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NMED
Hazardous Waste Bureau

Mr. Butch Tongate
Deputy Secretary
New Mexico Environment Department (NMED)
1190 St. Francis Drive, Suite N-4050
Santa Fe, New Mexico 87502

Dear Mr. Tongate

Attached please find the *Pilot SVE Shutdown Test Work Plan.* This letter WP will address the respiration and short-term testing, along with the long-term rebound testing, on selected soil vapor monitoring (SVM) wells. Data from this shutdown test will be used in the design of SVE expansion at the BFF site.

Please contact Mr. L. Wayne Bitner at (505) 853-3484 or at ludie.bitner@us.af.mil or Mrs. Victoria Branson at (505) 846-6362 or at victoria.branson@us.af.mil if you have questions.

Sincerely

TOM D. MILLER, Colonel USAF
Commander

Attachment: Pilot SVE Shutdown Test Work Plan

cc:
NMED-HWB (Kieling, Cobrain, Moats, McDonald, Brandwein) w/attch
NMED (McQuillan, Longmire) w/attch
NMED-GWQB (Schoeppner) w/attch
NMED-PSTB (Reuter) w/attch
NMED-OGC (Kendall) w/o attch
EPA Region 6 (King) w/o attch
AFCEC-CZRY (Bodour) w/ attch
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KAFB4216

40 CFR 270.11
DOCUMENT CERTIFICATION
DECEMBER 2014

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.

TOM D. MILLER, Colonel, USAF
Commander, 377th Air Base Wing

This document has been approved for public release.

KIRTLAND AIR FORCE BASE
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Original December 31, 2014, Revised Version February 10, 2015

Subject: Kirtland Air Force Base Bulk Fuel Facility – Pilot Soil Vapor Extraction Shutdown Test Work Plan

This Kirtland Air Force Base (KAFB) Bulk Fuel Facility (BFF) Soil Vapor Extraction (SVE) Shutdown Testing Letter Work Plan (WP) has been prepared by CB&I Federal Services LLC (CB&I) for the U.S. Army Corps of Engineers (USACE), Albuquerque District, under Contract No. W912DY-10-D-0014. The in-situ respiration and rebound tests will inform the location and design of a more robust remedial strategy for the BFF vadose zone. Details on the additional investigation (Work Plan 2) and system design/installation (Work Plan 3) activities will follow as separate work plans, which will be developed from the results of the SVE shutdown test.

This WP provides details on the approaches and methodologies that will be followed in conducting an in-situ respiration test and short-term and long-term rebound tests, on selected soil-vapor monitoring (SVM) points. In this WP, the reference to "SVM points" is used to refer to discrete SVM well locations and discrete screen depths. The current catalytic oxidizer (CATOX) SVE system will be off for the entire duration of the respiration and rebound tests so that accurate measurements can be made to monitor microbiological activity and hydrocarbon concentration changes under non-flow conditions in the vadose zone.

The objectives of this WP are to collect data to:

- Calculated in-situ biodegradation of residual fuel hydrocarbon through respiration testing at selected SVM points. Respiration testing examines oxygen (O_2) utilization to assess biodegradation occurring throughout the BFF SVE monitoring network. The results will show: areas where residual volatile fuel hydrocarbons are aerobically biodegrading, areas where the volatile fraction of the fuel hydrocarbon has been depleted but biodegradation of the non-volatile jet fuel constituents is continuing, and areas where volatile fuel hydrocarbon fraction is not measured and biodegradation is either not ongoing or is occurring at rates that would not benefit from active aeration.
- Further delineate the distribution of residual hydrocarbons in the vadose zone through rebound testing at selected SVM points. During rebound testing, total soil-vapor hydrocarbon (TSVH) concentrations will be measured over time to monitor the rate, extent, and location of changes in concentration. SVM locations showing rapid and large TSVH concentration increases will indicate the presence of residual contaminant mass to target for treatment.
- Identify potential migration pathways throughout the vadose zone. The rates and extent of rebound will be compared between adjacent monitoring locations throughout the SVE monitoring network in the BFF vadose zone. Patterns of rebound rates will help point toward potential locations of migration pathway.
- Inform the need for and location of additional subsurface investigation. While the BFF SVM network is extensive and data generated to date suggest good coverage of the contamination, the results from the respiration and rebound testing will refine the delineation of vadose zone contamination. However, if rebound trends between adjacent monitoring locations show increasing trends towards a specific monitoring location and that monitoring location is not "bounded" by surrounding monitoring locations that confirm the direction of the trend, an additional SVM points may be needed. Soil-vapor rebound results also will determine the location for continuous soil coring recovery to confirm/correlate the contamination with the TSVH results, and to locate and characterize residual hydrocarbon in the vadose zone. The cores

will be extended approximately 10 to 20 feet below the water table in an attempt to locate, quantify and characterize floating and/or submerged light non-aqueous phase liquid (LNAPL). The details for additional subsurface investigation activities will be provided in a separate work plan to be submitted following the completion of the shutdown test using the test data.

In-situ respiration and rebound test results and additional subsurface investigation data will be used to design an effective and efficient interim measure for the vadose zone that could include any of a number of remediation technologies (i.e., SVE, bioventing, excavation, etc.). While it is desirable to use the existing SVE infrastructure to the extent possible, the objective is to enhance the understanding of the conceptual site model (CSM) and design of an interim measure that removes contaminant mass from the vadose zone effectively. Details on the design and implementation of the optimized interim measure will be provided in follow-on work plan(s) to be submitted after the completion of the additional subsurface investigations.

The following sections of this WP provide details on the SVE shutdown testing methodologies and the data analyses and reporting procedures.

1. SVE SHUTDOWN TESTING

The SVE shutdown test provides a unique opportunity to assess the subsurface conditions at the BFF after 12 years of SVE operation. During shutdown, in-situ respiration and short-term rebound monitoring will be performed in tandem on select existing SVM points (see below for SVM point selection logic). In-situ respiration testing will provide data that will be used for calculation of biodegradation rates in the vadose zone. Long-term rebound testing will continue on a subset of the SVM points following the completion of the in-situ respiration and short-term rebound testing. The short-term and long-term rebound test will evaluate soil-vapor concentration recovery after shut down of the CATOX system.

The current CATOX system will be shut down for approximately 3 months to allow sufficient time for the long-term rebound test to be completed and to collect data necessary to optimize the design and operation of the vadose zone remediation system(s).

Prior to SVE shut down, baseline sampling will provide information on current vadose zone conditions during SVE operation. O_2 and carbon dioxide (CO_2) data collected after SVE shutdown will allow calculation of the in-situ biodegradation rates throughout the vadose zone. Changes in soil-vapor hydrocarbon concentrations will demonstrate the soil-vapor hydrocarbon rebound potential, and the trends in the concentration increases within individual SVM points and between adjacent SVM points may provide indications of potential fuel migration pathways from the leak points to the water table and the location of residual hydrocarbon mass to target with SVE or other appropriate measures.

In-situ respiration and rebound testing will provide data necessary to make informed decisions for moving the vadose zone remediation effort effectively towards completion. Because excessive soil-vapor purging during sampling can produce erroneous readings, and because overpurging produces no benefit, care must be taken to minimize the volume of soil vapor extracted when conducting respiration testing (EPA, 1995). Due to the potential for regular SVM activities to impact the quality and accuracy of the data collected during shutdown testing, KAFB is requesting no quarterly SVM samples be collected for the first two Quarters of Calendar Year (CY) 2015 due to the length and timing of the long-term rebound test. At the completion of the long-term rebound test, a complete round of quarterly SVM samples will be collected as a quarterly sampling event, prior to resuming SVE operations. Although samples will be collected from the same SVM points included in the quarterly SVM protocol, consideration must be given to the use of the data when comparing the results to previous quarterly SVM events when the SVE system was operational.

The data collected during the proposed shutdown testing will facilitate an in-depth analysis of the remaining contamination in the vadose zone and the biodegradation rates associated with that contamination. The extended data set from the SVE shutdown test will advance our understanding of the conditions in the BFF vadose zone and will add value to the soil-vapor data that are normally collected during the quarterly sampling events. Having enhanced understanding of subsurface conditions will facilitate effective SVE expansion design and optimal SVE system operation. As such, it would be extremely beneficial to avoid interferences with the tests to ensure that the collected data are of the highest quality possible.

Prior to baseline sampling and respiration/rebound testing, all SVM and SVE points will be securely capped to prevent soil-vapor points from exhaling soil-vapor gas or inhaling atmospheric air due to barometric pressure increases or decreases. Soil-vapor points in the BFF have been observed to respond to changes in barometric pressure, so preventing these wells from inhaling or exhaling will ensure better accuracy during testing as atmospheric conditions will not be able to influence the deep vadose zone through soil-vapor points. Well caps will be inspected for integrity according to the guidelines in Appendix A before readings or samples are collected from a soil-vapor point.

Barometric pressure gauges and water level transducers will be installed in SVE wells KAFB-106161, KAFB-106160, and one additional well inside the BFF area for the duration of the shutdown test. Barometric pressure gauges will be installed inside the well vault but outside the well cap so that accurate readings of barometric pressure changes can be made. Water level transducers and barometric pressure gauges will be set to record data every hour.

1.1 Baseline Sampling

Baseline measurements will be made on all of the 287 SVM points while the CATOX system is still operating. Soil-vapor baseline measurements will be collected as described in Appendix A. The sampling system and the soil-vapor sampling method described in Appendix A have been modified from the methodologies outlined in Section 5.3 of the Vadose Zone Investigation Work Plan (USACE, 2011a) and Section 3.0 of the Quality Assurance Project Plan (QAPjP) (USACE, 2011b) to allow for minimal soil-vapor volumes to be withdrawn during the in-situ respiration testing. This will provide more representative data in close proximity to the sampled SVM point. The following parameters will be measured using a Horiba Model MEXA 584L portable auto emissions analyzer (herein referred to as the Horiba):

- Total hydrocarbons in parts per million by volume (ppmv)
- Percent O_2
- Percent CO_2
- Vacuum/pressure (inches of water column [inches WC])

After baseline measurements are collected, the CATOX system will be shut down using normal shutdown procedures outlined in Section 6.0 of the SVE System Operations and Maintenance Plan (August 2013). The SVE wells currently connected to the CATOX system (KAFB-106149, KAFB-106150, KAFB-106154, KAFB-106160, and KAFB-106161) will be closed at the well heads prior to shut down of the extraction system to prevent atmospheric air from entering the points and interfering with the initial measurements during the in-situ respiration and short-term rebound testing.

1.2 In-Situ Respiration and Short-Term Rebound Testing

The in-situ respiration and short-term rebound tests will be performed concurrently during the first two weeks of the shutdown period.

The objective of the in-situ respiration and short-term rebound testing is to provide an accurate representation of the biological activity and the residual contamination distribution in the BFF vadose zone. A total of 61 SVM points will be included in the in-situ respiration and short-term rebound testing. Thirty (30) of the SVM points that will be included in the in-situ respiration testing and will be selected based on the results from the baseline testing following the logic described in Table 1. Candidate respiration testing SVM points will be selected to cover a range of subsurface conditions as described in Table 1, and to provide effective coverage of the BFF vadose zone in areas where monitoring is warranted but not covered by the 31 SVM points selected for the selected for short and long-term rebound testing, discussed below. Once the baseline data are available, a table of the 30 respiration testing points will be provided to the New Mexico Environment Department (NMED) ahead of the shutdown testing for review and approval.

Thirty-one (31) SVM points have already been selected for the rebound testing (Table 2). All 31 of the SVM points selected for the long-term rebound testing will be included in the in-situ respiration and short-term rebound testing (see Section 1.3). The 31 SVM points were selected based on soil-vapor data collected during Fourth Quarter CY 2012 and Second Quarter CY 2014. These two quarters represent the highest historical soil-vapor data and the most recent soil-vapor data, respectively. The SVE system area of influence is defined as the area within the 0.5-inch WC vacuum isopleth, as reported in Appendix L of the Pre-Remedy Quarterly Monitoring Reports.

Following SVE shut down, soil vapor will be sampled from the selected 61 SVM points using the Horiba and the sampling method described in detail in Appendix A. The initial sampling will be initiated within 2 hours after SVE shut down. Subsequent sampling frequencies for each SVM point will be determined based on the observed O_2-utilization rates. SVM points demonstrating a higher O_2-utilization rate will be sampled on a more frequent basis. During the initial 24 hours of post-shutdown monitoring, a crew of six individuals will monitor the SVM points during the day and night. Respiration monitoring will continue until O_2 concentrations decrease to less than 5 percent or 2 weeks is reached, whichever comes first.

Measured O_2 concentrations will be used to create an O_2-utilization curve. A biodegradation rate can then be calculated (see Section 2.1) for the discrete locations represented by the SVM points throughout the vadose zone. The time series of TSVH data from the short-term rebound will be used along with the time series of TSVH data from the long-term rebound test (see Section 2.2) to observe trends in hydrocarbon concentration responses throughout the vadose zone as the subsurface adjusts toward undisturbed conditions (i.e., under SVE-induced vapor flow).

Table 1. Potential Observations Among Hydrocarbon, O_2 and CO_2 Data and the Logic for Soil-vapor Point Selection for Inclusion in the In-situ Respiration and Short Term Rebound Testing	
Data Observations	**Implications**
High Hydrocarbon (>1,000 ppmv), Depressed O_2 (<19.5 %), Elevated CO_2 (>1%)	SVM points with these characteristics may coincide with high-concentration residual fuel, or may be under the influence of nearby residual fuel with a large volatile fraction remaining. The depressed O_2 combined with elevated CO_2 is a strong indicator that aerobic biodegradation is occurring during SVE operation. These SVM points would be prime candidates for in-situ respiration, and short-term and long-term rebound testing.
Moderate Hydrocarbon (250 – 1,000 ppmv), Depressed O_2 (<19.5%), Elevated CO_2 (>1%)	SVM points with these characteristics may be in proximity to residual fuel contamination with a large or moderately reduced volatile fraction remaining, and aerobic biodegradation is occurring under SVE operation. These SVM points would be prime candidates for in-situ respiration, and short-term and long-term rebound testing.
Low Hydrocarbon (250 – 50 ppmv), Depressed O_2 (<19.5%), Elevated CO_2 (>0.5%)	SVM points with these characteristics may be in proximity to residual fuel contamination with a large percentage of the volatile fraction depleted and aerobic biodegradation is occurring during SVE operation. A minimum of five SVM points showing this data signature should be included in the in-situ respiration and long-term rebound testing. If many soil-vapor points are observed in this category, points will be selected to ensure lateral and vertical coverage of the area within the influence of the SVE system. Note that short-term rebound data will be collected during the rebound test, but observation of rapid hydrocarbon rebound is not anticipated.
Very-low Hydrocarbon (<50), Ambient O_2 (>20%), Ambient CO_2 (<0.1%)	SVM points with these characteristics may or may not be in proximity of residual fuel contamination. A review of historic vapor data is warranted to determine how these points might be used. If available, a minimum of three SVM points with low hydrocarbon and ambient O_2 and CO_2 and previously recorded hydrocarbon concentrations greater than 1,000 ppmv should be included in the in-situ respiration and short-term rebound testing. The results from testing these SVM points will indicate residual fuel contamination that has been depleted of the volatile fraction and that would not show up on the short-term or long-term rebound test, and also will quantify the biodegradation rate of the remaining non-volatile contaminant fraction. One SVM point that matches the data observations without historic hydrocarbon detection should be included in the in-situ respiration testing and will serve to determine the background respiration rate against which the respiration rates at the other 30 SVM points will be compared.

Table 2. SVM Points for Long-Term Rebound Testing		
Well Number	**Zone**	**Monitoring Depths**
SVMW-03	Near edge of area influenced by SVE	100
		250
		350
SVMW-06	Inside area influenced by SVE	100
		252
		302
SVMW-10	Outside area influenced by SVE	100
		150
		250
KAFB-106112	Inside area influenced by SVE	250
		350
		450
KAFB-106113	Probably outside area influenced by SVE	350
		450
KAFB-106114	Near edge of area influenced by SVE	350
		450
KAFB-106116	Inside area influenced by SVE	350
		450
KAFB-106117	Inside area influenced by SVE	350
		450
KAFB-106119	Inside area influenced by SVE	150
		250
		350
		450
KAFB-106128	Inside area influenced by SVE	350
		450
KAFB-106129	Possibly influenced by SVE	250
		350
		450
KAFB-106131	Possibly influenced by SVE	350
		450

1.3 Long-Term Rebound Testing

The objective of the long-term rebound testing is to extend the period of rebound monitoring to allow sufficient time for contaminant concentrations in the soil vapor to respond to contaminant that might be held in lower-permeability lithology, which will provide a more accurate representation of the residual contamination distribution in the BFF vadose zone. Hydrocarbon concentrations in the network of 31 SVM points listed in Table 2 will continue to be measured over the 3 months of the shutdown period.

Following the short-term rebound test, long-term rebound SVM points will be monitored daily for 1 week, weekly for 5 weeks, and then biweekly until TSVH concentrations become asymptotic or for three biweekly sampling events, whichever comes first. These samples will be analyzed using the Horiba following the sampling method described in Appendix A.

1.4 Complete SVM Network Quarterly Sampling

At the conclusion of the shutdown test and before SVE operation resumes, a full round of SVM sampling will be conducted from the network used in the quarterly monitoring sampling program following the sampling methodology described in Appendix A pending discussions with and approval from the NMED. Samples will be analyzed in the field for TSVH (ppmv) using the Horiba and samples will be submitted to a laboratory for Method TO-15, Method CARB422 for EDB, Method APH (air-phase petroleum hydrocarbons), and fixed gases analyses.

The field and laboratory analyses deployed for BFF vadose zone monitoring are complimentary and not redundant. The analytical instruments used under the different methods employ different detectors and require different dilution factors to keep values in the calibrated range of the respective instrument. As such, the analyses do not provide the same output but rather provide a more in-depth representation of the subsurface conditions. The results from the analyses are used for different purposes and are thus not expected nor needed to replicate values with precision. The field hydrocarbon analyses are an aggregate measurement of the volatile hydrocarbon composition and are used throughout the test to track trends. The laboratory analytical methods provide compound-specific and boiling point split (i.e., hydrocarbon fraction) results, which are useful for effectively assessing remediation effectiveness against the subsurface hydrocarbons.

2. DATA ANALYSIS AND REPORTING

2.1 In-situ Respiration Test

Biodegradation rates in the vadose zone are based on O_2-utilization rates, hydrocarbon oxidation stoichiometry, and relevant soil properties. Following the Bioventing Principles and Practice, Volume II (EPA, 1995), the O_2-utilization rate calculated from the field monitoring data is expressed as a percentage of O_2 as a function of time. O_2-utilization rates will only be calculated for the linear portion of the curve, as it is an indicator that O_2 is not limiting, and is therefore indicative of active biodegradation. The CO_2 data verify that the observed decreases in O_2 are the result of microbiological degradation, and not other oxygen consuming reactions. Increases in CO_2 concentrations that are concurrent with decreasing O_2 concentrations are indicative of biodegradation. (Note that CO_2 data are only used to verify biodegradation and are not used in biodegradation rate calculations because of potential errors associated with geochemical reactions involving CO_2 that can bias the results.)

In the field, soil-vapor O_2 and CO_2 concentrations will be measured using the Horiba. With frequent calibration and calibration checks, the Horiba will provide good-quality data to derive accurate O_2-utilization rates. Comparing the utilization rates between SVM points under the characteristics described in Table 1 will confirm that the measured O_2-utilization is above ambient and due to microbiological degradation of residual fuel hydrocarbons. Laboratory analyses are not required during in-situ respiration testing.

O_2 and CO_2 concentrations will be measured on a percent basis and are expected to change over the duration of the in-situ respiration test as aerobic microorganisms consume O_2 during hydrocarbon degradation and produce CO_2. The O_2 measurements are used to calculate the O_2-utilization rate, which is calculated as the slope of the decrease in O_2 concentrations over time as O_2 concentrations decrease from baseline concentration to 5% O_2. This value is used to calculate the biodegradation rate as shown in Equation 2.

Since the contamination at the BFF project site is fuel hydrocarbon based, hexane is used as the representative hydrocarbon for rate calculations. The stoichiometric relationship used for determination of degradation rates is therefore (EPA, 1995):

Equation 1:

$$C_6H_{14} + 9.5O_2 \rightarrow 6CO_2 + 7H_2O$$

Based on the utilization rates, the biodegradation rate is estimated using the following equation (EPA, 1995):

Equation 2:

$$-k_b = \frac{-\frac{k_o}{100}\theta_a \frac{1L}{1{,}000cm^3}\rho_{O_2}C}{\rho_K\left\{\frac{1kg}{1{,}000g}\right\}} = \frac{-k_o\theta_a\rho_{O_2}C(0.01)}{\rho_k}$$

Where:

k_b = biodegradation rate (milligrams/kilogram-day)
k_o = O_2-utilization rate (percent/day)
θ_a = gas-filled pore space (volumetric content at the vapor phase, cubic meters gas/cubic centimeter soil)
ρ_{O_2} = density of O_2 (milligrams/liter)
C = mass ratio of hydrocarbons to O_2 required for mineralization (1:3.5)
ρ_k = soil bulk density (grams/cubic centimeter)

The value for k_o will be directly measured during the respiration monitoring as described in Section 1.2. The remaining input values will be based on data obtained from the site, if available, or from industry standards and approved literature. The value for θ_a has the most variability; however, since the respiration testing will be conducted at a low gas-filled porosity, the value can be estimated in accordance with the steps outlined in the EPA manual for Bioventing Principles and Practice, Volume II (EPA, 1995)

2.2 Rebound Test

In the field, TSVH measurements will be made using the Horiba to analyze soil-vapor samples from 61 SVM points during the short-term rebound test and on 31 SVM points during the long-term portion of the rebound test (see Tables 1 and 2 for the SVM point selection logic for the in-situ respiration and short-term rebound testing and the list of 31 pre-selected long-term rebound SVM points, respectively). Using frequent calibration and calibration checks, the Horiba instrument will provide quality data that are sufficient in number to monitor increasing or decreasing TSVH concentrations at each of the 61 SVM points. The data will be used to asses TSVH concentration trends at each SVM point, and to compare the relative concentrations and the trends between the SVM points. The assessment should provide information on the locations and extent of residual contaminant in the vadose zone. The data also will be evaluated to update the CSM for residual hydrocarbon distribution and identify potential migration pathways through the vadose zone, which will inform decisions for additional investigation (Phase 2) and remedial activities (Phase 3) that will be described in future work plans.

The TO-15 and CARB422 analytical data will provide compound-specific delineation within the soil vapor across the monitored network, and will allow for comparison with pre-shutdown compound-specific distributions based on prior TO-15 and CARB422 analyses. Data from the 8015D analyses will be used to evaluate the rebound of gasoline range organics (GRO) and diesel range organics (DRO) along with petroleum-specific hydrocarbons included in the standard method analyte list. The TSVH rebound trends, and locations in combination with the final compound-specific rebound analyses, will inform the decisions on SVE system expansion and operation and/or other vadose zone remediation techniques, as well as the locations for future coring to assess potential LNAPL in the vadose zone and at the water table interface.

3. SCHEDULE

Approximate durations for specific tasks associated with shutdown testing are provided below:

Pre-shutdown (3-5 days)	Conduct baseline sampling
Day 0	Shut down the SVE system
Day 0-14	Perform respiration monitoring (at frequencies based on real time data as described above) using the Horiba Model MEXA 584L.
Day 0-14	Short-term rebound monitoring (at frequencies based on real time data as described above) using the Horiba Model MEXA 584L.
Day 15-21	Daily rebound monitoring using the Horiba Model MEXA 584L.
Day 22-56	Weekly rebound monitoring using the Horiba Model MEXA 584L.
Day 57-98	Biweekly rebound monitoring using the Horiba Model MEXA 584L.
Day 99-154	Complete SVM network quarterly sampling event.
Day 155	Resume SVE system operation.

4. REFERENCES

EPA. 1995. *Manual, Bioventing Principles and Practice, Volume II: Bioventing Design*. September.

USACE. 2011a. *Vadose Zone Investigation Work Plan, Bulk Fuels Facility (BFF) Spill, Solid Waste Management Units ST-106 and SS-111, Kirtland Air Force Base, Albuquerque, New Mexico.* Prepared by Shaw Environmental & Infrastructure, Inc., for the USACE Albuquerque District under USACE Contract No. W912DY-10-D-0014, Delivery Order 0002. March.

USACE. 2011b. *Quality Assurance Project Plan, Bulk Fuels Facility (BFF) Spill, Solid Waste Management Units ST-106 and SS-111, Kirtland Air Force Base, Albuquerque, New Mexico.* Prepared by Shaw Environmental & Infrastructure, Inc., for the USACE Albuquerque District under USACE Contract No. W912DY-10-D-0014, Delivery Order 0002. April.

APPENDIX A

SOIL-VAPOR SAMPLING AND FIELD ANALTYICAL METHODS

Soil Vapor Sampling and Field Analysis Procedure, revised February 2015

1.1 Introduction

All field personnel collecting soil-vapor samples are required to be trained and fully understand the sampling procedure outlined in this document. Any and all questions will be addressed prior to the start of sampling. Prior to the start of the soil-vapor sampling in 2015, all SVM points and SVE wells will be capped and sealed to minimize barometric-pumping interferences on sampling and analyses. Sealing the points/wells will be done by securing an air-tight cap onto each point/well head and adding a pneumatic quick connect fitting to each point/well that will serve as a sampling port for ease of access and to ensure that an air-tight seal is maintained. Each well port will be examined by the field personnel to confirm the integrity of each fitting and to immediately address and mitigate any problems or replace any defective parts.

1.2 Pre-Sampling Steps

1.2.1 Horiba Model MEXA 584L Calibration

It should be noted that the Horiba instrument can effectively measure petroleum hydrocarbons, O_2 and CO_2, which are the three parameters of concern for monitoring the effectiveness of vadose zone remediation technologies such as SVE and bioventing. However, the Horiba is sold as an engine exhaust monitoring instrument and the use for soil-vapor monitoring is different that the manufacture's intended purpose. While not the primary selling point of the instrument, the Horiba's sampling ability and the non-dispersive infrared detector (NDIR) and chemical cell detector make it a good instrument for TSVH, CO_2 and O_2 analyses.

Various engine exhaust and leak detection instruments are routinely used in the field for soil-vapor monitoring, but their use is often tailored to provide more representative data. CB&I evaluated the Horiba manufacturer's calibration procedure, which was developed for engine exhaust monitoring, and determined that a modified calibration method was in order to better ready the instrument for measuring soil-vapor petroleum hydrocarbon, O_2 and CO_2 concentrations. The modified calibration method will outperform the manufacture's process for soil-vapor monitoring, and includes a more representative calibration/calibration-check gas, more frequent calibration than specified by the manufacturer, frequent calibration checks (TSVH, O_2 and CO_2) during daily Horiba usage, and real-time data analysis to look for indicators of potential calibration deviations. At the start, middle and end of each work day, the Horiba will be calibrated for petroleum hydrocarbons, O_2 and CO_2 against a calibration standard of known concentrations in a premixed gas cylinder. The same calibration gas cylinder will be used to calibrate every Horiba instrument at the same time and by the same person to ensure consistent calibrations. This calibration gas will consist of 1,600 ppmv propane, 13.0% CO_2, and the remaining volume will consist of nitrogen.

The instrument will be calibrated by applying the premixed gas into the calibration port located on top of the instrument (see the Horiba Instruction Manual for assistance in identifying this port). After calibration is confirmed, the same gas will be used to fill a 3L Tedlar® bag. The customized sampling system shown in Figure 1 will be used to complete the calibration as follows.

Step 1 - Close all valves on the sampling system.
Step 2 - Connect the Horiba to the sampling system.
Step 3 - Open the valve on the Horiba port and ensure that the sampling system is purged according to the steps listed below under Section 1.2.2 Cross Contamination Purging for Sampling System.
Step 4 - Once within the given values, attach the Tedlar® bag to the male pneumatic fitting at the bottom of the sampling system.

Step 5 - Open the Tedlar® bag valve to allow the calibration gas to be pulled through the sampling system.
Step 6 – Record the instrument readouts when the instrument has stabilized and compare the results to the calibration gas concentrations.

If the values for TSVH, O_2 and CO_2 are within 5% of the calibration values made using the calibration port, the calibration process is complete. If values are outside of this range, perform a leak check as described in Section 1.2.4 and follow the calibration process again.

If at any point during sampling, a reading for petroleum hydrocarbons, O_2 or CO_2 reaches an unreasonable value (e.g., an O_2 concentration greater than 21%) or if a data value falls outside the trend indicated by previous readings at a given SVM point, a calibration check will be triggered. The expected range of values for petroleum hydrocarbons is from 0 to 10,000 ppmv, 0% to 22% for percent O_2 and 0% to 10% for percent CO_2. If any readings are outside of this range, a calibration check must be made and if necessary the instrument will need to be recalibrated.

During respiration testing, O_2 readings could fall to near zero; however, tracking to 5% is all that is needed for calculating biodegradation rates and 5% is within the Horiba's detectable range.

1.2.2 Cross Contamination Purging for Sampling System

The sampling system must be purged with ambient air before being attached to a SVM point sample port to minimize the potential for cross contamination between sample collections. To ensure the entire sample train is thoroughly purged, attach the pump to the setup and flush air through each opening and valve. All valves are to be opened during this process. Monitor the purging effectiveness using the Horiba to ensure no contaminates are still present and ambient air is being read by the Horiba. Values for ambient air are less than 5 ppmv hydrocarbons, between 20% to 22% for percent O_2, and 0% for percent CO_2. Purging must be done after sampling each SVM point.

1.2.4 Leak Check

At the beginning of each day, the sampling system can be leak checked by using the pump to apply pressure to the system. Simply reverse the pump intake and exhaust with the valve open to allow air into the system. Apply a Snoop® solution (or similar soapy leak detection solution) to any and all joints and look for indications of leaks. If any leaks are present, address immediately before sampling. The system will also be tested for leaks during the static pressure measurement at each well as described below.

1.3 Sampling Procedures

1.3.1 Sample Train Setup

The Horiba must be turned on, warmed up, and calibrated and then attached to the sampling system. The Horiba is turned on for the first time at the beginning of the day and then remains in the on position throughout the day. The Horiba is plugged into the 12V DC outlet in the truck using an AC inverter. All other equipment will be powered by generator and can be powered off in-between wells. The pump is attached and sealed with clamps to the setup. It is important that no valves be open prior to turning on the pump.

1.3.2 Static Pressure Measurement

Before taking the static pressure reading, the manometer instrument must be zeroed to atmospheric pressure. The screen should read "0.00 in WC". Using the static pressure adapter (Figure 2), which includes a sample-port adapter and manometer, take and record the static pressure of the well in inches of

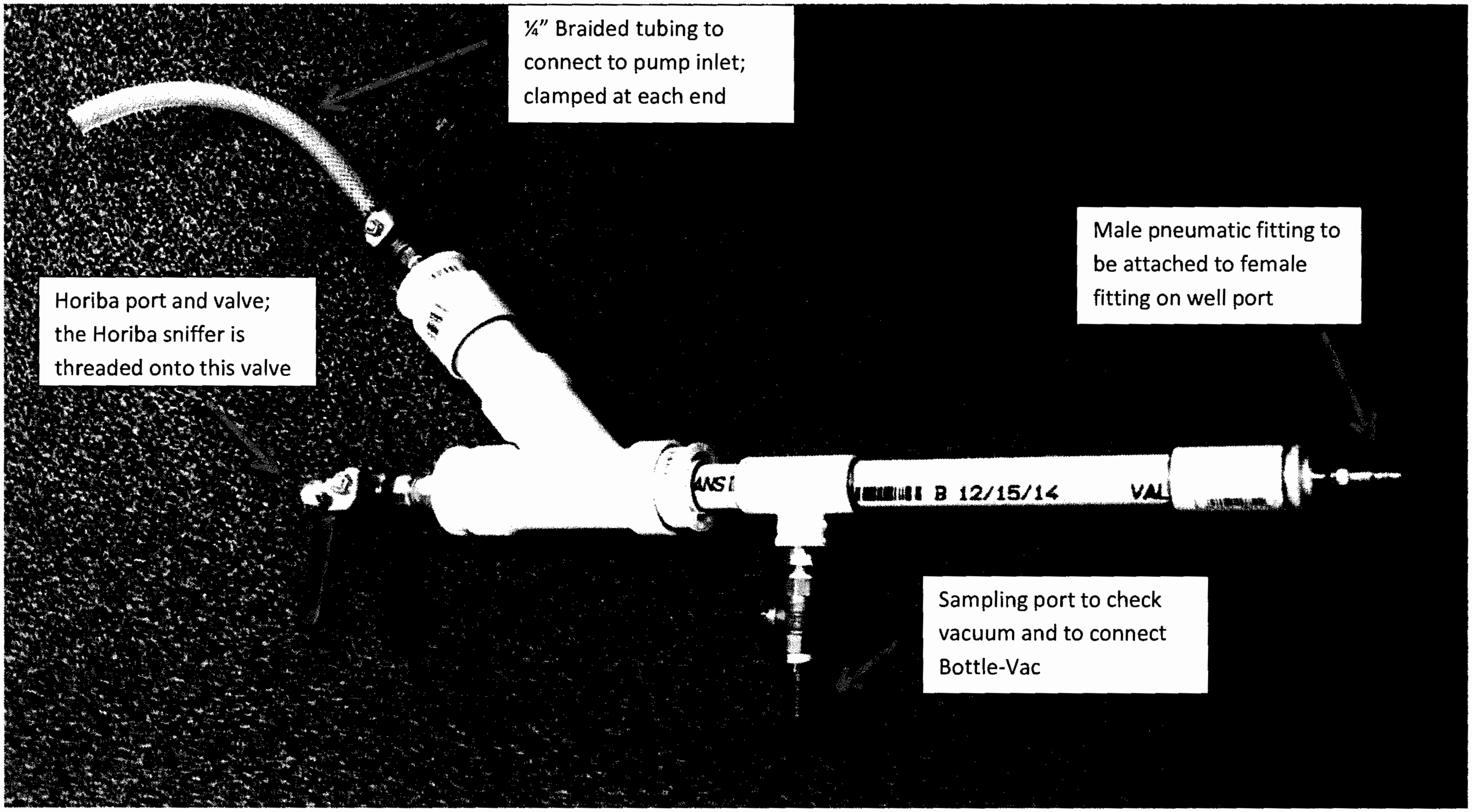

Figure 1. Soil Vapor Sampling System

Figure 2. Static Pressure Adapter