ENTERED

DEPARTMENT OF THE AIR FORCE
377TH AIR BASE WING (AFGSC)

30 October 2022

Colonel Jason F. Vattioni, USAF
Commander
377th Air Base Wing
2000 Wyoming Blvd SE
Kirtland Air Force Base NM 87117

Rec'd
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Mr. Rick Shean
Hazardous Waste Bureau (HWB) Chief
New Mexico Environment Department (NMED)
2905 Rodeo Park Drive East Building 1
Santa Fe NM 87505-6303

Dear Mr. Shean

This letter is in response to the NMED letter, dated September 16, 2022, regarding the *Request for Soil Vapor Sampling Monitoring Work Plan, Bulk Fuels Facility Spill Site Kirtland Air Force Base, New Mexico EPA ID # NM6213820974 HWB-KAFB-21-004* (hereafter NMED's letter). The Air Force respectfully requests clarification on several of the requirements contained in NMED's letter. The requested clarifications will allow the Air Force to produce the required work plan that correctly incorporates the NMED requirements and is compliant with United States Environmental Protection Agency (EPA) guidance.

NMED's letter states that several modifications are required in accordance with EPA guidance/recommendations but does not reference or provide the specific guidance. The Air Force contacted the EPA Office of Research and Development (ORD) and received in response the EPA Standard Operating Procedure (SOP) for soil gas sampling from Mr. John Zimmerman Jr., Research Physical Scientist, EPA ORD/CEMM/WECD/MMB (email from Mr. Zimmerman to the Air Force is attached). The Air Force has attached to this letter the SOP (Rev 0.0 dated April 18, 2001, and Rev 1.0 dated June 1, 2021). Several of the requirements expressed in the NMED's letter are inconsistent with this SOP and these discrepancies are discussed below.

The Air Force proposes for NMED consideration that the Soil Vapor Sampling Work Plan directed by NMED follow purging and sampling procedures of the EPA's Soil Gas Sampling SOP (Rev 1.0) provided by the EPA ORD. The NMED-approved sampling methodology currently employed at the Bulk Fuels Facility (BFF) site is more consistent with the EPA SOP (Rev 1.0) than with NMED's required modification. Following the EPA's SOP will maintain continuity and consistency with the soil vapor data sets collected since 2015.

The Air Force requests clarification for Items 1 and 2 in NMED's letter that requires changing the purge volume for soil vapor sampling from one well volume to three well volumes. This required change is inconsistent with the EPA SOP and previous NMED statements (relevant portions

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from NMED's February 25, 2015, approval letter for the *Soil Vapor Extraction (SVE) Shutdown Test Work Plan* provided below). This 2015 NMED-approved work plan describes the soil vapor monitoring methodology currently employed at the site.

> "*The Permittee's proposed work plan is consistent with EPA guidance and industry standards, and includes the following changes to the soil vapor monitoring protocol that resulted from the January 20, 2015 Vadose Zone Complex Site Initiative:*
>
> *1. All soil vapor monitoring and SVE points will be securely capped to prevent exhalation of soil vapor gas or inhalation of atmospheric air due to barometric pressure increases or decreases.*
>
> *2. Soil vapor purging will be reduced from 10 casing volumes to one casing volume to prevent readings that may not be representative of the monitored soil interval.*
>
> *3. The Horiba field instrument will be properly calibrated at the start, middle and end of each work day."*

NMED's newly proposed requirements directly contradict NMED's 2015 approval letter and changes the sampling methodology documented in prior approved NMED work plans. The Air Force is requesting that NMED clarify and provide a rationale as to why these changes are required, including the identification of any new information or specific guidance documents that justify the required change to an already approved NMED sampling methodology.

The Air Force and EPA ORD were unable to identify any EPA guidance that discussed the calculation of soil vapor purge volumes based on the well volume(s). The NMED reference to well volumes is applicable to groundwater monitoring but is not applicable to soil vapor monitoring. All EPA references found to date and the attached EPA SOP discuss purging casing volumes and/or sample string volumes, not well volumes. To ensure the work plan accurately calculates purge volumes for soil vapor sampling, the Air Force is requesting clarification on the discrepancy in NMED's directive to purge three well volumes versus the EPA SOP to purge one casing/sampling string volume. EPA's SOP (Rev 1.0) states:

> "*Unlike groundwater sampling, purging of a soil gas probe is designed to remove only the ambient air within the tubing.*"

In accordance with Item 3 of NMED's letter, the Air Force has calculated the purge times needed to meet the required purge volume of three well volumes and the required purge rate of 200 to 500 milliliters per minute (ml/min). These calculations indicate that approximately 4,777 hours of purging will be required per soil vapor sampling monitoring event. A single soil vapor monitoring point (SVMP) with the highest purge volumes will take approximately 70 hours to purge. The attached summary of calculated purge times is provided for your review.

Compliance with this condition is impractical due to the duration required to purge. A single sampling event will require approximately 477 days to complete well purging. Furthermore, compliance with the provision will make it impossible to meet the reporting deadlines for periodic monitoring reports. Therefore, the Air Force proposes for NMED consideration that in the

Soil Vapor Work Plan flow rates for purging be determined based on laminar flow calculations or the EPA SOP (Rev 1.0). EPA's SOP allows purging pumps that are capable of drawing 1 to 3 liters per minute and recommends that sample collection flow rates of 100 to 400 ml/min be used during sampling. Higher laminar flow rates can be utilized for purging to shorten the purge times thereby reducing the total time required to purge SVMPs while lower flow rates can be used during sample collection.

The Air Force requests clarification for Item 5 which requires analyzing samples for the historically monitored total petroleum hydrocarbon fractions. This required change is inconsistent with the previous NMED direction. The *Soil Vapor Optimization Memorandum* submitted to NMED on November 22, 2016 and subsequently approved by NMED on January 4, 2017, indicated that field-measured hydrocarbons (HC) provided similar results to the laboratory analyses for total petroleum hydrocarbons (TPH) fractions. From that document:

> "*Quarterly reports have demonstrated the close correlation between laboratory TPH results and HC results," (USACE, 2016b). Although both HC and TPH results are reported in the Quarterly Reports, only HC is discussed in the text and figures to evaluate areas of relative higher or lower concentrations. The Vadose Zone Working Group determined that removing laboratory analysis of TPH from the analytical suite and continuing to collect HC data with the Horiba would be the most useful and effective method of evaluating HC concentrations."*

The Air Force is requesting clarification and the supporting rationale as to why NMED requirements have changed. What new information or guidance documents justify the required change?

In addition, the Air Force is requesting clarification on the specific TPH fractions analytical method that NMED is requiring. Historically, the Massachusetts Department of Environmental Protection (MADEP) Air-Phase Petroleum Hydrocarbon analytical method was used at this site to collect petroleum hydrocarbon fraction data. However, this analytical method was and is not Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) certified and not performed in accordance with the DoD Quality Systems Manual, and therefore, the sample data lack the same level of analytical data quality necessary to comply with DoD policy. The Air Force is proposing that the DoD ELAP-certified method EPA TO-3 be used to collect TPH gasoline fraction data (C5-C10). The Air Force is requesting NMED's concurrence that this alternative analytical method is acceptable.

The Air Force also requests clarification on Item 6 which requires stabilization readings to be collected every one to two minutes during the purging of the last well volume. As Mr. John Zimmerman, EPA ORD, states in his response to Item 6:

> "*I have not found any EPA guidance documents that provides guidance in the collection or monitoring of other vapor parameters to show stabilization of the soil vapor being removed. This type of monitoring is done for water sampling but I have not seen it done for soil vapor sampling*."

The Air Force proposes for NMED consideration that the Soil Vapor Work Plan will follow the cited portion of Resource Conservation and Recovery Act Permit # NM9570024423

Part 6.15.6 from Item 6 but will not continue purging until field parameters have stabilized or record field readings during well purging. The Air Force proposes to continue to monitor purge gas with a photoionization detector during purging, but all other vapor field parameters will only be recorded after vapor well purging is completed.

NMED's clarification on the items discussed above will be critical in ensuring the Soil Vapor Sampling Work Plan meets NMED requirements correctly. In order to meet the regulatory due date of March 1, 2023, for the Soil Vapor Sampling Work Plan, the Air Force is requesting that NMED provide the requested clarifications by December 2, 2022. If you have any questions or concerns, please contact Mr. Ryan Wortman at the commercial line (505) 853-3484 or email ryan.wortman.3@us.af.mil.

Sincerely

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JASON F. VATTIONI, Colonel, USAF
Commander

4 Attachments:
1. EPA 2021 and 2001 SOPs for Soil Gas Sampling
2. EPA ORD's email response to NMED's September 16, 2022, letter
3. Well Volume Summary Table
4. Well Volume Calculations and Schematic

cc:
NMED (Stringer), letter and CD
NMED Resource Protection Division (Catechis), letter and CD
NMED HWB (Shean, Andress, Cobrain, Wear), 2 Hard Copies/2 CDs
AFCEC/CZ (Clark, Kottkamp, Segura, Wortman), electronic only
EPA Region 6 (King), electronic only
EPA ORD (Zimmerman), electronic only
USACE-ABQ District Office (Moayyad, Hernandez, Watts-Gravett), electronic only
Public Info Repository, Administrative Record/Information Repository (AR/IR) and File

40 CFR 270.11
DOCUMENT CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

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30-Oct-2022

JASON F. VATTIONI, Colonel, USAF
Commander, 377th Air Base Wing

Date

This document has been approved for public release.

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28-Oct-2022

KIRTLAND AIR FORCE BASE
377th Air Base Wing Public Affairs

Date

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EPA 2021 and 2001 SOPs for Soil Gas Sampling

SOIL GAS SAMPLING

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SOIL GAS SAMPLING

1.0 SCOPE AND APPLICATION

Soil gas monitoring provides a quick means of detecting volatile organic compounds (VOCs) in the soil subsurface. Using this method, underground VOC contamination can be identified, and the source, extent, and movement of pollutants can be traced.

This standard operating procedure (SOP) outlines the methods used for the installation of soil gas points; the collection of soil gas using Tedlar bags, sorbent tubes, and/or SUMMA canisters; and measurement of organic vapor levels in the soil gas using a photoionization detector (PID), flame ionization detector (FID) and/or other air monitoring devices.

A Quality Assurance Project Plan (QAPP) in Uniform Federal Policy (UFP) format describing the project objectives must be prepared prior to deploying for a sampling event. The sampler needs to ensure that the methods used are adequate to satisfy the data quality objectives (DQOs) listed in the QAPP for a particular site.

The procedures in this SOP may be varied or changed as required, dependent on site conditions, equipment limitations or other procedural limitations. In all instances, the procedures employed must be documented on a Field Change Form and attached to the QAPP. These changes must be documented in the final deliverable.

2.0 METHOD SUMMARY

The Site, environment, and nature and depth of the VOCs of interest will determine the best way to collect the samples of interest. The actual methods used can be modified as needed based on the Site and project goals.

An appropriately-sized diameter hole is driven into the ground using manual (i.e., slam bar) or power-driven mechanical methods or the use of direct push sampling mounted on an all-terrain track unit. Small, shallow samples (less than 5 feet below ground surface) near the perimeter of a residential home, for example, would most easily be obtained using a slam bar while a direct push unit may collect samples in a field at a depth up to 50-feet (ft), or when frozen ground, very dense clays, pavement, etc. are present. The slam bar or rod is withdrawn after reaching the desired depth. The removal is done carefully to prevent collapse or otherwise compromise the hole. Afterwards a probe is carefully inserted into the hole. The top of the sample hole is sealed at the surface to prevent infiltration of ambient air, generally with modeling clay or wetted bentonite. More permanent or long-term installations may be sealed with sand, soil, and bentonite. The hole is allowed to equilibrate and a volume of air is first purged from the hole using a vacuum pump. The volume of the hole and/or tubing should be calculated to determine how much air will need to be purged. After returning to pressure, a sample can be withdrawn from the hole.

A monitoring instrument such as a MultiRAE Pro or TVA-2020 may be connected to the probe with a Teflon connector. VOC readings are recorded in the field on data sheets or in a logbook. Samples may then be collected with sorbent tubes, Tedlar bags or SUMMA canisters and then are typically sent to a laboratory for analysis. Bagged samples may be analyzed in a field laboratory using portable gas chromatography (GC) or gas chromatography/mass spectrometry (GC/MS) instrumentation, if available.

Other field air monitoring devices, such as a landfill gas meter (e.g., GEM 5000, measuring percent levels of oxygen, carbon dioxide and methane), can also be used, depending on specific site conditions and goals. Measurement of soil temperature using a temperature probe may also be desirable.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

3.1 Tedlar Bags

Soil gas samples are generally collected in 1.0-liter (L) Tedlar bags. Bagged samples should be stored in the dark (i.e., in opaque containers) and protected from mechanical damage during transit to the laboratory. Further, bagged samples should be maintained at ambient temperature by placing them in coolers and out of direct sunlight. Samples should be analyzed as soon as possible, preferably within 24 to 48 hours following sample collection. Refer to Environmental Response Team (ERT) SOP, *Tedlar Bag Sampling*, for additional information.

3.2 Sorbent Tubes

Soil gas can be drawn directly onto sorbent tubes (i.e., carbon tubes) and analyzed by GC or GC/MS methodologies. Bagged samples can also be drawn onto tubes. If sorbent tubes are to be used, special care must be taken to avoid contamination. Refer to ERT SOP, *Charcoal Tube Sampling in Ambient Air* for additional information. Samples should be refrigerated at less than or equal to (≤) 6 degrees Centigrade (°C) during storage and analyzed within the holding time of the analytical method. For example, halogenated, aromatic and straight chain hydrocarbons typically have a 30-day holding time from date of collection to analysis using National Institute for Standards and Technology (NIOSH) methods 1003, 1500 and 1501. Samples collected on multi-sorbent tubes should be analyzed as soon as possible after sampling.

3.3 SUMMA Canisters

SUMMA canisters used for soil gas sampling have a 6-L sample capacity and are certified clean by GC/MS analysis before being used in the field. After sampling is completed, they are stored and shipped in travel cases. Most volatile organic compounds (VOCs) can be recovered from canisters with minimal loss up to thirty days. Refer to ERT SOP, *SUMMA Canister Sampling,* for additional information.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

4.1 PID Measurements

A number of factors specific to soil gas can affect the response of a PID (e.g., MultiRAE Pro). High humidity can cause lamp fogging and decreased sensitivity. This can occur when soil moisture levels are high, or when a soil gas probe is in the saturated zone. High concentrations of methane can cause a downscale deflection of the meter. High and low temperature, and naturally occurring compounds, such as terpene hydrocarbons in wooded areas, will affect instrument response. Refer to ERT SOP, *Operation of the MultiRAE Pro Wireless Portable Detector* for additional information.

4.2 FID Measurements

A number of factors specific to soil gas can affect the response of an FID (e.g., TVA 2020). High humidity, percent levels of carbon dioxide (CO_2) or low oxygen (O_2) levels can cause the FID to flame out or not ignite at all. This can be significant when soil moisture levels are high, or when a soil gas probe is in the saturated zone. The FID can only read organic-based compounds (they must contain carbon in the molecular structure). The FID also responds poorly to hydrocarbons and halogenated hydrocarbons (such as gasoline, propane fuel). High and low temperature, electrical fields and FM radio transmission will also affect instrument response. Consult the instrument

manual for additional information.

4.3 Factors Affecting the Concentrations of Organic Compounds in Soil Gas

Concentrations of organic compounds in soil gas can be affected by the physical and chemical characteristics of the soil and by soil moisture. Organic molecules can be tightly adsorbed to the surface of chemically active soil particles, such as clays, thus reducing the concentration in the soil interstitial spaces. Similarly, some organic compounds can be dissolved in the soil water or associated with soil organic components (i.e., humic acids).

Soil porosity and permeability will affect the movement of soil gas and the recharge rate of the soil gas well. The movement of organic vapors through fine textured soil may be very slow, thus limiting the sample volume available and the use of this technique. Existing information and soil surveys prepared by the Soil Conservation Service should be consulted prior to planning and designing a soil gas survey.

The presence of a high, or perched water table, or of an impermeable underlying layer (such as a clay lens or layer of buried slag) may interfere with the movement and sampling of the soil gas. Knowledge of site geology is useful in such situations and can prevent inaccurate sampling.

4.4 Soil Probe Clogging

A common problem with the soil gas sampling is clogging of the probe. A clogged probe can be identified by using an in-line vacuum gauge or by listening for the sound of the pump laboring. This problem can usually be eliminated by using a wire cable to clear the probe (see Section 7.1.3.).

4.5 Underground Utilities

Prior to selecting sample locations, an underground utility search must be completed. The local utility companies can be contacted and requested to mark the locations of their underground lines. Each sample location should also be screened with a metal detector or magnetometer to verify that no underground metallic or ferro-magnetic pipes or drums are present.

4.6 Cleanliness of Tedlar Bags

If Tedlar bag samples will be analyzed by a GC/MS with detection limits lower than those of standard air monitoring instrumentation (0.1 to 1 parts per million [ppm]), each bag should be baked and purged with high purity nitrogen or zero air prior to usage. The ERT/SERAS Laboratory documents their Tedlar bag cleaning in their analytical SOP.

5.0 EQUIPMENT/APPARATUS

5.1 Slam Bar Method

- Slam bar
- Soil gas probes: stainless steel tubing, 1/4" O.D., 5-foot (ft) length
- Flexible wire or cable
- "Quick Connect" fittings
- Modeling clay
- Vacuum box
- Pumps, capable of drawing approximately 1.0 to 3.0 liters per minute (L/min)

- ¼" outer diameter (O.D.) Teflon tubing, 2-ft to 3-ft lengths
- ¼" inner diameter (I.D.) Tygon tubing
- Tedlar bags, (typically 1.0-L)
- Sample documentation (soil gas sample labels, field data sheets, logbook, etc.)
- PID/FID, or other field air monitoring devices
- Cooler(s)
- Metal detector or magnetometer
- Portable GC instrument (optional)
- Summa canisters (plus shipping cases)
- Large dark plastic bags

5.2 Power Hammer Method

- Power (Demolition) hammer
- ½" O.D. steel probes, extensions, and points
- Dedicated aluminum sampling points
- ¼" I.D. Teflon tubing, 2-ft to 3-ft lengths
- "Quick Connect" fittings
- Modeling clay or Bentonite
- Vacuum box
- Pumps, capable of drawing approximately 1.0 to 3.0 L/min
- ¼" O.D. Tygon tubing
- Tedlar bags, (typically 1.0-L)
- Sample documentation (soil gas sample labels, field data sheets, logbook, etc.)
- PID/FID or other field air monitoring devices
- Cooler(s)
- Metal detector or magnetometer
- Portable GC instrument (optional)
- Summa canisters (plus shipping cases)
- Generator w/extension cords (optional)
- High lift jack assembly (optional)
- Large dark plastic bags

5.3 Direct-Push (Geoprobe) Method

- Tubing; polyethylene, Teflon, or stainless steel
- Gas sampling cap
- Robe rods
- Tubing adaptor(s)
- Expendable point holder, threaded
- Expendable drive point(s)
- O-rings for expendable point holder
- O-rings for adaptor
- O-rings for probe rods
- O-rings for gas sampling cap
- Vacuum pumps
- Tape
- Tedlar bags, (typically 1.0-L)
- SUMMA canisters (plus shipping cases)

- Sample documentation (soil gas labels, field data sheets, logbook, etc.)
- Metal detector or magnetometer
- Cooler(s)
- Large dark plastic bags
- Portable GC instrument (optional)
- Bentonite

6.0 REAGENTS

- Calibration gases, accompanied by certificates of analysis
- Deionized, organic-free water
- Methanol, High Performance Liquid Chromatography (HPLC) grade
- Ultra-zero grade compressed air
- Propane torch

7.0 PROCEDURES

7.1 Soil Gas Probe Installation

7.1.1 Slam Bar Method

1. Make a hole slightly deeper than the desired sampling depth. For sampling up to 5 feet, use a 5-ft single piston slam bar. For deeper depths, use a piston slam bar with threaded 4-ft-long extensions.

2. Place the tip of the rod on the ground; the piston of the slam bar is used to drive the rod to the desired depth. Record the number of blows required to reach the desired depth.

3. After the hole is made, withdraw the slam bar carefully to prevent the collapse of the walls.

4. Insert the soil gas probe carefully into the hole. To prevent plugging of the probe, insert a decontaminated metal wire or cable, slightly longer than the probe and with an O.D. slightly less than the I.D. of the rod, in the probe rod; 1- to 2-inches of wire should protrude from the end of the probe. Insert the probe to the full depth of the hole, then pull up three to six inches. Clear the probe by moving the cable up and down several times.

5. Seal the top of the sample hole at the surface to prevent infiltration of ambient air. Knead a golf-ball size lump of clean modeling clay until it becomes soft. Mold the clay carefully around the probe at the soil surface to seal the space between the probe and the hole.

6. If semi-permanent soil gas installations are required, leave the probe in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite.

7.1.2 Power Hammer Method

1. Use a power hammer to make holes when the soil is very hard, frozen or fine textured (clay), or when soil gas from beneath pavement or concrete is collected.

2. Drive the probe to the desired depth (up to 12 feet may be attained with extensions). Add threaded extensions until the desire depth is needed.

3. After the hole is made, withdraw the threaded rod carefully in such a manner to prevent collapse of the walls. If necessary, use a jack assembly to retrieve the rods.

4. Install the soil gas probe in the hole as described in Section 7.1.1, Steps 4 and 5.

5. If semi-permanent soil gas installations are required, leave the probe in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite.

7.1.3 Direct-Push Method

1. Direct-push sampling technology refers to soil gas samplers that are inserted into the ground without the use of slam bars, demolition hammers, or drilling rigs. The U.S. EPA/ERT utilizes a Direct-Push unit mounted on an all-terrain track mounted vehicle, and direct push tools. These tools are able to collect samples at depths greater than 50 ft, depending on soil conditions.

2. Drive sampling probes, consisting of 3-foot sections of flush-threaded, 1¼-inch hardened steel alloy steel rod tipped by an expendable steel point, into the ground to the target depth. Withdraw the probe tools to release the expendable tip and allow soil gas to flow into the tool's tubing.

3. To ensure a representative soil gas sample, purge a discrete volume of gas to rid the tubing of atmospheric air and allow the subsurface soil gas to enter the probe tubing. The volume of removed gas is determined by the volume of tubing employed in the probe. (Unlike groundwater sampling, purging of a soil gas probe is designed to remove only the ambient air within the tubing.)

4. After allowing the system to return to atmospheric pressure, withdraw an aliquot of soil gas from the probe. Collect duplicate samples as necessary and required.

5. If semi-permanent soil gas installations are required, leave the probe in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite.

7.2 Screening with Field Instruments

1. Consult appropriate SOPs and the manufacturers' manuals for the correct use and calibration of all instrumentation. Calibrate pumps prior to use in the field.

2. Calculate an amount of air, equivalent to the volume of the soil gas well, prior to sampling. Connect a vacuum pump to the sample probe using a section of Teflon tubing. Turn on the pump and adjust to a flow rate of between 1.0 and 3.0 L/min. Evacuate the calculated volume of air from the hole by pulling a vacuum through the probe for the specified length of time. Longer time is required for sample wells of greater depths.

3. After evacuation, connect a monitoring instrument (i.e. PID or FID) to the probe using a Teflon connector. Upon stabilization, record the reading on data sheets or in a logbook.

4. Readings may be above or below the range set on the field instruments. Reset the range, or the record the response as a greater than or less than value. Consider the recharge rate of the well with soil gas when screening at a different range setting.

7.3 Tedlar Bag Sampling

1. Follow step 2 of section 7.2 to evacuate well volume. If air monitoring instrument screening was performed prior to sample collection, evacuation is not necessary.

2. Use the vacuum box and sampling train (see an example in Figure 1) to collect the sample. The sampling train is designed to minimize the introduction or loss of contaminants due to adsorption and other factors. All internal surfaces (exposed to the sample) are either Teflon or stainless steel. Draw a vacuum indirectly to avoid contamination from sample pumps.

3. Place the Tedlar bag inside the vacuum box, attach it to the sampling port and open the valve (if utilized). Attach the sample probe to the sampling port via Teflon tubing and a "Quick Connect" fitting or through a direct pass-through (liquid-tight cord connector).

4. Draw a vacuum around the outside of the bag, using a pump connected to the vacuum box evacuation port, via Tygon tubing and a "Quick Connect" fitting. The negative pressure inside the box causes the bag to inflate, drawing the sample into the bag.

5. Break the vacuum by removing the Tygon line from the pump. Remove the bagged sample from the box and close the bag valve. Record the date, time, sample location ID, and the PID/FID instrument reading(s) on sample bag label and on data sheets or in logbooks.

6. Do not label bags directly with a marker or pen (particularly those containing volatile solvents) or affix adhesive labels directly to the bags. Inks and adhesive may diffuse through the bag material and contaminate the sample. Tie labels to the metal eyelets provided on the bags or attached to the side portion (non-sample area) of the bag, folded in half and attached to itself.

7. Generate chain of custody sheets to accompany all samples to the laboratory.

7.4 Sorbent Tube Sampling

1. Select appropriate sorbent tube and sampling equipment based on desired analytes. Note: Sorbent tube sampling should only be used with media sampled at low flow rates (less than 1 liter per minute). Calibrate the pumps with the individual sampling trains.

2. Follow Section 7.2, step 2 to evacuate well volume. If PID/FID readings were taken prior to taking a sample, evacuation is not necessary.

3. Attach the sampling train inlet to the soil gas via the ¼" Teflon tubing.

4. Initiate sampling. After the desired time has elapsed, disconnect the sample train from the soil gas well, check and record the final flow rate. Process and label the samples for shipment to the analytical laboratory as specified in the SOP or analytical method.

5. Generate chain of custody sheets to accompany all samples to the laboratory.

7.5 SUMMA Canister Sampling

1. Follow Section 7.2, step 2, to evacuate well volume. If PID/FID readings were taken prior to taking a sample, evacuation is not necessary.

2. Attach a certified clean, evacuated 6-L SUMMA canister via the ¼" Teflon tubing.

3. Open valve on SUMMA canister. The sample flow rate should be determined based on soil conditions to ensure that there is time for adequate soil gas recharge to reduce the possibility of surface gas intrusion into the sample. Typical flow rates can range from 100 to 400 milliliters per minute.

4. Record sample number, sample location, date collected and work assignment number on a chain of custody form and on a blank tag attached to the canister.

5. Generate chain of custody sheets to accompany all samples to the laboratory.

8.0 CALCULATIONS

8.1 Field Screening Instruments

Instrument readings are usually read directly from the meter. In some cases, the background level at the soil gas location may be subtracted as follows:

Final Reading = Sample Reading - Background Reading

8.2 Probe Volume

The volume of the soil gas probe or sample tubing to be purged:

$V = \pi r^2 h$

V = volume
r = radius
h = height or length of probe or tubing

Calculations used to determine concentrations of individual components by field portable GC or GC/MS analysis are beyond the scope of this SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

9.1 General QA/QC Procedures

- All data must be documented on field data sheets, logbooks or as per requirements dictated by field activities.
- Any instrument must be operated and maintained according to the instructions supplied by the manufacturer, unless otherwise specified in the UFP-QAPP.
- Records must be maintained, documenting the training of the operators that use instrumentation and equipment for the collection of environmental information.

- Maintain a chain of custody record from the time a sample is collected to its final deposition. Custody seals demonstrate that a sample container has not been opened or tampered with during transport or storage of samples.

9.2 Sample Probe Contamination

To avoid cross-contamination between samples, use discrete sample probes or decontaminate sample probes between uses.

Decontaminate sample probes simply by drawing ambient air through the probe until the PID reading is at background. Contamination can also be removed by decontaminating with methanol and deionized water, and then air-drying. For persistent contamination, use of a portable propane torch may be needed. Using a pair of pliers to hold the probe, run the torch up and down the length of the sample probe for approximately 1-2 minutes. Let the probe cool before handling. When using this method, make sure to wear gloves to prevent burns. Having more than one probe per sample team will reduce lag times between sample stations while probes are decontaminated.

9.3 Sample Train Contamination

The Teflon line forming the sample train from the probe to the Tedlar bag, sorbent tube or SUMMA® should be changed for each new sample well.

9.4 FID/PID Calibration

The FID and PID must be calibrated before use and should be bump tested at least once a day using the appropriate calibration gases to confirm performance. It is not recommended to calibrate daily.

9.5 QA/QC Samples

Quality assurance/quality control (QA/QC) samples provide information on the variability and usability of environmental sample results. Various QA/QC samples may be collected to detect error or potential sources of sample bias. QA/QC samples are submitted with the field samples for analysis to aid in identifying the origin of analytical discrepancies. Following the QA/QC sample analysis, a determination can be made as to how the analytical results should be used. Collocated samples, background samples, field blanks, trip blanks and lot blanks are the most commonly collected QA/QC field samples. Performance evaluation (PE) samples and blank spikes provide additional measures of data QA/QC control. QA/QC results may suggest the need for modifying sample collection, preparation, handling, or analytical procedures if the resultant data do not meet site-specific QA or data quality objectives. Refer to ERT SOP #2005, *Quality Assurance/Quality Control Samples*, for further details, and suggested frequencies for submittal of QA/QC samples. Additional information may be obtained from method-specific sampling or analytical SOPs or from the analytical method being followed.

10.0 DATA VALIDATION

Data verification (completeness checks) must be conducted to ensure that all data inputs are present for ensuring the availability of sufficient information. Results for QA/QC samples should be evaluated for contamination. This information should be utilized to qualify the environmental sample results accordingly with data quality objectives. The ERT contractor's Task Leader (TL) is responsible for completing the UFP-QAPP verification checklist for each project.

11.0 HEALTH AND SAFETY

Based on Occupational Safety and Health Administration (OSHA) requirements, a site-specific health and safety plan (HASP) must be prepared for response operations under the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard, 29 CFR 1910.120. Field personnel working for EPA's ERT should consult the Emergency Responder Health and Safety Manual currently located at https://response.epa.gov/_HealthSafetyManual/manual-index.htm for the development of the HASP, required personal protective equipment (PPE) and respiratory protection.

Because the sample is being drawn from underground, and no contamination is introduced into the breathing zone, soil gas sampling usually occurs in Level D. Nevertheless, ambient air should be constantly monitored using a PID or FID to obtain background and breathing zone readings during the sampling procedure.

When conducting soil gas sampling, appropriate PPE (leather gloves, steel-toed shoes, Tyvek safety suit) should be worn, and proper slam bar techniques should be implemented. An underground utility search must be performed prior to sampling (See Section 4.5).

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13.0 APPENDICES

A - Figure

APPENDIX A
Figure
SOP: ERT-PROC-2042-21
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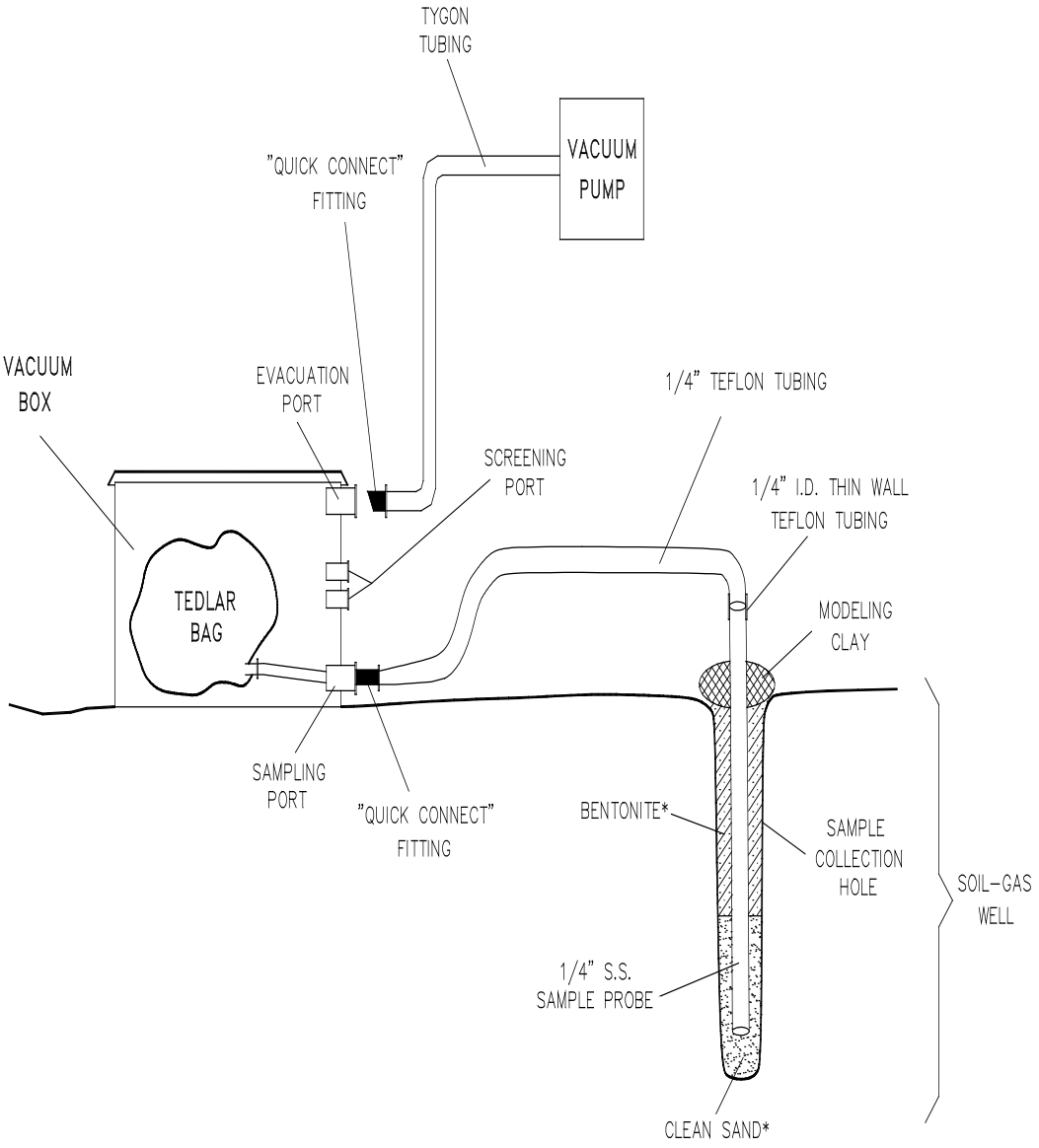
FIGURE 1. Sampling Train Schematic



* USED ONLY FOR SEMIPERMANENT INSTALLATIONS

SOIL GAS SAMPLING

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* These sections are affected by Revision 0.0

SUPERCEDES: SOP #2042; Revision 0; 6/1/96; U.S. EPA Contract EP-W-09-031.

1.0 SCOPE AND APPLICATION

Soil gas monitoring provides a quick means of detecting volatile organic compounds (VOCs) in the soil subsurface. Using this method, underground VOC contamination can be identified, and the source, extent, and movement of pollutants can be traced.

This standard operating procedure (SOP) outlines the methods used for the installation of soil gas wells; the collection of soil gas using Tedlar bags, sorbent tubes, and/or Summa canisters; and measurement of organic vapor levels in the soil gas using a Photo Ionization Detector (PID), Flame Ionization Detector (FID) and/or other air monitoring devices.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute United States Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

A d-inch (")diameter hole is driven into the ground using manual (i.e., slam bar) or power driven mechanical (i.e., Geoprobe) methods. Soil gas can be sampled at specific depths by controlled penetration and/or the use of a longer bar or bar attachments. A ¼"outer diameter (O.D.) stainless steel probe is inserted into the hole. The hole is sealed around the top of the probe using clean modeling clay. The gas contained in the interstitial spaces of the soil is pulled through the probe using an air sampling pump. The sample may be stored in Tedlar bags, drawn through sorbent cartridges, or analyzed directly using a field portable instrument such as a PID. An air sampling pump is not used for Summa canister sampling of soil gas; sampling is achieved by soil gas equilibration with the evacuated Summa canister.

Power driven mechanical devices may be used to make holes when conditions make the use of manual devices unfeasible (i.e., frozen ground, very dense clays, pavement, etc.). Commercially available soil gas sampling probes (hollow, ½" O.D. steel probes) can be driven to the desired depth using a power hammer (e.g., demolition hammer or Geoprobe). Soil gas samples can be drawn through the probe itself, or through Teflon tubing inserted through the probe and attached to the probe point. Samples are collected and analyzed as described below.

Other field air monitoring devices, such as the Combustible Gas Indicator (CGI) and the Organic Vapor Analyzer (OVA), can also be used, depending on specific site conditions. Measurement of soil temperature using a temperature probe may also be desirable. Bagged samples may be analyzed in a field laboratory using portable gas chromatography (GC) instrumentation, or shipped to a laboratory using an overnight service.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

3.1 Tedlar Bags

Soil gas samples are generally collected in 1.0-liter (L) Tedlar bags. Bagged samples should be stored in the dark (i.e., in opaque containers) and protected from mechanical damage during transit

to the laboratory. Further, bagged samples should be maintained at ambient temperature by placing them in coolers and out of direct sunlight. Samples should be analyzed as soon as possible, preferably within 24 to 48 hours following sample collection. Refer to ERT/SERAS SOP# 2102, *Tedlar Bag Sampling*, for additional information.

3.2 Sorbent Tubes

Soil gas can be drawn directly onto sorbent tubes (i.e., Tenax tubes) and analyzed by Gas Chromatography/Mass Spectrometer (GC/MS) methodologies. Bagged samples can also be drawn onto tubes. If sorbent tubes are to be used, special care must be taken to avoid contamination. Refer to ERT/SERAS SOP# 2104, *Tenax/CMS Tube Sampling*, for additional information. Samples should be refrigerated at 4 ^{o}C during storage and analyzed within 30 days of collection. Samples taken on multi-sorbent tubes should be analyzed as soon as possible after sampling.

3.3 Summa Canisters

The Summa canisters used for soil gas sampling have a 6-L sample capacity and are certified clean by GC/MS analysis before being used in the field. After sampling is completed, they are stored and shipped in travel cases. Most volatile organic compounds (VOCs) can be recovered from canisters with minimal loss up to thirty days. Refer to ERT/SERAS SOP# 1704, *Summa Canister Sampling*, for additional information.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

4.1 PID Measurements

A number of factors specific to soil gas can affect the response of a PID (e.g., HNu PI 101). High humidity can cause lamp fogging and decreased sensitivity. This can occur when soil moisture levels are high, or when a soil gas probe is in the saturated zone. High concentrations of methane can cause a downscale deflection of the meter. High and low temperature, electrical fields, FM radio transmission, and naturally occurring compounds, such as terpene hydrocarbons in wooded areas, will affect instrument response. Refer to ERT/SERAS SOP# 2114, *Photoionization Detector (PID) HNu* for additional information.

4.2 FID Measurements

A number of factors specific to soil gas can affect the response of an FID (e.g., OVA Model 128). High humidity can cause the FID to flame out or not ignite at all. This can be significant when soil moisture levels are high, or when a soil gas probe is in the saturated zone. The FID can only read organic based compounds (they must contain carbon in the molecular structure). The FID also responds poorly to hydrocarbons and halogenated hydrocarbons (such as gasoline, propane fuel). High and low temperature, electrical fields and FM radio transmission will also affect instrument response. Consult the instrument manual for additional information.

4.3 Factors Affecting the Concentrations of Organic Compounds in Soil Gas

Concentrations of organic compounds in soil gas can be affected by the physical and chemical characteristics of the soil and by soil moisture. Organic molecules can be tightly adsorbed to the

surface of chemically active soil particles, such as clays, thus reducing the concentration in the soil interstitial spaces. Similarly, some organic compounds can be dissolved in the soil water or associated with soil organic components (i.e., humic acids).

Soil porosity and permeability will affect the movement of soil gas and the recharge rate of the soil gas well. The movement of organic vapors through fine textured soil may be very slow, thus limiting the sample volume available and the use of this technique. Existing information and soil surveys prepared by the Soil Conservation Service should be consulted prior to planning and designing a soil gas survey.

The presence of a high, or perched water table, or of an impermeable underlying layer (such as a clay lens or layer of buried slag) may interfere with the movement and sampling of the soil gas. Knowledge of site geology is useful in such situations, and can prevent inaccurate sampling.

4.4 Soil Probe Clogging

A common problem with the soil gas sampling is clogging of the probe. A clogged probe can be identified by using an in-line vacuum gauge or by listening for the sound of the pump laboring. This problem can usually be eliminated by using a wire cable to clear the probe (see Section 7.1.3.).

4.5 Underground Utilities

Prior to selecting sample locations, an underground utility search must be completed. The local utility companies can be contacted and requested to mark the locations of their underground lines. Each sample location should also be screened with a metal detector or magnetometer to verify that no underground metallic or ferro-magnetic pipes or drums are present.

5.0 EQUIPMENT/APPARATUS

5.1 Slam Bar Method

- Slam bar
- Soil gas probes: stainless steel tubing, 1/4" O.D., 5-foot (ft) length
- Flexible wire or cable
- "Quick Connect" fittings
- Modeling clay.
- Vacuum box
- Pumps, capable of drawing approximately 3.0 L/min
- ¼" Teflon tubing, 2-ft to 3-ft lengths
- ¼" Tygon tubing
- Tedlar bags, 1.0-L
- Sample documentation (soil gas sample labels, field data sheets, logbook, etc.)
- PID/FID, or other field air monitoring devices
- Cooler(s)
- Metal detector or magnetometer
- Portable GC instrument
- Summa canisters (plus shipping cases)

- Large dark plastic bags

5.2 Power Hammer Method

- Power (Demolition) hammer
- ½" O.D. steel probes, extensions, and points
- Dedicated aluminum sampling points
- ¼" Teflon tubing, 2-ft to 3-ft lengths
- "Quick Connect" fittings
- Modeling clay.
- Vacuum box
- Pumps, capable of drawing approximately 3.0 L/min
- ¼" Tygon tubing
- Tedlar bags, 1.0-L
- Sample documentation (soil gas sample labels, field data sheets, logbook, etc.)
- PID/FID or other field air monitoring devices
- Cooler(s)
- Metal detector or magnetometer
- Portable GC instrument
- Summa canisters (plus shipping cases)
- Generator w/extension cords.
- High lift jack assembly
- Large dark plastic bags

5.3 Direct-Push (Geoprobe) Method

- Tubing; polyethylene, Teflon, or stainless steel
- Gas sampling cap
- robe rods
- Tubing adaptor(s)
- Expendable point holder, threaded
- Expendable drive point(s)
- O-rings for expendable point holder
- O-rings for adaptor
- O-rings for probe rods
- O-rings for gas sampling cap
- Vacuum pumps
- Tape
- Tedlar bags, 1.0-L
- Summa canisters (plus shipping cases)
- Sample documentation (soil gas labels, field data sheets, logbook, etc.)
- Metal detector or magnetometer
- Cooler(s)
- Large dark plastic bags
- Portable GC instrument

6.0 REAGENTS

- Calibration and spike gases
- Deionized, organic-free water
- Methanol, High Performance Liquid Chromatography (HPLC) grade
- Ultra-zero grade compressed air
- Propane torch

7.0 PROCEDURES

7.1 Soil Gas Probe Installation

7.1.1 Slam Bar Method

1. A hole slightly deeper than the desired sampling depth is made. For sampling up to 5 feet, a 5-ft single piston slam bar is used. For deeper depths, a piston slam bar with threaded 4-ft-long extensions is used.

2. The tip of the rod is placed on the ground and the piston of the slam bar is used to drive the rod to the desired depth. The number of blows required to reach the desired depth is recorded.

3. After the hole is made, the slam bar is carefully withdrawn to prevent the collapse of the walls.

4. The soil gas probe is carefully inserted into the hole. To prevent plugging of the probe, a decontaminated metal wire or cable, slightly longer than the probe and with an O.D. slightly less than the inner diameter (I.D.) of the rod, is inserted in the probe rod; 1- to 2-inches of wire should protrude from the end of the probe. The probe is inserted to full depth of the hole, then pulled up three to six inches. The probe is cleared by moving the cable up and down several times.

5. The top of the sample hole is sealed at the surface to prevent infiltration of ambient air. A golf-ball size lump of clean modeling clay is kneaded until it becomes soft. The clay is carefully molded around the probe at the soil surface to seal the space between the probe and the hole.

6. If semi-permanent soil gas installations are required, the probe remains in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite.

7.1.2 Power Hammer Method

1. A power hammer may be used to make holes when the soil is very hard, frozen or fine textured (clay), or when soil gas from beneath pavement or concrete is collected.

2. A power hammer is used to drive the probe to the desired depth (up to 12 feet may be attained with extensions). Threaded extensions are added until the desire depth is needed.

3. After the hole is made, the threaded rod is carefully withdrawn. This should be done

in such a manner to prevent collapse of the walls. If necessary, a jack assembly may be used to retrieve the rods.

4. The soil gas probe is installed in the hole as described in Section 7.1.1, Steps 4 and 5.

5. If semi-permanent soil gas installations are required, the probe remains in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite.

7.1.3 Direct-Push Method

1. Direct-push sampling technology refers to soil gas samplers that are inserted into the ground without the use of slam bars, demolition hammers, or drilling rigs. The U.S. EPA/ERT utilizes a Direct-Push unit mounted on an all-terrain track mounted vehicle, and direct push tools. These tools are able to collect samples at depths greater than 50 feet, depending on soil conditions.

2. Sampling probes, consisting of 3-foot sections of flush-threaded, 1¼-inch hardened steel alloy steel rod tipped by an expendable steel point, are driven into the ground to the target depth. The probe tools are withdrawn to release the expendable tip and allow soil gas to flow into the tool's tubing.

3. To ensure a representative soil gas sample, a discrete volume of gas is purged to rid the tubing of atmospheric air and allow the subsurface soil gas to enter the probe tubing. The volume of gas removed is determined by the volume of tubing employed in the probe. (Unlike groundwater sampling, purging of a soil gas probe is designed to remove only the ambient air within the tubing.)

4. After allowing the system to return to atmospheric pressure, an aliquot of soil gas is withdrawn from the probe. Duplicate samples are collected as necessary and required.

5. If semi-permanent soil gas installations are required, the probe remains in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite.

7.2 Screening with Field Instruments

1. It is recommended that any appropriate SOPs and the manufacturers' manuals be consulted for the correct use and calibration of all instrumentation. Pumps should be calibrated prior to use in the field.

2. An amount of air, equivalent to the volume of the soil gas well must be calculated prior to sampling. Connect a vacuum pump to the sample probe using a section of Teflon tubing. The pump is turned on and adjusted to a flow rate of 3.0 L/minute. The calculated volume of air is evacuated from the hole by pulling a vacuum through the probe for the specified length of time. Longer time is required for sample wells of greater depths.

3. After evacuation, a monitoring instrument (i.e. HNu or OVA) is connected to the probe using a Teflon connector. Upon stabilization, the reading is recorded on soil gas data sheets.

4. Readings may be above or below the range set on the field instruments. The range may be reset, or the response recorded as a greater than or less than figure. The recharge rate of the well with soil gas must be considered when resampling at a different range setting.

7.3 Tedlar Bag Sampling

1. Follow step 1 of section 7.2 to evacuate well volume. If air monitoring instrument screening was performed prior to sample collection, evacuation is not necessary.

2. Use the vacuum box and sampling train (Figure 1) to collect the sample. The sampling train is designed to minimize the introduction or loss of contaminants due to adsorption and other factors. All parts used are either Teflon or stainless steel, and a vacuum is drawn indirectly to avoid contamination from sample pumps.

3. Place the Tedlar bag inside the vacuum box, attach it to the sampling port and open the valve. The sample probe is attached to the sampling port via Teflon tubing and a "Quick Connect" fitting.

4. Draw a vacuum around the outside of the bag, using a pump connected to the vacuum box evacuation port, via Tygon tubing and a "Quick Connect" fitting. The negative pressure inside the box causes the bag to inflate, drawing the sample into the bag.

5. Break the vacuum by removing the Tygon line from the pump. Remove the bagged sample from the box and close the valve. Record the date, time, sample location ID, and the PID/FID instrument reading(s) on sample bag label and on data sheets or in logbooks.

6. Bags should not be labeled directly with a marker or pen (particularly those containing volatile solvents) nor should adhesive labels be affixed directly to the bags. Inks and adhesive may diffuse through the bag material and contaminate the sample. Labels should be tied to the metal eyelets provided on the bags.

Chain of custody sheets must accompany all samples.

7.4 Sorbent Tube Sampling

Samples collected in Tedlar bags may be adsorbed onto sorbent tubes for further analysis by GC/MS.

7.4.1 Additional Apparatus

- Syringe, with a Luer-lock tip, capable of drawing a soil gas or air sample from a Tedlar bag onto a sorbent tube. The syringe capacity is dependent upon the volume of sample being drawn onto the tube.

- Adapters, for fitting the sorbent tube between the Tedlar bag and the sampling syringe. The adapter attaching the Tedlar bag to the sorbent tube consists of a reducing union (¼" to 1/16" O.D. - Swagelok cat. # SS-400-6-ILV or equivalent) and a length of ¼" O.D. Teflon tubing, which replaces the nut on the 1/16" (Tedlar bag) side. A ¼" I.D. Teflon or silicone O-ring replaces the ferrules in the nut on the

¼" (sorbent tube) side of the union.

- The adapter, attaching the sampling syringe to the sorbent tube, consists of a reducing union (¼" to 1/16" O.D. - Swagelok Cat. # SS-400-6-ILV or equivalent) and a ¼" I.D. Teflon or silicone O-ring, which replaces the ferrules in the nut on the ¼" (sorbent tube) side and the needle of a Luer-lock syringe inserted into the 1/16" side (held in place with a 1/16" ferrule). The Luer-lock end of the needle can be attached to the sampling syringe. It is useful to have a Luer-lock on/off valve situated between the syringe and the needle.

- Two-stage glass sampling cartridge (¼" O.D. x c" I.D. x 5c") contained in a flame-sealed tube containing two sorbent sections retained by glass wool:

- Teflon-capped culture tubes or stainless steel tube containers for sorbent tube storage and shipping. These containers should be conditioned by baking at 120^{o} C for at least two hours. The culture tubes should contain a glass wool plug to prevent sorbent tube breakage during transport. Reconditioning of the containers should occur between uses or after extended periods of disuse (i.e., two weeks or more).

- Nylon gloves or lint-free cloth. (Hewlett Packard Part # 8650-0030 or equivalent.)

7.4.2 Sample Collection

- Handle sorbent tubes with care, using nylon gloves (or other lint-free material) to avoid contamination.

- Immediately before sampling, break one end of the sealed tube and remove the sorbent cartridge.

- Connect the valve on the Tedlar bag to the sorbent tube adapter. If using a Tenax/CMS sorbent tube, connect the sorbent tube to the sorbent tube adapter with the Tenax (white granular) side of the tube facing the Tedlar bag. Connect the sampling syringe assembly to the carbon molecular sieve [CMS (black)] side of the sorbent tube. Fittings on the adapters should be finger-tight. Open the valve on the Tedlar bag. Open the on/off valve of the sampling syringe. Depending on work plan stipulations, at least 10% of the soil gas samples analyzed by field screening methods must be submitted for confirmation GC/MS analysis (according to a modified TO-17method for sorbent tubes). Each soil gas sample must be absorbed on replicate sorbent tubes. The volume adsorbed on a sorbent tube is dependent on the total concentration of the compounds measured by field screening methods as follows:

Total Concentration (ppm)	Sample Volume (mL)
>10	Use Serial Dilution
10	10-50
5	20-100
1	100-250

- After sampling, remove the tube from the sampling train with gloves or a clean

cloth. DO NOT LABEL OR WRITE ON THE SORBENT TUBE.

- Place the sorbent tube in a conditioned stainless steel tube holder or culture tube. Culture tube caps should be sealed with Teflon tape.
- Each sample tube container (not tube) must be labeled with the site name, sample number, date sampled, and volume sampled. Verify that all sample containers are properly labeled.
- Chain of custody sheets must accompany all samples to the laboratory.

7.5 Summa Canister Sampling

1. Follow Section 7.2, step 1, to evacuate well volume. If PID/FID readings were taken prior to taking a sample, evacuation is not necessary.
2. Attach a certified clean, evacuated 6-L Summa canister via the ¼" Teflon tubing.
3. Open valve on Summa canister. The soil gas sample is drawn into the canister by pressure equilibration. The approximate sampling time for a 6-L canister is 20 minutes.
4. Sample number, sample location, date collected and work assignment number must be recorded on a chain of custody form and on a blank tag attached to the canister.
5. Chain of custody sheets must accompany all samples to the laboratory.

8.0 CALCULATIONS

8.1 Field Screening Instruments

Instrument readings are usually read directly from the meter. In some cases, the background level at the soil gas location may be subtracted:

Final Reading = Sample Reading - Background Reading

8.2 Field Portable GC Analysis

Calculations used to determine concentrations of individual components by field portable GC analysis are beyond the scope of this SOP and are covered ERT/SERAS SOP #2109, *Photovac GC Analysis for Soil, Water and Air/Soil Gas*.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

9.1 Sample Sorbent Tubes

Before field use, a quality assurance (QA) check must be performed on each batch of sorbent tubes by thermal desorption/cryogenic trapping GC/MS. These tubes are prepared and cleaned in accordance with EPA Method EMSL/RTP-SOP-EMD-013 by the vendor. Prior to purchasing a lot of tubes from a vendor, ten tubes from the lot are sent to the SERAS laboratory where the tubes

are tested for cleanliness, precision and reproducibility.

Sample tubes should be stored out of ultraviolet (UV) light (i.e., sunlight) and kept on ice until analysis. Samples should be collected in duplicate, whenever possible.

9.2 Sample Probe Contamination

Sample probe contamination is checked between each sample by drawing ambient air through the probe using a vacuum pump (e.g., Gilian pump) and checking the response of the FID/PID. If readings are higher than background, replacement or decontamination is necessary.

Sample probes may be decontaminated simply by drawing ambient air through the probe until the HNu reading is at background. Contamination can also be removed by decontaminating with methanol and deionized water, then air drying. For persistent contamination, use of a portable propane torch may be needed. Using a pair of pliers to hold the probe, run the torch up and down the length of the sample probe for approximately 1-2 minutes. Let the probe cool before handling. When using this method, make sure to wear gloves to prevent burns. Having more than one probe per sample team will reduce lag times between sample stations while probes are decontaminated.

9.3 Sample Train Contamination

The Teflon line forming the sample train from the probe to the Tedlar bag should be changed on a daily basis. If visible contamination (soil or water) is drawn into the sampling train, it must be changed immediately. When sampling in highly contaminated areas, the sampling train should be purged with ambient air, via a vacuum pump (e.g., Gilian pump), for approximately 30 seconds between each sample. After purging, the sampling train can be checked using an FID or PID, or other field monitoring device, to establish the cleanliness of the Teflon line.

9.4 FID/PID Calibration

The FID and PID must be calibrated at least once a day using the appropriate calibration gases.

9.5 Trip Blanks

A trip blank detects any sample contamination during shipping and storage. With the exception of Summa canisters, the trip blank is prepared and added to the site samples after sampling has been completed and prior to shipment.

9.5.1 Tedlar Bags

Each cooler containing Tedlar bag samples must contain one Tedlar bag of ultra-zero grade air, acting as a trip blank, when samples are shipped to an outside laboratory. A chain of custody record must accompany each cooler of samples and should include the blank that is dedicated to that group of samples.

9.5.2 Sorbent Tubes

At least one trip blank per cooler must be submitted with the sorbent tube samples. The ends of the sorbent tube are broken but no air is drawn through the tube.

9.5.3 Summa Canisters

Canister trip blanks are evacuated containers that are shipped to and from the site with the canisters used for air sampling.

9.6 Field Blanks

A field blank detects sample contamination during the handling and shipping process. The field blank must be associated with an actual sampling event.

9.6.1 Tedlar Bags

For each day of sampling, a Tedlar bag is filled with ultra-zero air at the beginning of the day. The field blank is handled in the same manner as the samples.

9.6.2 Sorbent Tubes

For each day of sampling, a field blank must be submitted for sorbent tubes. The ends of the sorbent tube are broken at the beginning of the day but no air is drawn through the tube.

9.7 Trip Standards

If Tedlar bags are used for sampling, each cooler containing samples should contain a Tedlar bag of standard gas to calibrate the analytical instruments (Photovac GC, etc.). This trip standard will be used to determine any changes in concentrations of the target compounds during the course of the sampling day (e.g., migration through the sample bag, degradation, or adsorption). A fresh trip standard must be provided and placed in each cooler pending additional sample collection. A chain of custody record must accompany each cooler of samples and should include the trip standard that is dedicated to that group of samples.

9.8 Lot Blanks

9.8.1 Tedlar Bags

Prior to use, one bag is removed from each lot of Tedlar bags to be used for sampling and checked for possible contamination as follows: Fill the test bag with ultra-zero grade air; withdraw a sample from the bag and analyze using a field portable GC or any other applicable field instrument used for sample analysis. This procedure will ensure sample container cleanliness prior to the start of the sampling effort.

9.8.2 Summa Canister Check

From each lot of four cleaned Summa canisters, one is used for a GC/MS certification check. If the canister passes certification, it is re-evacuated and all four canisters from that lot are available for sampling. If the chosen canister is contaminated, the entire lot of four Summa canisters must be re-cleaned, and a single canister is re-analyzed by GC/MS for certification.

9.8.3 Sorbent Tubes

Provide a minimum of one sorbent tube per sampling event. Do not break the ends of the tube.

9.9 Options

9.9.1 Duplicate Samples

A minimum of 5% of all samples should be collected in duplicate (i.e., if a total of 100 samples are to be collected, five samples should be collected in duplicate). In choosing which samples to duplicate, the following criteria applies: if, after filling the first Tedlar bag and evacuating the well for 15 seconds, the second HNu reading (or other field monitoring device being used) matches or is close to (within 20%) the first reading, a duplicate sample may be taken.

9.9.2 Spikes

A Tedlar bag spike and sorbent tube spike may be desirable in situations where high concentrations of contaminants other than the target compounds are found to exist (landfills, etc.). The additional level of QA/QC attained by this practice can be useful in determining the effects of interferences caused by these non-target compounds. Summa canisters containing samples are not spiked.

10.0 DATA VALIDATION

10.1 Blanks

For each target compound, the concentration found in the sample must be greater than three times the level (for that compound) found in the appropriate blank (lot, field, and trip) that accompanied that sample, to be considered valid.

11.0 HEALTH AND SAFETY

Because the sample is being drawn from underground, and no contamination is introduced into the breathing zone, soil gas sampling usually occurs in Level D. Nevertheless, ambient air should be constantly monitored using the HNu P101 to obtain background and breathing zone readings during the sampling procedure. As long as the levels in ambient air do not rise above background, no upgrade of the level of protection is needed.

When conducting soil gas sampling, appropriate personal protective equipment [PPE (leather gloves, steel-toed shoes, Tyvek safety suit)] should be worn, and proper slam bar techniques should be implemented Also, an underground utility search must be performed prior to sampling (See Section 4.5).

12.0 REFERENCES

Gilian Instrument Corp. 1983. *Instruction Manual for Hi Flow Sampler: HFS113, HFS 113 T, HFS 113U, HFS 113 UT.*

HNu Systems, Inc. 1975. *Instruction Manual for Model PI 101 Photoionization Analyzer.*

New Jersey Department of Environmental Protection. 1992. *Field Sampling Procedures Manual*.

U.S. Environmental Protection Agency. 1984. *Characterization of Hazardous Waste Sites - A Methods Manual: Volume II.* Available Sampling Methods. 2nd ed. EPA-600/4-84-076.

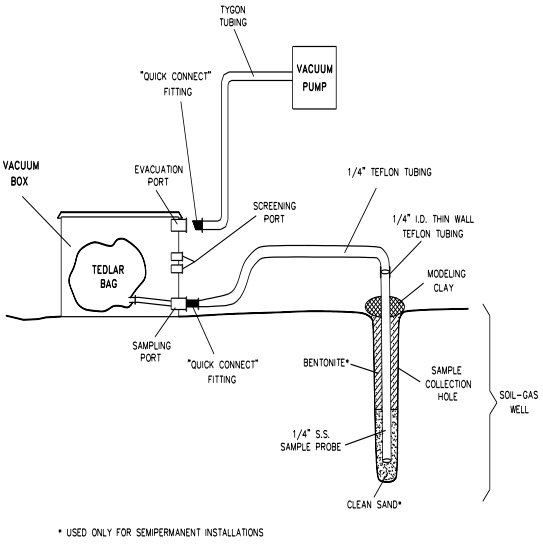
U.S. Environmental Protection Agency. 1995. *Superfund Program Representative Sampling Guidance. Volume 2: Air (Short-Term Monitoring).* EPA 540-R-95/140. Interim Final.

13.0 APPENDICES

A - Figures
B - HNu Field Procedure

APPENDIX A
Figure
SOP # 2042
April 2001

FIGURE 1. Sampling Train Schematic



APPENDIX B

HNu Field Procedure
SOP # 2042
April 2001

HNu Field Procedure

The following sections detail the procedures that are to be followed when using the HNu in the field.

Startup Procedure

a. Before attaching the probe, check the function switch on the control panel to ensure that it is in the off position. Attach the probe by plugging it into the interface on the top of the readout module. Use care in aligning the prongs in the probe cord with the plug in; don't force the probe cord.

b. Turn the function switch to the battery check position. The needle on the meter should read within or above the green battery area on the scale. If not, recharge the battery. If the red indicator light comes on, the battery needs recharging.

c. Turn the function switch to any range setting. Look into the end of the probe for no more than two to three seconds to see if the lamp is on. If it is on, it will give a purple glow. Do not stare into the probe any longer than three seconds. Long term exposure to UV light can damage eyes. Also, listen for the hum of the fan motor.

d. To ZERO the instrument, turn the function switch to the standby position and rotate the zero adjustment until the meter reads zero. A calibration gas is not needed for this instrument. If the span adjustment setting is changed after the zero is set, the zero should be rechecked and adjusted, if necessary. Wait 15 to 20 seconds to ensure that the zero reading is stable. If necessary, readjust the instrument to zero.

Operational Check

a. Follow the start-up procedure.

b. With the instrument set on the 0-20 ppm range, hold a solvent-based magic marker near the probe tip. If the meter deflects upscale, the instrument is working.

Field Calibration Procedure

a. Follow the start-up procedure and the operational check.

b. Set the function switch to the range setting for the concentration of the calibration gas.

c. Attach a regulator to a disposable cylinder of isobutylene gas. Connect the regulator to the probe of the HNu with a piece of clean Tygon tubing. Turn on the regulator valve.

d. After fifteen seconds, adjust the span dial until the meter reading equals the concentration of the calibration gas used. Be careful to unlock the span dial before adjusting it. If the span has to be set below 3.0, calibrate the instrument internally or return to equipment maintenance for repair.

e. Record in the field logbook: the instrument ID no. (EPA decal or serial number if the instrument is a rental); the initial and final span settings; the date and time; concentration and type of calibration gas used; and the name of the person who calibrated the instrument.

Operation

a. Follow the start-up procedure, operational check, and calibration check.

b. Set the function switch to the appropriate range. If the concentration of gases or vapors is unknown, set the function switch to the 0-20 ppm range. Adjust it if necessary.

c. While taking care not to permit the HNu to be exposed to excessive moisture, dirt, or contamination, monitor the work activity as specified in the site specific Health and Safety Plan.

d. When the activity is completed or at the end of the day, carefully clean the outside of the HNu with a damp disposable towel to remove any visible dirt. Return the HNu to a secure area and place on charge.

e. With the exception of the probe's inlet and exhaust, the HNu can be wrapped in clear plastic to prevent it from becoming contaminated and to prevent water from getting inside in the event of precipitation.

Attachment

EPA ORD's email response to NMED's September 16, 2022, letter

-----Original Message-----
From: Zimmerman, John <Zimmerman.JohnH@epa.gov> Sent: Monday, October 17, 2022 9:17 AM
To: Stapleton, Mark <Mark.Stapleton@noblis.org>
Cc: WORTMAN, RYAN J GS-13 USAF AFCEC AFCEC/CZO <ryan.wortman.3@us.af.mil>; Schumacher, Brian <Schumacher.Brian@epa.gov>
Subject: [URL Verdict: Neutral][Non-DoD Source] RE: [External - Non-Noblis]
RE: Well Purging

Hi Mark,

1. The only reference to purge volume that I could find in the US EPA ERT SOP #2042 that they reference is in section 7.1.3 it states: "To ensure a representative soil gas sample, a discrete volume of gas is purged to rid the tubing of atmospheric air and allow the subsurface soil gas to enter the probe tubing. The volume of gas removed is determined by the volume of tubing employed in the probe. (Unlike groundwater sampling, purging of a soil gas probe is designed to remove only the ambient air within the tubing.)" This would imply that only the internal volume of any tubing utilized is the only volume of air to remove prior to sampling. There is no mention of the removal of three of the purge volume be removed before sampling in the referenced document.

2. See answer to question #1.

3. I haven't found any specific guidance from EPA on flow rate but agree that the 200-500ml/min flow is the generally accepted industry standard for shallow depth soil vapor wells. These flow rates are suggested to maintain laminar flow in the sampling system while purging and sampling.
We usually sample at flow rates of no more than 200mL/min but we are usually only sampling at shallow depths of up to 20 feet bgs. I did find in the refenced EPA ERT SOP #2042 the following: Section 7.2.2 states the flow rate to utilize during well purging and screening with field Instruments is 3.0 L/min but no mention of a different flow rate during sampling is found made in this or any other section.

4. In the refenced EPA ERT SOP #2042 the following: Section 7.5 states the approximate sampling time when utilizing a 6 L summa canister is 20 minutes but no mention of a flow rate is made in this section.

5. There are no specific EPA guidance on including historically monitored total petroleum hydrocarbon fractions in the analytical suite for all soil vapor samples at a site. I suspect this is a site / permit specific requirement by the state agency.

6. I have not found any EPA guidance documents that provides guidance in the collection or monitoring of other vapor parameters to show stabilization of the soil vapor being removed. This type of monitoring is done for water sampling but I have not seen it done for soil vapor sampling.

I hope I have been able to provide some answers to your questions of that this information is useful to you. If you have any more questions or would like to discuss these issue further, let me know.

Sincerely,

John H. Zimmerman Jr., M.Sc.

Research Physical Scientist

US EPA/ORD/CEMM/WECD/MMB

109 T.W. Alexander Drive

RTP, NC 27711

Phone: (919) 541-9719

Fax: (919) 541-4499

Email: Zimmerman.johnh@epa.gov

From: Stapleton, Mark <Mark.Stapleton@noblis.org>
Sent: Wednesday, October 12, 2022 6:57 AM
To: Zimmerman, John <Zimmerman.JohnH@epa.gov>
Cc: Ryan Wortman <ryan.wortman.3@us.af.mil>
Subject: RE: [External - Non-Noblis] RE: Well Purging

John,

Just wanted to touch base with you regarding the questions/issues below. We are drafting a response to the letter we provided to you and hope to have it completed by the end of the week. Our plan is to submit the response to our chain of command early next week for signatures and delivery to the state by
the end of the month.

Sincerely,
J. Mark Stapleton, PhD, PE, BCEE

Attachment

Well Volume
Summary Table

Soil Vapor Monitoring Well Volumes

Sample Location	Unique Database ID	Screened Interval (ft) Top	Screened Interval (ft) Bottom	Well Casing Diameter (in)	Casing Area (sq ft)	Filter Pack Length (ft)	Well Casing Volume (cu ft)[1]	Filter Pack Blank Casing Volume (cu ft)[2]	Borehole Diameter (in)	Filter Pack Area (sq ft)	Filter Pack Volume (cu ft)[3]	Sample Train Volume (cu ft)[4]	Well Volume (cu ft)[5]	3X Well Volume (cu ft)[5]	Purge time at 500 mL/min Flowrate (min)
KAFB-106028	KAFB-106028-150	148.75	151.25	0.5	0.0014	20.0000	0.21	0.109	9.63	0.51	3.93	0.01	4.15	12.4	704.8
	KAFB-106028-250	248.75	251.25	0.5	0.0014	20.0000	0.34	0.082	9.63	0.51	3.96	0.01	4.31	12.9	732.6
	KAFB-106028-350	348.75	351.25	0.5	0.0014	20.0000	0.48	0.055	9.63	0.51	3.99	0.01	4.48	13.4	760.4
	KAFB-106028-450	448.75	451.25	0.5	0.0014	20.0000	0.62	0.027	9.63	0.51	4.01	0.01	4.64	13.9	788.2
KAFB-106108	KAFB-106108-025	15.3	25.3	0.75	0.0031	12.0000	0.08	0.74	11.75	0.75	2.88	0.01	2.97	8.9	503.7
	KAFB-106108-050	40	50	0.75	0.0031	13.5000	0.15	0.79	11.75	0.75	3.28	0.01	3.44	10.3	584.8
	KAFB-106108-150	140.2	150.2	0.75	0.0031	13.0000	0.46	0.72	9.63	0.51	1.91	0.01	2.38	7.1	404.3
	KAFB-106108-250	240.3	250.3	0.75	0.0031	13.0000	0.77	0.68	9.63	0.51	1.95	0.01	2.73	8.2	463.2
	KAFB-106108-350	340.3	350.3	0.75	0.0031	14.5000	1.07	0.71	9.63	0.51	2.22	0.01	3.30	9.9	561.1
	KAFB-106108-450	440	450	3	0.0491	19.7000	22.09	0.00	9.63	0.51	3.98	0.01	26.08	78.2	4430.4
KAFB-106109	KAFB-106109-025	15.2	25.2	0.75	0.0031	12.0000	0.08	0.74	11.75	0.75	2.88	0.01	2.97	8.9	503.7
	KAFB-106109-050	40.1	50.1	0.75	0.0031	13.0000	0.15	0.76	11.75	0.75	3.16	0.01	3.32	10.0	564.2
	KAFB-106109-150	140	150	0.75	0.0031	14.5000	0.46	0.80	9.63	0.51	2.13	0.01	2.60	7.8	441.6
	KAFB-106109-250	240.2	250.2	0.75	0.0031	13.0000	0.77	0.68	9.63	0.51	1.95	0.01	2.73	8.2	463.2
	KAFB-106109-350	340.6	350.6	0.75	0.0031	13.6000	1.08	0.67	9.63	0.51	2.08	0.01	3.17	9.5	537.9
	KAFB-106109-450	440	450	3	0.0491	22.2000	22.09	0.00	9.63	0.51	4.49	0.01	26.59	79.8	4516.3
KAFB-106110	KAFB-106110-025	15	25	0.75	0.0031	12.0000	0.08	0.74	11.75	0.75	2.88	0.01	2.96	8.9	503.6
	KAFB-106110-050	40.1	50.1	0.75	0.0031	12.0000	0.15	0.70	11.75	0.75	2.91	0.01	3.08	9.2	522.9
	KAFB-106110-150	140.3	150.3	0.75	0.0031	13.0000	0.46	0.72	9.63	0.51	1.91	0.01	2.38	7.1	404.3
	KAFB-106110-250	240	250	0.75	0.0031	13.0000	0.77	0.68	9.63	0.51	1.95	0.01	2.73	8.2	463.1
	KAFB-106110-350	340.2	350.2	0.75	0.0031	14.0000	1.07	0.69	9.63	0.51	2.14	0.01	3.23	9.7	548.1
	KAFB-106110-450	440	450	3	0.0491	19.4000	22.09	0.00	9.63	0.51	3.92	0.01	26.02	78.1	4420.1
KAFB-106111	KAFB-106111-025	15.2	25.2	0.75	0.0031	13.0000	0.08	0.80	11.75	0.75	3.12	0.01	3.20	9.6	544.4
	KAFB-106111-050	40.1	50.1	0.75	0.0031	12.0000	0.15	0.70	11.75	0.75	2.91	0.01	3.08	9.2	522.9
	KAFB-106111-150	140.3	150.3	0.75	0.0031	15.0000	0.46	0.83	9.63	0.51	2.20	0.01	2.67	8.0	454.2
	KAFB-106111-250	240.3	250.3	0.75	0.0031	14.0000	0.77	0.73	9.63	0.51	2.10	0.01	2.88	8.6	488.7
	KAFB-106111-350	340.4	350.4	0.75	0.0031	15.5000	1.08	0.76	9.63	0.51	2.37	0.01	3.46	10.4	587.2
	KAFB-106111-450	440.3	450.3	3	0.0491	18.6000	22.10	0.00	9.63	0.51	3.76	0.01	25.87	77.6	4395.2
KAFB-106112	KAFB-106112-025	15	25	0.75	0.0031	13.0000	0.08	0.80	11.75	0.75	3.12	0.01	3.20	9.6	544.3
	KAFB-106112-050	40	50	0.75	0.0031	13.5000	0.15	0.79	11.75	0.75	3.28	0.01	3.44	10.3	584.8
	KAFB-106112-150	140	150	0.75	0.0031	15.0000	0.46	0.83	9.63	0.51	2.20	0.01	2.67	8.0	454.1
	KAFB-106112-250	240	250	0.75	0.0031	17.0000	0.77	0.89	9.63	0.51	2.55	0.01	3.33	10.0	565.0
	KAFB-106112-350	339	349	0.75	0.0031	15.0000	1.07	0.74	9.63	0.51	2.30	0.01	3.38	10.1	573.4
	KAFB-106112-450	439	449	3	0.0491	18.5000	22.04	0.00	9.63	0.51	3.74	0.01	25.79	77.4	4380.9
KAFB-106113	KAFB-106113-020	10	20	0.75	0.0031	13.5000	0.06	0.83	11.75	0.75	3.24	0.01	3.31	9.9	562.1
	KAFB-106113-050	40	50	0.75	0.0031	13.5000	0.15	0.79	11.75	0.75	3.28	0.01	3.44	10.3	584.8
	KAFB-106113-150	140	150	0.75	0.0031	13.0000	0.46	0.72	9.63	0.51	1.91	0.01	2.38	7.1	404.2
	KAFB-106113-250	240	250	0.75	0.0031	14.0000	0.77	0.73	9.63	0.51	2.10	0.01	2.88	8.6	488.5
	KAFB-106113-350	340	350	0.75	0.0031	14.5000	1.07	0.71	9.63	0.51	2.22	0.01	3.30	9.9	561.0
	KAFB-106113-450	440	450	3	0.0491	19.0000	22.09	0.00	9.63	0.51	3.84	0.01	25.94	77.8	4406.4
KAFB-106114	KAFB-106114-025	15	25	0.75	0.0031	13.0000	0.08	0.80	11.75	0.75	3.12	0.01	3.20	9.6	544.3
	KAFB-106114-050	40	50	0.75	0.0031	13.0000	0.15	0.76	11.75	0.75	3.16	0.01	3.32	10.0	564.1
	KAFB-106114-150	140	150	0.75	0.0031	13.0000	0.46	0.72	9.63	0.51	1.91	0.01	2.38	7.1	404.2
	KAFB-106114-250	235	245	0.75	0.0031	13.0000	0.75	0.68	9.63	0.51	1.95	0.01	2.71	8.1	460.5
	KAFB-106114-350	340	350	0.75	0.0031	13.0000	1.07	0.64	9.63	0.51	1.99	0.01	3.07	9.2	522.0
	KAFB-106114-450	439.6	449.6	3	0.0491	13.0000	22.07	0.00	9.63	0.51	2.63	0.01	24.71	74.1	4197.1
KAFB-106115	KAFB-106115-025	14.6	24.6	0.75	0.0031	13.0000	0.08	0.80	11.75	0.75	3.12	0.01	3.20	9.6	544.1
	KAFB-106115-050	39.6	49.6	0.75	0.0031	13.0000	0.15	0.76	11.75	0.75	3.16	0.01	3.32	10.0	563.9
	KAFB-106115-150	144.6	154.6	0.75	0.0031	13.0000	0.47	0.72	9.63	0.51	1.91	0.01	2.39	7.2	406.6
	KAFB-106115-250	239.6	249.6	0.75	0.0031	13.0000	0.77	0.68	9.63	0.51	1.95	0.01	2.72	8.2	462.9
	KAFB-106115-350	339.6	349.6	0.75	0.0031	13.0000	1.07	0.64	9.63	0.51	1.99	0.01	3.07	9.2	521.8
	KAFB-106115-450	439.6	449.6	3	0.0491	17.0000	22.07	0.00	9.63	0.51	3.44	0.01	25.52	76.5	4334.4
KAFB-106116	KAFB-106116-025	10	20	0.75	0.0031	14.0000	0.06	0.86	11.75	0.75	3.36	0.01	3.43	10.3	582.5
	KAFB-106116-050	40	50	0.75	0.0031	15.0000	0.15	0.87	11.75	0.75	3.64	0.01	3.81	11.4	646.7
	KAFB-106116-150	140	150	0.75	0.0031	19.0000	0.46	1.05	9.63	0.51	2.79	0.01	3.26	9.8	553.9
	KAFB-106116-250	240	250	0.75	0.0031	14.5000	0.77	0.76	9.63	0.51	2.17	0.01	2.95	8.9	501.3
	KAFB-106116-350	340	350	0.75	0.0031	14.5000	1.07	0.71	9.63	0.51	2.22	0.01	3.30	9.9	561.0
	KAFB-106116-450	440	450	3	0.0491	19.0000	22.09	0.00	9.63	0.51	3.84	0.01	25.94	77.8	4406.4
KAFB-106117	KAFB-106117-025	15	25	0.75	0.0031	13.0000	0.08	0.80	11.75	0.75	3.12	0.01	3.20	9.6	544.3
	KAFB-106117-050	40	50	0.75	0.0031	12.5000	0.15	0.73	11.75	0.75	3.04	0.01	3.20	9.6	543.5
	KAFB-106117-150	140	150	0.75	0.0031	13.0000	0.46	0.72	9.63	0.51	1.91	0.01	2.38	7.1	404.2
	KAFB-106117-250	240	250	0.75	0.0031	13.0000	0.77	0.68	9.63	0.51	1.95	0.01	2.73	8.2	463.1
	KAFB-106117-350	340	350	0.75	0.0031	12.5000	1.07	0.61	9.63	0.51	1.91	0.01	3.00	9.0	509.0
	KAFB-106117-450	440	450	3	0.0491	22.0000	22.09	0.00	9.63	0.51	4.45	0.01	26.55	79.6	4509.4

Soil Vapor Monitoring Well Volumes

Sample Location	Unique Database ID	Screened Interval (ft) Top	Screened Interval (ft) Bottom	Well Casing Diameter (in)	Casing Area (sq ft)	Filter Pack Length (ft)	Well Casing Volume (cu ft)[1]	Filter Pack Blank Casing Volume (cu ft)[2]	Borehole Diameter (in)	Filter Pack Area (sq ft)	Filter Pack Volume (cu ft)[3]	Sample Train Volume (cu ft)[4]	Well Volume (cu ft)[5]	3X Well Volume (cu ft)[5]	Purge time at 500 mL/min Flowrate (min)
KAFB-106118	KAFB-106118-025	15	25	0.75	0.0031	13.0000	0.08	0.80	11.75	0.75	3.12	0.01	3.20	9.6	544.3
	KAFB-106118-050	40	50	0.75	0.0031	15.0000	0.15	0.87	11.75	0.75	3.64	0.01	3.81	11.4	646.7
	KAFB-106118-160	150	160	0.75	0.0031	14.0000	0.49	0.77	9.63	0.51	2.06	0.01	2.56	7.7	434.3
	KAFB-106118-265	255	265	0.75	0.0031	15.0000	0.81	0.78	9.63	0.51	2.25	0.01	3.07	9.2	521.8
	KAFB-106118-350	340	350	0.75	0.0031	15.0000	1.07	0.74	9.63	0.51	2.30	0.01	3.38	10.1	574.0
	KAFB-106118-450	440	450	3	0.0491	22.2000	22.09	0.00	9.63	0.51	4.49	0.01	26.59	79.8	4516.3
KAFB-106119	KAFB-106119-025	15	25	0.75	0.0031	13.0000	0.08	0.80	11.75	0.75	3.12	0.01	3.20	9.6	544.3
	KAFB-106119-050	40	50	0.75	0.0031	14.0000	0.15	0.82	11.75	0.75	3.40	0.01	3.56	10.7	605.4
	KAFB-106119-150	140	150	0.75	0.0031	14.0000	0.46	0.77	9.63	0.51	2.06	0.01	2.53	7.6	429.1
	KAFB-106119-250	240	250	0.75	0.0031	15.0000	0.77	0.78	9.63	0.51	2.25	0.01	3.03	9.1	514.0
	KAFB-106119-350	340	350	0.75	0.0031	14.0000	1.07	0.69	9.63	0.51	2.14	0.01	3.23	9.7	548.0
	KAFB-106119-450	440	450	3	0.0491	18.0000	22.09	0.00	9.63	0.51	3.64	0.01	25.74	77.2	4372.1
KAFB-106120	KAFB-106120-025	15	25	0.75	0.0031	15.0000	0.08	0.92	11.75	0.75	3.60	0.01	3.68	11.1	625.8
	KAFB-106120-050	40	50	0.75	0.0031	17.0000	0.15	0.99	11.75	0.75	4.13	0.01	4.29	12.9	729.2
	KAFB-106120-150	140	150	0.75	0.0031	16.0000	0.46	0.88	9.63	0.51	2.35	0.01	2.82	8.5	479.0
	KAFB-106120-250	240	250	0.75	0.0031	15.0000	0.77	0.78	9.63	0.51	2.25	0.01	3.03	9.1	514.0
	KAFB-106120-350	340	350	0.75	0.0031	16.0000	1.07	0.79	9.63	0.51	2.45	0.01	3.53	10.6	599.9
	KAFB-106120-450	434	444	3	0.0491	16.5000	21.79	0.00	9.63	0.51	3.33	0.01	25.14	75.4	4270.5
KAFB-106121	KAFB-106121-025	15	25	0.75	0.0031	16.4000	0.08	1.01	11.75	0.75	3.93	0.01	4.02	12.1	682.9
	KAFB-106121-050	40	50	0.75	0.0031	15.0000	0.15	0.87	11.75	0.75	3.64	0.01	3.81	11.4	646.7
	KAFB-106121-145	135	145	0.75	0.0031	16.5000	0.44	0.91	9.63	0.51	2.42	0.01	2.88	8.6	488.9
	KAFB-106121-250	240	250	0.75	0.0031	15.0000	0.77	0.78	9.63	0.51	2.25	0.01	3.03	9.1	514.0
	KAFB-106121-350	340	350	0.75	0.0031	17.0000	1.07	0.83	9.63	0.51	2.60	0.01	3.68	11.1	625.9
	KAFB-106121-440	430	440	3	0.0491	19.2000	21.60	0.00	9.63	0.51	3.88	0.01	25.49	76.5	4329.9
KAFB-106122	KAFB-106122-025	15	25	0.75	0.0031	15.0000	0.08	0.92	11.75	0.75	3.60	0.01	3.68	11.1	625.8
	KAFB-106122-050	40	50	0.75	0.0031	15.0000	0.15	0.87	11.75	0.75	3.64	0.01	3.81	11.4	646.7
	KAFB-106122-150	140	150	0.75	0.0031	14.0000	0.46	0.77	9.63	0.51	2.06	0.01	2.53	7.6	429.1
	KAFB-106122-250	240	250	0.75	0.0031	15.0000	0.77	0.78	9.63	0.51	2.25	0.01	3.03	9.1	514.0
	KAFB-106122-350	340	350	0.75	0.0031	16.0000	1.07	0.79	9.63	0.51	2.45	0.01	3.53	10.6	599.9
	KAFB-106122-450	434	444	3	0.0491	17.0000	21.79	0.00	9.63	0.51	3.44	0.01	25.24	75.7	4287.7
KAFB-106123	KAFB-106123-025	15	25	0.75	0.0031	15.0000	0.08	0.92	11.75	0.75	3.60	0.01	3.68	11.1	625.8
	KAFB-106123-050	40	50	0.75	0.0031	15.0000	0.15	0.87	11.75	0.75	3.64	0.01	3.81	11.4	646.7
	KAFB-106123-150	140	150	0.75	0.0031	15.0000	0.46	0.83	9.63	0.51	2.20	0.01	2.67	8.0	454.1
	KAFB-106123-250	240	250	0.75	0.0031	15.0000	0.77	0.78	9.63	0.51	2.25	0.01	3.03	9.1	514.0
	KAFB-106123-350	340	350	0.75	0.0031	16.0000	1.07	0.79	9.63	0.51	2.45	0.01	3.53	10.6	599.9
	KAFB-106123-450	432	442	3	0.0491	18.0000	21.70	0.00	9.63	0.51	3.64	0.01	25.34	76.0	4305.3
KAFB-106124	KAFB-106124-025	15.1	25.1	0.75	0.0031	15.5000	0.08	0.95	11.75	0.75	3.72	0.01	3.80	11.4	646.2
	KAFB-106124-050	40.1	50.1	0.75	0.0031	15.0000	0.15	0.87	11.75	0.75	3.64	0.01	3.81	11.4	646.7
	KAFB-106124-150	140.1	150.1	0.75	0.0031	15.0000	0.46	0.83	9.63	0.51	2.20	0.01	2.67	8.0	454.1
	KAFB-106124-250	240.1	250.1	0.75	0.0031	15.0000	0.77	0.78	9.63	0.51	2.25	0.01	3.03	9.1	514.1
	KAFB-106124-350	340.1	350.1	0.75	0.0031	17.3000	1.07	0.85	9.63	0.51	2.65	0.01	3.73	11.2	633.8
	KAFB-106124-450	440.1	450.1	3	0.0491	22.0000	22.09	0.00	9.63	0.51	4.45	0.01	26.55	79.7	4510.2
KAFB-106125	KAFB-106125-025	15.2	25.2	0.75	0.0031	25.0000	0.08	1.53	11.75	0.75	6.00	0.01	6.08	18.2	1033.4
	KAFB-106125-050	40.2	50.2	0.75	0.0031	16.0000	0.15	0.93	11.75	0.75	3.89	0.01	4.05	12.2	688.0
	KAFB-106125-150	140.2	150.2	0.75	0.0031	15.5000	0.46	0.86	9.63	0.51	2.28	0.01	2.75	8.2	466.7
	KAFB-106125-250	240.2	250.2	0.75	0.0031	15.8000	0.77	0.82	9.63	0.51	2.37	0.01	3.15	9.4	534.5
	KAFB-106125-350	340.2	350.2	0.75	0.0031	14.4000	1.07	0.71	9.63	0.51	2.20	0.01	3.29	9.9	558.5
	KAFB-106125-450	440.2	450.2	3	0.0491	20.6000	22.10	0.00	9.63	0.51	4.16	0.01	26.27	78.8	4463.0
KAFB-106126	KAFB-106126-025	15.1	25.1	0.75	0.0031	15.0000	0.08	0.92	11.75	0.75	3.60	0.01	3.68	11.1	625.9
	KAFB-106126-050	40.1	50.1	0.75	0.0031	16.0000	0.15	0.93	11.75	0.75	3.89	0.01	4.05	12.1	688.0
	KAFB-106126-150	140.1	150.1	0.75	0.0031	15.4000	0.46	0.85	9.63	0.51	2.26	0.01	2.73	8.2	464.1
	KAFB-106126-250	240.1	250.1	0.75	0.0031	15.6000	0.77	0.81	9.63	0.51	2.34	0.01	3.12	9.3	529.4
	KAFB-106126-350	340.1	350.1	0.75	0.0031	17.0000	1.07	0.83	9.63	0.51	2.60	0.01	3.69	11.1	626.0
	KAFB-106126-450	440.2	450.2	3	0.0491	21.0000	22.10	0.00	9.63	0.51	4.24	0.01	26.35	79.1	4476.7
KAFB-106127	KAFB-106127-025	15	25	0.75	0.0031	15.0000	0.08	0.92	11.75	0.75	3.60	0.01	3.68	11.1	625.8
	KAFB-106127-050	40	50	0.75	0.0031	15.0000	0.15	0.87	11.75	0.75	3.64	0.01	3.81	11.4	646.7
	KAFB-106127-150	140	150	0.75	0.0031	16.0000	0.46	0.88	9.63	0.51	2.35	0.01	2.82	8.5	479.0
	KAFB-106127-250	240	250	0.75	0.0031	18.0000	0.77	0.94	9.63	0.51	2.70	0.01	3.48	10.4	590.4
	KAFB-106127-350	340	350	0.75	0.0031	15.0000	1.07	0.74	9.63	0.51	2.30	0.01	3.38	10.1	574.0
	KAFB-106127-450	440	450	3	0.0491	21.0000	22.09	0.00	9.63	0.51	4.24	0.01	26.34	79.0	4475.1
KAFB-106128	KAFB-106128-025	15	25	0.75	0.0031	11.0000	0.08	0.67	11.75	0.75	2.64	0.01	2.72	8.2	462.8
	KAFB-106128-050	40.1	50.1	0.75	0.0031	12.0000	0.15	0.70	11.75	0.75	2.91	0.01	3.08	9.2	522.9
	KAFB-106128-150	140.2	150.2	0.75	0.0031	13.0000	0.46	0.72	9.63	0.51	1.91	0.01	2.38	7.1	404.3
	KAFB-106128-250	240.3	250.3	0.75	0.0031	15.0000	0.77	0.78	9.63	0.51	2.25	0.01	3.03	9.1	514.2

Soil Vapor Monitoring Well Volumes

Sample Location	Unique Database ID	Screened Interval (ft) Top	Screened Interval (ft) Bottom	Well Casing Diameter (in)	Casing Area (sq ft)	Filter Pack Length (ft)	Well Casing Volume (cu ft)[1]	Filter Pack Blank Casing Volume (cu ft)[2]	Borehole Diameter (in)	Filter Pack Area (sq ft)	Filter Pack Volume (cu ft)[3]	Sample Train Volume (cu ft)[4]	Well Volume (cu ft)[5]	3X Well Volume (cu ft)[5]	Purge time at 500 mL/min Flowrate (min)
	KAFB-106128-350	340.4	350.4	0.75	0.0031	13.0000	1.08	0.64	9.63	0.51	1.99	0.01	3.07	9.2	522.2
	KAFB-106128-450	440	450	3	0.0491	14.0000	22.09	0.00	9.63	0.51	2.83	0.01	24.93	74.8	4234.7
KAFB-106129	KAFB-106129-025	15.1	25.1	0.75	0.0031	12.5000	0.08	0.77	11.75	0.75	3.00	0.01	3.08	9.3	524.0
	KAFB-106129-050	39.7	49.7	0.75	0.0031	12.7000	0.15	0.74	11.75	0.75	3.09	0.01	3.25	9.7	551.6
	KAFB-106129-150	140.2	150.2	0.75	0.0031	13.5000	0.46	0.75	9.63	0.51	1.98	0.01	2.45	7.4	416.8
	KAFB-106129-250	240.1	250.1	0.75	0.0031	13.5000	0.77	0.70	9.63	0.51	2.02	0.01	2.80	8.4	475.9
	KAFB-106129-350	337.4	347.4	0.75	0.0031	13.0000	1.07	0.64	9.63	0.51	1.99	0.01	3.06	9.2	520.6
	KAFB-106129-450	440.7	450.7	3	0.0491	22.0000	22.12	0.00	9.63	0.51	4.45	0.01	26.58	79.7	4515.2
KAFB-106130	KAFB-106130-025	15	25	0.75	0.0031	14.5000	0.08	0.89	11.75	0.75	3.48	0.01	3.56	10.7	605.4
	KAFB-106130-050	40	50	0.75	0.0031	15.0000	0.15	0.87	11.75	0.75	3.64	0.01	3.81	11.4	646.7
	KAFB-106130-150	150	160	0.75	0.0031	15.0000	0.49	0.83	9.63	0.51	2.20	0.01	2.70	8.1	459.3
	KAFB-106130-250	240	250	0.75	0.0031	13.0000	0.77	0.68	9.63	0.51	1.95	0.01	2.73	8.2	463.1
	KAFB-106130-350	340	350	0.75	0.0031	14.0000	1.07	0.69	9.63	0.51	2.14	0.01	3.23	9.7	548.0
	KAFB-106130-450	440	450	3	0.0491	17.0000	22.09	0.00	9.63	0.51	3.44	0.01	25.53	76.6	4337.7
KAFB-106131	KAFB-106131-025	15	25	0.75	0.0031	13.0000	0.08	0.80	11.75	0.75	3.12	0.01	3.20	9.6	544.3
	KAFB-106131-055	45	55	0.75	0.0031	13.0000	0.17	0.76	11.75	0.75	3.16	0.01	3.34	10.0	566.7
	KAFB-106131-150	140	150	0.75	0.0031	13.0000	0.46	0.72	9.63	0.51	1.91	0.01	2.38	7.1	404.2
	KAFB-106131-245	235	245	0.75	0.0031	13.0000	0.75	0.68	9.63	0.51	1.95	0.01	2.71	8.1	460.5
	KAFB-106131-350	340	350	0.75	0.0031	13.0000	1.07	0.64	9.63	0.51	1.99	0.01	3.07	9.2	522.0
	KAFB-106131-450	430	440	3	0.0491	22.0000	21.60	0.00	9.63	0.51	4.45	0.01	26.05	78.2	4426.0
KAFB-106132	KAFB-106132-025	15	25	0.75	0.0031	14.0000	0.08	0.86	11.75	0.75	3.36	0.01	3.44	10.3	585.1
	KAFB-106132-050	40	50	0.75	0.0031	13.0000	0.15	0.76	11.75	0.75	3.16	0.01	3.32	10.0	564.1
	KAFB-106132-175	165	175	0.75	0.0031	19.0000	0.54	1.05	9.63	0.51	2.79	0.01	3.34	10.0	566.9
	KAFB-106132-250	240	250	0.75	0.0031	14.0000	0.77	0.73	9.63	0.51	2.10	0.01	2.88	8.6	488.5
	KAFB-106132-350	340	350	0.75	0.0031	14.0000	1.07	0.69	9.63	0.51	2.14	0.01	3.23	9.7	548.0
	KAFB-106132-450	440	450	3	0.0491	22.5000	22.09	0.00	9.63	0.51	4.55	0.01	26.65	79.9	4526.6
KAFB-106133	KAFB-106133-025	15	25	0.75	0.0031	13.0000	0.08	0.80	11.75	0.75	3.12	0.01	3.20	9.6	544.3
	KAFB-106133-050	40	50	0.75	0.0031	14.0000	0.15	0.82	11.75	0.75	3.40	0.01	3.56	10.7	605.4
	KAFB-106133-170	160	170	0.75	0.0031	14.0000	0.52	0.77	9.63	0.51	2.06	0.01	2.59	7.8	439.6
	KAFB-106133-250	240	250	0.75	0.0031	14.0000	0.77	0.73	9.63	0.51	2.10	0.01	2.88	8.6	488.5
	KAFB-106133-350	339	349	0.75	0.0031	14.0000	1.07	0.69	9.63	0.51	2.14	0.01	3.22	9.7	547.4
	KAFB-106133-450	439	449	3	0.0491	20.0000	22.04	0.00	9.63	0.51	4.04	0.01	26.09	78.3	4432.4
KAFB-106134	KAFB-106134-025	15	25	0.75	0.0031	13.0000	0.08	0.80	11.75	0.75	3.12	0.01	3.20	9.6	544.3
	KAFB-106134-050	40	50	0.75	0.0031	14.0000	0.15	0.82	11.75	0.75	3.40	0.01	3.56	10.7	605.4
	KAFB-106134-170	160	170	0.75	0.0031	13.0000	0.52	0.72	9.63	0.51	1.91	0.01	2.44	7.3	414.6
	KAFB-106134-250	240	250	0.75	0.0031	13.0000	0.77	0.68	9.63	0.51	1.95	0.01	2.73	8.2	463.1
	KAFB-106134-350	340	350	0.75	0.0031	13.0000	1.07	0.64	9.63	0.51	1.99	0.01	3.07	9.2	522.0
	KAFB-106134-450	440	450	3	0.0491	22.0000	22.09	0.00	9.63	0.51	4.45	0.01	26.55	79.6	4509.4
KAFB-106135	KAFB-106135-025	15	25	0.75	0.0031	14.0000	0.08	0.86	11.75	0.75	3.36	0.01	3.44	10.3	585.1
	KAFB-106135-050	40	50	0.75	0.0031	14.5000	0.15	0.85	11.75	0.75	3.52	0.01	3.69	11.1	626.0
	KAFB-106135-150	140	150	0.75	0.0031	14.0000	0.46	0.77	9.63	0.51	2.06	0.01	2.53	7.6	429.1
	KAFB-106135-250	240	250	0.75	0.0031	14.0000	0.77	0.73	9.63	0.51	2.10	0.01	2.88	8.6	488.5
	KAFB-106135-350	340	350	0.75	0.0031	14.0000	1.07	0.69	9.63	0.51	2.14	0.01	3.23	9.7	548.0
	KAFB-106135-450	440	450	3	0.0491	22.5000	22.09	0.00	9.63	0.51	4.55	0.01	26.65	79.9	4526.6
KAFB-106136	KAFB-106136-025	15	25	0.75	0.0031	13.5000	0.08	0.83	11.75	0.75	3.24	0.01	3.32	10.0	564.7
	KAFB-106136-050	40	50	0.75	0.0031	14.0000	0.15	0.82	11.75	0.75	3.40	0.01	3.56	10.7	605.4
	KAFB-106136-150	140	150	0.75	0.0031	15.0000	0.46	0.83	9.63	0.51	2.20	0.01	2.67	8.0	454.1
	KAFB-106136-250	240	250	0.75	0.0031	17.0000	0.77	0.89	9.63	0.51	2.55	0.01	3.33	10.0	565.0
	KAFB-106136-350	340	350	0.75	0.0031	15.0000	1.07	0.74	9.63	0.51	2.30	0.01	3.38	10.1	574.0
	KAFB-106136-450	440	450	3	0.0491	20.0000	22.09	0.00	9.63	0.51	4.04	0.01	26.14	78.4	4440.7
KAFB-106137	KAFB-106137-025	15	25	0.75	0.0031	13.8000	0.08	0.85	11.75	0.75	3.31	0.01	3.40	10.2	576.9
	KAFB-106137-050	40	50	0.75	0.0031	14.0000	0.15	0.82	11.75	0.75	3.40	0.01	3.56	10.7	605.4
	KAFB-106137-150	140	150	0.75	0.0031	15.0000	0.46	0.83	9.63	0.51	2.20	0.01	2.67	8.0	454.1
	KAFB-106137-250	240.1	250.1	0.75	0.0031	13.0000	0.77	0.68	9.63	0.51	1.95	0.01	2.73	8.2	463.1
	KAFB-106137-350	340.5	350.5	0.75	0.0031	13.0000	1.08	0.64	9.63	0.51	1.99	0.01	3.07	9.2	522.2
	KAFB-106137-450	440	450	3	0.0491	22.0000	22.09	0.00	9.63	0.51	4.45	0.01	26.55	79.6	4509.4
KAFB-106138	KAFB-106138-025	15	25	0.75	0.0031	15.0000	0.08	0.92	11.75	0.75	3.60	0.01	3.68	11.1	625.8
	KAFB-106138-050	40	50	0.75	0.0031	16.0000	0.15	0.93	11.75	0.75	3.89	0.01	4.05	12.1	687.9
	KAFB-106138-150	140	150	0.75	0.0031	15.0000	0.46	0.83	9.63	0.51	2.20	0.01	2.67	8.0	454.1
	KAFB-106138-250	240	250	0.75	0.0031	17.0000	0.77	0.89	9.63	0.51	2.55	0.01	3.33	10.0	565.0
	KAFB-106138-350	340	350	0.75	0.0031	15.5000	1.07	0.76	9.63	0.51	2.37	0.01	3.46	10.4	587.0
	KAFB-106138-450	440	450	3	0.0491	20.5000	22.09	0.00	9.63	0.51	4.14	0.01	26.24	78.7	4457.9
KAFB-106139	KAFB-106139-025	15	25	0.75	0.0031	13.0000	0.08	0.80	11.75	0.75	3.12	0.01	3.20	9.6	544.3
	KAFB-106139-050	40	50	0.75	0.0031	13.0000	0.15	0.76	11.75	0.75	3.16	0.01	3.32	10.0	564.1

Soil Vapor Monitoring Well Volumes

Sample Location	Unique Database ID	Screened Interval (ft) Top	Screened Interval (ft) Bottom	Well Casing Diameter (in)	Casing Area (sq ft)	Filter Pack Length (ft)	Well Casing Volume (cu ft)[1]	Filter Pack Blank Casing Volume (cu ft)[2]	Borehole Diameter (in)	Filter Pack Area (sq ft)	Filter Pack Volume (cu ft)[3]	Sample Train Volume (cu ft)[4]	Well Volume (cu ft)[5]	3X Well Volume (cu ft)[5]	Purge time at 500 mL/min Flowrate (min)
	KAFB-106139-150	140	150	0.75	0.0031	15.5000	0.46	0.86	9.63	0.51	2.28	0.01	2.75	8.2	466.6
	KAFB-106139-250	240	250	0.75	0.0031	16.0000	0.77	0.83	9.63	0.51	2.40	0.01	3.18	9.5	539.5
	KAFB-106139-350	340	350	0.75	0.0031	15.0000	1.07	0.74	9.63	0.51	2.30	0.01	3.38	10.1	574.0
	KAFB-106139-450	440	450	3	0.0491	22.5000	22.09	0.00	9.63	0.51	4.55	0.01	26.65	79.9	4526.6
KAFB-106140	KAFB-106140-025	15	25	0.75	0.0031	13.3000	0.08	0.82	11.75	0.75	3.19	0.01	3.28	9.8	556.5
	KAFB-106140-050	40	50	0.75	0.0031	13.1000	0.15	0.76	11.75	0.75	3.18	0.01	3.35	10.0	568.3
	KAFB-106140-150	141.8	151.8	0.75	0.0031	14.8000	0.47	0.82	9.63	0.51	2.17	0.01	2.65	7.9	450.0
	KAFB-106140-250	240	250	0.75	0.0031	19.2000	0.77	1.00	9.63	0.51	2.88	0.01	3.66	11.0	621.0
	KAFB-106140-350	340	350	0.75	0.0031	14.5000	1.07	0.71	9.63	0.51	2.22	0.01	3.30	9.9	561.0
	KAFB-106140-450	440	450	3	0.0491	21.0000	22.09	0.00	9.63	0.51	4.24	0.01	26.34	79.0	4475.1
KAFB-106141	KAFB-106141-025	15	25	0.75	0.0031	15.0000	0.08	0.92	11.75	0.75	3.60	0.01	3.68	11.1	625.8
	KAFB-106141-050	50	60	0.75	0.0031	13.0000	0.18	0.76	11.75	0.75	3.16	0.01	3.35	10.1	569.3
	KAFB-106141-170	160	170	0.75	0.0031	15.0000	0.52	0.83	9.63	0.51	2.20	0.01	2.73	8.2	464.5
	KAFB-106141-250	240	250	0.75	0.0031	15.5000	0.77	0.81	9.63	0.51	2.32	0.01	3.10	9.3	526.8
	KAFB-106141-350	340	350	0.75	0.0031	17.0000	1.07	0.83	9.63	0.51	2.60	0.01	3.68	11.1	625.9
	KAFB-106141-450	440	450	3	0.0491	21.0000	22.09	0.00	9.63	0.51	4.24	0.01	26.34	79.0	4475.1
KAFB-106142	KAFB-106142-030	20	30	0.75	0.0031	14.0000	0.09	0.86	11.75	0.75	3.36	0.01	3.46	10.4	587.7
	KAFB-106142-050	40	50	0.75	0.0031	18.0000	0.15	1.05	11.75	0.75	4.37	0.01	4.54	13.6	770.5
	KAFB-106142-170	160	170	0.75	0.0031	15.5000	0.52	0.86	9.63	0.51	2.28	0.01	2.81	8.4	477.0
	KAFB-106142-250	240	250	0.75	0.0031	15.0000	0.77	0.78	9.63	0.51	2.25	0.01	3.03	9.1	514.0
	KAFB-106142-350	340	350	0.75	0.0031	12.0000	1.07	0.59	9.63	0.51	1.84	0.01	2.92	8.8	496.0
	KAFB-106142-450	440	450	3	0.0491	22.0000	22.09	0.00	9.63	0.51	4.45	0.01	26.55	79.6	4509.4
KAFB-106V1	106-V1-100-102.5	100.1	102.1	0.75	0.0031	4.5000	0.31	0.07	10.00	0.55	0.91	0.01	1.24	3.7	209.9
	106-V1-115-117.5	110.6	112.6	0.75	0.0031	5.1000	0.35	0.06	10.00	0.55	1.05	0.01	1.41	4.2	238.7
	106-V1-157.5-160	157.6	159.6	0.75	0.0031	4.7000	0.49	0.04	10.00	0.55	0.98	0.01	1.48	4.4	251.6
	106-V1-215-217.5	215.1	217.1	0.75	0.0031	4.0000	0.67	0.02	10.00	0.55	0.85	0.01	1.52	4.6	258.8
	106-V1-250-252.5	250.1	252.1	0.75	0.0031	4.2000	0.77	0.01	10.00	0.55	0.90	0.01	1.69	5.1	286.5
	106-V1-270-272.5	260.6	262.6	0.75	0.0031	6.0000	0.81	0.00	10.00	0.55	1.31	0.01	2.12	6.4	360.8
KAFB-106V2	106-V2-100-102.5	100.2	102.2	0.75	0.0031	5.0000	0.31	0.08	10.00	0.55	1.01	0.01	1.34	4.0	227.2
	106-V2-115-117.5	115.1	117.1	0.75	0.0031	4.6000	0.36	0.06	10.00	0.55	0.95	0.01	1.32	3.9	223.5
	106-V2-157.5-160	157.9	159.9	0.75	0.0031	5.4000	0.49	0.05	10.00	0.55	1.13	0.01	1.63	4.9	276.6
	106-V2-215-217.5	215.1	217.1	0.75	0.0031	5.5000	0.67	0.03	10.00	0.55	1.17	0.01	1.84	5.5	312.9
	106-V2-250-252.5	250.2	252.2	0.75	0.0031	4.0000	0.77	0.01	10.00	0.55	0.86	0.01	1.64	4.9	279.2
	106-V2-270-272.5	267.55	269.55	0.75	0.0031	3.8000	0.83	0.00	10.00	0.55	0.83	0.01	1.67	5.0	282.9
KAFB-106V3	KAFB-106V3-007	5	7	0.75	0.0031	5.1000	0.02	0.27	10.00	0.55	0.85	0.01	0.88	2.6	149.1
	KAFB-106V3-015	13	15	0.75	0.0031	5.0000	0.05	0.25	10.00	0.55	0.85	0.01	0.90	2.7	153.1
	KAFB-106V3-272	267	272	3	0.0491	10.3000	13.35	0.00	10.00	0.55	2.25	0.01	15.61	46.8	2651.5
SVEW-01	SVEW-01-260	245	260	2	0.0218	26.0000	5.67	0.00	9.63	0.51	5.25	0.01	10.94	32.8	1857.9
SVEW-02/03	SVEW-02-060	45	60	2	0.0218	27.0000	1.31	0.59	9.63	0.51	4.87	0.01	6.19	18.6	1050.9
SVEW-02/03	SVEW-03-160	145	160	2	0.0218	29.0000	3.49	0.00	9.63	0.51	5.86	0.01	9.36	28.1	1590.3
SVEW-04/05	SVEW-04-313	298	313	2	0.0218	25.0000	6.83	0.55	9.63	0.51	4.51	0.01	11.35	34.0	1927.3
SVEW-04/05	SVEW-05-460	445	460	2	0.0218	15.0000	10.04	0.00	9.63	0.51	3.03	0.01	13.08	39.2	2221.4
SVEW-06/07	SVEW-06-060	45	60	2	0.0218	15.0000	1.31	0.33	9.63	0.51	2.70	0.01	4.02	12.1	683.4
SVEW-06/07	SVEW-07-160	145	160	2	0.0218	24.5000	3.49	0.00	9.63	0.51	4.95	0.01	8.45	25.4	1435.8
SVEW-08/09	SVEW-08-260	245	260	2	0.0218	25.5000	5.67	0.56	9.63	0.51	4.60	0.01	10.28	30.8	1746.2
SVEW-08/09	SVEW-09-460	435	450	2	0.0218	27.5000	9.82	0.00	9.63	0.51	5.56	0.01	15.39	46.2	2613.5
SVEW-10	SVEW-10-410	400	410	2	0.0218	15.0000	8.94	0.33	9.63	0.51	2.70	0.01	11.66	35.0	1980.5
SVEW-11	SVEW-11-410	400	410	2	0.0218	20.8000	8.94	0.45	9.63	0.51	3.75	0.01	12.70	38.1	2158.2
SVEW-12	SVEW-12-410	400	410	2	0.0218	20.0000	8.94	0.44	9.63	0.51	3.61	0.01	12.56	37.7	2133.7
SVEW-13	SVEW-13-410	400	410	2	0.0218	21.2000	8.94	0.46	9.63	0.51	3.82	0.01	12.78	38.3	2170.4
SVMW-01	SVMW-01-050	50	52.5	0.5	0.0014	6.0000	0.07	0.129	10.00	0.55	1.18	0.01	1.26	3.8	214.3
	SVMW-01-100	100	102.5	0.5	0.0014	5.4000	0.14	0.110	10.00	0.55	1.07	0.01	1.22	3.7	206.7
	SVMW-01-250	250.7	253.2	0.5	0.0014	9.2000	0.35	0.048	10.00	0.55	1.96	0.01	2.31	6.9	393.2
	SVMW-01-300	308.5	311	0.5	0.0014	7.0000	0.42	0.000	10.00	0.55	1.53	0.01	1.96	5.9	333.1
SVMW-02	SVMW-02-050	50	52.5	0.5	0.0014	6.0000	0.07	0.110	10.00	0.55	1.20	0.01	1.28	3.8	217.4
	SVMW-02-100	97	99.5	0.5	0.0014	12.0000	0.14	2.160	10.00	0.55	0.46	0.01	0.60	1.8	102.5
	SVMW-02-150	150	152.5	0.5	0.0014	5.5000	0.21	0.016	10.00	0.55	1.18	0.01	1.40	4.2	238.1
SVMW-03	SVMW-03-050	50	52.5	0.5	0.0014	5.0000	0.07	0.000	10.00	0.55	1.09	0.01	1.17	3.5	199.1
	SVMW-03-100	100	102.5	0.5	0.0014	6.0000	0.14	1.011	10.00	0.55	0.30	0.01	0.45	1.3	76.0
	SVMW-03-250	250	252.5	0.5	0.0014	9.0000	0.34	0.567	10.00	0.55	1.40	0.01	1.75	5.3	297.3
	SVMW-03-300	300	302.5	0.5	0.0014	6.0000	0.41	0.000	10.00	0.55	1.31	0.01	1.73	5.2	294.1
SVMW-04	SVMW-04-050	50	52.5	0.5	0.0014	6.5000	0.07	1.898	10.00	0.55	0.48	0.01	0.40	1.2	67.8
	SVMW-04-100	98	100.5	0.5	0.0014	14.0000	0.14	1.091	10.00	0.55	1.96	0.01	2.11	6.3	358.5
	SVMW-04-250	250	252.5	0.5	0.0014	8.0000	0.34	0.327	10.00	0.55	1.42	0.01	1.77	5.3	301.0

Soil Vapor Monitoring Well Volumes

Sample Location	Unique Database ID	Screened Interval (ft) Top	Screened Interval (ft) Bottom	Well Casing Diameter (in)	Casing Area (sq ft)	Filter Pack Length (ft)	Well Casing Volume (cu ft)[1]	Filter Pack Blank Casing Volume (cu ft)[2]	Borehole Diameter (in)	Filter Pack Area (sq ft)	Filter Pack Volume (cu ft)[3]	Sample Train Volume (cu ft)[4]	Well Volume (cu ft)[5]	3X Well Volume (cu ft)[5]	Purge time at 500 mL/min Flowrate (min)
	SVMW-04-300	297.5	300	0.5	0.0014	7.0000	0.41	0.000	10.00	0.55	1.53	0.01	1.95	5.8	330.5
SVMW-05	SVMW-05-050	50	52.5	0.5	0.0014	7.5000	0.07	1.604	10.00	0.55	0.03	0.01	0.11	0.3	19.3
	SVMW-05-100	100	102.5	0.5	0.0014	6.0000	0.14	1.113	10.00	0.55	0.20	0.01	0.35	1.0	58.7
	SVMW-05-230	229.5	231	0.5	0.0014	5.0000	0.31	0.600	10.00	0.55	0.49	0.01	0.82	2.4	138.5
	SVMW-05-290	287.5	290	0.5	0.0014	5.0000	0.40	0.000	10.00	0.55	1.09	0.01	1.50	4.5	254.1
SVMW-06	SVMW-06-050	50	52.5	0.5	0.0014	6.0000	0.07	1.361	10.00	0.55	0.05	0.01	0.03	0.1	4.9
	SVMW-06-100	99.5	102	0.5	0.0014	6.5000	0.14	0.873	10.00	0.55	0.55	0.01	0.69	2.1	117.9
	SVMW-06-252	252	254.5	0.5	0.0014	5.5000	0.35	0.463	10.00	0.55	0.74	0.01	1.09	3.3	185.8
	SVMW-06-302	302.5	305	0.5	0.0014	12.0000	0.42	0.000	10.00	0.55	2.62	0.01	3.04	9.1	517.0
SVMW-07	SVMW-07-050	49.5	52	0.5	0.0014	6.0000	0.07	0.015	10.00	0.55	1.29	0.01	1.37	4.1	233.5
	SVMW-07-100	95.5	98	0.5	0.0014	6.0000	0.13	0.013	10.00	0.55	1.30	0.01	1.44	4.3	244.6
	SVMW-07-150	147	149.5	0.5	0.0014	5.0000	0.20	0.000	10.00	0.55	1.09	0.01	1.30	3.9	221.6
SVMW-08	SVMW-08-050	50	52.5	0.5	0.0014	8.2000	0.07	0.025	9.63	0.51	1.63	0.01	1.71	5.1	291.1
	SVMW-08-100	100	102.5	0.5	0.0014	7.5000	0.14	0.033	9.63	0.51	1.48	0.01	1.63	4.9	277.3
	SVMW-08-250	250	252.5	0.5	0.0014	7.5000	0.34	0.007	9.63	0.51	1.51	0.01	1.86	5.6	316.3
	SVMW-08-266[1]	266	268.5	0.5	0.0014	16.5000	0.37	0.000	9.63	0.51	3.33	0.01	3.71	11.1	630.3
SVMW-09	SVMW-09-050	50	52.5	0.5	0.0014	9.2000	0.07	0.025	9.63	0.51	1.83	0.01	1.92	5.7	325.5
	SVMW-09-100	100	102.5	0.5	0.0014	12.0000	0.14	0.025	9.63	0.51	2.40	0.01	2.55	7.7	433.2
	SVMW-09-250	250	252.5	0.5	0.0014	10.8000	0.34	0.008	9.63	0.51	2.17	0.01	2.53	7.6	429.5
	SVMW-09-266	266	268.5	0.5	0.0014	11.0000	0.37	0.000	9.63	0.51	2.22	0.01	2.60	7.8	441.5
SVMW-10	SVMW-10-050	50	52.5	0.5	0.0014	8.0000	0.07	0.057	9.63	0.51	1.56	0.01	1.64	4.9	278.7
	SVMW-10-100	100	102.5	0.5	0.0014	7.9000	0.14	0.022	9.63	0.51	1.57	0.01	1.72	5.2	292.9
	SVMW-10-150	150	152.5	0.5	0.0014	9.5000	0.21	0.010	9.63	0.51	1.91	0.01	2.13	6.4	361.5
	SVMW-10-250	250	252.5	0.5	0.0014	10.3000	0.34	0.000	9.63	0.51	2.08	0.01	2.44	7.3	413.7
SVMW-11	SVMW-11-050	50	52.5	0.5	0.0014	8.2000	0.07	0.025	9.63	0.51	1.63	0.01	1.71	5.1	291.1
	SVMW-11-100	100	102.5	0.5	0.0014	8.2000	0.14	0.014	9.63	0.51	1.64	0.01	1.79	5.4	304.6
	SVMW-11-250	250	252.5	0.5	0.0014	7.3000	0.34	0.007	9.63	0.51	1.47	0.01	1.82	5.5	309.6
	SVMW-11-260	260	262.5	0.5	0.0014	22.5000	0.36	0.000	9.63	0.51	4.55	0.01	4.91	14.7	834.9
SVMW-12	SVMW-12-150	150	152.5	0.5	0.0014	7.5000	0.21	0.027	9.63	0.51	1.49	0.01	1.71	5.1	289.9
	SVMW-12-250	250	252.5	0.5	0.0014	7.5000	0.34	0.015	9.63	0.51	1.50	0.01	1.85	5.6	315.1
	SVMW-12-350	350	352.5	0.5	0.0014	7.5000	0.48	0.016	9.63	0.51	1.50	0.01	1.99	6.0	338.0
	SVMW-12-450	450	452.5	0.5	0.0014	15.0000	0.62	0.000	9.63	0.51	3.03	0.01	3.66	11.0	621.4
SVMW-13	SVMW-13-150	150	152.5	0.5	0.0014	8.8000	0.21	0.025	9.63	0.51	1.75	0.01	1.97	5.9	334.9
	SVMW-13-250	250	252.5	0.5	0.0014	8.4000	0.34	0.014	9.63	0.51	1.68	0.01	2.04	6.1	346.2
	SVMW-13-350	350	352.5	0.5	0.0014	9.3000	0.48	0.011	9.63	0.51	1.87	0.01	2.36	7.1	400.7
	SVMW-13-450	450	452.5	0.5	0.0014	13.8000	0.62	0.000	9.63	0.51	2.79	0.01	3.42	10.2	580.2
SVMW-14	SVMW-14-150	150	152.5	0.5	0.0014	11.0000	0.21	0.031	9.63	0.51	2.19	0.01	2.41	7.2	409.4
	SVMW-14-250	250	252.5	0.5	0.0014	8.8000	0.34	0.045	9.63	0.51	1.73	0.01	2.09	6.3	354.6
	SVMW-14-350	350	352.5	0.5	0.0014	8.0000	0.48	0.013	9.63	0.51	1.60	0.01	2.09	6.3	355.8
	SVMW-14-450	450	452.5	0.5	0.0014	8.2000	0.62	0.000	9.63	0.51	1.66	0.01	2.28	6.9	388.0
SVMW-15	SVMW-15-150	150	152.5	0.5	0.0014	7.8000	0.21	0.044	9.63	0.51	1.53	0.01	1.75	5.2	297.2
	SVMW-15-250	250	252.5	0.5	0.0014	8.8000	0.34	0.030	9.63	0.51	1.75	0.01	2.10	6.3	357.1
	SVMW-15-350	350	352.5	0.5	0.0014	8.0000	0.48	0.011	9.63	0.51	1.61	0.01	2.10	6.3	356.1
	SVMW-15-450	450	452.5	0.5	0.0014	15.5000	0.62	0.000	9.63	0.51	3.13	0.01	3.76	11.3	638.6

Notes:

[1] Equation 1: See attached schematic and equations

[2] Equation 2: See attached schematic and equations

[3] Equation 3: See attached schematic and equations

[4] Equation 4: See attached schematic and equations

[5] Equation 5: See attached schematic and equations

A porosity of 40% was used for this calculation.

cu ft = Cubic foot
ft = foot
in = inch(es)
min = minute(s)
mL = mililiter
sq ft = square feet

Attachment

Well Volume Calculations and Schematic

Equation 1: Well Casing Volume

$$V_1 = \Pi * \frac{D^2}{4} * H_1$$

$$V_1 = \Pi * \frac{\left(\frac{0.75\ \text{in}}{12\ \frac{\text{in}}{\text{ft}}}\right)^2}{4} * (50\ \text{ft}) = 0.15\text{ft}^3$$

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Equation 2: Filter Pack Blank Casing Volume

$$V_2 = \left(\Pi * \frac{{D_1}^2}{4} * H_2 * n_1\right) + \left(\Pi * \frac{{D_2}^2}{4} * H_2 * n_2\right)$$

$$V_2 = \left(\Pi * \frac{\left(\frac{0.75\ \text{in}}{12\ \frac{\text{in}}{\text{ft}}}\right)^2}{4} * (16\ \text{ft}) * 3\right) + \left(\Pi * \frac{\left(\frac{3\ \text{in}}{12\ \frac{\text{in}}{\text{ft}}}\right)^2}{4} * (16\ \text{ft}) * 1\right) = 0.93\text{ft}^3$$

Equation 3: Filter Pack Volume

$$V_3 = \left(\Pi * \frac{D^2}{4} * H_2 * p\right) - V_2$$

$$V_3 = \left(\Pi * \frac{\left(\frac{11.75\ \text{in}}{12\ \frac{\text{in}}{\text{ft}}}\right)^2}{4} * (16\ \text{ft}) * 40\%\right) - 0.93\ \text{ft}^3 = 3.89\text{ft}^3$$

Equation 4: Sample System Volume:

Note that the sample train consists of 6-feet of ½-inch fluorinated ethylene propylene tubing and 1-foot of ½-inch quick connect fittings.

$$V_4 = \Pi * \frac{D^2}{4} * L$$

$$V_4 = \Pi * \frac{\left(\frac{0.5\ \text{in}}{12\ \frac{\text{in}}{\text{ft}}}\right)^2}{4} * (6\ \text{ft} + 1\ \text{ft}) = 0.01\text{ft}^3$$

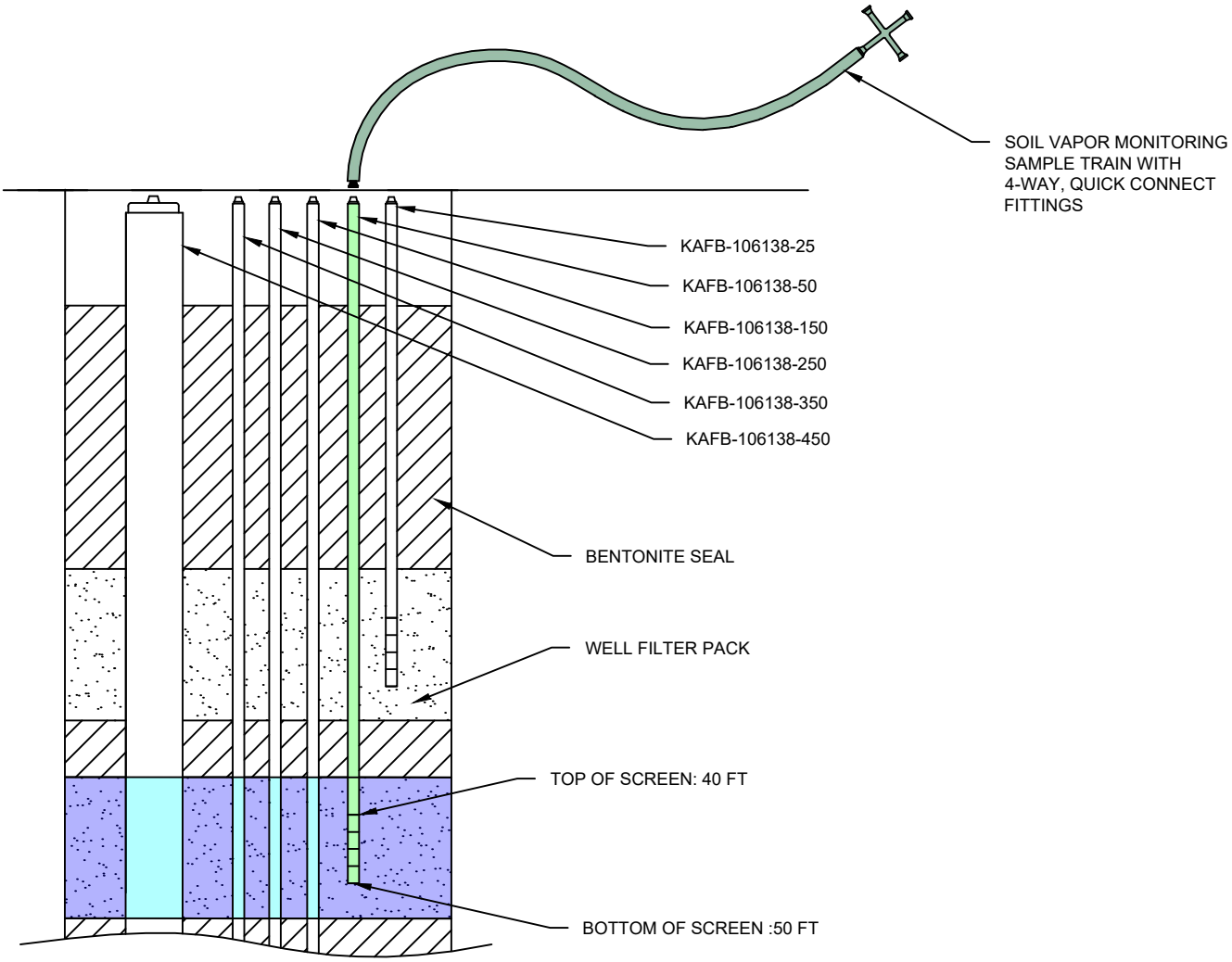
Equation 5: Well Volume = Well Casing Volume plus the Filter Pack Volume plus the Sample System Volume

$$V_5 = V_1 + V_3 + V_4$$

$$V_5 = 0.15\text{ft}^3 + 3.89\text{ft}^3 + 0.01\text{ft}^3 = 4.05\text{ft}^3$$

D= Diameter of SVM well string.
H_1 = Total depth of SVM well string.
H_2 = Height of filter pack at the given SVM well string.
L = Length of sample system.
n1 = Number of 0.75-inch well casings (excluding the given well string) within the sand packed interval.
n2 = Number of 3-inch well casings (excluding the given well string) within the sand packed interval.
P = Porosity (40% was used for this calculation)
V_1 = Well casing volume
V_2 = Filter pack blank casing volume
V_3 = Filter pack volume
V_4 = Sample system volume
V_5 = Well volume

FIGURE 1
KAFB-106138 NESTED SOIL VAPOR MONITORING WELL CONSTRUCTION



WELL CASING VOLUME: VOLUME OF THE WELL STRING FROM SURFACE TO THE BOTTOM OF THE SCREEN. SEE EQUATION 1 FOR CALCULATION.

FILTER PACK BLANK CASING VOLUME: VOLUME OF THE ANNULAR SPACE OCCUPIED BY THE WELL SCREEN AND WELL CASINGS OF ADDITIONAL WELL STRINGS WITHIN THE FILTER PACK ACROSS THE SCREENED INTERVAL. SEE EQUATION 2 FOR CALCULATION.

FILTER PACK VOLUME: VOLUME OF THE WELL FILTER PACK ACROSS THE SCREENED INTERVAL OF THE GIVEN WELL STRING. NOTE THAT THE BLANK CASING VOLUME OF WELL CASINGS CROSSING THE FILTER PACK AREA HAVE BEEN REMOVED FROM THE FILTER PACK VOLUME. SEE EQUATION 3 FOR CALCULATION.

SAMPLE TRAIN VOLUME: THE SAMPLE TRAIN CONSISTS OF 6-FEET OF 1/2-INCH FLUORINATED ETHYLENE PROPYLENE TUBING AND 1-FOOT OF 1/2- INCH QUICK CONNECT FITTINGS. SEE EQUATION 4 FOR CALCULATION.

NOT TO SCALE
BGS=BELOW GROUND SURFACE
FT=FEET

KIRTLAND AIR FORCE BASE		INSTALLATION START DATE/TIME:	INSTALLATION END DATE/TIME:
PROJECT NO.:	WELL ID:	GEOLOGIST:	DRILLER: