U. S. Army Corps of Engineers Soil Vapor Extraction Subsurface Performance Checklist

Installation Name ______________________________

Site Name / I.D. ______________________________

Evaluation Team ______________________________

Site Visit Date ______________________________

This checklist is meant to aid in evaluating the overall performance of a soil vapor extraction (SVE) system for removing volatile organic vapors from the soil vadose zone. This checklist is divided into the following sections:

1) Evaluation team composition
2) Typical treatment objectives
3) References
4) Data collection requirements
5) Performance analysis calculations
6) Adequacy of operations and maintenance
7) Typical performance problems
8) Alternatives for possible cost savings
9) Supplemental notes and data.

The checklist provides suggestions for information gathering, and space has been provided to record data and notes from the site visit. Supplementary notes, if required, should be numbered to correspond to the appropriate checklist sections.

1) Evaluation Team Composition

The following disciplines should be included in the evaluation team for the soil vapor extraction system.

- Geologist (attend site visit, subsurface performance evaluation)
- Process Engineer (attend site visit, treatment system evaluation)
- Regulatory Specialist (regulatory requirements)
- Cost Engineer (cost of alternatives)

2) Typical Treatment Objectives

Verify that the treatment objectives established when the SVE system was designed and installed are clear and still valid. If the objectives are not clearly defined, describe reasonable objectives based on information from the owner and regulator.

Soil vapor extraction is typically used for removing organic vapors to remediate vadose zone soils and to remove the source of groundwater contamination. The primary objective of SVE is removal of contaminant mass, but regulations may require achieving a stipulated concentration in the soil. The goals for the soil vapor extraction system should consider the nature of the risk associated with the site. If the primary goal is protection of ground water, the SVE system should reduce the soil concentrations to levels that would not result in groundwater concentrations exceeding acceptable risk at an exposure point.

3) References

Coordinate this checklist with the Vapor/Off-gas Blower and Piping; Process Instrumentation and Control; Environmental Monitoring, Extraction and Monitoring Wells, and if applicable, the Vapor Phase Carbon checklists. The following references may also be helpful:

EM 1110-1-4001 [1]: Soil Vapor Extraction and Bioventing
EPA 600/R-96/041: Diagnostic Evaluation of In-Situ SVE-Based System Performance
EPA 542/R-97/007: Analysis of Selected Enhancements for Soil Vapor Extraction

4) Data Collection Requirements

Record the following information needed to run performance calculations and to check the operation of the SVE system. Record the appropriate units with each value.

a) Describe the objectives for the SVE system. (e.g., source removal, vapor containment)

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b) What is the estimated future operation period or time for remediation? What is the basis for this estimate?

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c) Operating Data

Collect the following SVE system data for the most recent year of operation. Any additional historical data will be helpful. Identify any missing data.

- Pressure measurements at each well and the barometric pressure at that time
- Vapor flow rate at each well and the vapor flow rate at the blower inlet
- Vapor temperature at each well, and at the blower inlet and outlet
- Relative humidity of the extracted gas (if activated carbon is being used to treat off-gas)
- Volume of liquid in the air-water separator
- Blower amperage, run-time, and on/off cycles

- Vapor contaminant concentrations at each well and monitoring point

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(Contaminant monitoring might consist of sampling and field screening with a photoionization detector, flame ionization detector, field gas chromatograph, or detector tubes or might involve sampling for laboratory analysis. Refer to the Environmental Monitoring checklist.)

d) Are measurements made with adequate frequency (say every 3-12 months in a single round) to determine if capture or air throughput are affected by changes in extraction rate, soil moisture content, or groundwater levels? Are measurements made on a seasonal basis if seasonal fluctuations in parameters such as soil moisture content or water table level are expected?

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e) Are flows, vacuum levels, and concentrations measured in each extraction well? Are these parameters monitored with the same frequency as at the monitoring points?

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f) Have air permeability tests been conducted on the extraction wells and air conductivity values calculated for those locations?

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g) Have tracer tests been conducted to verify air flow paths and adequate travel times/velocities? *(Normally done only where the site complexity justifies its use or where unusual vacuum/contaminant response to extraction is observed.)*

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h) Has there been unexpected contamination found outside the capture zone or any indication of an unknown source?

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i) Are measurements of water table fluctuations made to determine the possible effects on the SVE system's performance?

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j) Record the nameplate information from the vacuum blower, pumps, and other mechanical equipment for future reference.

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k) Sketch a process flow diagram (PFD), including valves and instrument locations, on the back of this sheet or on a separate sheet.

l) If modeling was performed, obtain a copy of the original SVE modeling done as part of the system design.
(The design modeling may be useful in evaluating the operation of the system.)

5) Performance Analysis Calculations

a) Prepare vapor flow rate versus time graphs for each extraction well. Are the vapor extraction rates the same as those in the design specifications? Have the vapor extraction rates changed since the initial period of operation?

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b) Construct vacuum isopleth maps of the site. Is the vacuum distribution consistent with that predicted during design? Does the vacuum distribution (in three dimensions) indicate capture of vapors and prevention of migration to receptors?

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c) Are monitoring points distributed adequately to determine vacuum distribution, flow paths, or containment? Are monitoring points distributed adequately to determine if adequate air flow or vapor capture is achieved in three dimensions? *(In most cases, vacuum monitoring points set at multiple depths are needed to verify vertical flow components.)*

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d) Construct concentration versus time graphs for all contaminants of concern in each extraction well. Construct isopleth maps of the current soil gas concentrations for each contaminant of concern. Have contaminant concentrations been declining in most of the target zone?

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e) Have individual wells or the system as a whole reached a consistent asymptote on the concentration versus time graph without significant rebound? *("Significant rebound" might be defined as an increase of 25-50% above the asymptote concentration value.)*

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f) Are the well depths and screened intervals adequate to optimally direct air through the target zone? Is there evidence of preferential flow paths or hydrogeologic boundaries that were not considered in the system design? *(Prepare hydrogeologic cross sections using available well boring logs, including the extraction wells, if cross sections of the area of concern are not available.)*

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h) Estimate travel times or velocities for air through the target zone. Do the travel times/velocities indicate adequate throughput in the entire target zone? *(Consider three-dimensional flow, particularly at open or leaky sites. Refer to EM 1110-1-4001, Chapter 5.)*

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6) Adequacy of Operations and Maintenance

a) Has the entire system been operating with enough consistency to achieve its objective in a reasonable time? *(A good operational target should be 90% uptime or better.)*

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b) Are monitoring points constructed and maintained so as to yield reliable results (e.g., short screens, checked for plugging/response)?

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c) Would the use of active or passive air injection possibly help direct air through the target zone more effectively? Would a surface cover help direct air more effectively through the target zone (the surface cover cost would have to cost effective)?

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d) Verify that the ancillary equipment are maintained per manufacturers recommendations.

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e) Verify that instruments, controls, and alarms are working. Are there provisions to notify an operator of malfunctions when the unit is unattended?

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f) Is the vapor extraction properly distributed among the wells to optimally treat the target zone effectively? *(It may be appropriate to recommend an optimization study if there is some indication that the system is pumping more than necessary to achieve goals.)*

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g) Verify that the concentrations are sampled and analyzed in accordance with the sampling and analysis plan designed to assess the system performance. Determine if any additional monitoring is needed to evaluate the operating conditions.

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7) Typical Performance Problems

a) Is there evidence of too much air flow through the soil such that travel times are too small, or that diffusion limitations hamper the effectiveness of the high extraction rates? *(If extracting air at higher rates does not increase the mass removal rate, the system may be moving more air than necessary.)*

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b) Is there evidence of short-circuiting along the well casing, through nearby utility corridors, or through soil fractures or other subsurface features? Consider well replacement or relocation.

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c) Have the VOC concentrations in the extracted gas (in combined influent or from most wells) approached an asymptotic concentration value? This may be caused by diffusion limitations, continuing source, or poor well placement. Consider whether reduced flows, system pulsing, additional wells. thermally enhanced SVE, or bioventing might remove additional contaminant mass.

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d) Are there portions of the target zone in which contaminant concentrations have failed to decline in response to SVE? This may be due to inadequate air flow in that portion of the target zone, diffusion limitations, high soil moisture content perhaps to due to surface irrigation, or a continued source of contaminants in that area. Consider increasing air extraction rates from certain wells or the entire system, adding wells in areas of inadequate extraction, limiting irrigation, or excavating hot spot soils.

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e) Are extremely high concentrations of VOCs, at or near explosive levels, present in the extracted gas? This may be due to a continuing source, floating product, high levels of residual contaminants, or accumulation of methane. Consider adding dilution air, reducing the flow rate from "hot spot" wells, or replacing the SVE off-gas treatment system with a flare or internal combustion engine (ICE) treatment system.

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f) Do the VOC concentrations in the extracted gas vary significantly over time? This may be due to ground water fluctuations, soil moisture variations due to precipitation, or a periodic continuing source. Consider controlling groundwater levels, installing a surface cover, or other source removal alternatives.

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g) Have the total extraction rates failed to reach the expected design rates or the extraction rates needed for efficient operation? This may be due to poor well installation, improper well design, improper flow balancing or blower design, water table upwelling, or unexpected stratigraphy. Consider replacing wells, adding wells, rebalancing the air flows in the system, controlling groundwater levels, or resizing the blower.

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h) Is there evidence that contaminant vapors have escaped containment by the SVE system? This may be due to inadequate flow from certain wells to create proper capture zones, prolonged system shutdown, preferred airflow pathways, or other outside sources of contaminants. Consider increasing the extraction rates from selected wells or the entire system, adding wells in selected areas, reducing downtime, or augmenting SVE with other source removal alternatives.

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i) If the SVE and off-gas treatment systems are located outside, are there provisions to drain water lines and sump(s) when the unit is shut down? Inspect the aboveground systems for proper insulation and / or heat tracing to prevent rupture of lines due to formation of ice during operation.

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8) Alternatives for Possible Cost Savings.

The contaminant compounds remaining in the vadose soils and/or their concentrations may have changed sufficiently that other alternatives are more cost effective. Consider the following:

a) Has the system reached its cleanup objectives? Determine if the SVE operation is still necessary, or have the concentrations decreased so that the operation can be terminated? Can the off-gas treatment system be taken off line due to decreased levels of contaminants in the vapor stream?

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b) If the cleanup objectives have not yet been met, can the system be turned off and natural attenuation be allowed to achieve the cleanup objective while remaining protective of human health and the environment? *(Refer to Air Force protocols for evaluating natural attenuation)*

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c) Can individual wells be removed from the system? Can the above-ground system operate efficiently at a reduced flow rate? Evaluate the cost savings by reducing the number of wells. *(In some cases, the capacity gained by removing non-productive wells may allow higher airflow rates through more contaminated parts of the site. However, the blowers may need to be adjusted or replaced with different sized units to accommodate changes in airflow / vacuum requirements.)*

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d) Can additional wells be placed in the plume or the extraction rates from existing wells be redistributed in a way that would economically speed remediation? (*New wells may replace several existing wells and may achieve objectives at a lower total flow. Detailed SVE modeling and extraction system optimization should be recommended as part of a separate study, if appropriate and justified by the potential costs savings.)*

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e) In some cases, other technologies may be able to accomplish the same objectives or speed clean up. The application of these alternative technologies should be economically justified based on present worth analysis compared to the cost of the current system.

- Thermal Enhancement to SVE *(See EPA 542/R-97/007)*
- Vacuum-Enhanced Pumping or Multiphase Extraction
- Soil Excavation for source removal
- Bioventing *(Bioventing may eliminate the costs of treating off-gas, but may not adequately remediate heavy hydrocarbons.)*
- Soil Fracturing *(See EPA 542/R-97/007. Diffusion limitations may still limit mass removal.)*

9) Supplemental Notes and Data

There are _______ pages of supplemental notes and data attached to this checklist.

[1] EM: USACE Engineering Manual, available at www.usace.army.mil/inet/usace-docs/