FINAL

Protocol for Performing Indoor Air and Near-slab Soil Gas Assessments
700 South 1600 East PCE Plume Superfund Site
Salt Lake City, Utah

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1.0 Introduction

This document provides a protocol for the use of real-time on-site gas chromatography/mass spectrometry (GC/MS) analysis to screen for indoor sources, identify potential points for vapor intrusion, screen for the presence of volatile organic compounds in soil gas and indoor air, and direct 24-hour SUMMA canister sampling at selected locations (with TO-15 analyses) to evaluate the potential for vapor intrusion in structures associated with the Accelerated Operable Unit-1 (AOU-1) portion of the 700 South 1600 East PCE Plume (Plume).

The AOU-1 Remedial Investigation will involve an assessment structure including residential, commercial, and public buildings within the Study Area. The objectives of the investigation are several-fold:

- Determine, using real-time indoor air sampling via portable laboratory equipment and confirmatory EPA TO-15 analyses for volatile organic compounds (VOCs), if there is an immediate threat to human health in structures associated with the Plume.
- Expedite the indoor air assessment using real-time data from a field-portable GC/MS to identify indoor sources and identify potential vapor intrusion points during negative depressurization followed by positive pressurization of the entire structure or key discrete portions, as determined practical in the field.
- Collect indoor and near-slab soil vapor data as part of a collaborative data-set that will support the overall remedial investigation of both the groundwater plume and vapor intrusion potential, development of a periodic indoor air monitoring program for AOU-1, future risk assessment, and refinement of the conceptual site model.
- Determine the relationship between a subset of co-located TO-15 grab samples and field-portable GC/MS air sample results for determining the comparability of the field instrument to provide acceptable and usable real-time data.

This vapor intrusion investigational approach was adopted from an Environmental Security Technology Certification Program (ESTCP) Project No. ER- 201119-Final Report (GSI, 2013) and ER-201119-GD- Standard Protocol (GSI, 2014) and provides an alternative to the conventional investigation method of indoor air and sub-slab testing. The project-specific Quality Assurance Project Plan (QAPP) and Sampling and Analysis Plan (SAP) (including Standard Operating Procedures (SOPs) for HAPSITE preparation and general operation) were

also used as references for this Protocol, as well as the Infinicon HAPSITE Smart Plus™ and HAPSITE-ER™ Operating Manuals.

The Protocol relies on the use of on-site data acquisition of indoor air volatile organic contaminants and near-slab soil gas using field portable gas chromatography/mass spectrometry (GC/MS) for real-time assessment of structures. The protocol also provides a methodology for locating and quantifying sources of indoor air contamination should indoor air contaminants be identified during the assessment process. For this study, the field portable instrument will be the HAPSITE Smart Plus™ or HAPSITE ER Chemical Identification System™ (HAPSITE). Indoor air constituents detected above initial action screening levels proposed by the Department of Veterans Affairs (VA) will be confirmed by conventional 24-hour SUMMA canister sampling. The SUMMA canister samples will be analyzed using Environmental Protection Agency (EPA) Method TO-15 Select Ion Monitoring (SIM) and TO-15 laboratory analyses by a National Environmental Laboratory Accreditation Program (NELAP)-certified off-site laboratory.

The following activities will be performed as part of the Protocol. Real-time assessment using the HAPSITE™ will determine the nature and applicability of specific activities. For AOU-1, the decision criteria are contained in the technical memorandum: Vapor Intrusion Screening Levels and Removal Action Levels 700 South 1600 East PCE Plume, Salt Lake City, Utah dated 10/17/2014.

- Selection of Structures for Vapor Intrusion Assessment (Section 3.0) – selection of structures to be included in the Remedial Investigation.
- Pre-Assessment Activities (Section 4.0) – confirmation of access agreements/ permissions, schedules, and address for testing; property owner/occupant review of questionnaire for locating potential indoor air background sources; and building condition assessment for sampling locations.
- HAPSITE™ Use, Calibration and QC Checks (Section 5.0) – use and operation, initial calibration; continuing calibration and tuning checks, overnight storage, and regular maintenance.
- Outdoor (upwind) Real-time Qualitative Sampling (Section 6.0) - conduct ambient outdoor (background) testing at an upwind location adjacent to the structure using the HAPSITE ™ in analyze mode to identify presence of target VOCs.
- Initial (upon entry) Survey of indoor VOC Concentrations/Identification of Interior Background Sources (Section 7.0) – room-by-room (or groups of room openly connected) walk through of the structure using the HAPSITE™ in survey mode to identify the presence of any elevated VOC concentrations, followed by localized (sub-areas of rooms) assessments as indicated by initial results to identify and record locations of interior background sources.
- Survey of Potential Vapor Intrusion Entry Points (Section 8.0) – areas identified during initial building condition assessment inspection to assess for vapor entry points using HAPSITE™ in survey mode.
- Initial Real-Time Quantitative Sampling (Section 9.0) – under ambient conditions, interior floor-by-floor and (if necessary) room-by-room quantitative assessment of target chlorinated VOCs: Tetrachloroethylene (PCE); Trichloroethylene (TCE); cis-1,2-Dichloroethylene **(**cis-1-2-DCE); and, Vinyl Chloride (VC).

- Negative Pressure Real-Time Quantitative Sampling (Section 10.0) – place the building interior, or if the structure is divided into discrete areas, the portion of the building interior identified as having the greatest potential for vapor intrusion, under negative pressure, and conduct continuous (repeated samples at a central location) quantitative sampling for target chlorinated VOCs during initial depressurization and air exchange, followed by quantitative sampling using the HAPSITE™ on all other floors while building is under negative pressure.
- Positive Pressure Real Time Quantitative Sampling (Section 11.0) – place the building interior, or if the structure is divided into discrete areas, the same portion of the interior where depressurization was previously performed, under positive pressure and conduct continuous (repeated samples at a central location) quantitative sampling in the same locations and sampling procedures as used during the negative depressurization.
- SUMMA Canister Sampling (Section 12.0) – SUMMA™ canisters (24-hour samples) deployed after interior background source are identified and after quantitative HAPSITE™ sampling under ambient and negative pressure, if data indicates exceedances of the established risk action screening levels for any analyte.
- Near-Slab Real-Time Soil Gas Sampling (Section 13.0) – perform real-time, near-slab soil gas quantitative evaluation of contaminants of interest using the HAPSITE™ in analytical mode. Collect SUMMA canister samples at selected sampling probe locations adjacent to structures where indoor SUMMA™ canisters were collected, plus at least two soil gas locations without detectable COCs in soil gas.
- Data Management and Distribution (Section 14.0) – data management and distribution to project participants.

2.0 Problem Definition

A PCE plume (Plume) has been detected in the vicinity of the George E. Wahlen VA Medical Center (VAMC or Facility). The Plume underlies the neighborhoods surrounding the intersection of 700 South and 1600 East in Salt Lake City, Utah, a blended commercial and residential area of approximately 300 acres. PCE was detected at parts per billion (ppb) levels in one of Salt Lake City's secondary drinking water wells (removed from service in 2004) and the Mt. Olivet Cemetery irrigation well. PCE has also been detected at ppb levels in shallow and deep groundwater, surface water springs, and in storm sewers in this area.

VA subsequently designated the primarily residential area on and just below the Wasatch Fault Scarp as AOU-1, also known as the East Side Springs area. This area is characterized by numerous small seeps and springs, some of which discharge PCE-containing groundwater to the land surface near the suspected downgradient margin of the PCE plume. The residential areas just to the north of AOU-1 and a dry gulch just to the east of AOU-1 are included in AOU-1. The northernmost and easternmost portions of AOU-1 are not currently known to contain springs or seeps, and the depth-to-groundwater beneath the surface is not known. However, the proximity of these areas to the groundwater table and springs containing PCE warrant further study to determine whether any subsurface contaminants related to the Site extend to those areas and pose risks to human health and/or the environment.

The primary public health concern within AOU-1 is the potential for vapor intrusion of chlorinated volatile organic compounds, associated with the Plume, into surrounding homes, schools, and other structures in the East Side Springs area. The potential public health threat is the accumulation of volatilized PCE and its degradation by-products from contaminated

groundwater into proximal occupied structures above regional screening levels; thus creating an inhalation exposure hazard. The potential pathways for PCE (and associated degradation products) into indoor air may include the surrounding or underlying soil gas, surface water springs, and shallow groundwater in the vicinity of the structure or dwelling.

This protocol outlines performing real-time and conventional indoor-air assessment of structures associated with the East Side Springs in order to rapidly assess excess risk associated with contaminated indoor air resultant of VI and to obtain legally defensible data for future mitigation decisions.

3.0 Selection of Structures for Remedial Investigation Initial VI Assessment

Prior to field-activities, the VA and technical team will coordinate the solicitation of property owners for voluntary testing of their property for VI assessment. VA plans to approach the 50 or so property owners that have already indicated a willingness to allow testing and pending access permission, structures on these properties will constitute the initial group of buildings to be tested for potential vapor intrusion. VA's goal is to identify a sufficient number of structures within the known location of the Plume and outside the Plume that may exhibit a full-spectrum of indoor air vapor concentrations for the contaminants of interest. Of the 50 or so properties to date where owners have volunteered for testing, some are located within the approximate known areas of the Plume where PCE detections in the surface springs were encountered, some are above the Plume in areas where groundwater is at least 30 to 50 feet below the surface, some are located over shallow groundwater that is outside the Plume, and some are located a considerable distance from the known Plume extent and well above the groundwater table.

The rationale for testing a range of locations within the Remedial Investigation Area is to: (1) maximize the probability of encountering structures with a spectrum of measurable concentrations of the contaminants of interest in the known impact areas; and (2) maximize the probability of encountering some structures with no or minimal levels of the contaminants. The combined data-set will be used as an early guide to recruit additional sampling locations and prioritize the recruitment based on potential for vapor intrusion.

4.0 Pre-Assessment Activities

Pre-assessment activities include the following: (1) confirming that an access agreement/permission of the property owner is in place, confirming the schedule for the investigation, and the structure's address; (2) reviewing questionnaire responses in order to evaluate potential indoor air background sources; (3) identifying indoor air sampling locations and evaluating the structural conditions that may affect vapor intrusion; and (4) noting the locations of background sources (to the extent possible) of materials containing chlorinated volatile organics. The activities noted for 1, 2, and 3, above, may be done in advance of the arrival of the sampling team whenever possible. Removal of significant background sources, including non-target sources such as gasoline or paint thinners that are likely to potentially overwhelm the field instruments, will be discussed with owner upon arrival and removed from the structure with their permission to the extent possible. For this effort, the assessment team will consist of two individuals, at least one of which is trained and certified by the equipment vendor on the use of the HAPSITE.

4.1 Confirmation of Access Agreements, Schedules, and Addresses

Prior to arriving at the testing site, the assessment team will confirm with the VA that permission for access is in place, the scheduled date and address are correct, and a responsible party will be at the building to grant access and provide pertinent information. For the day of the assessment, upon arrival of the sampling team, the property owner will be asked to close all windows, exterior and interior doors, and shut off any forced air climate control equipment for the duration of each sampling task that requires no air circulation (i.e., indoor source survey and entry point survey, negative depressurization). Between sampling tasks and during personnel breaks or lunchtimes, forced air climate controls can be restarted to maintain indoor temperatures. Homes with baseboard electric heat or hot-water radiator heat do not require systems to be turned off.

4.2 Review of Building Questionnaire Responses

A questionnaire will be filled out by the property owner or building occupant prior to on-site assessment and reviewed by the assessment team. The questionnaire will include information regarding the layout of the structure (e.g., number of floors, approximate square-footage, rooms on each floor, attached structures); and the type and location of potential background sources (dry cleaning, glues, solvents, fuels, cleaning products). This information will be used to (1) identify initial sampling locations; and (2) locate and document any potential background sources prior to conducting any screening or sample collection.

4.3 Building Survey

Upon arrival at the building, if the structure was not able to be inspected and the layout obtained prior to the sampling date, the assessment team will perform a walk-through to confirm the layout of the structure. The assessment team will sketch a floor plan layout showing each room on each level with approximate dimensions of each room. Any obvious interior background sources identified from the questionnaire or during the walk-through will be documented as to the type of product and its location within the structure. Unless the source is creating high concentrations of indoor VOCs that will overwhelm the HAPSITE™, all identified background sources will be left in place. The potential source and location will be recorded on the sampling record, as well as the presence of any fixed sources that cannot be removed such as new carpet, freshly painted surfaces, etc. From the building survey, initial quantitative sampling locations will be marked on the layout sketch. These initial locations shall be, at a minimum, on every level and generally centered within the level.

5.0 HAPSITE™ Use, Calibration, and QC Checks

5.1 HAPSITE™ Use

The HAPSITE™ will be operated by a KD Analytical Trained and Certified assessment team member. The trained assessment team member will be familiar with the general use of the instrument, as well as with the project specific measurements and QC requirements.

The HAPSITE™ will be used in two modes - Quantitative Analyze and Qualitative Survey. In Quantitative Analyze mode the instrument will detect and quantify the target chlorinated VOCs: PCE, TCE, cis-1,2-DCE, and VC. The sensitivity of the HAPSITE™ for chlorinated VOCs in Analyze Mode is 0.1 to 0.5 µg/m3, which is below the characterization criteria (EPA RSLs; in parentheses) for PCE, but close to the criteria for the other selected target analytes: PCE (11.0 µg/m3, TCE (0.48 µg/m3), VC (0.17 µg/m3), and cis-1,2-DCE (no value established by EPA). In Qualitative Survey Mode the instrument will be used as a screening tool for the

continuous-reading of the target analytes. The sensitivity of the HAPSITE ™ for the target analytes in Survey Mode is in the low mg/m3 range. Survey mode will be used to assess the location of background sources from indoor products and materials, as well as determine potential entry points for subsurface vapor contaminants.

For the Analyze Mode, a project-specific sample intake and analysis method has been developed for the HAPSITE™ by the operator focusing on the target analytes: PCE, TCE, cis 1,2-DCE, and VC. The selective ion monitoring (SIM) mode will be used to increase the detector sensitivity for the target analytes. The customized method for the HAPSITE™ will include selecting the characteristic ions for each compound targeted, the temperature settings, GC temperature profiles, including ramp times and rates, and the timing and mass measurements associated with each scan set in the method. The equipment vendor is providing the method programming pre-installed as a selection option on the HAPSITE™. These parameters can also be modified or reset according to manufacturer instructions provided in the HAPSITE™ Operations Manual (included as an attachment to the SAP). The method will be designed for low concentration samples (i.e., 0.1 – 10 ppbV range). However, if high concentrations are encountered (e.g., 100 – 1,000 ppbv), the method can be modified simply by reducing the sampling duration – effectively diluting the sample and raising the lower quantification limit for any lower concentration VOCs.

In the Survey Mode, the HAPSITE™ by-passes the GC column and sends a continuous sample directly to the mass spectrometer detector. Survey mode for this project will be used to continuously search for indoor background generating materials and for screening potential entry points for subsurface vapors. For the Survey Mode, the HAPSITE™ is carried from room to room and the concentrator probe placed near a suspected source or near potential vapor intrusion points (e.g., foundation cracks) to identify concentrations of VOCs, as further discussed below.

5.2 Calibration and QC Checks

For the Analyze Mode, tuning, initial calibration, continuing calibrations, and QC checks will be performed to assure that the instrument meets the data quality objectives specified in the Quality Assurance Project Plan.

Prior to the analyses of any samples, blanks, or calibration standards in Analyze Mode, the instrument performance check (tuning check) will be performed to establish that the HAPSITE™ meets the mass spectral ion abundance criteria. The instrument tuning check (also known as the continuing calibration verification; CCV) gas will be analyzed initially following the calibration of the HAPSITE™ and once per 24-hour time period of operation. In the event the instrument performance check standard does not meet criteria, the HAPSITE™ will not be used in Analyze mode until corrections (including recalibration) are made in accordance with the Operators Manual, however, the Survey Mode may be used to look for the selected ions of the chemicals of interest.

The HAPSITE™ will be calibrated using a minimum of five chemical concentrations that span the monitoring range of interest (0.1 ppbv to 100 ppmv) in an initial calibration sequence to determine instrument sensitivity and the linearity of GC/MS response for the target compounds (PCE, TCE, cis-1,2-DCE, and VC). QA criteria for calibration curve acceptability are: Relative Standard Deviation (RSD) <20%; RSD of RF < 30%; and curve fit R-Squared (R^2) ≥ 0.98, where the RSD % is the measure of the linearity of the concentration levels (ion counts) in the calibration curve for each compound; and the Relative Standard Deviation of the Response Factor (RSD of RF %) is the measure of the linearity of the response factors for each

compound in the calibration curve, where the response factor is a measure of the relative response (ion count) of an analyte compared to that of an internal standard. Calibration will be conducted in accordance with the procedures described in detail within the HAPSITE™ Operation Manual attached to the SAP. R^2 is the coefficient of determination or correlation coefficient squared and measures variation in the y variable attributable to the x variable. In the case of instrument calibration, this is the instrument reading relative to the known concentration of a calibration standard.

Prior to the daily analysis of samples and blanks, but after tuning criteria and initial calibration have been met, the initial calibration of the GC/MS system must be routinely checked by analyzing a continuing calibration verification (CCV) standard to ensure that the instrument continues to remain within control limits. The CCV standard will be performed once every 24 hours.

The initial equipment checks and QA analyses will be performed using a project-specific method and calibration library provided onboard the instrument. If the QA results fall outside of the desired performance goals, the instrument will be recalibrated.

In the event a sample concentration overwhelms the HAPSITE™ (i.e., concentrations completely saturate the detector as indicated by analytical results), the instrument will require purging of the analytical system with nitrogen in accordance with the Operators Manual to clean the detector before the next sample can be analyzed. Purging shall continue until the instrument results (blanks) indicate the no carry-over concentrations remain.

5.3 Storage and Routine Maintenance

The HAPSITE should be stored in a climate-controlled, dry location where it can be plugged into a stable power outlet and left in “Stand-by” mode – even over weekends. The use of Stand-by mode maintains the system temperature and carrier gas pumps and preserves the system calibration so that daily startup times are considerably shorter. A properly stored HAPSITE in standby mode can maintain its reliability and calibration for up to a month.

The routine maintenance schedule of the HAPSITE is described in the QAPP and in the Operators Manual. Key maintenance includes switching tuning standard cylinders and performing self-test programs before beginning sampling. The internal power source (battery) for the HAPSITE™ provides only two to three hours of operation time and, except when using the instrument in Survey Mode, the HAPSITE should be placed on the floor or on a cart and connected to external electrical 110 Volt AC power.

6.0 Outdoor Real-time Qualitative Sampling

After confirming that the HAPSITE™ meets tuning and continuing calibration requirements, and upon arrival at a testing site, the HAPSITE™ shall be operated in Analyze Mode to collect an ambient outdoor background sample. The sample is acquired in order to define the ambient (outdoor) concentration of the target VOCs.

The outdoor quantitative sampling should be conducted upwind, but within 10 to 30 feet of the structure to be assessed. The sample is collected upwind of the building at a height of approximately three to five feet above the ground surface (approximating the breathing zone). Outside weather conditions shall be recorded including temperature, barometric pressure, wind direction, and an estimate of wind velocity (categorical).

7.0 Identification of Interior Background Sources

Consumer products and household items are commonly found to be significant sources of chlorinated VOCs in indoor air (see Table below).

CHEMICAL[1]	GENERAL CATEGORIES
1,2-DCA	Molded plastic products, air fresheners
Carbon Tetrachloride	Aerosol cans, refrigerants, dry cleaned clothes, varnish
Chloroform	Dry cleaned clothes, fire extinguishers, adhesive remover, chlorinated drinking water
PCE	Dry cleaned clothes, automotive brake cleaners, metal degreasers, hobby craft glue
TCE	Self-defense pepper spray, degreaser, rug-cleaners
Trans-1,2-DCE	Taxidermy foam, refrigerants, cleaning solutions
1,1,1-TCA	Cleaners, adhesives, aerosol cans

1) Data sources: U.S. Department of Health and Human Services. Household Products Database. 2012.

After collecting a quantitative outdoor ambient background sample, the HAPSITE™ shall be switched to operate in Survey Mode inside the building to identify the presence of any elevated VOC concentrations. The initial indoor survey should be conducted by walking through the structure room-by-room (or groups of openly connected rooms) while holding the HAPSITE™ probe at waist level and observing instrument responses (ion count). The initial room to room survey will be followed by localized (sub-areas of rooms) assessments as indicated by initial results to identify and record locations of interior background sources.

The indoor source identification procedure involves using a combination of continuous-read qualitative analysis in survey mode, visual inspection, and isolation. In continuous-reading survey mode, the instrument is used to scan potential sources for the specific target analytes. In survey mode, scan near storage units (e.g., cabinets, closets, storage containers, etc.) and product containers found in the room(s) with the highest concentration of the target VOCs detected during the initial survey and quantitative testing. As the potential source area is approached, the ion counts on the instrument will increase. If an instrument response is observed for a storage unit such as a cabinet or drawer, with permission of the property representative, examine the unit for products or materials. Examine the product labels to see if the target VOC is identified on the label and note the type of product on the sampling record. Do not remove the products, return the unit to its as found condition, and proceed with the assessment. If permission is not granted to inspect a storage unit, the area will be noted as a possible source of background contamination.

Locations of identified indoor sources will be recorded on the electronic sampling forms and rooms with elevated VOCs not tied to an indoor source shall be noted for further investigation for vapor intrusion points.

8.0 Survey of Potential Vapor Intrusion Entry Points

Areas identified in the initial VI assessment inspection and during the initial walk-through of the structure for potential vapor intrusion entry points will be assessed using the HAPSITE™ in survey mode. The vapor intrusion entry survey will be concurrent with the indoor source survey to the extent practical.

The instrument will be used to scan potential vapor entry points such as sumps, floor drains, expansion joints, plumbing penetrations, or foundation cracks. The sampling port is placed near the potential vapor entry point. If the ion counts increase in the vicinity of the entry point, then there is evidence that there is a vapor intrusion problem. In addition, any VOCs identified by type by the instrument will be recorded. The particular room (or rooms) shall be further evaluated in quantitative mode under depressurization conditions.

9.0 Initial Real-time Quantitative Sampling

After the initial Survey for indoor background and vapor intrusion points for target VOCs has been completed, the HAPSITE™ shall be switched to Analyze Mode to conduct real-time quantitative indoor air sampling and analysis (under ambient pressure conditions). Based on the structural assessment, floor plan of the structure, and Survey Mode results, an initial indoor sample for quantitative analysis will be collected from the three to five foot high breathing zone interval in each major floor level within the building; for example, the basement, main floor, and second floor of the structure. Additional samples may be collected from potential indoor source areas such as an attached garage and from specific rooms where the initial survey indicated evidence of elevated VOCs.

If the concentration of the target VOCs in all areas is below detection limits or below the screening action level concentrations, then it can be concluded that there are no significant background sources of indoor air contamination. The assessment then proceeds to performing an indoor air assessment under negative pressure conditions (Section 10.0). If target VOCs in one or more major areas are detected above screening levels, then a more detailed quantitative assessment is performed to determine the specific rooms associated with the areas exhibiting the highest concentrations. For example, if the VOC concentrations from the first round of sampling were highest in the basement, each room in the basement would be sampled in quantitative mode.

10.0 Negative Pressure Real-Time Quantitative Sampling

Building depressurization (negative pressure) can exacerbate a vapor intrusion problem and may be a conservative means of detecting vapor intrusion within a structure. The structure will be placed under a stable differential pressure of -5 pascals using a variable speed louvered air door installed in a doorway located at the lowest possible level at the structure. A recording digital manometer will be used to measure the indoor versus outdoor pressure differential and the structure will be maintained under negative differential pressurization for 30 minutes (or until at least 2.5 air exchanges have occurred) before initiating sampling. The louvered air door to be employed in the depressurization will be capable of exhausting up to 6,000 cubic feet per minute of air; however, depending on construction tightness of the structure, particularly in homes built prior to the 1970s, air leakage into the home may not allow attaining of the -5.0 pascal target depressurization level. In this case, testing will proceed as long as any differential depressurization can be achieved. In the event the structure does not achieve a one pascal depressurization relative to the outdoors, this will be taken as an indicator that the structure

construction is so leaky with respect to outdoor air that depressurization does not naturally occur and will be noted on the sampling forms, and the sampling will continue to verify that no increases in concentrations occurred..

The HAPSITE™ will be deployed in Analyze Mode in a high-risk location (defined as the lowest living or occupied level of a structure and where vapor intrusion is most likely to occur) immediately prior to the start and operated continuously (one sample every eight minutes or as often as instrument cycling allows) during negative pressurization until the 2.5 air exchanges have been attained. Upon achieving conditions stated above, additional quantitative sampling will be performed on every level of the structure, in the same locations used during the ambient characterization. If the previous entry point screening using the HAPSITE™ in Survey mode identified an area of probable vapor intrusion, then a quantitative measurement will be performed in that room while it is under negative depressurization.

It is important to note that the residences and structures to be tested range in size from single floor dwellings to large public buildings and range in age from 30 to over 100 years. In the event that an entire structure cannot effectively be placed under negative pressure due to size, floor plan layout, or extreme air leakage, the blower door will be located to depressurize the lowest level of the structure where vapor intrusion is most likely to occur, as indicated by the previous testing results. The final decision will be made by the field team leader, and the decision rationale noted in the electronic field record.

11.0 Positive Pressure Real Time Quantitative Sampling

Building pressurization (positive pressure) can assist in the differentiation of indoor background sources and actual vapor intrusion. The structure will be placed under a stable differential pressure of +5 pascals using a variable speed louvered air door installed at the same location as used for the negative depressurization discussed in Section 10.0. In addition, if the initial indoor source survey and ambient quantitative analysis results suggest an indoor source on an upper level, the pressurization test will be conducted with the blower door installed on that level. A recording digital manometer will be used to measure the indoor versus outdoor pressure differential and the structure will be maintained under positive differential pressurization for 30 minutes (or until at least 2.5 air exchanges have occurred) before initiating sampling. Testing will proceed as long as any differential pressurization can be achieved. In the event the structure does not achieve pressurization relative to the outdoors, the building will be assumed to be too leaky to pressurize and any reduction in vapor concentrations is the result of fresh air dilution.

The HAPSITE™ will be deployed in Analyze Mode in a high-risk location (defined as the lowest living or occupied level of a structure and where vapor intrusion is most likely to occur) immediately prior to the start and operated continuously (one sample every eight minutes or as often as instrument cycling allows) once positive pressurization is achieved until the 2.5 air exchanges have been attained. Upon achieving conditions stated above, additional quantitative sampling, at a minimum, will be performed on every level of the structure, in the same locations used during the ambient characterization. If the previous entry point screening using the HAPSITE™ in Survey mode identified an area of probable vapor intrusion, then a quantitative measurement will be performed in that room while it is under positive pressurization.

It is important to note that the residences and structures to be tested range in size from single floor dwellings to large public buildings and range in age from 30 to over 100 years. In the event that an entire structure cannot effectively be placed under positive pressure due to

building size, floor plan layout, or extreme air leakage, the blower door will be located to pressurize the lowest level of the structure where vapor intrusion is most likely to occur, as indicated by the previous testing results, and secondly, in the area noted as most likely containing indoor source materials. The final decision will be made by the field team leader, and the decision rationale noted in the electronic field record.

12.0 SUMMA™ Canister Sampling

Laboratory confirmation samples will be collected from structures where any quantitative HAPSITE ambient indoor or quantitative HAPSITE™ depressurization analyses exceed the screening action levels for any target VOC. Sample collection will use a 24-hour composite sample from a SUMMA™ canister and will be analyzed by Method TO-15.

For residences or other occupied buildings meeting this criteria, at least one indoor air sample for lab analysis will be collected per building. This sample will typically be collected in the lowest regularly occupied level of the home (either a finished basement or first floor) in contact with the ground. If the specific construction or configuration of a residence suggests one indoor sample will not be representative, or field-based detections of any contaminant of interest are detected in widely separated multiple locations, then a second indoor air sample may be collected from another living space, working space, or an unfinished basement room, as indicated by HAPSITE™ characterization results. A house or dwelling's heating and cooling systems can be used during the SUMMA™ Canister sampling.

Non-residential structures such as school buildings and businesses will be screened for indoor air sources, vapor entry points, and negative/positive pressurization as described above, and SUMMA™ canister sample locations will be selected based on the uses of the lower levels of the structure or where VI is most likely to occur. In particular, basement level classrooms in school buildings may be tested with SUMMA canisters for lab analysis regardless of the HAPSITE™ results.

In addition, at least three structures that exhibit concentrations below screening levels (including at least one location with no HAPSITE™ detection of target VOCs) will be sampled using 24-hour SUMMA canisters.

The indoor air samples for full laboratory analysis will be collected into laboratory-supplied six-liter SUMMA™ canisters over a 24-hour period, as detailed below:

- A clean and inerted six-liter Summa canister under a 25 in. Hg vacuum equipped with a flow regulator will be placed at a height of three to five feet above the floor in the center of the space to be sampled.
- The flow regulator will be set to collect a 24-hour time weighted sample (approximately 4 ml/min).
- Sampling will be stopped (i.e., the valves closed and the canister disconnected) after about 24 hours once the vacuum reaches about 5 in. Hg).
- The sampling crew will record the sample name, initial and final vacuums, initial and final sampling times, canister and flow controller serial numbers, and other pertinent information on the field sampling summary and laboratory Chain of Custody (CoC) forms.
- Canisters will be packed in a rigid wall shipping container, such as a cooler or heavy-duty cardboard box (ice is not required), if shipping is required.

- A custody seal will be placed over the openings to the shipping container.
- The shipping container will be shipped or delivered immediately to the laboratory for analysis.
- All samples will be accompanied by the CoC as described in the QAPP.

SUMMA™ Canister sampling will be conducted in accordance with the SOPs provided in the SAP.

As an additional confirmation on the accuracy and precision of the HAPSITE™, up to six instantaneous SUMMA™ grab samples will be collected and analyzed for TO-15 parameters in residences where VOCs are detected during the HAPSITE quantitative sampling. The grab samples will be co-located with the HAPSITE™ sample probe and collected by opening the SUMMA™ canister valve to allow the canister to fill concurrently with the HAPSITE sample intake process. The results will represent the VOC concentrations present at a given location at the time of collection and can be correlated compared directly to HAPSITE quantitative results similar to a duplicate sample analysis.

13.0 Near-Slab Real-Time Soil Gas Sampling and Analysis

The near-slab soil gas characterization approach will be implemented concurrent with the indoor air characterization to identify and characterize target VOCs present in soils adjacent to tested structures. The purpose of the soil gas sampling is two-fold (1) provide soil gas concentrations near structure foundations for support of the AOU-1 Vapor Intrusion Risk Assessment pathway evaluation process; and (2) provide information to help define the potential extents of the underlying groundwater VOC plume.

Near-slab soil gas characterization will be performed adjacent (within five feet) to all structures screened and assessed for indoor vapor intrusion. Soil vapor probes will be driven adjacent to the structure's foundation to a depth approximately six inches below the base of the foundation or to the top of the water table, whichever occurs first. Samples will be collected with a peristaltic pump and Tedlar® bags, field screened with a PID and multi-gas meter, then a second sample collected in the same manner and field-screened in real-time with the portable GC/MS in analyze mode to identify and quantify any target VOCs present in soil pore space adjacent to structures. At locations where groundwater is not encountered at the base of the foundation, after sampling, the probe rod will be driven another five feet, if soil conditions allow, and the sampling process repeated to obtain vertical delineation data for soil gas. If groundwater is encountered, the approximate depth-to-water will be measured and recorded, the probe re-installed to just above the water table, and a soil gas sample collected just above the water level.

Soil gas samples will also be collected in SUMMA™ canisters and analyzed for full volatile organics (TO-15) analysis for any near-slab characterization sample where indoor SUMMA™ canisters are collected. In addition, three selected locations throughout AOU-1 where the field portable GC/MS did not detect target VOCs in soil gas above screening levels will be sampled. Sampling for laboratory analyses will be accomplished using SUMMA™ canisters equipped with flow regulators to collect 24-hour time-averaged samples from the soil vapor probes.

In addition to confirmatory VOC analyses, five percent of the soil gas sampling locations within the PCE plume area will be selected for additional Semi-Volatile Organic Compound (SVOC) analyses using method TO-13A. Method TO-13A employs laboratory-supplied sorbent tubes

attached inline between the vapor probe and a vacuum pump set at a flow rate of 5 L/min for 480 minutes (8 hours). SVOC samples are for informational purposes to support full characterization of the plume nature and extent, and possible future risk assessment of the Site.

The procedures for emplacing the soil gas probes, testing the integrity of the seal, and for collecting and analyzing samples both for the HAPSITE™ and the TO-15 Method and TO-13A Method are described in the QAPP (Section 2.3.2) and the SAP (Section 5.4).

14.0 Data Management and Distribution

14.1 Data Management

Information that will be included in the project data record relative to the indoor air study include field log books, sample collection and handling records, operational records, GPS data, chain-of-custody forms sample receipt records, and shipping documentation. Field log books may be kept electronically via hand-held tablets.

The project field team leader will be required to maintain a field logbook of daily activities. A separate logbook of suitable material that will be bound with consecutively numbered pages will be used for this project. All entries will be legibly written in black ink. Any entry errors are corrected by drawing one solid line through the incorrect entry followed by the user's initials and date. The bottom of each page is signed and dated by the individual making the entries. Factual and objective language will be used. All entries will be complete and accurate enough to allow reconstruction of each field activity. Activities should be recorded contemporaneously.

The field logbook cover will include the following information:

- job name, contract, and delivery order numbers,
- site activity name,
- start date,
- end date of last logbook entry.

Daily entries of the following minimum information will be recorded in the logbook as follows:

- date and time, expressed in 24-hour (military) format;
- sampling start/stop times;
- weather conditions;
- personnel present;
- field observations;
- site identification and building layout (visual sketches where appropriate);
- location of sampling points (GPS coordinates and/or visual sketches where appropriate);
- description of sample;
- sample identification number;
- number of samples taken;
- time of sample collection;
- number of Quality Assurance/Quality Control (QA/QC) samples taken;
- type and mode of field instrumentation;
- names of people collecting samples;
  all calibrations done;
- any other field instruments;

- any general observations or notes;
- any deviations from the sampling plan.

Sample custody will be documented on standardized CoC records, an example of which is included in Attachment 3 of the QAPP. The CoC record establishes the documentation necessary to trace sample possession from time of collection through sample analysis and final disposition. A sample is in the custody of a person if any of the following criteria are met:

- the sample is in a person's physical possession;
- the sample is in a person's view after being in his or her physical possession;
- the sample was in a person's physical possession and was then locked up or sealed to prevent tampering; and/or
- the sample is kept in a secured area.

Field forms including soil gas sampling data sheet, indoor air sampling data sheets, HAPSITE calibration, and QC information will be used during field work. Examples of these forms can be found in Attachment D of the QAPP.

Photographs will be taken in the field to document sampling locations and conditions. Digital camera photographs will be taken with the date/time record turned on. Photographs of all sampling locations will be taken with the sample number. A photographic log will be kept in which the date, location, photographer's name, and direction the photographer is facing (if appropriate) will be recorded. Photographs will be labeled, placed in a binder or stored electronically, and submitted at the end of the field work. Selected photographs will be used in reports as deemed necessary or appropriate.

14.2 Data Distribution

Data distribution, in the form of reports and memos, are described in the QAPP (Section 4.2) and are summarized below:

- *Weekly Field Status Reports* – Communicates to VA Remedial Project Manager (RPM) weekly progress and any significant preliminary findings, QA/QC issues, and changes to the field schedule.
- *Progress Reports* – Communicates the progress made by VA and its consultants on a monthly basis regarding site investigation, community involvement, achievement of project milestones, and the myriad of actions that encompass the investigation of AOU-1.
- *Environmental Media Reports* – Communicates in brief the conclusions of individual investigation events (Indoor Air, Soil Gas, Surface Water, and Groundwater) for AOU-1 and any laboratory analysis associated with the event. These reports will be written by the Program Manager and submitted to the VA RPM, EPA, and Utah Department of Environmental Quality (UDEQ).
- *Nonconformance Reports* – Identifies any deviations of planned or expected scope-of-work activities relating to the investigation of AOU-1. Reports may pertain to field data collection, health and safety events, etc. These reports will be written by the FET Program Manager or QA Manager. The reports will be submitted to the VA RPM and Quality Assurance Manager, and if needed, the EPA and UDEQ.

- *Laboratory Audits/Corrective Action Reports* – Communicates the result of any third-party audit or review of the analytical laboratory that is supporting the FET investigation activities. This report will be written by the CLP (soil and water media results) and ALS Global Labs (soil gas and air) laboratory designated personnel. The reports will be submitted to the FET Program Manager, VA RPM and Quality Assurance Manager, UDEQ RPM and the EPA RPMs.
- *Remedial Project Managers (RPM) Debriefings* – Weekly conference calls between VA, EPA, UDEQ and other key stakeholders to discuss previous week's field efforts and investigation.
- *Data Validation Reports* – Communicates the results of laboratory data validation for each media (indoor air, soil gas, surface water, and groundwater) to VA, EPA, and UDEQ. Each report will provide a summary of the data validation process, a list of analytes having changed data qualifiers, a list of analytes rejected during validation, and a determination of the usability of the data. The data validation reports will be prepared by the FET lead data validator and the QA/QC Manager.
- *Remedial Investigation Report (RI Report)* – Communicates the conclusions of all investigation events for AOU-1 and any laboratory analysis associated with the event. The RI Report will also contain summaries of data validation reports and deviations from the SAP and QAPP.

15.0 References

ESTCP (2013). *Use of GC/MS Analysis to Distinguish Between Vapor Intrusion and Indoor Sources of VOCs –Final Report* - ESTCP Project ER-201119, November 2013.

ESTCP (2014). *Use of GC/MS Analysis to Distinguish Between Vapor Intrusion and Indoor Sources of VOCs – Standardized Protocol for On-Site Evaluation of Vapor Intrusion* - ESTCP Project ER-201119, July 2014.

Quality Assurance Project Plan (QAPP), 700 South and 1600 East Street PCE Plume, AOU-1: East Side Springs, Salt Lake City, Utah – October 1, 2014.

Sampling and Analysis Plan (SAP), 700 South and 1600 East Street PCE Plume, AOU-1: East Side Springs, Salt Lake City, Utah – October 1, 2014.

INFICON (2006). *Operation Manual for the HAPSITE Smart Plus – 074-472-P1C*.