomethane)	*10.53*	*X*	*X*	*X*	*5-Nonanone*	*9.10*	*X*	*X*	*X*
2-Methyl-1,3-butadiene	*8.85*	*X*	*X*	*X*	*n-Octane*	*10.24*	*X*	*X*	*X*
2-Methylbutanal	*9.71*	*X*	*X*	*X*	*3-Octanone*	*9.19*	*X*	*X*	*X*
2-Methylbutane	*10.31*	*X*	*X*	*X*	*4-Octanone*	*9.10*	*X*	*X*	*X*
2-Methyl-1-butene	*9.12*	*X*	*X*	*X*	*1-Octene*	*9.52*	*X*	*X*	*X*
3-Methyl-1-butene	*9.51*	*X*	*X*	*X*	*n-Pentane*	*10.53*	*X*	*X*	*X*
3-Methyl-2-butene	*8.67*	*X*	*X*	*X*	*cis-1,3-Pentadiene*	*8.59*	*X*	*X*	*X*
Methyl tert-Butyl Ether	*9.41*	*X*	*X*	*X*	*trans-1,3-Pentadiene*	*8.56*	*X*	*X*	*X*
Methyl n-Butyl Ketone	*9.34*	*X*	*X*	*X*	*n-Pentanal*	*9.82*	*X*	*X*	*X*
Methyl Butyrate	*10.07*	*X*	*X*	*X*	*2,4-Pentanedione*	*8.87*	*X*	*X*	*X*
Methyl Cellosolve	*n.p.*	*X*	*X*	*X*	*2-Pentanone*	*9.39*	*X*	*X*	*X*
Methyl Cellosolve Acetate	*n.p.*	*X*	*X*	*X*	*3-Pentanone*	*9.32*	*X*	*X*	*X*
Methyl Chloroacetate	*10.35*	*X*	*X*	*X*	*1-Pentene*	*9.50*	*X*	*X*	*X*
*Methylchloroform (1,1,1-TCA)**	*11.25*	*X*	*X*	*X*	*Perfluoro-2-butene**	*11.25*	*X*		*X*
Methylcyclohexane	*9.85*	*X*	*X*	*X*	*Perfluoro-1-heptene*	*10.48*	*X*	*X*	*X*
Methylcyclohexanol	*9.80*	*X*	*X*	*X*	*n-Perfluoropropyl Iodide*	*10.36*		*X*	*X*
Methlcyclohexanone	*9.05*	*X*	*X*	*X*	*n-Perfluoropropyl-iodomethane*	*9.96*	*X*	*X*	*X*
4-Methylcyclohexene	*8.91*	*X*	*X*	*X*	*n-Perfluoropropyl-methyl Ketone*	*10.58*	*X*	*X*	*X*
Methylcyclopropane	*9.52*	*X*	*X*	*X*	*Phenol*	*8.69*		*X*	*X*
Methyl Dichloroacetate	*10.44*	*X*	*X*	*X*	*Phenyl Ether*	*8.09*	*X*	*X*	*X*
Methyl Ethanoate	*10.27*	*X*	*X*	*X*	*Phenyl Isocyanate*	*8.77*	*X*	*X*	*X*
Methyl Ethyl Ketone (MEK)	*9.53*	*X*	*X*	*X*	*Phosphine*	*9.96*	*X*	*X*	
Methyl Ethyl Sulfide	*8.55*	*X*	*X*	*X*	*Pinene*	*8.07*	*X*	*X*	*X*
2-Methyl Furan	*8.39*	*X*	*X*	*X*	*Propadiene*	*10.19*	*X*	*X*	*X*
Methyl Iodide	*9.54*	*X*	*X*	*X*	*n-Propanal*	*9.95*	*X*	*X*	*X*
*Propane**	*11.07*	*X*	*X*	*X*	*1,2,3-Trichloropropane*	*n.p.*	*X*	*X*	*X*
1-Propanethiol	*9.20*	*X*	*X*	*X*	*Triethylamine*	*7.50*	*X*	*X*	*X*
n-Propanol	*10.51*	*X*	*X*	*X*	*1,2,4-Trifluorobenzene*	*9.37*	*X*	*X*	*X*
Propanone	*9.69*	*X*	*X*	*X*	*1,3,5-Trifluorobenzene*	*9.32*	*X*	*X*	*X*
Propene	*9.73*	*X*	*X*	*X*	*Trifluoroethene*	*10.14*	*X*	*X*	*X*

Compound	IP (eV)	GC	PID	FID	Compound	IP (eV)	GC	PID	FID
Prop-1-ene-2-ol	*8.20*	*X*	*X*	*X*	*1,1,1-Trifluoro-2-iodoethane*	*10.10*	*X*	*X*	*X*
Prop-2-ene-1-ol	*9.67*	*X*	*X*	*X*	*Trifluoroiodomethane*	*10.40*	*X*	*X*	*X*
Propionaldehyde	*9.98*	*X*	*X*	*X*	*Trifluoromethylbenzene*	*9.68*	*X*	*X*	*X*
n-Propyl Acetate	*10.04*	*X*	*X*	*X*	*Trifluoromethylcyclohexane*	*10.46*	*X*	*X*	*X*
n-Propyl Alcohol	*10.20*	*X*	*X*	*X*	*1,1,1-Trifluoropropene*	*10.90*	*X*	*X*	*X*
n-Propylamine	*8.78*		*X*	*X*	*Trimethylamine*	*7.82*	*X*	*X*	*X*
n-Propylbenzene	*8.72*	*X*	*X*	*X*	*2,2,4-Trimethyl Pentane*	*9.86*	*X*	*X*	*X*
Propylene	*9.73*	*X*	*X*	*X*	*2,2,4-Trimethyl-3-pentanone*	*8.82*	*X*	*X*	*X*
Propylene Dichloride	*10.87*	*X*	*X*	*X*	*n-Valeraldehyde*	*9.82*	*X*	*X*	*X*
Propylene Imine	*8.76*	*X*	*X*	*X*	*Vinyl Acetate*	*9.19*	*X*	*X*	*X*
Propylene Oxide	*10.22*	*X*	*X*	*X*	*Vinyl Bromide*	*9.80*	*X*	*X*	*X*
n-Propyl Ether	*9.27*	*X*	*X*	*X*	*Vinyl Chloride (Chloroethene)*	*10.00*	*X*	*X*	*X*
n-Propyl Formate	*10.54*	*X*	*X*	*X*	*4-Vinylcyclohexene*	*8.93*	*X*	*X*	*X*
Propyne	*10.36*	*X*	*X*	*X*	*Vinyl Ethanoate*	*9.19*	*X*	*X*	*X*
Pyridine	*9.32*		*X*	*X*	*Vinyl Fluoride*	*10.37*	*X*	*X*	*X*
Styrene	*8.47*	*X*	*X*	*X*	*Vinylidene Chloride (1,1-DCE)*	*10.00*	*X*	*X*	*X*
Tetrabromoethane	*n.p.*	*X*	*X*	*X*	*Vinyl Methyl Ether*	*8.93*	*X*	*X*	*X*
Tetrachloroethylene (PCE)	*9.32*	*X*	*X*	*X*	*o-Vinyl Toluene*	*8.20*		*X*	*X*
1,1,1,2-Tetrachloropropane	*n.p.*	*X*	*X*	*X*	*o-Xylene*	*8.56*	*X*	*X*	*X*
1,1,2,2-Tetrachloropropane	*11.10*	*X*	*X*	*X*	*m-Xylene*	*8.56*	*X*	*X*	*X*
Tetrafluoroethene	*10.12*	*X*	*X*	*X*	*p-Xylene*	*8.45*	*X*	*X*	*X*
Tetrahydrofuran	*9.54*	*X*	*X*	*X*	*2,4-Xylidine*	*7.65*		*X*	*X*
1,1,1,2-Tetrachloropropane	*n.p.*	*X*	*X*	*X*	*Trichloroethylene (TCE)*	*9.45*	*X*	*X*	*X*
*1,1,2-Trichloroethane**	*11.00*	*X*	*X*	*X*	*Trichloromethyl Ethyl Ether*	*10.08*	*X*	*X*	*X*

** The sensitivity of these compounds are enhanced using an 11 eV lamp instead of the standard 10.6 eV lamp.*

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STANDARD OPERATING PROCEDURE – BER-32

ACQUISITION OF LOCATION DATA USING GLOBAL POSITION SYSTEM (GPS) GENERAL PRACTICE FOR HAND HELD UNITS

Effective Date: August 14, 2000
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ATTACHMENT 1 Available Gps Unit List
ATTACHMENT 2 Data Collection Form

DISCLAIMER:

This Standard Operating Procedure (SOP) was developed based on a compilation of best available information, knowledge, field experience, and general industry practices to provide guidance to KDHE staff in performing the activities defined herein, in a consistent and standardized manner. This document does not contain regulatory or statutory requirements unless specified.

KDHE has made every attempt to present the information in a clear and concise manner for a variety of users. However, KDHE is not responsible for the misuse or misinterpretation of the information presented herein. Under no circumstances shall KDHE be liable for any actions taken or omissions made by non-KDHE users of this document.

In general, this document should be used as a reference. Differences may exist between the procedures referenced in this document and what is appropriate under site-specific conditions. This document does not represent an endorsement of practitioners or products mentioned in the document.

1.0 PURPOSE

This document is to provide the user of handheld global positioning system (GPS) units with the guidance required to collect, edit and report consistent, reliable, and repeatable geospatial data sets (latitude and longitude) for use within the Kansas Department of Health and Environment (KDHE), Bureau of Environmental Remediation (BER). Intended audiences for which this document was prepared include BER staff involved with the planning and conducting of GPS surveys as well as BER staff involved with processing and reporting the collected data sets.

2.0 APPLICABILITY

This document is a general use Standard Operating Procedure (SOP) to be used for handheld GPS units and is not to be used as a SOP for specific brands of GPS models.

3.0 DEFINITIONS AND ACRONYMS

Accuracy: How close a fix comes to the actual position.

Acquisition: The ability to find and lock on to satellite signals for ranging.

Autonomous GPS: A single receiver GPS unit which collects uncorrected positions calculated by the receiver using code measurements.

Average Position Waypoint Collection: A function on most handheld GPS receivers that allows the user to average position samples overtime and save the averaged result as a waypoint. Averaging reduces the effects of position error that results in a more accurate position reading.

Continuously Operated Reference Station (CORS): The National Geodetic Survey (NGS), an office of NOAA's National Ocean Service, coordinates a network of continuously operating reference stations (CORS). Each CORS site provides Global Navigation Satellite System (GNSS - GPS) carrier phase and code range measurements in support of 3-dimensional positioning activities throughout the United States and its territories.

Data Quality Objective (DQO): Qualitative and quantitative statements of the overall level of uncertainty that a decision-maker will accept in results or decisions based on environmental data. They provide the statistical framework for planning and managing environmental data operations consistent with user's needs.

Datum: A datum is a horizontal or vertical reference system for making survey measurements and computations. Improving technology has led to more precise values for the same geographic points over time. To use recently collected data in conjunction with preexisting data, it is necessary to match data and coordinate systems between data sets. Examples of datums are NAD-27, NAD-83 and WGS-84 (North American Datum of 1927, North American Datum of 1983, World Geodetic System 1984).

Differential GPS (DGPS): A technique for reducing the error in GPS-derived positions by using additional data from a reference GPS receiver at a known position. The most common form of DGPS involves determining the combined effects of navigation message ephemeris and satellite clock errors (including the effects of SA) at a reference station and transmitting pseudorange corrections, in real time, to a user's receiver, which applies the corrections in the process of determining its position.

Dilution Of Precision (DOP): A dimensionless number that accounts for the contribution of relative satellite geometry to errors in position determination. DOP has a multiplicative effect on the User Equivalent Range Error (UERE). Generally, the wider the spacing between the satellites being tracked by a GPS receiver, the smaller the error is in position. The most common quantification of DOP is through the Position Dilution Of Precision (PDOP) parameter. PDOP is the number that, when multiplied by the root mean square (rms) UERE, gives the rms position error. Other DOPs include the Geometric Dilution Of Precision (GDOP), Horizontal Dilution Of Precision (HDOP), and Vertical Dilution Of Precision (VDOP).

Federal Geographic Data Committee (FGDC): A committee composed of representatives from Department of Agriculture, Defense, Commerce, Energy and other federal departments and agencies that has a purpose of promoting a coordinated development, sharing, and dissemination of geographic data which in turn improves content, quality, and documentation while reducing duplication of that data.

Global Position System (GPS): GPS is a U.S. spaced based radio navigation system that provides reliable positioning, navigation, and timing services to civilian users and military users on a continuous world wide basis. A constellation of 24 satellites orbit the earth every 12 hours at nominal altitudes of 11,000 miles. GPS satellites emit radio signals that allow GPS receivers to accurately determine locations and times of receiving units at any point on the earth's surface.

Geographical Information Systems (GIS): A computer system designed for storing, manipulating, analyzing, and displaying data in a geographic context.

Horizontal Positional Accuracy: The accuracy of location data on a 2-dimensional surface.

National Standard for Spatial Data Accuracy (NSSDA): This standard is classified as a Data Usability Standard by the Federal Geographic Data Committee (FDGC) Standards Reference Model. A data usability standard describes how to express "the applicability or essence of a data set or data element," and includes, "data quality, assessment, accuracy, and reporting or documentation standards" (FDGC, 1996 p.8).

Post Processing Differential GPS: Using post processing differential GPS data collection techniques, the base station receiver and roving receiver have no data link between them. Each receiver independently records data that allows for differential correction when processed with data from the roving receivers collecting data during the same time period. During the collection period, the two receivers must maintain a lock on the same set of satellites so that the raw data collected from a receiver at a known location can be combined with the raw data from the roving receiver using appropriate software. This results in the location data being more accurate and reliable.

Real-Time Differential GPS: A data collection process whereby a GPS receiver gets real-time correction data from another source in order to filter out sources of error. One way to get correction data is from a GPS receiver called a base unit or base station which remains stationary. This GPS receiver at the known position computes formats and transmits corrections through a data or radio link with a roving GPS receiver. The roving unit receives the correction data from the base station and applies it to its current observations to log more accurate and reliable data. Newer wireless GPS receivers can connect to the internet via a wireless PDA or laptop computer to retrieve information from geostationary satellites, obtain correction information, and apply the correction information in real time.

Selective Availability (SA): The policy and procedure of denying to most nonmilitary GPS users the full accuracy of the system. SA is achieved by dithering the satellite clock (delta-process) and degrading the navigation message ephemeris (epsilon-process). Selective Availability (SA) was an intentional degradation of public GPS signals implemented for national security reasons. At the direction of the President, SA was discontinued in May 2000 to make GPS more responsive to civil and commercial users worldwide.

User Equivalent Range Error (UERE): Any error contributing to the error budget of stand-alone GPS receiver positioning, expressed as an equivalent error in the range between a user's receiver and a satellite.

Waypoint: A destination or point. The coordinates of locations along the desired path as measured in geographic coordinates of longitude and latitude.

Wide Area Augmentation System (WAAS): A system that enhances GPS and is available over a wide geographical area. The WAAS being developed by the Federal Aviation Administration, in concert with other agencies, will provide WADGPS corrections, additional ranging signals from geostationary (GEO) satellites, and integrity data on the GPS and GEO satellites. Because this correction originates from a satellite, it is still subject to some of the errors as non-WAAS satellites.

4.0 QUALIFICATIONS OF OPERATOR

a. The operator shall be familiar with all applicable procedures described in the GPS unit's operators manual.

b. The operator shall be familiar with the basic operations and functions described below.

1. **Give a location:** A GPS unit accurately triangulates your position by receiving data from multiple orbiting satellites. Normally your location is given in coordinates (Latitude and Longitude) or Universal Transverse Mercators (UTMs).

2. **Point to Point Navigation:** A location or destination is called a "waypoint." For example you can establish a starting waypoint at a specific locale by using location function. If you have coordinates for the site you are headed to, a GPS can give you a straight line, point to point bearing and distance to your destination.

3. **Route Navigation:** By combining multiple waypoints in a route, you can move point to point with intermediate bearing and distance guides. Once you reach the first predetermined waypoint the GPS receiver can direct you to the next waypoint or the user can do it manually.

4. **Track:** This function on a GPS unit allows the user to create a track of where the user has been. Typically, the user can configure the GPS unit to drop "trackpoints," intervals of either time or distances. This allows the user to retrace his or her steps and get back to the start point.

c. The operator shall be familiar with this SOP and any other applicable Bureau programs.

d. The operator shall have a clear understanding of datums, coordinate systems, coordinate formats and other terms related to GPS operation.

e. The operator shall understand how to read the information displayed on the GPS unit, such as reading coordinates and their formats. Typically, coordinate formats can be changed through the preferences screen on the GPS unit. The most common formats are described below. ARCmap and Identified Sites List require (ISL) location data to be in the format described in example number 2 below.

1. **DMS (degrees / Minutes / Seconds)**
   Example: N47° 37' 12" W122° 19' 45"

2. **Decimal Degrees (DD):** A decimal equivalent of DMS. This is the format required for input to ARCMap and ISL from an excel spreadsheet or access database. Conversion of DMS to DD is degrees plus minutes divided by 60 plus seconds divided by 3600.
   Example: N47°37'12" W122°19'45", would read N47.62°, W122.3292°

3. **DDM (Degrees, Decimal Minutes):** A decimal version of DMS. In this format, Degrees remain unchanged, the difference is that the seconds are converted to decimal by dividing seconds by 60.
   Example: N47° 37' 12" W122° 19' 45", would read N47°37.2' W122°19.75'

4. **UTM (Universal Transverse Mercator):** A military derived grid system which is not tied to latitude and longitude. It divides the map into a square grid with the grid lines all 1000 meters apart. Most topographic maps have UTM grid lines printed on them. This system is metric based and requires no conversion of minutes and seconds.
   Example: 10T 055368 5274319
   10T identifies the map zone, **0550368** is the east/west or easting, while **5274319** is the north/south or northing.

f. The operator shall have a clear understanding of the importance of accurate data collection and the secondary use of that data.

5.0 PLANNING AND IMPLEMENTING GPS SURVEYS

The following sections outline the basic steps involved in systematic planning and conducting a GPS survey. Several steps must be taken prior to using a GPS receiver to obtain successful GPS data for secondary use.

5.1 DEFINE DATA OBJECTIVES OF GPS SURVEY

Establish the ultimate objective of the survey. Determine level of accuracy required to meet data quality objectives (DQO). Is an autonomous GPS receiver required or a differential GPS (DGPS) receiver required? For autonomous receivers the horizontal accuracy varies dependent upon the quality of the unit being used (autonomous GPS receivers can achieve greater accuracies through post processing of data). For greater horizontal data accuracy requirements, a DGPS unit that operates a roving GPS receiver in conjunction with a base unit receiver may be required. DGPS units are used when location data accuracy is required on a sub meter or even sub centimeter level. This SOP documents the procedure to be used for handheld GPS receivers. The following Categories provide suggested benchmarks for establishing quality control based on intended use of the data collected.

Category I: For enforcement, litigation, direct support of rules and regulations, projects of national significance and highly influential scientific assessment.

Category II: Development of rules and regulations and influential scientific information.

Category III: Validation, general applications and feasibility studies.

Category IV: Screening, exploratory and pure knowledge.

Note: Differential GPS should be employed for Categories I and II or where accuracy measurements on a sub meter level are required.

5.2 DEFINE PROJECT AREA TO BE SURVEYED

Establish overall project area and the limits of the survey to be completed. Utilize all available resources. A 7.5-Minute quadrangle map is ideal when surrounding environments need to be taken into consideration. Use street maps or site maps already available to plan survey accordingly.

5.3 PRE-SURVEY RECONNAISSANCE

Perform a site reconnaissance or walk of the area or features where location data is to be collected. Prepare a sketch of the site with features to be mapped and cross reference the locations to be located with the list developed in the planning stage so that features or facilities to be mapped are not omitted from the survey. If necessary, operator should clear obstructions that may impede or restrict the collection of accurate locational data.

5.4 LIST OF POINTS OR LOCATIONS TO BE SURVEYED

Develop a list of facilities or features targeted for data collection. If possible plot general locations on a field map or site map. If the proposed survey point is on private property care should be taken to pursue appropriate notification and access protocol.

5.5 DEFINE EQUIPMENT NEEDS

Select from a list of equipment currently available for use by BER staff. Selected equipment shall be appropriate for the intended use of the data to be collected. Is a PC and associated software with interface cable, or powered antenna required?

5.6 EQUIPMENT TEST AND SETUP

Prior to departing from office, the user shall check the GPS receiver for proper operation. Check to see if the GPS unit is fully charged and receives good satellite signal in an outdoor environment. If the unit has a self diagnostic program; use the program to check for errors (this should be completed by GSS staff if using their equipment). Check to see if the unit is loaded with the necessary software, map data, and enough storage available to complete survey objectives. Operation manuals provide unit specific procedures which should be referenced to complete system checks on the equipment prior to use in the field (see Attachment 1 for available GPS equipment).

GPS units contain many settings that can serve as quality checks during data acquisition. For instance a minimum number of visible satellites can be specified for data acquisition. The unit will provide a warning signal if less than the minimum specified are available. Four satellites in view are the minimum required, but additional satellites can provide the receiver with stronger signals to select from and perhaps better geometry for calculations. GPS receivers can also calculate a Dilution of Precision (DOP) for Horizontal (HDOP), for Time (TDOP), and general Position

(PDOP) values and is often referenced with lower values leading to more accurate measurements. PDOP values of 6 or less are generally acceptable and limits on PDOP can usually be programmed into the unit or software that interfaces with the receiver.

DOP values in Relation to Quality Categories			
DOP Value	Rating	Description	Suggested for Quality Category
1	Ideal	Highest possible confidence level.	I
2-3	Excellent	Meets all but most demanding needs.	I or II
4-6	Good	Appropriate for most needs.	II, III, or IV
7-8	Moderate	For less demanding uses. Positional measurements could be used for calculations, but the fix quality could still be improved. A more open view of the sky is recommended.	IV
9-20	Fair	Low confidence level. Positional measurements should be discarded or used only to indicate a very rough estimate of the current location.	Not recommended
>20	Poor	Very low confidence level. Measurements are inaccurate by as much of as half a football field and should be discarded.	Not recommended

Note: These Quality Categories in the above table are suggested. Other factors may supersede the information in the table.

5.7 EXECUTION AND COLLECTION OF LOCATION DATA:

GPS location data is collected for multiple points of interest with different data objectives required for the varying Sections within the Bureau of Environmental Remediation. Examples where location data are needed but not limited to are sites on the ISL where contamination has been confirmed or suspected, source facilities, former waste pits or piles, locations where soil, groundwater, or surface water samples were collected for laboratory analysis; monitor well locations; land features such as creeks, streams, or springs; Underground Storage Tanks (UST), Aboveground Storage Tanks (AST), and Leaking Underground Storage Tanks (LUST) locations.

1. Calibrate the unit and ensure all appropriate settings are correct according to the unit's operation manual.

2. Acquire Satellite lock: To provide reliable location information, a GPS receiver must receive good signal strength from a minimum of four satellites. To acquire satellites, the user must turn on the GPS unit and go to the satellite screen.

3. This screen will display the current configuration of the satellites and the strength of signal coming from each one.

4. A clear view of the sky gives the user the best opportunity for an optimal satellite lock. Tree canopies and tall buildings that obscure the view overhead or of the horizon can impede reception.

5. The user must be sure the coordinate system and datum are correctly defined in the GPS unit prior to data collection.

6. Large sites containing multiple source areas or facilities can be identified through collecting location data from each corner of the site in addition to each source area or facility located within that site.

7. Each source facility or area should have GPS data collected at or near its center and should have a specific KDHE project code associated with it.

8. Individual sites or properties that are five acres or less in size should have a single set of location data collected. Most GPS units allow the user to store the locational information in the unit itself as a waypoint and allow the user to label that point with a brief description.

9. When pictures are taken of specific points on a property or site, location data is beneficial to have. Most GPS units allow the user to store the locational information in the unit itself as a waypoint and allow the user to label that point with a brief description.

10. As the user is collecting location data, the user shall record the coordinates along with a label and brief description of the point being surveyed in a site specific log book or data collection form (see Attachment 2). By recording location data in a log book or on a collection form, the user ensures data will not be lost if he or she experiences equipment failure. When recording data using decimal degrees; a minimum of five decimal places is required.

When recording data using degrees decimal minutes, three decimal places are required.

11. If an equipment malfunction is encountered consult the operation manual for guidance on troubleshooting.

12. When the user has completed the survey and has arrived back to the office; download the collected data in the appropriate format and using appropriate software (GSS does this for their equipment).

13. Clear the unit memory for the next operator so that the possibility for the next user to mix data sets is minimized.

5.8 DATA ASSESSMENT AND PROCESSING

Post processing should be conducted after returning from the field to the office where tools for post processing are more easily controlled. Common steps in post processing are transferring the data from the field equipment to the office work stations, conducting the initial stages of processing, computation of the solutions for critical factors, data conversion for use in a GIS, and the final documentation and reporting.

6.0 REFERENCES

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U.S. Environmental Protection Agency, Office of Environmental Information, *Global Positioning Systems – Technical Implementation Guidance*, EPA/250/R-03/001, September 2003.

U.S. Environmental Protection Agency, *Interim Guidance for Developing Global Positioning System Data Collection Standard Operating Procedures and Quality Assurance Project Plans*, EPA/600/R-08/020, February 2008.

U.S. Environmental Protection Agency, *Terms of Environment: Glossary, Abbreviations, and Acronyms*, EPA/175-B-97-001, December 1997.

Attachment 1

Kansas Department of Health and Environment GPS Equipment List and Configurations
NSSDA 95% Confidence Level for Horizontal Accuracy

No.	Derived Horizontal Accuracy (meters)	Derived Vertical Accuracy (meters)	Reported Accuracy (meters) Horiz /	Verti	Equipment	Type	Date
1	1.95	N/A	2		Thales Mobile Mapper CE/CX	Autonomous (WAAS)	2008
2	1.42	1.58	1	2	Thales Mobile Mapper CE/CX	Differential Post processing - 1 minute	2008
3	1.07	1.10	1	1	Thales Mobile Mapper CE/CX	Differential Post processing 1&5 minute external antennae on bipod	2008
4	2.875	N/A	3		Thales Mobile Mapper Pro	Autonomous (WAAS)	2005 2008
5	1.087	N/A	1	3	Thales Mobile Mapper Pro	Differential Post Processing 1minute	2005 2008
6	16.926		17		Garmin GPS III Plus	Autonomous	2004
7	7.006	N/A	7		Garmin e trex Legend	Autonomous (WAAS)	2004
8	5.373	N/A	5		Delorme GPS/Timble Recon Datalogger	Autonomous (Bluetooth connection between GPS unit, Antennae & Datalogger	2008
9		N/A	7			1:1500 scale - Digital Ortho Photo	2005

Source: *KDHE, GPS Equipment configurations, July 2008.*

Thales MobileMapper CE and CX were found to be equivalent units. Newer technology utilized by the CX made post processing of collected data feasible. Post processing with the CE was unreliable. (In 2007, the manufacturer replaced the CE model with the CX model).

Note: All data were compared to the NGS Independent Source. All post-processing was completed using nearest CORS at 5 second intervals. Post-processing data for 2005 were derived from receivers mounted on a bi-pod. Post-processing data for 2008 were collected on both handheld units and bi-pod mounted units. Autonomous data were collected from handheld receivers.

Attachment 2
DATA COLLECTION FORM

SITE INFORMATION

Today's Date: _____

Brief Description of Weather Conditions: _____

_____

New Site or Existing Site (circle one)? _____New / Existing

Site Name: _____

Site Address: _____

City: _____

County: _____

KDHE Project Code: _____

LOCATION DATA

Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Identifier or Label

GPS Unit Used for Collection of Data: _____

Photographs Taken (circle one)? _____Yes / No

Collectors Name: _____ **Bureau / Section:** _____

STANDARD OPERATING PROCEDURE – BER-36

WATER LEVEL, PRODUCT, AND WELL DEPTH MEASUREMENTS

Effective Date: January 1, 2011

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ATTACHMENT A **Electronic Water Level Indicator**

ATTACHMENT B **Steel Tape**

ATTACHMENT C **Airline**

ATTACHMENT D **Interface Probe**

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1.0 INTRODUCTION

The objective of this Standard Operating Procedure (SOP) is to establish basic procedures for measuring depth to groundwater, separate chemical phase product levels, and total well depths in monitoring and observation wells. Groundwater level measurements are generally used to construct potentiometric surface maps. Groundwater level data is also used to determine sample purge volumes, hydraulic conductivity, groundwater flow direction, flow velocity, hydraulic gradients, impacts from pumping, or other groundwater stresses.

2.0 METHOD SUMMARY

Prior to field activities, field personnel should have specific information including well identification and location, well casing diameter, casing material, lock number and keys, legal access to the wells, and the length and depth to the well screen. The diameter of the well casing will decide which type of equipment will be used for measuring, purging, and sampling the well or separate chemical phase product.

A surveyed reference point should be marked on the top of the well casing. The reference point, from which all measurements will be taken, should be documented in the field notebook. All field personnel must be made aware of the reference point being used in order to ensure the collection of comparable data.

The well cap must be removed several minutes before measuring begins to allow the water levels in the wells to equilibrate to atmospheric pressure. If possible, water level measurements should proceed from the least to the most contaminated wells. Additionally, the water level measurements of all site wells should be done consecutively before any purging and sampling activities take place. This will ensure the representation of aquifer conditions.

For electric water level indicators, lower the probe into the well until the water surface is reached as indicated by a tone or light on the indicator. Record the distance from the water surface to the reference point. If a separate chemical phase product is present in the well, an interface probe meter is used to measure the product thickness and water level. Continue to lower the probe to the bottom of the well in order to measure the total well depth. All measurements must be made to an accuracy of one-hundredth of a foot (0.01 foot). Remove the electric water level indicator and decontaminate the equipment between all well measurements.

3.0 EQUIPMENT

3.1 WATER LEVEL INDICATORS

3.1.1 Electronic Water Level Indicator

Electronic water level indicators typically consist of dual insulated conductor wires in a flat tape or coaxial cord whose exposed ends are separated by an air gap in a probe and containing a circuit and a source of battery power in the indicator spool. When the probe comes in contact with the water, the circuit is closed and a light and/or audible buzzer attached to the spool will signal contact by lighting up and/or producing an audible tone. Measurements should be made and recorded to the nearest 0.01 foot.

3.1.2 Chalked Steel Tape

Steel tapes are steel bands typically less than an inch wide mounted to a hand-wound reel. A slender weight is attached to the ring at the end of the tape to ensure plumbness. Older tapes may use a lead weight, which presents concerns with water quality. The weight should be either brass or stainless steel. The lower few feet of tape are chalked by pulling the tape across a piece of blue carpenter's chalk. The wet chalk mark identifies the portion of the tape that was submerged. Chalk may result in impacts to groundwater quality analysis.

3.1.3 Airline

Airlines are used in higher capacity industrial and municipal wells. This method involves the installation of a small-diameter pipe or tube (the airline) from the top of the well to a point about 10 feet below the lowest anticipated water level or below the pump intake. Compressed air is used to purge the water from the tube. The pressure, in pounds per square inch (psi), needed to purge the water from the airline is multiplied by 2.31 (feet of water for one psi) which will equal the length in feet of the submerged airline. The depth of water below the center of the pressure gauge can be easily calculated by subtracting the length of the airline below the water surface from the total length of the airline. Airlines can become clogged with mineral deposits or bacterial growth, or develop leaks, and consequently yield false information. A series of airline measurements should be checked periodically by steel tape or an electric water level indicator.

3.2 NON-AQUEOUS PHASE LIQUID MEASURING DEVICE

3.2.1 Interface Probe Meter

Interface probe meters typically consist of dual insulated conductor wires in a flat tape or coaxial cord whose exposed ends are separated by an air gap in a sensor probe and containing an infra-red and conductivity circuit and a source of battery power in the indicator spool. When the sensor probe comes in contact with product, the infra-red circuit detects the product and a light and/or audible buzzer attached to the spool will signal contact by lighting up and/or producing a steady audible tone. When the sensor probe comes in contact with water, the conductivity circuit differentiates between the product (non-conductive) and water (conductive) and a light and/or audible buzzer attached to the spool will signal contact by lighting up and/or producing an intermittent audible tone. Measurements should be made and recorded to the nearest 0.01 foot.

4.0 PROCEDURES

4.1 REFERENCE POINT

Static groundwater levels must be measured from the permanently marked reference point where the top of the well casing was professionally surveyed. The reference point is typically surveyed to establish its position above sea level to an accuracy of 0.01 feet. If no mark is apparent, field personnel should take both water level and total well depth measurements from the north side of the top of the casing and should record this procedure in the field notebook. Monitoring well measurements for water level and total depth should be consistently measured from one reference point in order to properly assess groundwater data. Whenever possible, the inner casing is recommended as reference point, because of the general instability of the outer casings due to frost heaving, vehicular damage, and other activities which could cause movement of the casings.

4.2 MEASURING GROUNDWATER LEVELS

1. Select a water level measuring device based on the site specific conditions.

2. Prior to field work, check the conductivity of the electronic water level indicator by placing the electrode probe into clean water to

close the circuit for testing. A light on the indicator spool should flash and/or an audible buzzer will make a tone that identifies a closed circuit. Note: Do not use distilled water to check the circuit. Electronic water level indicators will not respond to distilled water. Also, check the decontamination condition of the indicator.

3. Start at the least contaminated well, if known.

4. Lay plastic sheeting around the well to minimize the likelihood of contamination of equipment from soil adjacent to the well.

5. Remove the locking well cap and well casing cap. Allow several minutes to pass before measuring begins to allow the water level in the well to equilibrate to atmospheric pressure.

6. Turn on the electronic water level indicator by turning the sensitivity switch on the indicator spool clockwise. The sensitivity switch controls the volume of the audible tone put off by the indicator when the electrode probe comes in contact with water. If using a steel tape, pull the tape across a piece of blue carpenter's chalk.

7. Slowly lower the electrode probe down the well. If utilizing a steel tape, lower the chalked steel tape from the reference point at the top of the well until a short length of tape is submerged. The weight and tape should be lowered into the water slowly to prevent splashing. Submergence of the weighted tape may temporarily cause the water level to rise in small-diameter cased wells.

8. When the electronic water level indicator detects water, check to make sure the electrode probe is not coming into contact with water cascading down the side of the well casing. Raise and lower the tape until the light and/or buzzer goes off and on. This will indicate whether the water level is rising, falling, or is remaining static in the well. For the chalked steel tape, lower the tape into the well until the lower two feet of the tape is submerged.

9. Measure the water level depth relative to the reference point on the top of the monitoring well casing and record the measurement on the tape to the nearest 0.01 foot. Recheck the measurement by taking two to three readings. For the chalked steel tape, the water level depth below the reference point is determined by subtracting the length of the wet tape (indicated by the wet chalk) from the total length of tape lowered into the well. Record the time and date of the water level measurement, the reference point, measurement method, and the water level.

10. Begin rewinding the electrode probe and tape back onto the indicator spool or the steel tape back onto the hand-held spool. Decontaminate the measuring device between each well following KDHE's SOP BER-05 *Decontamination of Equipment*.

4.3 MEASURING NON-AQUEOUS PHASE LIQUID PRODUCT

1. Prior to performing measurements, complete the steps 1-5 as described above in 4.2 Measuring Groundwater Levels.

2. Perform a battery test by turning on the device by pushing the "Start" button on the indicator spool. A brief tone and light will indicate the interface probe meter is functional and a flashing light will indicate the meter is on. Check the decontamination condition of the interface probe prior to field work.

3. Carefully lower the sensor probe into the well.

4. As the sensor probe encounters the product (greater than 1 millimeter thick) a steady audible tone will sound. Measure the NAPL depth relative to the reference point on the top of the monitoring well casing and record the measurement to the nearest 0.01 foot. Recheck the measurement by taking two to three readings.

5. Lower the sensor probe through the NAPL layer very slowly. When passing through the product into water, some product may adhere to the sensor probe. When the water interface is encountered, a second intermittent audible tone is generated. Raise and lower the probe to remove any product from the probe. The water/product interface should be measured as the probe is raised slowly back up. Record the reading to the nearest 0.01 foot and re-check the reading two to three times.

6. To determine if dense non-aqueous phase liquid (DNAPL) is present in the well, continue to lower the sensor probe. If the steady audible tone sounds, determine the top of the heavy product layer by recording the reading to the nearest 0.01 foot and re-check the reading two to three times. Continue lowering the sensor probe until the tape slackens when the bottom of the well has been reached. Again record the depth reading to the nearest 0.01 foot and re-check the reading two to three times. Record the time and date of the water level and product measurements, the reference point, and the water and product level depth measurements.

7. Begin rewinding the sensor probe and tape back onto the indicator spool. Decontaminate the measuring device between each well following KDHE's SOP BER-05 Decontamination of Equipment.

8. Field personnel shall document the description of the product, including thickness of the product layer, color, odor, viscosity, and indicate the type of product suspected.

4.4 MEASURING TOTAL WELL DEPTH

The total depth of the well must be measured at each sampling event to determine any changes in the condition of the well, checking the well casing integrity, or any siltation building up in the well screen. An electronic water level indicator should only be used to measure total well depth if it has been designed to do so. If the indicator has not been designed to measure total water depth, fully submerging the electronic water level indicator probe may cause water to enter the probe, resulting in a possible shorting out of the indicator or leading to a shorter life of the equipment. A weighted steel or fiberglass tape may also be used for measuring. To measure the total depth of a well:

1. Turn off the electronic water level indicator by turning the sensitivity switch on the indicator spool counter-clockwise.

2. Lower the electrode probe or weighted tape down the well casing until the tape becomes slack, indicating the tape has reached the bottom of the well.

3. Pull the tape taut and record the depth reading to the nearest 0.01 foot and re-check the reading two to three times.

4. Begin rewinding the electrode probe and/or tape back onto the indicator spool. Decontaminate the measuring device between each well following KDHE's SOP BER-05 *Decontamination of Equipment.*

5.0 QUALITY CONTROL/QUALITY ASSURANCE

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout, problems, and/or replacement must occur prior to sampling/operation and must be documented.
- To ensure accurate data is collected, repeated measurements should be made within 0.01 feet.
- Decontamination of equipment must take place between well sampling and measurements in accordance with KDHE's SOP BER-05 *Decontamination of Equipment*.

6.0 REFERENCES

1. Illinois United States Geological Survey, Water Science Center, *Introduction to Field Methods for Hydrologic and Environmental Studies*, U.S. Geological Survey Open-File Report 01-50, il.water.usgs.gov/pubs/ofr01_50_chapter4_4.pdf, 2001.

2. United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*, Ground Water Forum Issue Paper, EPA designation EPA/542/S-02/001, May 2002.

3. United States Environmental Protection Agency (Region 4), Science and Ecosystem Support Division, Safety, Health and Environmental Management Program Procedures and Policy, SESD Operating Procedure-Groundwater Level and Well Depth Measurement, SESDPROC-105-R1, November 2007.

4. Kansas Department of Health and Environment, Bureau of Environmental Remediation, Quality Management Plan III, Appendix A-Standard Operating Procedures, BER-01 *Collection of Groundwater Samples at Known or Suspected Groundwater Contamination Sites*, August 2010.

5. Kansas Department of Health and Environment, Bureau of Environmental Remediation, Storage Tank Section, *Petroleum Storage Tank Release Trust Fund Monitoring Request for Proposal,* Revision 5, April 2008.

6. Solinst, Interface Meter Operating Instructions Model 122, http://www.solinst.com/Downloads/Inst/122ins/122ins.pdf, October 2002.

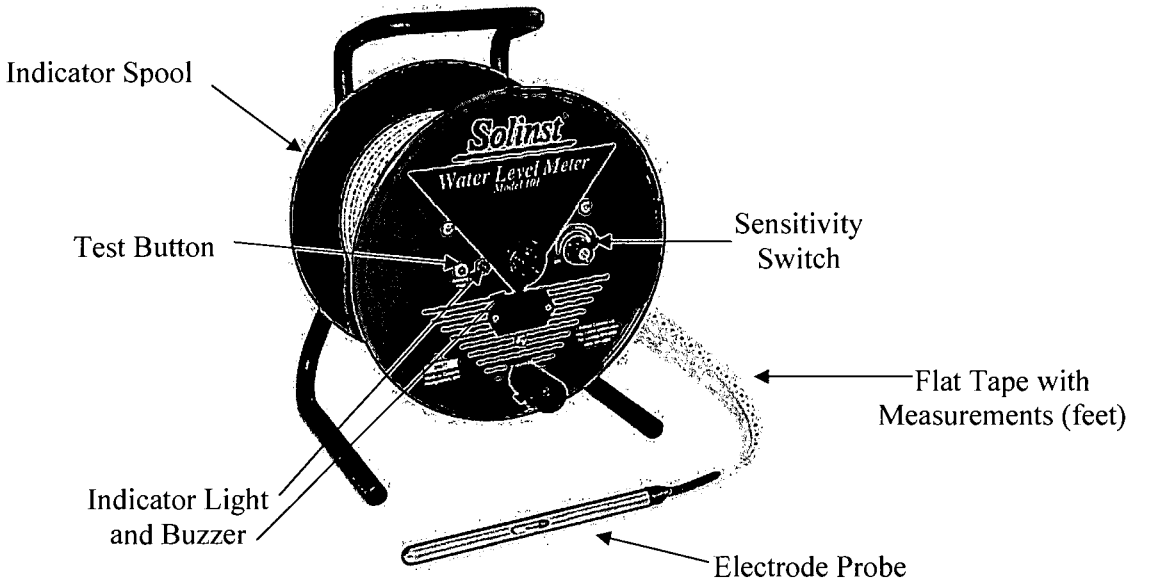
7. Los Alamos National Laboratory, *Environmental Program Directorate Standard Operating Procedure for Manual Groundwater Level Measurements*, SOP-5223, October 2008.

8. New Jersey Department of Environmental Protection, Guidance Documents, Field Sampling Procedures Manual, *Chapter 6 – Sample Collection,* http://www.state.nj.us/dep/srp/guidance/fspm/pdf/chapter06_all.pdf, August 2005.

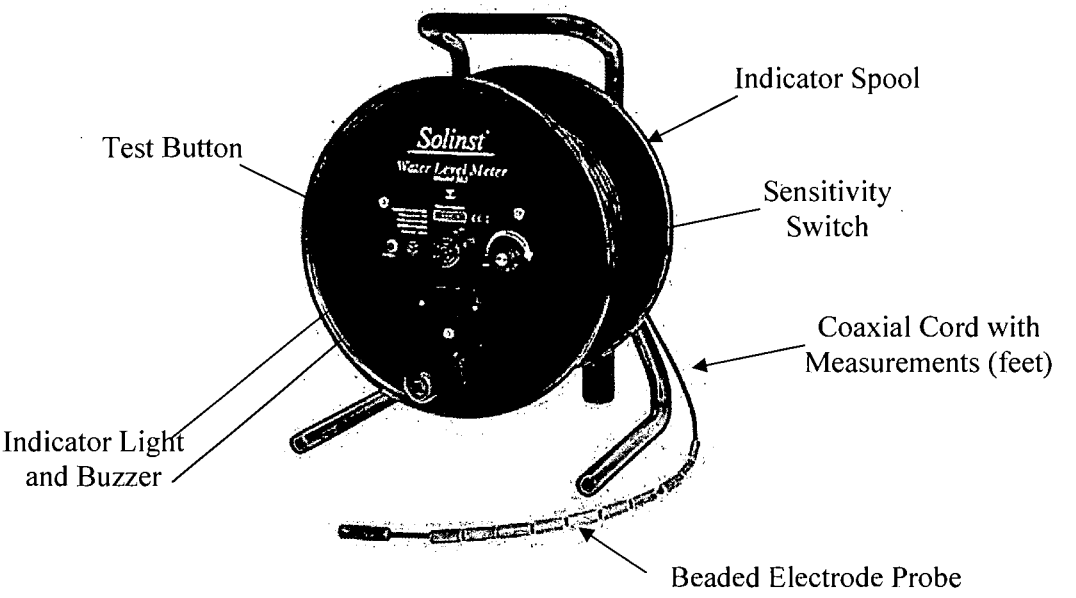
9. RETEC Group, Inc., Standard Operating Procedure (SOP) 231 Water-Level Measurements, April 2002.

ATTACHMENT A

ELECTRONIC WATER LEVEL INDICATOR



Electronic Water Level Indicator for well casing diameters greater than 1 inch.

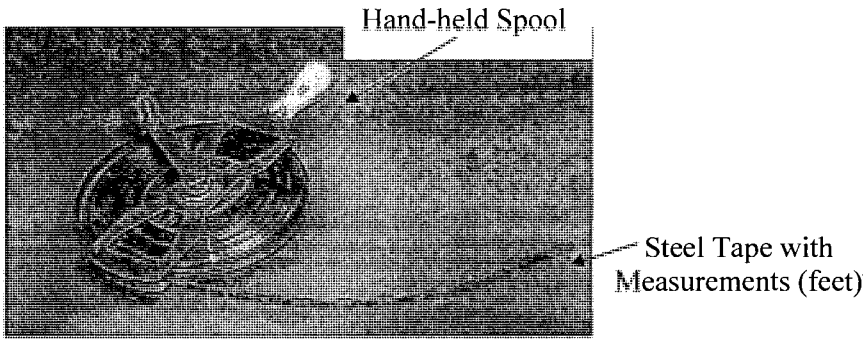


Electronic Water Level Indicator for well casing diameters less than 1 inch.

Note: KDHE does not recommend, endorse, or require specific brands of equipment.

ATTACHMENT B

STEEL TAPE



EXAMPLE OF HAND-HELD STEEL TAPE.

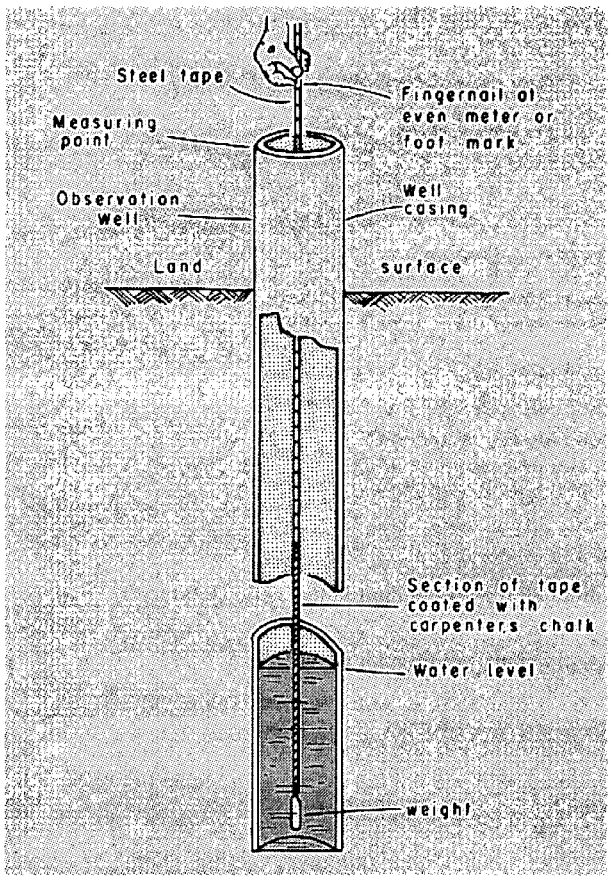


Diagram: Collecting a water level measurement with a weighted and chalked steel tape.

Note: KDHE does not recommend, endorse, or require specific brands of equipment.

ATTACHMENT C

AIRLINE

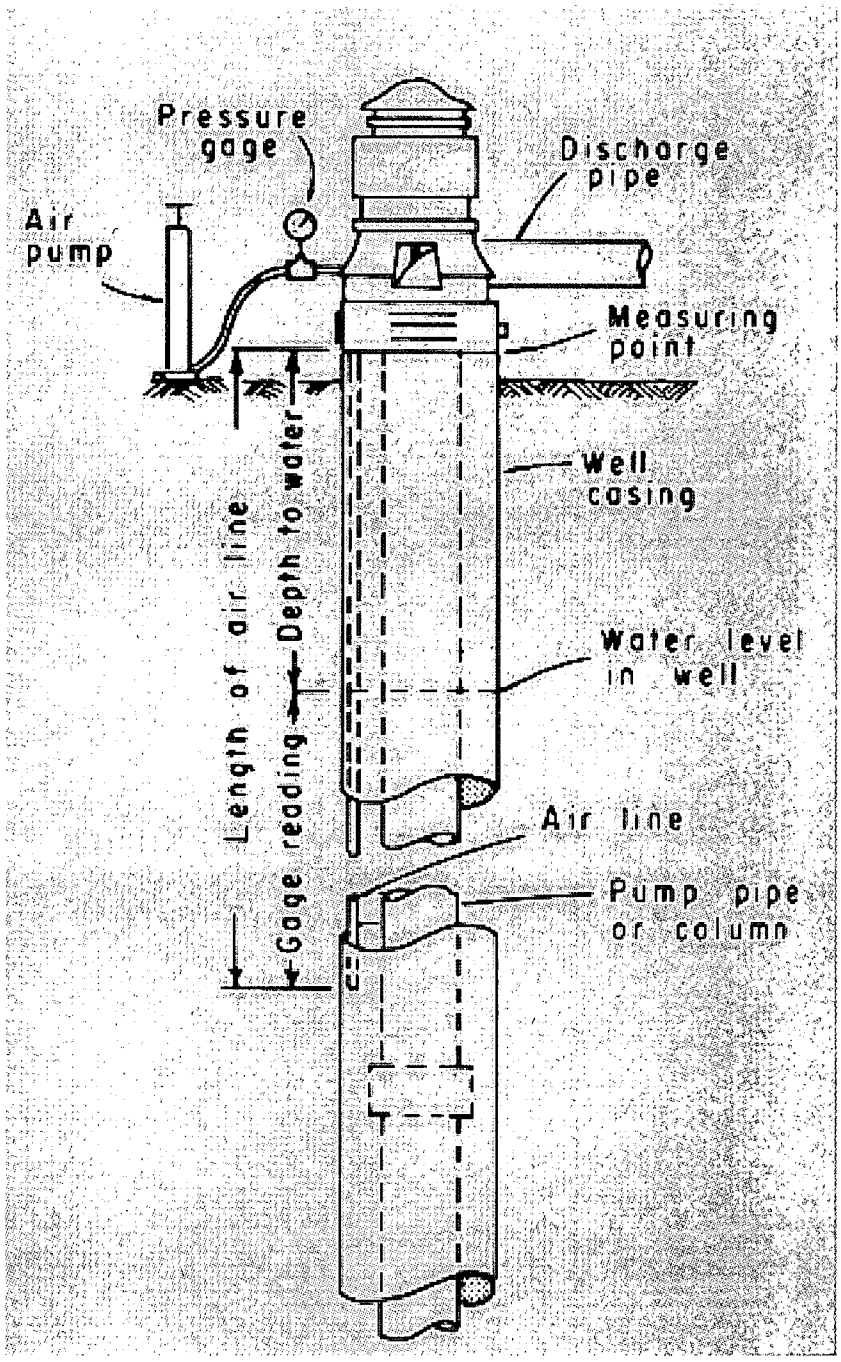
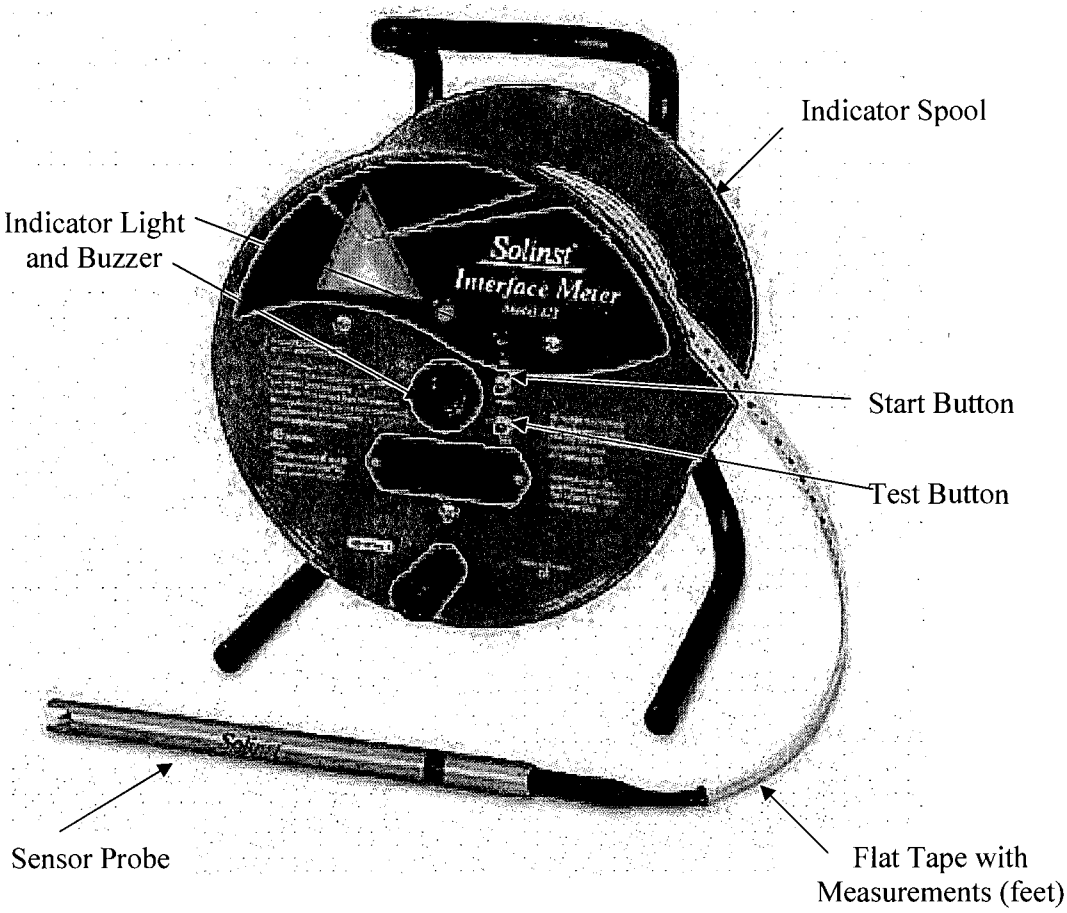


Diagram: Collecting a water level measurement with an airline.

ATTACHMENT D

INTERFACE PROBE



Note: KDHE does not recommend, endorse, or require specific brands of equipment.

Appendix C

Health and Safety Plan

anteagroup

Health, Safety, Security & Environment

Union Pacific Railroad

Site Health and Safety Plan

Project Number:	UPR8263A
Project Name:	Ft. Scott, KS – Double Circle Farm Supply Site
Address:	Northwest of National Avenue and West Elm Street
City, State	Fort Scott, KS 66502

Prepared By:	Antea Group
Address:	150 St. Peters Centre Boulevard, Suite C
City, State, Zip:	St. Peters, MO 63376

Telephone:	636.486.1950	Fax:	636.939.9923

Updated: September 17, 2015

Inogen Environmental Alliance

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APPENDICES

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Appendix B I-3 First Report Field Form
Appendix C e-Railsafe Badges
Appendix D Hazardous Chemical Property Information and MSDS
Appendix E Five (5) Day Safety Checklist (optional)
Appendix F Job Safety Analysis
Appendix G Air Monitoring Log
Appendix H Sound Level Survey Log
Appendix I Behavior Based Safety Observation Field Checklist

FIGURES

Route to Hospital Map
Site Map
Journey Management Plan Map and Instruction
Traffic Control Plan Map

UNION PACIFIC RAILROAD SITE HEALTH AND SAFETY PLAN

Antea Group believes that all work-related injuries and illnesses are preventable and has a goal of zero work related injuries and illnesses for its worksites. This plan outlines the processes and procedures Antea Group will employ to achieve this goal.

- The Project Manager or Site Safety Officer (SSO) will hold daily on-site safety meetings ***prior to the start of field work*** to review site safety concerns, procedures, review key elements of the Site Health and Safety Plan (HASP) and Job Safety Analyses (JSAs) with all members of the field crew, including Antea Group employees and subcontractors. Other site safety meetings will be held as needed. Subcontractor personnel must participate in safety discussions as requested by Antea Group. See Antea Group's tailgate meeting checklist and guidance document for details (Appendix A).
- All field team members who may be exposed to site impacts during the course of their work, shall have completed OSHA 40-hour HAZWOPER and annual refresher training (29 CFR 1910.120), CPR and First Aid Training, the Union Pacific e-RailSafe and Contractor On-rail training. ***Documentation of training shall be readily available***.
- Each Antea Group team member must review, sign and date the HASP and the Antea Group Acknowledgement Agreement at the end of this document. Each subcontractor employee and visitor must review the HASP and sign, date, and describe their affiliation on the Subcontractor Acknowledgement Agreement at the end of this document.
- The signed HASP is kept in the field and readily available for duration of field work and returned to the project file upon completion of field activities.
- The HASP shall be revised or rewritten if site activities are changed significantly, if areas of differing hazard are involved, or as information about contaminants and hazards changes. Changing conditions may justify either increasing or decreasing HASP restrictions and action levels, depending upon the additional information generated.
- **STOP WORK AUTHORITY—ALL WORKERS HAVE THE AUTHORITY AND RESPONSIBILITY TO STOP ANY WORK, OR REFUSE TO DO WORK, THAT THEY FEEL IS UNSAFE.**

1.0 GENERAL INFORMATION

ANTEA GROUP PROJECT NUMBER:	**UPR8263A**		
Client:	Union Pacific Railroad	Site Owner:	UPRR
Site Name:	Ft. Scott, KS – Double Circle Farm Supply Site	Client Claim/PO Number:	
Site Address:	Northwest of National Avenue and West Elm Street, Fort Scott, KS		
Project Manager:	Addie Mette		
Plan Prepared by:	Danielle Mattingly	Date:	3/3/15
Approved by:	Addie Mette	Date:	3/4/15
Revised by:	Kathy Shields	Date:	9/17/15
Revision Approved by:	Addie Mette	Date:	9/20/15

Place date(s) in appropriate box (es) for current phase(s) of site activities.

Site Activities	Soil Borings	Monitoring Well Installation	Tank Removal	Soil Excavation	Recovery Well Installation	Pilot Tests	Treatment System Construction	Soil and Ground Water Sampling	LNAPL Recovery	O&M
Site Assessment		2009								
Remedial Investigation								2009 - present		
Site Remediation Activities				2010						

2.0 EMERGENCY CONTINGENCY PLAN

2.1 Local Emergency Telephone Numbers

Can 911 be used at this site? Yes [x] No [ ] If yes, be certain it is activated and enhanced.

Since cellular telephones may not reach a local 911 operator, also supply the following information. (provide area code)

Ambulance	911/(620) 223-5050	Fire Department	911/(620) 223-2140
Hospital Emergency Room	911/(620) 223-2200	Police Department	911/(620) 223-1440
Poison Control Center	(800) 222-1222	Sheriff Department	911/(620) 223-1440
(List utility companies as appropriate)		WorkCare	(888) 449-7787
		UP Risk Mgmt Communication Center (RMCC)	(888) 877-7267

2.2 Hospital Routes

INCLUDE A MAP WITH HIGHLIGHTED EMERGENCY HOSPITAL ROUTE(S) at the end of the HASP.

Emergency Hospital* Name: Mercy Health Center Phone number: (620) 223-2200

Hospital Address: 401 Woodland Hills Blvd, Fort Scott, KS 66701

Hospital Directions: South on N. National Ave. toward W. Pine St. (1.7 mi). Turn Left onto S. National Ave. (0.1 mi)

Turn Right onto KS-7 S/US-69 S/S Main St. (1.0 mi). Turn Right onto Jayhawk Rd. (0.3 mi). Turn Right to stay on Jayhawk Rd. (79 ft).

End at Mercy Hospital Fort Scott

*** Hospital should be notified immediately if an injury occurs which requires medical attention.**

Estimated driving distance: 3.1 Miles Estimated driving time: 8 Minutes

Does hospital accept chemically contaminated patients? Yes [x] No [ ]

RECOMMEND DRIVING FROM THE SITE TO THE HOSPITAL PRIOR TO WORK START-UP.
CHECK FOR ROAD CLOSURES AND/OR DETOURS. AMEND HOSPITAL DIRECTION MAP AS NEEDED.

2.3 Evacuation Routes

Identify prevailing wind direction, if known. Evacuation route and meeting location must be upwind or crosswind):

PRIMARY EVACUATION ROUTE AND MEETING LOCATION: **To be determined at start of each work day and dependent on wind direction.**

SECONDARY EVACUATION ROUTE AND MEETING LOCATION: **To be determined at start of each work day and dependent on wind direction.**

2.4 Emergency Contacts

PHONE NUMBERS (provide area codes)			
	Name or Description	**Work**	**24-hr. Contact**
	Consultant		
Project Manager:	Addie Mette	636.442.4777	636.448.0244
Office Leader:	Addie Mette	636.442.4777	636.448.0244
Region Manager:	Mark Mathiowetz	303.615.3119	303.808.2756
Health and Safety Sr. Specialist:	Darius Szewczak	651.697-5163	651.341-3810
Antea Group Operator	**Emergency Number 800-651-3117**	800.477-7411	800.888-1331
	(above number for System issues)	(Co. Switchboard)	(Co. Switchboard)
	Consultant PM to call		
Client Contact:	Jeff McDermott, Site Rem Mgr 1400 Douglas St., STOP 1030 Omaha, NE 68179	402.544-3675	
Site Contact:			
Site Owner:	Union Pacific Railroad		
	Regulatory Agency		
Applicable Regulatory Agency:	KDHE – Andrea Schiller	(785)296-0489	
Union Pacific Response Management Communications Center (RMCC)		(888) 877-7267	

2.5 Reporting Procedures and First Aid

Call emergency services (911) ASAP if situation is an emergency, i.e. workers or the public are in immediate peril.

Report all accidents, injuries, and illnesses IMMEDIATELY to the Antea Group PM, Office Leader, or Antea Group HSSE. **Antea Group is a member of WorkCare, a 24-hour occupational medical management service. If an employee is injured or becomes ill, immediately contact WorkCare at (888) 449-7787 to assist in the medical evaluation and management of the employee.**

Report all NEAR MISSES as soon as reasonably possible (no later than 24 hours after the event). Use Antea Group's online reporting system to submit your near miss. If necessary, use the attached reporting form to capture facts and details immediately while in the field. See Appendix B for reporting form.

2.5.1 First Aid Equipment

- Standard first aid kit/CPR mask
- Portable eye wash

2.5.2 First Aid Procedures

If an emergency, call 911. <u>All Antea Group employees onsite must have up-to-date first aid/CPR training.</u>

Ingestion:	Follow instructions from Poison Control Center or the MSDS, contact an Antea Group Safety Specialist to engage Antea Group's medical case management service (WorkCare), as necessary.
Inhalation:	Move victim to fresh air. Contact an Antea Group Safety Specialist to engage Antea Group's medical case management service (WorkCare), as necessary
Dermal Exposure:	Remove contaminated clothing. Wash thoroughly with soap and water. Contact an Antea Group Safety Specialist to engage Antea Group's medical case management service (WorkCare), as necessary

A first aid kit and portable eyewash is provided in each employee's field bag and is available on-site. If a worker suffers a chemical splash in the eye, flush the eye for 15 minutes and arrange for off-site medical treatment immediately. Workers will also be instructed to thoroughly wash with soap and water any unprotected skin that comes in direct contact with contaminated soil or water. Contact an Antea Group Safety Specialist to engage Antea Group's medical case management service (WorkCare), as necessary.

Trained workers who choose to provide CPR or First Aid must use Universal Precautions to control possible exposure to blood borne and infectious agents. CPR kits are available in employee field bags.

2.5.3 Site Emergencies

In the event of a fire or explosion, or other imminently dangerous situation (e.g. rupturing a natural gas line), evacuate the site immediately and call the appropriate emergency phone numbers listed in Section 2.4. Call the Antea Group PM or Office Leader and inform him/her of the situation as soon as possible.

If a product line is damaged, shut down the fuel supply immediately. In many cases, the release from a product line will be contained in the excavation, limiting the need for immediate spill response. However, if there is a surface release of fuel, call the local fire department or hazardous materials response (HAZMAT) unit. Phone numbers are listed in Section 2.4. Any release of material remaining after the emergency response will be addressed once the area is deemed safe by emergency responders.

a) Small Spills and Releases
Drums containing waste or recovered liquid must be in sound condition (new or reconditioned drums) with lids that seal and can be tightened in place. If possible, drums should be placed on an impermeable surface in a secure location prior to Antea Group's field team leaving the site.

For areas where small spills or leaks may occur, suitable quantities of absorbent materials (pads, socks, floor dry, etc.) and salvage drums or containers must be available. Drums and containers used during spill clean-up shall meet the appropriate regulations (DOT, OSHA and EPA) for the wastes that they contain. Wastes must be properly characterized for disposal.

b) Remediation Systems
See Section 5.0 (Remediation Systems) for spill prevention measures for remediation systems.

2.6 SITE RESOURCES

If no, identify closest available resource with directions. Pump-In-Petes, 603 S. National Ave, Fort Scott, KS. Directions from site: Head South on N. National Ave. toward W. Pine St. (0.6 mi). Convenience store will be on the left (0.6 mi/2 minutes.

Water supply available on site:	Yes		No	x	Bathrooms available on site:	Yes		No	x
Telephone available on site:	Yes		No	x	Electricity available on site:	Yes		No	x
Other resources available on site:	Yes		No	x	If "yes", identify:				

2.7 Project Health and Safety Team

Team Members (list)	
Project Manager:	Addie Mette
Public Information:	Union Pacific Railroad
Antea Group on-site Personnel: (On-site personnel Are responsible for Antea Group site health and safety.)	Various Field Staff
	Various Field Staff
Antea Group Site Safety Officer:	Senior Antea Group on-site personnel

PROJECT TEAM OSHA TRAINING RECORDS
(DOCUMENTATION MUST BE AVAILABLE FROM ANTEA GROUP AND APPROPRIATE CONTRACTORS UPON REQUEST)

Name	40 Hr Training Date	8-Hr Refresher Date	Site Supervisor Training Date	e-Railsafe and Contract Onrail Training
Mike O'Malley	03/09/07	05/07/15	08/16/10	06/10/14
Matthew Cauthon	05/23/14	05/07/15	06/04/15	06/10/14
Danielle Mattingly	06/01/10	05/07/15	03/28/12	08/12/14

All workers who have to potential to be exposed to site impacts must have up-to-date HAZWOPER training. In addition, Antea Group employees must, at a minimum, have defensive driver training, first aid/CPR and medical monitoring. See subcontractor section (Section 12.0) for minimum required subcontractor training.

ADDITIONAL UPR REQUIRED TRAINING
e-RailSafe training will be completed by each person prior to entering the Site. Each employee and subcontractor shall have on their person the e-RailSafe Identification Card, which is prominently displayed and current. Copies of the e-Railsafe Identification Cards for staff are attached in Appendix C. Subcontractors visiting the Site for a short time period may have the e-RailSafe requirement waived upon approval of the UPR Environmental Site Manager.

2.8 Perimeter Establishment

Map/Sketch attached:	Yes	x	No		**Site secured:**	Yes		No	x
Perimeter identified:	Yes	x	No		**Zone(s) of Contamination identified:**	Yes	x	No	

2.9 Work Zones

An exclusion zone will be identified for each site or site activity. The exclusion zone will be clearly marked with yellow **CAUTION** tape, barricades and\or cones (recommended cone height – 42 inches), as needed. A contamination reduction zone and support zone will be established for any site with site contaminant levels that pose a health threat to site workers or the public. No person will be allowed in the exclusion zone or contamination reduction zone without approval from the Antea Group Site Safety Officer.

2.10 Site Security

Site security must be determined on a site-specific basis. The need for additional personnel, on-site security guards, fencing, etc. should be discussed with the client site manager, or other members of management. Equipment stored overnight will be locked and secured to prevent vandalism and protect the public. A description of the additional safety requirements should be listed below:

LIST SITE SECURITY MEASURES:

When work scheduling requires that an excavation be left open overnight, security fencing will be erected to restrict access to the site or work zones described in Section 2.9.

2.11 Site Map

Attach a site map to the "Figures" section at the end of the Site Health and Safety Plan. The Site Map can also to be used to outline Site Traffic Control (Section 10.0.)

3.0 SITE CHARACTERIZATION

A. Summary of Previous Site Investigation(s): See Project Files

B. Source of Previous Site Investigation Information: See Project Files

C. General Facility Description:

Railroad Right-of-Way [ ] Rail Yard [ ] Lease Property [ ] Other:

Description: Active [ ] Years has the site been operating: [ ] Closed/Abandoned [x]

Current property use (operations on-site, products, raw materials used, etc.): Vacant lot with railroad tracks.

Was the site previously used for industrial purposes: Yes [x] No [ ]

Describe previous site uses: Former fertilizer storage facility/farm supply

Surface cover on-site includes:

x	Soil/bare ground		Clay caps		Plastic cover
x	Grass		Paving/asphalt	x	Water bodies
	Woods		Swamp	x	Brush/scrub
x	Buildings		Unpaved roads	x	Other Railroad tracks

Approximate site surface area: _____ sq. ft. or _____ acres

Percentage of surface area: paved ____ % bare soil ____ %

vegetated 100 % under water ____ %

Potential for dust generation on-site: High [ ] Medium [x] Low [ ]

Any site access restrictions: Yes [ ] No [x] Please list:

Fenced/locked [ ] Posting (signs) [ ] Security guards [ ]

Evidence of public access to the site? Yes [ ] No [x]

If "yes," describe:

D. Regulatory Contacts

Are regulatory agencies involved with the site (Y/N)? Federal? N State? Y Local? N

Name	Agency	Phone (incl. area code)
Andrea Schiller	KDHE	(785) 296-0489
		( )
		( )
		( )

4.0 WASTE CHARACTERIZATION

4.1 Waste/Contaminant Type(s)

Characteristic(s):

[ ] Liquid	[ ] Soil	[ ] Solid	[ ] Sludge	[ ] Gas
[ ] Corrosive	[ ] Ignitable	[ ] Radioactive	[ ] Explosive	[ ] Flammable
[ ] Volatile	[ ] Toxic	[ ] Reactive	[ ] Unknown	[ ] Other

4.2 Major Spills/Releases

Type	Date	Chemical	Quantity	Impacted Media*
Flood	1994	Urea	23 tons	Soil and Groundwater
		Potash	15 tons	Soil and Groundwater
		Phosphate	25 tons	Soil and Groundwater

(*air, surface water, soil, or ground water)

Free Product: Yes [ ] No [x] Dissolved: Yes [x] No [ ]

Have removal actions occurred? Yes [x] No [ ]

If "yes," describe: Nitrate presumptive remedy consisting of excavation of surficial and shallow subsurface soils impacted with nitrate and ammonia was implemented in August 2010. Post-excavation groundwater monitoring to assess effectiveness of the excavation is ongoing.

Is there evidence that contaminants present could cause vapor problems in structures on-site?
Yes [ ] No [x] If "yes," is building mechanically ventilated? Yes [ ] No [ ]
Exhaust Ventilation: _____ General Building Ventilation: _____

4.3 Chemicals/Waste Stored On-site (including petroleum products)

		How Many?	Size?	Chemical?
	Drums			
	Tanks			
	Vats			
	Surface impoundments			
	Pits/landfills			
	Other			

Identify all chemical products Antea Group will use or store on site:
Alconox/Liquinox used for decontamination of equipment. HCl, nitric acid for water sample preservative. Common first aid ointments.

Material Safety Data Sheets (MSDSs) are **required** for site chemicals.
Please indicate where MSDSs can be found for this site:
(Attach as Appendix D)

[X] MSDS Log/Binder (In Field) [ ] Attached (Additional Info. Optional)

5.0 REMEDIATION SYSTEM INFORMATION

(Complete when applicable)

Is there a remediation system onsite? Yes [ ] No [x]

Describe: _____

List the Remediation System hazards identified at this site:

[ ]	Inadequate Ventilation	[ ]	Unguarded Equipment	[ ]	Slip, trip, fall or overhead hazards
[ ]	Noise Exposures	[ ]	Confined Space	[ ]	Security Issues
[ ]	Energized Equipment requiring lockout/tagout	[ ]	Temperature Extremes	[ ]	List Other:

If building ventilation system is not adequate, identify manual ventilation procedure: _____

Identify PPE/procedures required to mitigate the remaining system hazards identified above: _____

Have sound level surveys been conducted on site? Yes [ ] No [ ]

If "Yes," record range of survey results and approximate distance from source. Note: hearing protection must be worn if noise levels prevent normal conversation at a distance of three feet, or anytime noise levels are measured to be over 85 dB.

dBA	Source	Distance from Source	Date

Check all energy sources on the remediation site:

[ ]	Electrical	[ ]	Mechanical	[ ]	Other (describe) _____
[ ]	Thermal	[ ]	Hydraulic		
[ ]	Chemical	[ ]	Pneumatic		

Are written Lockout/Tagout procedures required? Yes [ ] No [x] Where are they located? _____

Remediation Systems in Shutdown Mode (See Antea Group's Lockout/Tagout practice for details)
Remediation systems that are shut down for **service or maintenance** reasons for extended periods of time, will be locked and tagged in accordance with the requirements of 29 CFR 1910.147, OSHA's Lockout/Tagout standard, outlined in Antea Group's Lockout/Tagout written practice.

Remediation systems shut down for business reasons **other than equipment service or maintenance** (i.e. outside the scope of 29 CFR 1910.147), and which will be left in that condition at least until the next visit by an Antea Group employee, will be secured in accordance with the following procedure.

a) The system will be locked, using a standard Antea Group padlock, so that the power cannot be turned on, and a yellow "caution" tag will be applied. The tag must include the following information:

   1) Caution
   2) Do not operate
   3) Do not remove the tag unless authorized
   4) Name of person applying the tag
   5) Date tag applied
   6) Reason why equipment is shut down

b) Systems shutdown and locked for other business reasons can only be unlocked and have the tag removed with the approval of the Antea Group Project Manager for the site or the Office Leader for that region. However, unlike systems locked and tagged under 29 CFR 1910.147:

   - The person applying or removing the lock and tag does not have to be an authorized Lockout/Tagout trained employee under 29 CFR 1910.147.
   - The person removing the lock and tag does not have to be the same person who applied the devices.

Remediation System Spill Prevention
Antea Group remediation systems are often designed with several controls to prevent spills. Check the controls below found on the system onsite.

☐	high/high alarms	☐	redundant high/high float	☐	List Other:
☐	secondary containment	☐	floor sump		
☐	transfer tank	☐	backwash tank		

Vessels, piping, valves and other system components should be inspected to detect leaks or the potential for future leaks. Floats should be routinely cleaned and tested to ensure for their proper functionality. Inspections and tests should occur at the frequencies outlined in the system O&M Manual or other maintenance documents.

In case of an emergency: shut down the system (if it is safe to do so), evacuate to the designated meeting point, and follow the emergency contact procedures in Section 2.4, as necessary.

Have procedures for remediation system shutdown or emergency procedures been provided to site owner or manager?

☐ Yes ☒ No

6.0 HAZARD EVALUATION

Identify all chemicals that are present or are suspected of being present on site and list their maximum concentrations in soil/water. Information on hazardous properties is listed in **Appendix D.**

Chemical Name	TLV/*PEL*	**Maximum Concentration in Soil	*Maximum Concentration in Water	Health Hazards/ Comments
Diesel Fuel	14 ppm	<14.5 ug/kg	298 ug/l	Possible Carcinogen. Exposure Routes: Inhalation, skin absorption, ingestion, skin and/or eye contact. Symptoms: Irritant eyes/skin coughing, headache, giddiness, pneumonitis, shortness of breath, chest pain, pulmonary edema, nausea, vomiting, cramping, headache, nausea, vomiting, fatigue. Target Organs: Kidney, gastrointestinal, blood, skin.
Ammonia	50 ppm	NA	3.5	Exposure Routes: Inhalation, skin absorption, ingestion, skin and/or eye contact. Symptoms: Irritation eyes, nose, throat; dyspnea (breathing difficulty) wheezing, chest pain; pulmonary edema; pink frothy sputum; skin burns, vesiculation liquid: frostbite. Target Organs: Eyes, skin, respiratory system.
Nitrates	1000 ppm	5.17	211	Exposure Routes: Inhalation, skin absorption, ingestion, skin and/or eye contact. Symptoms: Essentially non-hazardous, possible Irritation of eyes/stomach. Target Organs: None known.

(*P*) = results pending; (NA) = not analyzed; **For "Free Product/LNAPL use the soluble limit at Standard Temperature and Pressure.**
**Most recent results for each constituent for each well.*
*** Excludes soil results that have been verified by more recent borings to be unrepresentative of soil conditions*

Potential Hazards (check boxes that apply to the site):

	corroded containers		open lagoons		underground tanks		air stack emissions
x	overhead electric lines		visible leachate		surface tanks		visible on-site releases
	visible soil contamination		odors		observed tanks		visible off-site releases
	observed free product		dust		confined spaces		visible on-site erosion
	underground utilities		open pits		excess debris		on-site surface water contamination
	building contamination		no hazards		high traffic issues	x	Railroad tracks

List Other _____

7.0 PERSONAL PROTECTION & MONITORING EQUIPMENT GUIDELINES

7.1 Personal Protection

Level of Protection: B [ ] C [ ] D [X] List any modifications: See below

1. **All personnel working on Antea Group sites must wear: long pants, sleeved shirt (short sleeves are acceptable), hard hat, high visibility traffic safety vests (must comply with 23 CFR 634 high visibility clothing - ANSI/SEA 107-2004 Class 2 or 3), safety glasses and safety shoes. All PPE must be fully deployed from the time of site entry to departure from the site. Hearing protection must be kept with personnel at all times for quick deployment. Personnel may need to wear additional or more protective eye, ear and hand PPE appropriate for their work tasks.**

2. Nitrile / Tyvek gloves and tyvek/saranex suits should be worn if contact with contaminated water or soil is likely. Tyvek tops shall be worn when gauging wells with free product or engaging in free product removal.

3. Hearing protection must be worn if noise levels prevent normal conversation at a distance of three feet, or anytime noise levels are measured to be over 85 dB.

   Hearing protection, in the form of plugs or muffs, must be worn when Antea Group Employees are within:
   - 100 feet of a locomotive/refrigeration car or roadway/work equipment.
   - 15 feet of power operated tools
   - 150 feet of jet blowers or pile drivers
   - When background noise is so high that a worker has to shout to be heard at a distance of 3 feet
   - 150 feet of retarders in use (when within 10 feet, Contractor Employees must wear dual ear protection – plugs and muffs).

4. No smoking, eating, or drinking is allowed in the exclusion or contamination reduction zones. Smoking is only allowed in areas pre-approved by the Antea Group PM and client. **No Smoking is allowed anywhere on UP property.**

5. No Antea Group personnel shall conduct a permit required confined space entry. In addition, no personnel shall approach any excavation area where there is danger of a wall collapse.

6. Respiratory protection is dependent on conditions listed below Section 7.2. Minimum Level C respiratory protection for petroleum release sites consists of a half-face air purifying respirator with organic vapor cartridges. However, recommended cartridges for petroleum release sites are combination P100 filters with organic vapor/acid gas cartridges.

PPE

All Antea Group personnel and subcontractors who enter the site will be required to wear modified Level D PPE which will be fully deployed at all times while on the Union Pacific Railroad sites. Upgrades to modified Level D (tyvek) will be needed when handling free product. Level C may be necessary depending on site conditions and/or air monitoring. Current respirator fit testing documentation is required for personnel who may upgrade to Level C PPE attire.

PPE UTILIZATION REQUIREMENTS

Hard Hat (ANSI Z 89.1)	At all times (all PPE levels)
Leather Steel-toe boots (ANSI Z 41.1)	At all times (all PPE levels)
Rubber Steel-toe Boots	When ponded water is present, during rain events, etc., at the discretion of the Project Manager or Field Project Supervisor.
Safety Glasses/Sunglasses (ANSI Z 87.1)	At all times (all PPE levels, except when full-face respirators are used)
Hearing Protection	At all times near operating machinery (use arm's length rule); when noise level exceeds 85 dB, or within 100 feet of a locomotive engine.
Bright-colored Orange Traffic Safety Vest	At all times (all PPE levels) - must comply with 23 CFR 634 high visibility clothing-ANSI/ISEA 107-2004 Class 2 or 3)
Chemical Resistant Gloves (Nitrile)	Needed when handling recovered NAPL.
Cotton or Leather Work Gloves	As needed to mitigate hand/finger hazards identified in Tailgate Safety Meeting.
Rain gear; cold weather gear	As necessary when working in wet conditions.
Tyvek or other protective suit	When handling recovered NAPL or when conditions of potential exposure to contaminated soil or water exist as indicated by air monitoring (but below action levels), or by existing analytical data (Modified Level D). Required when in Level C PPE.
Snake Leggings or similar leg protection	When walking in vegetated areas of the site.
Life Vests (personal flotation devices)	When working from a boat or in water above ankle depth.
Other: attire	100% cotton clothing; blue jeans; shirts with minimum 4" sleeves; long hair must be restrained; no dangling jewelry

7.2 Surveillance Equipment and Materials

1. Calibration: A qualified individual will calibrate the photoionization detector (PID) or flame ionization detector (FID) before field activities.

2. Frequency: The worker breathing zone will be initially monitored every hour (at a minimum) and recorded in Appendix G. If previous site monitoring data indicates that there are exposures are below action level, monitoring frequency may be reduced, as long as site conditions have not changed and site activities will not create new exposures. Periodic monitoring can be stopped when site monitoring data indicates that breathing zone shows no hazardous conditions or air contaminants. However, if monitoring is stopped, data to support this decision must be available onsite for review. (Table for recording data is provided in Appendix G.)

   In addition to periodic site monitoring, breathing zone monitoring should always be conducted and documented (in Appendix G) during tasks that may result in continuing or new exposures, such as active drilling, probing, or excavating. If there are more stringent state or federal regulatory requirements for site monitoring, those requirements must be followed.

3. Instrumentation

Instrument	Breathing Zone Reading	PPE Upgrade or Other Actions To Be Taken
Photo ionization detector (PID) or Flame ionization detector (FID)	Total Org.Vapors Bkgrd - 2 ppm 2 - 100 ppm 100 - 300 ppm 300- 500 ppm >500 ppm	**Level D.** Work may continue. **Level D.** Collect benzene detector tubes (unless there is previous site data to show that benzene at these PID levels is below 0.5 ppm) **Level C.** Air-purifying respirator with organic vapor canisters required if levels continue for **two hours or more** in the breathing zone. Workers can choose to don respirators at lower levels if nuisance odors are a concern. Collect benzene detector tubes. **Level C if levels continue for 15 minutes in the breathing zone**. If levels continue beyond 15 minutes **STOP WORK**. Contact HSSE Specialist. **STOP WORK, leave immediate area--** Contact HSSE Specialist.
Benzene Detector Tube (Draeger, Rae, etc)	< 0.5 ppm 0.5-1 ppm >1 ppm	**Level D.** Work may continue. **Level C.** Work may continue. **STOP WORK**—Contact HSSE Specialist
Explosion Meter	< 10% of LEL 10 - 20% of LEL > 20% of LEL	**Work may continue. Evaluate inhalation potential.** **Work may continue. Eliminate all ignition sources, Reduce the concentration &increase monitoring** frequency, consider use of ventilation. **Work must stop until LEL is Below 10%!**
Oxygen Meter	< 19.5% O_2 19.5% to 23.5% O_2 >23.5% O_2	**Leave area.** Re-enter only with SCBA. **Work may continue.** Investigate causes of changes above/below 21%. **Work must stop.** Ventilate before returning and retest atmosphere. O_2-rich atmospheres pose explosion hazards.
Hydrogen Sulfide (H_2S) Colorimetric Tubes or Monitors-- Some states with high regional H_2S have special, local monitoring requirements.	0-5 ppm 5-10 ppm >10 ppm	**Continue working.** **Requires Level B** including supplied air respirator or SCBA. Increase monitoring frequency. Contact HSSE Specialist. Supplied air respirator required due to poor warning properties and toxicity.
Sound Level Meter	< 85 dBA 85 - 90 dBA > 90 dBA	Suggest wearing hearing protection when it is necessary to raise voice to be heard at distance of 3 feet. **Hearing protection required.** Install warning signs for fixed noise sources. **Hearing protection required.** Employer must have Hearing Conservation Program.

8.0 SAFETY STANDARD OPERATING PROCEDURES (ALSO SEE APPENDIX E FOR JOB SAFETY ANALYSIS)

8.1 Chemical Hazards

A photoionization detector (PID) or flame ionization detector (FID) will be used to measure the relative concentration of hydrocarbon vapors. Monitoring for exposure to benzene vapors may be done using activated charcoal tubes and vacuum pumps, vapor badges, or benzene colorimetric tubes in the breathing zone when working with heavily contaminated soil or water. Action limits for use of respiratory protective equipment are outlined in Section 7.2, above. All respiratory protection equipment shall be NIOSH/MSHA-approved and use shall conform to OSHA 29 CFR 1910.134. Antea Group's written Respiratory Protection Program detailing selection, use, cleaning, storage, medical monitoring, training, and fit testing of respiratory protective equipment is available to all employees via Antea Group's intranet.

In addition to being inhalation hazards, hydrocarbon compounds can also be absorbed through the skin. Skin contact with liquid hydrocarbons or fuel hydrocarbon-bearing soil should be prevented. In situations where sampling would result in direct skin contact with hydrocarbon liquids, saturated soil or contaminated equipment, nitrile gloves will be worn.

Drilling or digging may also liberate pockets of hydrogen sulfide (H_2S). While the characteristic "rotten egg" odor of H_2S is detectable at levels as low as 0.0005 ppm, prolonged detection is unreliable due to its olfactory fatigue properties. In open air on a typical petroleum remediation site, risk from exposure to H_2S is minimal. However, should H_2S be encountered or

expected, workers shall be instructed to stop drilling/digging and move to an upwind location until the vapors have dissipated, as measured by H_2S colorimetric detector tubes or other direct-reading instruments. The bore hole or excavation will be immediately backfilled.

When working in areas that are not open air and/or have to potential to accumulate gases or vapors, a combination explosimeter/oxygen (O_2) meter will be available on-site to monitor the levels of flammable gases, such as petroleum vapors and methane. An explosimeter should be used by a subcontractor to verify that the atmosphere inside an underground storage tank has been inerted prior to allowing the tank to be moved from its location.

8.2 Physical Hazards

1. Mechanical hazards: Ensure that mechanical equipment is properly guarded and overhead hazards are removed or secured to prevent being struck or entrapped by moving parts or heavy equipment or falling objects.

   Maintain a safe distance from heavy equipment and moving machinery parts.

   Tools and equipment used on site shall be in proper working condition. Workers using tools and equipment must be properly trained in their use.

   Antea Group has adopted a practice to eliminate the wide-spread use of fixed open-bladed knives (FOBKs), such as pocket or utility knives. FOBKs are not allowed on Antea Group field sites without prior approval by the Antea Group PM. Safer alternatives such as safety knives, shears, etc. should be used in place of FOBKs. See Antea Group's FOBK practice for more details.

2. Electrical hazards: Be aware of underground and overhead utilities. For protective measures against underground electrical cables see Section 8.3, Underground Utilities.

   For overhead power lines, OSHA requires a minimum distance of 10 feet from overhead lines transmitting up to 50kVs and an additional 4" of distance for every 10kV after 50kV, from any unguarded, energized overhead line. For example: 15 feet from lines transmitting up to 200kVs and 25 feet from 350kV lines. However, because power lines, rig masts and other elevated objects can move due to wind or other forces, **it is Antea Group's policy to maintain at least 20 feet clearance from any lines, or an additional 5 feet from any OSHA minimum distance that exceeds 20 feet.** If it is critical to work within 20 feet of a line, or at OSHA minimum distance, efforts should be made to have the lines covered ("shrouded") or shut off and locked out by the local power company. If neither can be accomplished, contact an Antea Group HSSE specialist to discuss.

   Generators, powered hand tools and extension cords used on Antea Group sites must be grounded. Extension cords must be inspected at the start of each work day to ensure that they are not damaged. Frayed or otherwise damaged extension cords shall not be used onsite, and must be taken out of service unless they can be properly repaired.

   Heavy equipment, including drilling rigs and vacuum trucks, must be grounded when the potential for static electricity build up and its uncontrolled release exists. Confirm with the equipment operator that equipment is grounded as needed. All equipment will be properly locked/tagged out when required by the Energy Lockout/Tagout Program and Safe Electrical Work Policy and Procedure for Antea Group Project Work. Do not stand in water when operating electrical equipment.

3. Open excavations: Open excavations deeper than 6 feet that are not clearly visible to site workers and the public must have fall protection measures in place, such as barricades and warning signs. When scheduling or work conditions necessitate leaving excavations open overnight, security fencing will be erected to restrict access to the site or work zones described in Section 2.9.

   Excavations must be properly constructed and maintained as per Section 8.12 of this HASP.

4. Hazardous plants or animals: Poisonous plants, and stinging, biting or other dangerous animals can be encountered on field sites. Identify workers with any allergies. Do not touch any plants that you cannot identify. Clear brush from monitoring well locations and other work areas. If necessary, arrange for vegetation removal by a landscaping company.

Do not approach or provoke any animals, including spiders or insects. If a worker is bitten or stung by insect or spider, provide first aid and monitor the worker for a reaction. If an insect, or spider bite is suspected to be serious, or a worker is bitten by snake or other animal, seek medical attention immediately. If the bite is not an emergency, call WorkCare at (888) 449-7787 for medical assistance.

5. Slip, trip fall hazards: will be minimized by maintaining good housekeeping practices at all times. Keep the work area free of debris, unused tools, extra supplies, or any other objects that could interfere with walking and working surfaces.

6. Traffic hazards: Railroad site work frequently necessitates working in parking lots, streets or other areas with vehicular traffic in addition to working in close proximity to railroad tracks. In such instances, the work team will be wearing neon traffic safety vests and will use a combination of traffic cones (each cone/flag configuration must be a minimum of 42-inches in height) and barricades as necessary to prevent contact between workers, pedestrians and motor vehicles. Please refer to the PM approved Site Specific Traffic Plan (sketch) attached in front of the Hospital Route Plan in the back of this HASP. When working around near or on railroad tracks make sure that the UP RR safety procedures are followed.

7. Rail Safety: activities will be performed at an active railroad service facility. All personnel involved in site operations conducted as part of the project shall adhere to the Health and Safety requirements of the UPRR Former HPWP facility in addition to the requirements identified in this plan.

8. Heat stress: the high temperatures and possible high humidity create a significant potential for heat stress-related illness.

9. Pinch-point hazards: the use of heavy equipment during drilling operations and other activities presents multiple pinch point hazards.

10. Poisonous snakes: rattlesnakes have been observed on the site.

11. Drowning: the steep slopes and potentially poor or uncertain footing along waterways, creeks, drainage ditches and other surface water bodies represent a potential hazard.

8.3 Underground Utilities

A minimum of 72 working hours prior to excavating, Underground Service Alert or the state equivalent will be contacted and informed of the scheduled field activities:

Name UPRR Call Before You Dig Phone (800) 336-9193

The underground service locator company will identify which underground utilities (e.g. electrical, gas, sewer, water, telephone, cable TV) are present and will notify their respective owners. The utilities will be located by their owners. Prior to drilling or direct push, air excavation to 120% the width of the hole and a depth of at least 5 feet will be performed at all times to ensure no utilities, lines or tanks are in the way. See Section 8.12. Overhead utilities should be identified, as well.

Utility service locator company has been notified? **If applicable attach contact sheet to back of document.**	Date(s)	Confirmation #, if applicable:	

If you are planning to drill the same location as a previously installed point and the diameter of the new boring/well is larger, you must manually clear the borehole.

8.4 Work Limitations (time of day, weather, heat/cold stress)

In the event of severe weather, such as high winds, heavy rain or snow, tornadoes, electrical storms, or extreme temperatures, the SSO and PM shall determine whether work can continue without compromising site worker health and safety.

In high ambient temperatures are present (especially with high humidity), ***follow heat-stress precautions***. Drink plenty of cool water and/or electrolyte-replacement beverages (e.g., Gatorade). Take frequent breaks out of direct sunlight removing protective clothing. Provide shade to workers if necessary. Increase the number of breaks if pulse does not return to normal resting pulse during breaks. Alter schedules so work is conducted during early morning or evening hours. Work shall progress only under conditions of adequate lighting.

Symptoms of heat exhaustion and heat stress include:

- Profuse sweating **or** complete cessation of sweating;
- Changes in skin color;
- Increased respiration;
- Vision problems, confusion;
- Body temperatures in excess of 100°F; and
- Increased heart rate.

Any member of the work team who exhibits these symptoms should immediately be removed from the area and observed while resting in a shaded area after removal of impervious or restrictive clothing and after consumption of cool water or electrolyte fluid. If symptoms persist, immediate medical attention shall be sought.

In cold temperatures, especially when combined with high wind, follow hypothermia precautions:

- Drink warm liquids and take frequent work breaks in a wind-sheltered area. Monitor co-workers for signs of shivering, lack of coordination, or confusion. Remove workers exhibiting these signs from the work area to a heated warming shelter.
- Dress in removable layers of insulated clothing to prevent sweating and use protective waterproof gear;
- Frostbite (superficial or deep tissue) can occur on any exposed skin at temperatures of 30.2°F or colder.
- If available clothing does not give adequate protection to prevent hypothermia or frostbite (which can occur on any exposed skin), work should be modified or suspended until adequate clothing is available or until conditions improve.

If extreme cold conditions are encountered (e.g. < 10° F), discuss proper clothing requirements and a warming break schedule with the Project Manager. Consider rescheduling the work if possible.

8.5 Fire and Explosion Hazards

Each site will be inspected for fire and explosion hazards during a pre-work site walk-through.

During the course of underground storage tank removal, drilling, or remediation of petroleum impacted soil or ground water, the potential for fire and explosion of flammable vapors exists. Extreme caution should be taken to monitor for the presence of flammable vapors or conditions that could create flammable conditions. Explosimeters are available for this monitoring and action levels are defined in Section 7.2. Fire extinguishers must be available on all sites with the potential for flammable vapors or electrical fires (i.e., systems, control panels). Use of fire extinguishers by employees trained in their use is limited to employee rescue or extinguishing relatively small, controllable fires. Antea Group does not expect or require its employees to fight fires.

In the event of a fire or explosion, the following action plan should be followed:

Shut down equipment and shut off all supply lines immediately if this can be done safely. (Notify the site operator to shut down operations, if necessary.)

Evacuate the immediate area. At this point you may not know if a soil vapor fire has started or if a supply line, natural gas line, etc. has been hit. Tank, supply line, or remediation system fires are extremely hazardous and precautions must be taken to evacuate the area immediately.

Call 911 to notify the fire department. Antea Group employees are not trained fire brigades. Every fire should be treated as an emergency. Even if site personnel extinguish the fire, professional fire departments should evaluate the situation to ensure that the danger is over and that a fire will not reoccur.

Evaluate the situation to identify the source of the flammable vapors and to assess the danger to employees, the public and property. From a safe distance, try to determine if the fire is due to a ruptured supply line, ignited soil vapors or methane, or is electrical. This information should be communicated to the fire department. Small fires from known sources (i.e., engine

fires, electrical panel fires, etc.) may be extinguished if the employee can do it without high risk. A soil vapor fire may eventually burn itself out. Soil stockpiles must be placed away from nearby structures and property lines. Extinguishing fires in fuel vapor-laden soils with clean soil may be possible. **Employees or subcontractors shall not enter an excavation to attempt to extinguish a fire.**

Fire, Explosion and Vacuum Truck Operations—vacuum truck operators must ensure that the truck and hoses are properly bonded and grounded prior to initiating vacuum operations and that vacuum truck hoses are properly tested for continuity each work shift.

Vacuum truck operators must ensure that the materials to be collected are compatible with residual materials that may already be in the truck or the truck must be washed prior to use. Hydrocarbons and other vapors created by the vacuum pump exhaust shall be vented away from the work area and away from areas where people are present.

See section 8.10 below for Hot Work requirements.

8.6 Noise/Hearing Protection

Workers shall be instructed in the recognition of noise hazards and shall be provided, and trained in the use of, hearing protective devices. Monitoring should be performed for on-site noise sources that are suspected to be above 85 dB. Record sound readings in Appendix H. If monitoring has not been performed for suspected noise sources, hearing protection must be worn. As a general rule, hearing protection should be worn when working around heavy equipment, particularly drill rigs, or when background noise is such that a worker has to raise their voice to be heard at a distance of 3 feet.

Hearing protection, in the form of plugs or muffs, must be worn when Antea Group Employees are within:

- 100 feet of a locomotive/refrigeration car or roadway/work equipment.
- 15 feet of power operated tools
- 150 feet of jet blowers or pile drivers
- When background noise is so high that a worker has to shout to be heard at a distance of 3 feet
- 150 feet of retarders in use (when within 10 feet, Contractor Employees must wear dual ear protection – plugs and muffs).

8.7 Levels of Protection

Work on Railroad sites must be performed, at a minimum, in the following Level D protection:

- hard hat (a Antea Group requirement, unless wearing the hard hat creates additional safety risks and there are no overhead hazards present),
- steel-toed (safety-toed) work shoes/boots, meeting ANSI/ASTM standards
- sleeved shirt (short sleeve minimum) and long pants, or cotton coveralls
- eye protection- safety glasses (ANSI Z87), goggles or face shield as required
- high visibility safety vest (ANSI Class II preferred)
- gloves- sampling (nitrile) or work (leather, synthetic leather, Kevlar, etc. depending on work tasks), and
- hearing protection, as needed.

If monitoring equipment or site conditions indicate the need to upgrade the level of protection to Level C at a petroleum release site, air-purifying respirators with organic vapor canisters (at a minimum) will be donned, Tyvek coveralls with hoods, chemical resistant inner and outer gloves, and disposable boot covers will be donned as necessary. Contact a safety specialist regarding dermal protection.

At no time will an Antea Group employee conduct work on any site requiring Level A protection. On work sites requiring Level B protection, workers will be provided with additional training and equipment. H&S Sr. Specialist must review and approve the work plan for Level B work before the work can be performed.

8.8 Decontamination Procedure

Level: B. [ ] C. [ ] D. [X]

Contamination may result from walking through contaminated soils or liquids, splashing liquids during sampling, use of or contact with contaminated equipment, or contact with air contaminants. Due to the volatile nature of petroleum hydrocarbons that may be encountered during drilling, hand-augering and sample collection procedures, the need to decontaminate equipment and vehicles will be minimal. Field team workers will be instructed to observe the following precautions to assure contaminants will not remain in contact with their skin.

- Tools, equipment and personnel will be decontaminated using procedure appropriate for level of personal protection worn.
- All contaminated, disposable clothing will be properly bagged for disposal and left on site. All personnel will be instructed to wash hands, face, neck and forearms at the end of the work shift and to shower at the end of the workday.
- No eating or drinking will be permitted in the vicinity of heavy equipment and/or drilling and excavating activities. Smoking is only permitted in pre-designated area when approved by Antea Group and the client.

Special decontamination requirements: _____

8.9 Confined Spaces

If entry into a confined space is necessary, a trained Antea Group subcontractor shall be used and a Confined Space Entry Permit must be completed and authorized, and confined space entry procedures followed. Detailed information on Antea Group's Confined Space Entry procedures can be found in the Antea Group Health & Safety Manual. Contact a Senior Health & Safety Specialist before any permit required confined space entry.

Does this site have any permit-required confined spaces?	Yes	[ ]	No	[X]
Does someone need to enter the permit-required confined space as part of the work?	Yes	[ ]	No	[ ]

If "yes," the Antea Group project team must confirm the subcontractor's permit required confined space program and employee training have been reviewed as part of the Antea Group pre-qualification process.

8.10 Hot Work

See Antea Group's Hot Work Practice for details on permit requirements, hazardous locations, and fire suppression requirements. Hot work is defined as work that requires electric or gas welding, flame cutting, any non-intrinsically safe electrical equipment, and other work equipment capable of producing flames, sparks, or ignition sources. Hot work permits must be provided when required by OSHA regulations. Concrete and asphalt coring, saw cutting, and air knifing may be considered hot work if performed in a location with potential for a hazardous atmosphere. Saw cutting, coring and air knifing **may not require a hot work permit**, however the following precautions should be in place.

- Subcontractor Job Safety Analyses (JSAs) for concrete or asphalt coring, saw cutting and air knifing should include the potential for sparking hazards associated with these tasks, and the mitigating measures taken to prevent sparking and the possibility of fires. (For air knifing, static electricity is a spark producing concern as well.)
- The field team must test the atmosphere with a PID, or explosimeter and O2 meter (if you think it may be warranted) to determine if the atmosphere is safe to work in. Action levels for PID, explosimeter and O2 meter readings are located in Section 7.2 of this document.
- Inspect the area to ensure it is free of material that could ignite if a spark landed on it (spilled fuel, wood/paper debris, highly flammable clothing, etc.).

- A worker will serve as a fire watch and observe the work, with a portable fire extinguisher (minimum size 10 lbs) within immediate access. The fire watch can stop when the spark producing work stops. The fire watch can be an Antea Group employee or a subcontractor employee. The job must be coordinated prior to arriving onsite.
- Use engineering and institutional controls to minimize or eliminate the hazard. When saw cutting, we should be performing wet cutting. Even when wet saw cutting, try to cut in a direction away from a vapor source so that any sparks travel away from the hazard.

Is a hot work permit required for this site? If so, please attach as an appendix to this HASP. Yes ☐ No ☐

8.11 Investigation – Derived Material Disposal

Soil cuttings and well development or sampling water shall be placed in 55-gallon drums on-site, unless on-site disposal is allowed under both regulatory and client requirements. Drums must be in sound condition (new or reconditioned drums) with lid that seals and can be tightened in place. Disposal methods of drummed soil and water will be determined based on laboratory analytical data.

Drums stored on site until disposal shall be labeled, sealed, and if possible, placed on an impermeable surface in a secure location prior to Antea Group's field team leaving the site. At a minimum, non-hazardous waste containers must be marked with a description of the material, and emergency contact information (company name and phone number). Hazardous waste must be marked and labeled so that the container complies with applicable DOT or RCRA requirements. Drums must be removed within 90 days of waste generation.

8.12 Excavations

All soil excavation and utility trenching is to be undertaken in strict conformance with all applicable local, state, and federal regulations. Subcontractors performing excavations on-site must have a competent person in charge of the excavation, who performs daily inspections of the excavation. Entry into excavated areas or trenches is allowed only when:

1. Shoring, sloping and spoil pile placement is in conformance with 29 CFR 1926 Subpart P, and
2. Personal protection and monitoring, as detailed in this Site Health and Safety Plan, have been implemented, and there is no hazardous atmosphere or other unsafe condition in the excavation.

9.0 DRILLING AND EXCAVATING HEALTH AND SAFETY GUIDANCE PROCEDURES

9.1 Prep

Prior to conducting any subsurface work, a mark-out must ALWAYS be called in (approximately three working days before field work is scheduled - depending on the area). In some areas, not all mark-outs are performed by the "Call Before You Dig System," thus contacting the appropriate utility companies and assuring their mark-outs must be tracked by Antea Group or the subcontractor responsible for the mark-outs. Private utility mark-outs should also be arranged when site work and conditions warrant it.

- Always search the file and request the client search files for an as-built of the facility.

9.2 When on Site

- Subcontractors are required to perform an on-site inspection of their heavy machinery each day prior to the start of fieldwork. The Antea Group Site Safety Officer (SSO) will observe the inspection. Any safety concerns identified by the subcontractor must be addressed prior to the use of the equipment. During the inspection, the subcontractor must verify that all rig/vehicle kill switches are working properly. Antea Group employees on-site must be informed of the location of the kill switches and how to operate them.

- As part of your on-site health and safety meeting, walk the site with the field team to identify any additional site hazards and determine possible boring locations (make sure the locations shown on the work plan/site plan are in areas free of utilities/subsurface structures). Make sure all utilities have been marked out properly. It is Antea Group's responsibility to ensure all boring or excavation locations are clear of utilities prior to drilling. Often "as-builts" are incorrect or not available.

- Attempt to determine how all utilities are running. For the most part, utilities can run anywhere and can bend and twist in any direction but, there are a few basic things to keep in mind. Usually water and sewer lines will run to a bathroom. Electrical lines will run in between on-site lights and buildings. Storm water drains usually tie into one another and you can get a general idea of how they run by looking into them and seeing what direction the line is going. Obviously any cut outs in the asphalt should be avoided, especially if observed around the USTs.

- WE SHOULD NOT DRILL OR EXCAVATE WITHIN TEN FEET OF ANY TANK FIELD, ASTs, USTs OR FUELING RACKS. IN ADDITION, DO NOT DRILL IN BETWEEN THE FUELING RACKS OR THE TANK FIELD, unless required by government agencies and approved by the client. Should drilling be required within ten feet of the above noted systems, an "air knife" should be utilized to a depth of at least ten feet below grade surface (bgs). Drilling within five feet of the above noted systems will require the fueling systems to be shut down. It may be helpful to open up tank field manways and identify the general direction that the product lines are running.

- ALWAYS AIR EXCAVATE (120% the width of the proposed hole) TO A DEPTH ONE FOOT BELOW THE ESTIMATED DEPTH OF UTILITIES AND AT LEAST FIVE FEET below ground surface. If you are drilling in the same location as a previously installed point and the diameter of the new boring/well is larger, you must manually clear the borehole. In addition, if you didn't advance the "old" boring yourself, you can't assume that it is a safe drilling location. Refusal may have been encountered in the "old" location. If refusal is encountered prior to five feet, move to a new location. If you make three attempts without success, call the project manager to discuss alternatives. If you can't reach the PM contact your Office Leader for further instruction.

- If you encounter pea-gravel while excavating STOP. Call the Antea Group PM for further instruction. Utilities or USTs may be present.

- If you hit/damage any utility/subsurface feature IMMEDIATELY contact the office for further instruction. If you can't reach the PM contact your Office Leader for further instruction. Also contact your HSSE Advisor.

9.3 Drilling Activities

- Drilling operations shall at all times be under the immediate supervision of a contractor's representative who has authority to modify the work methods as necessary to ensure safety.
- Contractors shall ensure properly designed cribbing (i.e., wooden mats) is always carried with the mobile drill rig to the work site.
- Where practical, drilling should always take place on "level" surfaces. If the proposed site is not level, consideration should be given to selecting another suitable site that is level, or to leveling the site by re-grading.
- Drilling locations must be clear of underground and overhead hazards as discussed in this HASP.
- Additionally, the guidance provided in the Environmental Remediation Drilling Safety Guidelines (ERDSG) industry document **should** be followed.

10.0 TRAFFIC CONROL AND ON-SITE VEHICLES/MOBILE EQUIPMENT

Petroleum site work frequently necessitates working in parking lots, streets or other areas with vehicular traffic. In such instances, the work team will be wearing high visibility traffic safety vests (ANSI Class II minimum recommended) and will use a combination of traffic cones (recommended height - 42-inches) and barricades as necessary to prevent contact between workers, pedestrians and motor vehicles. Proper placement of large contractor vehicles such as field trucks and drill rigs to add a layer of protection should be considered.

Check for specific DOT requirements when working in or near a road or road right-of-way. In such cases, traffic control set up will need to be subcontracted to a traffic control subcontractor.

The PM shall develop a **Site Specific Traffic Control Plan** for high traffic sites, or other high-risk locations. The plan (map) should include known site traffic patterns and the control equipment set up used to divert or restrict traffic and to define site work (exclusion) zones. **Include Traffic Control Plan in the "Figures" section at the end of the HASP.**

Onsite Vehicles:

- Enter and exit through the gates or pathway provided and designated for this use.
- Vehicles will not be driven over unprotected hoses or exposed piping.
- Vehicles may be left running **only** when operating auxiliary equipment or lights, and then only when driver can ensure the vehicle is secure with the transmission in park or neutral, the parking brake set and the wheels chocked.

- **Back-up Moves by Engr. Employees and Contractors (Rule Updated Date – April 23, 2013)**
  Work must be planned to minimize back-up moves and to avoid driving into areas requiring back-up moves. No back-up move is allowed when a forward move can safely be made. Employee(s) in the cab of a vehicle must not distract the driver with unnecessary conversation or other distractions until the back-up move is completed.

  Before initiating a back-up move, the driver must:

  1. Walk around the vehicle and confirm that it is safe to move unless a second person is directing the move as described in (A).
  2. Sound horn if back up alarm is inoperative or unavailable.

  When safe to do so, proceed not exceeding 5 MPH and complying with either (A) or (B) below.

  (A) When a second person is available to direct the back-up move (i.e any other employees or contractors in the vehicle or present at the work location):
  - A job briefing must be performed prior to movement, addressing the direction of move and position of person protecting the move.
  - The person directing the movement, when safe to do so, must be near the rear of the vehicle.
  - Driver must immediately stop if the person who is directing the movement disappears from the driver's view.

  (B) When a second person is not available:
  - The driver must stop every 150 feet, secure the vehicle and visually confirm that nothing has entered the path of the rearward movement of vehicle.
  - This will be repeated consecutively every 150 feet or until back-up move is no longer required.

  There are two exceptions to (A) and (B) above that do not require a second person to direct the moves or the driver to walk around the vehicle and then stop every 150 feet.

  (1) Short turn-around move or backing into a parking spot that requires a reverse moves of 15 feet or less if there are no other persons on the ground within 150 feet and the vehicle has pulled by the area to ensure a safe move can be made.
  (2) Delivery of materials or equipment to a work site if there are no persons on the ground within 150 feet of the move and there is no equipment standing on an adjacent track.

Earth Moving Activities:
All mobile earth-moving equipment on-site must comply with 29 CFR 1926.602 for back-up alarms or signal persons.

Dig and Haul Projects:
Dump trucks should only dump the load on **level** ground so the hazard of "tip-over" is avoided. If absolutely necessary, the dump truck can dump into the slope (i.e., back of truck facing directly uphill).

Any truck that has a raised bed dumping feature (i.e., dump-truck) must always lower bed before driving forward to leave the immediate work area. This is due to two hazards:

- *Tip-over* due to change in gravity of raised bed and
- *Hitting overhead obstacles* (like power lines or canopies).

11.0 JOURNEY MANAGEMENT PLAN

Provide directions for the preferred route from Antea Group's office to the field site, with the preferred/safest exit and entry points to the site. Also, provide any specific information of problem traffic areas that should be avoided when traveling in the area of the site. Information can be provided via maps, written instruction or both, as appropriate and available. Use the "Figures" section at the end of

the HASP. Information regarding onsite traffic flow and mobile equipment is provided in Antea Group's Traffic Control Plan in Section 10.0.

Additional Comments:

- Seatbelts must be worn by all occupants in traveling vehicles
- Including the requirements for drivers to have all appropriate licenses, and to have received defensive driver training within the last two years.

11.1 Lone or Isolated Worker

Workers shall not be put into a situation where he/she is left alone or isolated with no means of quickly summoning help should he/she become incapacitated due to injury or vehicle accident.

- A positive means of communication, i.e. a device such as a walkie-talkie, vehicle radio or cell phone, shall be provided to all field personnel.
- Lone employees shall check in with their supervisor or their field office at the start of the day, mid-day, and a final status report call at the end of the day (so others know where the worker is and that he/she is safe).
- In high hazard/crime affected areas, consider assigning two workers.

12.0 SUBCONTRACTOR TRAINING AND SAFETY DOCUMENTS

All subcontractors must meet OSHA training requirements for the work they will perform while onsite. Subcontractor workers that have the potential to be exposed to site impacts must have initial HAZWOPER training and up-to-date annual 8-hr refresher training. In addition, subcontractors driving on Antea Group business must have completed a defensive driver training class within the last two years.

Subcontractors shall be responsible for the development and implementation of their own HASP and/or job safety analyses (JSAs) to cover duties and hazards specific to that subcontractor's area of expertise or on-site functions. Subcontractors are given the opportunity to review Antea Group's HASP, and must sign the document, prior to the start of on-site work. Subcontractors are required to provide JSAs or written safety standard operating procedures, for the primary tasks they perform on-site. Contractors are required to review these safety documents with the work team during the appropriate on-site safety meetings (tailgate, etc). Any discrepancies or conflicting safety requirements between Antea Group and subcontractor HASPs shall be addressed prior to the start of field work.

All subcontractor employees must attend and participate in all on-site safety meetings as required by Antea Group. All on-site subcontractor workers must be able to effectively communicate with all field workers in English. If not, a translator/mentor must be assigned to those employees that cannot communicate in English to assure that all employees understand the safety information communicated on-site.

Any hazardous work situations, unsafe acts and conditions, near misses, or other safety incidents must be reported to the Antea Group Site Safety Officer immediately so that corrective measures may be taken, and the information can be reported to Antea Group management in a timely manner.

13.0 BEHAVIORAL SAFETY OBSERVATIONS

Behavior Based Safety is an established method of using reinforcement to change unsafe individual behaviors. The process starts with a behavioral hazard analysis to identify "at-risk" behaviors. These can be determined by using near miss/incident reviews, JSAs, audits, etc. Using the inventory of at-risk behaviors, a checklist is then developed to assist in the observation of work behavior. Observers record safe and at-risk behaviors and provide feedback to workers about their performance. The feedback reinforces the necessity for safe behaviors. Observation data also is used to identify barriers to safe behavior. Removing these barriers lowers the workers' exposure to at-risk conditions and makes it easier for employees to work safely. Antea Group has developed a behavior based safety observation (BBSO) checklist from an analysis of its near miss/incident data, JSAs and auditing data. The checklist is attached as Appendix I. Field teams should perform one BBSO per field event. BBSOs can be performed on Antea Group employees or subcontractors.

14.0 ADDITIONAL UPRR TRACK SAFETY AND REQUIRED TRAINING

The project will be performed at an active railroad facility, which presents numerous potential railroad related health and safety hazards. All personnel involved in site operations conducted as part of the project shall adhere to the following requirements:

- At the time of entry on UPRR property, the contractor (Antea Group or subcontractors) is required to notify the UPRR Site Remediation Manager as well as the site Representative in charge, of their presence, work area, activities, and duration on site.

- All personnel working on UPRR property will be required to wear ANSI-approved safety glasses with side shields, hard hats, and above the ankle safety-toe footwear that conforms with ANSI requirements. All personnel working or passing within 25 feet of the nearest rail are required to wear orange reflective vests. All personnel are to be informed of and comply with all other requirements for PPE as defined in this HASP, or OSHA regulations.

- The contractor must not wear red clothing as this indicates an emergency and, as such, requires an approaching train to stop.

  The contractor shall promptly notify the UPRR Project Manager of any OSHA reportable injuries occurring to any person that may arise during work performed on the job site. Likewise, the UPRR PM is to be immediately notified of the discovery of unknown materials or potentially explosive materials.

- The contractor shall have non-delegable duty to control its employees and subcontractors, while they are on the job site or any other property of the railroad (or any other property subject to the project) to ensure they do not use, are under the influence of, or have in their possession any alcoholic beverage or illegally obtained drug, narcotic, or firearms.

- In live-track operations, all personnel and equipment must maintain a distance of 25 feet, unless the contract necessitates working within this 25-foot exclusion zone. When doing so, employees and equipment must first have authorization from UPRR. When authorized work is within the 25-foot exclusion zone, a UPRR Employee-in-Charge must be present at all times unless the conditions outlined in the June 29, 2001 letter from Bill Wimmer, UPRR Sr. Assistant Vice President of Engineering, to all engineering contractors (discussed below) are met and work is not within 10 feet of the tracks. The Employee-in-Charge will authorize all movements within 25 feet of any tracks and define appropriate safety measures to govern work within this 25-foot exclusion zone.

- In live-track operations, if the contract necessitates personnel or equipment work within 25 feet of the track, all employees must first have authorization from UPRR, and have been trained and certified in "On Track Railroad Safety." On Track Safety procedures (UPRR, Chief Engineer's Bulletin 136.0; Appendix B) must be followed when personnel or equipment work within 25 feet of the track. **Maintain a distance of at least 25 feet to any track unless the railroad's EIC (Employee In Charge) is present to authorize movements."**

- All personnel must expect the movement of trains, engines, cars, or other moveable equipment at any time on any track, and in either direction.

- All unattended equipment including vehicles must be parked a minimum of 25 from any track and a minimum of 250 feet from any road crossing. Before leaving the equipment, the operator must stop the engine and secure the equipment against movement.

- Personnel must not stand on, sit on, walk on, or occupy track.

- Personnel must not walk between rails of the track unless required by assigned duty and have the proper protection provided. If required, personnel must step over and not on top of rails, frogs, switches, or guards when walking near or crossing tracks. When standing, walking or working between or near tracks, do not rely on other personnel to notify you of an approaching train, engine, or other equipment. Keep a careful lookout for trains, locomotives, cars, or other moving equipment.

- Unauthorized personnel are not permitted on equipment, including locomotives and cars.

- When required to cross tracks, employees must stop, look in both directions for approaching trains or equipment, if the track is clear, the employee must walk or drive straight across tracks when possible and keep a careful lookout in both directions for moving equipment. Keep a minimum distance of 20 feet from the nearest end of stationary rail cars. Expect movement of trains, engines, cars, or other moveable equipment at any time on any track, and in either direction. Extreme caution must be used at all track crossings.

- When a train is approaching, personnel working within 25 feet of the active rail must stop work, stop machines and equipment operation, and move away from the track. Personnel must stand clear of the track when trains are approaching and passing and do not stand on adjacent track. Personnel must never stand with their back to the approaching or passing train, and be aware of objects protruding from the train that could strike personnel or equipment.

- Violent arm, flag, or flashlight movement while trains are approaching and passing indicates an emergency and requires the train to stop, and must not be done unless an emergency exists.

- When employees are near passing trains or equipment, they must: move away from the track to avoid being struck by protruding objects; stand clear of the track when trains are approaching or passing; not stand on the track while trains are passing on an adjacent track.

- All personnel must maintain a safe distance from equipment and not: cross or step foul of tracks closely in front of or behind moving equipment or close to the end of equipment; go between equipment if the opening is less than 50 feet; cross tracks in front of or behind standing equipment unless there is at least 20 feet between the employee and the equipment.

- Employees must not get on, cross through, crawl, sit, or lie under cars, regardless of whether cars are standing still or moving.

- Any damage to UPRR property must be reported immediately to the UPRR Employee-in-Charge of the project and site. Any contact or damage to track, signal, or structure that could result in derailment is to be reported by the quickest possible means to the UPRR representative and the UPRR Response Management Communications Center at 1-888-UPRR-COPS (1-888-877-7267). Any release that causes pollution or contamination to UPRR property is prohibited. Should a release occur, it must be reported immediately to the UPRR Employee-in-Charge.

Based on a memorandum dated June 29, 2001 from Mr. Bill Wimmer, Vice-President - Engineering of UPRR, the following includes documentation of a policy exception granted to specific Engineering Department contractors who are engaged in conducting environmental investigations and cleanups. This policy exception allows these contractors to work without a railroad employee present at the work site under the following conditions:

- All contractor employees are trained on FRA's Roadway Worker Protection (RWP) regulations and UP's Minimum Safety Requirements for Engineering Department Contractors.

- A contractor employee will be assigned as the Employee-In-Charge (EIC) for purposes of On-Track Safety. The EIC must be qualified as such under RWP regulations. The EIC must ensure 100% rules compliance by all employees.

- No personnel or equipment may get any closer than 10 feet to the nearest rail of any tracks except to cross the tracks. If it will be necessary for personnel or equipment to work closer than 10 feet to a track, a qualified UP employee must be present to provide the appropriate form of On-Track Safety (see Appendix B for further details on On-Track Safety- Chief Engineer's Bulletin 136.0).

- Equipment or vehicles may not cross the tracks anywhere but at a road crossing.

- A RWP-qualified lookout must provide Train Approach Warning when personnel or equipment will be working within 25 feet of any track. The EIC may serve as the lookout as long as he/she is not performing any other duties. When warned of an approaching train, all personnel must immediately move to a place of safety that is at least 25 feet from any track.

- The EIC must participate in a job briefing with the designated railroad representative prior to work each day. This job briefing may be conducted over the telephone but, at a minimum, must include a discussion of the work areas, speed of trains through that area, sight restrictions and other operating conditions. EIC must be reminded that trains do not whistle in advance of private road crossings. The EIC will then conduct a thorough job briefing with all contractor employees prior to work.

- All contractor employees must wear orange, reflective vests or similar workwear approved by the railroad's representative any time they are working within 25 feet of any track. Level D personal protective equipment (PPE), as described in Section 7.0, as well as hearing protection is required at the Site.

Working Around Live Tracks (Red Zones)

Prior to beginning work on live track the Contractor-In-Charge must notify a Railroad representative and a job briefing must be conducted with the Railroad representative. Engineering Department Contractors are governed by FRA Roadway Worker Protection regulations, referenced in Section 6, which requires some form of On-Track Safety prior to fouling any track.

Red Zones are defined as that area within an arm's length of the track, or any physical position, which places the employee in a life-threatening situation. The following two rules are key to Red Zone compliance.

Alert to Train Movement

Contractor Employees must expect the movement of trains, engines, cars or other moveable equipment at any time, on any track and in either direction.

Sufficient Distance

Maintain a safe distance from equipment and DO NOT:

- Cross or step foul of tracks closely in front of or behind moving equipment or close to the end of equipment.
- Go between standing equipment if the opening is less than 50 feet.
- Cross tracks in front of or behind standing equipment unless there is at least 20 feet between the employee and the equipment.
- Use three-point contact when getting on and off locomotives and cars.

In locomotive and car repair facilities where equipment has been spotted for repair, and the distance between that equipment or around the end of equipment is less than specified, Contractor Employees may go between or around the equipment provided that the equipment is under Blue Signal Protection of Workmen in accordance with Rule 5.13 and the employee knows that no movement will be made by the equipment.

These are two of many Red Zone rules that deal with moving equipment. Any questions that arise related to working in the Red Zone should be directed to the Railroad Representative.

14.0 ACKNOWLEDGMENT AGREEMENT

14.1 Antea Group Employee

SITE HEALTH AND SAFETY PLAN REVIEW RECORD

I acknowledge that I have read and understood the contents of this Site Health and Safety Plan and I agree to abide by all provisions as set forth. I have also checked in with the site client contact to alert them of our presence and for any daily safety issues. Please note: "no implements are to be brought on a Antea Group site, or while performing Antea Group business that are, or are intended to be used, as weapons (such as: guns, knives, etc.)". Firearms are expressly prohibited. By signing below you are certifying, that this policy is upheld. Antea Group retains the option to audit your personnel and equipment to assure your compliance.

NAME	SIGNATURE	CELL PHONE	DATE

NAME	SIGNATURE	CELL PHONE	DATE

14.2 Subcontractor & Visitor

SITE HEALTH AND SAFETY PLAN REVIEW RECORD

I have been given the opportunity to review the Health and Safety Plan for this site and have been briefed on its contents and on the nature of the contaminants and the level and degree of exposure likely as a result of participation in this project. I agree to conform to all the requirements of this plan. (This HASP does not replace the requirement or liability for your company to have its own safety program and HASP.) I also acknowledge that this plan is specific for this Antea Group site and may not address unforeseen hazards not included in the Site Health and Safety Plan or your specific contracted task. Please note: "no implements are to be brought on a Antea Group site, or while performing Antea Group business that are, or are intended to be used, as weapons (such as: guns, knives, etc.)". Firearms are expressly prohibited.

By signing below I am certifying that this policy is upheld. Antea Group retains the option to audit your personnel and equipment to assure your compliance.

ALL WORKERS HAVE THE AUTHORITY TO STOP, AND/OR REFUSE TO PERFORM, ANY UNSAFE WORK.

NAME & AFFILIATION	SIGNATURE	8 Hr. Refresher *(Date Taken)*	E-Rail Safe *(Date Taken)*	CELL PHONE	DATE

NAME & AFFILIATION	SIGNATURE	8 Hr. Refresher *(Date Taken)*	E-Rail Safe *(Date Taken)*	CELL PHONE	DATE

APPENDIX A
DAILY TAILGATE MEETING
OUTLINE/CHECKLIST

DAILY TAILGATE MEETING OUTLINE/CHECKLIST

SITE INFORMATION	
Date:	
Site Name:	Ft. Scott, KS – Double Circle Farm Supply Site
Site Location:	Northwest of National Avenue and W. Elm Street, Fort Scott, KS
Project / Site Number:	UPR-8363-A
Name of Antea Group Employee Leading Meeting	
Title of Antea Group Employee Leading Meeting:	

	YES	NO
Are all field team members in attendance for the tailgate meeting?		
Are there potential language barriers or concerns?		
Is safety information provided in language(s) that all workers understand? (If no an interpreter is required.)		
Identified worker with the least years of experience. Name: Company:		
How many years (or months) experience for worker? # of yrs / months:		
How many workers have less than 1 year experience?		
Is each one assigned an on-site mentor?		

TAILGATE DISCUSSIONS POINTS ***(see next page for additional guidelines)***	**COVERED**	
	YES	**NO**
INTRODUCTION- site background, field team introductions, training documentation review		
SITE HAZARDS- perform site walk-thru with team, locate utility markings, work locations, ID any site hazards		
Locate site/facility Emergency Stop switches		
EMERGENCY ACTION PLAN - emergency #s, evacuation signal & routes (walk them), 1st aid kits, training, etc		
WORK HAZARDS- scope-of-work, etc		
Antea Group discuss safety of Antea Group tasks to be performed- review JSAs		
Contractor(s) discusses safety of contractor work tasks to be performed- review JSAs		
List JSAs reviewed		
Heavy machinery inspection, kill switches located and tested		
Hand tools, power tools and other equipment inspected ***INSPECT portable fire extinguishers onsite***		
On-site impacts, other chemical on-site- monitoring procedures, PPE upgrade and action levels		
ONSITE VEHICLE MOVEMENT AND SPOTTER REQUIREMENTS - discuss movement of work vehicles and spotter procedures		
HIGHLIGHT SPECIFIC WORK CONCERNS- e.g. excavation, drilling, utilities, power lines, traffic, weather, etc.		
PPE REVIEW - review standard PPE, upgrades needed		
Gloves available on site match the glove type(s) listed in the JSAs for today's work? *NOTE: Any gloves not listed in JSA cannot be used onsite without management approval and field editing of onsite JSA*		
TRAINING		
1. Current (annual) On Track Safety Training completed? Personnel being compliant?		
2. UPR engineering Department required safety training?		
3. OSHA 40 Hour training? Cards on person?		
NOTIFICATIONS		
1. Cable & utility locates completed?		
2. Communicated effectively with local railroad personnel.		
3. Coordinated job activities with operating department personnel?		

DAILY TAILGATE MEETING OUTLINE/CHECKLIST

4. Notified Security (UPR Police) of presence on railroad property.		
5. Aware of requirement to notify UPR of any OSHA reportable injuries occurring on the job site?		
6. Maintain control of employees while on the job site and ensure compliance with UPR Drug and Alcohol policy? Immediately report non-compliance to UPR project manager.		
7. UPR No Smoking Policy.		
ON-TRACK SAFETY REVIEW		
1. Working within 25' of track requires a flagman (Engineering Department rule).		
2. Working within 4' of track (Fouling track)?		
3. Instruct proper way to cross tracks?		
4. When crossing between cars, 2 car lengths distance required.		
5. When walking near a locomotive, establish eye contact with operator.		
6. Discuss Red Zones at every HASP meeting.		
7. Type of On Track Safety being used? Train Approach Warning - TAW		
ANTEA GROUP OR CLIENT SPECIFIC SAFETY PROTOCOLS - FOBK practice, utility clearance requirements, etc.		
REQUIRED PERMITS. LIST:		
PROACTIVE SAFETY ACTIONS - report all near misses, stop work authority, STOP WORK as needed,		
FEEDBACK - Worker questions, comments, concerns		
Have all worker signed the site health and safety plan?		

DAILY TAILGATE MEETING OUTLINE/CHECKLIST

TAILGATE MEETING ATTENDANCE *(use additional sheets if required)*		
Worker Name	**Company Name**	**Signature**

AFTERNOON TAILGATE MEETING		YES	NO
Afternoon Tailgate held?			
List Topics:			
Name & Title or worker leading afternoon tailgate meeting:			

DAILY TAILGATE MEETING OUTLINE/CHECKLIST

DAILY TAILGATE MEETINGS

Daily tailgate meetings shall be held at the start of each work day, shift or task change.

The daily tailgate meetings shall review the planned work activities for the day, discuss and resolve the risks and mitigations, discuss any Health, Safety, Security and Environment (HSSE) concerns and raise the HSSE consciousness of each worker before they start work.

These meetings shall include, but are not limited to:

- A review of relevant Health and Safety Plan (HASP) elements to be performed at an appropriate frequency. A review shall be done whenever the HASP is updated and should also be done regularly to remind workforce of relevant elements.
- A Hazard Communication (HAZCOM) review.
- Address the risks of any issues arising from the site walk and the location of on-site equipment and materials.
- Complete the tailgate safety meeting forms.
- A review of applicable permit/s.
- A review of the right and obligation to 'Stop Work.'
- Complete and review *Job Safety Analyses* (JSAs) for the tasks to be completed. The focus should be on how to complete activities on a given site during that work day and activity. The JSA discussion should include identification of 'Stop Work' triggers.
- Implement the controls set forth in the HASP and JSAs. Verify that all parties on site have a complete understanding of the work plan and controls that are in place.
- In addition, allocate resources and complete permits.

PARTICIPATION AND PREPARATION

Effective daily tailgate meetings require participation. Team members should recognize the connection between the meetings and their personal safety.

Involvement of all team members is a critical factor for a successful meeting.

The conductor of the daily tailgate meeting shall prepare by achieving a thorough understanding of: JSAs, HASP, the scope of work, the subcontractors on site, and client requirements.

Additionally, the conductor of the meeting should have the required checklists available to verify that he or she covers all applicable and necessary topics.

TAILGATE MEETING LOCATIONS

When selecting the location of the meetings, the following shall be considered:

- Safety of personnel.
- Background noise.
- Uncomfortable or cramped locations.
- Weather and environment.

APPENDIX B
I-3 FIRST REPORT FIELD FORM

I-3 – FIRST REPORT FIELD FORM

All injuries/illnesses to Antea Group employees, contractor employees, and contractor or subcontractor employees require immediate notification to your Manager, and Lisa Hartwig or Dustin Rusch

GENERAL INFORMATION	
Antea Group Employee Name Reporting:	
Date of Incident:	
City/State of Antea Group Office:	St. Peters, MO
Site Project/ID Number:	UPR-8263-A
Site Location (Street, City, State):	Northwest of National Avenue and W. Elm Street, Fort Scott, KS
Antea Group Project Manager Name:	
Subcontractor Name (if applicable):	
Incident Location (Street, City, State):	
Short Description of Incident:	

CONDITIONS					
Weather:		Temperature:		Lighting:	

WHEN DID INCIDENT OCCUR						
	Month	Day	Year	Time (hrs)	(min)	AM/PM
Occurred						
Reported						

DETAILS		
Witness Name (s)	Employee/Contractor/Other	Phone #

Equipment Involved:	
Incident Type:	

Environmental Release Info	Product / Material	Amount	Unit

Full Description of Incident:	
Immediate Actions Taken:	

Reported by:	
Date:	

APPENDIX C
e-RAILSAFE BADGES

APPENDIX D
HAZARDOUS CHEMICAL PROPERTY INFORMATION
AND
MSDS (MATERIAL SAFETY DATA SHEETS)

PETROLEUM CLASS III HASP--HAZARDOUS PROPERTY INFORMATION (REV. 12-05-00)

Material	Water Solubility A & B	Specific Gravity[C]	Vapor Density[D]	Flash Point °F[E]	Vapor Pressure mm/Hg[F]	%LEL/ %UEL[G]	LD 50 mg/kg[H]	TLV-TWA *PEL*[I]	IDLH Level[J]	Recommended Respiratory Protection/Max. Use Concentration *Odor Threshold*[K]	Hazard Property[L]	Dermal Toxicity[M]	Acute Exposure Symptoms[N]
Benzene	0.18%	0.877	2.8	12	75 (20 °C)	1.2/7.8	930	*0.5 ppm* 1 ppm	500 ppm	½/OV/1ppm FF/OV/10 ppm *4.68 ppm*	BCDGI	CGI	BCDFHIKLMNO QR
Diesel Fuel	Insoluble	0.81-0.90	NA	130	NA	0.6-1.3 6-7.5	None Estab.	100 mg/m³ (14 ppm)	None Estab.	*0.7 ppm*	BCD	CI	BCDFHIKLMNP
Ethylbenzene	0.014%	0.867	4.45	70	10 (26 °C)	0.8/6.7	3500	100 ppm *100 ppm*	800 ppm	½/OV/1000 ppm *140 ppm*	BCDI	CFI	ABFHIKLMNPQ R
Gasoline	Insoluble	0.72-0.76	3-4	-50	Var.	1.4/7.6	None Estab.	300 ppm	None Estab.	½/OV/300 ppm *.25 ppm*	BCD	CI	BCEFHIKLMNP
Kerosene	Insoluble	0.83-1.0	4.5	100-165	5	0.7/5.0	None Estab.	100 mg/m³	None Estab.	*1 ppm*	CD	CI	BCDFHIKLMNP
Lead (elemental)	Insoluble[B]	11.34	NA	NA	NA	NA	Varies by Cmpd.	0.05 mg/m³ *0.05 mg/m³*	100 mg/m³	½/HEPA/0.05 mg/m³ FF/HEPA/0.25 mg/m³	C		ACDFGHOR
MTBE (methyl tertiary butyl ether)	Moderate	0.74	Unavlbl.	-16	245 (25 °C)	1.6/8.4	2.96 g/kg	40 ppm *None Estab.*	None Estab.	Unavailable	BD	A	BFK
Naphthalene	Insoluble	1.145	4.42	190	.23 (25 °C)	.9/5.9	490	10 ppm *10 ppm*	250 ppm	½/OV/10 ppm FF/OV/<50 ppm	C	CGI	BKLNQ
Tetraethyl lead	Insoluble[B]	1.653	8.6	199	0.2 mm (20 °C)	1.8/ Unkn	12.3	0.10 mg/m³ (Skin) *0.075 mg/m³ (Skin)*	40 mg/m³	Supplied Air Warning Unknown	CG	CFI	N
Tetramethyl lead	Insoluble[B]	1.999	6.5	100	22.5 mm (20 °C)	Unkn/ Unkn	105	0.15 mg/m³ (Skin) *0.075 mg/m³ (Skin)*	40 mg/m³	Supplied Air Poor Warning	CG	CFI	N
Toluene	0.05	0.866	3.2	39	21 (20 °C)	1.27/7	2000	50 ppm (Skin) *200 ppm*	2000 ppm	½/OV/200 ppm FF/OV/400 ppm *0.17-40 ppm (300-400 ppm)--Olfactory Fatigue*	BCI	BHE	BEFHIKLMNOP Q
Xylenes	Insoluble	0.868	3.68	63-81	9 mm (20 °C)	1.1/6.6-7.0	5000	100 ppm *100 ppm*	900 ppm	½/OV/<100 ppm	BCI	CFI	BEFHIKLMNP

RAILROAD HASP--HAZARDOUS PROPERTY INFORMATION
Explanations and Footnotes

A	Water solubility expressed as 0.2 g means 0.2 grams per 100 grams of water at 20 °C. Water solubility is expressed in different terms in different references. Many references use the term "insoluble" for materials that will not readily mix with water, such as gasoline. However, most of these materials are water soluble at the part per million or part per billion level. Gasoline, for example, is nearly insoluble and will be found as a discrete layer on top of the ground water. But certain gasoline constituents, such as benzene, toluene, and xylene, will also be found in solution in the ground water at the part per million or part per billion level.
B	Solubility of metals depends on the compound in which they are present.
C	Specific gravity is the ratio of the density of a substance to the density of a reference substance. For solids and liquids, the reference substance is water; for gases, the reference substance is air. Specific gravity is expressed in units of g/cc (for solids and liquids) or g/l (at 0 °C and 760 mm Hg) for gases.
D	Vapor density is the weight/unit volume expressed as grams/cubic centimeter liquids.
E	Flash point is the temperature at which a liquid or volatile solid gives off sufficient vapor to form an ignitable mixture with the air. Flash points may be determined by the open cup method or closed cup method. Several chlorinated hydrocarbons exhibit no flash point in the conventional sense, but will burn in the presence of high energy ignition sources or will form explosive mixtures at temperatures above 200 °F.
F	Vapor pressure is the pressure at a given temperature of a vapor in equilibrium with its liquid or solid form. It is expressed as mm Hg at 1 atm. Temperatures vary...see chart.
G	Lower explosive limit (LEL) and Upper explosive limit (UEL) are the minimum and maximum concentrations of a gas or vapor in air that will support flame. LEL and UEL are expressed as % in air at ambient or room temperature.
H	LD_{50} is the quantity of a substance administered by ingestion that is necessary to kill 50% of the test animals exposed to it within a specified time.
I	Threshold limit value as a time-weighted average (TLV-TWA) is the concentration for a normal 8-hr workday and 40-hr work week to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. Values reported are the current ACGIH Threshold Limit Value-Time Weighted Average (TLV-TWA) and OSHA Permissible Exposure Limit (PEL). All PELs are based on pre-1989 values, per OSHA's 1993 decision to vacate the 1989 PELs.
J	Immediately Dangerous to Life and Health (IDLH) concentrations represent the maximum concentrations from which, in the event of a respirator failure, one could escape within 30 minutes without a respirator and without experiencing any escape-impairing or irreversible health effects.
K	Recommended Respiratory Protection/Max. Use Concentration is used to show the limits for respirator style and contaminant concentration. The codes in the table refer to the following: ½ = Half-face, air-purifying respirator FF = Full-face, air-purifying respirator OV = Organic vapor canisters HEPA = High Efficiency Particulate Air canisters PAPR = Powered Air-purifying Respirator The Odor Threshold is the lowest concentration at which one may detect an odor or experience a warning effect such as taste, eye irritation, etc., which varies with individual susceptibility.
L	Hazard Property: A - Corrosive; D - Volatile; G - Carcinogen B - Flammable; E - Reactive; H - Infectious C - Toxic; F - Radioactive; I - Reproductive Toxin *Note: A reproductive toxin is a compound (chemical) that affects the reproductive organs (generally the sperm and eggs, but sometimes the physical structure of the testes or ovaries, too). It can affect the reproductive organs of males, females, or both; it can affect the reproductive organs of an adult or child; it can affect the reproductive organs of a developing fetus with or without affecting the mother.*
M	Dermal toxicity data is summarized in the following three categories: 1. **Skin Penetration** A - negligible penetration (solid-polar) + B - slight penetration (solid-nonpolar) ++ C - moderate penetration (liquid/solid-nonpolar) +++ D - high penetration (gas/liquid-nonpolar) 2. **Systemic Potency** E - Slightly Toxic (LD50 = 5 - 15 g/kg) Lethal dose for 70 kg adult = 1 pint to 1 quart F - Moderately Toxic (LD50 = 0.5 - 5 g/kg) Lethal dose for 70 kg adult = 1 ounce to 1 pint G - Extremely toxic (LD50 = 5 - 50 mg/kg) Lethal dose for 70 kg adult = 7 drops to 1 teaspoon 3. **Local Potency** H - slight - reddening of the skin I - moderate - irritation/inflammation of skin J - extreme - tissue destruction/necrosis
N	Acute Exposure Symptoms A - abdominal pains; G - diarrhea; M - respiratory irritation B - central nervous system depression; H - drowsiness; N - skin C - comatose; I - dyspnea; O - tremors D - convulsions; J - fever; P - unconsciousness E - confusion; K - headache; Q - vomiting F – dizziness; L - nausea; R - weakness

APPENDIX E
FIVE (5) DAY SAFETY CHECKLIST
(OPTIONAL)

5 DAY SITE SAFETY CHECKLIST
(OPTIONAL)

Site Name:	Fort Scott, KS – Double Circle Farm Supply Site
Project Number:	UPR-8263-A

DATE:			
Pre-Mobilization		**OK**	**NA**
Updated health and safety plan			
Emergency phone numbers for utilities included			
Proper personal protective equipment (PPE) selected & inspected			
• Hard Hat			
• Safety Glasses (with side shields)			
• Safety Vest			
• Work Gloves			
• Sampling gloves (PM specify type):			
• Protective coveralls (specify, Tyvek, Nomex, etc.):			
• Safety Boots			
• Respirator/cartridges (PM identify proper cartridges) :			
Other Protective Equipment			
Eye wash (check expiration date)			
Fire extinguisher (visually inspected within last 30 days)			
First aid kit (inventory and check expiration dates)			
Safety cones (or flashing traffic light)			
Underground utility hazards identified and addressed			
Underground utility hazards identified and addressed (provide public utility one-call ticket or job number			

On-Site Pre-Work	**DATE (mm/dd/yy)**				
Review site hazards and HASP w/ site workers					
Notified UPR EIC about the days schedule activities					
Review route to hospital					
Site workers sign HASP acknowledgement page					
Place HASP and emergency numbers in visible location					
Designate evacuation signal and meeting place					
Delineate exclusion zone					
Check subcontractor PPE-					
• Hard Hat					
• Safety Glasses (with side shields)					
• Work Gloves					
• Sampling Gloves					
• Protective Coveralls (specify, Tyvek, Nomex, etc).					
• Safety Boots					
• Respirator					
• Subcontractors					

5 DAY SITE SAFETY CHECKLIST (OPTIONAL) (continued)

On-Site Pre-Work	DATE (mm/dd/yy)				
Subcontractors-					
• Subcontractor has own HASP or field SOPs on-site (when required)					
• Confirm sub. Equipment (e.g., drill rig, ext. cords) is in sound working condition)					
• *Drilling subcontractor:* drill rig kill switch identified, located and tested					

On-Site Work	DATE (mm/dd/yy)				
Proper PPE worn by site workers					
Breathing zone monitoring performed and recorded					

UPR ON-TRACK SAFETY REVIEW	DATE (mm/dd/yy)				
Working within 25 feet of track requires UP Flagman					
Working within 4' feet of track. Fouling track-Understand definition of Red Zone					
Proper way to cross track.					
When crossing between cars, 2 car lengths required.					
Make eye contact with train operator.					

(Specify any new hazards identified on-site not addressed by site HASP. If new hazard cannot be mitigated by the existing scope-of-work and/or available equipment on-site, stop work and immediately contact the site project manager.)

(Sign and date at the end of the field work.)

Name:	
Signature:	
Date:	

REPORT ALL INCIDENTS AND NEAR MISSES IMMEDIATELY

APPENDIX F
JOB SAFETY ANALYSIS

JOB SAFETY ANALYSIS

Job Safety Analysis for: ***(State Task)***			
CONTRACTOR:	*Antea Group Consultants*	DATE:	
PROJECT MANAGER/SITE SUPERVISOR (List Name(s)::)			
PERMITS REQUIRED (Y/N) List Type: **?**			
JSA TEAM MEMBERS:			
LOCATION OF WORKSITE	Street, w/Cross Street:		
	City, State, Zip:		
DESCRIPTION OF WORK:			
Team Leader Reviewed by Signature:		Date:	

Sequence of Basic Job/Task Steps *List the tasks required to perform the activity in the sequence they are carried out.*	**Potential Hazards (Energy Sources) Involved with Task/Environment** *Against each task list the hazards that could cause injury when the task is performed.*	**Control Measures (Eliminate, Control, Protect)** *List the control measures required to eliminate or minimize the risk of injury arising from the identified hazard.*	**Stop Work Triggers** STOP

JOB SAFETY ANALYSIS

Sequence of Basic Job/Task Steps *List the tasks required to perform the activity in the sequence they are carried out.*	**Potential Hazards (Energy Sources) Involved with Task/Environment** *Against each task list the hazards that could cause injury when the task is performed.*	**Control Measures (Eliminate, Control, Protect)** *List the control measures required to eliminate or minimize the risk of injury arising from the identified hazard.*	**Stop Work Triggers**

JOB SAFETY ANALYSIS

Sequence of Basic Job/Task Steps *List the tasks required to perform the activity in the sequence they are carried out.*	Potential Hazards (Energy Sources) Involved with Task/Environment *Against each task list the hazards that could cause injury when the task is performed.*	Control Measures (Eliminate, Control, Protect) *List the control measures required to eliminate or minimize the risk of injury arising from the identified hazard.*	Stop Work Triggers

APPENDIX G
AIR MONITORING LOG

AIR MONITORING LOG

PAGE _____ OF _____

PROJECT NUMBER:	UPR-8263-A	EMPLOYEE NAME:	
PROJECT NAME:	FORT SCOTT, KS – DOUBLE CIRCLE FARM SUPPLY SITE	DATE:	

Equipment	Sampling For	Serial Number	Calibration Date
Photo Ionization Detector (PID):			
Flame Ionization Detector (PID):			
Combustible Gas/Oxygen Meter			
Detector Tube Pump (e.g., Draeger, Sensidyne)/ Colorimetric Detector Tubes			

Weather Conditions:	Temperature:		Relative Humidity:	

Sample Time (indicate am or pm)	PID Reading (ppm) *background=*	FID Reading (ppm) *background=*	Combustible Gas/ Oxygen Meter Readings (indicate %LEL and $\%O_2$) *background= %LEL ___ %O2*	Colorimetric Detector Tube Reading (indicate units: ppm, %, etc.) *background = N/A*	Sample Location and Activity Occurring During Sampling	Comments, Including Breathing Zone or Area Sample, PPE Worn, and Actions Taken *BACKGROUND READING*

AIR MONITORING LOG

Sample Time (indicate am or pm)	PID Reading (ppm) *background=*	FID Reading (ppm) *background=*	Combustible Gas/ Oxygen Meter Readings (indicate %LEL and $\%O_2$) *background= %LEL___ %O2*	Colorimetric Detector Tube Reading (indicate units: ppm, %, etc.) *background = N/A*	Sample Location and Activity Occurring During Sampling	Comments, Including Breathing Zone or Area Sample, PPE Worn, and Actions Taken *BACKGROUND READING*

PAGE _____ OF _____

APPENDIX H
SOUND LEVEL SURVEY LOG

SOUND LEVEL SURVEY LOG

PAGE _____ OF _____

PROJECT NUMBER:	**UPR-8263-A**	**EMPLOYEE NAME:**	
PROJECT NAME:	**FORT SCOTT, KS – DOUBLE CIRCLE FARM SUPPLY SITE**	**DATE:**	

Project Number:_____ Project Name:_____ Date:

Serial Number (SLM):		Serial Number (Calibrator:	
Calibration Readying (dBA):		Polst Sampling Calibration Reading* (dBA):	

* Calibration readings will depend upon the calibrator that is being used.

Sample Time (indicate am or pm)	Readings (dBA)	Specific Activity Occurring During Sampling	Noise Source/Sample Location**	Comments, Including PPE Worn and Actions Taken

** Please draw a simple site map and indicate sample locations on the back of this page.

APPENDIX I
BEHAVIOR BASED SAFETY OBSERVATION FIELD CHECKLIST

anteagroup

BEHAVIOR BASED SAFETY OBSERVATION FIELD CHECKLIST

Date:		Time:	
Site Name:	Fort Scott, KS – Double Circle Farm Supply Site	Worker Observed:	
Project Number:	UPR-8263-A	Observer:	

Observations	Safe	Unsafe
	Write NA for any Non-applicable items	
Attended/participated in tailgate meeting		
Follows JSA and HASP work steps and safety procedures		
Works safely within defined work areas, traffic control/exclusion zone set up		
Wears required PPE		
PPE is good condition		
Uses correct tool(s) for job		
Tools inspected and/or in safe working condition		
Maintains good housekeeping		
Uses safe lifting techniques/ does not lift over 50 lbs without assistance		
Overall assessment of worker behaviors		

Feedback
Other Observations/Comments (areas of strong performance and areas for improvement):

Commitment (observed worker please sign)

I _____ (print name) have been informed of the above assessment, I understand all feedback, and I am committed to performing my work safely by:

- reporting to work physically rested and mentally alert
- observing and coaching my co-workers to ensure they work safely
- following procedures and not taking short cuts or improvising
- stopping all unsafe work, and
- demonstrating ZERO tolerance for willful unsafe actions.

Signature:		Date:	

FIGURES

ROUTE TO HOSPITAL MAP
SITE MAP
JOURNEY MANAGEMENT PLAN MAP AND INSTRUCTION
TRAFFIC CONTROL PLAN MAP

Site Health and Safety Plan
Hospital Map
Double Circle Farm Supply Site – Fort Scott, KS

Mercy Health Center
Jayhawk Rd, Fort Scott, KS
(620) 223-2200

Driving directions

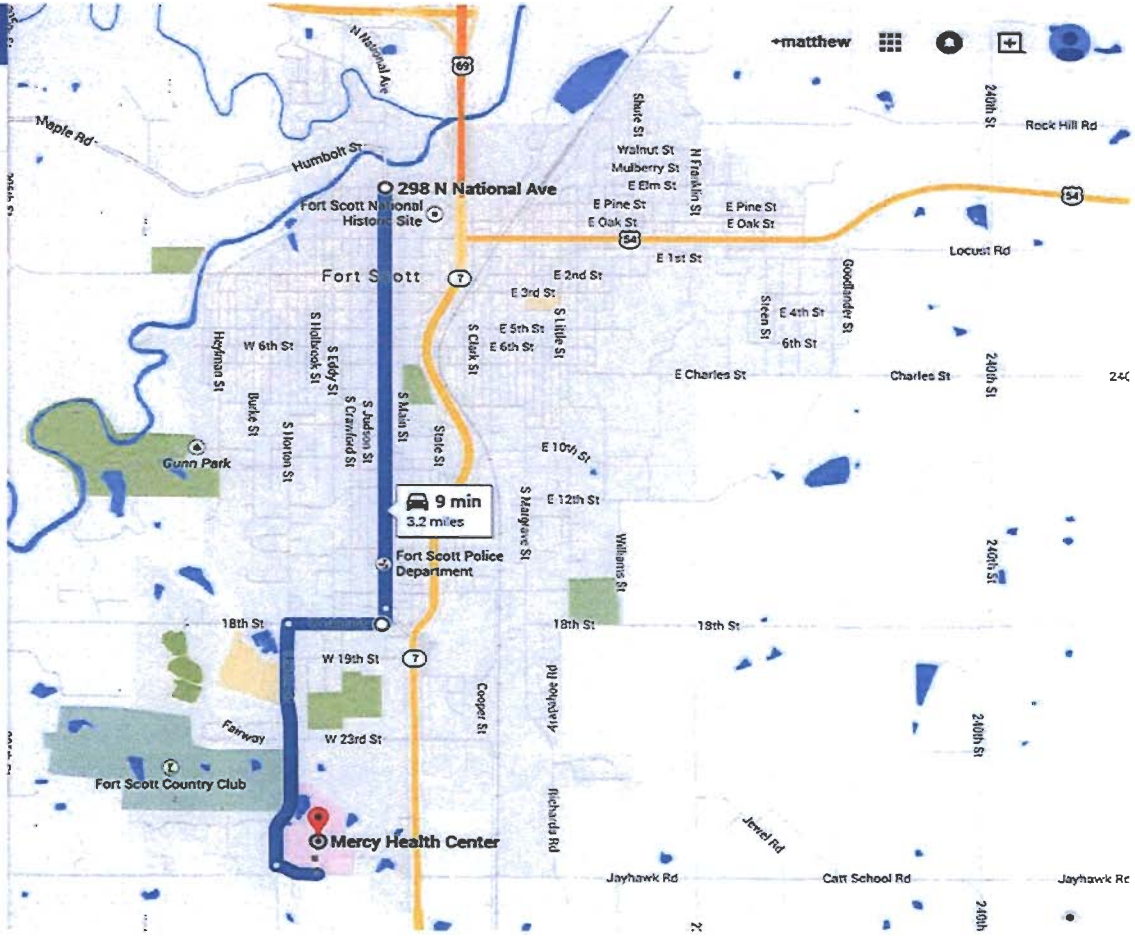
via N National Ave and Horton St — 9 min
9 min without traffic · Show traffic — 3.2 miles

298 N National Ave
Fort Scott, KS 66701

- Head south on N National Ave toward W Pine St
  1.7 mi
- Continue straight onto National Ave
  325 ft
- Turn right onto W 18th St
  0.9 mi
- Turn left onto Horton St
  1.0 mi
- Turn left onto 30th St/Jayhawk Rd
  Continue to follow Jayhawk Rd
  0.2 mi

Mercy Health Center
Fort Scott, KS 66701

These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.



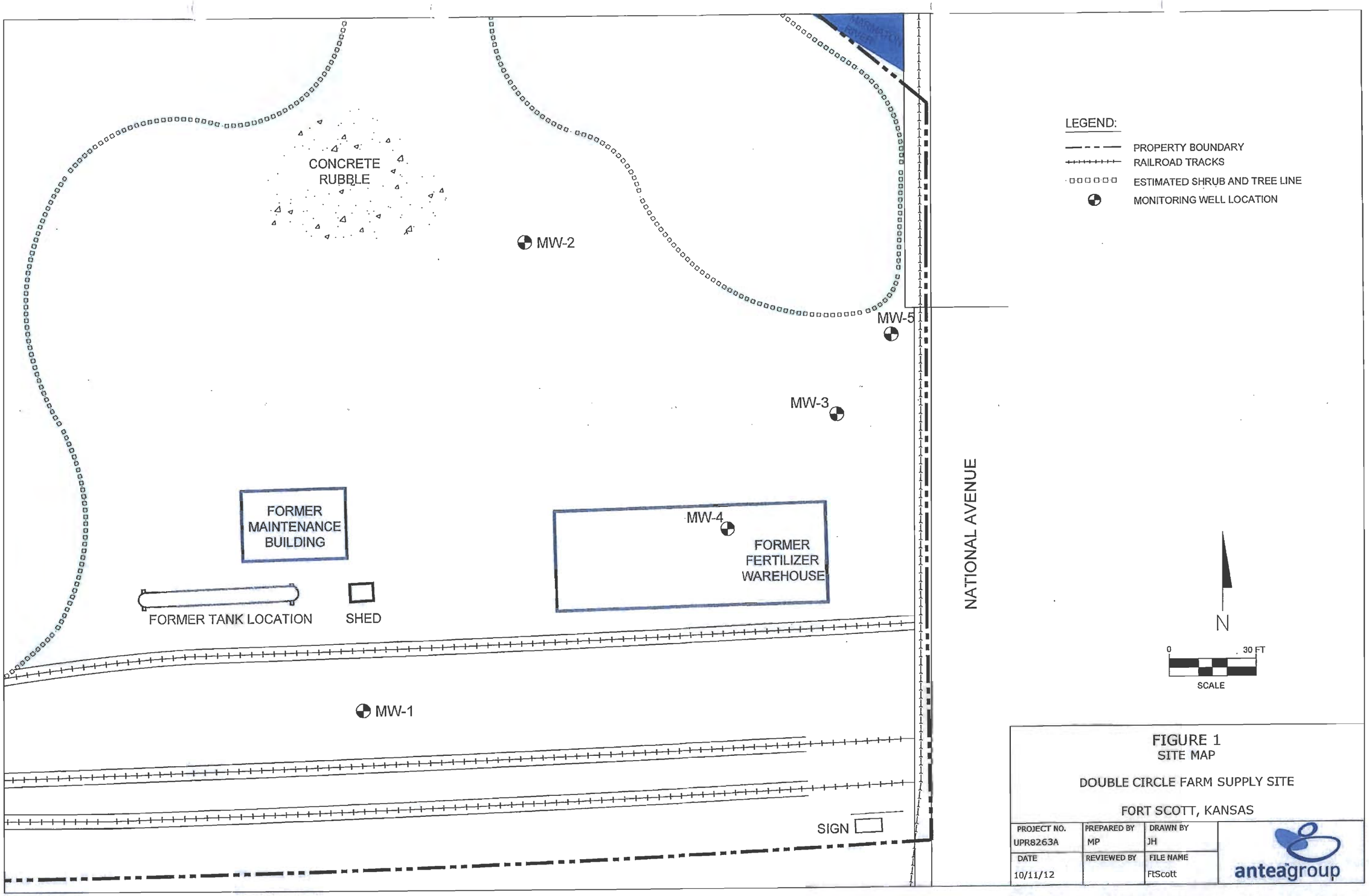


FIGURE 1
SITE MAP

DOUBLE CIRCLE FARM SUPPLY SITE

FORT SCOTT, KANSAS

PROJECT NO.	PREPARED BY	DRAWN BY
UPR8263A	MP	JH
DATE	REVIEWED BY	FILE NAME
10/11/12		FtScott

anteagroup

Appendix D

PeroxyChem Injection Data Sheets

Emulsified Lecithin Substrate Demand Calculations

PeroxyChem

16-Mar-2015

Customer:	**Antea Group**	**Prepared by:**	
Contact:	**Jack Sheldon**	**Josephine Molin**	
Site Location:	**Fort Scott, KS**	**1-773-991-9615**	
Proposal Number:	**PeroxyChem-18165**	**Josephine.Molin@peroxychem.com**	

ELS PRODUCT OVERVIEW

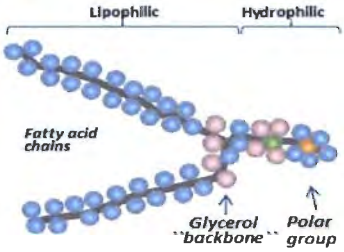
ELS™ is a lecithin-based microemulsion composed of complex organic carbon used to enhance anaerobic bioremediation. ELS is delivered as an easy to handle 25% liquid emulsion that is cold water soluble and can be applied via existing wells, hydraulic injection networks, or direct push technology.

ELS is available in 5-USG pails, 50-USG drums, and 275-USG totes.

Key attributes:

• Stable emulsions: Lecithin is composed primarily of phospholipids, which have both hydrophilic and hydrophobic regions in their molecular structure. As a result, ELS can be expected to form a more stable emulsion compared to oils that are strictly hydrophobic compounds.

• Essential nutrients: Lecithin's molecular structure includes both phosphorous and nitrogen. These structural nutrients are slowly released into the groundwater and become available for microbial consumption as the phospholipid molecules are fermented. This supports extended dehalogenation activity more effectively than competitive products that contain added inorganic nutrients which are rapidly consumed and can be lost through precipitation reactions or wash-out of the treatment zone.



• Longevity: ELS contains a range of organic carbon substrates including phospholipids, fatty acids, complex carbohydrates, and simple sugars. As a result, its more readily degradable components serve to rapidly establish reducing conditions while its more complex components provides an extended hydrogen release of up to two years.

SITE INFORMATION / ASSUMPTIONS

	Value	Unit	Comment
Treatment Area Dimensions:			
Width of targeted zone (perpendicular to gw flow)	30	ft	customer supplied
Length of targeted zone (parallel to gw flow)	30	ft	customer supplied
Depth to top of treatment zone	43	ft bgs	customer supplied
Treatment zone thickness	10	ft	customer supplied
Treatment volume	9,000	ft3	calculated value
Total Porosity	35	%	default value
Groundwater volume	3,150	ft3	calculated value
Soil bulk density	90	lbs/ft3	default value
Soil mass	405	ton	calculated value

SITE INFORMATION / ASSUMPTIONS (continued)

Transport characteristics:

Treatment time / design life for one application	1	years	default value
Linear groundwater flow velocity	0	ft/year	calculated value
Distance of inflowing gw over design life	0	ft	calculated value
Effective porosity for groundwater flow	10	%	default value
Volume of water passing region over design life	0	ft3	calculated value
Soil type	low permeability		customer supplied
Fraction organic carbon in soil, foc	0.010		estimated value

CONTAMINANTS OF CONCERN (COCs)

Constituent	GW (mg/L)	Soil* (mg/kg)	Total COI Mass** (lb)
Nitrate - see below under competing electron acceptors			

GEOCHEMICAL DATA

Competing Electron Acceptors	GW (mg/L)	
Dissolved oxygen	0.38	customer provided
Nitrate (as N)	20	customer provided
Manganese (estimated conc. Mn(II) generated)*	10	default value
Iron (estimated conc. Fe(II) generated)*	1880	customer provided
Sulfate	400	customer provided

*An estimated projection of dissolved concentrations of Mn and Fe following ERD/ISCR were used to estimate H demand from the reduction of oxidized Fe and Mn minerals (typically only a portion of actual soil concentrations will be reduced).

ORP (mV)	80
pH	9.1

STOICHIOMETRIC DEMAND CALCULATIONS

	GW (mg/L)	Soil (mg/kg)
H2 Demand from COIs	0.00	0.00
H2 Demand from Competing Electron Acceptors	72.97	0.00
Total H2 Demand	72.97	0.00
H2 Demand from Soil within Targeted Area	0.00	lb
H2 Demand from GW within Targeted Area	14.35	lb
H2 Demand from Influx over Design Life	0.00	lb
Total Estimated H2 Demand	14.35	lb

ELS DEMAND CALCULATIONS

The Stoichiometric demand for the targeted area was calculated using available data presented above, noting that the Stoichiometric demand represents minimum requirements and require a complete geochemical data set to be calculated accurately. Therefore, the resulting ELS dosing required to meet the estimated Stoichiometric demand was compared to our minimum guidelines for the selected type of application, selecting the higher number.

Application type: Plume Treatment

	Value	Unit
Concentration ELS in GW to meet H2 demand	835.8	mg/L
Safety factor*	2	
Recommended conc. of ELS in pore water	1,672	mg/L
Mass of ELS required	329	lbs
Mass ELS per container	420	lbs
Number of Containers	1	containers
Mass ELS (rounded up based on container size)	420	lbs

*A safety factor has been applied to account for uncertainties in data and variability in the rate and extent of hydrogen consumption.

COST ESTIMATE

Item	Quantity	Unit	Price	Cost
ELS [1, 2]	420	lbs	$1.05	$441
Shipping Estimate [3]	1	lump sum	$250	$250
TOTAL COST [4]				**$691**

1) Price valid for 90 days from date at top of document. Terms: net 30 days.

2) Any applicable taxes not included. Please provide a copy of your tax exempt certificate or resale tax number when placing your order. In accordance with the law, applicable state and local taxes will be applied at the time of invoicing if PeroxyChem has not been presented with your fully executed tax exemption documentation.

3) Shipping rate provided is an estimate. Standard delivery time can vary from 1-3 weeks from time of order, depending upon volume. Expedited transport can be arranged at extra cost. Unless requested otherwise, costs assume standard ground transport via truck, with no need for a lift gate or pallet jack.

4) All sales are per PeroxyChem's Terms and Conditions.

Disclaimer:

The estimated dosage and recommended application methodology described in this document are based on the site information provided to us, but are not meant to constitute a guaranty of performance or a predictor of the speed at which a given site is remediated. The calculations in the Cost Estimate regarding the amount of product to be used in your project are based on stoichiometry or default minimum guideline values, and do not take into account the kinetics, or speed of the reaction. Note that the Stoichiometric mass represents the minimum anticipated amount needed to address the constituents of concern (COCs). As a result, these calculations should be used as a general approximation for purposes of an initial economic assessment. PeroxyChem recommends that you or your consultants complete a comprehensive remedial design that takes into consideration the precise nature of the COC impact and actual site conditions.

INSTALLATION

ELS will be delivered as a 25% liquid emulsion of carbon substrate in 55-USG drums, with 50 USG/190 litres per drum. Upon request ELS is also available in 5 USG pails, 275 USG totes or in a tanker truck.

Depending on the application method employed, between 10% and 100% of the effective porosity is normally targeted during ELS injection, with a higher percent pore fill normally targeted during low-flow injections into wells and injection networks. This is in contrast to applications via direct push technology (DPT) where normally around 10 to 15% is targeted. To facilitate the desired injection volume, ELS will be diluted in the field.

The below table shows examples of mixing recipes for a 55-USG drum of ELS and the resulting total injection volume and percent pore fill. The below mixing recipe may be scaled depending on the size of the mixing batch and packaging size, if alternative packaging is used.

ELS Mixing Recipe (per 50 USG drum)

Dilution:	**3-fold**	**10-fold**	**25-fold**
Volume ELS emulsion per drum (USG)	50	50	50
Volume water (USG)	100	450	1,200
Resulting total volume (USG)	150	500	1,250
Resulting ELS concentration (% lecithin)	8.3%	2.5%	1.0%
Total volume water (USG)	100	450	1,200
Total injection volume (USG)	150	500	1,250
Resulting injection volume to total pore volume	0.6%	2.1%	5.3%

Injection recommendations (can be altered):

The ELS solution could be injected via fixed wells or using direct push. The injection spacing would be determined based on the radius of influence achieved for the specific implementation method and lithology.

	Value	**Unit**	**Comment**
Dilution of ELS emulsion (can be altered)	10		can be altered
Total volume of water required	453	U.S. gallons	calculated value
Volume of solution to inject	503	U.S. gallons	calculated value
Injection spacing	10	ft	customer provided
Number of injection points	9	locations	calculated value
Injection volume per point	56	U.S. gallons	calculated value
Injection volume per vertical foot	6	U.S. gallons	calculated value
Injection volume to total pore space volume	2	percent	calculated value

Note that the construction estimates presented above can be readily modified in the field or per recommendations from the injection contractor as required (for example, the concentration of the ELS solution could be changed to modify the total injection volume or the injections spacing could be altered based on installation technology).

Emulsified Lecithin Substrate Demand Calculations

PeroxyChem

16-Mar-2015

Customer:	**Antea Group**	**Prepared by:**	
Contact:	**Jack Sheldon**	**Josephine Molin**	
Site Location:	**Fort Scott, KS**	**1-773-991-9615**	
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ELS PRODUCT OVERVIEW

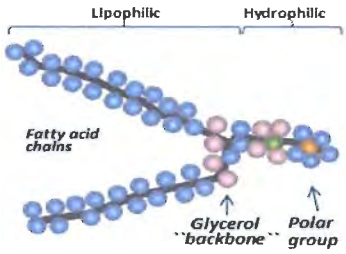
ELS™ is a lecithin-based microemulsion composed of complex organic carbon used to enhance anaerobic bioremediation. ELS is delivered as an easy to handle 25% liquid emulsion that is cold water soluble and can be applied via existing wells, hydraulic injection networks, or direct push technology.

ELS is available in 5-USG pails, 50-USG drums, and 275-USG totes.

Key attributes:

• Stable emulsions: Lecithin is composed primarily of phospholipids, which have both hydrophilic and hydrophobic regions in their molecular structure. As a result, ELS can be expected to form a more stable emulsion compared to oils that are strictly hydrophobic compounds.

• Essential nutrients: Lecithin's molecular structure includes both phosphorous and nitrogen. These structural nutrients are slowly released into the groundwater and become available for microbial consumption as the phospholipid molecules are fermented. This supports extended dehalogenation activity more effectively than competitive products that contain added inorganic nutrients which are rapidly consumed and can be lost through precipitation reactions or wash-out of the treatment zone.



• Longevity: ELS contains a range of organic carbon substrates including phospholipids, fatty acids, complex carbohydrates, and simple sugars. As a result, its more readily degradable components serve to rapidly establish reducing conditions while its more complex components provides an extended hydrogen release of up to two years.

SITE INFORMATION / ASSUMPTIONS

	Value	Unit	Comment
Treatment Area Dimensions:			
Width of targeted zone (perpendicular to gw flow)	80	ft	customer supplied
Length of targeted zone (parallel to gw flow)	100	ft	customer supplied
Depth to top of treatment zone	43	ft bgs	customer supplied
Treatment zone thickness	10	ft	customer supplied
Treatment volume	80,000	ft3	calculated value
Total Porosity	35	%	default value
Groundwater volume	28,000	ft3	calculated value
Soil bulk density	90	lbs/ft3	default value
Soil mass	3,600	ton	calculated value

SITE INFORMATION / ASSUMPTIONS (continued)

Transport characteristics:			
Treatment time / design life for one application	1	years	default value
Linear groundwater flow velocity	0	ft/year	calculated value
Distance of inflowing gw over design life	0	ft	calculated value
Effective porosity for groundwater flow	10	%	default value
Volume of water passing region over design life	0	ft3	calculated value
Soil type	low permeability		customer supplied
Fraction organic carbon in soil, foc	0.010		estimated value

CONTAMINANTS OF CONCERN (COCs)

Constituent	GW (mg/L)	Soil* (mg/kg)	Total COI Mass** (lb)
Nitrate - see below under competing electron acceptors			

GEOCHEMICAL DATA

Competing Electron Acceptors	GW (mg/L)	
Dissolved oxygen	0.1	customer provided
Nitrate (as N)	149	customer provided
Manganese (estimated conc. Mn(II) generated)*	10	default value
Iron (estimated conc. Fe(II) generated)*	233	customer provided
Sulfate	407	customer provided

*An estimated projection of dissolved concentrations of Mn and Fe following ERD/ISCR were used to estimate H demand from the reduction of oxidized Fe and Mn minerals (typically only a portion of actual soil concentrations will be reduced).

ORP (mV)	80	
pH	9	

STOICHIOMETRIC DEMAND CALCULATIONS

	GW (mg/L)	Soil (mg/kg)
H2 Demand from COIs	0.00	0.00
H2 Demand from Competing Electron Acceptors	90.07	0.00
Total H2 Demand	90.07	0.00
H2 Demand from Soil within Targeted Area	0.00	lb
H2 Demand from GW within Targeted Area	157.46	lb
H2 Demand from Influx over Design Life	0.00	lb
Total Estimated H2 Demand	157.46	lb

ELS DEMAND CALCULATIONS

The Stoichiometric demand for the targeted area was calculated using available data presented above, noting that the Stoichiometric demand represents minimum requirements and require a complete geochemical data set to be calculated accurately. Therefore, the resulting ELS dosing required to meet the estimated Stoichiometric demand was compared to our minimum guidelines for the selected type of application, selecting the higher number.

Application type: Plume Treatment

	Value	Unit
Concentration ELS in GW to meet H2 demand	1031.7	mg/L
Safety factor*	2	
Recommended conc. of ELS in pore water	2,063	mg/L
Mass of ELS required	3,607	lbs
Mass ELS per container	420	lbs
Number of Containers	9	containers
Mass ELS (rounded up based on container size)	3,780	lbs

*A safety factor has been applied to account for uncertainties in data and variability in the rate and extent of hydrogen consumption.

COST ESTIMATE

Item	Quantity	Unit	Price	Cost
ELS [1, 2]	3,780	lbs	$1.05	$3,969
Shipping Estimate [3]	1	lump sum	$800	$800
TOTAL COST [4]				**$4,769**

1) Price valid for 90 days from date at top of document. Terms: net 30 days.

2) Any applicable taxes not included. Please provide a copy of your tax exempt certificate or resale tax number when placing your order. In accordance with the law, applicable state and local taxes will be applied at the time of invoicing if PeroxyChem has not been presented with your fully executed tax exemption documentation.

3) Shipping rate provided is an estimate. Standard delivery time can vary from 1-3 weeks from time of order, depending upon volume. Expedited transport can be arranged at extra cost. Unless requested otherwise, costs assume standard ground transport via truck, with no need for a lift gate or pallet jack.

4) All sales are per PeroxyChem's Terms and Conditions.

Disclaimer:

The estimated dosage and recommended application methodology described in this document are based on the site information provided to us, but are not meant to constitute a guaranty of performance or a predictor of the speed at which a given site is remediated. The calculations in the Cost Estimate regarding the amount of product to be used in your project are based on stoichiometry or default minimum guideline values, and do not take into account the kinetics, or speed of the reaction. Note that the Stoichiometric mass represents the minimum anticipated amount needed to address the constituents of concern (COCs). As a result, these calculations should be used as a general approximation for purposes of an initial economic assessment. PeroxyChem recommends that you or your consultants complete a comprehensive remedial design that takes into consideration the precise nature of the COC impact and actual site conditions.

INSTALLATION

ELS will be delivered as a 25% liquid emulsion of carbon substrate in 55-USG drums, with 50 USG/190 litres per drum. Upon request ELS is also available in 5 USG pails, 275 USG totes or in a tanker truck.

Depending on the application method employed, between 10% and 100% of the effective porosity is normally targeted during ELS injection, with a higher percent pore fill normally targeted during low-flow injections into wells and injection networks. This is in contrast to applications via direct push technology (DPT) where normally around 10 to 15% is targeted. To facilitate the desired injection volume, ELS will be diluted in the field.

The below table shows examples of mixing recipes for a 55-USG drum of ELS and the resulting total injection volume and percent pore fill. The below mixing recipe may be scaled depending on the size of the mixing batch and packaging size, if alternative packaging is used.

ELS Mixing Recipe (per 50 USG drum)

Dilution:	**3-fold**	**10-fold**	**25-fold**
Volume ELS emulsion per drum (USG)	50	50	50
Volume water (USG)	100	450	1,200
Resulting total volume (USG)	150	500	1,250
Resulting ELS concentration (% lecithin)	8.3%	2.5%	1.0%
Total volume water (USG)	900	4,050	10,800
Total injection volume (USG)	1,350	4,500	11,250
Resulting injection volume to total pore volume	0.6%	2.1%	5.4%

Injection recommendations (can be altered):

The ELS solution could be injected via fixed wells or using direct push. The injection spacing would be determined based on the radius of influence achieved for the specific implementation method and lithology.

	Value	**Unit**	**Comment**
Dilution of ELS emulsion (can be altered)	10		can be altered
Total volume of water required	4,074	U.S. gallons	calculated value
Volume of solution to inject	4,527	U.S. gallons	calculated value
Injection spacing	10	ft	customer provided
Number of injection points	80	locations	calculated value
Injection volume per point	57	U.S. gallons	calculated value
Injection volume per vertical foot	6	U.S. gallons	calculated value
Injection volume to total pore space volume	2	percent	calculated value

Note that the construction estimates presented above can be readily modified in the field or per recommendations from the injection contractor as required (for example, the concentration of the ELS solution could be changed to modify the total injection volume or the injections spacing could be altered based on installation technology).