U. S. Army Corps of Engineers
In Situ Air Sparging Subsurface Performance Checklist

Installation Name ______________________________

Site Name / I.D. ______________________________

Evaluation Team ______________________________

Site Visit Date ______________________________

This checklist is meant to assist the team in evaluating the overall performance of an in situ air sparging (ISAS) system for removing volatile contaminants from groundwater. It 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 an ISAS system:

- Hydrogeologist (site visit, subsurface performance evaluation)
- Process Engineer (site visit, above-ground equipment evaluation)
- Regulatory Specialist (regulatory requirements)
- Cost Engineer (cost of alternatives)

2) Typical Treatment Objectives

Verify that the treatment objectives established when the air sparging system was designed and installed are clear and still valid.

In situ air sparging systems are typically used to remediate groundwater contamination plumes through volatilization of the contaminants to the vadose zone, and to stimulate bioremediation in the saturated zone or in both the vadose and saturated zones.

Clean up goals can include the reduction of contaminant concentrations to below some standard either throughout the plume or downgradient of a sparging line/trench. If bioremediation is desired, the objectives may be to achieve and sustain an adequate level of oxygen and nutrients in the target zone, with the anticipation that bioremediation will achieve a specified cleanup level.

3) References

This checklist should be coordinated with the Process Instrumentation and Control, Extraction and Monitoring Well, and Environmental Monitoring checklists. The following references may also be helpful:

EM 1110-1-4005 [1]: In Situ Air Sparging
EPA 600/R-96/041: Diagnostic Evaluation of In-Situ SVE-Based System Performance

4) Data Collection Requirements

The following information should be routinely collected to evaluate the performance of an in situ air sparging system. Record the appropriate units with each value.

a) Describe the objectives for the ISAS system. If current objectives are poorly defined or not defined at all, describe what might be reasonable objectives given information from the owner and regulator. *(e.g., reduce groundwater contaminant concentrations, biodegradation)*

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

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c) Obtain representative operating data as follows:

- Air Distribution: Obtain air flow and air pressure data for each sparging well. These parameters should be monitored with the same frequency as the monitoring points and should be re-measured when operational changes are made.
- Chemical Monitoring: Refer to the Environmental Monitoring checklist. Groundwater sampling and analysis should be conducted at each monitoring point for dissolved oxygen and the contaminants of concern. Monitoring should focus on early identification of plume diversion due to displacement of water by air in the sparging areas.
- Well Performance. Refer to the Extraction and Monitoring Wells checklist for physical maintenance issues. Note that pulsing of sparging wells can enhance infiltration of silt. Sound the depth of the sparging wells on a regular basis.

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

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

f) If modeling was performed, obtain a copy of the original ISAS modeling done as part of the system design. *(The design modeling may be useful in evaluating the operation of the system. Modeling is not typically done for air sparging)*

g) Are appropriate parameters measured that adequately describe the airflow paths? (e.g., neutron probe response, time-domain reflectometry, electrical resistivity tomography, dissolved oxygen concentrations, air bubbling, air pressure measurements)

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h) Are monitoring points distributed adequately in cross section to determine if sufficient air contact is achieved in all three dimensions? *(In most cases, monitoring points set at multiple depths are needed to verify vertical air distribution.)*

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i) Are measurements of water table fluctuations made to determine the possible effects on the ISAS system performance? Are these measurements made with adequate frequency?

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j) Have tracer tests been conducted to verify air flow paths and adequate travel times/velocities?

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5) Performance Analysis Calculations

Every system is different and the evaluation of the performance data must be made with the specific objectives and system configuration in mind. The following are general considerations that are common to most ISAS systems.

a) Prepare hydrogeologic cross sections using available well/boring logs, including the sparging wells, if no cross sections of the area of concern are available. Evaluate the potential for preferential flow paths or hydrogeologic boundaries not considered in design and which may affect system performance.

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b) Prepare air flow versus time graphs for each injection well to determine if past flow rates differ significantly from current conditions.

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c) Construct ground water concentration versus time graphs for the contaminants of concern at each monitoring point. Have individual monitoring points 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 at the time of shutdown of the sparging system.)*

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d) Construct ground water contaminant concentration isopleth maps of the site. Do the contaminant concentrations indicate that the treatment is effective throughout the target zone?

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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 the monitoring points constructed to yield reliable results (e.g., short screens, checked for plugging/response)?

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c) Verify that the air flows are balanced if multiple sparging wells are used.

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d) Verify that air injection pressures are low enough to avoid fracturing the soil.

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e) Verify that the contaminant concentrations are sampled and analyzed in accordance with a 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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f) Are ground water samples being collected at proper locations (e.g., at points at some distance from sparging wells yet still within the target zone)?

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7) Typical Performance Problems

a) Is there evidence of short-circuiting along the well casing, through nearby utility corridors, or through soil fractures or other subsurface features? This may be due to poor well installation, preferential air flow paths and may require well replacement or relocation.

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b) Have contaminant concentrations been declining in most of the target zone? If concentrations are not declining significantly, consider the possible existence of additional source zones that may require remedial action, the likelihood of inadequate air distribution, or preferential air flow paths. These conditions may require that additional wells be installed, air flow rates be increased, efforts be made to verify air flow paths, that ISAS be augmented with other treatment processes, or that ISAS be replaced by an alternate technology.

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c) Did concentrations rebound following cessation of sparging? This may be due to short circuiting of air through the monitoring points (i.e., monitoring well concentrations do not reflect aquifer concentrations), inadequate air distribution, or ongoing sources. Consider replacing monitoring points, increasing sparging well density, increasing air flow to each well, or other source removal alternatives.

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d) Is there good evidence for adequate air distribution in three dimensions based on relatively reliable indicators?

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e) Are the air flows unevenly distributed among the various wells in a multi-well system? Determine if this may be due to incorrect flow control valve settings, differences in depth to water in various wells, clogging of the wells, inconsistent well construction, or significantly different pressure drops in certain piping legs.

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f) Has there been unexpected contamination found outside the target zone or any indication of an unknown source? *(An investigation into another source may be warranted.)*

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g) Is there evidence that vapors are escaping to undesirable locations? These locations can include buildings or utility corridors. If the ISAS system is accompanied by a SVE system, refer to the subsurface performance checklist for SVE systems. Causes may include improper operation of the accompanying SVE system, preferred hydrogeologic pathways, other outside sources of contaminants. It may be necessary to re-evaluate the site geology to identify stratigraphic control on injected air paths, increase SVE extraction rates from certain wells or the entire system, install additional SVE wells in areas of inadequate extraction, or re-consider other source removal alternatives.

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h) Is there evidence that water table fluctuations have affected the distribution of air, isolated contaminants, or introduced additional contaminants into the treatment zone.

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i) Are increasing injection pressures required to achieve airflow? This may be due to biofouling, or siltation of the sparging wells, or rising water levels. Consider well rehabilitation or well replacement.

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8) Alternatives for Possible Cost Savings

a) Has the system reached its cleanup objectives? Determine if the ISAS operation is still necessary or have the concentrations decreased so that the operation can be terminated?

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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 – Technical Protocol for Evaluating natural Attenuation of Chlorinated Organics in Groundwater, and Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater, available at http://www.afcee.brooks.af.mil/er/toolbox.htm)*

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c) Can additional wells be placed in the plume, or can the injection rates from existing wells be redistributed in a way that would economically speed up remediation? *(Air sparging system optimization may be recommended as part of a separate study, if appropriate. Such a study should only be recommended if justified by potential cost savings.)*

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d) Evaluate the aboveground system for ability to achieve cost savings by reducing the number of wells. Can changes be made in the above-ground system to achieve efficient operation at a reduced flow rate? In some cases, the capacity gained by removing non-productive wells may allow higher air flow rates through the more contaminated parts of the site. However blowers may need to be adjusted or possibly replaced by different sized units to accommodate changes in airflow / vacuum requirements.

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e) If the ISAS system is accompanied by an SVE system, is it still necessary to capture the vapors with SVE? In some cases, there is no risk in allowing the sparged air to pass upward into the unsaturated zone without capture. For aerobically degradable contaminant vapors, the sparged air may function in a manner similar to bioventing such that biological processes in the unsaturated zone consume much of the contaminant vapor.

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f) Has pulsing of the system been considered? Pulsing is an approach that may be applicable to sites with diffusion limited mass transfer. (*Note that pulsing may increase silting of the wells.)*

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g) In some cases, other technologies may be able to accomplish the same objectives and/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.

- In-situ Bioremediation. (e.g., co-metabolic degradation of chlorinated VOCs)
- Permeable Reaction Walls. (e.g., for chlorinated organics using zero-valent iron)
- In-Situ Chemical Oxidation. (e.g., ozone, hydrogen peroxide)
- Natural Attenuation.
- Ground Water Extraction (may be needed to control plume)
- Ground Water Recirculation Wells (may be useful where stratigraphy may limit air sparging)

9) Supplemental Notes and Data

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

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

2 Air Force Center for Environmental Excellence (AFCEE) Protocol, available at www.afcee.brooks.af.mil/ER/toolbox.htm