



**QUALITY ASSURANCE PROJECT PLAN and SAMPLING AND ANALYSIS PLAN
FORMER LOBELL REFINERY EXPANDED INVESTIGATION AND UST REMOVAL PROJECT
CASPER, WYOMING**

Former Lobell Refinery Orphan Site Remediation Program (OSRP) File 57.004

Submitted to:

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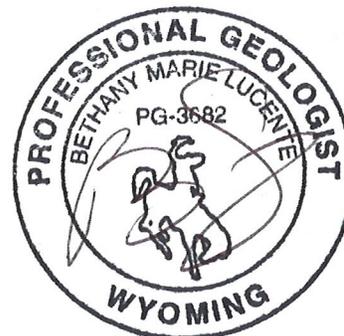
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INTRODUCTION

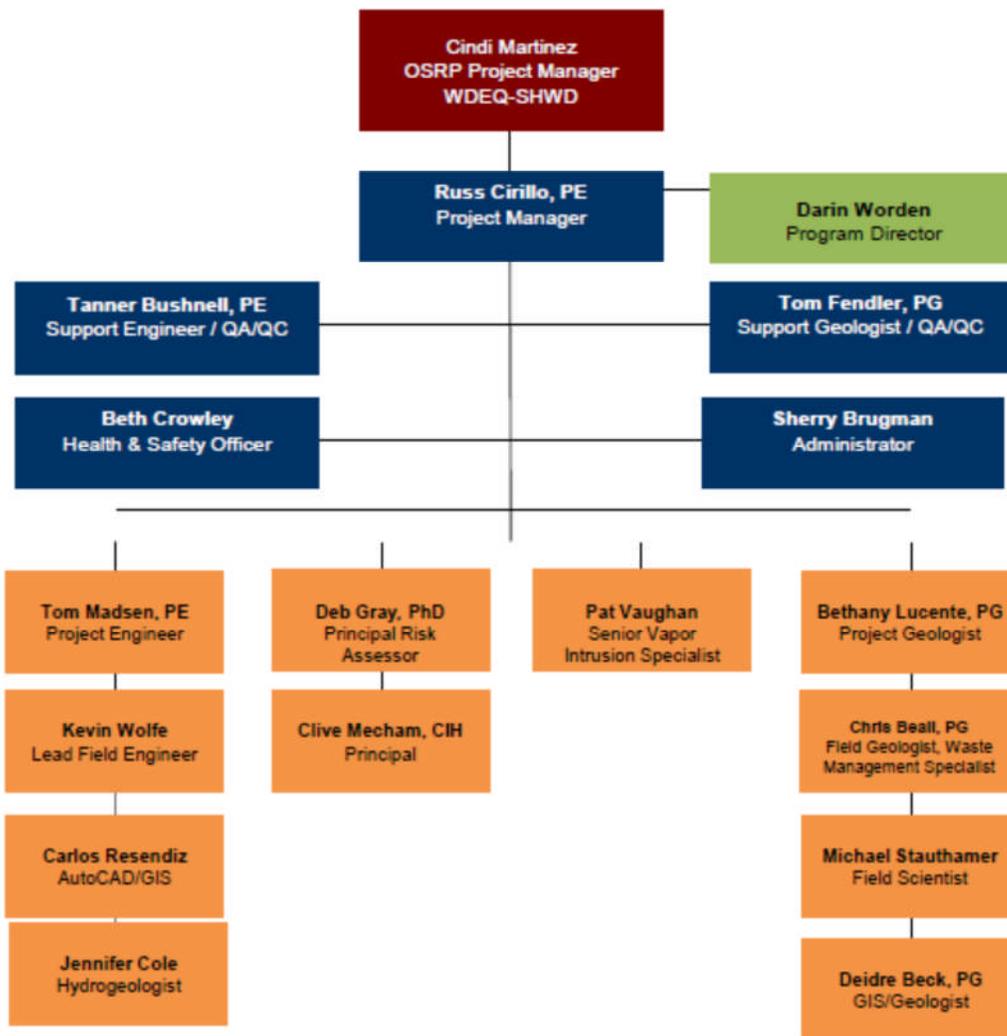
The purpose of this document is to present the Quality Assurance Project Plan (QAPP) and the Sampling and Analysis Plan (SAP), including the Data Quality Objectives (DQOs), for the Wyoming Department of Environmental Quality (WDEQ), Solid and Hazardous Waste Division Orphan Site Program for the Former Lobell Refinery (the Site) Expanded Investigation and Underground Storage Tank (UST) Removal Project. This document was prepared by Stantec Consulting Services Inc. (Stantec) to describe sample collection and analyses and quality assurance quality control (QA/QC) procedures for soil, soil gas and groundwater sampling associated with the Former Lobell Refinery Expanded Investigation (the Project) site (Figure 1). The proposed scope of work includes installation and sampling of groundwater monitoring wells, soil gas probes and passive soil-gas modules (Figure 2). Indoor air samples and sampling of existing wells is also included in the scope of work for the Project.

QUALITY ASSURANCE PROJECT PLAN (QAPP)

1.0 PROJECT ORGANIZATION

The following section describes Stantec’s key staff roles and responsibilities directly applicable to the Lobell Project. An organizational chart providing Stantec’s project team is also presented below.

**FIGURE 3
 FORMER LOBELL REFINERY EXPANDED INVESTIGATION AND UST
 REMOVAL PROJECT
 ORGANIZATIONAL CHART**



1.1 Stantec Quality Assurance

The quality assurance (QA) manager has the authority to objectively review projects and identify problems, and use the appropriate corporate resources to resolve any quality related problems. The quality assurance manager for this project is Tanner Bushnell, PE, located in Salt Lake City, UT. The QA manager is responsible for the following:

- Implementing the QA Program;
- Reviewing QA section in project reports as applicable;
- Revising and reviewing the QAPP, as necessary;
- Identifying, initiating, reviewing and following up on any response actions if necessary;
- Consulting with Stantec project team, as needed, on appropriate QA/QC measures and corrective actions;
- Arranging audits on project activities, if necessary; and
- Providing written reports on QA/QC activity, if necessary.

1.2 Stantec Project Manger

The project manager for the Project is Russ Cirillo, PE located in Denver, CO. Russ will be responsible for coordinating a comprehensive site visit, tracking work assignments, reviewing work plans and maintaining communication with the WDEQ. He will also coordinate laboratory sample shipments and communication on laboratory receipt, as well as collecting field data to maintain project files. Russ has the support of the team shown in the organizational chart to collaborate and maintain the pertinent project data.

1.3 Project Laboratory Organization and Responsibilities

For this Project, Stantec will use ChemSolutions, located in Centennial, Colorado, for laboratory analyses. ChemSolutions is a WDEQ pre-qualified laboratory, and has American Association for Laboratory Accreditation (A2LA). ChemSolutions' laboratory custody, analytical, and quality control protocols are summarized below in the sampling and analysis (SAP) plan located in section 9.0

2.0 BACKGROUND AND SITE HISTORY

The following sections contain background information that was adapted from Tetra Tech historical reports for the Project.

The former Lobell Refinery area has been occupied by a number of different businesses and companies since the late 1800s. Pennsylvania Oil and Gas Company built and operated a petroleum refinery on the site from 1895 to 1903. The refinery was then purchased by Lobell, who operated it from 1903 until 1911. Sanborn Maps from that period indicated several tanks were located at the site extending across Wolcott Street.

Historical documents indicate there was an open oil storage pit located somewhere on the site, which was later filled in by the City of Casper because it was deemed a public health hazard.

Historical records also show that from 1911 to present time, the former Lobell Refinery site was owned and/or occupied by several different owner/operators, including but not limited to Midwest Refining Company, Stanolind Oil and Gas Company, Standard Oil Company, Chicago Northwestern Railway Company, and the Goodstein Property Trust. An electricity generation plant was once present on the northwest corner of the site, which was fueled first by coal and later by fuel oil. Northern Utilities also operated a warehouse located along the southern edge of the property.

According to historical records, a railroad siding was located along the north side of Collins Drive until it was removed between 1961 and 1967. The railroad track located along the north edge of the Wolcott Street Site is now a pathway as part of the “Rails to Trails” initiative to convert former railways into recreation areas.

Several site assessments and limited environmental site investigations have been performed since 1995 to characterize the contamination in the area of the former Lobell Refinery, which also incorporates the Wolcott Street Site. The environmental studies conducted at the former Lobell Refinery have included projects completed under the direction of WDEQ, United States Environmental Protection Agency (USEPA), and private entities. These investigations are briefly summarized below.

- In 1995, two railroad tank car underground storage tanks beneath the northwest portion of the Site were emptied, cleaned and abandoned in place under the Wyoming Underground Storage Tank Program, Facility No. 4176.
- In 1997, URS on behalf of the USEPA investigated reports of seeps of viscous liquids rising to the ground surface through cracks in the sidewalks at the Site. Eight polynuclear aromatic hydrocarbon (PAH) compounds were detected at the Site. A report from URS Operating Services, Inc. (Denver, CO), entitled, “November 1997: *Analytical Results Report for Focused Site Inspection, J.H. Lobell Refinery Site, Casper, Wyoming, CERCLIS ID# WY0001654391,*” was submitted to EPA Region VIII under Contract No. 68-W5-0031.
- In 2003, a limited environmental site assessment was conducted by Inberg Miller Engineers (IME). The report entitled, “*Subsurface Exploration Service, 421 South Center Street Property, Casper Wyoming,*” reported the presence of total petroleum hydrocarbon diesel range organics (TPH-DRO) in both shallow and deep soils in the eastern portions of the Site.

Former Lobell Refinery Expanded Investigation and UST Removal Project Quality Assurance Project Plan and Sampling and Analysis Plan



- In 2004, an additional site assessment was performed by Gene R. George & Associates, Inc. (GRGA). Activities included subsurface soil borings. Results confirmed the occurrence of weathered TPH-DRO in concentrations above the Wyoming DEQ Voluntary Remediation Program soil cleanup levels (2,410 mg/kg to 8,200 mg/kg) in the soil. The source of the weathered hydrocarbons was attributed to the former refinery operations from over 100 years ago. Concentrations of tetrachloroethylene (PCE) and trichloroethylene (TCE) were also found in groundwater at the site, with maximum levels of 340 µg/L and 16 µg/L, respectively.
- From 2010 to 2011, limited site characterization studies were conducted at the Site by Tetra Tech and included subsurface soil sampling, direct push borings, test pit sampling, and assessment of the surface and subsurface acidic hydrocarbon seep material at Wolcott Street. Data collected was used to assess the vertical distribution of contamination in proximity to potential source areas.
- From July 30, 2012, through September 19, 2012 Tetra Tech performed acid sludge excavation and remediation, followed by restoration of the area. Approximately 9,300 square feet of asphalt/concrete road surface and 668 square feet of sidewalk were removed from the remedial area to expose the acidic waste/soil for excavation and subsequent treatment by neutralization. An estimated total of 835 cubic yards of acidic waste/soil and native soil was excavated from the remedial area. Approximately 805 cubic yards of acidic waste/soil was successfully pH neutralized on-site and transported to the Casper Regional Landfill for final disposal as petroleum contaminated soil. In the remedial areas excavated, the removal of the source of acidic hydrocarbon seep material effectively eliminated the surface exposure pathway and the subsequent potential public exposure to surface seeps.
- After acid sludge remediation, residual impacts of PCE remained in the groundwater monitoring wells. Additional investigation of tanks indicated that six small USTs are present in an area directly north and adjacent to the Casper Dry Cleaners.

3.0 PROJECT TASK DESCRIPTION

Tasks associated with the Project include a comprehensive site visit, additional site assessment/subsurface investigation, and cleaning and removal of USTs. Removing the USTs will reduce the source mass in soil and groundwater thereby reducing risk to human health and/or the environment. Project closeout tasks will be completed once site closure requirements are met.

Tasks include:

- Groundwater monitoring well installation;
- Soil and groundwater sample collection;
- Soil gas well installation and sampling
- Sub slab soil gas probe installation and sampling;
- Indoor and outdoor air sampling;
- Sample preservation and handling;
- Chain-of-custody control;
- Analytical procedures;
- Data validation and evaluation; and
- Corrective actions.

Additional details of the tasks to be completed are presented in Section 6.0 of the SAP.

3.1 Site Records

Stantec's project manager will maintain site information in the project file. These files will contain project details such as maps and descriptions, meeting notes, telephone conversations, electronic mail, interviews, records of previous work done, permits if needed and any photographs of the site. These files will be maintained electronically in the Stantec office. Documentation generated for the project, including electronic copies of reports and other project-critical documents (communication, notes, etc.) will be transmitted to the WDEQ.

3.2 Field Records

Field records will be recorded in a field notebook or on project specific data sheets with numbered pages, and will contain equipment maintenance and calibration logs, chain of custody forms, well construction logs and notes, field procedures, and health and safety plans. Field sketches will also be included to document observations, sampling and drilling points, sampling details (volumes purged, methods used, equipment decontamination, etc...) and weather conditions.

4.0 DATA QUALITY OBJECTIVES (DQOS)

Data will be collected during the Project to create the appropriate baseline information needed for the work to be completed. The DQOs define the level of quality to ensure that the type, quantity and quality of environmental data used in decision making are appropriate for the intended purpose. The DQO process is intended to:

- Summarize project specific requirements;
- Clarify the appropriate data to collect, both physical and chemical;
- Identify the appropriate constituents of concern as well as the appropriate detection limits; and
- Define levels of errors that will be acceptable to support the objectives of the project scope.

Quality assurance criteria used to evaluate data quality are described below. The principal indicators noted below are precision, bias, accuracy, representativeness, comparability, completeness and sensitivity.

4.1 Precision

Precision describes the reproducibility of measurements under a given set of conditions. For duplicate or replicate measurements, precision is expressed as the relative range of the two values.

$$RR = 100 \frac{|A - B|}{([A + B] / 2)}$$

Where A and B are the reported concentrations for sample replicate or duplicate analysis. The precision of laboratory analyses will be assessed by comparing the analytical results between matrix spike/matrix spike duplicate (MS/MSD) for inorganic and organic analyses. The QA objectives of the project relative to data precision are the same as the laboratory's statistically derived control limits.

4.2 Bias

Bias is a systematic or persistent distortion of a measurement process that causes error in one direction. Standard field sampling procedures, and appropriate sample preparation and analytical methods will be used to minimize bias. Submittal of trip, equipment, and field blanks for laboratory analysis and laboratory control samples will aid in identifying bias resulting from sampling design, calibration errors, response factor shifts, matrix for interferences, and/or chronic laboratory contamination. When possible, bias assessments should be based on analysis of spiked samples rather than reference materials so that the effect of the matrix on recovery is incorporated into the assessment.

4.3 Accuracy

Accuracy is the closeness of agreement between an observed value and an accepted reference value. Accuracy will be monitored with the use of field blanks. At least one field blank will be collected for each sampling event with a minimum of 1 per 20 samples. The QA objectives for data accuracy are the same as the laboratory's statistically derived control limits for organics and method limits for metals.

4.4 Representativeness

Representativeness is a qualitative expression of the degree to which sample data represent the characteristics of a population, a sampling point, or an environmental condition. Representativeness will be maximized by selecting appropriate sampling locations and numbers of samples, and utilizing appropriate analytical methods. In addition, field sampling procedures will be followed to maximize representativeness, including decontamination of sampling equipment between locations to minimize cross-contamination, purging wells prior to sampling, and well development to remove fines/sediment.

4.5 Comparability

Comparability is a qualitative measure of the confidence that one data set may be compared with another. For similar samples and sample conditions, data from one sample set should be comparable with another. Comparability of data is achieved through the use of standardized methods for sample collection and analysis, and the use of standardized units of measure. Evaluation of comparability is dependent on the other quality assurance criteria (e.g. precision and representativeness).

4.6 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. Completeness will be maximized by following the procedures summarized above to obtain valid (precise, unbiased, accurate, representative, and comparable) data. The completeness is calculated using the following equation:

$$\text{Completeness} = \frac{\text{Valid Data Obtained}}{\text{Total Data Obtained}} \times 100$$

4.7 Sensitivity

Sensitivity reflects the capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest. All environmental samples will be submitted to ChemSolutions in Centennial, Colorado, certified by the A2LA.

SAMPLING AND ANALYSIS PLAN

5.0 PLAN PURPOSE

The purpose of the Project is to conduct a comprehensive site visit, an additional site assessment/subsurface investigation including vapor evaluations indoors and sub slab, and clean and remove the historic USTs. Removing the USTs will eliminate one of the potential sources in soil and groundwater, thereby reducing risk to human health and/or the environment. Soil and groundwater sampling Cleanup Levels are listed in Table 1 and are referenced in WDEQ Fact Sheets 12 and 13.

This SAP addresses the following sample collection and analyses procedures:

- Soil and groundwater sample collection;
- Soil gas sampling (shallow and sub-slab soil gas);
- Indoor and outdoor air sampling;
- Sample preservation and handling;
- Chain-of-custody control;
- Analytical procedures, including laboratory;
- QA/QC protocols for field and laboratory work;
- Data validation and evaluation; and
- Corrective actions.

The objective of additional site assessment is to provide data regarding the nature and extent of impacts, including the types, locations, concentrations, and extent of identified chlorinated solvent impacts, as well as evaluating which environmental media are affected. Data collected during the investigation will include site-specific hydrogeology and subsurface characteristics, including groundwater flow direction, hydraulic gradient, soil types and lithology.

6.0 SAMPLE COLLECTION

Field QC during sample collection will be maintained by employing standard operating procedures, using appropriate sample containers and preservation, and by collecting and analyzing field QC samples. The quality of field measurements will be ensured by proper calibration and operation of field equipment.

- Soil Samples will be collected from new monitoring wells that will be installed in the fall of 2013 (Figure 2).
- Groundwater samples will then be collected from the new monitoring wells, as well as the 11 existing monitoring wells.
- Soil gas samples will be collected from shallow soil gas wells; passive soil gas modules and sub slab gas probes;
- Indoor samples will be collected from designated locations and outdoor air will be sampled in two locations.

Proposed sample locations are depicted on Figure 2. Procedures applicable to the Project are described below.

6.1 Soil Screening and Sample Collection

Soil samples will be collected in advance of the drill bit or auger with a split spoon sampler wherever possible. Soil screening samples will be collected every five feet where possible, at zones of obvious impacts, and at the water table. Soil Samples will also be collected from the soil borings created when installing the shallow soil gas monitoring wells and submitted for physical analysis.

Soil samples from the boreholes will be field screened for relative volatile organic compounds (VOC) using a photoionization detector (PID) equipped with a lamp that is at least 10.6 electron-volts (eV) (sufficient to ionize and detect aromatic hydrocarbons). In order for the PID to be sensitive enough to measure a specific range of VOCs, the PIDs eV lamp needs to be higher than the eV of the compound of interest. PCE and its degradation byproducts have an eV range below 10.0. Prior to use, the PID will be calibrated according to manufacturer's instructions, at a minimum on a daily basis. The field screening process will include placing the soil sample of interest into a Ziploc™ type plastic bag. The soil sample will then be allowed to equilibrate with the interior atmosphere of the bag, generally around five minutes, before the headspace of the bag is screened with the PID.

The soil will also be classified and described in the field according to the Unified Soil Classification System (USCS). The soil descriptions will also include visual observations including soil color, moisture content, and visual signs of contamination. Soil sampling intervals, field screening results, and USCS classifications will be recorded on a borehole log form for each borehole. Soil samples selected for laboratory analysis will be packed into clean, laboratory-supplied 4-ounce glass sample containers, labeled, immediately placed in an ice-filled insulated cooler, and shipped under chain-of custody

protocol to the project laboratory. The most heavily impacted soil sample collected (based on field screening) from each boring will be submitted for laboratory analysis.

Stantec samplers will follow standard operating procedures for describing soils, field screening soil samples, handling and collecting soil samples, and labeling and documenting soil samples. To ensure that representative soil samples are collected, Stantec samplers will be trained in sampling and screening procedures and equipment prior to performing the work.

Soil samples collected from the installation of the soil gas wells will be analyzed for physical parameters (e.g., bulk dry density, total and water filled porosity, moisture content, etc.). Assuming that the lithology of each borehole is relatively uniform, a sample will be collected from approximately three to four feet below ground surface and placed in a clean jar supplied by the lab. If lithology varies significantly in the borehole, samples will be collected for each soil type. The data will be used to derive site specific inputs to the Johnson and Ettinger model, if needed.

6.2 Groundwater Monitoring and Sample Collection

Depth to static water levels and thickness of immiscible layers (if present) will be measured prior to groundwater monitoring, well purging and sampling. Groundwater samples from newly installed wells will be collected after the wells have been developed by removing water until the turbidity is visibly low or after at least five to ten casing volumes from each well have been removed. Development of the well should not occur for at least 24 hours after well completion.

Groundwater samples will be collected using a bailer to remove a minimum of three well volumes (existing wells), at least 24 hours after the development of the well. Groundwater will be sampled when the well has recovered to at least 80% of its original water level. Field measurements will be collected including dissolved oxygen (DO), oxidation reduction potential (ORP), pH, specific conductance, and temperature using a clean and calibrated YSI 556 multi-parameter meter. Ideally, stable water quality parameters are achieved (i.e. temperature, specific conductance, and oxidation reduction potential vary by less than 10% and pH varies by less than 0.1) during measurement of field parameters. If stable parameters are not achieved, field measurement equipment will be verified to be operating correctly and any necessary corrections made. If no equipment issues are identified, the sampler will contact the project manager to ensure that the samples will meet the objectives of the project.

Laboratory-supplied and preserved containers will be filled at each sampling location. The sample containers will be sealed, labeled, placed in an ice-filled insulated cooler, and shipped under chain-of-custody protocol to the project laboratory for analysis. Groundwater purging and sampling information will be recorded on groundwater sampling forms.

Stantec samplers will follow standard operating procedures for measuring depth to water, detecting and measuring free product thicknesses, purging or low-flow sampling of monitoring wells, handling and collecting groundwater samples, making field

measurements, and labeling and documenting groundwater samples. Stantec samplers will be trained in sampling techniques and making field measurements prior to performing the work.

6.3 Soil Gas Sample Collection

Evaluation of the nature and extent of soil gas impacts and potential for vapor intrusion at existing and possible future occupied buildings within the study area boundaries will include resampling of 11 existing soil gas wells and installation and sampling of new shallow soil gas probes (approximately 5 feet below ground surface); sub-slab soil gas probes; and, placement of passive soil gas modules within two public right-of-ways. Due to the time that has elapsed, it is necessary to resample existing soil gas wells to assess temporal changes which may have occurred since 2010. Details of the proposed soil gas sampling are described in Figure 2 and below.

6.3.1 Soil Gas and Sub-Slab Probe Sampling

All existing soil gas probes (11 probes) will be resampled to assess temporal and spatial changes which may have occurred since 2010. Semi-permanent soil gas monitoring wells will be installed to further define the extent of soil gas impacts. At least one soil sample from each new boring will be submitted to the Project Laboratory for physical analysis (e.g., bulk dry density, total and water filled porosity). Data will be used to derive site specific inputs to the Johnson & Ettinger model, if needed.

Sub-slab soil gas probes are proposed for locations depicted on the attached Figure 2. Probes will be installed as described in the Project Investigation Work Plan. Because sub-slab probes are prone to ambient air leakage around the surface seal, additional time is required for the surface seal to adequately cure and subsurface conditions to equilibrate. In addition, non-VOC caulking may also be used to further stabilize tubing at the surface seal. Sub-slab soil gas samples will not be collected for at least 2-hours after probe installation.

Prior to collecting soil gas samples, the samplers will inspect to verify that the Summa™ canister is in good condition and that the canister is properly sealed. The canister will be verified as closed prior to removing any fittings required to connect the flow restricting device. Receipt vacuum measurements will be used to calculate $\Delta P_{\text{lab-field}}$ to determine evidence of canister leakage during shipment from the laboratory. If the receipt vacuum is less than 25-inch Hg, the canister will not be used.

Samples are collected in one-liter stainless steel, passivated batch-certified canisters at a flow rate of less than 200 ml/min. Procedures for soil gas sampling are provided in the SOP provided in Appendix A.

6.3.2 Passive Soil Gas Modules

In order to cost-effectively evaluate the possible transport of soil gas within utility backfill materials and to limit disruption of traffic along public right-of-ways, Stantec will deploy approximately passive soil gas modules (e.g. AGI Universal Samplers) spaced on

approximately 50-foot centers near identified utility lines within E. Collins Drive and E. 5th Street. Modules will be installed to a depth of approximately three feet below the surface using a portable rotary drill hammer fitted with a one-inch diameter drill bit. After attaching a retrieval string, the module is inserted into the hole, which then is sealed with a cork. Modules will remain in-place for approximately 5 to 10 days before retrieval and analysis using US EPA Method 8260B at the Applied Geochemical Imaging, LLC laboratory in Elkton Maryland. Sample results are expressed on a mass basis and as such the results cannot be compared to concentration-based vapor intrusion screening levels. However, analysis will allow development of a mass gradient to identify possible routes of soil gas transport.

6.3.3 Indoor/Outdoor Air Sampling

6.3.3.1 Building Survey

A baseline indoor air quality survey is required to identify chemicals that may skew or complicate the interpretation of the indoor air sampling results and to prepare the building for the sampling process by temporarily removing potential background vapor sources. Prior to sample collection, representatives from Stantec and the WDEQ will meet with the owner and/or tenant representative and conduct a pre-sampling survey and walk-through of each building selected for sampling. The pre-sampling survey and walk-through are intended to identify conditions that may affect or interfere with the proposed testing. Indoor and outdoor air sampling locations will also be identified. Information from the pre-sampling survey and walk-through will be recorded on an Indoor Air Quality Building Survey form (“the Building Survey”), which will include a building chemical storage and use inventory. A copy of the Building Survey form is provided in Appendix B. A building survey will identify:

- Preliminary chemical identification obtained from product labels, chemical inventories, MSDS sheets. The location of each chemical use or storage area will be noted on a building as-built drawing, provided by the occupant or owner, or on another scaled drawing. In addition, particular use and period of use, review of disposal practices, and details about occupant behavior and location relative to the building layout will be noted. The building owner/tenant will be asked about their knowledge of historical chemical use and/or recent changes to formulations used as part of the interview process. The survey will also note whether the use will interfere with planned analytical assessment from vapor intrusion.
- Personnel, operations, and typical hours that the building is occupied.
- Building construction, slab material including depth of slab(s) or presence of post-tensioning reinforcement, localized crawl spaces and, presence and location of cracks in slab, building sumps or other possible preferential pathways for vapor intrusion. A portable photo-ionization detector (PID) with sensitivity in the parts per billion range will be used to assist identification of VOC sources or conduits.

- Information regarding the air ventilation systems, including air handler zones. Visual observations will be evaluated along with a short-form HVAC checklist (Appendix C) completed by the building engineer or other qualified person.

The building walkthroughs also will include direct measurement of the following indoor air parameters: carbon dioxide, temperature, and relative humidity. A TSI Q-Trak Model 7575 fitted with a Model 982 multi-function probe or equivalent instrument will be used to make these direct measurements which will be compared to published standards (ASHRAE) to evaluate general HVAC system performance.

Based on the chemical inventory, with permission from the owner or tenant, as appropriate, products that may contain COCs will be removed where possible from the building at least 24 hours prior to sampling and until the sampling is complete. It is preferable that the removed chemical products will be stored off-site; however, if the owner/tenant objects, these products may be stored in a sealed container outside the building (e.g., storage shed).

The results of the building survey will be provided to Site personnel and/or building occupants with specific instructions to help minimize the potential for indoor air background contamination during sampling activities.

6.3.3.2 Indoor/Outdoor Air Sampling

Indoor air samples will be collected at the Salvation Army building and the 12-24 Club building, in accordance with best industry practices; the US EPA 2002 Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils or the most current version (draft revisions are currently under comment). The number and location of samples will be evaluated at the time of the Field Reconnaissance/Building Surveys. During the indoor air sampling event, Stantec will also concurrently collect two outdoor air samples to assess possible contribution of chemicals from outdoor air into indoor air. The duration of sample collection will correspond to the normal building occupancy patterns but in no case less than eight-hours in duration.

All samples will be collected in six-liter individually-certified stainless steel passivated canisters fitted with laboratory-certified flow controllers to regulate collection rates during sampling and gauge vacuum. Due to generally very low indoor air screening levels, analysis will be performed using US EPA TO-15 in the Selective Ion Mode (SIM). Canisters will be placed 3 to 5 feet off the floor on stable chairs, boxes or stools. Details of the sampling procedures are identified in the SOP, Indoor Air Sampling, presented in Appendix D.

Indoor air and soil gas data will initially be compared to the US EPA Office of Solid Waste and Emergency Response Vapor Intrusion Screening Levels (VISL Calculator Version 3.0) and WDEQ-Specific Action levels, to assist WDEQ with evaluating the need for future actions. For concentrations detected above screening levels, the most recent version of the Johnson & Ettinger model (SG-ADV Version 3.1) may be used at WDEQ's request to evaluate potential vapor intrusion risk using site-specific information collected as described above.

6.4 Quality Control Samples

The quality of the data collected during the investigation will be evaluated during each phase of the project. Evaluation of the analytical data will include inspection of the results of QC samples. Field QC samples submitted to the laboratory will include, at a minimum:

- Trip Blanks: One per groundwater sampling event or with each analytical batch, with a minimum of 1 per 20 samples.
- Field Blanks: One for each analytical batch of groundwater samples with a minimum of 1 per 20 samples.
- Equipment Blanks (rinsate blank): One equipment blank (one time only).
- Blind Duplicates: One for each analytical batch of groundwater samples with a minimum of 1 per 20 samples.
- Field Duplicates: One for each analytical batch of groundwater samples with a minimum of 1 per 20 samples.

6.4.1 Trip Blanks

Trip blanks will be prepared by the laboratory prior to sampling and will consist of two 40-milliliter volatile organic analysis vials containing preserved reagent grade water. The bottles will be filled with no headspace and capped with a Teflon-lined cap. Trip blanks are used to evaluate container contamination during transport from and to the laboratory.

6.4.2 Field Blanks

Field blanks for water will be prepared at a representative sampling location by filling sample containers with clean deionized or distilled water. Field blanks are used to evaluate potential sample contamination due to airborne contaminants at the sampling location during sample collection, storage, and transport.

6.4.3 Equipment Blanks

Equipment blanks will be collected immediately after decontaminating non-dedicated sampling equipment or new disposable equipment by pouring clean deionized or distilled water over or pumping it through the sampling equipment, then collecting the water in appropriate sample containers. Equipment blanks are used as a qualitative measure to verify effectiveness of decontamination procedures.

6.4.4 Method Blank

For soil gas sampling, one method blank per canister batch will be collected using laboratory-supplied zero air to assess the canister cleaning procedures used by the laboratory.

6.4.5 Blind Duplicates

To ensure laboratory accuracy, two separate samples are collected in the field from the same source at the same time. The sets are labeled with different identifiers and submitted blind to the laboratory.

6.4.6 Field Duplicates

To document the precision of the sampling process, independent samples are collected as close as possible to the same point in space and time. They are two separate samples taken from the same source, stored in separate containers, and analyzed independently. Soil gas sample duplicates will be simultaneously collected using laboratory-supplied duplicate sampling tees.

6.5 Operation of Field Equipment

Field monitoring may include field screening and soil classification, immiscible layer and groundwater depth measurements, pH, ORP, DO, temperature, and specific conductance measurements. Field equipment will be calibrated on a frequency according to the manufacturer's instructions. Field equipment will be inspected before use to ensure that the equipment is working and adequate amounts of consumables (i.e., calibration standards) and spare parts are available. Between measurements, field equipment will be washed with a phosphate free detergent and rinsed with distilled water. To ensure valid measurements, Stantec personnel will be trained in the operation of the field equipment prior to taking measurements. Corrective action will be warranted if unexpected results are obtained.

6.5.1 Photoionization Detector

Relative VOC concentrations in soil headspace will be measured in the field using a portable PID equipped with a lamp that has at least a 10.6 eV measurement potential. The PID will be calibrated prior to use on a minimum daily basis using 100 parts per million (ppm) isobutylene gas. The calibration of the PID will be checked against the isobutylene standard periodically and every time drift is suspected. The calibration and measurements will be made according to manufacturer's instructions.

6.5.2 Multi-Parameter Water Meter

Measurements of pH, ORP, DO, temperature, and specific conductance of water samples will be made using a YSI 556 multi-parameter meter. Prior to use each day, the meter will be calibrated with commercially prepared 3-point pH buffer solutions, redox, and conductivity standards. The DO probe will be calibrated based on percent saturation and site elevation. The calibration of the instrument will be checked periodically and recalibrated if needed. The calibration and measurements will be made according to manufacturer's instructions.

Other field instruments such as water level indicators and free product interface probes will be operated according to manufacturer's instructions. Field measurements and other supporting data will be recorded in the field notebook or on the appropriate field data forms.

7.0 SAMPLE HANDLING AND CHAIN-OF-CUSTODY CONTROL

7.1 Sample Preservation and Handling

Samples will be collected in laboratory-prepared containers with appropriate preservatives. After collection, each sample will be sealed, labeled, and placed in an ice-filled, insulated cooler. The sample containers will be sealed in zippered plastic bags and packed in bubble wrap or other packing material to prevent breakage. Ice will be double-bagged in zippered plastic bags and placed around, among, and on top of the sample containers to maintain a sample temperature of 4 degrees Celsius (°C) or less during shipment to the laboratory. Remaining space in the cooler will be filled with non-collapsible packing material.

The completed chain-of-custody form will be placed in a zippered plastic bag inside the cooler. Tamper evident custody seals will be attached across the cooler opening. The cooler lid will be secured with packing tape by wrapping the cooler completely in at least two locations. A completed shipping label will be affixed to the top of the cooler, and the cooler will be relinquished to an overnight courier service to minimize handling time. Sampling events and sample shipping will be scheduled to optimize receipt and quick processing by the project laboratory.

Soil gas and indoor/outdoor air samples must be stored and shipped at ambient temperature to avoid condensation within the canister. Sample identification will be written on laboratory-supplied tags which are then affixed to the canister. In no case may anything be written on the canister.

7.2 Chain of Custody Control

Sample chain-of-custody protocol and documentation procedures will be followed throughout the investigation to ensure sample integrity from collection to analysis. For all samples, the chain-of-custody will be maintained during sample collection, transfer of samples between personnel, and shipment to the laboratory. Chain-of-custody forms will be used to document and track samples submitted for laboratory analysis.

Field documentation and chain-of-custody procedures will be as follows:

- Field sampling personnel will record sample collection details in the field log book and appropriate data forms. Sample collection details will include sample designation, date and time of collection, sampler's name, sample description, environmental medium (water, soil, air, waste), sample location, and depth.

- All sample containers will include labels that are filled out with indelible ink. Labels will include sample designation, date and time of collection, preservation (if applicable), sampler's name, and required laboratory analyses.
- The sampler will be responsible for custody of the samples until they are transferred or shipped to the laboratory.
- All samples will be accompanied by a completed chain-of-custody form with attached duplicate copies. The sampler will keep one copy of the completed chain-of-custody form. If transfer of custody is required prior to shipment, the parties relinquishing and receiving the samples will sign, date, and include the time of transfer on the chain-of-custody form.
- Custody during shipping will be maintained by shipping samples in secure coolers sealed with packing tape. Each cooler will contain a separate signed chain-of-custody form identifying the contents.

8.0 ANALYTICAL PROCEDURES

For this Project, Stantec will use ChemSolutions, located in Centennial, Colorado, for laboratory analyses. ChemSolutions is a WDEQ pre-qualified laboratory, and has A2LA certification. ChemSolutions' laboratory custody, analytical, and quality control protocols are summarized below.

8.1 Custody Procedures

ChemSolutions will follow standardized laboratory custody procedures to ensure that samples are received and properly logged into the laboratory, and that all associated documentation, including chain-of-custody forms, is complete and consistent with the samples received. Complete documentation of all sample storage will be maintained in order to preserve the integrity of the samples. Stantec will be notified of any inconsistencies between sample bottles and chain of custody information.

8.2 Analytical Methods

Laboratory analyses will be performed in accordance with WDEQ requirements. The specific analyses performed on each sample will depend on the type of fuel released (gasoline, diesel, used oil, etc.), and the data requirements for remediation system design. This section identifies the WDEQ-required analytical methods for specific analyses.

Analytical methods for soil and groundwater samples include:

- Volatile organic compounds including benzene, toluene, ethyl benzene, and total xylene (BTEX) using US EPA Method 8260B
- Semi volatile organic compounds using US EPA Method 8270C
- Total RCRA Metals using US EPA methods 6010/7470/7471
- Gasoline-range total petroleum hydrocarbons (TPH-GRO) and TPH-DRO using US EPA Method 8015B

Analytical methods for soil gas include:

- Volatile organic compounds using EPA Method TO-15 modified GC/MS Full Scan for soil gas; and,
- Fixed gases (O₂, CO₂, CH₄, N₂ and Helium) using ASTM D-1946. Note: since helium is routinely used as a carrier gas by laboratories, helium analysis must be specified on the chain-of-custody.

The analytical method for indoor and outdoor air samples will be:

- Volatile organic compounds using EPA Method TO-15 Selective Ion Mode (SIM).

8.3 Practical Quantitation Limits

The Practical Quantitation Limits (PQLs) are the routinely reported lower limits of quantitation that take into account day-to-day fluctuations in instrument sensitivity as well as other factors. These PQLs are the levels to which the laboratory routinely reports results to minimize false positive or false negative results. The PQL is normally two to ten times the method detection limit (MDL). PQLs for the Project shall be the minimum achievable for the specified analytical method. Laboratory PQLs will be compared to site-specific action levels to ensure that concentrations equal to or less than the action level can be detected.

8.4 Quality Control Procedures

ChemSolutions has A2LA certification, and is on the WDEQ Storage Tank Program list of pre-qualified laboratories. ChemSolutions laboratory quality control procedures are summarized in Appendix E.

8.5 Calibration Procedures and Frequency

All laboratory equipment and instruments will be operated, maintained and calibrated by trained individuals according to the manufacturer's guidelines and recommendations, as well as to criteria set forth in the applicable analytical methodology. Documentation of calibration information will be maintained by ChemSolutions, see Appendix E.

9.0 DATA VALIDATION AND EVALUATION

Additional assessment data will be compiled and used to evaluate environmental impacts that may have occurred during historical operations at the Project sites. Tables will be prepared to include sample identification, date collected, concentrations of detected analytes, and practical quantitation limits for analytes not detected. Data evaluation will provide information regarding the nature and extent of contamination, including the types, locations, concentrations, and distribution of contaminants and affected media. Data collected will include site-specific hydrogeology and subsurface characteristics, including groundwater flow direction, hydraulic gradient, soil types, and stratigraphy.

9.1 Field Data

Data will be qualitatively checked for consistency with previous monitoring and sampling events. Survey data will be visually verified for relative topography. Calculations such as groundwater elevations will be verified. Groundwater elevation maps will be sketched in the field for reasonableness with respect to previous data and topography. References to maps or photographs may also be recorded.

9.2 Laboratory Data

Third-party data validation will be performed by Diane Short and Associates. The integrity of the analytical data will be validated using the results of analysis of samples such as field QC samples, method blanks, laboratory control samples, etc. Other validation measures of the data include a check of received-cooler temperatures, holding times, surrogate recoveries, detection limits, sample bias, and laboratory QA/QC samples. Trip blanks, field blanks, and equipment blanks will be used to 1) qualitatively assess if procedures are adequate for QC, and 2) to initiate corrective action for sample handling procedures if blanks indicate the presence of contamination.

10.0 CORRECTIVE ACTIONS

10.1 Field Programs

Field staff will be responsible for documenting and reporting all suspected deficiencies in data quality. The deficiencies will be documented in the field notebook and reported to the Stantec Project Manager. Typical field procedures to correct problems may include:

- Repeating the measurements
- Adjusting the field instruments
- Checking and replacing or recharging batteries
- Recalibrating field instruments
- Replacing probes or field meters
- Stopping work

10.2 Laboratory Analyses

Failure to meet established analytical controls prompts corrective action. In general, corrective action may take several forms and may involve a review of the calculations, a check of the instrument maintenance and operation, a review of analytical technique and methodology, and reanalysis of quality control and field samples. If a potential problem develops that cannot be solved directly by the responsible laboratory personnel, the Stantec project manager must be contacted immediately.

11.0 REFERENCES

Wyoming Department of Environmental Quality (WDEQ), 2010. *Semi-Annual Report, Former Lobell Refinery, WDEQ Orphan Site # 57.004, Casper, Wyoming*. Prepared by Tetra Tech. Prepared for Wyoming Department of Environmental Quality Solid and Hazardous Waste Division, Cheyenne, Wyoming. November 24, 2010. Available at: http://deq.state.wy.us/volremedi/downloads/Orphan%20Site%20Downloads/Lobell_OS/Former_Lobell_Refinery_Semi_Annual_Report_2010.pdf

TABLE

Combined Cleanup Level Table

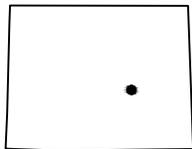
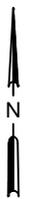
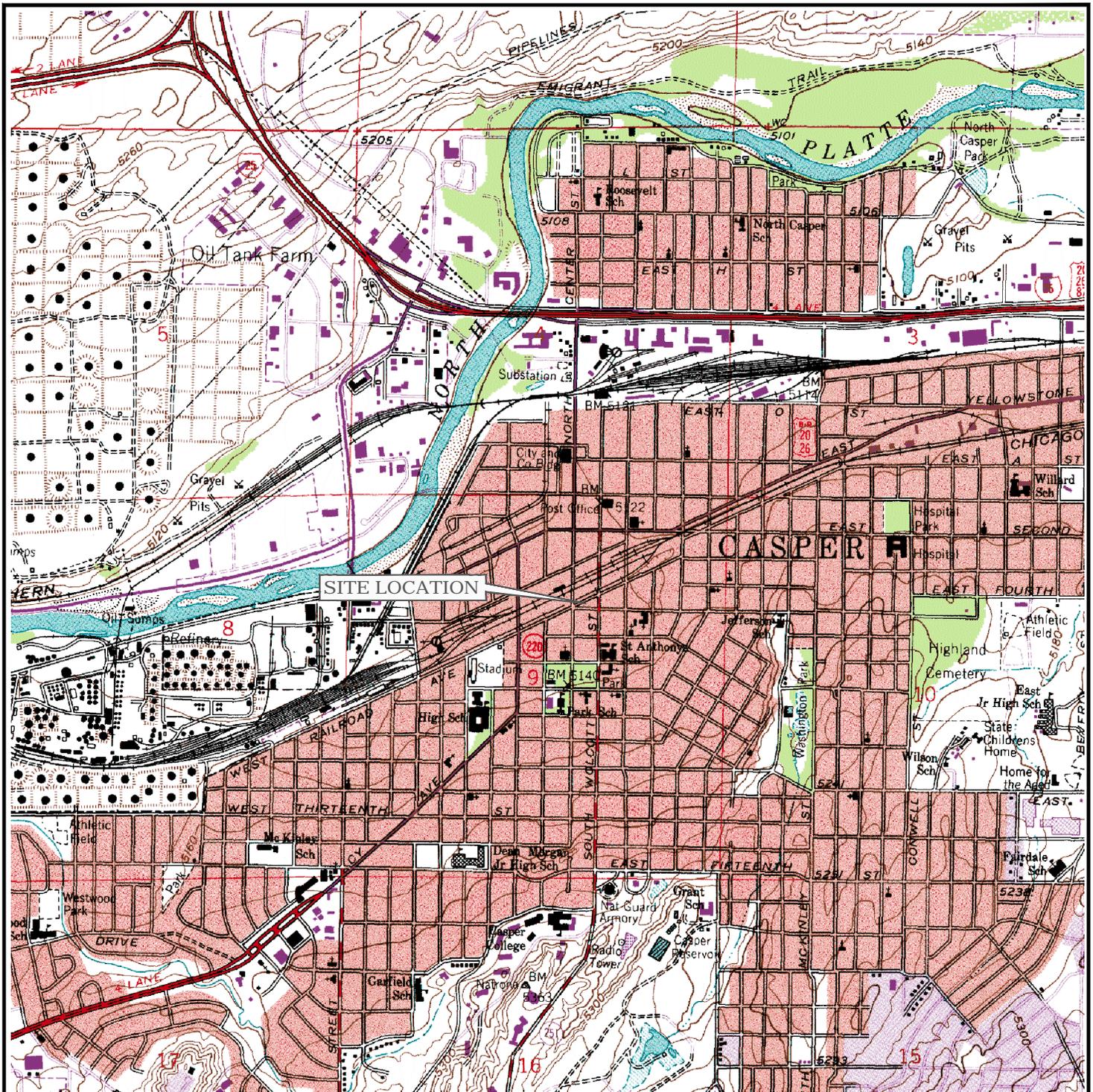
Effective June 30, 2009

CAS No.	Contaminant	Migration to Groundwater ^a (mg/kg)	Water Cleanup Levels (ug/L)	Residential Air (µg/m ³)	Industrial Air (µg/m ³)	Sub-Slab Vapor ^b (µg/m ³)
	Volatile Organics Compounds (VOCs)					
75-35-4	1,1-Dichloroethylene	1.83E+00	7.00E+00	2.10E+02	8.80E+02	2.10E+04
156-59-2	1,2-Dichloroethylene (cis)	1.75E-02	7.00E+01	NE	NE	NE
156-60-5	1,2-Dichloroethylene (trans)	2.86E-02	1.00E+02	6.30E+01	2.60E+02	6.30E+03
127-18-4	Tetrachloroethylene (PCE)	2.10E-03	5.00E+00	9.40E+00	4.70E+01	9.40E+02
79-01-6	Trichloroethylene (TCE)	2.00E-03	5.00E+00	4.30E-01	3.00E+00	4.30E+01
75-01-4	Vinyl chloride	6.30E-04	2.00E+00	1.60E-01	2.80E+00	1.60E+01

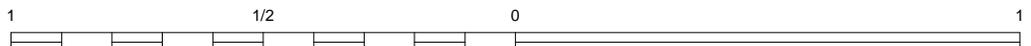
- a Migration to groundwater levels are calculated by WDEQ/VRP effective October 2013.
- b Sub-slab vapor cleanup level based on residential air cleanup level and an attenuation factor of 0.01
- c. United States Environmental Protection Agency Regions 3, 6, and 9 (per information available on the website on September 24, 2013) contaminants at Superfund Sites.
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm



FIGURES



WYOMING



SCALE IN MILE



SCALE IN FEET

REFERENCE: USGS 7.5 MINUTE QUADRANGLE; CASPER, WYOMING



Stantec

3995 SOUTH 700 EAST, SUITE 300
SALT LAKE CITY, UTAH
PHONE: (801) 261-0090 FAX: (801) 266-1671

FOR:

WY DEQ
E COLLINS DR
CASPER, WYOMING

JOB NUMBER:
212280100

DRAWN BY:
ARA

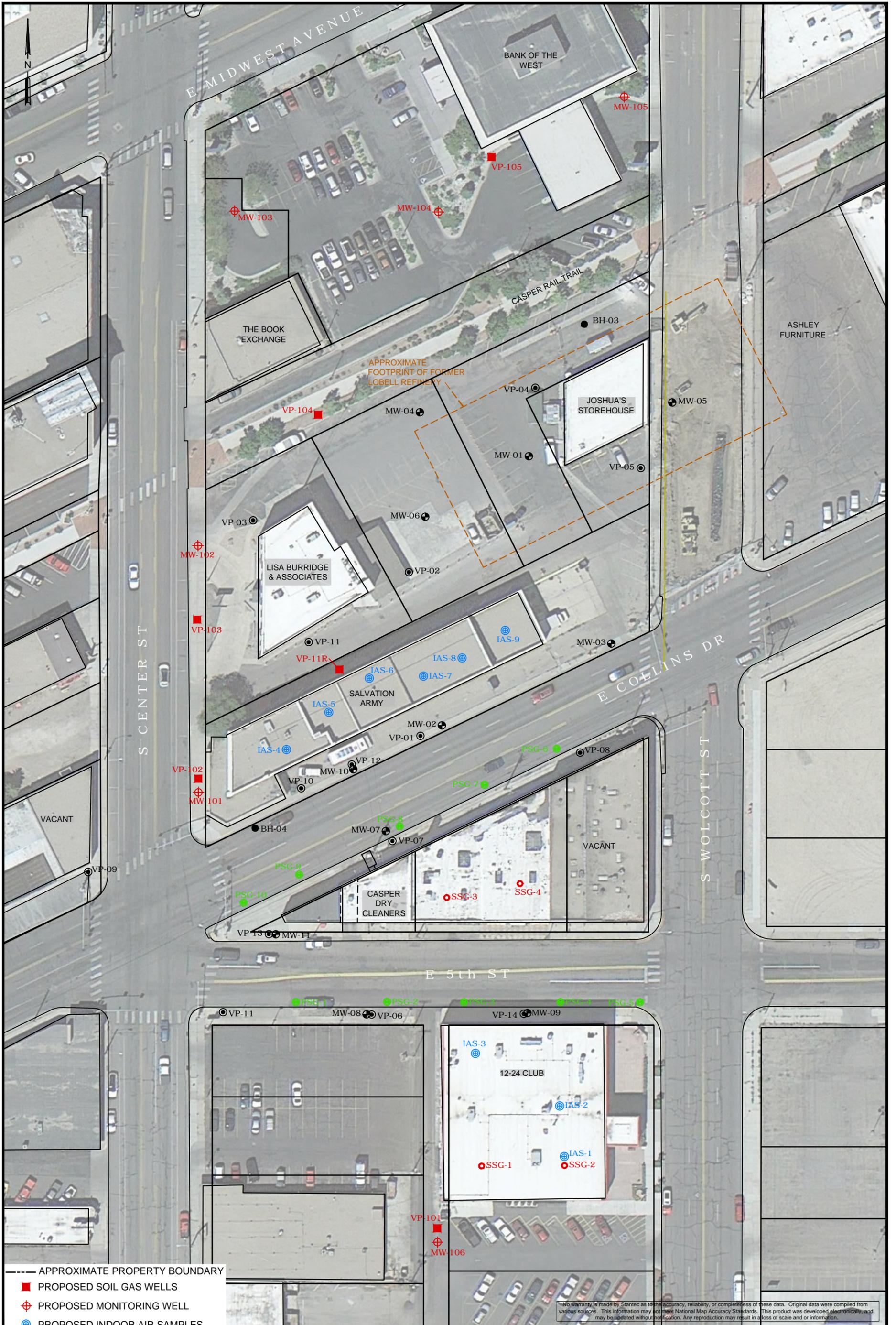
CHECKED BY:
D. WORDEN

APPROVED BY:
RJC

FIGURE:

1

DATE:
8/19/13



- - - - APPROXIMATE PROPERTY BOUNDARY
 ■ PROPOSED SOIL GAS WELLS
 ⊕ PROPOSED MONITORING WELL
 ⊕ PROPOSED INDOOR AIR SAMPLES
 ● PROPOSED PASSIVE SOIL GAS MODULES
 ● PROPOSED SUB-SLAB SOIL GAS PROBES

0 60 120

APPROXIMATE SCALE IN FEET

No warranty is made by Stantec as to the accuracy, reliability, or completeness of these data. Original data were compiled from various sources. This information may not meet National Map Accuracy Standards. This product was developed electronically, and may be updated without notification. Any reproduction may result in a loss of scale and/or information.

 3995 SOUTH 700 EAST, SUITE 300 SALT LAKE CITY, UTAH PHONE: (801) 261-0090 FAX: (801) 266-1671	FOR:		WY DEQ E COLLINS DR CASPER, WYOMING		SITE MAP WITH PROPOSED WELL LOCATIONS	FIGURE: 2			
	JOB NUMBER:	212205045	DRAWN BY:	ARA			CHECKED BY:	D. WORDEN	APPROVED BY:



APPENDIX A



1.0 PURPOSE & APPLICABILITY

The purpose of this document is to define the standard operating procedure (SOP) for the installation and sampling of sub-slab and shallow soil vapor points. For purposes of this SOP, the term shallow soil vapor refers to soil vapor present at approximately five feet below the ground surface. The ultimate goal of the installation and sampling program is to obtain samples that meet acceptable standards of accuracy, precision, comparability, representativeness and completeness. All steps that could affect tracking, documentation, or integrity of samples have been explained in sufficient detail to allow different sampling personnel to collect samples that are equally reliable and consistent.

This procedure provides descriptions of equipment, field procedures, sample containers, decontamination, documentation, storage, holding times, and field QA/QC procedures necessary to collect sub-slab vapor and soil gas samples from vapor points.

This procedure may apply to all sub-slab and soil vapor vapor point sampling by Stantec personnel or their subcontractors.

While the SOP is intended to be strictly followed, it must be recognized that field conditions may force some modifications to the SOP. Any modification to the procedure shall be approved by the Project Manager or Task Leader in advance. Where SOP modification is planned sufficiently in advance, regulatory agency concurrence will be sought prior to conducting the specific activity. When direct contact with regulatory agency staff is not possible, or unscheduled delays will result, such as during field activities, regulatory agency will be notified of deviations from the SOPs, in writing, as soon as possible after the occurrence.

2.0 DEFINITIONS

HASP	Health and Safety Plan
OSHA	Occupational Safety and Health Administration
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
FSP	Field Sampling Plan
SOP	Standard Operating Procedure
WP	(Project) Work Plan

3.0 HEALTH AND SAFETY CONSIDERATIONS

Refer to the site-specific HASP for health and safety considerations applicable to sub-slab vapor and soil gas sampling points.

Consideration of Health & Safety risks prior to performing this work is paramount. This risk review can be performed by making our generic Job Safety Analysis site specific in our site-specific HASP. Of course, there are many items that need to be considered.



Soil Vapor Sampling SOP

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The following is just a short list of the items. Careful consideration of these items by the project team is essential, and the ultimate responsibility of the project manager.

- Traffic guidance and control. Even plans developed by outside traffic control contractors need to be carefully evaluated to be sure that they serve our staff and our contractor's best interests. Follow Stantec's Traffic Guidance and Control Procedure.
- Personal protective equipment including high visibility traffic vest, gloves, appropriate clothing.
- Heat and cold stress.
- Biological hazards such as insects and spiders. Therefore appropriate clothing is required such as long sleeve shirts and long pants. Spiders are often encountered with well.
- Bloodborne pathogens. Some of our sites may have syringes and other drug paraphernalia that must be avoided.
- Chemical exposure on sites with open contamination. Respiratory protection may be necessary. Proper selection of respiratory protection is as essential as understanding its limitations, i.e., negative pressure respiratory protection does not supply oxygen in an oxygen-deficient atmosphere.
- Use of air monitoring instrumentation will not likely be necessary. We must be careful to make sure that our instrumentation is appropriate for the airborne contaminants of interest and that our staff understands the limitations of the instrumentation. Staff must also understand and perform calibration including zero-ing with zero gas cylinders and appropriate other calibration gases.
- Decontamination of equipment and personnel must be properly designed and constructed to be sure that contamination is kept within the boundaries of the exclusion zone.
- Noise and proper use of hearing protection devices such as ear plugs and muffs.
- Emergency action plan must be carefully coordinated in advance between Stantec, our subcontractor, the client and emergency responders.
- Ergonomics should be considered when setting up equipment. Ensure that staff does not lift more than 50lbs alone.

All of these risks and others must be discussed with project subcontractors, if applicable, and clients to ensure they are properly addressed. Once the issues have been addressed at a project management level, they must be communicated to the staff actually performing the work. Details of procedures, instrument measurements, and other activities must be recorded in the field log and/or on data collection forms.



4.0 RESPONSIBILITIES AND QUALIFICATIONS

The Project Manager or Task Leader will be responsible for assigning project staff to complete sub-slab vapor and or soil vapor sampling activities. The Task Leader will also be responsible for assuring that this and any other appropriate procedures are followed by all project personnel.

The project staff assigned to the sub-slab vapor and or shallow soil gas sampling task will be responsible for completing their tasks according to this and other appropriate procedures. All staff will be responsible for reporting deviations from the procedure or nonconformance to the Task Leader, Project Manager, or Project QA/QC Officer.

Only qualified personnel shall be allowed to perform soil vapor sampling. At a minimum, Stantec employees qualified to perform soil vapor sampling will be required to have:

- Read this SOP;
- Indicated to the Task Leader that all procedures contained in this SOP are understood;
- Completed the OSHA 40-hour training course and/or 8-hour refresher course, as appropriate; and
- Previously performed soil vapor sampling in a manner generally consistent with the procedures described in this SOP.

Stantec employees who do not have previous experience sampling soil vapor will be trained on site by a qualified Stantec employee and supervised directly by that employee until they have demonstrated an ability to perform the procedures.

The Project Manager shall document personnel qualifications related to this procedure in the project QA files.

5.0 REQUIRED MATERIALS

The following is a typical list of equipment that may be needed to perform sub-slab and soil vapor sampling:

- Rotary hammer drill and associated drill bits;
- Photoionization detector (PID) or other air monitoring instrumentation as required by the HASP;
- 4-mil-thick plastic sheeting;
- Tape measure;
- Broom, dustpan or hand vacuum;
- ¼-inch diameter Teflon (or NylafloTM) tubing;



- Stainless steel vapor implants;
- #3 sand
- Bentonite chips
- Portland cement or non-VOC caulking material
- Three-way stop cock valves;
- One-liter Summa™ canisters;
- Stainless steel trowels, putty knives or similar soil working tool;
- Waterproof marking pens;
- Coolers (with ice) for sample storage and shipment;
- Soil gas sample data forms/clip board;
- Nitrile gloves, or other specified chemical resistant gloves;
- Work gloves;
- Camera and film or disks;
- Personal safety gear (hard hat, steel-toed boots, ear plugs, safety glasses, etc.).

6.0 SUB-SLAB VAPOR IMPLANT INSTALLATION

Sub-slab soil vapor sampling point installation will be completed as follows.

- Ensure that all sub-slab utility locations (public and private) are marked prior to installation
- Using a commercial rotary hammer drill, a small diameter hole (approximately 1-inch) will be advanced approximately 2 inches into the slab. A smaller diameter hole (1/2 to 3/4-inch) will then be drilled through the remainder of the slab and extended approximately 3 inches into the sub-slab material. Care will be taken during advancement of the bit to avoid creating cracks in the surrounding slab. Dust and loose cuttings generated during drilling will be collected using a small hand broom and dustpan. A vacuum may be used to remove concrete and dust but in no event shall the vacuum inlet hose be placed directly over the borehole.
- Approximately 1 inch of #3 sand will be placed at the bottom of the borehole. A stainless steel soil vapor implant, fitted with a short length of 1/4-inch outer diameter Teflon tubing, will be inserted and centered into the bore hole followed by addition of sand to a depth such that the vapor implant will be embedded at the mid-point of the sand pack and the entire length of screen will be surrounded by the sand pack. Approximately 2 inches of dry granular bentonite will be added above the sand pack followed by approximately 1 inch of hydrated bentonite. Bentonite is not to be hydrated in-place to avoid to avoid transport of water to sand pack. Please see attached sub-slab vapor point schematic for construction details.
- Since movement of the tubing can create an annulus for entrance of ambient air into the sample train, measures will be taken to ensure that the tubing is immobilized. This includes the application of quick-dry Portland cement at the surface and a non-VOC caulking (e.g. EcoSafe). The temporary sub-slab implant will be completed with a tubing cap or ball valve fitted with an end cap and allowed to harden and equilibrate a minimum



of 30 minutes if temperature and humidity are adequate to completely cure bentonite and cement grout. In most cases it is recommended that samples not be collected for 18 hours to ensure that an adequate surface seal has formed.

7.0 SOIL VAPOR PROBE INSTALLATION

Shallow soil vapor probes will be installed approximately 5.0 feet below ground surface (bgs). Each soil vapor probe location will be completed using a 3-inch diameter hand auger to advance the borehole to the target depth.

Following drilling, a soil vapor probe will be installed and constructed at each location as follows.

- Approximately six inches of #3 sand will be placed at the bottom of the borehole.
- A stainless steel soil vapor implant, consisting of a stainless steel screen will be attached to ¼-inch outside diameter Teflon[®] tubing and centered into the borehole at a depth of five feet bgs.
- The annular space will be then filled with sand to 6 inches above the vapor implant.
- Approximately six to twelve inches of dry granular bentonite will be placed immediately above the sand pack. The annulus above the dry bentonite will be filled with hydrated bentonite, placed in four inch lifts, to two inches below the surface.
- The top two inches of the borehole will be filled to grade with cement grout.
- The soil gas probe will be completed with a tubing cap or ball valve fitted with a cap.
- Use of a hand auger will greatly disturb subsurface soil and as such one week is recommended for subsurface equilibration to occur prior to sample collection. Follow individual state guidance regarding equilibration times for probe installations using direct push or hollow-stem auger. Note: Use of air rotary or roto-sonic drilling may require longer equilibration times. Mud rotary drilling is never acceptable for soil gas probe emplacement.

Note: for nested multi-depth soil vapor wells, will follow the same procedure for each selected depth.

8.0 VAPOR SAMPLE COLLECTION

8.1 PERMEABILITY TESTING

If there is a potential for low flow conditions due to soil lithology permeability may be assessed quantitatively by connecting a vacuum gauge to the implant tubing (as close as possible to



surface seal). A pump and flow-meter equipped with rotameter are then used to withdraw soil gas at a measured rate. If a flow rate of approximately 100 mL/min with an applied vacuum of less than 100 inches water column (in. wc.) cannot be sustained for 2 to 3 minutes, low flow conditions exist. An alternate procedure for sample collection under low-flow conditions may include collection of a smaller aliquot of soil gas followed by a period of time for the vacuum to dissipate (dependent of gas permeability of soils around sand pack). The process is repeated until approximately 800 mL of soil gas is collected in the 1-liter Summa® canister.

8.2 Leak Testing

Leakage of atmospheric air into the sampling equipment during sample collection can compromise sample integrity and dilute measured soil vapor concentrations, possibly to the point that the concentration is below the method reporting limit (i.e., a false negative). Contaminants in ambient air can also enter the sampling system and be detected in the sample from a non-contaminated sampling implant (i.e., a false positive). Air leakage can occur at the land surface into the implant and, less likely, through loose fittings in the aboveground sampling equipment. Leak testing must be performed at every vapor monitoring well location each time a soil vapor sample is collected.

To avoid leaks, the connections, fittings, and other parts associated with the sampling equipment will be checked to verify that they tightly fit.

To test for leaks, two methods will be used. The first method involves performing a vacuum test (shut-in test) on the aboveground sampling equipment (e.g., valves, lines and fittings) as follows:

- Assemble the aboveground sampling apparatus (valves, tubing and fittings).
- Evacuate lines to a measured vacuum of 100 inches Water Column (in H₂O) using a gas-tight syringe or sampling pump. If a pump is used, the valve is closed and the pump turned off. If constant vacuum pressure is maintained for 1 minute, the sampling equipment will pass the vacuum test. If there is observable loss of vacuum, fittings will be re-tightened and the test repeated. Results of the vacuum leak test will be recorded on the soil vapor sample collection data log.

The second leak check procedure involves using a tracer gas to test for ambient air leakage around the surface seal and into the sampling system. Helium as the tracer gas is recommended because it has low toxicity, does not disrupt analytical measurements, is generally not found at contaminated sites, and has a high purity. Helium may be obtained from an analytical laboratory or directly from a helium supplier.

- A sampling enclosure (shroud) will be constructed to facilitate leak testing during soil vapor sample collection. With the assumption that the surface sampling train has passed the shut-in test, the shroud will be of sufficient size to cover the surface seal.
- Tubing from the subsurface probe is passed through a dedicated opening in the shroud and capped. The sampling enclosure is then filled to at least 90% laboratory-grade



helium as measured using a helium detector (e.g., Dielectric[®] MGD thermal conductivity detector). Rapid depletion of helium indicates that there is an inadequate seal between the shroud and ground surface and corrective measures are necessary.

- Helium present in the sample train may be measured in the field by collecting purge air in a Tedlar bag. A separate line and valve is connected to a Tedlar bag placed inside a lung box. The sample is collected using a small sampling pump. Alternatively, purge air may be directly collected into a Tedlar bag if a twin-port sampling pump is used. Helium is measured using the portable helium detector. If logistically feasible, these methods allow for corrective measures to be taken at the time of sample collection. However, in all cases, all samples will also be analyzed in the laboratory using U.S EPA Method TO-3C or ASTM D-1946 (fixed gases).
- The presence of helium in the bag of less than 5% of the helium concentration in the shroud generally is not indicative of ambient air intrusion (and subsequent dilution of the sample) into the sample train. Helium present at higher percentages will require corrective action including reapplication of materials used to establish the surface seal. Particular attention should be paid to ensuring that soil vapor implant tubing is immobilized to prevent annulus formation around it. In the event that helium is detected at greater than 5% of the shroud concentration after corrective measures, the boring must be abandoned and relocated. If a field detector is used that provides parts per million measurements these may be converted (for helium only) to percent helium as follows:

$$\text{Percent Helium} = \text{Parts Per Million (ppmv)} \times 0.0001$$

8.3 Purging

After the sampling equipment passes the vacuum test, the implant or well is purged to remove internal air from the sample train (tubing and vapor implant only). Three volumes will be purged from each sampling location. Purge volumes will be calculated by:

$$\text{Volume to be purged} = \text{Number of purge volumes} \times (4.46 \text{ ml/foot of } 0.25 \text{ in. OD tubing} \times \text{depth})$$

If each purge volume is anticipated to be less than 50 mL, purging may be performed using a gas-tight syringe¹.

The flow rate during purging will be approximately equivalent to the flow rate during sampling, which is set by the flow controller provided by the laboratory. Purge data for each implant/well will be recorded on the soil vapor sampling log.

8.4 Collecting Soil Vapor Samples

¹ Alternatively the purge may be performed at each location using a purge Summa canister. An approximate 1-inch of mercury (in Hg) drop in vacuum pressure in the 6-L purge canister corresponds to an approximate purge volume of 200 mL.



8.3.1 Connecting Soil Vapor Sampling Equipment

The initial vacuum of each canister will be measured using the laboratory-supplied vacuum gauge. In no case will a canister be used if the initial vacuum is measured to be at or less than 25 in Hg.

Following inspection, the vapor implant tubing will be routed through a dedicated opening in the shroud, the tubing cap removed and a compression fitting attached. The tubing will then be connected to the Summa™ canister.

With the leak test shroud still in place, collection of soil vapor samples from a particular implant will begin within 30 minutes of purging. Each sample from the soil vapor wells will be collected in a 1-L batch-certified² Summa™ canister at an approximate collection rate of 175 ml/min for shallow soil vapor samples and approximately 50 ml/min for sub-slab soil vapor samples.

- The valve on the Summa™ canister is opened.
- The pressure gauge on the flow controller will be observed to verify that the vacuum in the canister is decreasing over time. If the flow controller is working correctly, it will take approximately 20 minutes for the vacuum to decrease to 5 in Hg for sub-slab soil vapors samples and approximately 5 to 10 minutes for shallow soil vapor samples; however, the actual sampling duration may be slightly more or less. The Summa™ canister valve will be closed and sampling will cease when a vacuum of 5 in Hg is obtained.
- A duplicate sample will be collected using a laboratory-supplied dual collection manifold.
- Sample collection and tracer gas monitoring data for each implant will be recorded on the soil vapor sample collection data log.

8.5 Sample Storage and Transport

Soil vapor samples will be properly labeled and placed within secure packaging received from the laboratory. Soil vapor samples will not be chilled since contaminants may condense in the canisters at low temperatures. Soil vapor samples will be shipped via next-day air. Samples will be transported under chain-of-custody protocol (including noting the final canister vacuums and serial numbers of the canisters and flow controllers). Pre-field planning will prevent sample shipments from arriving at the laboratory during weekends.

9.0 DECONTAMINATION

Re-use of soil vapor sampling equipment is not allowed.

10.0 QUALITY CONTROL CHECKS AND ACCEPTANCE CRITERIA

² 'Batch certification' means that 10 percent of the canisters processed (i.e., cleaned using a combination of dilution, heat and high vacuum) in a given batch were sampled and analyzed by GC/MS, and that concentrations of target compounds in the tested canisters were below 0.2 parts per billion vapor (ppbv).



Refer to the Quality Assurance Project Plan for specific quality control checks and acceptance criteria.

Outline quality control checking procedures, including frequency requirements and acceptance criteria. Acceptance criteria may take the form of an illustration such as a chart of acceptable results with tolerances, or other appropriate forms.

11.0 DOCUMENTATION

A record will be maintained during the sampling procedure that will contain at a minimum:

- Sample identification,
- Sample depth,
- Weather conditions,
- Sampler name,
- Volume of air purged removed,
- Purging method,
- Start and end vacuum readings,
- Helium measurements in shroud at start, 15 minutes and/or end of sampling,

The data shall be recorded on a Soil Vapor Sample Collection Data Form for each vapor well.



APPENDIX B

INDOOR AIR QUALITY BUILDING SURVEY



This form must be completed for each building involved in an indoor air investigation.

Preparer's Name: _____ Date Prepared: _____

Preparer's Affiliation: Stantec Consulting Services, Inc.

Telephone Number: _____

OCCUPANT INFORMATION	
Name	
Address	
City, State ZIP	
Home Telephone	
Office Telephone	

OWNER or LANDLORD INFORMATION	
Name <small>(if different from Occupant)</small>	
Address	
City, State ZIP	
Telephone	

A. Building Construction

Single Family
 Multiple Dwelling
 Commercial

1. Type (check appropriate responses):

- | | |
|---------------------------------------|-------------------------------------|
| <input type="checkbox"/> Ranch | <input type="checkbox"/> Two-Family |
| <input type="checkbox"/> Raised Ranch | <input type="checkbox"/> Duplex |
| <input type="checkbox"/> Split Level | <input type="checkbox"/> Office |
| <input type="checkbox"/> Colonial | <input type="checkbox"/> Warehouse |
| <input type="checkbox"/> Mobile Home | <input type="checkbox"/> Strip Mall |

Apartment Building: # of Units: _____

Other: _____

2. Building Age: _____ Number of Floors: _____

3. Area of the Building (square feet): _____



4. Is the building insulated? YES NO
 5. How sealed is the building? _____
 6. Roll-up Doors Present? _____ Normally Open? _____
 7. Number of elevators in the building: _____
 8. Condition of the elevator pits (sealed, open earth, etc.) _____
 9. General description of building construction materials: _____
-

B. Foundation Characteristics (check all that apply)

1. Full basement Crawlspace Slab on Grade- Post Tension Slab? _____
 Other: _____
2. Basement Floor Description: Concrete Dirt Wood
 Other: _____
 - a) Basement is: Wet Dry Damp
 - b) Sump present? YES NO Water in sump? YES NO
 - c) Basement is: Finished Unfinished Other: _____
 - d) Is basement sealed? YES NO
Provide a description: _____
3. Concrete floor description: Unsealed Painted Covered with: _____
4. Foundation walls: Poured Concrete Block Stone Wood
 Other: _____

C. Identify all potential soil gas entry points and their size (e.g., cracks, voids, pipes, utility ports, sumps, drain holes, etc.). Include these points on the building diagram.

D. Heating, Ventilation, and Air Conditioning (check all that apply)

1. Type of heating system(s):
 Hot Air Circulation Steam Radiation
 Hot Water Radiation Electric Baseboard



- Heat Pump
- Un-Vented Kerosene Heater
- Wood Stove
- Other (specify): _____

2. Type of fuel used:
- Natural Gas
 - Fuel Oil
 - Electric
 - Wood
 - Coal
 - Solar
 - Other: _____

3. Location of heating system: _____

4. Is there air conditioning? YES NO
- If YES: Central Air Window Units
- Specify location: _____

5. Are there air distribution ducts present? YES NO

6. Describe the supply and cold air return duct work including whether there is a cold air return and comment on the tightness of duct joints: _____

7. Is there a whole house fan? YES NO
- What is the size of the fan? _____

8. Temperature settings inside during sampling (note day and night temperatures).
- a. Daytime Temperature(s) _____
 - b. Nighttime Temperature(s) _____
- (Note times if system cycles during non-occupied hours during the day.)

9. Estimate the average time doors and windows are open to allow fresh outside air into the building. Note rooms that frequently have open windows or doors: _____

D. Potential Indoor Sources of Pollution

- 1. Is the laundry room located inside the building? YES NO
- 2. Has the building ever had a fire? YES NO
- 3. Is there an attached garage? YES NO
- 4. Is a vehicle normally parked in the garage? YES NO
- 5. Is there a kerosene heater present? YES NO



Distance from well to septic system: _____
Type of septic tank additives: _____

F. Plan View

Sketch each floor and if applicable, indicate air sampling locations, possible indoor air pollution sources, preferential pathways and field instrument readings.

G. Potential Outdoor Sources of Pollution

Draw a diagram of the area surrounding the building being sampled. If applicable, provide information on the spill locations (if known), potential air contamination sources (industries, service stations, repair shops, retail shops, landfills, etc.), outdoor air sampling locations, and field instrument readings.

Also, on the diagram, indicate barometric pressure, weather conditions, ambient and indoor temperatures, compass direction, wind direction and speed during sampling, the locations of the water wells, septic systems, and utility corridors if applicable, and a statement to help locate the site on a topographical map.

H. Date of last painting of surfaces at the facility: _____

Location where painting occurred: _____

I. Date of last carpet replacement: _____

Location(s): _____

I. Describe Process/Manufacturing/Storage Areas:

J. Existing Soil Vapor Control Devices (pipes, vents, blowers, HVAC Add-ons)
Describe Observations, Locations



K. Wall Surfaces (painted, textured)_____

L. Noted Interior Sinks for VOCs_____



APPENDIX C

HVAC Checklist - Short Form

Building Name: _____ Address: _____

Completed by: _____ Date: _____ File Number: _____

OCCUPIED SPACE

Thermostat types _____

Zone/ Room	Thermostat Location	What Does Thermostat Control? (e.g., radiator, AHU-3)	Setpoints		Measured Temperature	Day/ Time
			Summer	Winter		

Humidistats/Dehumidistats type _____

Zone/ Room	Humidistat/ Dehumidistat Location	What Does It Control?	Setpoints (%RH)	Measured Temperature	Day/ Time

- Potential problems (note location) _____
- Thermal comfort or air circulation (drafts, obstructed airflow, stagnant air, overcrowding, poor thermostat location) _____
- Malfunctioning equipment _____
- Major sources of odors or contaminants (e.g., poor sanitation, incompatible uses of space) _____

HVAC Checklist - Short Form

Building Name: _____ Address: _____
 Completed by: _____ Date: _____ File Number: _____

DISTRIBUTION SYSTEM

Zone/ Room	System Type	Supply Air		Return Air		Power Exhaust		
		ducted/ unducted	cfm'	ducted/ unducted	cfm'	cfm'	control	serves (e.g. toilet)

Condition of distribution system and terminal equipment (note locations of problems)

- Adequate access for maintenance? _____
- Ducts and coils clean and obstructed? _____
- Air paths unobstructed? supply _____ return _____ transfer _____ exhaust _____ make-up _____
- Note locations of blocked air paths, diffusers, or grilles _____
- Any unintentional openings into plenums? _____
- Controls operating properly? _____
- Air volume correct? _____
- Drain pans clean? Any visible growth or odors? _____

Filters

Location	Type/Rating	Size	Date Last Changed	Condition (give date)



APPENDIX D



1.0 PURPOSE & APPLICABILITY

The objective of this SOP is to develop a consistent approach to the evaluation of indoor air quality (“IAQ”) within a building environment. Indoor air quality may be affected by chemical use or storage within the building; intrusion of subsurface soil gas through the building foundation (vapor intrusion); or from biological contaminants originating from the building interior or external environment. The goal of this portion of an IAQ investigation is to identify the scope of the problem through the use of interviews, verbal or written responses to questionnaires, facility walk-through and the collection of information regarding the facility air handling and conditioning system (typically known as the HVAC system) and, to translate this information into measurable objectives.

2.0 DEFINITIONS

Indoor Air Quality: the totality of attributes of air within a building envelope that affect human health and well-being. Such attributes can include gaseous and particulate contaminants of a biologic or chemical nature; air exchange rates; temperature; and, relative humidity.

Constant Air Volume System (CAV): an air handling system that maintains a constant air flow while varying the temperature to meet heating and cooling needs.

Design: the development of a general strategy or approach and includes a translation of goals to specific measurement objectives.

Incidence: The number of people developing adverse health effects (symptoms) within a specified time period.

Prevalence: The number of people currently experiencing symptoms without regard to time of onset. Prevalence refers to ALL cases whereas incidence refers to NEW cases.

Sick Building Syndrome: A condition associated with non-specific ailments (headache, respiratory, eye, nose, throat irritation, fatigue etc.) with many possible causes and consistent temporal relationship where symptoms often disappear or improve when the worker leaves the worksite.

Variable Air Volume System (VAV): an air handling system that conditions the air to a constant temperature by varying the outside air flow.

Building-related Illness: Includes clinically defined symptoms with a known etiology (e.g., biologic agents) that have documented physical signs and laboratory findings. These types of illnesses include legionellosis and hypersensitivity diseases caused by thermophilic actinomycetes, *Flavobacterium* spp, fungi and non-pathogenic amoeba.

3.0 HEALTH AND SAFETY CONSIDERATIONS



Health and Safety considerations will generally match those required by the facility under assessment. For residences, if entrance to a crawl space is required, head and eye protection will be required.

4.0 QUALITY ASSURANCE PLANNING CONSIDERATIONS

The inherent difficulty of IAQ work relates to its reliance on subjective information to direct quantitative and sometimes qualitative measurement. Therefore, QA assessment is restricted to appropriate compliance with methods of measurement including sample collection and analysis.

Passivated Summa™ canisters: When collecting indoor and outdoor air samples, only laboratory individually-certified canisters and flow controllers should be used.

Personal sampling pumps: In the event that air samples are required, care must be taken to calibrate the flow rate of the pump both before and after sampling. The pump must be fully charged or connected to an external power source. Most NIOSH and OSHA methods specify a volume range of air to be collected. As such, accurate measurement of flow rate (and duration of sample collection) is essential.

Direct-Reading Detector Tubes: Generally, the accuracy of direct reading methods is +/- 25%. Care must be taken to follow manufacturer recommendations for operation of the hand pump in a uniform manner.

Infrared Analyzers: Direct reading instrument such as those employed for the measurement of carbon dioxide, provide immediate measurement and can be moved quickly from one location to another. Care must be taken to properly establish the zero and span settings. Calibration should be performed before and after sampling activities. Some devices require thermal equilibrium prior to use.

5.0 REQUIRED MATERIALS

If screening measurements are requested¹, the following types of equipment will be required:

Combination devices are convenient where available or when the project budget provides for equipment rental (i.e., TSI® Q-Trak Model 7565, Vulcain Safety Palm® or equivalent device capable of measuring temperature, relative humidity and carbon dioxide²). If unavailable, a sling psychrometer/thermometer may be used to measure temperature and relative humidity. Alternatively detector tubes may be used to measure carbon dioxide concentrations.

A rotating vane anemometer for the measurement of air velocity.

¹ The investigator is cautioned that single-point measurements are not reliable indicators of overall indoor air quality or the adequacy of HVAC system performance.

² Levels of CO₂ are normally highest in the late morning and late afternoon and will vary with occupancy during the day. Measurements should be taken in areas with the highest



occupancy, where IAQ problems have been noted, at outdoor air intakes and at exhaust plenums. The investigator should take measurements with the analyzer away from his or her body to prevent contributing their expired (breath) CO₂ to the measurement. Measurements are generally collected at a height between the desk and head level.

6.0 METHOD

An investigation regarding IAQ is highly variable and dependent on site-specific conditions. For this reason, a generally accepted procedure consists of the following:

Employer Interview:

During the interview, collect as much information as possible regarding:

- The average and peak occupant densities vs. design occupancy.
- The magnitude and distribution of employee complaints or illnesses.
- Recent renovation or remodeling activities that may have introduced new building materials or altered original (or most current) air flow patterns (i.e., construction of new offices in previously open space).
- The employers knowledge of the HVAC system serving their space including who is responsible for maintenance, frequency of maintenance and any problems noted in the past.

Employee Interview:

Where required, this is the most subjective portion of any IAQ investigation. The usefulness of the information is dependent on interviewer skills and experience. The interviewer should always be aware that responses are sometimes perceptual and may be influenced by other factors such as personal stress and job satisfaction. Do not ask questions that may guide the employee in one direction or another. At a minimum, the employee interview should be conducted with the goal of acquiring the following information:

- The nature of complaints and associated symptoms
- The area(s) in which the complaints occur
- Do the symptoms subside or go away when the employee leaves work? If so, how long does it take?
- Were the symptoms triggered by a specific event?
- Has the employee seen a physician for the problem? If so, what was the diagnosis?
- Is the employee taking medication for the symptoms?
- Determine if there are predisposing conditions such as a history of allergy, disability, smoking, etc.

Building Survey (Initial Walk-around Inspection):

The objective of the initial walk-around inspection is to gather sufficient information so that appropriate sampling and analysis may be designed where required. Although screening measurements (i.e. temperature, relative humidity, CO₂, etc.) may be taken at



this time, the investigator is cautioned that these parameters may vary considerably both temporally and spatially. At a minimum, the following information should be collected:

- If one has not been provided, develop a workspace layout drawing that identifies office enclosures, operating areas, employee locations (especially those with IAQ complaints), locations of air exhausts and intakes, and observed physical barriers to air flow (i.e., ceiling-mounted video screens or large electronic displays).
- Identify potential sources of indoor air contaminants such as photo-copiers, blueprint machines, chemical storage (open and closed containers), the presence of new building materials, air fresheners, positive- or negative-pressure work areas, smoking areas and the presence of water leaks and/or water damaged building materials (i.e., stained sheetrock or ceiling materials). Also, the presence of discolored carpet or carpet with rings or lines may indicate improper drying from carpet cleaning that may serve as a reservoir for biological contamination.
- Identify potential outdoor sources such as close proximity to vehicle exhaust (parking lots or structures and drive-through areas), construction activity that may generate dust, the relation of the workspace to outdoor air intakes and industrial operations that may generate fumes, gases, particulates and odors.
- Subjective changes in air flow or temperature.
- Note the overall condition of the HVAC system with particular emphasis on clogged filters, presence of standing water, obvious signs of physical deterioration and evidence of recent maintenance. The presence of accumulated dust on office furnishings and workspaces may also indicate improperly operating air handling systems.
- Note the presence of exhaust outlets in close proximity to diffusers.
- Note the presence and description of odors (fuel, solvent, moldy)

Exit Interview:

Following the interviews and initial walk-around inspection, the investigator may be required to conduct an exit interview with the client or designated building representative that:

- Summarizes the activities performed by the investigator,
- Describes obvious deficiencies noted or areas identified as being of potential concern,
- Outline the tasks to be performed such as development of a sampling and analysis plan, longer term monitoring of HVAC system performance.

7.0 PREPARATION OF BUILDING FOR SAMPLING

Potential interference from products or activities identified in the building survey need to be controlled including removal of the source from the building prior to sampling. If this is not possible, ensuring that all containers are tightly sealed may be effective. Note, the inability to remove or control potential VOC sources may be justification for not



sampling. However, if the goal of the air sampling is to determine whether products are an indoor source of VOCs then removing these sources does not apply.

Air sampling is generally designed to represent typical exposure and as such the buildings HVAC system should be operated under normal conditions. For example, during cooler months the system should be operated under normal occupied conditions (i.e., 65 to 70 ° F) for at least 24 hours prior to and during the scheduled sampling time.

For 24 hours prior to sampling avoid:

- Unreasonable opening of windows fireplace dampers and vents
- Operation of ventilation fans
- Smoking in the house
- Using combustion devices (wood stoves, auxiliary heating equipment).
- Allowing containers of gasoline or oil to be stored in the house
- Use of air fresheners or odor eliminators
- Cleaning or waxing furniture or floors with petroleum-based products
- Engaging in any hobbies which use VOCs
- Applying pesticides

8.0 COLLECTION OF SAMPLES

Air samples should be collected from an adequate number of locations to evaluate likely sources of VOCs and to assess potential exposure to building occupants in various locations. In residences air samples should be collected from the basement, first floor and the ambient air outside the structure. The outdoor sample should be collected from a location determined (at the time of sampling) to be upwind. For commercial structures, preference should be given to collection of an ambient air sample near fresh air intakes. All samples should be collected from a height representing a normal breathing zone (approximately 3 to 5 feet off the floor).

Time-integrated samples should be collected over the following durations:

- 8 Hours- Commercial use buildings
- 24 hours- residences
- Ambient air samples should be collected over the same sampling duration as the indoor air samples.

Sample collection techniques vary depending on the analytical method(s) chosen for the specific project but generally involve collection of air samples using canisters or sorbent-containing cartridges. The majority of sampling and analysis methods in use today have been adapted from US EPA methods for analysis of toxic organic chemicals (*Compendium of Methods for Determination of Toxic Organic Chemicals in Ambient Air*, US EPA EPA/625/R-96/010b, January 1999) and focus primarily on the assessment of potential vapor intrusion using stainless steel, passivated canisters. As such general sampling methodology for canister sampling is provided below.

- Determine applicable sampling duration



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- Only individually-certified canisters and flow controllers should be used for indoor air sampling. Individual certification means that each canister processed (i.e., cleaned using a combination of dilution, heat and high vacuum) is sampled and analyzed for the project-specific target analyte list by GC/MS, and that concentrations of target compounds are below project reporting limits. Each Summa™ canister is equipped with laboratory-supplied certified flow controller to regulate collection rates during sampling and vacuum gauge. Individual certification is made as a sampling train and must be sampled as such (i.e., a particular flow controller is matched with a particular canister). Accordingly the laboratory provides a unique identification number for each canister and flow controller which must be entered on the field log and chain-of-custody form.
- Upon receipt of canisters from the laboratory, measure and record initial receipt vacuum using the laboratory-supplied vacuum gauges. These gauges provide relative measurements only since they are not calibrated and as such there may be 0.5 to 1.5 in Hg differences between laboratory ship vacuum and receipt vacuum. Receipt vacuum measurements will be used to calculate $\Delta P_{\text{lab-field}}$ to determine evidence of canister leakage during shipment from the laboratory. **If the receipt vacuum is less than 25 in Hg do not use it.** Verify initial receipt vacuum as follows:
 - Confirm that canister valve (located on the side of canister) is closed
 - Remove brass cap and attach vacuum gauge
 - Open and close canister valve quickly
 - Read vacuum on gauge and record on field form and chain-of-custody
 - Verify that canister valve is closed, remove gauge and replace brass cap.
- Place canisters in locations selected during the building survey and at a height of 3 to 5 feet off the floor. Canisters may be placed on stable chairs, boxes or stools.
- To collect sample:
 - Remove brass cap and attach certified flow controller (generally 7/16 and 9/16" wrenches are required)
 - Place the brass cap at the end of the flow controller and quickly open and close the valve. If the needle on the gauge drops, the sampling train is not airtight. Tighten all fittings and repeat process.
 - Remove brass cap and open valve approximately ½ turn or until resistance is no longer felt.
 - Monitor sampling at least once (mid-point of sampling duration). Assuming a linear function between volume of sample and canister vacuum, at the halfway point of an 8-hour sampling duration using 6 liter canister, the vacuum gauge should read around 15 in Hg. If the gauge reads less than 10 in Hg it may mean that the canister is filling too quickly because of a leak in the sample train. Retighten all fittings and make notations regarding this on the field data sheet.
 - At the completion of the sampling duration, the gauge should read between 5 and 3 in Hg to avoid need for laboratory application of increased canister dilution factors.
 - Record end vacuum on chain-of-custody and field data form along with the end time, date and samplers initials. The same information must be written on the laboratory supplied sample tag. **Never write directly on the canister.**



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- Canisters are stored and returned to the laboratory at normal temperature.



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ACCEPTANCE

Author/Originator

Corporate Quality Assurance Officer

Stantec Operations Management



APPENDIX E

1.0 CALIBRATION PROCEDURES

1.1 Traceability of Calibration

Wherever applicable, calibration of analytical support equipment and instruments is traceable to national standards of measurement.

1.2 Reference Standards

Reference standards of measurement (such as Class S or equivalent weights or traceable thermometers) are used for calibration only. Reference standards are subjected to in-service checks between calibrations and verifications.

1.3 General Requirements

Each calibration is dated and labeled with or traceable to the method, instrument, analysis date, and each analyte name, concentration and response (or response factor). Sufficient information is recorded to permit reconstruction of the calibration. Acceptance criteria for calibrations comply with method requirements or are established and documented.

1.4 Analytical Support Equipment

Analytical support equipment includes: balances, ovens, refrigerators, freezers, incubators, water baths, temperature measuring devices and volumetric dispensing devices if quantitative results are dependent on their accuracy, as in standard preparation and dispensing or dilution into a specified volume. All such support equipment is:

- Maintained in proper working order. The records of all activities including service calls are kept;
- Calibrated or verified at least annually, using NIST traceable references when available, over the entire range of use. The results of such calibration must be within the specifications required of the application for which is equipment is used or the equipment is removed from service until repaired.

Prior to use on each working day, balances, ovens, refrigerators, freezers, incubators and water baths are checked with NIST traceable references (where possible) in the expected use range. The acceptability for use or continued use is according to the needs of the analysis or application for which the equipment is being used. Mechanical volumetric dispensing devices (except Class A glassware) are checked for accuracy quarterly.

1.5 Instrument Calibration

Calibration procedures for all laboratory instruments will consist of an initial calibration and a calibration verification. All calibration standards are ISO9001 Certified and traceable to NIST standards. The SOP for each analysis performed in the laboratory describes the calibration procedures, their frequency, acceptance criteria and the conditions that will require recalibration. In all cases, the initial calibration is verified using a secondary source calibration verification solution. ChemSolutions maintains a

sample logbook for each instrument which contains the following information: instrument identification, serial number, date of calibration, analyst, calibration solutions run and the samples associated with these calibrations.

All results are calculated based on the response curve from the initial calibration and are bracketed by calibration standards or reported as having a lower confidence level.

If the initial calibration fails, the analysis procedure is stopped and evaluated. For example, a second standard may be analyzed and evaluated or a new initial calibration curve may be established and verified. In all cases, the initial calibration must be acceptable before analyzing any samples.

A calibration verification check standard is analyzed at the beginning and end of each batch of samples. An exception to this policy is for internal standard methods (e.g. most organic methods). For these analyses, the calibration check is only analyzed at the beginning of the analytical sequence. The concentration of this calibration check is described in each method SOP. If a calibration check standard fails, and routine corrective action procedures fail to produce a second consecutive calibration check within acceptance criteria, a new initial calibration curve is constructed. If the continuing calibration acceptance criteria are exceeded high (i.e., high bias), and there are non-detects for the corresponding analyte in all environmental samples associated with the continuing calibration check, then those non-detects may be reported, otherwise the samples affected by the unacceptable check are reanalyzed after a new calibration curve has been established, evaluated and accepted. If the continuing calibration acceptance criteria are below the low limit, results may be reported if sample results indicate a concentration above an action level and accurate values are not required by the customer. Otherwise, additional sample analysis does not occur until a new calibration curve is established and verified.

2.0 TEST METHODS AND STANDARD OPERATING PROCEDURES

ChemSolutions maintains Standard Operating Procedures (SOPs) that accurately reflect all laboratory activities such as assessing data integrity, corrective actions, handling customer complaints, and all test methods. Each SOP indicates the effective date, the revision number, and the signature(s) of the QA Officer and Laboratory Director.

SOPs are used to ensure consistency and to save time and effort. Any departure from documented policies and procedures or standard specifications may be permitted after review and written approval of the Technical Director, Laboratory Director and QA Officer.

2.1 SOPs for Sample Management

These SOPs describe the receipt, handling, scheduling, and storage of samples.

Sample Receipt and Handling -- These procedures describe the precautions to be used in opening sample shipment containers and how to verify that chain-of-custody has been maintained, examine samples for damage, check for proper preservatives and temperature, and log samples into the laboratory sample streams.

Sample Scheduling -- These procedures describe the sample scheduling in the laboratory and includes procedures used to ensure that holding time requirements are met.

Sample Storage -- These procedures describe the storage conditions for all samples, verification and documentation of daily storage conditions, and how to ensure that custody of the samples is maintained while in the laboratory.

2.2 SOPs for Reagent/Standard Preparation

These SOPs describe how to prepare standards and reagents. Information concerning specific grades of materials used in reagent and standard preparation, appropriate glassware and containers for preparation and storage, and labeling and record keeping for stocks and dilutions is included.

2.3 SOPs for General Laboratory Techniques

These SOPs describe all essentials of laboratory operations that are not addressed elsewhere. These techniques should include, but are not limited to, glassware cleaning procedures, operation of analytical balances and use of volumetric glassware.

2.4 SOPs for Test Methods

Procedures for test methods describing how the analyses are actually performed in the laboratory are specified in method SOPs. These SOPs for sample preparation, cleanup and analysis are based on reference methods published by EPA, ASTM, AWWA, and other organizations and on internally developed methods validated according to EPA's Performance-Based Measurement System. Each method SOP includes:

- 1) identification of the test method;
- 2) applicable matrix or matrices;
- 3) method detection limit;
- 4) scope and application, including components to be analyzed;
- 5) summary of the method;
- 6) definitions;
- 7) interferences;
- 8) safety;
- 9) equipment and supplies;
- 10) reagents and standards;
- 11) sample collection, preservation, shipment and storage;
- 12) quality control;
- 13) calibration and standardization;
- 14) procedure;
- 15) calculations;
- 16) method performance;
- 17) pollution prevention;
- 18) data assessment and acceptance criteria for quality control measures;
- 19) corrective actions for out-of-control data;
- 20) contingencies for handling out-of-control or unacceptable data;
- 21) waste management;
- 22) references; and

23) any tables, diagrams, flowcharts and validation data

2.5 SOPs for Equipment Calibration and Maintenance

These SOPs describe how to ensure that laboratory equipment and instrumentation are in working order. These procedures include calibration procedures and schedules, maintenance procedures and schedules, maintenance logs, service arrangements for all equipment, and spare parts available in-house. Calibration and maintenance of laboratory equipment and instrumentation are in accordance with manufacturers' specifications or applicable test specifications.

3.0 INTERNAL QUALITY CONTROL CHECKS

3.1 Laboratory Quality Control Samples

The data acquired from QC procedures are used to estimate the quality of analytical data, to determine the need for corrective action in response to identified deficiencies, and to interpret results after corrective action procedures are implemented. Each method SOP includes a QC section which addresses the minimum QC requirements for the procedure. The internal QC checks may differ slightly for each individual procedure but in general are described below.

- a) Method Blanks are performed at a frequency of a minimum of one per batch of samples per matrix type per sample extraction or preparation test method. The results of these samples are used to determine batch acceptance.
- b) Laboratory Control Sample (QC Check Sample) is analyzed at a minimum of 1 per batch of 20 or fewer samples per matrix type per sample extraction or preparation method. The results of these samples are used to determine batch acceptance.
- c) Matrix Spikes (MS) are performed at a frequency of one in 20 samples per matrix type per sample extraction. The sample(s) selected for spiking are rotated among received samples so that various matrix problems may be noted and/or addressed. Poor performance in a matrix spike generally indicates a problem with the sample composition, and not the laboratory analysis, and is reported to assist in data assessment.
- d) Surrogates - Surrogate compounds are added to all samples, standards, and blanks for all organic chromatography test methods except when the matrix precludes its use or when a surrogate is not available. Poor surrogate recovery generally indicates a problem with the sample composition and is reported to assist in data assessment.
- e) Spike Components - In general, all reportable components are in the spike mixes. However, in cases where the components interfere with accurate assessment (such as simultaneously spiking chlordane, toxaphene and PCBs in Method 608), the test method has an extremely long list of components (such as Methods 8270 or 8260) or components are incompatible, a representative number (10%) of the listed components are used. The selected components of each spiking mix represent all chemistries, elution patterns and masses and include permit specified analytes and other client requested components. All reported components are used in the spike mixture within a

two-year time period, and no one component or components dominates the spike mixture.

f) Matrix Spike Duplicates (MSDs) or Laboratory Duplicates are analyzed at a minimum of 1 in 20 samples per matrix type per sample extraction or preparation test method. The selected sample(s) are rotated among received samples so that various matrix problems may be noted and/or addressed. Poor performance in the duplicates generally indicates a problem with the sample composition and is reported to assist in data assessment.

3.2 Detection Limits

For analytes for which spiking is a viable option, detection limits are determined by a Method Detection Limit (MDL) study as described in by 40 CFR Part 136, Appendix B. The method detection limit is initially determined for the compounds of interest in each method in laboratory pure reagent water or Ottawa sand.

An MDL study is not performed for any component for which spiking solutions are not available. For these types of analytes, the detection limit is based on the signal to noise ratio from the analysis of a QC check sample or calibration standard.

A Reporting Limit is established by the concentration of the lowest standard in the initial calibration.

3.3 Selectivity

a) Absolute and relative retention times aid in the identification of components in chromatographic analyses and help evaluate the effectiveness of a column to separate constituents. Acceptance criteria for retention time windows are documented in each method SOP.

b) A confirmation is performed to verify a compound identification when positive results are detected on a sample from a location that has not been previously tested. Such confirmations are performed on organic tests except when the analysis involves the use of a mass spectrometer.

c) Acceptance criteria for mass spectral tuning are contained in SOPs.

3.4 Demonstration of Method Capability

Prior to acceptance and use of any method, satisfactory initial demonstration of method performance is required. This initial demonstration of method performance is performed each time there is a significant change in instrument type, personnel or test method.

4.0 SPECIFIC ROUTINE PROCEDURES USED TO EVALUATE DATA QUALITY

Quality control acceptance criteria are used to determine the validity of the data based on the analysis of internal quality control check (QC) samples. The specific QC samples and acceptance criteria are found in the laboratory SOPs. Typically, acceptance criteria are taken from published EPA methods. Where no EPA criteria exist, laboratory generated acceptance criteria are established. Acceptance criteria for bias are based on

the historical mean recovery plus or minus three standard deviation units, and acceptance criteria for precision range from zero (no difference between duplicate control samples) to the historical mean relative percent difference plus three standard deviation units.

Analytical data generated with QC samples that fall within prescribed acceptance criteria indicate the laboratory was in control. Data generated with QC samples that fall outside the established acceptance criteria indicate the laboratory was "out-of-control" for the failing tests. These data are considered suspect and the corresponding samples are reanalyzed or reported with qualifiers.

Many published EPA methods do not contain recommended acceptance criteria for QC sample results. In these situations, ChemSolutions uses 70 - 130% as interim acceptance criteria for recoveries of spiked analytes, until in-house limits are developed. In-house limits are based on a 95% confidence interval and must include a minimum of 20 data points.

4.1 Laboratory Control Samples

A laboratory control sample (LCS) is analyzed with each batch of samples to verify that the accuracy of the analytical process is within the expected performance of the method. The results of the laboratory control sample are compared to acceptance criteria to determine usability of the data. Data generated with LCS samples that fall outside the established acceptance criteria are judged to be out-of-control. These data are considered suspect and the corresponding samples are reanalyzed or reported with qualifiers.

4.2 Matrix Spikes/Matrix Spike Duplicates

Results from MS/MSD analyses are primarily designed to assess data quality in a given matrix, and not laboratory performance. In general, if the LCS results are within acceptance criteria, performance problems with MS/MSD results may either be related to the specific sample matrix or to an inappropriate choice of extraction, cleanup, or determinative methods. If any individual percent recovery in the matrix spike (or matrix spike duplicate) falls outside the designated acceptance criteria, ChemSolutions will determine if the poor recovery is related to a matrix effect or a laboratory performance problem. A matrix effect is indicated if the LCS data are within acceptance criteria but the matrix spike data exceed the acceptance criteria.

4.3 Surrogate Recoveries

Surrogates are exclusively used in organic analyses. Surrogate recovery data from individual samples are compared to surrogate recovery acceptance criteria in the methods. As for MS/MSD results, surrogate recoveries are used primarily to evaluate data quality and not laboratory performance.

4.4 Method Blanks

Method blank analyses are used to assess acceptance of sample results. The source of contamination is investigated and measures taken to correct, minimize or eliminate the problem if:

- The blank contamination exceeds a concentration greater than 1/10 of the measured concentration of any sample in the associated sample batch; or
- The blank contamination exceeds the concentration present in the samples and is greater than 1/10 of the specified regulatory limit.

Each sample in the affected batch is assessed against the above criteria to determine if the sample results are acceptable. Any sample associated with the contaminated blank is reprocessed for analysis or the results reported with appropriate data qualifying codes.