Sampling and Analysis Plan
Cheyenne PCE Plume Orphan Site (#57.019)
Cheyenne, Wyoming

Prepared by:

EnviroGroup Limited
Centennial, Colorado

Prepared for:

State of Wyoming
Department of Environmental Quality
Solid & Hazardous Waste Division

October 5, 2009

Project No. WQ-0663

EnviroGroup Limited
The environmental solutions company

Sampling and Analysis Plan
Cheyenne PCE Plume Orphan Site (#57.019)
Cheyenne, Wyoming

Prepared by:

EnviroGroup Limited
Centennial, Colorado

Prepared for:

State of Wyoming
Department of Environmental Quality
Solid & Hazardous Waste Division

October 5, 2009

Project No. WQ-0663

Prepared By:	10/5/09 Date
Reviewed By:	10/5/09 Date
Approved By:	10/5/09 Date

TABLE OF CONTENTS

1.0 INTRODUCTION 1-1
1.1 PURPOSE AND SCOPE 1-1
2.0 SITE VISIT AND KICK-OFF-MEETING 2-3
3.0 FIELD INVESTIGATION 3-4
3.1 SOIL INVESTIGATION 3-4
3.2 GROUNDWATER INVESTIGATION 3-4
3.2.1 Existing Wells 3-4
3.2.2 Monitoring Well Installation 3-5
3.2.3 Well Development and Groundwater Sampling 3-6
3.2.4 Groundwater Flow Direction 3-7
3.3 SOIL VAPOR INVESTIGATION 3-7
3.3.1 Soil Vapor Probe Installation 3-7
3.3.2 Soil Vapor Probe Sampling and Analysis 3-8
3.3.3 Ambient Air Sampling 3-10
3.4 INDOOR AIR INVESTIGATION 3-11
3.4.1 Indoor Air Sampling and Analysis 3-11
3.4.2 Sub-Slab Vapor Probe Installation, Sampling, and Analysis 3-11
3.4.3 Ambient Air Sampling 3-12
4.0 ECOLOGICAL RISK ASSESSMENT 4-1
5.0 DECONTAMINATION AND MANAGEMENT OF INVESTIGATIVE DERIVED WASTES 5-2
6.0 SCHEDULE OF IMPLEMENTATION AND REPORTING 6-1
7.0 REFERENCES 7-1

LIST OF FIGURES

Figure 1 Proposed Investigation Locations

Figure 2 Shallow Monitoring Well Completion (Typical)

Figure 3 Proposed Project Schedule

LIST OF APPENDICES

Appendix A Quality Assurance/Quality Control Plan

Appendix B Health and Safety Plan

Appendix C Sample Collection Methods for Groundwater, Surface Water, Soil Vapor, Soil and Sediment Standard Operating Procedure

Appendix D Installation and Sampling of Sub-Slab Vapor Probes for Analysis Using EPA Method TO-15 to Support Vapor Intrusion Investigation Standard Operating Procedure

1.0 INTRODUCTION

This Sampling and Analysis Plan (SAP) has been prepared by EnviroGroup Limited (EnviroGroup) for the Wyoming Department of Environmental Quality, Solid and Hazardous Waste Division (WDEQ). This SAP was developed based on WDEQ Fact Sheets for Sampling and Analysis Plans (WDEQ, 2007) and Site Characterization (WDEQ, 2007). This SAP describes the planned steps for conducting a Site Investigation at the Cheyenne PCE Plume Orphan Site (Site) in a several block area of downtown Cheyenne, Wyoming (Figure 1).

This section presents the purpose and scope of the Site Investigation and describes the procedures that will be used while conducting investigation activities at the Site.

1.1 PURPOSE AND SCOPE

Previous investigations have indicated the presence of tetrachloroethene (PCE) and some trichloroethene (TCE) in shallow groundwater and soil gas in the area and 10 potential sources of contamination, including one existing and two former dry cleaners (Figure 1). Pumping of groundwater from basement sumps at the nearby Herschler Building may influence local groundwater flow direction. Based on our review of these data, we have developed a Preliminary Site Conceptual Model that provides a basis for our investigation approach. The purpose of this Site Investigation is to confirm the results of previous investigations and evaluate the potential for impacts to drinking water wells and indoor air at the Site.

The scope of this SAP is to complete Site Investigation tasks as presented in the EnviroGroup Cost Proposal dated July 24, 2009, and the Revised Cost Proposal dated August 28, 2009 to the extent authorized by WDEQ. The scope of this investigation includes: a Site visit and kick-off meeting to assess current Site conditions including collection of existing data and information and identification of existing private and groundwater monitoring wells, if any; sampling and analysis of up to four existing private wells (including a sump water sample from the Herschler building); review of existing data; installation of 10 shallow and three deep groundwater monitoring wells; collection of three soil samples from source zones; installation and sampling of 40 active soil vapor probes, mobile laboratory analysis of soil vapor samples; fixed-based laboratory analysis of 20% of the soil vapor samples, indoor air and sub-slab vapor sampling in six to 12 buildings (or at multiple locations in up to six buildings), as approved by WDEQ; ambient air sampling; completion of an Ecological Risk

Assessment; and data evaluation and reporting, including providing recommendations for next steps based on results of the investigation.

This SAP presents the minimum level of effort to meet the Site Investigation objectives, described above. Based on the results of the investigation, recommendations for the next steps (e.g., interim measures, additional Site characterization, and/or a remedial alternative evaluation) will be provided. This SAP does not include mitigation of buildings, evaluation of remedial alternatives, or design and implementation of remediation technologies.

2.0 SITE VISIT AND KICK-OFF-MEETING

Prior to field investigation activities, EnviroGroup Limited will conduct a Site visit and meet with the WDEQ project manager to assess current Site conditions, collect existing data and information, refine the work plan and data quality objectives if necessary, identify existing private or groundwater monitoring wells in the Site area, if any, and begin access arrangements.

3.0 FIELD INVESTIGATION

This section presents the proposed field investigation program for soil, groundwater, soil vapor, and indoor air investigation activities and summarizes proposed analytical parameters. All work will be performed in accordance with applicable portions of the Quality Assurance/Quality Control (QA/QC) Plan and Health and Safety Plan (HASP) presented in Appendix A and B, respectively.

3.1 SOIL INVESTIGATION

Thirteen boreholes (for monitoring well installation) will be advanced under the oversight of EnviroGroup personnel, at locations selected by EnviroGroup Limited, from ground surface to an average depth of approximately 18 feet below ground surface (bgs) using a direct-push rig (i.e. Geoprobe® or equivalent) at the Site. Soil cores will be collected using an acetate sleeve from each borehole from ground surface to the total depth of each borehole. Soil lithologies will be continuously logged by an experienced geologist. A ppbRAE organic vapor analyzer will be used as a field screening tool to measure organic vapor concentrations at each borehole to evaluate locations prior to well construction. Up to three soils samples will be collected in PCE source zones based on groundwater and soil vapor data, assuming access to source areas is granted. Soil samples will be biased toward the most contaminated soil based on field observations and screening measurements. The remaining soil core will be managed as investigation derived waste (see Section 5).

Soil samples will be placed into laboratory-supplied containers, labeled, logged onto chain of custody documents, and stored on ice for submittal to TestAmerica-Denver for volatile organic compound (VOC) analysis using United States Environmental Protection Agency (USEPA) Method 8260b.

3.2 GROUNDWATER INVESTIGATION

Field investigation procedures for the groundwater portion of the investigation including monitoring well installation, well development, and groundwater sampling are described below.

3.2.1 Existing Wells

A review of the Wyoming State Engineer's Office water rights database indicates that one or two private wells may be permitted in the area of interest, although several monitoring wells

owned by WDEQ are identified. Up to four private wells identified during the Site visit will be sampled following EnviroGroup standard operating procedures and WDEQ Fact Sheet procedures. Additionally, one of the private well samples may include a sump water sample collected from the Herschler Building (V-shaped building on the east side of Figure 1).

Samples collected from private wells will be collected from tap locations after several minutes of purging. A groundwater sample collected from the sump location will be collected using a dedicated disposable bailer. Groundwater samples will be collected using laboratory-supplied containers, labeled, logged onto chain of custody documents, and stored on ice for submittal to TestAmerica–Denver for VOC analysis using USEPA Method 8260b.

3.2.2 Monitoring Well Installation

Upon completion of borehole advancement, the 13 boreholes will be completed as monitoring wells. Wells will be constructed to allow for collection of "targeted" groundwater samples. At least one nested well pair will be installed to evaluate the vertical extent of contamination, at a location slightly downgradient of the potential source area identified during the soil vapor survey.

Ten boreholes will be completed as shallow monitoring wells to evaluate groundwater flow directions and to further understand groundwater conditions along the western and southern boundaries of the plume. These 10 boreholes will be completed as shallow 2 inch diameter, PVC groundwater monitoring wells with a screen slot size of 0.020 inch, a five foot screen interval located just at and across the water table, and completed with a flush-mount protective casing.

Three boreholes (i.e., one upgradient, one immediately downgradient of the probable source zone near the dry cleaners at Randall and 28th Avenue, and one between the source zone and the Herschler Building) will be completed as deeper monitoring wells to allow a better understanding of the three dimensional nature of the plume, which could be complicated by sump pumping at the Herschler Building. These 3 boreholes will be completed as deeper 2 inch diameter, PVC groundwater monitoring wells with a screen slot size of 0.020 inch, a ten foot screen interval located below the water table and extending approximately 15 feet deeper then the shallow wells, and completed with a flush-mount protective casing. Wells will be constructed in accordance with applicable WDEQ groundwater rules and regulations (Chapter 11, Part G – Well Construction and Abandonment).

A diagram of a typical shallow monitoring well completion is presented on Figure 2.

EnviroGroup will contact and coordinate with the public underground utility locate service. Because this service does not necessarily locate all underground utilities, we assume that the WDEQ will provide EnviroGroup with all information they have regarding utilities in the vicinity of the Site. EnviroGroup will not be liable for any damages or costs caused by drilling into unanticipated utilities, sewers, or other underground features at cleared and approved locations.

3.2.3 Well Development and Groundwater Sampling

New monitoring wells will be developed by surging the water column with a disposable bailer to suspend fine particles of sediment so that they can be removed by subsequent bailing. Surging will be repeated throughout well development in an effort to flush the fine particles from the sand filter surrounding the well screen. Development will continue by purging water from the well using a disposable bailer. Three to ten wetted casing volumes (i.e., the volume of groundwater standing in the casing under steady-state conditions) of water may be removed from each well.

Upon completion of monitor well development activities, new wells will be allowed to rest overnight to recharge. Groundwater samples will be collected using Low-Flow Purge (LFP) methods from each new monitor well. This method relies on the removal of groundwater at a rate similar to the well's rate of recharge (i.e., the groundwater column height during pumping should not vary more than approximately 10 percent from its steady-state condition or by keeping the drawdown at a minimal level (e.g., 0.33 feet); and is documented in the USEPA's Groundwater Sampling Guidelines for Superfund and RCRA Project Managers (Yeskis, D. and Zavala, B, 2002). Additional information regarding LFP procedures is provided in the EnviroGroup Limited Sample Collection Methods standard operating procedure provided in Appendix C.

Field water quality parameters (pH, temperature, specific conductance, oxidation-reduction potential, and dissolved oxygen) will be measured using a flow-through cell. Once three successive readings of two or more field water quality parameters have stabilized, sampling may begin. Samples should be collected directly from the discharge port of the pump prior to passing through the flow cell. If stabilization of field water quality parameters does not occur, the sample should be collected once 3 to 6 wetted casing volumes have been removed.

Groundwater samples will be collected using LFP methods with dedicated, disposable tubing and placed into laboratory-supplied containers, labeled, logged onto chain of custody documents, and stored on ice for submittal to TestAmerica –Denver for VOC analysis using USEPA Method 8260b. Two Quality Assurance/Quality Control samples will be collected in accordance with the requirements presented in the QA/QC Plan located in Appendix A.

3.2.4 Groundwater Flow Direction

The Northing, Easting, ground surface elevation, and top of casing elevation of any previous monitoring wells located in good condition and new groundwater monitor wells will be surveyed by a licensed surveyor and referenced to a consistent site datum. Groundwater level data will be collected from each of the monitoring wells after they have equilibrated from well development activities. Water level measurement data will be used to develop a representation of the shallow groundwater surface and to assess groundwater flow direction.

3.3 SOIL VAPOR INVESTIGATION

Field investigation procedures for the soil vapor portion of this investigation including soil vapor probe installation, sampling, and analysis using mobile and fixed-based laboratories and ambient air sampling are described below.

3.3.1 Soil Vapor Probe Installation

Forty (40) permanent soil vapor probes will be installed to a depth of approximately 5 feet bgs at the Site to provide information regarding the probable nature and extent of the groundwater plume, to identify potential source areas, assess the potential role of sewers as pathways, and identify areas and buildings for vapor intrusion (building) testing, as appropriate.

Boreholes will be advanced under the oversight of EnviroGroup personnel, at locations selected by EnviroGroup Limited, from ground surface to approximately 5 feet bgs using a direct-push rig (i.e. Geoprobe® or equivalent) at the Site. Upon completion of drilling activities, and using freshly-gloved hands, each soil vapor probe assembly will be immediately placed into the borehole by drilling personnel. Soil vapor probes will be constructed using 0.25 inch inner diameter (I.D.) by 6 inch long, stainless steel screens connected to 0.25 inch outer diameter (O.D.) Nylaflow® tubing. Screens will be placed at the desired sampling depth (typically in the middle of the sampling zone, described below) and the tubing extended up the center of the borehole to approximately 6 inches above ground surface and fitted with an air-tight valve. Screens will be placed in the soil vapor sampling zone (typically two feet in length), but may be adjusted based on soil stratigraphy and moisture content. Stainless steel screens will be centered within each sampling zone and the annulus surrounding each screen backfilled with typically two feet of clean silica sand (or glass beads, 60 – 120 sieve size). Soil vapor probe sampling zones will then be sealed with a bentonite seal. Granular bentonite will be installed in nominal 8 inch lifts (with distilled water hydration following each lift) to a height of approximately two feet above the silica sand. The remaining annulus will then be backfilled to grade with granular bentonite, installed in two foot lifts (with distilled water hydration between each lift). A five inch

diameter flush-mount well vault will be concreted around the top of each soil vapor probe tube to minimize infiltration of water or outdoor air.

To minimize the potential for cross-contamination during investigation activities, the ends of each length of soil vapor probe tubing will be capped and tubing placed inside an air-tight storage bag or container and kept away from hydrocarbons and truck exhaust. All tubing will remain capped, except during soil vapor probe installation, and will be stored inside the cab of the EnviroGroup vehicle. All stainless steel probe screens will be kept in an air-tight container until installation to avoid contamination.

3.3.2 Soil Vapor Probe Sampling and Analysis

Soil vapor probe sampling and analysis procedures for mobile laboratory and fixed-based laboratory methods are described below.

Mobile Laboratory Sampling and Analysis

Soil vapor samples will be collected from 40 soil vapor probes for mobile laboratory analysis to provide real-time information on the nature and extent of VOCs, allowing rapid evaluation of suspected source areas, transport pathways, and potentially impacted buildings. A mobile laboratory provided by Dr. Blayne Hartman, one of the leading experts in vapor intrusion, will be utilized to provide real-time laboratory analysis of soil vapor samples. Soil vapor data will be used to evaluate plume extent and better define and characterize source areas.

Soil vapor samples will be collected in the field using current state of the art procedures and soil vapor probes will not be disturbed for at least 24 hours before sampling. During soil vapor sampling activities, a clean, small plastic or stainless steel shroud with two small ports will be placed over each soil vapor probe and weighted down. An air-tight seal of hydrated bentonite or foam will be placed on the ground surface around the edge of the shroud where it contacts the ground. The soil vapor probe tube, which is fitted with an air-tight valve, will be extended up through the air-tight seal of hydrated bentonite or foam to the exterior side of the shroud. If required, the probe tubing will be extended above ground surface with an additional piece of Nylaflow® tubing. All connections will be located inside the shroud to verify that the seals are air-tight.

Each soil vapor tube, connected to an air-tight valve, will be connected with a tedlar bag attached to one side of the valve and the sampling tube on the other side of the valve (both outside of the shroud). Prior to purging or sampling activities, helium tracer gas will be released via a small diameter tube through a port in the shroud into the enclosure beneath the shroud. A sample of the air inside the shroud will be measured through the second port using

a portable helium detector to determine the concentration of helium within the enclosure beneath the shroud.

Three purge volumes (calculated based on the volume of probe tubing and screen) will be purged, at a flow rate of 0.1 liters per minute, through the shroud into a 60 ml calibrated gas-tight syringe and transferred to the tedlar bag. The tedlar bag will then be connected to a portable helium detector to measure for the presence of helium gas in the purged vapors. If high concentrations (>10% of the shroud concentration) of helium are observed in the purge vapors, the soil vapor probe seal and shroud seals will be checked and/or enhanced to reduce the infiltration of ambient air into the enclosure and another sample collected. If helium concentrations are less than 10%, a soil vapor sample will be collected in a clean, 60 ml calibrated gas-tight syringe or tedlar bag and immediately hand delivered to the mobile laboratory for analysis.

The mobile laboratory uses a gas chromatography-mass spectrometry (GC/MS) and will perform soil vapor analysis for PCE and TCE utilizing USEPA Method 8021 with nominal reporting limits of 5.0 µg/m3.

Fixed-Based Laboratory Sampling and Analysis

Soil vapor samples will be collected from 20% of the soil vapor probes (i.e., eight) for fixed-based VOC laboratory analysis to demonstrate comparability of sample results.

Soil vapor samples will be collected in the field using current state of the art procedures and soil vapor probes will not be disturbed for at least 24 hours before sampling. During soil vapor sampling activities, a clean, small plastic or stainless steel shroud with two small ports will be placed over each soil vapor probe and weighted down. An air-tight seal of hydrated bentonite or foam will be placed on the ground surface around the edge of the shroud where it contacts the ground. The soil vapor probe tube, which is fitted with an air-tight valve, will be extended up through the air-tight seal of hydrated bentonite or foam to the exterior side of the shroud. If required, the probe tubing will be extended above ground surface with an additional piece of Nylaflow® tubing. All connections will be located inside the shroud to verify that the seals are air-tight.

Each soil vapor tube, connected to an air-tight valve, will be connected with a tedlar bag attached to one side of the valve and the sampling tube on the other side of the valve (both outside of the shroud). Prior to purging or sampling activities, helium tracer gas will be released via a small diameter tube through a port in the shroud into the enclosure beneath the shroud. A sample of the air inside the shroud will be measured through the second port using

a portable helium detector to determine the concentration of helium within the enclosure beneath the shroud.

Three purge volumes (calculated based on the volume of probe tubing and screen) will be purged, at a flow rate of 0.1 liters per minute, through the shroud into a 60 ml calibrated gas-tight syringe and transferred to the tedlar bag. The tedlar bag will then be connected to a portable helium detector to measure for the presence of helium gas in the purged vapors. If high concentrations (>10% of the shroud concentration) of helium are observed in the purge vapors, the soil vapor probe seal and shroud seals will be checked and/or enhanced to reduce the infiltration of ambient air into the enclosure and another sample collected. If helium concentrations are less than 10%, a soil vapor sample will be collected.

Soil vapor samples will be collected using dedicated, laboratory-set regulators (at a flow rate of 0.1 liters per minute) installed on 1 liter (L) Summa® (or equivalent) canisters supplied and certified clean (i.e. batch certification) to reporting limit levels by Centek Laboratories, LLC, (Centek), a National Environmental Laboratory Accreditation Conference (NELAC)-certified laboratory. Soil vapor samples will be shipped under chain-of-custody documentation to Centek and analyzed for VOCs by USEPA Method TO-15 with minimum reporting limits of 1µg/m^3 or less.

3.3.3 Ambient Air Sampling

Ambient air samples will be collected at the same time as soil vapor samples during mobile and fixed-based laboratory sampling to provide information on potential background levels of compounds of concern due to ambient air.

During mobile laboratory analysis, one ambient air sample will be collected per day, from a representative/upwind location, approximately five feet above ground surface near the location of the mobile laboratory. Ambient air samples will be collected using a clean, 60 ml calibrated gas-tight syringe.

During fixed-based laboratory analysis, one ambient air sample will be collected per day, from a representative/upwind location, approximately five feet above ground surface, concurrently with all soil vapor samples in the investigation area. Ambient air samples will be collected using dedicated, laboratory-set regulators (based on an estimated sample duration) installed on 1 L Summa® (or equivalent) canisters supplied and certified clean (i.e. batch certification) to reporting limit levels by Centek, a NELAC-certified laboratory. Ambient air samples will be shipped under chain-of-custody documentation to Centek and analyzed for VOCs by USEPA Method TO-15 with minimum reporting limits of 1µg/m^3 or less.

3.4 INDOOR AIR INVESTIGATION

Indoor air or sub-slab vapor sampling will be conducted in six to 12 buildings (or up to a total of six indoor air and six sub-slab vapor samples at two locations in 6 buildings), as approved by WDEQ, judged to have the greatest potential for vapor intrusion impacts based on the results of groundwater, soil vapor, and Johnson and Ettinger (J&E) modeling. Additionally, one duplicate sample (i.e. indoor air and sub-slab vapor) will be collected. Ideally, testing will be conducted during the winter heating season when heat stack effects typically result in greater building depressurization and a higher potential for vapor intrusion (although testing out of the heating season is still viable).

Field investigation procedures for indoor air sampling, sub-slab vapor probe installation and sampling, and ambient air sampling for this portion of the investigation are described below.

3.4.1 Indoor Air Sampling and Analysis

Indoor air samples will be collected from the lowest potential living/working space within each selected home/commercial building near the Site, subject to the granting of access by the building owner. If there is no response to requests for access, or if access is denied, the location in question will not be sampled and the WDEQ will be notified.

At residential locations, a 24 hour sample will be collected from the lowest potential living/working space within each home, away from vents and windows and in a centrally-located area, at a height of approximately 3 feet above the floor. Homes with operating radon mitigation systems will not be sampled, unless the radon system has been turned off for at least one week prior to sampling and remains off during sampling. At commercial locations, 8 hour samples will be collected from the lowest potential working space within each commercial building. A chemical inventory survey will conducted at each sample location prior to sampling.

Indoor air samples will be collected using dedicated, 8 or 24 hour laboratory-set regulators installed on 1 or 6 L Summa® (or equivalent) canisters, equipped with particulate filters, supplied and certified clean (i.e. batch certification) to reporting limit levels by Air Toxics Ltd., a NELAC-certified laboratory. Indoor air samples will be shipped under chain-of-custody documentation to Air Toxics Ltd. and analyzed for VOCs by USEPA Method TO-15 with minimum reporting limits of 0.8 $\mu g/m^3$ for PCE and 0.25 $\mu g/m^3$ for TCE. Remaining VOCs will be reported with nominal reporting limits of 1$\mu g/m^3$ or less.

3.4.2 Sub-Slab Vapor Probe Installation, Sampling, and Analysis

One 8 hour or 24 hour sub-slab vapor sample will be collected below the concrete slab at each selected residential home or commercial building, contemporaneous with indoor air

sampling, for comparison to the indoor air results. The results of the sub-slab vapor samples will assist in the determination of whether soil vapor is the source of any VOCs in the indoor air samples. To the extent possible and as permitted by the owners, the sub-slab vapor samples will be collected in a central location, away from foundation footings and obvious slab perforations, on the lowest floor of the building.

Temporary probes will be installed by drilling approximately 3/8 inch diameter holes through the basement or first floor slabs, as applicable, no further than 2 inches into the underlying sub-slab materials. The 3/8 inch hole will be over-drilled with a larger (3/4 inch or 1 inch) hole to a depth of about 1 inch below the slab surface. A new, clean length of 1/8 inch or 1/4 inch nylon tubing will be inserted into the hole to the base of slab (leaving the bottom of the tube exposed for gas entry), and sealed in the hole with Sculpey modeling clay or hydrated bentonite. The hole will be cleaned carefully prior to inserting the tubing to ensure a good bond between the concrete and the clay.

Sub-slab vapor probes will be constructed in a manner similar to the schematic shown in the Installation and Sampling of Sub-Slab Vapor Probes for Analysis Using EPA Method TO-15 to Support Vapor Intrusion Investigation Standard Operating Procedure provide in Appendix D. The probe and tubing will be purged (three volumes) using an air-tight, 60 ml calibrated syringe and helium tracer gas will be used during the purging phase (in the same manner as recommended for soil vapor probes) to ensure that the probes are well sealed. Samples will be collected over either an 8 hour or 24 hour period concurrent with the indoor air samples, as described in the previous section.

Sub-slab vapor samples will be collected using dedicated, 8 or 24 hour laboratory-set regulators installed on 1 or 6 L Summa® (or equivalent) canisters, equipped with particulate filters, supplied and certified clean (i.e. batch certification) to reporting limit levels by Air Toxics Ltd., a NELAC-certified laboratory. Sub-slab vapor samples will be shipped under chain-of-custody documentation to Air Toxics Ltd. and analyzed for VOCs by USEPA Method TO-15 with minimum reporting limits of 0.8 $\mu g/m^3$ for PCE and 0.25 $\mu g/m^3$ for TCE. Remaining VOCs will be reported with nominal reporting limits of 1$\mu g/m^3$ or less.

3.4.3 Ambient Air Sampling

Ambient air samples will be collected at the same time as indoor air and sub-slab vapor sampling to provide information on potential background levels of compounds of concern due to ambient air. During indoor air and sub-slab vapor sampling, one ambient air sample will be collected per day, from a representative/upwind location, approximately five feet above ground surface, concurrently with all indoor air and sub-slab vapor samples in the investigation area. One duplicate ambient air sample will be collected.

Ambient air samples will be collected using dedicated, 8 or 24 hour laboratory-set regulators installed on 1 or 6 L Summa® (or equivalent) canisters, equipped with particulate filters, supplied and certified clean (i.e. batch certification) to reporting limit levels by Air Toxics Ltd., a NELAC-certified laboratory. Ambient air samples will be shipped under chain-of-custody documentation to Air Toxics Ltd. and analyzed for VOCs by USEPA Method TO-15 with minimum reporting limits of 0.8 $\mu g/m^3$ for PCE and 0.25 $\mu g/m^3$ for TCE. Remaining VOCs will be reported with nominal reporting limits of 1$\mu g/m^3$ or less.

4.0 ECOLOGICAL RISK ASSESSMENT

An Ecological Risk Assessment (ERA) will be conducted, consistent with Voluntary Remediation Program (VRP) guidance, consisting of an Ecological Exclusion Assessment (EEA). The Step 1 EEA checklist from WDEQ Fact Sheet #14 for ERA Steps 1 and 2 Ecological Exclusion and Scoping Assessments (WDEQ, 2007) will be completed, including site location and size and the possible presence of rare, threatened, and endangered species. Information about the presence of rare, threatened, or endangered species will be obtained by contacting the Wyoming Natural Diversity Database.

The EEA checklist will be supported by documentation including a site map or aerial photo, information about threatened and endangered species on or near the site, and photographs showing the affected area, site, and surroundings. If significant impacts are suspected, recommendations for additional assessments will be provided.

5.0 DECONTAMINATION AND MANAGEMENT OF INVESTIGATIVE DERIVED WASTES

We anticipate that there will be minimal amounts of investigative derived wastes (IDW) associated with the installation of monitoring wells and soil vapor probes, well development, and groundwater sampling activities. We estimate that 4 drums of soil and 4 drums of water, potentially hazardous for only PCE, may be generated during investigation activities. No IDW should be generated during sampling collection from private wells/sump location. Additionally, it is our understanding that WDEQ is the generator of any IDW and will provide signatures for any required manifests and disposal forms.

All drilling equipment will be decontaminated between borehole/monitoring well and soil vapor probe locations. Drilling equipment will be cleaned using a detergent and potable/distilled/deionized water wash following by a triple-rinse with distilled or deionized water. Decontaminated equipment will then be allowed to air dry or appropriately stored for later use.

Drill cuttings/soil cores may have significant levels of chemicals of concern (e.g., PCE), and will be visually inspected for the presence of non-aqueous phase liquids (NAPLs) and field screened with a ppbRAE to measure organic vapor concentrations at each borehole location. Soils exhibiting NAPL or elevated organic vapor concentrations will be segregated and containerized separately from soils not exhibiting these properties to facilitate characterization and minimize disposal costs. Cuttings will be placed into 55 gallon drums, properly labeled with a pending label, and stored at a location designated by WDEQ pending laboratory analytical results.

Decontamination and groundwater purge water will be visually inspected for the presence of NAPL. Waters exhibiting a visual sheen will be segregated and containerized separately from waters not exhibiting a sheen to facilitate characterization and minimize disposal costs. Decontamination and groundwater purge waters will be placed into 55 gallon drums, properly labeled with a pending label, and stored at a location designated by WDEQ pending laboratory analytical results.

All other IDW (e.g., disposable gloves, used LFP tubing, etc…) will be bagged and placed into a waste container upon completion of investigation activities.

An inventory of each day's IDW will be recorded in a bound field book and/or on appropriate field forms. The inventory will reference the date and area of generation and be provided to the WDEQ for its use in the proper management of the IDW. The WDEQ will remain the

sole owner of any IDW generated by investigation activities; however, EnviroGroup will assist the WDEQ with assessing waste transportation and disposal options.

Soil and water drums will be characterized by the WDEQ based upon laboratory analytical results from soil and groundwater samples. Soil and groundwater drums will be picked-up, transported, and disposed of by Arvada Treatment Center, of Arvada, Colorado, a Part B permitted hazardous waste treatment, storage, and disposal facility. We understand that WDEQ is the generator of any IDW and will provide signatures for any required manifests and disposal forms.

6.0 SCHEDULE OF IMPLEMENTATION AND REPORTING

We anticipate that field investigation activities can be initiated within 30 days of WDEQ approval of this SAP, provided that appropriate contractors and equipment are available and weather and access permitting. A preliminary schedule is provided on Figure 3.

Findings from this investigation will be presented in a final investigation report. At a minimum, the report will include:

- Documentation of all project activities;
- A discussion of all field procedures and observations;
- Data validation, tabulation, and evaluation of groundwater, soil, soil vapor, indoor air, and ambient air analytical data;
- The results of JE modeling;
- Borehole documentation and well completion diagrams;
- Groundwater and soil concentration maps; and
- Conclusions and recommendations for the next steps (e.g., interim measures, additional site characterization, and/or remedial alternative evaluation), if necessary.

It is anticipated that the draft final investigation report will be completed within 60 days of receipt and validation of the final laboratory data to be included in the report.

7.0 REFERENCES

Yeskis, D. and Zavala, B, Technology Innovative Office, Office of Solid Waste and Emergency Response, United States Environmental Protection Agency, 2002. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers (EPA 542-S-02-001), May.

Wyoming Department of Environmental Quality. Chapter 11, Part G, Well Construction and Abandonment.

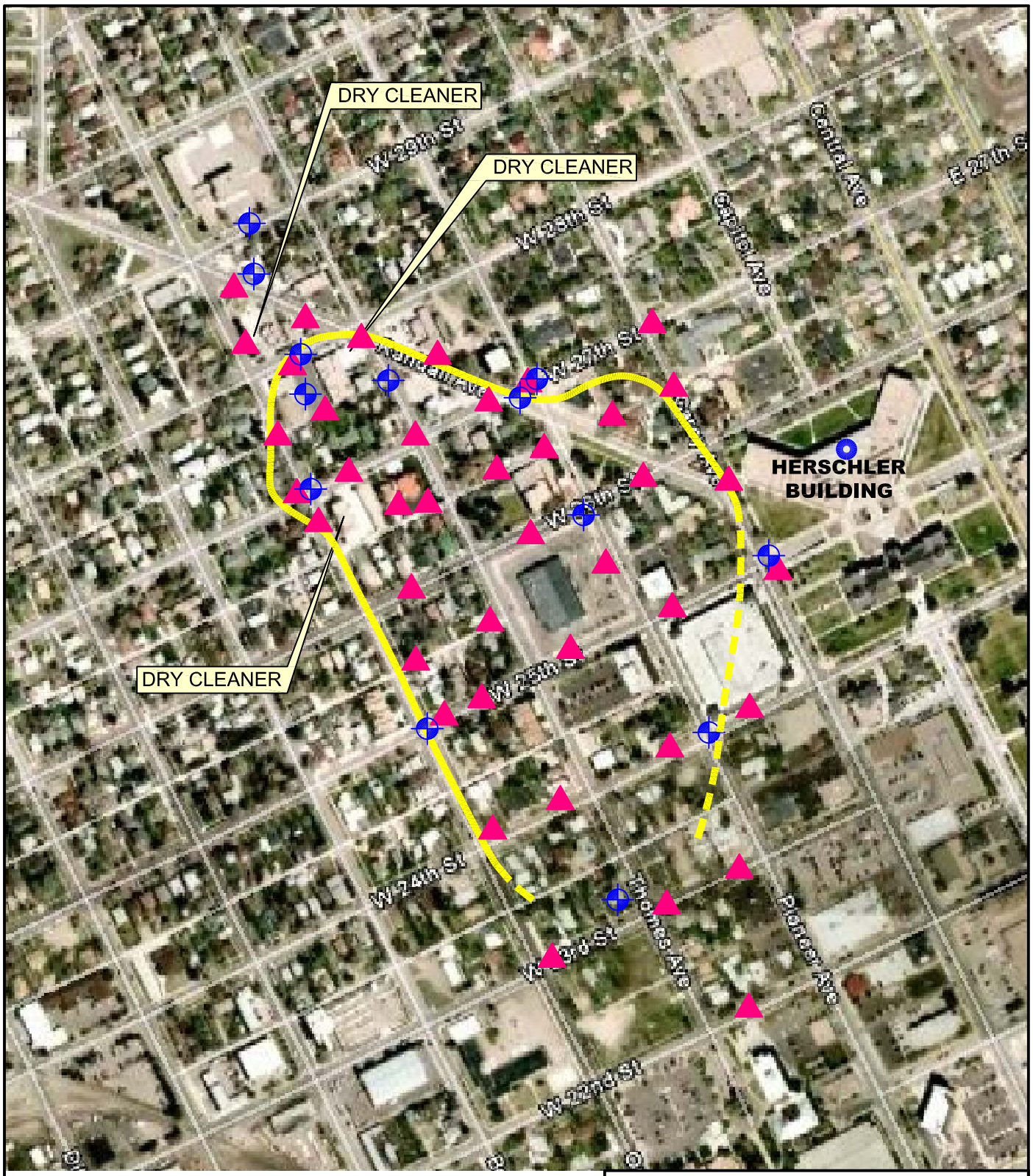
Wyoming Department of Environmental Quality, 2007. Fact Sheet #8, Site Characterization, March 1.

Wyoming Department of Environmental Quality, 2007. Fact Sheet #14, Ecological Exclusion Assessment-Steps 1 and 2 Ecological Exclusion and Scoping Assessments, March 6.

Wyoming Department of Environmental Quality, 2007. Fact Sheet #29, Sampling and Analysis Plans. June 28.

FIGURES

R:\WDEQ\WQ0663_CheyennePCE\Drawings\Proposed Sample Locations.dwg, 10/5/2009 12:51 PM



LEGEND

- PROPOSED SOIL VAPOR LOCATION
- PROPOSED MONITORING WELL
- SUMP
- HISTORICALLY DETECTED PCE CONTAMINATION AREA

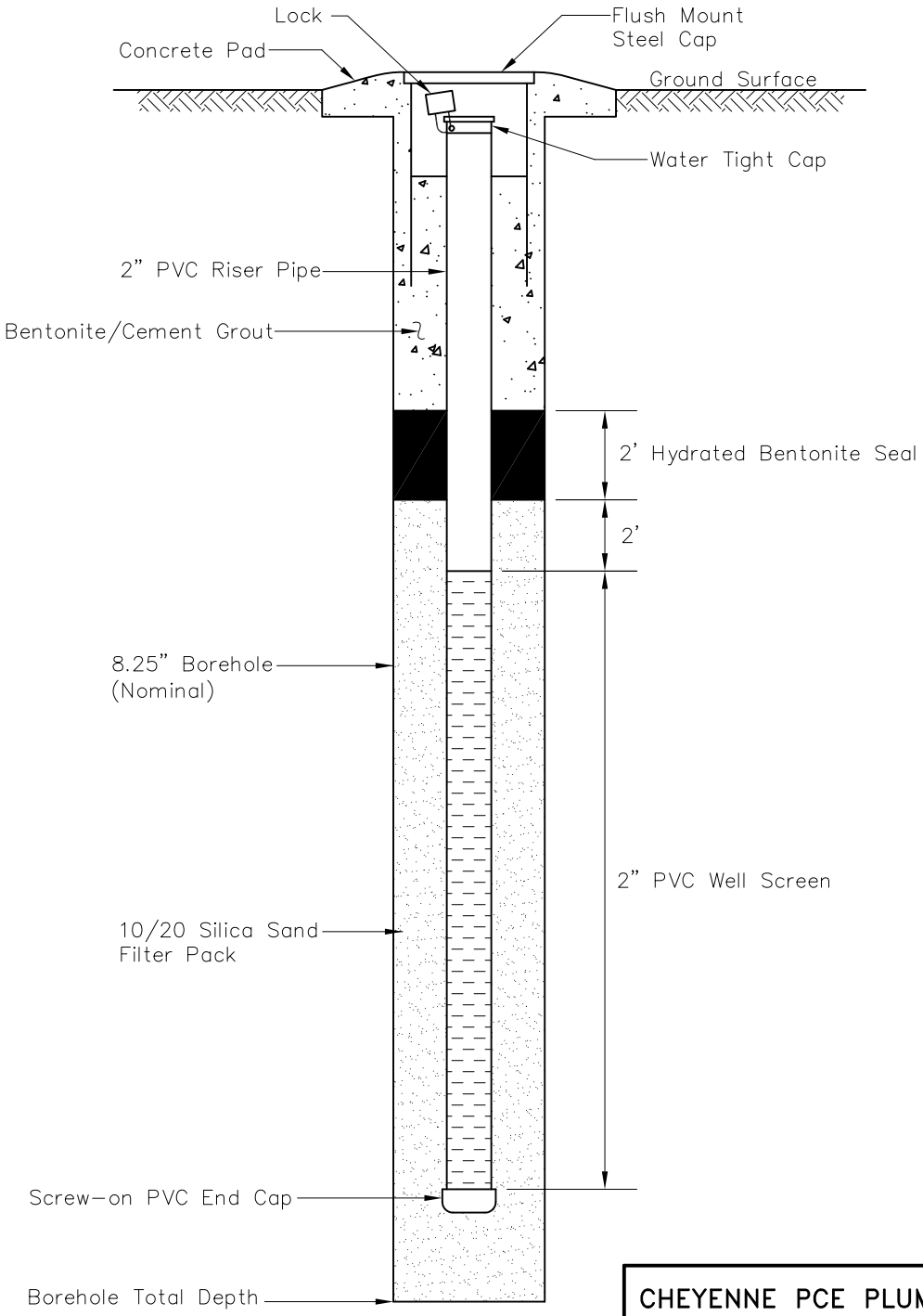
N

CHEYENNE PCE PLUME ORPHAN SITE
Cheyenne, Wyoming

PROPOSED INVESTIGATION LOCATIONS

EnviroGroup Limited
Centennial, Colorado

FIGURE 1	SEPT 2009
WQ-0663	

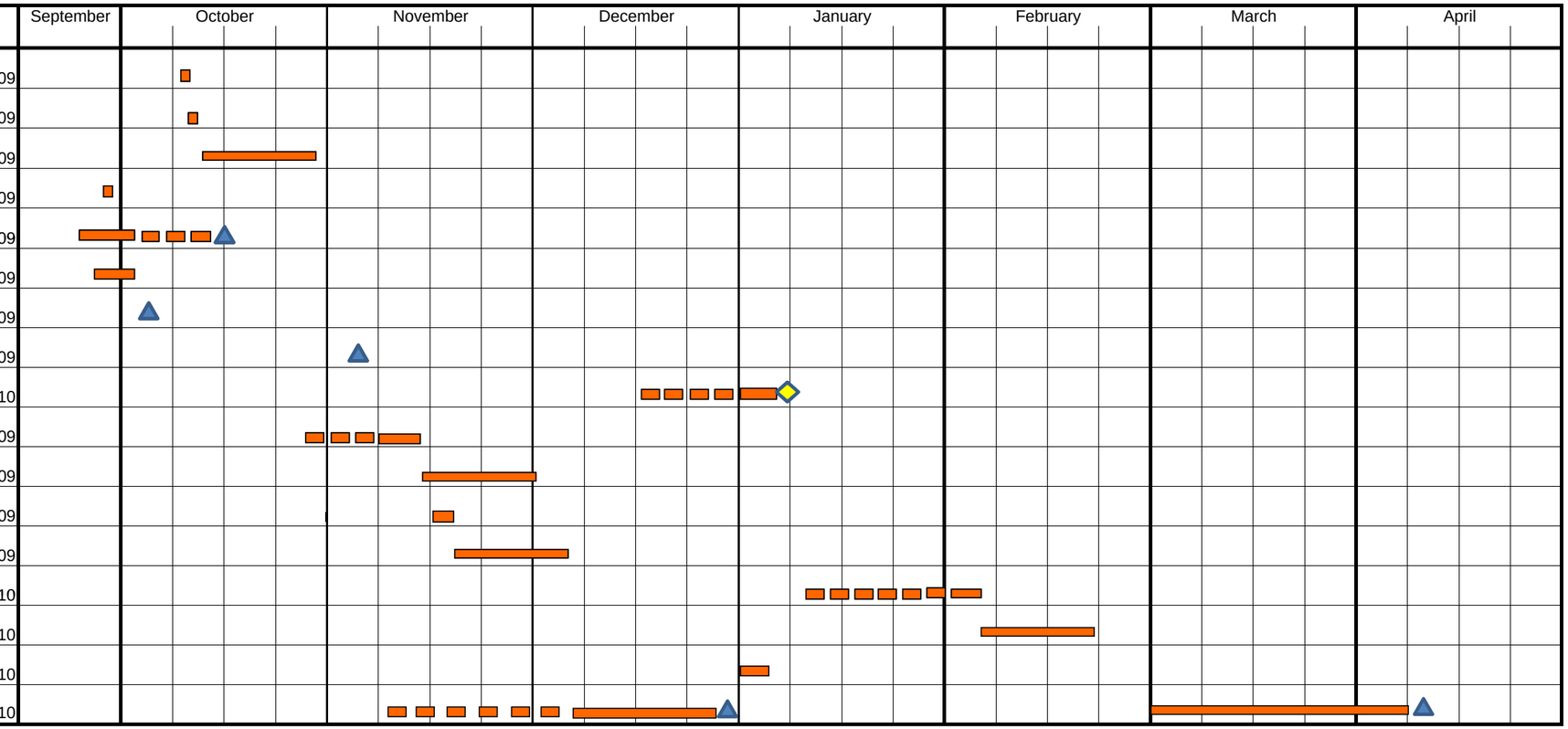


NOTE:
Proposed well screen length (i.e. 5 feet) may be placed just at and below the water table. Longer screens could be positioned somewhat higher to allow for water table fluctuations.

CHEYENNE PCE PLUME ORPHAN SITE Cheyenne, Wyoming		
SHALLOW MONITORING WELL COMPLETION (TYPICAL)		
EnviroGroup Limited Centennial, Colorado	FIGURE 2	SEPT 2009
	WQ-0663	

Figure 3
Proposed Project Schedule
Cheyenne PCE Plume Orphan Site (#57.019)
Cheyenne, Wyoming

Activity	Start	End
Task 1 - Site Visit & Kick-Off Meeting	10/7/2009	10/8/2009
Task 2 - Sample Existing Wells	10/8/2009	10/9/2009
Lab Analysis	10/9/2009	10/23/2009
Task 3 - Review Existing data to identify data gaps	9/29/2009	9/30/2009
Task 4 - Work Plans	9/28/2009	10/2/2009
Task 5 - Community Outreach & Environmental Education Plan Development	9/29/2009	10/2/2009
Letter	10/2/2009	10/2/2009
Flyer	11/4/2009	11/4/2009
Prep for Public Meeting and Presentation	12/21/2009	1/8/2010
Task 6 GW Field Program	11/9/2009	11/13/2009
Lab Analysis	11/13/2009	11/26/2009
Task 7 SV Field Program	11/16/2009	11/18/2009
Lab Analysis	11/18/2009	12/1/2009
Task 8 Indoor Testing Program	1/2/2010	1/4/2010
Lab Analysis	1/4/2010	1/15/2010
Task 9 -Ecological Risk Assessment (Steps 1 & 2)	1/4/2010	1/8/2010
Task 10 -Data Evaluation and Report	11/13/2009	4/14/2010



Note:
Public meeting to take place in January and indoor air testing will occur approximately a month after the public meeting

Deliverable
Meeting
Preparation or intermittent activity
Continuous Activity

APPENDIX A

QUALITY ASSURANCE/QUALITY CONTROL PLAN

Quality Assurance/Quality Control Program Plan
Cheyenne PCE Plume Orphan Site (#57.019)
Cheyenne, Wyoming

Prepared by:

EnviroGroup Limited

Centennial, Colorado

Prepared for:

State of Wyoming

Department of Environmental Quality

Solid & Hazardous Waste Division

October 5, 2009

Project No. WQ-0663

TABLE OF CONTENTS

TABLE OF CONTENTS ..... **I**
1.0 PROJECT MANAGEMENT **1**
1.1 Project Background 1
1.2 Responsible Personnel and QAQCPP Distribution 1
1.2.1 Responsible Personnel 1
1.2.2 QAQCPP Distribution 6
1.3 Authorized Laboratories 6
1.4 Task Descriptions 10
1.4.1 Groundwater Monitoring 10
1.4.2 Soil Vapor Sampling 10
1.4.3 Indoor Air Sampling 10
1.4.4 Soil Characterization 10
1.5 Quality Objectives and Data Criteria 11
1.6 Special Training Requirements 12
1.7 Documentation and Records 13
1.7.1 Field Notebooks 13
1.7.2 Field Reporting Forms 14
2.0 MEASUREMENTS AND DATA ACQUISITION **15**
2.1 Standard Operating Procedures 15
2.1.1 Indoor Air Quality Sampling 15
2.1.2 Drilling 16
2.1.3 Monitoring Well Installation 16
2.1.4 Monitoring Well Development 21
2.1.5 Groundwater Monitoring Procedures 22
2.1.6 Surface Water Sample Collection 28
2.1.7 Soil Vapor Sampling 29
2.1.8 Soil Sample Collection 31
2.1.9 Equipment Decontamination 31
2.1.10 Investigation Derived Wastes 32
2.2 Sample Handling and Custody Requirements 34
2.2.1 Sample Handling 34
2.2.2 Sample Custody Documentation 34
2.3 Analytical Method Requirements 35
2.4 Quality Assurance/Quality Control Requirements 37
2.4.1 Laboratory QA/QC Requirements 37
2.4.2 Field QA/QC Requirements 37
2.5 Equipment Inspection, Maintenance and Calibration Requirements 41
2.6 Inspection and Acceptance Criteria for Supplies and Consumables 41
3.0 DATA VALIDATION AND USABILITY **42**
3.1 Data Review, Validation and Verification Requirements 42
3.2 Data Validation Procedures 42
3.2.1 Data Validation Procedures 43
3.2.2 Laboratory Data Verification 46

3.2.3 Validation Criteria and Flagging Requirements for Indoor Air Samples.....47
3.3 Database Management.....49
4.0 PROJECT ASSESSMENT AND OVERSIGHT 50
4.1 Corrective Action.....50
4.1.1 Corrective Actions Taken by the Analyst.....50
4.1.2 Corrective Actions Taken by Field Personnel.....52
4.2 Reports to Management.....52

LIST OF FIGURES

Figure 1.1 Responsible Personnel.....3
Figure 1.2 QA/QC Plan Acknowledgement Form.....7
Figure 2 Shallow Monitor Well Design.....19

LIST OF TABLES

Table 1.1 Authorized Laboratories.....8
Table 2.1 Stabilization Criteria for Water Quality Indicator Parameters.....30
Table 2.2 Anticipated Analytical Methods.....36
Table 2.3 Field QA/QC Sampling Requirements.....38
Table 3.1 Laboratory Verification Parameters.....48
Table 3.2 Validation Criteria and Flags for Indoor Air Sample Results.....49

LIST OF APPENDICES

Appendix A Field Forms
Appendix B Indoor Air Analytical Data Flags

1.0 PROJECT MANAGEMENT

1.1 PROJECT BACKGROUND

The Cheyenne PCE Plume orphan site is an area approximately 20 acres in size within a roughly 5 block by 3 block area of historic downtown Cheyenne, Wyoming. The site is centered 1 block directly west of the Herschler Building, 122 West 25th Street, and consists of a mixture of single and multi-home residential properties and commercial businesses.

Previous investigations have indicated the presence of tetrachloroethene (PCE) and some trichloroethene (TCE) in shallow groundwater and soil gas in the area and 10 potential sources of contamination, including one existing and two former dry cleaners (Figure 1). Pumping of groundwater from basement sumps at the nearby Herschler Building may influence local groundwater flow direction. Based on our review of these data, we have developed a Preliminary Site Conceptual Model that provides a basis for our investigation approach. The purpose of this Site Investigation is to confirm the results of previous investigations and evaluate the potential for impacts to drinking water wells and indoor air at the Site.

This Quality Assurance/Quality Control Program Plan (QA/QC Plan) was developed in accordance with U.S. EPA guidance[1] to document earlier work and to define the quality objectives for future work conducted at the Cheyenne site.

1.2 RESPONSIBLE PERSONNEL AND QA/QC PLAN DISTRIBUTION

The following section describes the positions responsible for this QA/QC Plan and outlines the distribution of the QA/QC Plan.

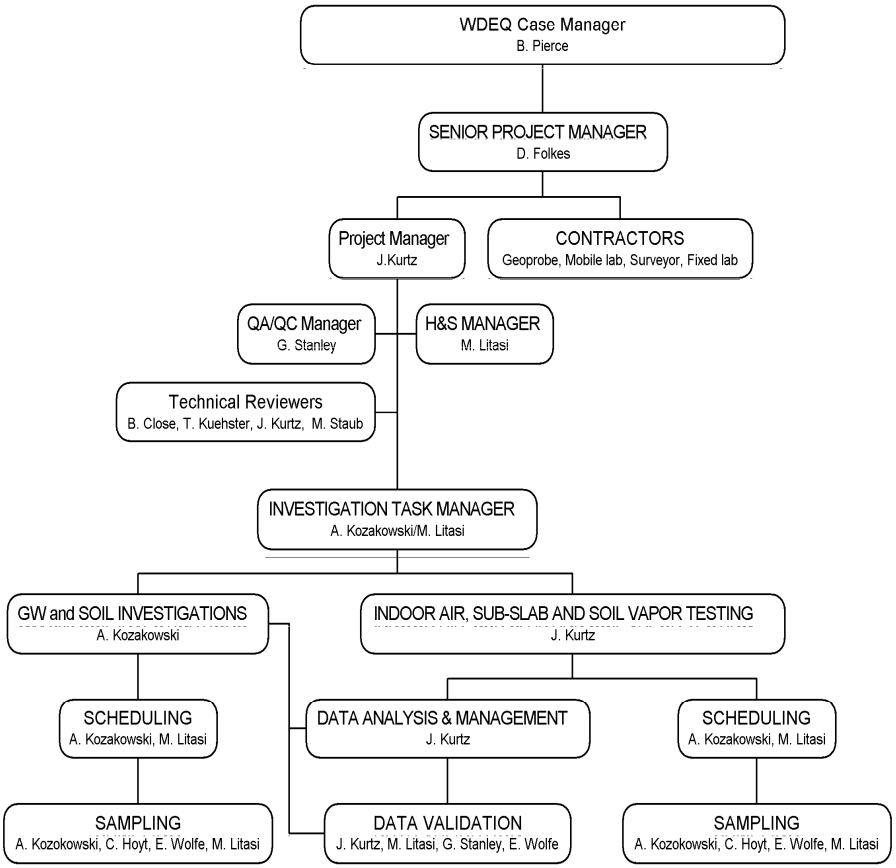
1.2.1 Responsible Personnel

An organizational chart, presented as Figure 1.1, identifies each position in the project team and

the individual currently occupying that position. The responsibilities for each position are also presented in this Section.

[1] U.S. EPA, March 2001. EPA Requirements for Quality Assurance Project Plans. EPA QA/R-5. Office of Environmental Information, Washington, D.C. EPA/240/B-01/003 and U.S. EPA, December 2002. EPA Guidance for Quality Assurance Project Plans. EPA QA/G-5. Office of Environmental Information, Washington, D.C. EPA/240/R-02/009.

Figure 1.1
Responsible Personnel



ORG_Chey.opx

WDEQ Case Manager

The WDEQ Case Manager is the individual assigned by the Wyoming Department of Environmental Quality to a specific project as the primary regulatory contact. This person is familiar with project procedures and requirements. The WDEQ Case Manager is authorized to review, approve, approve with modifications, or deem unacceptable, requisite deliverables, and to perform oversight activities as necessary.

EnviroGroup Project Manager

The EnviroGroup Project Manager has the overall responsibility for ensuring that the assigned activities and deliverables meet applicable WDEQ objectives and the quality standards outlined in this QA/QC Plan. Specifically, the responsibilities of the EnviroGroup Project Manager include:

- Communication and coordination with the WDEQ Case Manager;
- Ensure that the Quality Assurance, Health and Safety and Task Managers roles are assigned and being properly performed;
- Implementation of WDEQ activities assigned by the Site Manager;
- Monitoring and reporting project progress;
- Management of the EnviroGroup project team and its subcontractors to ensure unified, productive project accomplishments; and
- Review of EnviroGroup project work and deliverables.

EnviroGroup QA/QC Manager

The EnviroGroup QA/QC Manager is responsible for ensuring that all EnviroGroup work is conducted in compliance with this QA/QC Plan. This individual, or his or her designee, performs both scheduled and random reviews and audits of EnviroGroup activities for compliance with this QA/QC Plan and WDEQ requirements, and reports directly to the EnviroGroup Project Manager on the outcome of reviews and audits and the status of any

corrective action required to address QA deficiencies.

EnviroGroup Health and Safety Manager

The EnviroGroup Health and Safety Manager is responsible for ensuring that EnviroGroup personnel and subcontractors comply with the Site-Specific Health and Safety Plan and any Contractor-developed Health and Safety Plans involving EnviroGroup personnel on the project.

EnviroGroup Technical Reviewers

These individuals perform independent technical reviews of reports and calculations to ensure that technical requirements have been adequately addressed. A qualified Technical Reviewer must have training and/or experience in the work being reviewed.

EnviroGroup Task Managers

These individuals function under the general direction and supervision of the EnviroGroup Project Manager and are responsible for the day-to-day implementation of specific tasks and the preparation of specific deliverables. These individuals will perform general supervisory functions for individual project tasks, ensuring their completion in a timely manner which conforms to WDEQ requirements. A qualified Task Manager must have training and/or experience in the area of work, and any registrations required by law for that work (e.g., professional engineer or geologist).

Contractors and Subcontractors

Contractors and Subcontractors, to be selected by the EnviroGroup Project Manager, are responsible for conducting work associated with site investigations, and implementing approved remedies. During remedy design, Contractors and Subcontractors may provide information on construction procedures and capabilities, construction concerns, available material specifications, and may perform constructability reviews.

1.2.2 QAQCPP Distribution

All project personnel are to receive and are required to read a copy of the most recent version of the QA/QC Plan. A form (Figure 1.2) acknowledging the individual's agreement to follow the procedures and policies contained in the QA/QC Plan must be completed by all project personnel.

1.3 AUTHORIZED LABORATORIES

The laboratories authorized to perform analyses on environmental samples are identified in Table 1.1. WDEQ may authorize additional laboratories subsequent to this QA/QC Plan revision. Any such laboratories will be added to Table 1.1 in future revisions of this QA/QC Plan. The identified laboratories are authorized to subcontract analytical work as necessary, with the approval of the project manager. Any subcontracted analytical work will meet or exceed the quality objectives described in Section 1.5.

FIGURE 1.2

QAQCPP ACKNOWLEDGEMENT FORM

I, _____, of _____ have read the Quality Assurance/Quality Control Program Plan (QA/QC Plan) for the Orphan PCE Plume Site in Cheyenne, Wyoming, dated _____, along with the Wyoming Department of Environmental Quality's acceptance letter dated _____and agree to follow the procedures contained therein.

Dated this _____ day of _____, _____.

_____

(Signature)

_____

(QA/QC Team Member)

TABLE 1.1

AUTHORIZED LABORATORIES

Authorized Laboratory	Indoor Air	Groundwater	Soil	Soil Vapor
Air Technology Laboratories **(formerly Advanced Technology Laboratories)** 18501 E. Gale Avenue, Suite 130 City of Industry, CA 91748 Phone: (626) 964-4032/(888) 920-4032 Fax: (626) 964-5832 Project Mgr: Mark Johnson/Joann DeLaossa	X			
Analytica Environmental Laboratories 12189 Pennsylvania Street Thornton, CO 80241 Phone: (303) 469-8868 ext. 103 Fax: (303) 469-5254 Project Mgr: Joe Egry		X	X	X
Energy Laboratories 2393 Salt Creek Highway (82601) PO Box 3258 Casper, WY 82602-3258 Phone: (307) 235-0515/(888) 235-0515 Fax: (307) 234-1639 Project Mgr: To Be Determined		X	X	
Air Toxics, Ltd. 180 Blue Ravine Rd, Ste B Folsom, CA 95630 Phone: (800) 985-5955 Fax: (916) 985-1020 Project Mgr: Kyle Vagadori	X			X
Centek Laboratories 143 Midler Park Drive Syracuse, NY 13206 Phone: (315) 431-9730 Fax: (315) 431-9731 Project Mgr: Michael Palmer	X			X
Vista Geoscience 400 Corporate Circle, Suite R Golden, CO 80401 Phone: (303) 278-1911 Fax: (303) 278-0104 Project Mgr: John Fontana		X	X	X
Pace Analytical Services, Inc. 9608 Loiret Boulevard Lenexa, KS 66219 Phone: (913) 599-5665 Fax: (913) 599-1759 Project Mgr: Derek Varney		X	X	
Pace Analytical Services, Inc. 1700 Elm Street, Suite 200 Minneapolis, MN 55414 Phone: (612) 607-1700	X			

Authorized Laboratory	Indoor Air	Groundwater	Soil	Soil Vapor
Fax: (612) 607-6444 Project Mgr: Daryl Peterson				
Hartman Environmental Geoscience, Inc. 717 Seabright Ln Solana Beach, CA 92075 Phone: (858) 518-0522 Project Mgr: Blayne Hartman				**X**
Paragon Analytics 225 Commerce Drive Fort Collins, CO 80524 Phone: (800) 443-1511 Fax: (970) 490-1522 Project Mgr: Julie Ellingson		**X**	**X**	
Test America Laboratories, Inc. 4955 Yarrow Street Arvada, CO 80002 Phone: (303) 736-0100 Fax: (303) 431-7171 Project Mgr: Lori Parsons		**X**	**X**	
Test America Laboratories, Inc. 3585 Cadillac Ave, Ste A Costa Mesa, CA 92626 Phone: (714) 258-8610 Fax: (714) 258-0921 Project Mgr: Manny Velasquez	**X**			X

1.4 TASK DESCRIPTIONS

Groundwater, soil, soil vapor and indoor air sampling is conducted as described in the following Sections. Additional groundwater, soil, soil vapor, and indoor air investigations may also be conducted as necessary. Pre-determined schedules are generally not applicable to such additional work.

1.4.1 Groundwater Monitoring

Groundwater monitoring at selected monitoring wells and private wells is to be conducted at this site. Confirmation sampling or additional sampling conducted to meet specific project needs may be conducted at any time.

1.4.2 Soil Vapor Sampling

Soil Vapor samples are collected in accordance with requirements specified in the Sampling and Analysis Plan (October 5, 2009).

1.4.3 Indoor Air Sampling

Indoor air samples are collected in accordance with requirements specified in the Sampling and Analysis Plan (October 5, 2009).

1.4.4 Soil Characterization

WDEQ-required soil sampling is being conducted to assess the nature and extent of soil impacts resulting from solvent releases at several former dry cleaning facilities. The results of this work may be used for the development of corrective measures, as necessary.

Investigation procedures for the soil characterization work were addressed in the October 5, 2009 Sampling and Analysis Plan.

1.5 QUALITY OBJECTIVES AND DATA CRITERIA

This section addresses quality control issues associated with field and laboratory investigations of indoor air, groundwater, soil, and soil vapor. The quality assurance objective for field and laboratory investigations is to provide defensible analytical data that are accurate, precise, representative, comparable between labs and complete to the degree defined by this QA/QC Plan and required for the performance of monitoring obligations, the evaluation of remedial alternatives, and the design of remedies. Routine field and laboratory procedures are described in Section 2.4. Procedures for ensuring compliance with data quality objectives are described in Section 3. The definitions provided below for accuracy and precision are derived from SW-846.

Accuracy

The closeness of agreement between an observed value and an accepted reference value. When applied to a set of observed values (such as field and laboratory QA sample results), accuracy estimates will reflect a combination of random and systematic (i.e., bias) components. In practice, accuracy estimates rely on a determination of the percent recovery measured in spiked samples:

$$\text{Recovery} = \%R = ((C_s - C_u)/C_n)*100$$

where:

C_s = Measured concentration of the spiked sample
C_u = Measured concentration of the unspiked sample
C_n = Nominal (theoretical) concentration increase resulting from spiking the sample, or the nominal concentration of the lab control sample

Precision

The agreement among a set of replicate measurements without assumption or knowledge of the true value. Precision is estimated by means of duplicate/replicate analyses. The samples used for this assessment should contain concentrations of analyte above the laboratory's reporting limit, and may involve the use of matrix spikes. A quantifiable estimate of precision is made based on the relative percent difference (RPD):

$$RPD\ (\%) = ((C_1 - C_2)/C_{Avg})*100$$

where:

C_1 = Measured concentration of the first sample
C_2 = Measured concentration of the sample duplicate/replicate
C_{Avg} = Average of the two concentrations

Representative

Representativeness is measured by the collection of duplicate samples, from the same location or point, when applicable. Representativeness also is ensured by using approved sampling and decontamination protocols in the field (e.g., EPA-540/P-87/001).

Comparability

Comparability is a qualitative term describing the degree of confidence with which one data set can be compared to another. This is most directly assessed by monitoring the laboratory's daily and monthly performance in the analysis of known quality control check samples for the parameters of interest. Comparability also is ensured by using approved analytical methods (e.g., SW-846) and applicable QA/QC procedures.

Completeness

Completeness refers to the amount of valid data obtained from a measurement system compared with the amount that was expected to be obtained under normal conditions.

1.6 SPECIAL TRAINING REQUIREMENTS

Personnel engaged in field and management tasks will be qualified by education and/or experience to perform the required work. Any additional requirements for health and safety

training, etc., will be addressed in separate task-specific documents (i.e., HASP).

1.7 DOCUMENTATION AND RECORDS

This section identifies the documents and records typically generated as part of field activities, and describes typical elements for each.

1.7.1 Field Notebooks

Information pertinent to a field investigation, monitoring or implementation activity and to the review of applicable results will be recorded in a bound field notebook with consecutively numbered pages. Entries made in the field notebook will be made in waterproof ink. If required, corrections will consist of line-out deletions which are to be initialed and dated. Typical information documented in the field notebook may include:

- Author's name, title and signature;
- Date and time of entry;
- Names and responsibilities of field crew members;
- Details of sampling locations, including sketches, as appropriate;
- Date and time of sample collection;
- Sample identification and description;
- Details of any required procedural deviations, such as sampling or schedule changes;
- Calibration or maintenance of field equipment;
- Required or miscellaneous field observations; and
- Weather conditions.

Field investigations and sampling situations vary widely, and actual site conditions are

sometimes not fully anticipated at the time of workplan preparation. However, information recorded in the field notebook should be sufficient to allow an adequate reconstruction of events, if necessary. The field notebook will be kept in the team member's possession or in a secure place during the investigation and will become a part of the permanent project file.

1.7.2 Field Reporting Forms

Examples of applicable field reporting forms are included in Appendix A. Entries made on field reporting forms will be made in waterproof ink. If required, corrections will consist of line-out deletions which are to be initialed and dated. The following field reporting forms are included in Appendix A, and may be used as needed:

- Borehole Log
- Monitoring Well Construction Detail forms
- Well Development Record
- Field Water Quality Sampling and Analysis form
- Organic Vapor Analysis – Borehole Soil Headspace Samples form
- Soil Vapor Sample Log
- Water Level Record
- Indoor Air Sample questionnaires and forms
- Photographic Log
- Inventory of Containerized Material

2.0 MEASUREMENTS AND DATA ACQUISITION

The following section describes procedures and protocols for obtaining field measurements and samples.

2.1 STANDARD OPERATING PROCEDURES

Standard operating procedures related to anticipated field activities are addressed below. Standard operating procedures for unanticipated field activities will be developed as necessary, and will be incorporated into the QA/QC Plan by reference or insertion.

2.1.1 Indoor Air Quality Sampling

Indoor air quality sampling technicians will interview building occupants and record observations about the surroundings (Appendix A) immediately prior to initiating and completing the indoor air quality sample collection procedure. Indoor air quality samples will be collected in laboratory-prepared SUMMA canisters, over a 24-hour period for residential samples and an 8-hour period for commercial buildings, following the procedures established by EPA Method TO-15. The canisters will be laboratory-cleaned, laboratory-evacuated to a vacuum of 0.05 torr, sealed and shipped by the lab under chain of custody procedures to the facility or to the air sampling technicians. The canisters will be placed at the lowest actual or potential living area in the home or office away from air or heating vents, windows, or doors. Beginning and ending canister conditions (i.e., canister pressure) will be noted and recorded (Appendix A). The canisters will be stored at room temperature before and after use, and will be shipped to the laboratory in batches under chain of custody procedures. The Method TO-15 holding time of 30 days (between sample collection and analysis) will not be exceeded.

2.1.2 Drilling

Borings typically will be advanced by hollow stem augers. Deep drilling requirements may use air rotary techniques provided that, a) the air stream is scrubbed with a device capable of removing oil and other potential contaminants; b) potentially contaminated groundwater is captured for testing and possible offsite disposal; and c) drill cuttings are trapped with a centrifugal device or beneath an appropriate blanket, as necessary. Shallow installations may be installed by solid stem augering and/or direct-push (e.g., GeoProbe®) techniques.

Standard split spoon samplers or continuous coring devices may be used in subsurface soil sampling, as necessary. When split spoon samplers are used, blow counts will be recorded for each 6-inch increment/interval to document soil density. Drill cuttings will be inspected and described for intervals not sampled by split spoon or continuous coring devices. Soils recovered from split spoon samplers, continuous coring devices, or drill cuttings will be described by an experienced geologist or engineer. Soil samples will be screened for the presence of organic vapors or other gasses utilizing a clean, calibrated photo-ionization meter (PID) that is capable of reading in parts per billion which may be rented, provided by the client, or owned by EnviroGroup and results will be recorded in a field notebook. An appropriate borehole log form is included in Appendix A.

Drilling and sampling equipment will be decontaminated prior to and between uses as described in Section 2.1.10. Drill cuttings and unused soil samples will be containerized or otherwise managed pending the results of analyses designed to evaluate the need for appropriate offsite disposal (Section 2.1.11).

2.1.3 Monitoring Well Installation

Construction procedures and materials used in the installation of monitoring wells to date have relied upon best industry practices. Monitoring wells will be installed in accordance with the

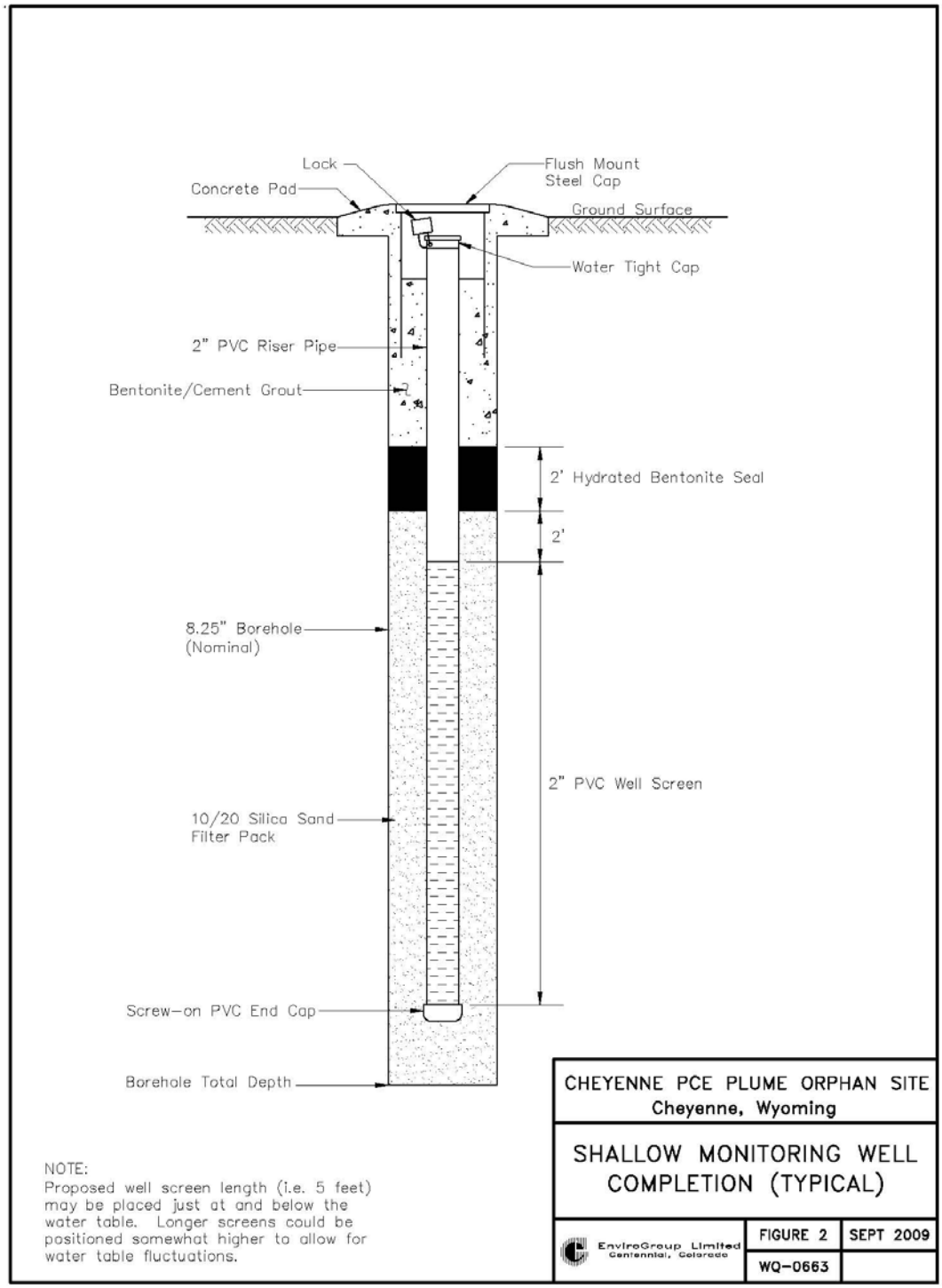
requirements described in Part G, Chapter 11, Water Quality Rules and Regulations (Water Quality, 1984)

Shallow Monitor Well and Piezometer Installation

Shallow monitor wells are single-casing designs constructed of two inch flush-threaded PVC materials (Figure 2.1). All procedures, materials and measurements will be documented by a qualified geologist or engineer on suitable field forms (see Appendix A). Solvent-based PVC cements will not be used for any reason in the construction or repair of monitor wells or piezometers. Shallow monitor wells will typically be installed in borings advanced by hollow stem augers (Section 2.1.2). When hollow stem augers are used, all well completion materials will be installed through (inside) the augers, and may be hand-placed or tremmied into position. Solid stem augers may also be used to advance borings for the installation of shallow wells (Section 2.1.2). Solid stem augers are removed from the boring prior to the installation of casing and other completion materials, which may also be hand-placed or tremmied into position.

Machine slotted well screen (typically 0.010 to 0.020 inch slots), fitted with a threaded bottom cap, will generally be installed to the boring's total depth. If the boring is drilled deeper than the desired well completion depth, the boring may be backfilled with graded silica sand or chipped bentonite, as appropriate, to the desired depth prior to the installation of casing and other completion materials. The relationship between the top of the well screen and the water table may vary to accommodate specific well design parameters. Graded silica sand will be placed in the annulus to an approximate height of one to three feet above the top of the well screen. Approximately two to three feet of granular, chipped or pelleted bentonite will be placed above the silica sand and hydrated with groundwater, if present, or two to three gallons of potable water. The bentonite will be allowed to hydrate and swell for at least 20 to 30 minutes prior to the placement of grout.

Figure 2.1 - Shallow Well Design


Lock
Flush Mount Steel Cap
Concrete Pad
Ground Surface
Water Tight Cap
2" PVC Riser Pipe
Bentonite/Cement Grout
2' Hydrated Bentonite Seal
2'
8.25" Borehole (Nominal)
2" PVC Well Screen
10/20 Silica Sand Filter Pack
Screw-on PVC End Cap
Borehole Total Depth
NOTE:
Proposed well screen length (i.e. 5 feet) may be placed just at and below the water table. Longer screens could be positioned somewhat higher to allow for water table fluctuations.
CHEYENNE PCE PLUME ORPHAN SITE
Cheyenne, Wyoming
SHALLOW MONITORING WELL COMPLETION (TYPICAL)
EnviroGroup Limited
Centennial, Colorado
FIGURE 2
SEPT 2009
WQ-0663

Following the hydration of the bentonite seal, grout will be placed in the annulus to a height within approximately 2 to 3 feet of the ground surface. Acceptable grouts include neat Portland cement slurries (mixed at a rate of 6 gallons of potable water per 94 pound sack of cement), concrete (for very shallow completions), and cement/bentonite mixtures. Bentonite, if used, will be powdered and will be added at a rate of no more than 8 percent by dry weight. The volume of additional water added to a cement/bentonite grout will not exceed 3/4 gallon for each 1 percent of bentonite added (i.e., no more than 12 gallons per 94 pound sack of cement mixed with 8 percent powdered bentonite).

Grout will be allowed to harden and gain strength overnight before the placement of concrete to secure a flush-mount well vault or above-ground steel protective casing. The PVC well casing will be sealed with an expanding-type plug. Locks are required on all limited access flush-mount and steel protective casing completions.

Deep Monitor Well Installation

Deep monitor wells are double-casing designs constructed of two inch flush-threaded PVC well casing materials, placed inside a larger diameter surface casing of steel or PVC. All procedures, materials and measurements will be documented by a qualified geologist or engineer on suitable field forms (see Appendix A). Solvent-based PVC cements will not be used for any reason in the construction or repair of monitor wells or piezometers. Deep monitor wells will typically be installed in borings advanced by hollow stem augers (Section 2.1.2). When hollow stem augers are used, all well completion materials will be installed through (inside) the augers. The use of air rotary drilling techniques may also be used provided a) the air stream is scrubbed with a device capable of removing oil and other potential contaminants; b) potentially contaminated groundwater is captured for testing and possible offsite disposal; and c) drill cuttings are trapped with a centrifugal device or beneath an appropriate blanket, as necessary (Section 2.1.2).

Steel or PVC surface casings are installed to isolate the well screen from potentially contaminated groundwater at shallower depths. Steel (galvanized or bare) and PVC in 6, 8, or 10 inch diameters are commonly available materials suitable for use as surface casings. Steel surface casing may be flush-threaded or thermally welded as necessary. However, PVC surface casing must be flush-threaded if more than one joint of casing is required. The interval to be sealed by surface casing may be drilled and sampled with ordinary (e.g., 4-1/4 inch inside diameter) hollow stem augers and subsequently reamed with larger hollow or solid stem augers to a diameter sufficient to provide an annulus of at least 2 inches around the surface casing (i.e., final boring diameter at least 4 inches larger than the nominal surface casing diameter).The annulus around surface casing must be grouted prior to deepening the boring. The grout may be placed by one of several methods, the selection of which is to be determined by the drilling contractor and the supervising geologist or engineer. Some acceptable grouting methods are described below:

- Calculate the volume of grout required (i.e., the volume of the boring minus the volume of the surface casing). Seal the bottom of the surface string with a wooden plug. Mix the grout and place it (hand-poured or tremmied) in the boring. Insert the plugged surface string to its desired depth, thereby forcing the grout into the annulus.
- Install the surface casing and pump or tremmie grout into the annulus.
- Install the surface casing. Place the grout inside the surface casing, and force it into the annulus by means of a plunger.

Grout sealing the surface casing will be allowed to harden and gain strength at least overnight before re-entering the cased hole (with drilling tools of smaller diameter than the surface casing). The wooden plug (if used) in the base of the surface casing is easily penetrated with auger, air rotary or coring bits. The boring will be advanced to the desired depth beneath the base of the surface casing using the techniques described in Section 2.1.2.

Machine slotted well screen (typically 0.010 to 0.020 inch slots), fitted with a threaded bottom cap, will generally be installed to the boring's total depth. If the boring is drilled deeper than the desired well completion depth, the boring may be backfilled with graded silica sand or chipped bentonite, as necessary, to the desired depth prior to the installation of casing and other completion materials. Graded silica sand will be tremmied into the annulus to an approximate height of one to three feet above the top of the well screen. Approximately two to three feet of granular, chipped or pelleted bentonite, or a prepared bentonite slurry, will be tremmied or pumped above the sand filter and hydrated with groundwater, if present, or two to three gallons of potable water as necessary. If dry bentonite products are used for the seal, the bentonite will be allowed to hydrate and swell for at least 20 to 30 minutes prior to the placement of grout.

Following the hydration of the bentonite seal, grout will be placed atop the seal and will extend into the surface casing (i.e., overlap with the grouted interval of the surface casing) at least four feet, but not more than eight feet (to minimize potentially destructive heat buildup caused by curing cementious grouts). Acceptable grouts are described in Section 2.2.3. The upper, non-grouted, portions of the surface casing may be backfilled with another stabilizing material, such as chipped bentonite, once the grout has hardened.

Grout will be allowed to harden and gain strength at least overnight before the placement of concrete to secure a flush-mount well vault or above ground steel protective casing. The PVC well casing will be sealed with an expanding-type plug. Locks are required on all limited access flush-mount and steel protective casing completions.

2.1.4 Monitoring Well Development

All monitor wells are to be developed to the extent practicable prior to collecting groundwater samples or conducting permeability tests. Development will begin with the surging or agitation of the water column with a decontaminated (Section 2.1.10) bailer or surge block to suspend fine particles of sediment so they can be removed by subsequent bailing or pumping. Surging will be

repeated throughout the development process in an effort to flush fine particles from the sand filter surrounding the well screen. It is not necessary to install a foot valve (i.e., a check valve) to the pump assembly, if used, during development because any falling water will contribute to the desired surging effect.

Water conditions and general well performance notes will be recorded on appropriate field reporting forms (Appendix A). Development will continue until the water is essentially clear and uncolored. For wells completed in granular formations, the removal of 10 to 15 wetted casing volumes (i.e., the volume of groundwater standing in the casing under steady-state conditions) during development is commonly sufficient to allow for the collection of representative groundwater samples. For wells completed in fine-grained formations, the removal of as few as three to five wetted casing volumes may be sufficient, since the primary goal in such wells is to flush the sand filter. Information typically provided during well development includes:

- Pre-development water level and well depth with the date and time of measurement;
- The method and duration of each surging event;
- Date and time each wetted casing volume was removed (allows a generalized assessment of the well and formation performance);
- A running total volume of groundwater removed, and a note regarding appearance; and
- Comments regarding the presence of odor or sheen observed, if any.

Groundwater purged during well development will be containerized and stored onsite pending an evaluation of applicable disposal requirements (Section 2.1.11).

2.1.5 Groundwater Monitoring Procedures

Prior to the sampling event, information on monitor well condition and construction, anticipated contaminant types and concentrations, and anticipated groundwater flow direction should be

collected for each well where sampling is proposed. Lesser contaminated wells should be sampled before more contaminated ones to minimize the effects of cross-contamination.

Water Level Measurements

Depth to groundwater is generally measured with an electronic water-sensing device. The measurement will be made relative to a surveyed measurement point at the well head (commonly the top of the PVC casing), and will be recorded to the nearest 0.01 foot.

Field Water Quality Measurements

Field water quality measurements provide a rapid means of characterizing general groundwater conditions and are also used during groundwater sampling to ensure that fresh formation water is obtained for laboratory analysis. The parameters used during any sampling event may vary, based on project requirements. However, several commonly measured parameters are identified and described below.

It should also be noted that the following descriptions are generalized. Personnel tasked with obtaining field water quality measurements should refer to the manufacturer's literature for calibration and use instructions and defer to them in the event of any discrepancy.

<u>pH Measurement</u>

1. Calibrate or verify the calibration, as appropriate, according to the manufacturer's instructions at least daily. The calibration must be based on at least two pH end-points (commonly pH 7 and pH 10, or pH 7 and pH 4); however, three pH end-point calibration (e.g., pH 4, pH 7, and pH 10) is becoming more common.
2. Rinse the calibration solution from the electrode with deionized water.
3. Once calibration has been established, insert the rinsed electrode into the well to be measured. Allow the reading to stabilize (possibly several seconds to a minute or more). A noticeable increase in stabilization time may indicate a need to clean or replace the

electrode. Record the stabilized pH value (pH is a dimensionless parameter, although the term 'standard pH units' is sometimes cited).

4. pH is somewhat dependent on temperature. Most electrodes automatically compensate for temperature. If the electrode used does not provide automatic temperature compensation, the sample temperature must also be measured and recorded.

Specific Conductance Measurement

1. Calibrate or verify the calibration, as appropriate, according to the manufacturer's instructions at least daily. Typically, only one calibration solution is used.
2. Rinse the calibration solution from the electrode with deionized water.
3. Once calibration has been established, insert the rinsed electrode into the well to be measured. Allow the reading to stabilize (possibly several seconds to a minute or more). A noticeable increase in stabilization time may indicate a need to clean or replace the electrode. Specific conductance is measured in units of milli- (m) or micro- (µ) Siemens or mhos (Siemens and mhos are equivalent).
4. Specific conductance is highly dependent on temperature. Most modern devices automatically compensate for temperature. If the device used does not, the sample temperature must also be measured and recorded.

Redox or ORP (Oxidation-Reduction Potential) Measurements

1. Calibrate or verify the calibration, as appropriate, according to the manufacturer's instructions at least daily. Each calibration or verification should be based on a freshly prepared (or newly opened) quantity of Redox buffer solution. Only a single-point calibration is required because of an internal reference point inherent to all redox electrodes.
2. Rinse the calibration solution from the electrode with deionized water. Once calibration has been established, gently lower the rinsed electrode into the well to be measured. Allow the reading to stabilize (possibly several seconds). An effort should be made to record redox values at approximately the same time in every sample (after each well casing purge) to minimize the effects of sample contact with

the atmosphere. Redox (or ORP) is measured in units of millivolts.

Dissolved Oxygen Measurement

1. Calibrate or verify the calibration, as appropriate, according to the manufacturer's instructions at least daily. If using a YSI 556 MPS Field Meter, the device must be on for at least 20 minutes prior to calibration.
    a. If using a Multiline P-4 Field Meter, the sponge in the calibration sleeve should be moist but not wet and the sleeve should be left on the probe during calibration but should be loosened to ensure that the Dissolved Oxygen sensor is vented to the atmosphere. If using the YSI 556 MPS Field Meter, perform the Dissolved Oxygen calibration in % Saturation. Make sure that the Dissolved Oxygen and Temperature probes are not immersed in water during the calibration procedure. The calibration cup should be loosely threaded to ensure that the Dissolved Oxygen sensor is vented to the atmosphere. Confirm that the unit compensates for barometric pressure changes. Allow approximately 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate. When the reading shows no significant change for approximately 30 seconds, press enter. Confirm the accuracy of calibration by measuring the dissolved oxygen concentration of a known dissolved oxygen solution (i.e. 0 mg/L). The USEPA Office of Environmental Measurement and Evaluation recommends that the confirmation reading be less than 0.5 mg/L (EPA, QA Bulletin, Calibration of Dissolved Oxygen Meters, February 2006).
2. Once calibration has been established, gently lower the rinsed electrode into the well to be measured. Allow the reading to stabilize (possibly several seconds to several minutes or more). An effort should be made to record Dissolved Oxygen readings in mg/L and % Saturation at approximately the same time in every sample to minimize the effects of sample contact with the atmosphere.

Groundwater Sample Collection

Groundwater samples may be collected immediately after development if necessary or desired. However, in situations involving volatile organic compounds, it may be desirable to allow the

formation to recover and stabilize at least overnight following well development before conducting groundwater purging and sampling activities. Groundwater sampling procedures, measurements and observations will be recorded on an appropriate field reporting form (Appendix A). Sample collection procedures are described below:

Low-flow pumping procedures will be used. This technique relies on the removal of groundwater at a rate similar to the well's rate of recharge (i.e., the groundwater column height during pumping should not vary more than approximately 10 percent from its steady-state condition or by keeping the drawdown at a minimal level (e.g., 0.33 feet); and is documented in EPA's Groundwater Sampling Guidelines for Superfund and RCRA Project Managers (EPA 542-S-02-001). There is no need to remove significant volumes of groundwater when using this technique, because laminar flow into the pump results in the nearly instantaneous recovery of fresh formation water from a discrete aquifer zone. Low-flow sampling procedures are described below:

- Measure and record the depth to water and total well depth, noting the date and time of measurement.
- Calculate one tubing volume (including the volume of water in the pump and flow cell) and one wetted casing volume (i.e., the volume of groundwater in the well casing).
- Lay out polyethylene sheeting around the well and place monitoring, purging and sampling equipment on the sheeting to minimize contamination from the surrounding area.
- Slowly lower the pump (e.g., peristaltic, bladder, submersible, etc.) and tubing down into the monitoring well until the location of the pump intake is set at a pre-determined location within the screen interval and record pump location in a field notebook or on a sampling form.
- Connect the discharge line to a flow through cell and attach the field parameter measurement meters. The discharge line from the flow through cell is directed to

a container to contain the purge water.

- Begin pumping the well at a low flow rate, monitoring the water level and adjusting the speed as needed to maintain a steady flow rate. Measure the discharge rate with a graduated cylinder and a stopwatch and record the flow rate and drawdown in a field notebook or on a sampling form.
- A minimum of one tubing volume (including the volume of water in the pump and flow cell) must be purged prior to recording the field water quality parameters. Field water quality parameters should be measured and recorded at regular intervals of time (i.e., every 3 to 5 minutes) in addition to recording the flow rate and water level or drawdown.
- Once three successive readings of the field water quality parameters provided in Table 4.1 have stabilized, sampling may begin. Samples should be collected directly from the discharge port of the pump prior to passing through the flow cell. If stabilization of field water quality parameters does not occur, the sample should be collected once 3 to 6 wetted casing volumes have been removed.

Groundwater samples to be analyzed for volatile organic compounds, for example, are to be decanted with a minimum of agitation into laboratory prepared sample vials. The sealed vial will be inverted for inspection. If an air bubble is observed, additional groundwater will be added to the sample to ensure a zero-headspace condition. The sample will be labeled and placed in a cooler as described in Section 2.2. If a drawdown of less than or equal to 0.33 feet cannot be maintained and the water level is approaching the top of the screened interval, reduce the flow rate or turn off the pump for 15 minutes and allow for recovery. Under no circumstances should the well be pumped dry. Begin pumping at a lower flow rate, if the water draws down to the top of the screened interval again, turn the pump off (only if the pump has a foot valve) and allow for recovery. If two tubing volumes have been removed, collect the sample the next time the pump is turned on. If this occurs, a note should be placed in the field notebook and sampling log with a recommendation for a different purge method.

Table 2.1 Stabilization Criteria for Water Quality Indicator Parameters	
Parameter	Stabilization Criteria
pH	+/- 0.1
Specific Electric Conductance (SEC)	+/- 3%
Oxidation-reduction Potential (ORP)	+/- 10 millivolts
Dissolved Oxygen (DO)	+/- 0.3 mg/l

Groundwater purged during sampling will be containerized and stored onsite pending an evaluation of applicable disposal requirements (Section 2.1.11).

2.1.6 Surface Water Sample Collection

Typically, the methodology employed for surface water sampling will be collection by dipper or by holding a sample bottle with a freshly gloved hand in the center of flow. If it becomes necessary to collect surface water samples where a multipoint sampling procedure is more appropriate, such a procedure will be specified.

The surface water quality samples will be representative of the environment being sampled and all steps will be taken, as necessary, to ensure that a representative sample has been obtained. Regardless of the sampling technique, homogenizing a composite sample prior to splitting with other groups or for other tests is essential. In some instances when incomplete mixing is suspected, or if performing dispersion analysis, discrete samples as well as composite samples may be collected. Homogenizing will be accomplished by repeatedly inverting the composite bottle for 30 seconds.

Temperature, pH, and specific conductance will be measured in the field following the procedures outlined in Section 2.1.6. Samples will be appropriately preserved.

2.1.7 Soil Vapor Sampling

Soil vapor samples are typically collected from small diameter borings for reconnaissance purposes. The vapor samples may be analyzed by mobile laboratory services in the field or delivered to a fixed laboratory for analysis.

Sampling Point Installation

Boreholes will be advanced under the oversight of EnviroGroup personnel, at locations selected by EnviroGroup Limited, from ground surface to approximately 5 feet bgs using a direct-push rig (i.e. Geoprobe® or equivalent) at the Site. Upon completion of drilling activities, and using freshly-gloved hands, each soil vapor probe assembly will be immediately placed into the borehole by drilling personnel. Soil vapor probes will be constructed using 0.25 inch inner diameter (I.D.) by 6 inch long, stainless steel screens connected to 0.25 inch outer diameter (O.D.) Nylaflow® tubing. Screens will be placed at the desired sampling depth (typically in the middle of the sampling zone, described below) and the tubing extended up the center of the borehole to approximately 6 inches above ground surface and fitted with an air-tight valve. Screens will be placed in the soil vapor sampling zone (typically two feet in length), but may be adjusted based on soil stratigraphy and moisture content. Stainless steel screens will be centered within each sampling zone and the annulus surrounding each screen backfilled with typically two feet of clean silica sand (or glass beads, 60 – 120 sieve size). Soil vapor probe sampling zones will then be sealed with a bentonite seal. Granular bentonite will be installed in nominal 8 inch lifts (with distilled water hydration following each lift) to a height of approximately two feet above the silica sand. The remaining annulus will then be backfilled to grade with granular bentonite, installed in two foot lifts (with distilled water hydration between each lift). A five inch diameter flush-mount well vault will be concreted around the top of each soil vapor probe tube to minimize infiltration of water or outdoor air.

To minimize the potential for cross-contamination during investigation activities, the ends of each length of soil vapor probe tubing will be capped and tubing placed inside an air-tight storage bag or container and kept away from hydrocarbons and truck exhaust. All tubing will

remain capped, except during soil vapor probe installation, and will be stored inside the cab of the EnviroGroup vehicle. All stainless steel probe screens will be kept in an air-tight container until installation to avoid contamination.

Soil Vapor Sample Collection

Soil vapor samples will be collected in the field using current state of the art procedures and soil vapor probes will not be disturbed for at least 24 hours before sampling. During soil vapor sampling activities, a clean, small plastic or stainless steel shroud with two small ports will be placed over each soil vapor probe and weighted down. An air-tight seal of hydrated bentonite or foam will be placed on the ground surface around the edge of the shroud where it contacts the ground. The soil vapor probe tube, which is fitted with an air-tight valve, will be extended up through the air-tight seal of hydrated bentonite or foam to the exterior side of the shroud. If required, the probe tubing will be extended above ground surface with an additional piece of Nylaflow® tubing. All connections will be located inside the shroud to verify that the seals are air-tight.

Each soil vapor tube, connected to an air-tight valve, will be connected with a tedlar bag attached to one side of the valve and the sampling tube on the other side of the valve (both outside of the shroud). Prior to purging or sampling activities, helium tracer gas will be released via a small diameter tube through a port in the shroud into the enclosure beneath the shroud. A sample of the air inside the shroud will be measured through the second port using a portable helium detector to determine the concentration of helium within the enclosure beneath the shroud.

Three purge volumes (calculated based on the volume of probe tubing and screen) will be purged, at a flow rate of 0.1 liters per minute, through the shroud into a 60 ml calibrated gas-tight syringe and transferred to the tedlar bag. The tedlar bag will then be connected to a portable helium detector to measure for the presence of helium gas in the purged vapors. If high concentrations (>10% of the shroud concentration) of helium are observed in the purge vapors, the soil vapor probe seal and shroud seals will be checked and/or enhanced to reduce the infiltration of ambient air into the enclosure and another sample collected. If helium concentrations are less than 10%, a soil vapor sample will be collected in a clean, 60 ml

calibrated gas-tight syringe or tedlar bag and immediately hand delivered to the mobile laboratory for analysis.

The mobile laboratory uses a gas chromatography-mass spectrometry (GC/MS) and will perform soil vapor analysis for PCE and TCE utilizing USEPA Method 8021 with nominal reporting limits of 5.0 µg/m3.

2.1.8 Soil Sample Collection

Soil sample collection procedures vary widely depending on project requirements. Samples of subsurface soils may be collected during drilling, as split spoon samples or drill cuttings (Section 2.1.2). Shallow subsurface and/or surface soil samples may be collected with various hand tools (e.g., shovels or scoops), hand augers, hand-coring devices, or even a freshly gloved hand. The soil samples should be placed in laboratory prepared jars or bags, as appropriate, and managed under the chain of custody procedures described in (Section 2.2). Equipment decontamination procedures are addressed in Section 2.1.10.

2.1.9 Equipment Decontamination

Equipment decontamination procedures vary in accordance with the type of equipment and the project requirements, and will be addressed as necessary in applicable workplans. Further, the use of dedicated and disposable equipment (e.g., bailers and rope) is advantageous in that it may eliminate a need for equipment decontamination prior to and between uses, and the preparation and analysis of associated field rinseate blanks.

However, the following procedures are applicable to typical equipment decontamination requirements:

- Physically clean the equipment. For large equipment (e.g., drilling augers, excavator buckets), spraying with high-pressure and (if necessary) high-temperature water provides

sufficient decontamination.

- For smaller equipment (e.g., shovels, split spoons, etc.), more aggressive procedures, such as those listed below, will also be used:
    - Provide a detergent and potable/distilled/deionized water wash.
    - If metals are an identified project concern, rinse the equipment with a dilute (10:1) nitric acid solution.
    - Follow the detergent water and/or the dilute acid rinse by a triple-rinse with distilled or deionized water.
- Air dry the decontaminated equipment and either use it immediately, or wrap and/or store it appropriately for later use.

2.1.10 Investigation Derived Wastes

Investigation derived wastes will be managed in accordance with the WDEQ Voluntary Remediation Program, Fact Sheet #29 Sampling and Analysis Plans (April 18, 2007)., and applicable local, state and federal laws and regulations.

Investigation derived wastes may include environmental media, such as drill cuttings, decontamination waters, and groundwater purged during development or sampling (IDW13), and solid wastes, such as used bailers, personal protective equipment, and decontamination waters (IDW23). We anticipate that there will be minimal amounts of investigative derived wastes (IDW) associated with the installation of monitoring wells and soil vapor probes, well development, and groundwater sampling activities. We estimate that 4 drums of soil and 4 drums of water, potentially hazardous for only PCE, may be generated during investigation activities. No IDW should be generated during sampling collection from private wells/sump location. Additionally, it is our understanding that WDEQ is the generator of any IDW and will provide signatures for any required manifests and disposal forms.

All drilling equipment will be decontaminated between borehole/monitoring well and soil vapor

probe locations. Drilling equipment will be cleaned using a detergent and potable/distilled/deionized water wash following by a triple-rinse with distilled or deionized water. Decontaminated equipment will then be allowed to air dry or appropriately stored for later use.

Drill cuttings/soil cores may have significant levels of chemicals of concern (e.g., PCE), and will be visually inspected for the presence of non-aqueous phase liquids (NAPLs) and field screened with a ppbRAE to measure organic vapor concentrations at each borehole location. Soils exhibiting NAPL or elevated organic vapor concentrations will be segregated and containerized separately from soils not exhibiting these properties to facilitate characterization and minimize disposal costs. Cuttings will be placed into 55 gallon drums, properly labeled with a pending label, and stored at a location designated by WDEQ pending analytical results. Decontamination and groundwater purge water will be visually inspected for the presence of NAPL. Waters exhibiting a visual sheen will be segregated and containerized separately from waters not exhibiting a sheen to facilitate characterization and minimize disposal costs. Decontamination and groundwater purge waters will be placed into 55 gallon drums, properly labeled with a pending label, and stored at a location designated by WDEQ pending analytical results. Assuming the IDW water is not classified as hazardous waste, and it cannot be disposed of in the local sanitary sewer, a water disposal plan will be submitted for approval by the WDEQ.

All other IDW (e.g., disposable gloves, used LFP tubing, etc…) will be bagged and placed into a waste container upon completion of investigation activities.

An inventory of each day's IDW will be recorded in a bound field book and/or on appropriate field forms. The inventory will reference the date and area of generation and be provided to the WDEQ for its use in the proper management of the IDW. The WDEQ will remain the sole owner of any IDW generated by investigation activities; however, EnviroGroup will assist the WDEQ with waste transportation and disposal options.

Soil and water drums will be characterized by the WDEQ based upon laboratory analytical results from soil and groundwater samples. Soil and groundwater drums will be picked-up, transported, and disposed of by Arvada Treatment Center, of Arvada, Colorado, a Part B permitted hazardous waste treatment, storage, and disposal facility. We understand that WDEQ is the generator of any IDW and will provide signatures for any required manifests and disposal forms.

2.2 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

The following section details the sampling handling and chain of custody requirements that must be followed when taking samples.

2.2.1 Sample Handling

Samples will be packaged and preserved in a manner prescribed by the applicable analytical method (Section 2.3). Method-specific holding time requirements will be observed.

2.2.2 Sample Custody Documentation

Sample Labels

All sample containers will be labeled. Labels will be completed with waterproof ink. Clear packaging tape may be applied over the completed label, as necessary, to prevent it from loosening in a cooler containing ice. Information commonly provided on sample labels includes:

- Sample number or designation;
- Site or project name;
- Sample collection date and time;
- Preservative and filtration status;

- Analytes requested; and
- Sampler's name or initials.

Chain of Custody Forms

All samples will be recorded chronologically on chain of custody forms. All entries to chain of custody documents will be made in ink. The chain of custody document(s) will be placed in a ziploc plastic bag and enclosed in the sample cooler or shipping container. The sample cooler will be custody-sealed as described below.

Custody Seals

Custody seals are used to assure the integrity of samples from the time the samples are collected and logged into the chain of custody system until the samples are received by analytical laboratory personnel. All samples will be shipped to the laboratory in coolers or other appropriate shipping containers. The cooler or shipping container will be custody-sealed in a manner which requires the destruction of the seal at the time of opening whenever a third party delivery service is used. Such coolers or shipping containers will also be taped shut, with a layer of clear packaging tape placed over the custody seal to minimize the likelihood of accidental destruction during shipping and handling.

2.3 ANALYTICAL METHOD REQUIREMENTS

Anticipated analytical methods for the analysis of indoor air, groundwater, soil, and soil vapor samples are listed in Table 2.2. Sample requirements for each anticipated analytical method are also presented in Table 2.2. Requirements for unanticipated analytical methods, if any, will be addressed in this QAPP by reference and/or insertion as applicable.

TABLE 2.2

ANTICIPATED ANALYTICAL METHODS AND SAMPLE HANDLING REQUIREMENTS

Method	Medium	Volume	Container	Filtration	Preservative	Holding Time
EPA TO-15 (SIM) (High- Resolution VOCs)	Indoor Air, Outdoor Air, Soil Vapor	N/A	SUMMA Canister	N/A	None	30 Days
EPA 8260B (VOCs)	Soil	4 oz	Glass/Teflon-lined cap	N/A	None, Cool 4°C	14 Days
EPA 8260B (VOCs)	Groundwater	2-40 ml	Glass/Teflon-lined cap	None	None, Cool 4°C	14 Days
EPA 8021 (VOCs)	Soil Vapor	1 L	Tedlar Bag/Syringe	N/A	None, Cool 4°C	3 Days
Water and Wastes (other parameters)	As Necessary	As Necessary	As Necessary	As Necessary	As Applicable	As Applicable

N/A – Not applicable.

2.4 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

2.4.1 Laboratory QA/QC Requirements

Authorized laboratories (Section 1.3) will analyze indoor air, soil, groundwater, surface water, and soil vapor samples in accordance with applicable EPA methods. Quality assurance/quality control (QA/QC) requirements and corrective action procedures are developed by each laboratory in accordance with applicable EPA method requirements and each lab's internal standard operating procedures and quality assurance plans. Laboratory QA/QC results will be reviewed during data validation (Section 3.2).

2.4.2 Field QA/QC Requirements

Field QA/QC sampling requirements are summarized in Table 2.3. The rationale for specific field QA/QC sampling requirements is discussed in the following sections. The results of field or trip blanks analyses will not be used to correct data. If contaminants are found in blanks, the source of the contamination should be identified and corrective action, possibly including resampling, should be initiated.

Indoor Air QA/QC Samples

Trip Blanks

Trip blanks are prepared to evaluate canister cleaning, shipping and field handling procedures. The samples consist of laboratory prepared canisters that are transported, handled and shipped in the same manner as the sample canisters. These may be omitted on a project specific basis.

TABLE 2.3

FIELD QA/QC SAMPLING REQUIREMENTS

QA/QC Sample	Frequency of Sample Collection			
	Groundwater/ Surface Water	**Soil**	**Soil Vapor**	**Indoor Air**
Trip Blank (VOCs Only)	1 per Sampling Event[1]	None	None	None
Field Blank	None[2]	1 per day per Sampler per Sampling Technique	1 per day	None
Duplicate	1 per 10 samples[3]	None	1 per day	1 per shipment batch
Replicate	1 per 10 samples[3]	None	None	None

Note: [1]Required when samples will be analyzed for volatile organic constituents. Not to exceed 72 hours in the field.
[2]Based on the use of dedicated, disposable sampling equipment. Otherwise, will follow same schedule as that specified for soil sampling events.
[3]At least one sample will be collected and analyzed per scheduled sampling event.

Field Duplicates

Field duplicates consist of two canister samples collected simultaneously and side by side. In the case of soil vapor samples for the mobile lab, sequential Tedlar bag samples will be collected. Field duplicates are prepared to evaluate sampling technique and laboratory procedures through the analysis of representative samples obtained from a relatively homogenous medium.

Groundwater and Soil QA/QC Samples

The use of dedicated, disposable sampling equipment is specified for groundwater monitoring at the site to minimize or eliminate the need for equipment decontamination and the preparation of field (equipment rinseate) blanks. Several field QA/QC samples may still be required, however, as described below.

Trip Blanks

Trip blanks are containers of organic-free water prepared by the laboratory for transport into the field for the duration of a sampling event. However, no trip blank should be allowed to stay in the field for an extended period. Therefore, a 72 hour maximum holding period has been established for trip blanks prepared for groundwater events. If groundwater sampling extends beyond a 72 hour event (three days), more than one trip blank will be required.

Field (Rinseate) Blanks

Field blanks, otherwise known as equipment rinseate blanks, are prepared to assess the decontamination of reusable sampling equipment. Field blanks will be prepared at a rate of one per day, per sampler, per sampling technique when the required sampling involves the use of reusable equipment.

Field Duplicates

Field duplicates are used to assess the degree of variability apparent due to both sampling technique and laboratory procedures by evaluating representative samples obtained from the same medium, collected sequentially from the same location. Field duplicate samples of

groundwater, for example, include the collection of one sample followed by the collection of a second (duplicate) sample. Soils are inherently non-homogenous and are subject to natural variations in composition and texture across small distances. It is not possible to isolate the effects of sampling technique and laboratory procedures from natural heterogeneity through the collection of duplicate samples. Therefore, field duplicates will not be collected during soil evaluations.

Field Replicates (Splits)

Field replicates are two or more samples split from an original container or sampling device in a manner which assures that the splits are the same in all respects, assuming the original sample is relatively homogenous. Replicate samples will be analyzed by the same analytical procedures at different laboratories to assess the variability between the laboratories. Soils are inherently non-homogenous and it is not possible to prepare representative splits of a soil sample in the field. Soil sample splits can, under certain circumstances, be prepared in the laboratory. However, the homogenization procedures commonly used to split samples in the lab (i.e., drying and sieving) are impractical for use with organic constituent analyses. Therefore, field replicates will not be prepared for soil samples, and soil replicates will only be laboratory-prepared when anticipated analyses are limited to inorganic constituents.

Soil Vapor QA/QC Samples

A mobile laboratory blank will be prepared and analyzed prior to initiating the day's sampling to ensure that adequate decontamination has been achieved. Field (equipment) blanks will be prepared by drawing a sample of ambient air through the sample collection system (i.e., vacuum pump, tubing, etc.).

Field duplicates consist of two canister samples collected simultaneously and side by side. In the case of soil vapor samples for the mobile lab, sequential Tedlar bag samples will be collected. Field duplicates are prepared to evaluate sampling technique and laboratory procedures through the analysis of representative samples obtained from a relatively homogenous medium.

2.5 EQUIPMENT INSPECTION, MAINTENANCE AND CALIBRATION REQUIREMENTS

All field and laboratory instrumentation must be calibrated prior to use. Laboratory instruments must be calibrated with calibration blanks and standards following SW-846, EPA 600/4-79-020, EPA/625/R-96/010b, etc., as appropriate. Divergence from acceptable benchmark criteria, defined by method-specific protocol and instrument type, requires correction before analysis can begin. Calibration blank and instrument performance standard check results must be recorded in the instrument logbook, which will also contain evaluation procedures, benchmark criteria and maintenance records. Standard Reference Materials from the National Institute of Standards and Technology, the EPA, or other certifiable sources should be obtained and analyzed to assess and ensure the accuracy of the measured parameter.

Field instrumentation to be used may include, for example, water level indicators, pH meters, conductance meters, redox meters, and thermometers. Water level indicator calibration will be verified in the field with a tape measure. The pH, conductance, and redox meters will be calibrated using known standards on a daily basis using the procedures outlined in Section 2.1.6. The thermometer requires factory calibration, but compliance with the manufacturer's specified calibration frequency, if any, will be confirmed.

2.6 INSPECTION AND ACCEPTANCE CRITERIA FOR SUPPLIES AND CONSUMABLES

Supplies and consumables specified for use in approved workplans or remedy designs will be obtained from reputable vendors. Field personnel or Task Managers, as appropriate, will confirm the specifications and quality of the supplied materials.

3.0 DATA VALIDATION AND USABILITY

The following sections describe the data validation process used at the Site.

3.1 DATA REVIEW, VALIDATION AND VERIFICATION REQUIREMENTS

The objectives of the quality assurance (QA) procedures described in the following sections are to; a) develop and maintain a computer database for the storage and management of project data that is accurate, complete and current, and capable of providing data to meet project needs in a timely manner; and b) provide for the general security of the data by preventing unauthorized data entry, modification or viewing.

Field and laboratory results will be reviewed and validated in accordance with the specifications presented in the following section. Analytical results will be electronically entered when possible to eliminate transcription errors. Hand entered results will be proofed as necessary by data validation personnel to guard against transcription errors.

3.2 DATA VALIDATION PROCEDURES

Analytical data will be validated and verified in terms of its ability to satisfy the data quality objectives for accuracy, precision and completeness specified by this QAPP and the analytical laboratory. Conditions requiring the invalidation of analytical data (i.e., elimination from the database and from future use) are rare, as noted in the following sections. However, conditions necessitating the flagging of data in the database are more common and will be evaluated based on the criteria that follow. Data flagged in the computer database are valid and usable in every way, but are flagged to alert the user that special care may apply to their use in interpretations.

3.2.1 Data Validation Procedures

Two types of data flags are recognized for environmental samples, including a) flags placed on results by the laboratory to denote problems with associated blanks, spikes, etc. (i.e., laboratory flags), and b) flags placed by data validation personnel to denote problems or issues associated with sample collection, site conditions or documentation (i.e., validation flags). In the database, laboratory flags are entered into the appropriate qualifier field as received (for example, 'J' for estimated concentrations). Results for soil, water, and soil vapor samples flagged by data validation personnel will be denoted by a '&' in the appropriate qualifier field. Validation criteria for indoor air quality sample results are slightly different and validation flags are more descriptive. Validation criteria and flags for indoor air quality samples are discussed in Section 3.2.3.

The laboratory may assign flags to indoor air quality sample results that denote method-specific quality control problems, such as matrix spike recoveries or blank contamination. Flagging nomenclature is not specified in EPA Compendium Method TO-15; however, a list of flags commonly used by the approved laboratories to denote these problems is included in Appendix B.

Documentation Reviews

One in twenty samples will be tracked through the field logbook and/or other field reporting forms, chain of custody documents and laboratory confirmation sheets (or executed chain of custody form) to ensure that there are no errors or discrepancies. If an error or discrepancy is found, the entire data pack (typically a set of 20) will be checked and all questionable data that cannot be assured to be free of quality concerns will be '&' flagged in the computer database or invalidated. Data will be evaluated if the origin of the sample is in doubt (e.g., sample numbers appear to be switched from one document to another). Errors will be noted and initialed on the raw data forms, but not altered or erased. In such cases, a single line will be drawn though the

error, and the correct entry will be written immediately beside the error, along with the validator's initials and the date.

Field logbooks and/or field reporting forms will be checked for calculation errors and proper field procedures for one in twenty samples. If an error is found, the entire data package will be checked. The EnviroGroup Task Manager or EnviroGroup Project Manager will use professional judgment to assess whether an error affects the quality or usability of data. Where quality may be affected, the data will be '&' flagged. Where errors cannot be corrected or quality assured, data may be invalidated subject to professional judgment, and WDEQ approval.

All samples will be analyzed within the required holding time limits specified in SW-846 or the appropriate reference. For example, the holding time for volatile organic compounds in water or soil is 14 days. Water samples will be preserved in accordance with applicable US EPA method specifications.. Samples not analyzed within specified holding time limits, and/or not appropriately preserved, will be invalidated unless profession judgment dictates that flagging would be more appropriate (e.g., consistent with historic observations), subject to WDEQ approval.

Field QA Sample Review

The preparation of trip and field blanks is required when sampling various media (refer to Table 2.3). Flagging is not required when fewer trip blanks or field blanks than required are collected, but a QA memo will be placed in the project file and the incident will be noted in the data transmittal for the sampling event. However, all sample results associated with contaminated trip blanks (i.e., samples collected after the trip blank's preparation) or field blanks (i.e., samples collected prior to the field blank's preparation) will be '&' flagged in the computer database if the blank's concentration exceeds 10% of the sample's concentration. Further, sample results may be invalidated if the blank concentration exceeds 50% of the sample concentration (subject to professional judgment and WDEQ approval). Data will not be flagged if the sample concentration is below the reporting limit, regardless of the blank concentration, because the

sample is obviously not cross-contaminated. Sample concentrations will not be corrected by subtracting blank concentrations.

Field duplicates are successive (rather than split) samples intended to assess variations due to sample collection, handling or analysis. It is recognized that natural variations in the environment can cause significant variations in concentrations. Field duplicate concentrations should agree with one another as described below:

Relative Concentration Relationship - Field Duplicates	**Criterion**
Concentrations < 10 Times the Reporting Limit	± Reporting Limit
Concentrations > 10 Times the Reporting Limit	RPD (± 20%)

The RPD (Relative Percent Difference) is calculated with the following equation:

$$RPD\ (\%) = (S1-S2)/[(S1+S2)/2] * 100$$

where: S1 and S2 are the two duplicated values, or the highest and lowest values if more than two sample duplicates are analyzed.

Duplicated sample results that do not meet the above criteria and are not consistent with historical results will be '&' flagged in the computer database. Flagging is not required when fewer field duplicates than required are collected, but a QA memo will be placed in the project file and the incident will be noted in the data transmittal for the sampling event.

Field replicates (splits) are related to two or more samples split from a single collection device or container (e.g., a bailer). Field replicates are submitted to different laboratories for analysis, and are intended to assess variations in laboratory performance. Field replicate concentrations should agree with one another as described below:

Relative Concentration Relationship - Field Replicates	**Criterion**
Concentrations < 10 Times the Reporting Limit	± Reporting Limit

Concentrations > 10 Times the Reporting Limit	RPD (± 20%)

The RPD is calculated with the following equation:

$$RPD\ (\%) = (S1-S2)/[(S1+S2)/2] * 100$$

where: S1 and S2 are the two replicated values, or the highest and lowest values if more than two sample replicates are analyzed.

Replicated sample results that do not meet the above criteria will be '&' flagged in the computer database. Flagging is not required when fewer field replicates than required are collected, but a QA memo will be placed in the project file and the incident will be noted in the data transmittal for the sampling event.

3.2.2 Laboratory Data Verification

Laboratory data reports will be reviewed for appropriate QA/QC procedures and data flagging. Applicable EPA analytical methods (e.g., SW-846, TO-15) encourage laboratories to develop in-house QA/QC limits, and require adherence to in-house limits for data reporting, flagging and corrective actions. Verification of appropriate laboratory flagging will be conducted during data validation in accordance with the criteria presented in Table 3.1.

Although it is the laboratory's responsibility to ensure that its results meet minimum internal QA/QC standards and are properly flagged, the data validation process will also include the following checks:

- Ensure that the required quality control tests (i.e., Table 3.1) were performed at the required frequency. If quality control results cannot be obtained from the laboratory, all associated data will be '&' flagged.
- Ensure that initial calibration verification and reference sample test results were within

laboratory-specified control limits. Any data reported with associated initial calibration verification or reference standards that are outside of control limits will be invalidated.

- Confirm that the laboratory properly flagged the data.

3.2.3 Validation Criteria and Flagging Requirements for Indoor Air Samples

As discussed in Section 3.2.1, validation criteria for indoor air quality samples are slightly different than those used for soil, water, and soil vapor samples. In addition, validation flags for indoor air quality sample results are more descriptive. Indoor air sample validation criteria and flags are described in Table 3.2.

TABLE 3.1

LABORATORY VERIFICATION PARAMETERS

Method	Parameter	Frequency	Criterion[2]
8000B[1]	Method Blanks (MB)	1 in 20 samples	<MDL
	Initial Calibration Verification (ICV)	Daily	±15-20%[3]
	Continuing Calibration Verification (CCV)	1 in 10 samples	±20%
	Reference Samples	1 in 10 samples	70-130%
	Matrix Spike (MS)/Duplicate pair or MS/Matrix Spike Duplicate (MSD) pair	1 in 20 samples	70-130%
	Laboratory Control Sample (LCS)	1 in 20 samples	70-130%
	Surrogate Recovery	Each Field Sample	In-House[3]
300[4]	MB	1 in 20 samples	<MDL
	ICV	Daily	90-110%
	CCV	1 in 10 samples	90-110%
	LCS	1 in 20 samples	80-120%
	MS/MSD	1 in 20 samples	80-120%

Notes: [1]Applicable to EPA 8000-series Methods (e.g., 8260B, 8270C, and 8021)
[2]Numerical criteria, where presented, is based on SW-846 guidance. In-house acceptance criteria are preferred by EPA, and will be used for verification assessments in each category during data validation.
[3]Compound-specific
[4]Applicable to EPA 300 series Methods (e.g., 300.0A and 365.2/365.3)

TABLE 3.2

VALIDATION CRITERIA AND FLAGS FOR INDOOR AIR SAMPLE RESULTS

Topic	Criteria	Basis for Flagging	Flag
Chain of Custody	see Section 3.2.1	Flag all results for all affected samples.	**C**
Holding Time	Must be < 30 Days	Flag all results for all affected samples.	**H**
Field Duplicates	see Table 2.3	Flag all results for all affected samples if an insufficient number of duplicate samples is collected.	**ID**
Field Duplicates	RPD < 50% (when results >5*reporting limit)	Flag all quantified concentrations in the duplicated samples that exceed RPD.	**P**
Trip Blank	see Table 2.3	Flag all quantified concentrations for all affected samples if an insufficient number of trip blanks is collected.	**IT**
Trip Blank	No detectable concentrations (see Section 3.2.1)	Flag all quantified concentrations of the compound detected in the trip blank when the blank's concentration exceeds 10% of the sample's concentration.	**T**
Pressure Gauge	Initial field vacuum greater than 27" Hg	Gauge is inaccurate. No effect on sample likely unless other problems also encountered.	**None**
Pressure Gauge	Initial field vacuum less than 24" Hg	Flag all results for all affected samples. There is less than full vacuum at the start of the test. Generally canisters with low initial vacuum are not used for sampling.	**g**
Pressure Gauge	Final field vacuum reading equal to 0" Hg	Flag all results for all affected samples. Test time may be less than 24 hours.	<
Pressure Gauge	For canisters sent to labs at sea level, initial post-test lab vacuum reading should be at least 2" Hg greater than the final field vacuum reading.	Flag all results for all affected samples. The canister may have leaked during its return to the lab, or the gauge may have been hit.	**G**
Pressure Gauge	Initial post-test lab vacuum reading should be no more than 6" Hg greater than final field vacuum reading.	If criteria not met, gauge problem is indicated. No impact on sample likely unless other problems also encountered. Cancels "<" flag because final field vacuum reading could not have been 0" Hg.	**None**
Test Time	More than 23 hours and less than 25 hours, based on start/stop date and time.	Flag all results for all affected samples.	**LT** or >
Canister Cleaning	Documentation of canister cleaning and non-detectable concentrations included in lab report.	Flag all results for all affected samples. There is a potential for false positives.	+
Canister Dedication		Flag all results for all affected samples. There is a potential for false positives.	^
Tuning Procedure		Flag all results for all affected samples. There is a potential for false positives	~
Rejected Data	Data specific as approved by the QA/QC Manager	Data specific	**R**

3.3 DATABASE MANAGEMENT

Analytical data generated during investigations and monitoring will be stored and managed in a computer database. Backups of databases will be made monthly for onsite archival in a locking fire-proof safe.

4.0 PROJECT ASSESSMENT AND OVERSIGHT

The following sections detail project assessment and oversight and describes the corrective action process that is in place to mitigate issues with data quality, if necessary.

4.1 CORRECTIVE ACTION

This section describes processes by which needed corrective actions are identified and implemented.

4.1.1 Corrective Actions Taken by the Analyst

Corrective actions to be taken by analytical laboratory personnel vary with the analysis being conducted, the matrix and effects of any interfering factors, and with the laboratory responsible for completing the work. These corrective action issues are managed internally by the laboratory in accordance with method requirements, the laboratory's QA/QC Plan and its internal operating procedures. At a minimum, however, laboratories conduct the quality assurance/quality control (QA/QC) evaluations described below. Results falling outside the laboratory's internal QA/QC ranges should be flagged by the laboratory, and described in its case narrative.

Errors, deficiencies, deviations, or laboratory events or data that fall outside of established acceptance criteria should be investigated. In some instances, corrective action may be needed to resolve the problem and restore proper functioning to the analytical process. The investigation of the problem and any subsequent corrective action taken should be documented.

QC Check Samples

Must fall within the laboratory's quality control limits. If a result is outside the limits, the test will be repeated, as necessary, or the associated sample results will be appropriately flagged.

Lab Duplicates

Should agree within ± 20 RPD. If a result is outside this limit, the test will be repeated, as necessary, or the associated sample results will be appropriately flagged.

Fortifications (Spikes)

Should agree within 75-125% to 70-130% (method- and component-specific) recovery. If a result is outside the limit, the test will be repeated, as necessary, or the associated sample results will be appropriately flagged.

4.1.2 Corrective Actions Taken by QA/QC Manager

This section describes processes by which corrective actions are identified by the QA/QC Team.

Quality Assurance Audits

Quality assurance (QA) audits will be performed annually to evaluate the adequacy of, and compliance with, the policies, methods and procedures established in this QAPP. QA audits will also be performed as deemed necessary by the Project Manager and/or WDEQ Case Manager. QA audits are not intended to evaluate the technical adequacy of an engineered design or its implementation.

Follow-Up Actions by the QA/QC Manager

The QA/QC Team will prepare a brief report of results from each audit. If deficiencies were identified in the course of an audit, the audit report will include an evaluation of the deficiencies and, if necessary, the required corrective actions. Within 30 days, the QA/QC Manager will perform a follow-up audit to verify that any necessary corrective actions have been implemented.

4.1.2 Corrective Actions Taken by Field Personnel

Field personnel are responsible for ensuring the accurate calibration and use of field instrumentation and other equipment. If an instrument's calibration is suspect or in error, corrective actions detailed in the instrument's manual will be followed. If a correction cannot be made, a replacement device will be obtained.

4.2 REPORTS TO MANAGEMENT

Quality assurance reports to the Project Manager and the Task Managers, as necessary, will consist of two formats:

- Upon the satisfactory completion of data validation efforts, the Project Manager and/or Task Managers will be notified of the data's quality, and of any cautions or restrictions associated with its use; and
- Following the completion of scheduled or unscheduled QA audits, the Project Manager and Task Managers will be notified of the audit's outcome, of any deficiencies, of the corrective action necessary to address any deficiencies, and of the outcome of any follow-up QA audits. The Project Manager will forward the results of audits to the WDEQ Case Manager.

APPENDIX A

FIELD FORMS

BOREHOLE LOG

CLIENT _____
PROJECT LOCATION _____
PROJECT NO. _____

BH NO. _____
PAGE _____ OF _____

NORTH	DRILLER		DATE START
EAST	RIG		DATE FINISH
GRD ELEV.	BITS	FLUIDS	TOTAL DEPTH
TOC ELEV.	LOGGED BY		WATER DEPTH

SAMPLE TYPES:

CT Cuttings
SS Split Spoon
DC Dry Core
WS Wash
NX NX Core
CS Continuous Sampler
Other: _____

SAMPLER SPECIFICATIONS:

Length _____
O.D. _____
I.D. _____
Material _____
Liner _____
Other _____

DEPTH (FT.)	BIT / CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SURFACE CONDITION: _____ SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core

LOCATION SKETCH	DENSITY: GRANULAR:		COHESIVE:		PROPORTIONS:		REMARKS/WEATHER
	0–10	Loose	0–4	Soft	0–10%	Trace	
	10–30	Med Dense	4–8	Med Stiff	10–20%	Little	
	30–50	Dense	8–15	Stiff	20–35%	Some	
	>50	Very Dense	15–30	Very Stiff	35–50%	And	

LOG STATUS:

PRELIMINARY: _____ FINAL: _____

EnviroGroup Limited
Centennial, Colorado

R:\Drawings\STD\Borelog5.dwg, 08/08/05 at 08:57

FIELD WATER QUALITY SAMPLING AND ANALYSIS

PROJECT: _____ LOCATION: _____

PROJECT NO. _____ PERSONNEL: _____

INSTRUMENTS: (Conductivity, Temperature, pH, Redox, etc.) _____

_____

GENERAL					
WELL/LOCATION					
WATER SOURCE					
DATE					
TIME					

SAMPLING CONDITIONS					
SAMPLING METHOD					
DEPTH OF SAMPLE (BGS / TOC)					
WELL DEPTH (BGS / TOC)					
WATER LEVEL (BGS / TOC)					
ONE WET CASING VOLUME For 2 inch wells: (TD-WL)x0.16=_____ gallons			For 1 inch wells: (TD-WL)x0.04=_____ gallons For 4 inch wells: (TD-WL)x0.65=_____ gallons		
APPEARANCE					

FIELD MEASUREMENTS					
VOLUME REMOVED (GAL)					
TOTAL VOLUME REMOVED (GAL)					
TEMPERATURE (°C or °F)					
CONDUCTIVITY (ATC, 25°C)					
pH					
REDOX (mV)					
OTHER					
PURGE OR SAMPLE					

SAMPLES COLLECTED AND SAMPLE ANALYSIS					
GROSS UF/UP					
DISSOLVED METALS F/HNO_3					
TOTAL METALS UF/HNO_3					
PETROLEUM HCs UF/HCl					
VOLATILE ORGANICS UF/UP UF/HCl					
SEMIVOLATILE ORGANICS UF/UP					
LAB/DATE SUBMITTED					

EnviroGroup Limited

SAMPLER'S INITIALS _____ DATE _____

INVENTORY OF CONTAINERIZED MATERIAL
GROUP # ___

Page__ of__

DRUM #	SOURCE[1]	CONTENTS[2]	DATE[3]	DATA SUMMARY WORKSHEET RESULTING STATEMENT	TRANSFER DATE[4]	DOCUMENT NO. (if appropriate)[5]

[1] For example, for soil cuttings, record the boring or well # and depth interval below ground surface.
[2] For example, soil cuttings, decon water, or sediment.
[3] Record date that material was first placed into drum. If material is ultimately classified by the generator as hazardous waste, this will be the date that the 90 day accumulation period begins.
[4] For example, date shipped off site or pumped into treatment system.
[5] For example, Bill of Lading or Manifest Number.

SOIL VAPOR SAMPLE LOG

Project Name: BROWN GROUP REDFIELD _____ Date:_____

Project Number:_____ Personnel:_____

_____

Weather Conditions:_____

_____

_____

SAMPLE DATA

Sample number:_____ Time Sample collected:_____

Temperature:_____ Method of collection:_____

Hole Diameter:_____ inches Tubing Diameter (ID) _____ feet

Sample Location:_____

Sample Depth information:

Push to Depth of _____ feet bgs.

Pull back _____ feet to a depth of _____ bgs.

Sample Depth Interval:_____ to _____ feet bgs

Describe push _____

Location Plat

Purge Volume Calculation:

Tubing Volume: _____ feet tubing X _____ cc/ft = _____ cc volume
Open Hole Volume: _____ feet hole X _____ cc/ft = _____ cc volume
Sample Comtainer type: _____ _____ cc volume
Total for one purge volume: _____ **cc volume**
Number of Purge Volumes to be removed prior to sampling: _____

TOTAL PURGE VOLUME TO BE REMOVED PRIOR TO SAMPLING _____ **cc volume**

Results of leak test:_____

Purge Volume Removed: initial vac _____ in Hg

Beginning Flow Meter Reading _____ cc flow vac _____ in Hg

Ending Flow Meter Reading _____ cc flow duration _____ (time)

Total purge volume remove _____ **cc**

Purge volumes removed _____ Recovered Sample ☐

Condition of "O" ring seal OK ☐ Failed ☐ No Recovery ☐

EnviroGroup Limited

WELL DEVELOPMENT RECORD

WELL: _____

WELL DEPTH = _____ FEET

WET-CASING VOLUME = _____ GALLONS

REFERENCE POINT FOR
DEPTH MEASUREMENTS = _____

PROJECT NAME: _____

PROJECT NUMBER: _____

LOCATION: _____

PERSONNEL: _____

INITIAL WATER LEVEL			SURGING		PURGING					
DATE	TIME	DEPTH	METHOD[1]	SURGE TIME	METHOD[1]	START TIME	END TIME	TOTAL VOLUME REMOVED	FINAL APPEARANCE[2]	COMMENTS (Odor, Sheen, etc.)

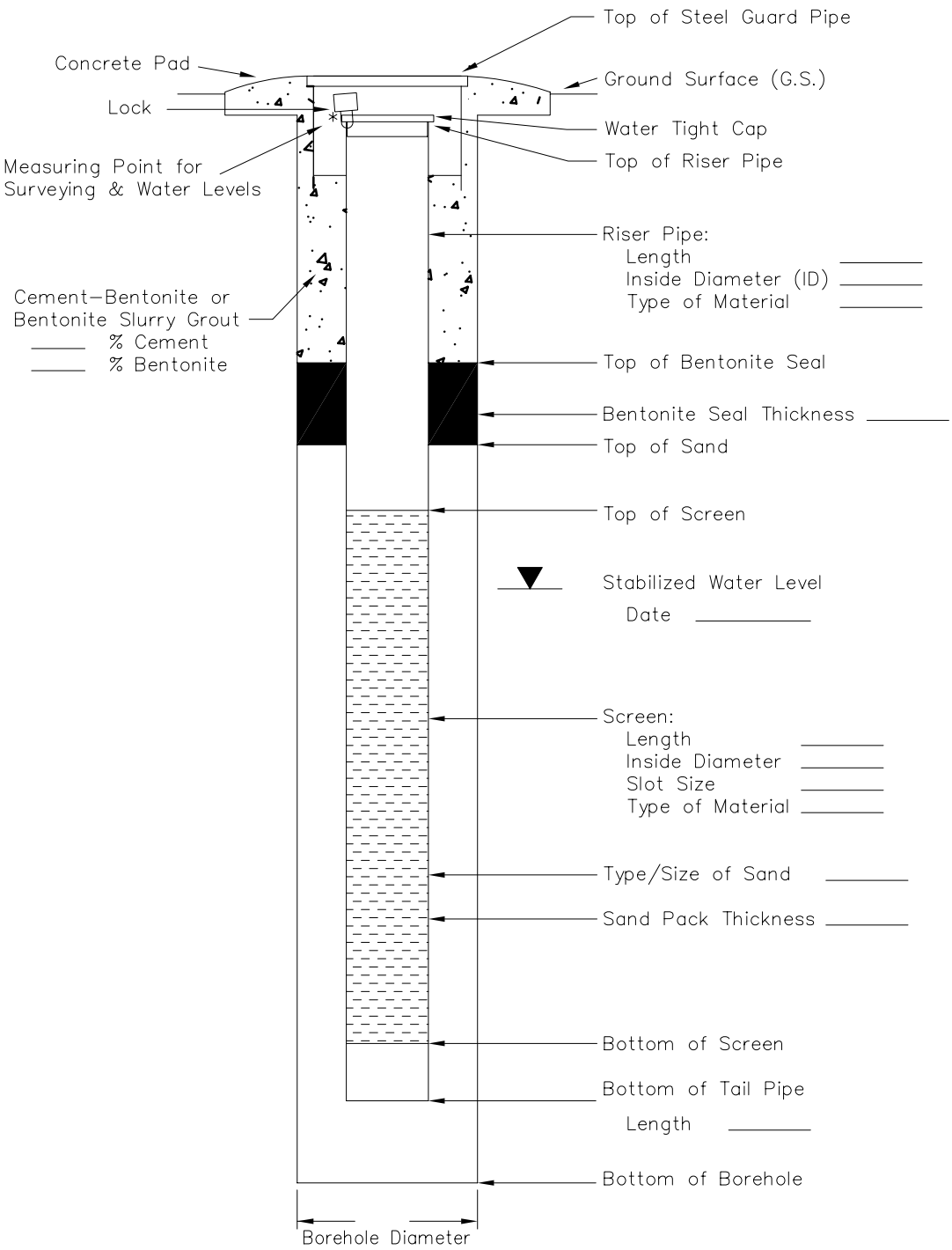
Notes: [1] Bailers, submersible pumps, etc.
[2] Turbidity estimate (slight, moderate or high) and Color

Project No: _____ Client: _____ Site: _____ WELL NO: _____

Well Location: _____ Date Installed: _____

Contractor: _____ Method: _____

MONITORING WELL CONSTRUCTION DETAIL
(Flush Mount)



	Depth from G.S. (feet)	Elevation
Top of Steel Guard Pipe	_____	_____
Ground Surface (G.S.)	_____	_____
Water Tight Cap		
Top of Riser Pipe	_____	_____
Riser Pipe: Length _____ Inside Diameter (ID) _____ Type of Material _____		
Top of Bentonite Seal	_____	_____
Bentonite Seal Thickness _____		
Top of Sand	_____	_____
Top of Screen	_____	_____
Stabilized Water Level Date _____	_____	_____
Screen: Length _____ Inside Diameter _____ Slot Size _____ Type of Material _____		
Type/Size of Sand _____		
Sand Pack Thickness _____		
Bottom of Screen	_____	_____
Bottom of Tail Pipe Length _____	_____	_____
Bottom of Borehole	_____	_____

* Describe Measuring Point:

_____

EnviroGroup Limited
Centennial, Colorado

R:\Drawings\STD\WELLFLS.DWG, 08/08/05 at 09:10

WELLFLS.DWG

APPENDIX B

INDOOR AIR ANALYTICAL DATA FLAGS

APPENDIX B

SITE HEALTH AND SAFETY PLAN

SITE HEALTH AND SAFETY PLAN

Site: Cheyenne PCE Plume Orphan Site #57.019
Cheyenne, WY

Project No. WQ-0663

Prepared by	M. Litasi	9/23/09 Date
Approved by		9/28/09 Date
Project Manager		9/28/09 Date

SITE HEALTH AND SAFETY PLAN

CONTENTS

SECTION **PAGE NO.**

1.0 PROJECT DESCRIPTION 3

2.0 PROJECT RESPONSIBILITIES 3

3.0 ELEMENTS 4

3.1 Hazard Analysis by Task and PPE Requirements 4
3.2 Training Requirements 4
3.3 Medical Surveillance Requirements 5
3.4 Air Monitoring Requirements 5
3.5 Site Control Measures 5
3.6 Personnel Decontamination 6

4.0 EMERGENCY RESPONSE PLAN 8

4.1 Emergency Numbers and Locations 8
4.2 First Aid and Fire Prevention/Protection 9

5.0 CONFINED SPACE ENTRY PROCEDURES 10

6.0 SPILL CONTAINMENT PROGRAM 11

MAP OF ROUTE TO NEAREST HOSPITAL 7

ATTACHMENTS

A SITE CHARACTERIZATION AND ANALYSIS
B PERSONNEL RESPONSIBILITIES
C BLANK FORMS

SITE HEALTH AND SAFETY PLAN

This Site Health and Safety Plan ("HASP") has been prepared in accordance with federal regulations promulgated at 29 CFR 1910.120 (b)(4), and addresses the elements referenced in subsections (A) through (J) of that section.

1.0 PROJECT DESCRIPTION

Site Cheyenne PCE Plume Orphan Site **Project No.** WQ-0663

Location Along Randal Ave., northwest to W. 30th Street and southeast to W. 22nd Street, Downtown Cheyenne, Wyoming

Facility Processes Residential and commercial areas including streets. Three dry cleaners in three blocks located along Randall Ave. and W. 27th Street.

Project Objectives Evaluation of groundwater, soil, soil and sub-slab vapor, and indoor and ambient air at and near the Site.

Anticipated Investigation Date(s) Fall 2009 through Spring 2010

Available Site Information is included in Attachment A

2.0 PROJECT RESPONSIBILITIES

	NAME
Project Manager	David Folkes, Jeff Kurtz
Health and Safety Manager	Martina Litasi
Site Health and Safety Supervisor	Martina Litasi (or appointed project personnel below)
Project Personnel (as applicable)	Aleksandra Miesak, Elizabeth Wolfe Martina Litasi, Garry Stanley, Charoen Sanpawanitchakit,

Personnel Responsibility Descriptions are included in Attachment B

Pre-Entry Briefing A Pre-Entry Briefing will be conducted by the Site Health and Safety Supervisor prior to initiating on-site work activities. All employees and contract personnel must attend.

HASP Effectiveness Inspections will be conducted by the Site Health and Safety Supervisor to determine the effectiveness of this HASP. Any deficiencies in the effectiveness of the HASP will be corrected.

3.0 ELEMENTS

3.1 Hazard Analysis by Task and PPE Requirements

Hazard analysis by task and PPE requirements are based on results of the Site Characterization and Analysis (Attachment A).

Potential Hazards

WORK ACTIVITIES	HAZARDOUS SUBSTANCES AND PHYSICAL HAZARDS	HAZARD ANALYSIS (Low, Med, High)	PPE LEVEL
Observe outdoor drilling, monitor well installation, and soil sample collection	Power Equipment Power Lines Slip, Trip, Fall Street traffic VOCs	Low-Med	D
Outdoor monitor well development and groundwater sample collection	Slip, Trip, Fall Street traffic VOCs	Low	D
Indoor and outdoor soil vapor and sub-slab soil vapor sample collection	Power Equipment Slip, Trip, Fall VOCs	Low-Med	D
Indoor and outdoor air sample collection	Slip, Trip, Fall VOCs	Low	N/A

Notes: Upgrades to Level A or B (supplied air) are not authorized under this HASP.
Entry into Permit-Required Confined Spaces is not authorized under this HASP (Section 5.0).

3.2 Training Requirements

PERSONNEL	40 HOUR OSHA[1]	FIRST AID/CPR[2]	8 HOUR SUPV.
Project Manager	Required	Not Required	Not Required
Site Health and Safety Supervisor	Required	Required	Required
Project Personnel	Required	Required	Not Required

Note: [1] Annual refresher training is also required to maintain compliance status.
[2] Re-certification is required every two years.

3.3 Medical Surveillance Requirements

All field personnel, regardless of potential exposure histories, respirator usage periods, or injury records, are required to participate in an employer-sponsored annual medical surveillance program. The content of the medical surveillance program will meet or exceed the minimum requirements promulgated at 29 CFR 1910.120 (f)(4).

3.4 Air Monitoring Requirements

WORK ACTIVITIES	DEVICE/ PARAMETER	FREQUENCY	ACTION LEVEL
Observe outdoor drilling, monitor well installation, and soil sample collection	ppbRAE 3000 PID	Periodically	1 ppm
Outdoor monitor well development and groundwater sample collection	None	N/A	N/A
Indoor and outdoor soil vapor and sub-slab soil vapor sample collection	None	N/A	N/A
Indoor and outdoor air sample collection	None	N/A	N/A

Action Levels, if specified, relate to the need for upgrades in PPE (Section 3.1), or temporary Stop-Work measures. In the case of risks to personnel through inappropriate oxygen levels or the inhalation of hazardous substances, Action Levels reference Breathing Zone Concentrations. In the case of potentially explosive mixtures, Action Levels reference concentrations at or near the source. Action Levels are developed in Attachment A. Air monitoring results will be collected at the frequency noted above. Blank forms are included in Attachment C.

The Site Health and Safety Supervisor has the authority to issue temporary Stop-Work orders to allow further evaluation of any situation resulting in exceedences of the Action Level. Air monitoring and observation will be continued until the Site Health and Safety Supervisor determines that conditions no longer pose a threat, or may be mitigated by an increase in PPE. Upgrades to Level A or B protection (supplied air) are not authorized under this HASP.

3.5 Site Control Measures

Work Zones

The use of zoning is warranted if work activities present a hazard to the general public and/or other persons due to the accessibility of the work area. All persons entering the Exclusion Zone must meet minimum requirements for training, use of PPE and medical surveillance.
Exclusion Zone - Modified Exclusion Zone: 20 foot radius from drilling locations. No exclusion zone applied to other work areas.

Contaminant Reduction Zone - Immediately adjacent to Modified Exclusion Zone, as required for personnel decontamination, in the event of an upgrade to Level C protection.

Clean/Support Zone - All other areas accessible by non-investigative personnel.

Is a **Site Map** provided in Attachment A? Yes

How is **Site Communication**, including emergency alerts, to be conducted?
Un-aided verbal and visual means, cellular telephones.

Most activities in potentially hazardous areas are to be conducted with a "**buddy**" who is able to a) provide assistance, b) observe his/her partner for symptoms of chemical exposure and/or heat/cold stress, c) periodically inspect the integrity of PPE, and d) notify the Site Health and Safety Supervisor or others if emergency help is needed. Work Activities deemed non-hazardous by the Site Health and Safety Supervisor and the Health and Safety Manager may be conducted by a single worker. For Work Activities requiring the use of contracted services (e.g., drilling, excavation, etc.), the contractors may serve as the "buddy" for purposes of this HASP. Requirements are summarized in the following table.

WORK ACTIVITIES	HAZARD ASSESSMENT	BUDDY SYSTEM
Observe outdoor drilling, monitor well installation, and soil sample collection	Low-Med	Yes
Outdoor monitor well development and groundwater sample collection	Low	No
Indoor and outdoor soil vapor and sub-slab soil vapor sample collection	Low-Med	Yes
Indoor and outdoor air sample collection	Low	No

Standard Operating Procedures, outlined in the Project Work Plan, will be reviewed by the Health and Safety Manager to assess overall health and safety aspects of the work.

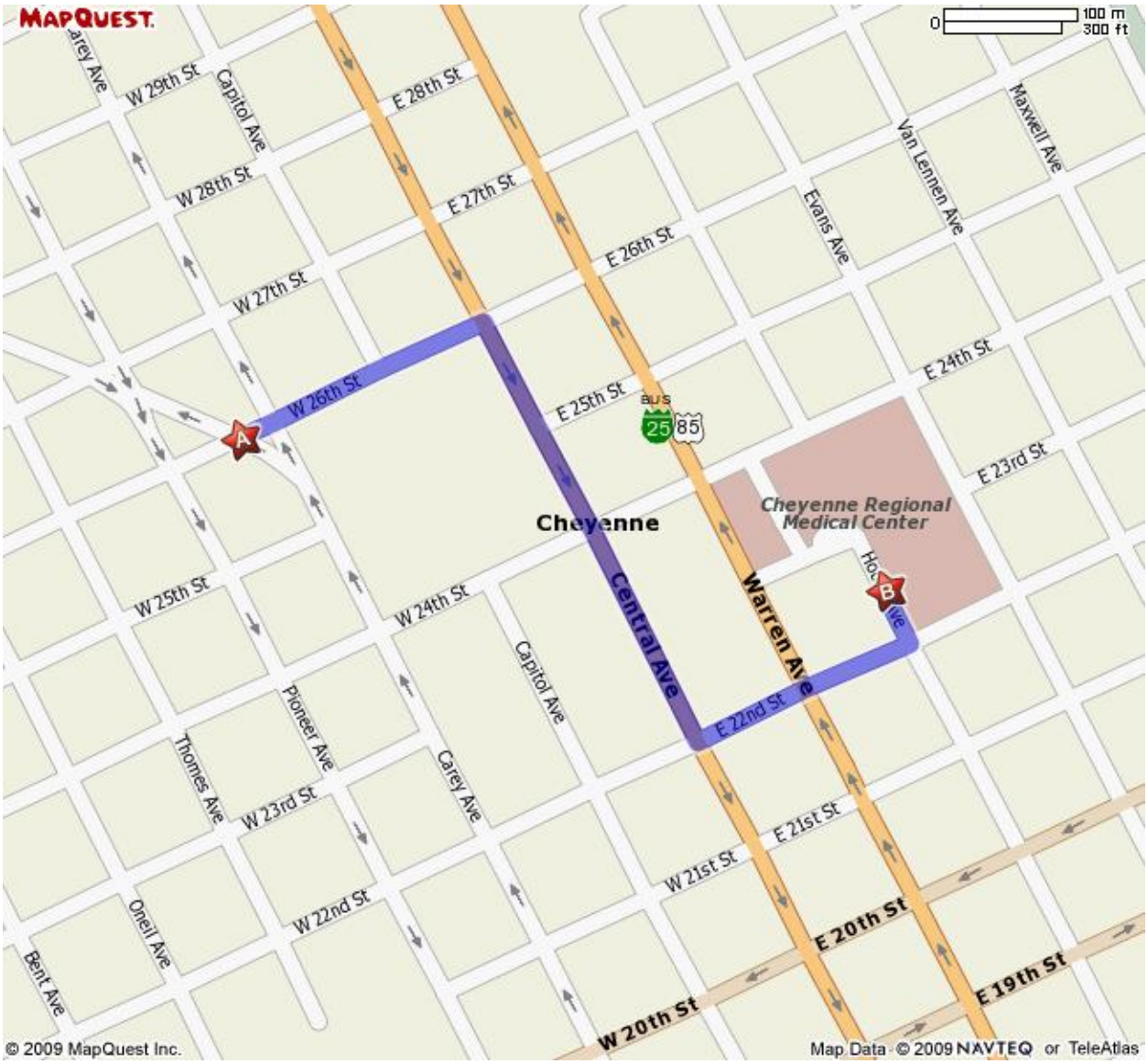
Route to Nearest Hospital – Cheyenne Regional Medical Center - From anywhere in the Site area, drive to the intersection of Randall Ave and West 26th Street. Drive northeast on West 26th Street along the north side of the Herschler Building. Turn right onto Central Ave. heading southeast. Turn left onto E. 22nd St. Turn left onto House Ave. Follow signs to Medical Center Emergency Room at 2301 House Ave., Cheyenne, Wyoming 82001.

A map of this route is presented on the following page.

3.6 Personnel Decontamination

Personnel decontamination, including the removal of any PPE, will occur in the Contaminant Reduction Zone (Section 3.5). Decontamination, or routine personal hygiene (as applicable), must be accomplished before eating, drinking or smoking. Used PPE and decontaminating solutions will be containerized for proper disposal.

MAP OF ROUTE TO NEAREST HOSPITAL



Starting location on map is from West 26th Street and Randall Ave.

Approx. driving time: 2-5 minutes depending on your location at the Site.

Approx. Mileage: <1 mile.

4.0 EMERGENCY RESPONSE PLAN

All injuries or emergencies will be immediately reported to the Site Health and Safety Supervisor, and, as appropriate, the proper authorities. Any injury resulting in a fatality, or in the hospitalization of three or more persons, will be verbally reported to the Area Director of the Occupational Safety and Health Administration within 8 hours, as required by 29 CFR 1904. Any injury requiring the services of a physician, hospital or paramedic will also be verbally reported to the Project Manager within 8 hours. An Accident Report (Attachment C) will be filed with the Health and Safety Manager by the Site Health and Safety Supervisor for all reported accidents.

In the event of an emergency, the Site Health and Safety Supervisor and staff personnel, as applicable, should take action to minimize other personnel's and the general public's exposure to dangerous situations. For example, if a natural gas line is broken, the Site Health and Safety Supervisor should immediately clear the area, contact the fire department and police, notify the utility company, and initiate the evacuation of the area. The Health and Safety Supervisor shall relinquish control of the emergency situation to the appropriate authorities upon their arrival.

4.1 Emergency Numbers and Locations

	NAME/ADDRESS	PHONE
HOSPITAL/AMBULANCE	Cheyenne Regional Medical Center 2301 House Ave Cheyenne, Wyoming 82001	(307) 432-3150 911
FIRE/POLICE/SHERIFF	N/A	911
UTILITIES: GAS **ELECTRIC** **WATER**	Wyoming One-Call	(800) 348-1030
NATIONAL EMERGENCY RESPONSE CENTER	N/A	(800) 424-8802
LOCAL EMERGENCY SPILL RESPONSE CENTER	Wyoming Department of Environmental Quality	(307) 777-7781
FACILITY SUPERVISOR	Bonnie Pierce (Wyoming Department of Environmental Quality)	(307) 328-0468 Alt. (307) 320-5936
PROJECT MANAGER	David Folkes / Jeff Kurtz 7009 S. Potomac St. Suite 300 Centennial, CO 80112	(303) 790-1340 Alt. (720) 560-1707

4.2 First Aid and Fire Prevention/Protection

- A first aid kit will be available in each work area at all times.
- At least one fire extinguisher will be available in all work areas involving the use of heavy equipment (e.g., drilling, excavation, etc.). A fire extinguisher is not required for work areas/activities ranked as low-risk (Section 3.1).
- Smoking is prohibited in the Exclusion Zone (Section 3.5), and in all other areas designated by facility management as No Smoking areas.

5.0 CONFINED SPACE ENTRY PROCEDURES

Per 29 CFR 1910.146, OSHA defines a Confined **Space** as any space that:

- Is large enough to bodily enter and perform work;
- Has limited or restricted means for entry and exit, and
- Is not intended for continuous occupancy.

OSHA further defines two classes of Confined Space:
Non Permit Spaces and **Permit Spaces**.

Non Permit Spaces are defined as Confined Spaces that:

- Do not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm.

Permit Spaces are defined as Confined Spaces that:

- Contain or have a potential to contain a hazardous atmosphere;
- Contain a material which has a potential to engulf an entrant;
- Have an internal configuration which could result in the asphyxiation of the entrant through inwardly converging walls, and
- Contain any other recognized serious safety or health hazard.

Examples of **Permit Spaces** may include:

Tanks	Pipelines	Cisterns	Tunnels	Boilers
Silos	Barges	Equip. Housings	Sewers	Stacks
Utility Vaults	Process Vessels	Manholes	Shafts	Septic Tanks

CONFINED SPACE ENTRY (PERMIT <u>OR</u> NON-PERMIT) IS NOT AUTHORIZED BY THIS HASP.

6.0 SPILL CONTAINMENT PROGRAM

The Site Health and Safety Supervisor and staff personnel, as applicable, should take action to control the spread of contamination and prevent or minimize exposures to other personnel and the public. However, personnel are not authorized to participate in Spill Containment procedures which require actions that are inconsistent with this HASP. If a significant release occurs, the Site Health and Safety Supervisor will contact Local Spill Response personnel (Section 4.1), the facility supervisor and the project manager.

ATTACHMENT A
SITE CHARACTERIZATION AND ANALYSIS

Pursuant to 29 CFR 1910.120(c), hazardous waste sites are to be evaluated to identify specific site hazards and to determine the appropriate safety and health control procedures needed to protect personnel from the identified hazards. Furthermore, pursuant to paragraph (2) of this section, a Preliminary Evaluation of the site's characteristics shall be performed prior to site entry by a qualified person in order to aid in the selection of appropriate employee protection methods. Immediately after initial site entry, a more detailed evaluation of the site's specific characteristics shall be performed by a qualified person to further identify existing site hazards and to further aid in the selection of the appropriate engineering controls and personal protective equipment for the tasks to be performed.

PRELIMINARY EVALUATION OF SITE CHARACTERISTICS

Conditions Immediately Dangerous to Life or Health (IDLH)

Are IDLH conditions known or suspected at the site? Yes___ No_X_
If "Yes", attach available information. If "No", list/describe evidence below: Investigative work is typically conducted indoors or outside in areas generally accessible to non-investigative personnel without special protective equipment.

Required Information

To the extent that this information is available, please respond to the following:

(i) Location and Approximate Size of the Site (Attach a map if available):
Location map is attached. The size of the area may be determined from the map. Site is approx. 8 by 6 city blocks in downtown Cheyenne, WY.

(ii) Description of the Work
- X Drilling/Well Installation
- X Soil Sampling
- X Groundwater Sampling
- ☐ Surface Water Sampling
- ☐ Excavation
- X Other Soil vapor and sub-slab soil vapor sample collection. Indoor and ambient air sample collection.

(iii) Anticipated Duration of the Work
Fall 2009 to Spring 2010

(iv) Site Topography and Accessibility by Air and Roads
The site is located in commercial and residential area in downtown Cheyenne, WY. The land is relatively flat with commercial and residential buildings, paved roads and sidewalks, and many areas with grass and trees. Three dry cleaners and a city building are located in the Site area. The area is accessible by roads and possibly air (i.e., helicopter) in some areas.

(v) Safety and Health Hazards at the Site
Physical Hazards – Heavy and power equipment; Slip, trip, and fall; equip. noise.
Lightning – Outdoor work activities will cease when electrical storms are observed in the area.
Power lines – No drilling will be conducted near high voltage transmission lines without proper clearance. A minimum distance of 10' is required when working around overhead powerlines.
Biological Hazards – Bees/wasps and black widow spiders.
Chemical Hazards - Chlorinated solvents in groundwater, soil and soil vapor.
Street Traffic – Vehicular traffic adjacent to work zone. Reflective safety vests will be worn at all times. Appropriate traffic control devices (e.g. safety cones, signs, etc...) will be utilized when working in traffic areas.

(vi) Pathways for Hazardous Substance Dispersion
Hazardous substances may occur in groundwater, soil, air, or soil vapor. Dispersion is likely limited to air and groundwater (if substances are volatilized from groundwater or soil).

(vii) Status and Capabilities of Emergency Response Team
Will use local emergency response (e.g., police, fire, ambulance, etc.).

(viii) Hazardous Substances and Health Hazards - Refer to 29 CFR 1910.1000 (Air Contaminants), Table Z-1-A, to complete the following table. Use additional sheets if necessary. Attach appropriate MSDS if available.

ANTICIPATED CONTAMINANTS	FINAL RULE LIMITS (ppm)			
	TWA	STEL	CEILING	SKIN DESIG.
1,1-Dichloroethene	N/A	N/A	N/A	N/A
Tetrachloroethene	100	N/A	200	N/A
Trichlorothene	100	N/A	200	N/A
Vinyl Chloride	1	5	N/A	Yes
Inert or Nuisance Dust (respirable fraction)	15 mppcf	N/A	N/A	N/A

For purposes of establishing air contaminant Action Limits, the smallest Final Rule Limit (from the above table) will be selected. Measurements of organic vapor concentrations (e.g., FID or PID) or compound-specific analysis (e.g., Dräger tubes) made in the breathing zone will be used to evaluate personnel exposure.

Personal Protective Equipment

Based on results of the Preliminary Evaluation of Site Characteristics, an ensemble of personal protective equipment (PPE) will be selected and used for the initial site entry which will provide protection to a level below permissible exposure limits (PELs) for known or suspected hazardous substances.

Does available information indicate the need for respiratory protection during the initial site entry?
Yes___ No_X_
If "No", list/describe evidence for no respiratory protection below: Investigative work is typically conducted indoors or outside with no anticipated above ground accumulations of respiratory hazards. Work areas are generally accessible to non-investigative personnel without special personal protective equipment.

If respiratory protection is not indicated prior to the initial site entry, the HASP will specify use of LEVEL D PPE. In the event conditions change during the Work, or are observed during the initial site entry to be different than anticipated, an upgrade to LEVEL C PPE may be required. No work requiring supplied air is allowed (i.e., no work requiring Level A or B PPE). Components and options for Level D and Level C PPE are presented below. Recommended PPE for initial site entry is indicated by an "X".

COMPONENT	LEVEL D	LEVEL C
Boots - Steel Toe/Shank	X	
Boots - Chemical Resistant		X
Chemical Resistant Apron		X
Ear Plugs	X	
Face Shield		X
Full/Half Respirator (with appropriate filters)		X
Gloves (Inner) - Chemical Resistant	X	X
Gloves (Outer) - Chemical Resistant		X
Hard Hat	X	X
Reflective Safety Vest	X	
Safety Glasses/Goggles	X	X
Work Gloves	X	

Monitoring

The following monitoring will be conducted during the initial site entry when the Preliminary Evaluation of Site Characteristics indicates the potential for a) ionizing radiation, or b) IDLH conditions, as appropriate:

- Monitoring with direct-reading radiation-sensing instruments (e.g., scintillometer);
- Monitoring with other direct-reading instruments which will indicate the presence of hazardous atmospheres, such as combustible or explosive mixtures, oxygen deficiencies, or toxic substances;
- Visually observing for signs of actual or potential IDLH or other dangerous conditions; and
- Performance of a continuing air monitoring program once Work Activities have begun.

Is there an indication of ionizing radiation? Yes___ No_X_

Is there an indication of IDLH conditions? Yes___ No_X

Is there an indication that personnel could be exposed to explosive, low-oxygen or toxic atmospheres during the work? Yes___ No_X

Risk Identification

Once the presence and concentrations of specific hazardous substances and health hazards have been established, the associated risks will be identified. Pursuant to the Hazard Communication Standard (29 CFR 1910.1200), personnel (including contractors) will be informed of any risks that have been identified. Risks to consider include, but are not limited to:

a) Exposures exceeding PELs or other published exposure levels;
b) IDLH conditions;
c) Potential skin absorption and irritation sources;
d) Potential eye irritation sources;
e) Explosion sensitivity and flammability ranges; and
f) Oxygen deficiencies.

Are any such conditions anticipated? Yes___ No_X_
If "Yes", list/describe below: These conditions are not anticipated for investigative tasks.

On the basis of identified and anticipated risks, recommend a preliminary ranking of the risk and PPE by Work Activity:

WORK ACTIVITIES	HAZARD ASSESSMENT	PPE LEVEL
Observe outdoor drilling, monitor well installation, and soil sample collection	Low- Medium	D
Outdoor monitor well development and groundwater sample collection	Low	D
Indoor and outdoor soil vapor and sub-slab soil vapor sample collection	Low - Medium	D
Indoor and outdoor air sample collection	Low	N/A

Employee Notification

Any information concerning the chemical, physical and toxicologic properties of each substance known or expected to be present on the site, that is available to the employer and relevant to the duties of the employee, will be made available to the affected employees prior to the commencement of their work activities. However, OSHA policy is to consider only virgin materials as being subject to disclosure under hazard communication guidelines. This work is not expected to expose workers to virgin materials.

Is any substance-specific information (e.g., MSDS) available at this time?
Yes___ No_X_
If "Yes", attach the substance-specific information.
There are no substance-specific information for virgin materials anticipated for investigative tasks.

ATTACHMENT B
PERSONNEL RESPONSIBILITIES

The Project team will consist of a Project Manager, a Health and Safety Manager, a Site Health and Safety Supervisor, and Project Personnel, as applicable. Personnel named in Section 2.0 of the Site Health and Safety Plan (HASP) have the following general responsibilities.

The **Project Manager** is responsible for:

- Confirming that personnel under their direction and oversight receive and are aware of the provisions of the HASP, are instructed in the work practices necessary to ensure safety, and are familiar with planned procedures for dealing with emergencies;
- Assuring the completion of HASP Acceptance Forms;
- Approving any changes to the HASP;
- Verifying that field personnel are in compliance with the hazardous waste worker health and safety training and medical surveillance requirements of 29 CFR 1910.120;
- Verifying that personnel are aware of the potential hazards associated with site operations;
- Obtaining permission for site access, and coordinating activities with facility management;
- Verifying the correction of any work practices or conditions that may result in injury or exposure to hazardous substances; and
- Verifying the preparation of any accident and routine job exposure forms.

The **Health and Safety Manager** is responsible for:

- Developing or reviewing and approving HASPs for use;
- Resolving disputes involving health and safety issues with guidance from the Project Manager and facility management;
- Assuring implementation of the HASP;
- Conducting safety inspection audits at work sites, or designating others to the task;
- Notifying the Project Manager of any Stop Work Orders issued during the Work Activities.

The **Site Health and Safety Supervisor** is responsible for:

- Implementing the HASP and reporting any deviations from the HASP to the Project Manager or the Health and Safety Manager;
- Enforcing the requirements of the HASP;
- Updating or modifying the HASP as site conditions change, in consultation with the Health and Safety Manager;
- Conducting periodic inspections to verify adherence to the HASP, and reporting inspection results to the Health and Safety Manager;
- Stopping work at any time if unsafe conditions are observed, and notifying the Health and Safety Manager;
- Monitoring on-site conditions and hazards;
- Verifying that all monitoring equipment is calibrated, operating properly and is properly maintained;
- Conducting safety briefings and site-specific training for on-site personnel and contractors;
- Selecting PPE, in consultation with the Health and Safety Manager;
- Periodically inspecting PPE and ensuring its proper storage and maintenance;
- Defining limited access zones on a daily basis, or as appropriate;
- Monitoring on-site personnel for signs of stress (e.g., cold/heat and fatigue);
- Coordinating emergency care, evacuation, rescue, etc.;
- Investigating and documenting accidents, illnesses and incidents occurring on-site;
- Enforcing the "buddy system", if necessary; and
- Escorting all agency personnel, or other visitors, inspecting the site in response to health and safety issues.

Project Personnel are responsible for:

- Complying with the HASP;
- Taking all reasonable precautions to prevent injury to themselves and to others;
- Performing only those tasks they believe they can do safely, and immediately reporting any accidents or unsafe conditions to the Site Health and Safety Supervisor; and
- Notifying the Site Health and Safety Supervisor of any special medical problems they may have and making other on-site personnel aware of the problem.

ATTACHMENT C
BLANK FORMS

- HASP Acknowledgement and Agreement
- Atmospheric Monitoring
- Instrument Calibration/Verification
- Personnel Exposure History
- Accident Report

AGREEMENT TO COMPLY WITH HEALTH AND SAFETY PLAN

I, _____, an employee or representative of _____, have read the Health and Safety Plan, dated _____ prepared for the _____ site. I understand my responsibilities and agree to abide by the Health and Safety Plan.

_____

Signature Date

_____

Signature of Site Health and Safety Supervisor Date

ATMOSPHERIC MONITORING

NAME(S)_____ DATE_____

PROJECT NAME_____ PROJECT NO._____

WEATHER CONDITIONS_____

ESTIMATED WIND DIRECTION AND SPEED_____

WORK ACTIVITIES_____

_____

MONITORING EQUIPMENT USED_____

_____

Atmospheric Measurements

TIME	READING	TIME	READING	TIME	READING

INSTRUMENT CALIBRATION/VERIFICATION

INSTRUMENT_____

SERIAL NO._____

Is the Instrument a rental unit? Yes___ No_____

If "Yes", did the rental company supply verification of calibration? Yes___ No_____

If "No", complete the following:

Calibrated by_____ Date_____

Standard Gas(es) Used_____

Pure Air Source? Yes___ No____

Battery Good? Yes___ No____ Charge_____

Comments:

PERSONNEL EXPOSURE HISTORY

PROJECT NAME_____ PROJECT NO._____

DATES (FROM/TO)_____

PERSONNEL AND CONTRACTORS ON-SITE

Name/Company	Duties	Exposure Above PELs?
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		

ACCIDENT REPORT

SITE_____ PROJECT NO. _____

LOCATION _____

DATE OF REPORT _____ PREPARERS NAME _____

NAME AND AFFILIATION OF INJURED _____

SSN _____ AGE _____ YEARS OF SERVICE/EXPERIENCE _____

TIME ON PRESENT JOB _____ TITLE/CLASSIFICATION _____

DATE OF ACCIDENT _____

SEVERITY OF INJURY _____ Disabling _____ Non-Disabling

_____ Medical Attention _____ No Medical Attention

_____ Fatality

CLASSIFICATION OF INJURY

Fractures	_____ Heat Burns	_____ Cold Exposure
Dislocations	_____ Chemical Burns	_____ Frostbite
Sprains	_____ Radiation Burns	_____ Heat Stroke
Abrasions	_____ Bruises	_____ Heat Exhaustion
Lacerations	_____ Blisters	_____ Concussion
Punctures	_____ Toxic Respiratory Exposure	_____ Faint/Dizziness
Bites	_____ Toxic Ingestion	_____ Dermal Allergy

PART OF BODY AFFECTED _____

DEGREE OF DISABILITY _____

ACCIDENT REPORT

DATE MEDICAL CARE WAS RECEIVED _____

PLACE WHERE MEDICAL CARE WAS RECEIVED _____

_____

_____

LOCATION OF ACCIDENT _____

Causative agent most directly related to accident (e.g., object, substance, material, machinery, equipment conditions) _____

_____

Was weather a factor? _____

Unsafe mechanical / physical / environmental conditions at the time of the accident (be specific)

_____

_____

Unsafe act by injured and/or others contributing to the accident (be specific) _____

_____

_____

Personal factors (e.g., improper attitude, lack of knowledge or skill, slow reaction, fatigue)

_____

_____

ACCIDENT REPORT

LEVEL OF PERSONAL PROTECTIVE EQUIPMENT (PPE) REQUIRED IN THE SITE-SPECIFIC HEALTH AND SAFETY PLAN FOR THIS ACTIVITY? _____

WAS PPE IN-USE A MODIFICATION OF THAT SPECIFIED IN THE HEALTH AND SAFETY PLAN? _____

WAS THE INJURED USING REQUIRED EQUIPMENT? _____

IF NOT, HOW DID ACTUAL EQUIPMENT DIFFER FROM THE PLAN? _____

_____

WHAT CAN BE DONE TO PREVENT THE REOCCURRENCE OF THIS TYPE INJURY? _____

_____

_____

WITNESSES TO THE ACCIDENT _____

_____

_____

_____

SIGNATURES

PREPARER _____

HEALTH AND SAFETY SUPERVISOR _____

ACCIDENT REPORT

DETAILED NARRATIVE DESCRIPTION OF ACCIDENT (How and why did the accident happen? What tools, circumstances or assigned duties contributed to the accident? Be specific. Use additional sheets if necessary)

APPENDIX C

SAMPLE COLLECTION METHODS FOR GROUNDWATER, SURFACE WATER, SOIL VAPOR, SOIL AND SEDIMENT STANDARD OPERATING PROCEDURE

Sample Collection Methods for Groundwater, Surface Water, Soil Vapor, Soil and Sediment

Standard Operating Procedure

Prepared by:

EnviroGroup Limited
Centennial, Colorado

Version 2.0

August 10, 2009

Prepared by	Date
Reviewed by	Date
Approved by	Date

TABLE OF CONTENTS

1 INTRODUCTION 1-1

2 DOCUMENTATION AND RECORDS 2-1

2.1 Field Notebooks 2-1
2.2 Field Reporting Forms.....2-2

3 FIELD MEASUREMENTS 3-1

3.1 Water Level and Free-Product Measurements.....3-1
3.1.1 Water Level Measurements 3-1
3.1.2 Free-Product Measurements 3-1
3.2 Field Water Quality Measurements 3-2
3.2.1 pH Measurement.....3-2
3.2.2 Specific Conductance Measurement.....3-3
3.2.3 Redox or ORP (Oxidation-Reduction Potential) Measurements . 3-4
3.2.4 Dissolved Oxygen Measurement 3-4
3.3 Field Soil Vapor Sampling Measurements 3-5
3.3.1 Feasibility Testing.....3-5
3.3.2 Leak Testing.....3-6
3.3.3 Field Measurement of Oxygen, Carbon Dioxide, and Methane .. 3-6
3.3.4 Methane Measurement.....3-7

4 SAMPLE COLLECTION.....4-1

4.1 Groundwater 4-1
4.1.1 Volatile Organic Compounds 4-4
4.1.2 Metals Analyses.....4-5
4.2 Surface Water Sample Collection 4-5
4.3 Soil Vapor Sampling.....4-6
4.3.1 Sampling Point Installation.....4-6
4.3.2 Soil Vapor Sample Collection 4-7
4.4 Soil Sampling 4-8
4.4.1 Soil Sample Collection 4-8

4.4.2 Excavation Soil Sample Collection or Screening 4-8
4.5 Sediment Sample Collection 4-9

5 EQUIPMENT DECONTAMINATION 5-1

6 INVESTIGATION DERIVED WASTES.....6-1

7 SAMPLE HANDLING AND CUSTODY REQUIREMENTS 7-1

7.1 Sample Handling.....7-1
7.2 Sample Custody Documentation.....7-1
7.2.1 Sample Labels..... 7-1
7.2.2 Chain of Custody Forms 7-1
7.2.3 Custody Seals..... 7-2

8 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS 8-1

8.1 Laboratory QA/QC Requirements 8-1
8.2 Field QA/QC Requirements.....8-1
8.3 Groundwater and Soil QA/QC Samples 8-2
8.3.1 Trip Blanks..... 8-2
8.3.2 Field (Rinsate) Blanks..... 8-3
8.3.3 Field Duplicates 8-3
8.3.4 Field Replicates (Splits)..... 8-3
8.4 Soil Vapor QA/QC Samples 8-4

9 EQUIPMENT INSPECTION, MAINTENANCE, AND CALIBRATION REQUIREMENTS 9-1

APPENDIX A FIELD REPORTING FORMS

1 INTRODUCTION

This Standard Operating Procedure (SOP) describes the general procedures that should be followed when conducting sample collection for groundwater, surface water, soil vapor, soil and sediment. Modifications to this SOP may be necessary due to regulatory requirements, site specific conditions, or client requests; however, any variations from this SOP must be approved by the EnviroGroup project manager. This SOP is a general guidance document and is not intended to encompass every detail of the topics addressed. The user should contact the project manager to determine whether any site-specific procedures affect this SOP.

All tasks identified in this SOP are to be carried out under a site-specific health and safety plan. Work shall not begin until necessary state and local permits and notifications have been acquired and utilities have been cleared, as required.

Prior to conducting field sampling, ensure that all necessary equipment is available, clean, and in good working condition.

2 DOCUMENTATION AND RECORDS

Field activities are logged by field personnel into a field notebook or onto standard field forms. Specific procedures for documenting field activities are provided below.

2.1 FIELD NOTEBOOKS

Record information pertinent to sample collection in a bound field notebook with consecutively numbered pages. Entries made in the notebook and on field reporting forms (discussed below) will be made in waterproof ink. If required, make corrections to entries by drawing a line through the error and initial and date the correction. Typical information documented in the field notebook may include:

- Author's name, title and initials;
- Date and time of entry;
- Names and responsibilities of field crew members;
- Details of sampling locations, including sketches and depths as appropriate;
- Date and time of sample collection;
- Sample identification and description (lithologic for soil/sediment samples);
- Details of any required procedural deviations, such as sampling or schedule changes;
- Calibration or maintenance of field equipment;
- Required or miscellaneous field observations; and
- Weather conditions.

Field conditions and sampling situations vary widely and actual site conditions are sometimes not fully anticipated at the time of work plan preparation. However, information recorded in the field notebook and on field reporting forms should be

sufficient to allow for an adequate reconstruction of events, if necessary. Keep the field notebook in the team member's possession or in a secure place during the sampling event as it will become a part of the permanent project file.

2.2 FIELD REPORTING FORMS

Examples of applicable field reporting forms are included in Appendix A. Entries made on field forms will be made in waterproof ink. If required, make corrections to entries by drawing a line through the error and initial and date the correction. The following field forms are included in Appendix A, and may be used as needed:

- Field Water Quality Sampling and Analysis Form
- Soil Vapor Sample Log
- Inventory of Containerized Material
- Photographic Log
- Chain of Custody (can use any labs form)

3 FIELD MEASUREMENTS

The following field measurement protocols apply to the collection of groundwater, surface water, and soil vapor samples. Field measurements shall be taken using clean, calibrated meters, which may be rented, provided by the client, or owned by EnviroGroup. Project personnel should consult with the project manager as to which meter(s) should be used.

3.1 WATER LEVEL AND FREE-PRODUCT MEASUREMENTS

This section describes the procedures used to measure depth to groundwater and free-product thickness, if applicable, in monitoring wells.

3.1.1 Water Level Measurements

Depth to groundwater generally is measured with an electronic water-sensing device. The measurement is made relative to a surveyed measurement point at the well head (commonly the top of the PVC casing), and is recorded to the nearest 0.01 foot. Water level measurement procedures are described below:

1. Turn the instrument on with the “ON/SENSITIVITY” switch. If the buzzer makes a loud signal and the light is visible, the battery is adequate for normal operation.
2. Gently lower the probe down the well to the groundwater surface. The light and buzzer will activate. At this point, adjust the probe sensitivity.
3. Water level measurements can now be taken from the top of the PVC casing (or acceptable reference point).

3.1.2 Free-Product Measurements

Free-product thickness is measured with an electronic interface probe. Free-product (e.g. hydrocarbons) may be found in monitoring wells at active or former service stations or other locations. The measurement is made relative to a surveyed measurement point at the well head (commonly the top of the PVC casing), and is recorded to the nearest 0.01 foot. Free-product thickness measurement procedures are described below:

1. Turn the instrument on with the “ON/TEST" switch. If the buzzer makes a loud signal and the light is visible, the battery is adequate for normal operation.

2. Gently lower the interface probe down the well until the signal activates then read the measurement at the top of the PVC casing (or acceptable reference point). Record this reading as the first fluid level.

3. Continue to gently lower the probe until the signal changes. Record the measurement at the top of the PVC casing (or acceptable reference point) as the second fluid level.

4. To determine the product layer thickness, subtract the first reading from the second reading.

3.2 FIELD WATER QUALITY MEASUREMENTS

Field water quality measurements provide a rapid means of characterizing general groundwater conditions and are also used during groundwater sampling to ensure that fresh formation water is obtained for laboratory analysis. Field water quality measurements may be taken in-situ (i.e., inside the well or closed flow cell) or ex-situ (i.e., in a sample pulled from the well). The decision to measure field water quality parameters in-situ or ex-situ will be made on a project-specific basis and may depend upon the parameters measured, diameter of the well to be sampled, and availability of field equipment. Field personnel should consult with the project manager and the project work plan to determine which procedure to use.

The field water quality parameters specified for a given sampling event may vary, based on project requirements. However, several commonly measured field parameters are described below.

It should also be noted that the following descriptions are generalized. Personnel tasked with obtaining field water quality measurements should refer to the manufacturer's literature for equipment calibration and use instructions.

3.2.1 pH Measurement

Before measuring a sample for pH, the follow steps must be taken.

1. Calibrate or verify the calibration, as appropriate, according to the manufacturer's instructions using two pH end-points (commonly pH 7 and pH 10, or pH 7 and pH 4). Three pH end-point calibration (e.g., pH 4, pH 7 and pH 10) may also be used and is becoming more common.

2. After calibrating, rinse the calibration solution from the electrode using deionized water.

3. Once calibration has been established, insert the rinsed electrode into a beaker containing the sample to be measured, if measuring pH ex-situ, or insert the pH electrode into the well or closed flow cell, if measuring pH in-situ. Allow the reading to stabilize (possibly several seconds to a minute or more). A noticeable increase in stabilization time may indicate a need to clean or replace the electrode. Record the stabilized pH value on the appropriate field form (pH is a dimensionless parameter, although the term 'standard pH units' is sometimes cited).

4. pH is somewhat dependent on temperature. Most electrodes automatically compensate for temperature. If the electrode used does not provide automatic temperature compensation, the sample temperature must also be measured and recorded.

3.2.2 Specific Conductance Measurement

1. Calibrate or verify the calibration, as appropriate, according to the manufacturer's instructions or at least daily.

2. Rinse the calibration solution from the electrode with deionized water.

3. Once calibration has been established, insert the rinsed electrode into a beaker containing the sample to be measured, if measuring specific conductance ex-situ, otherwise, insert the electrode into the well or closed flow cell to measure specific conductance in-situ. Allow the reading to stabilize and record the measurement on the appropriate field form (possibly several seconds to a minute or more). A noticeable increase in stabilization time may indicate a need to clean or replace

the electrode. Specific conductance is measured in units of milli- (m) or micro- (µ) Siemens or mhos (Siemens and mhos are equivalent).

4. Specific conductance is highly dependent on temperature. Most modern devices automatically compensate for temperature. If the device used does not, the sample temperature must also be measured and recorded.

3.2.3 Redox or ORP (Oxidation-Reduction Potential) Measurements

1. Calibrate or verify the calibration, as appropriate, according to the manufacturer's instructions or at least daily. Each calibration or verification should be based on a freshly prepared (or newly opened) quantity of Zobell's or equivalent solution. Only a single-point calibration is required because of an internal reference point inherent to all redox electrodes.

2. Rinse the calibration solution from the electrode with deionized water. Once calibration has been established, gently lower the rinsed electrode into the well casing or closed flow cell to be measured. Allow the reading to stabilize (possibly several seconds) and record the reading on the appropriate field form. An effort should be made to record redox values at approximately the same time in every sample (after each well casing purge) to minimize the effects of sample contact with the atmosphere. Redox is measured in units of millivolts.

3.2.4 Dissolved Oxygen Measurement

1. Calibrate or verify the calibration, as appropriate, according to the manufacturer’s instructions or at least daily. If using a YSI 556 MPS Field Meter, the device must be on for at least 20 minutes prior to calibration.

2. If using a Multiline P-4 Field Meter, the sponge in the calibration sleeve should be moist but not wet and the sleeve should be left on the probe during calibration but should be loosened to ensure that the dissolved oxygen sensor is vented to the atmosphere.

3. If using the YSI 556 MPS Field Meter, perform the dissolved oxygen calibration in % Saturation. Make sure the dissolved oxygen and temperature probes are not

immersed in water during the calibration procedure. The calibration cup should be loosely threaded to ensure that the dissolved oxygen sensor is vented to the atmosphere. Confirm the unit compensates for barometric pressure changes. Allow approximately 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate. When the reading shows no significant change for approximately 30 seconds, press enter. Confirm the accuracy of calibration by measuring the dissolved oxygen concentration of a known dissolved oxygen solution (i.e. 0 mg/L). The United States Environmental Protection Agency (EPA) Office of Environmental Measurement and Evaluation recommends that the confirmation reading be less than 0.5 mg/L (EPA, QA Bulletin, Calibration of Dissolved Oxygen Meters, February 2006).

4. Once calibration has been established, gently lower the rinsed electrode into the well casing or closed flow cell to be measured. Allow the reading to stabilize (possibly several seconds to several minutes or more). An effort should be made to record dissolved oxygen readings in mg/L and % Saturation at approximately the same time in every sample to minimize the effects of sample contact with the atmosphere.

3.3 FIELD SOIL VAPOR SAMPLING MEASUREMENTS

Field measurements associated with soil vapor sampling provide a means of characterizing general soil vapor conditions and are also used during soil vapor sampling to ensure that minimal ambient air is mixed with the subsurface vapor that is obtained for laboratory analysis. Field soil vapor related measurements may include: feasibility testing, leak testing, and field testing for oxygen, carbon dioxide, and methane. The decision to measure oxygen, carbon dioxide and methane will be made on a project-specific basis.

3.3.1 Feasibility Testing

After a soil vapor well has been installed, testing will be performed to determine if a representative soil vapor sample can be collected. The use of excessive vacuum may cause transfer of sorbed contaminants into the vapor phase or may cause a breach in the bentonite seal, allowing ambient air to infiltrate the sampling zone. Feasibility testing is

accomplished by applying a vacuum to the vapor well using a 20 to 100 cubic centimeter syringe connected to the end of the sampling train. If the syringe plunger does not hold its position, collection of a soil vapor sample at that location is probably not feasible.

3.3.2 Leak Testing

During soil vapor sampling activities, a clean, small plastic bucket or shroud will be inverted and placed over each soil vapor probe and weighted down. An air-tight seal of hydrated bentonite (or Sculpy Modeling clay) will be placed on the ground around the edge of the bucket where it contacts the ground. Prior to purging or sampling activities, helium tracer gas will be released via a small diameter tube, placed through the side of the bucket, into the enclosure beneath the bucket. The soil vapor probe tube will be connected to the sampling tube by a Swagelok®, or comparable, fitting and the sampling tube will extend up through a small diameter hole in the bucket to the 3-way valve and canister (both outside of the shroud). A sample of the air inside the shroud will be collected using a syringe and tested for helium concentration using a portable helium detector before the soil vapor sample is collected in the Summa canister. The helium concentration in the shroud will be used for determining leak percentage, as discussed below.

Immediately after soil vapor purging and prior to sampling, a soil gas sample will be collected by syringe through the 3-way valve in the sample tubing and analyzed in the field for the presence of helium gas using a portable monitoring device. If high concentrations (>10% of the shroud concentration) of helium are observed in the soil vapor sample, the soil vapor probe seal and enclosure seal will be checked and/or enhanced to reduce the infiltration of ambient air into the enclosure and another sample collected. If helium concentrations are less than 10%, a soil vapor sample will be collected in the sampling container and submitted for laboratory analysis.

3.3.3 Field Measurement of Oxygen, Carbon Dioxide, and Methane

Oxygen, carbon dioxide and methane analyses of samples collected for petroleum hydrocarbon analysis may be accomplished in the laboratory or the field. Methane analysis is only required when light non-aqueous phase liquid (LNAPL) is present or oxygen content is less than 10%.

Oxygen may be measured in the field with a field meter containing an electrochemical cell. Carbon dioxide may be measured in the field with a field meter with an infrared analyzer. Both of these chemicals, and methane, may be measured in the laboratory using EPA Method 3810M/D1946.

3.3.4 Methane Measurement

If methane is to be measured, upon completion of monitoring wells, each well will be sealed with an air-tight PVC slip cap. Methane gas concentrations will be measured in each well using a GEM™ 1000 Landfill Gas Monitor (or equivalent) by removing the PVC slip cap from the top of the well, being careful to minimize mixing of air, and inserting the tubing 18 to 24 inches into the well. Methane gas concentrations will be analyzed until stabilization or for a maximum of 1 minute and the sustained readings will be recorded as a percent of methane by volume and percent lower explosive limit (LEL). After the sample has been measured, the PVC slip cap will be replaced on the well and the surface casing cap replaced and locked.

Methane gas readings will be recorded in a field notebook along with the date and time of the sample measurement, weather conditions including temperature, wind speed and direction, and precipitation, if applicable.

4 SAMPLE COLLECTION

The following sections detail the procedures for collecting groundwater, surface water, soil vapor, soil, and sediment samples.

4.1 GROUNDWATER

Prior to initiating a sampling event, information on monitoring well condition and construction, anticipated contaminant types and concentrations, and anticipated groundwater flow direction should be collected for each well where sampling is proposed. Lesser contaminated wells, if known, should be sampled before more contaminated ones to minimize the effects of cross-contamination.

Groundwater samples may be collected immediately after development if necessary or desired. However, in situations involving volatile organic compounds, it may be desirable to allow the formation to recover and stabilize at least overnight following well development before conducting groundwater purging and sampling activities. Groundwater sampling procedures, measurements and observations will be recorded on an appropriate field reporting form (Appendix A). Typical sample collection procedures are described below:

- Measure and record the depth to water and total well depth, noting the date and time of measurement.
- Calculate the wetted casing volume (i.e., the volume of groundwater in the well casing).
- Purge groundwater from the well using a decontaminated (Section 5.0) submersible pump (fitted with a foot-valve and dedicated poly tubing), or dedicated, disposable polyethylene or Teflon bailer which is hoisted with new nylon rope.

- If a bailer is used for sample collection, allow the bailer to enter the water column softly. Hoist the bailer through the water column with a minimum of agitation. The bailer should be allowed to descend to the same approximate depth (approximately mid-screen) on each stroke.
- Field water quality parameters (e.g., pH, specific conductance, temperature, redox, and dissolved oxygen) should be measured prior to the removal of the first wetted casing volume and following the removal of each wetted casing volume.

The groundwater sample may be collected following the removal of the third wetted casing volume if field water quality parameters show relative stability (within approximately 10 percent) and two or more parameters show no significant trend of increasing or decreasing value.

Wells completed in fine-grained formations may be bailed dry prior to the removal of three wetted casing volumes. If a well is bailed dry, a sample may be collected without further purging. However, the sample should be obtained as soon as the well yields a sufficient volume for the sample.

Low-flow pumping procedures may also be used. This technique relies on the removal of groundwater at a rate similar to the well's rate of recharge (i.e., the groundwater column height during pumping should not vary more than approximately 10 percent from its steady-state condition or by keeping the drawdown at a minimal level (e.g., 0.33 feet); and is documented in EPA's Groundwater Sampling Guidelines for Superfund and RCRA Project Managers (EPA 542-S-02-001). There is no need to remove significant volumes of groundwater when using this technique, because laminar flow into the pump results in the nearly instantaneous recovery of fresh formation water from a discrete aquifer zone. Low-flow sampling procedures are described below:

- Measure and record the depth to water and total well depth, noting the date and time of measurement.
- Calculate one tubing volume (including the volume of water in the pump and flow cell) and one wetted casing volume (i.e., the volume of groundwater in the well casing).
- Lay out polyethylene sheeting around the well and place monitoring, purging and sampling equipment on the sheeting to minimize contamination from the surrounding area.
- Slowly lower the pump (e.g., peristaltic, bladder, submersible, etc.) and tubing down into the monitoring well until the location of the pump intake is set at a pre-determined location within the screen interval and record pump location in a field notebook or on a sampling form.
- Connect the discharge line to a flow through cell and attach the field parameter measurement meters. The discharge line from the flow through cell is directed to a container to contain the purge water.
- Begin pumping the well at a low flow rate, monitoring the water level and adjusting the speed as needed to maintain a steady flow rate. Measure the discharge rate with a graduated cylinder and a stopwatch and record the flow rate and drawdown in a field notebook or on a sampling form.
- A minimum of one tubing volume (including the volume of water in the pump and flow cell) must be purged prior to recording the field water quality parameters. Field water quality parameters should be measured and recorded at regular intervals of time (i.e., every 3 to 5 minutes) in addition to recording the flow rate and water level or drawdown.

Once three successive readings of the field water quality parameters provided in Table 4.1 have stabilized, sampling may begin. Samples should be collected directly from the discharge port of the pump prior to passing through the flow cell. If stabilization of field water quality parameters does not occur, the sample should be collected once 3 to 6 wetted casing volumes have been removed.

If a drawdown of less than or equal to 0.33 feet cannot be maintained and the water level is approaching the top of the screened interval, reduce the flow rate or turn off the pump for 15 minutes and allow for recovery. Under no circumstances should the well be pumped dry. Begin pumping at a lower flow rate, if the water draws down to the top of the screened interval again, turn the pump off (only if the pump has a check valve) and allow for recovery. If two tubing volumes have been removed, collect the sample the next time the pump is turned on. If this occurs, a note should be placed in the field notebook and sampling log with a recommendation for a different purge method.

Table 4.1 Stabilization Criteria for Water Quality Parameters

Parameter	Stabilization Criteria
pH	**+/- 0.1**
Specific Electric Conductance (SEC)	**+/- 3%**
Oxidation-reduction Potential (ORP)	**+/- 10 millivolts**
Dissolved Oxygen (DO)	**+/- 0.3 mg/l**

Equipment decontamination procedures are addressed in Section 5.0. If required, groundwater purged during sampling should be containerized and stored onsite pending an evaluation of applicable disposal requirements (Section 6.0).

4.1.1 Volatile Organic Compounds

Groundwater samples to be analyzed for volatile organic compounds (VOC's) are to be decanted with a minimum of agitation into laboratory prepared sample vials. If using the low-flow sampling procedure, the pump tubing must be completely full of groundwater to prevent the groundwater from being aerated as it flows through the tubing. The sealed vial should be inverted for inspection. If an air bubble is observed, add additional groundwater to the sample to ensure a zero-headspace condition. Label the sample and place it in a cooler as described in Section 7.0.

4.1.2 Metals Analyses

The following sections describe the methods used to collect samples for both dissolved and total metals analysis.

Dissolved Metals

Collect water samples to be analyzed for dissolved metals in a dedicated, disposable plastic container for filtration in the field. Filter sample through a 0.45-micron disposable filter cartridge directly into laboratory-prepared containers, using a decontaminated peristaltic pump and silicon tubing. Sample containers provided by the lab typically contain a nitric acid preservative. If this is not the case, add the preservatives immediately after the samples are filtered.

Total Metals

Water samples to be analyzed for total metals receive no filtration in the field and are preserved immediately upon collection.

4.2 SURFACE WATER SAMPLE COLLECTION

Typically, surface water samples are collected using a decontaminated dipper or laboratory supplied clean sample container placed in the center of flow. If it becomes necessary to collect surface water samples where a multipoint sampling procedure is more appropriate, such a procedure will be specified.

Surface water quality samples should be representative of the environment being sampled and all steps shall be taken, as necessary, to ensure that a representative sample has been obtained. Regardless of the sampling technique, homogenizing a composite sample prior to splitting with other groups or for other tests is essential. In some instances when incomplete mixing is suspected, or if performing a dispersion analysis, discrete samples as well as composite samples may be collected. Homogenizing will be accomplished by repeatedly inverting the composite bottle for 30 seconds.

pH, specific conductance, temperature, redox, and dissolved oxygen should be measured in the field following the procedures outlined in Section 3.0. Samples shall be appropriately preserved, depending upon the analytes (e.g., metals, VOC's, etc.).

4.3 SOIL VAPOR SAMPLING

Soil vapor samples are typically collected from small diameter borings for reconnaissance or field screening purposes. Soil vapor samples may be analyzed by mobile laboratory services in the field or delivered to a fixed laboratory for analysis.

4.3.1 Sampling Point Installation

Small diameter borings (typically 2 inches in diameter or less) may be advanced using direct-push techniques, an auger drill rig, or hand auger. The boring's depth may vary based on project requirements and equipment limitations, but generally will not be less than five feet. A porous aluminum (or fish tank micro-bubbler) tip, attached to small diameter (typically 3/8 inch) high density polyethylene (HDPE) or Nylaflow® tubing, may be installed in the open boring. Alternatively, a 1/4 inch by 6 inch, stainless steel screen may be installed in each probe. The screen will be connected to 1/8 or 1/4 inch nylon, HDPE, or Teflon® tubing utilizing Swagelok® fittings, or the equivalent. The tubing will be kept clean, bagged, and away from potential sources of contamination until installed. The screen will be placed at the desired sampling depth (in the middle of the sampling zone, described below) and the tubing will extend up the center of the borehole to approximately 2 feet above ground surface and fitted with an air-tight Swagelok® cap or air tight valve. A small portion of the annulus surrounding the porous aluminum tip or stainless steel screen (typically one to two feet) is backfilled with graded silica sand. The sampling interval should be in the middle of the interval of graded silica sand backfill. Granular bentonite is installed in 8-inch lifts (with distilled water hydration following each lift) to a height of approximately two feet above the graded silica sand. The remaining annulus is backfilled to grade with chipped bentonite, installed in 2-foot lifts (with distilled water hydration between each lift). A protective surface seal (cement or cement/bentonite mix) should be placed around the top of the well to prevent infiltration into the completed well. This surface seal should generally be at least one foot thick and should extend horizontally from the well for a distance of at least six inches, if possible.

Deep probes will be installed approximately 1 to 2 feet above the groundwater table, but no deeper than 20 feet below ground surface. Shallow probes will be installed in separate holes to avoid cross-communication between nested probes, off-set approximately 2 feet from the deep probes. Shallow probes will be installed at depths mid-way between the

deep probes and ground surface, typically at or below building foundation levels, and no shallower than 5 feet.

Soil samples or borehole cuttings may be screened in the field for the presence of organic vapors utilizing a MiniRae 2000© photoionization detector (PID) or similar equipment that is calibrated to manufacturer's specifications prior to field use with isobutylene and recalibrated as needed in the field. All PID values are recorded in parts per million (ppm) on borehole logs.

4.3.2 Soil Vapor Sample Collection

Subsurface conditions should be allowed to equilibrate prior to sampling. For wells installed by direct-push methods, sampling should not occur for at least 20 to 30 minutes after well installation. If wells are installed using hollow stem drilling methods, sampling should not be performed on the same day as well installation.

Prior to soil vapor sample collection, pumping system sealing qualities will be tested by applying a vacuum across the pumping system with the sampling point shut-out. Upon the successful completion of this calibration step, soil vapor will be drawn from the sampling point (Section 4.3.1) with a vacuum pump. At least three pumping system volumes (i.e., tubing plus vacuum pump displacement) will be purged through the system prior to sample collection. If sampling is performed within 48 hours of well installation using a hollow-stem auger, approximately two to three dead volumes of the sand pack will also be purged prior to sample collection. Once purged, a soil vapor sample will be drawn from the sampling point into a prepared glass sample bulb, or a 400 milliliter (mL) to one liter Summa canister, or a one liter tedlar sampling bag. A tedlar bag will only be used when the sample is to be analyzed by a local laboratory within 48 hours of sample collection. Flow rates for purging and sampling will not exceed 200 mL per minute. Vapor samples collected in tedlar bags will be immediately placed in a light-proof container (e.g., a cooler) and kept shaded until the sample's analysis, within 48 hours of collection.

4.4 SOIL SAMPLING

Soil sample collection procedures vary widely depending on project requirements. Samples of subsurface soils may be collected during drilling or excavation activities.

4.4.1 Soil Sample Collection

Shallow subsurface and/or surface soil samples may be collected with various hand tools (e.g., shovels or scoops), hand augers, hand-coring devices, or a freshly gloved hand. Deeper subsurface soil samples may be collected with split spoon samplers, continuous coring devices, or a hydraulic excavator (e.g., backhoe) in conjunction with methods listed above. Hand collected materials will be inspected, described, and recorded in a field notebook. Soil samples may be screened for the presence of organic vapors or other gasses utilizing a clean, calibrated meter (e.g., PID or methane meter) which may be rented, provided by the client, or owned by EnviroGroup and recorded in a field notebook. Soil samples should be placed in laboratory-prepared jars or bags, as appropriate, and managed under the chain of custody procedures described in Section 7.0. Equipment decontamination procedures are addressed in Section 5.0.

4.4.2 Excavation Soil Sample Collection or Screening

During investigation activities, soils may be sampled from a trench or pit excavated by a backhoe. Soil samples may be collected and/or screened during excavation activities or upon completion of excavation activities, in accordance with project requirements. If soil samples are collected during excavation activities and the excavation is classified as a confined space, the backhoe operator may be directed by field personnel to retrieve soil samples from the sidewalls or bottom of the excavation using the backhoe bucket. Soil samples collected from the excavator bucket should be collected from the edge or teeth of the bucket and immediately “trimmed” to remove undesired soil material or to remove surface layers that may have already lost volatiles. A hand tool device or a freshly gloved hand should be used to collect the soil sample to minimize sample volatilization.

Excavated materials should be inspected, described, and recorded in a field notebook. Soil samples may be screened for the presence of organic vapors or other gasses using a clean, calibrated meter (e.g., PID or methane meter) and recorded in a field notebook.

Soil samples should be placed in laboratory-prepared jars or bags, as appropriate, and managed under the chain of custody procedures described in Section 7.0. Equipment decontamination procedures are addressed in Section 5.0.

4.5 SEDIMENT SAMPLE COLLECTION

Sediment sample collection procedures vary widely depending on project requirements. Shallow subsurface and/or surface sediment samples may be collected with various hand tools (e.g., shovels or scoops), hand augers, hand-coring devices, or a freshly gloved hand. Sediment samples should be placed in laboratory-prepared jars or bags, as appropriate, and managed under the chain of custody procedures described in Section 7.0. Equipment decontamination procedures are addressed in Section 5.0.

5 EQUIPMENT DECONTAMINATION

Equipment decontamination procedures vary in accordance with the type of equipment and project requirements, and will be addressed as necessary in project-specific work plans. Further, the use of dedicated and disposable equipment (e.g., bailers and rope) is advantageous in that it may eliminate the need for equipment decontamination prior to and between uses, and the preparation and analysis of associated field rinsate blanks (Section 8.0).

If equipment decontamination is required, the following procedures apply:

- Physically clean the equipment. For large equipment (e.g., drilling augers, excavator buckets), spraying with high-pressure and (if necessary) high-temperature water provides sufficient decontamination. For smaller equipment (e.g., shovels, split spoons, etc.), more aggressive procedures, such as those listed below, will also be used:
- Provide a detergent and potable/distilled/deionized water wash.
- If metals are an identified project concern, rinse the equipment with a dilute (10:1) nitric acid solution.
- Follow the detergent water and/or the dilute acid rinse by a triple-rinse with distilled or deionized water.
- Air dry the decontaminated equipment and either use it immediately, or wrap and/or store it appropriately for later use.

6 INVESTIGATION DERIVED WASTES

Investigation derived wastes (IDW) shall be managed in accordance with a Colorado Department of Public Health and Environment (CDPHE) draft Interim Final Policy[1], and applicable local, state and federal laws and regulations. IDW may include environmental media, such as drill cuttings, decontamination waters, and groundwater purged during development or sampling, and solid wastes, such as used bailers and personal protective equipment. All IDW must be drummed and each drum labeled as 'Investigation Derived Waste', along with the date(s) of its generation, and the area(s) of its generation. Each drum will be assigned a tracking number.

An inventory of the day's IDW will be recorded in the field notebook and on the appropriate field form (Appendix A). The inventory should reference the date and area of generation, the drum's tracking number, and will be provided to the client for its use in the proper offsite management of the IDW.

[1] Colorado Department of Public Health and Environment. (Draft) Interim Final Policy and Guidance on Management of Investigation Derived Wastes (IDW) at RCRA Facilities.

7 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

The following sections describe the methods used to ensure samples are managed in accordance with sampling handling and chain of custody requirements.

7.1 SAMPLE HANDLING

Samples will be packaged and preserved in a manner prescribed by the applicable analytical method. Method-specific holding time requirements will be observed.

7.2 SAMPLE CUSTODY DOCUMENTATION

The following sections describe the proper procedure for labeling and documenting samples once they are collected.

7.2.1 Sample Labels

Label all sample containers using waterproof ink. Clear packaging tape may be applied over the completed label, as necessary, to prevent the label from loosening in a cooler containing ice. Information commonly provided on sample labels includes.

- Sample number or designation;
- Site or project name;
- Sample collection date and time;
- Preservative and filtration status;
- Analytes requested; and
- Sampler's name or initials.

7.2.2 Chain of Custody Forms

Record all samples chronologically on chain of custody forms. All entries to chain of custody documents will be made in ink. The chain of custody document(s) will be placed

in a Ziploc™ plastic bag and enclosed in the sample cooler or shipping container. The sample cooler will be custody-sealed as described below.

7.2.3 Custody Seals

Custody seals are used to assure the integrity of samples from the time the samples are collected and logged into the chain of custody system until the samples are received by analytical laboratory personnel. Ship all samples to the laboratory in coolers or other appropriate shipping containers. The cooler or shipping container must be custody-sealed in a manner which requires the destruction of the seal at the time of opening whenever a third party delivery service is used. Such coolers or shipping containers shall also be taped shut, with a layer of clear packaging tape placed over the custody seal to minimize the likelihood of accidental destruction during shipping and handling.

8 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

The following sections describe quality assurance quality control (QA/QC) requirements for sample collection.

8.1 LABORATORY QA/QC REQUIREMENTS

Only authorized laboratories shall be used to analyze groundwater, surface water, soil vapor, soil, and sediment samples in accordance with applicable EPA methods. Field personnel should consult with the project manager to determine which laboratories are authorized for use for their specific project. QA/QC requirements and corrective action procedures are developed by each laboratory in accordance with applicable EPA method requirements and each lab's internal standard operating procedures and quality assurance plans. Laboratory QA/QC results will be reviewed during data validation.

8.2 FIELD QA/QC REQUIREMENTS

Typical field QA/QC sampling requirements are summarized in Table 8.1. The rationale for specific field QA/QC sampling requirements is discussed in the following sections. The results of field or trip blanks analyses will not be used to correct data. If contaminants are found in blanks, the source of the contamination should be identified and corrective action, possibly including re-sampling, should be initiated.

Table 8.1 Field QA/QC Sampling Requirements

	Groundwater/ Surface Water	Soil	Sediment	Soil Vapor
Trip Blank (VOCs Only)	1 per Sampling Event 1	None	None	None
Field Blank	None2	1 per day per sampling technique	1 per day per sampling technique	1 per day
Duplicate	1 per 10 samples3	None	None	1 per day
Replicate4	1 per 10 samples3	None	None	None

Note:

1. Required when samples are analyzed for volatile organic constituents. Not to exceed 72 hours in the field.
2. Based on the use of dedicated, disposable sampling equipment. Otherwise, follow same schedule as that specified for soil sampling events.
3. At least one sample to be collected and analyzed per scheduled sampling event.
4. Replicate samples will be collected only if required by the project Work Plan.

8.3 GROUNDWATER AND SOIL QA/QC SAMPLES

The use of dedicated, disposable sampling equipment may be specified for groundwater monitoring to minimize or eliminate the need for equipment decontamination and the preparation of field (equipment rinsate) blanks. Several field QA/QC samples may still be required, however, as described below.

8.3.1 Trip Blanks

Trip blanks are containers of organic-free water prepared by the laboratory for transport into the field for the duration of a sampling event. However, no trip blank should be

allowed to stay in the field for an extended period. Therefore, a 72 hour maximum holding period has been established for trip blanks prepared for groundwater sampling events. If groundwater sampling extends beyond a 72 hour event (three days), more than one trip blank will be required.

8.3.2 Field (Rinsate) Blanks

Field blanks, otherwise known as equipment rinsate blanks, are prepared to assess the decontamination of reusable sampling equipment. Field blanks will be prepared at a rate of one per day, per sampler, per sampling technique when the required sampling involves the use of reusable equipment.

8.3.3 Field Duplicates

Field duplicates are used to assess the apparent degree of variability due to both sampling technique and laboratory procedures by evaluating representative samples obtained from the same medium, collected sequentially from the same location. Field duplicate samples of groundwater, for example, include the collection of one sample followed by the collection of a second (duplicate) sample. Soils and sediment are inherently non-homogenous and are subject to natural variations in composition and texture across small distances. It is not possible to isolate the effects of sampling technique and laboratory procedures from natural heterogeneity through the collection of duplicate samples. Therefore, field duplicates are not required during soil and sediment sampling.

8.3.4 Field Replicates (Splits)

Field replicates are two or more samples split from an original container or sampling device in a manner which assures that the splits are the same in all respects, assuming the original sample is relatively homogenous. Replicate samples, if required by the project, will be analyzed by the same analytical procedures at different laboratories to assess the variability between the laboratories. Soils and sediment are inherently non-homogenous and it is not possible to prepare representative splits of a soil or sediment sample in the field. Soil and sediment sample splits can, under certain circumstances, be prepared in the laboratory. However, the homogenization procedures commonly used to split samples in the lab (i.e., drying and sieving) are impractical for use with organic

constituent analyses. Therefore, field replicates will not be prepared for soil or sediment samples, and soil and sediment replicates will only be laboratory-prepared when anticipated analyses are limited to inorganic constituents.

8.4 SOIL VAPOR QA/QC SAMPLES

Sample collection bulbs provided by the sample collection contractor will be decontaminated prior to and between uses by heating in an oven at 100°C for 30 minutes. A laboratory blank will be prepared and analyzed prior to initiating the day's sampling to ensure that adequate decontamination has been achieved. Field blanks will be prepared by drawing a sample of ambient air through the sample collection system (i.e., vacuum pump, tubing, etc.). A field duplicate sample of soil vapor is generally collected immediately after the primary sample, similar to what is done during groundwater sampling.

9 EQUIPMENT INSPECTION, MAINTENANCE, AND CALIBRATION REQUIREMENTS

All field instrumentation must be calibrated prior to use. Field instrumentation to be used may include, for example, water level indicators, pH meters, specific conductance meters, redox meters, dissolved oxygen meters and thermometers. Water level indicator calibration will be verified in the field with a tape measure. The pH, conductance and redox meters will be field calibrated using known standards on a daily basis using the procedures outlined in Section 3.0. The thermometer requires factory calibration, but compliance with the manufacturer's specified calibration frequency, if any, will be confirmed. Vacuum gauges, oxygen and carbon dioxide meters, landfill gas monitors, and PID meters also require factory calibration; however, field calibration may be required.

APPENDIX A

FIELD WATER QUALITY SAMPLING AND ANALYSIS

PROJECT: _____ LOCATION: _____

PROJECT NO. _____ PERSONNEL: _____

INSTRUMENTS: (Conductivity, Temperature, pH, Redox, etc.) _____

_____

GENERAL					
WELL/LOCATION					
WATER SOURCE					
DATE					
TIME					

SAMPLING CONDITIONS					
SAMPLING METHOD					
DEPTH OF SAMPLE (BGS / TOC)					
WELL DEPTH (BGS / TOC)					
WATER LEVEL (BGS / TOC)					
ONE WET CASING VOLUME For 2 inch wells: (TD-WL)x0.16=_____ gallons			For 1 inch wells: (TD-WL)x0.04=_____ gallons For 4 inch wells: (TD-WL)x0.65=_____ gallons		
APPEARANCE					

FIELD MEASUREMENTS					
VOLUME REMOVED (GAL)					
TOTAL VOLUME REMOVED (GAL)					
TEMPERATURE (°C or °F)					
CONDUCTIVITY (ATC, 25°C)					
pH					
REDOX (mV)					
OTHER					
PURGE OR SAMPLE					

SAMPLES COLLECTED AND SAMPLE ANALYSIS					
GROSS UF/UP					
DISSOLVED METALS F/HNO_3					
TOTAL METALS UF/HNO_3					
PETROLEUM HCs UF/HCl					
VOLATILE ORGANICS UF/UP UF/HCl					
SEMIVOLATILE ORGANICS UF/UP					
LAB/DATE SUBMITTED					

EnviroGroup Limited

SAMPLER'S INITIALS _____ DATE _____

SOIL VAPOR SAMPLE LOG

Project Name: BROWN GROUP REDFIELD _____ Date:_____

Project Number:_____ Personnel:_____

_____

Weather Conditions:_____

_____

_____

SAMPLE DATA

Sample number:_____ Time Sample collected:_____

Temperature:_____ Method of collection:_____

Hole Diameter:_____ inches Tubing Diameter (ID) _____ feet

Sample Location:_____

Sample Depth information:

Push to Depth of _____ feet bgs.

Pull back _____ feet to a depth of _____ bgs.

Sample Depth Interval:_____ to _____ feet bgs

Describe push _____

Location Plat

Purge Volume Calculation:

Tubing Volume: _____ feet tubing X _____ cc/ft = _____ cc volume
Open Hole Volume: _____ feet hole X _____ cc/ft = _____ cc volume
Sample Comtainer type: _____ _____ cc volume
Total for one purge volume: _____ **cc volume**
Number of Purge Volumes to be removed prior to sampling: _____

TOTAL PURGE VOLUME TO BE REMOVED PRIOR TO SAMPLING _____ **cc volume**

Results of leak test:_____

Purge Volume Removed: initial vac _____ in Hg

Beginning Flow Meter Reading _____ cc flow vac _____ in Hg

Ending Flow Meter Reading _____ cc flow duration _____ (time)

Total purge volume remove _____ **cc**

Purge volumes removed _____ Recovered Sample ☐

Condition of "O" ring seal OK ☐ Failed ☐ No Recovery ☐

INVENTORY OF CONTAINERIZED MATERIAL
GROUP # ___

Page__ of__

DRUM #	SOURCE[1]	CONTENTS[2]	DATE[3]	DATA SUMMARY WORKSHEET RESULTING STATEMENT	TRANSFER DATE[4]	DOCUMENT NO. (if appropriate)[5]

[1] For example, for soil cuttings, record the boring or well # and depth interval below ground surface.
[2] For example, soil cuttings, decon water, or sediment.
[3] Record date that material was first placed into drum. If material is ultimately classified by the generator as hazardous waste, this will be the date that the 90 day accumulation period begins.
[4] For example, date shipped off site or pumped into treatment system.
[5] For example, Bill of Lading or Manifest Number.

PHOTOGRAPHIC LOG

Page _____ of _____

PROJECT NAME _____

PROJECT NUMBER _____

PHOTOGRAPHER _____

SITE _____

ENGINEER(S) _____

ROLL NUMBER _____

CAMERA MODEL _____

SERIAL NUMBER _____

FILM FORMAT: SLIDES ☐ PRINTS ☐

SIZE: _____ SPEED: _____

COMMENTS _____

FRAME ⓐ / NEG.	ⓑ DIRECTION	ⓒ DATE	ⓓ TIME	DESCRIPTION (Location, features, personnel)

ⓐ FRAME is the exposure number displayed on the camera.
NEG. is the number identification on the negative (as applicable).

ⓑ One of eight compass directions (e.g. northwest) should be used to describe the direction the camera is pointed. Alternatively an azimuth or relative orientation to a known datum may be used.

ⓒ The date is expressed for month/day/year.

ⓓ Time is documented using the 24 hour clock.

PHOTO

4-23-91

APPENDIX D

INSTALLATION AND SAMPLING OF SUB-SLAB VAPOR PROBES FOR ANALYSIS USING EPA METHOD TO-15 TO SUPPORT VAPOR INTRUSION INVESTIGATION STANDARD OPERATING PROCEDURE

Installation and Sampling of Sub-Slab Vapor Probes for Analysis Using EPA Method TO-15 to Support Vapor Intrusion Investigations

Standard Operating Procedure

Prepared by:

EnviroGroup Limited
Centennial, Colorado

Version 1.0

March 1, 2009

Prepared by	Date
Reviewed by	Date
Approved by	Date

TABLE OF CONTENTS

1 INTRODUCTION 1-1

2 DOCUMENTATION AND RECORDS 2-1

2.1 Field Notebooks 2-1
2.2 Field Records 2-1

3 SUB-SLAB VAPOR PROBE CONSTRUCTION AND INSTALLATION ...3-1

4 SUB-SLAB SAMPLING 4-1

5 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS 5-1

6 SUPPLY AND EQUIPMENT REQUIRMENTS 6-1

6.1 Temporary Probe Parts List 6-1
6.2 Permanent Probe Parts List 6-1
6.3 Equipment and Sampling Parts List 6-2

1 INTRODUCTION

This Standard Operating Procedure (SOP) describes the general procedures that should be followed during installation and sampling of sub-slab soil vapor probes. Modifications to this SOP may be necessary due to regulatory requirements, site specific conditions, or client requests; however, any variations from this SOP must be approved by the EnviroGroup project manager.

This SOP was developed to provide general guidance for the installation and sampling of sub-surface vapor probes and satisfies the general requirements of the "Guidance for Evaluating Soil Vapor Intrusion in the State of New York", NYSDOH, October 2006. This SOP is designed for use with either 1 Liter (L) or 6 L SUMMA® canisters with dedicated flow controllers. Sampling procedures may need to be adjusted by the EnviroGroup project manager for projects requiring the use of mini-cans (i.e. 400 to 600 milliliters (ml)) or other sample containers.

In some situations, sub-slab vapor samples may be collected from buildings with operating mitigation systems. Typically, the mitigation system should be turned off at least two weeks prior to sub-slab vapor sampling. However, much shorter system shut-down times may be allowed in special circumstances. A minimum of 24 hours is highly recommended.

The EnviroGroup project manager should be consulted to determine the number and location of sub-slab vapor probes, SUMMA® (or equivalent) stainless steel sample canister size, sampling duration, identified contaminants of concern, quality assurance samples, and concurrent indoor air or ambient (i.e. outdoor) air samples to be collected.

All tasks identified in this SOP are to be carried out under a site-specific health and safety plan. Work shall not begin until necessary state and local permits and notifications have been acquired and utilities have been cleared, as required.

Prior to conducting field sampling, ensure that all necessary equipment is available, clean, and in good working condition.

2 DOCUMENTATION AND RECORDS

Field activities are logged by field personnel into a field notebook. Specific procedures for documenting field activities are provided below.

2.1 FIELD NOTEBOOKS

Record information pertinent to sample collection in a bound field notebook with consecutively numbered pages. Entries made in the notebook and on field reporting forms (discussed below) will be made in waterproof ink. If required, make corrections to entries by drawing a line through the error and initial and date the correction. Typical information documented in the field notebook may include:

- Author's name, title and initials;
- Date and time of entry;
- Names and responsibilities of field crew members;
- Details of any required procedural deviations, such as sampling or schedule changes;
- Calibration or maintenance of field equipment; and
- Required or miscellaneous field observations.

Field conditions and sampling situations vary widely and actual site conditions are sometimes not fully anticipated at the time of work plan preparation. However, information recorded in the field notebook and on field reporting forms should be sufficient to allow for an adequate reconstruction of events, if necessary. Keep the field notebook in the team member's possession or in a secure place during the sampling event as it will become a part of the permanent project file.

2.2 FIELD RECORDS

To meet project objectives, field personnel should maintain adequate field records of conditions observed during sample collection. Documentation should consist of the

following:

- Sub-slab vapor probe locations with a sketch of the floor noting any penetrations of the slab, chemical storage areas, garages, doorways, stairways, or heating/cooling supply and return registers;
- Date, time, and duration of sample collection;
- Date that the mitigation system was turned off, if applicable;
- Sampling depth (both below slab and below grade);
- Sample identification;
- Identity of field personnel;
- Weather conditions (especially rainfall or snowfall within the last 48 hours);
- Ventilation conditions (heating or cooling system active and windows opened or closed);
- Sampling methods and devices;
- Sub-slab vapor purge volumes and rates;
- Helium concentrations under the shroud and in the purge gas for each sample;
- Volume of sub slab vapor sample (e.g. 400ml, 600ml, 1L or 6L);
- Sampling duration;
- Initial and final canister vacuum pressures;
- Apparent moisture content (dry, moist ,or saturated) of the sampling zone;
- Chain of custody protocols and records used to track samples;
- Analytes requested; and
- Documentation of the collection of indoor or ambient sir samples.

3 SUB-SLAB VAPOR PROBE CONSTRUCTION AND INSTALLATION

The following steps should be following during sub-slab vapor probe construction and installation:

- Prior to drilling holes in a foundation or slab, contact local utility companies to identify and mark underground utilities inside and outside the building (e.g., natural gas, water, sewer, refrigerant, electrical lines, etc.). Consult with the building manager, building maintenance department, or a private utility locator to identify the location of private utilities inside the building.

- Prior to installation of a sub-slab vapor probe, the building floor should be inspected and any penetrations (i.e. cracks, floor drains, utility perforations, sumps, etc.) should be noted and recorded. Information should be documented in field records.

- Locate sub-slab vapor probes away from any slab penetrations or building foundation walls. Typically, at least one probe should be installed in a central location. Project requirements will dictate sample locations based on objectives. Probe locations and distances to penetrations or foundation walls should be noted in the field records. Furthermore, if possible, locate sub-slab vapor probes in concealed locations so that probes will not be in the building occupants' way and that minor damage caused by drilling will not be easily noticed. If the slab is covered with carpet, carefully cut a right angle of approximately 6-inches by 6-inches into the carpet to access the slab.

- Prior to drilling, pre-assemble each sub-slab vapor probe (i.e. screen, approximately 36 inches of approved tubing, and two-way valve) to allow for a quick installation once the slab is penetrated. This will minimize potential mixing of sub-slab vapors with indoor air. Nylaflow or Teflon tubing are preferred. Polyethylene tubing is generally not an acceptable tubing material and should not be used.

- Using a 1 inch outer diameter (OD) masonry drill bit and a rotary hammer drill, advance the bit approximately 2 inches into the slab to partially penetrate the slab.

A 1.5 inch OD bit should be used for permanent installations.

- Using a smaller (0.5 inch OD) drill bit, advance the bit through the center of the larger hole and drill to an approximate depth of no further than 3 inches into the sub-slab material to create an open cavity. Do not use water when drilling or a vacuum to clean-up drilling debris. A small broom and dustpan may be used for surface clean-up.

- Immediately after the slab has been penetrated, the probe assembly should be gently inserted to the total depth of the penetration then raised 1 inch. Approximately 0.5 tablespoons of a clean, porous, inert backfill material (e.g. glass beads, washed #1 crushed stone, washed 10/20 silica sand, etc.) should be placed into the penetration around the probe assembly to backfill the annular space between the screen and the sub-slab material.

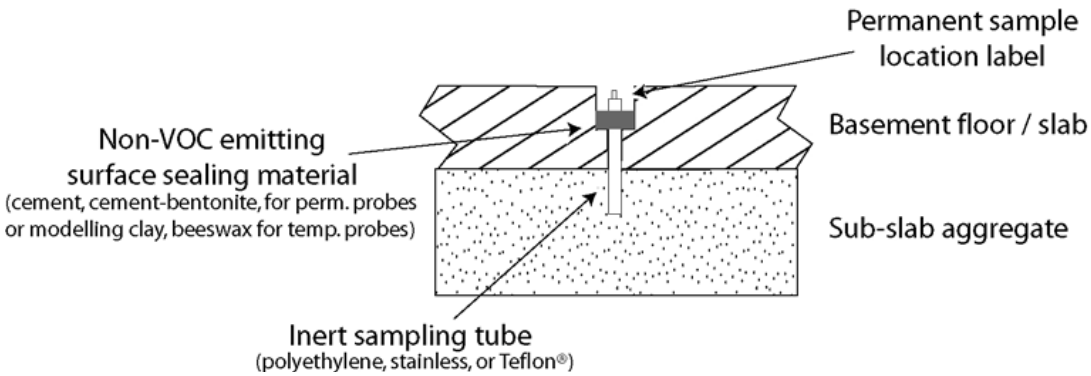
- For temporary installations, the remaining annular space should be sealed to the surface with a non-volatile organic compound (VOC) containing and non-shrinking product (e.g. bentonite, permagum grout, melted beeswax, sculpey modeling clay, etc.). The probe assembly tubing can remain on the slab surface.

- For permanent installation, the annular space should be sealed to the bottom of the larger 1.5 inch O.D. hole. The top of the probe assembly should be completed flush with the slab and have recessed stainless steel or brass plugs so as not to interfere with day-to-day use of building. A quick-drying portland cement (or acrylic based concrete filler) which expands upon drying (to ensure a tight seal) should be mixed with water to form a slurry and injected or pushed into the remaining annular space around the probe assembly. A putty knife or small stick can be used to clean the cement from around the top fitting so that it can be opened again with a wrench.

- Allow the surface seal (e.g. bentonite, cement, etc.) to cure and sub-slab vapor to re-equilibrate for a minimum of 1 hour prior to leak testing or sampling activities (24 hours is preferred).

A generalized schematic of a typical sub-slab vapor probe is illustrated in Figure 1.

Figure 1. Schematic of a generic sub-slab vapor probe
(From NYSDOH Guidance, October 2006)



4 SUB-SLAB SAMPLING

The following steps should be following during sub-slab sampling:

- Measure barometric pressure differential between sub-slab and indoor air utilizing a micro-manometer. A measurement should be taken immediately to minimize the potential mixing of sub-slab vapors and indoor air. Care should be taken by the EnviroGroup project manager during data interpretation.

- Place a small plastic shroud (e.g. cake cover) over sub-slab vapor probe and tubing and seal shroud to ground surface using hydrated bentonite and/or foam backing. Make sure to extend the tubing assembly through the air-tight seal of hydrated bentonite and/or foam backing to the exterior side of the shroud. If required, extend the probe tubing with an additional piece of clean, unused, approved tubing ensuring that any connections are made within the shroud. A schematic of a generic tracer test application is illustrated in Figure 2.

- Using a small diameter tube or regulator hose connected to a port located on the side of the shroud, gradually release a tracer gas (e.g. helium) into the enclosure beneath the shroud to enrich the atmosphere of the shroud. Then, if using helium as a tracer, attach a portable helium detector to a second port or "T" assembly to measure the concentration of the tracer gas within the shroud. The enclosure should be enriched to approximately 20 to 30% tracer gas.

- Once the air within the shroud has been enriched with a tracer gas, one to three sample train volumes of air (calculated based on the volume of annular space, probe tubing, and screen) should be purged prior to sample collection. Most states require three volumes of purging. The flow rate for purging must not exceed 200 ml per minute to minimize the potential for ambient air infiltration. Purging should be completed using an air-tight, 60 ml calibrated syringe. Purged vapors should not contain any moisture (i.e. water droplets). If so, a sample should not be collected. Note: Typically a minimum of 40 to 50 ml of purged vapors are required for tracer gas screening.

- Purge vapors may be transferred using the "T" assembly into a tedlar bag or directly screened from the syringe using a portable helium detector to measure for

the presence of helium gas in the purged vapors. If high concentrations (>10% of the shroud concentration) of helium are observed in the purged vapors, the sub-slab vapor probe seal and shroud seal should be immediately checked and/or enhanced to reduce the infiltration of ambient air into the shroud and another purge sample collected. If helium concentrations of less than 10% are observed, a sub-slab vapor sample may be collected. Prior to sample collection, purged vapors may be also screened for the presence of VOCs, methane, oxygen, or carbon dioxide. Consult with the EnviroGroup project manager to determine the maximum allowable purge volume and parameters required.

- Sub-slab vapor samples should be collected into certified, evacuated (i.e. batch or individual) 1 L or 6 L SUMMA® (or equivalent) stainless steel sample canisters with dedicated, laboratory-set flow controllers equipped with particulate filters. Extra canisters and flow controllers are recommended in case of equipment malfunctions.

- Utilizing a hand-held digital pressure gauge, check and record the initial vacuum in the canister. Remove the pressure gauge and attach the flow controller.

- To collect the sub-slab vapor sample, attach the SUMMA® (or equivalent) stainless steel sample canister with laboratory-set flow controller directly to the two-way valve of the probe assembly using a short length (e.g. 2 inches) of new, clean Tygon tubing so that the orifice of the flow controller touches the orifice of the valve. This will minimize contact of the sample to the Tygon tubing. Sample flow rates should not exceed 200 ml/min in order to minimize the potential for vacuum extraction of contaminants from the soil phase. The canister selected should meet sampling objectives and be certified clean by the laboratory.

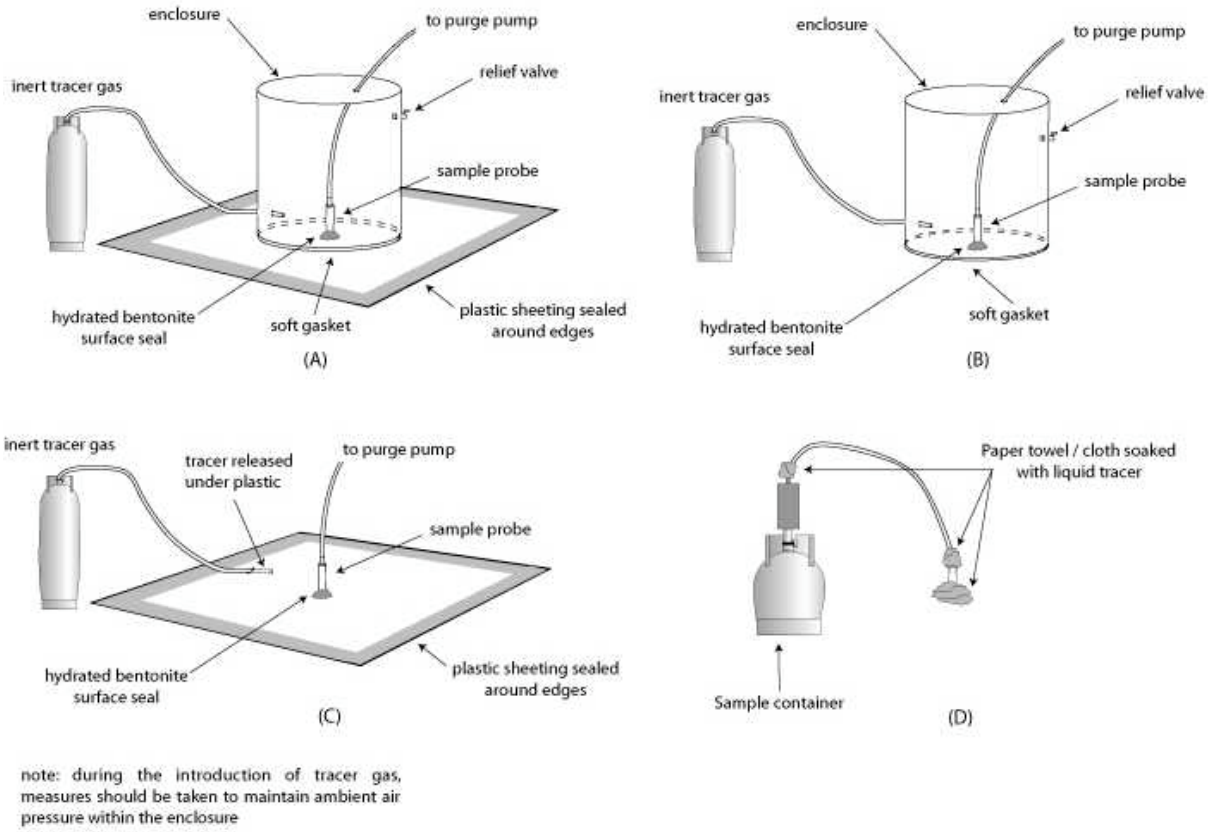
- Open the two-way valve and the canister valve. Record the initial field vacuum indicated on the flow controller (if provided).

- Close the canister valve when the pressure nears atmospheric pressure (i.e. 2 to 5 inches of mercury). Typically 8 hour or 24 hour samples may be collected, depending on project requirements. Record the final field vacuum indicated on the flow controller (if provided). Close and remove the flow controller and attach the hand-held digital pressure gauge. Open the canister valve and record the final field vacuum reading. Close the canister valve and remove the digital pressure

gauge. Place the dust cap on the canister.

- Package and ship canisters and flow controllers to a commercial laboratory for analysis by EPA Method TO-15 (generally in SCAN mode unless very low concentrations are expected).

Figure 2. Schematics of a generic tracer gas application
(From NYSDOH Guidance, October 2006)



note: during the introduction of tracer gas, measures should be taken to maintain ambient air pressure within the enclosure

5 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

General laboratory and field quality assurance quality control (QA/QC) requirements for soil vapor sample collection are provided in the Sample Collection Methods SOP, (EnviroGroup Limited, March 2009). However, the EnviroGroup project manager should be consulted to determine project specific QA/QC requirements.

Typically, to meet project objectives, a minimum of one duplicate sub-slab vapor sample per sampling event or 1 per 20 samples, whichever is greater should be collected. Duplicate samples should be collected simultaneously through either a “T” fitting or as a sequentially collected field duplicate. A trip blank and/or replicate sample may also be collected. Refer to the work plan for project QC requirements

6 SUPPLY AND EQUIPMENT REQUIRMENTS

The following sections describe the parts and equipment required for the installation of temporary or permanent sub-slab soil vapor probes.

6.1 TEMPORARY PROBE PARTS LIST

Temporary probe part information including applicable vendors and model numbers are provided below.

- Nylaflow tubing (0.25 inch O.D. x 0.190 inch I.D.)
- Elite Air Diffuser (i.e. Probe tips, A-983)
- Stopcock, 1 Way Male Valve (Cole Parmer 30600-01)

6.2 PERMANENT PROBE PARTS LIST

Permanent probe part information including applicable vendors and model numbers are provided below.

- Nylaflow Tubing (0.25 inch O.D. x 0.190 inch I.D.)
- Elite Air Diffuser (i.e. Probe tips, A-983)
- Stopcock, 1 Way Male Valve (Cole Parmer 30600-01)
- Swagelok Parts (Denver Valve and Fitting, 303-232-8844)
- 1/8 inch SS unions: SS-200-6
- 1/8 inch SS nuts: SS-202-1
- 1/8 inch SS ferrules: SS-200-set
- 1/8 inch SS plugs: SS-200-P
- 1/8 inch to ¼ inch reducer (to connect 1/8 inch tubing to Summa): SS-200-R-4

6.3 EQUIPMENT AND SAMPLING PARTS LIST

Equipment and sampling parts required for sub-slab soil vapor probe installation and sampling are provided below.

- Rotary Hammer Drill
- Generator (if power supply not available)
- 0.5 inch Masonry Drill Bit (should be at least 18 to 24 inches in length)
- 1 inch or 1.5 inch Masonry Drill Bit
- Silica Sand
- Bentonite (granular)
- Sculpey Modeling Clay
- Stopcock, 3 Way Male Valve (Cole Parmer 30600-02)
- Tygon Tubing (0.25 inch I.D.)
- Calibrated Syringe (60 cc, Air-Tite TL60)
- 1 Liter Tedlar Bag (SKC, 232-01)
- Shroud
- Helium Tank (disposable or cylinder with regulator attachments)
- Helium Detector
- VOC, Oxygen Carbon Dioxide, Methane Meters (if required)
- Digital Pressure Gauge
- Micro-manometer
- Concrete/Acrylic Concrete Filler
- Water

- Hand Broom/Dust Pan
- Bucket
- Paper Towels