23 May 2019

Technical Memorandum

To: Dale Myers, Washington State Department of Ecology

From: Julia Schwarz, Ty Schreiner

Subject: Boeing Field Chevron Pilot Study
K/J 1896033.00

This technical memorandum provides a summary of field oversight conducted by Kennedy Jenks on behalf of the Washington State Department of Ecology (Ecology). On 1 through 3 May 2019, G-Logics conducted an air sparge/soil vapor extraction (AS/SVE) pilot test at the Boeing Field Chevron site located at 10805 East Marginal Way South in Tukwila, WA. G-Logics personnel onsite for the pilot test included Zak Wall and Jon Stordahl. Adam Morine (EPI) was also onsite to help run the pilot test as a subcontractor to G-Logics. Russell Shropshire (Leidos) was onsite on behalf of Chevron on 1 and 2 May 2019. Julia Schwarz of Kennedy Jenks was onsite on 1 through 3 May 2019 to observe the pilot test on behalf of Ecology.

On 1 May 2019, the SVE system was tested in the upper saturated zone to evaluate the efficacy of SVE at the site. A blower step test was conducted extracting air from well SVE-1 at three different flow rates/pressures. A photo log is provided in Attachment A. At each step, flow rates and pressures were measured at SVE-1, a photoionization detector was used to measure volatiles extracted from well SVE-1, and pressures were measured at nearby wells screened in the upper saturated zone. Vacuum was observed in nearby wells. The maximum vacuum achieved at well SVE-1 was approximately 28 in H_20. PID measurements in outflow from SVE-1 were generally around 350 ppm regardless of the vacuum or air flow.

On 2 May 2019, the SVE system was operated at maximum pressure/flow while sparging into the upper saturated zone at AS-1. A photo log from 2 May 2019 is provided in Attachment B. Wells in the upper saturated zone were monitored for pressure, headspace gases with the PID, and bubbles. Observation frequency for these parameters was modified slightly from the work plan given field constraints including time to open wells to observe bubbles, and negative pressures observed in wells (unlikely to be bubbles). Sparging into well AS-1 at a rate of approximately 8 scfm with approximately 8 inches H_20 pressure at the well. PID measurements from well SVE-1 did not significantly increase from the step test day. Following system shutdown, DO measurements in some wells were lower than prior to the start of the test.

On 3 May 2019, the SVE system was operated at maximum pressure/flow while sparging into the lower saturated zone at AS-2. A photo log from 3 May 2019 is provided in Attachment C. Wells in the upper and lower saturated zone were monitored for pressure, headspace gases with a PID, and bubbles, and for DO prior to and following the test. Positive pressure was noted in lower zone wells prior to starting the test. Pressure fluctuations in the lower zone may be influenced by tidal cycles. Observation frequency for parameters to be collected during the test was again modified from the work plan due to field constraints (e.g. time to collect measurements from all wells). Approximately 9 scfm was injected into AS-2 with a steady pressure of approximately 8 psi. Large amounts of bubbles were observed in some lower saturated zone wells, including IP-5 and IP-7. Limited, intermittent, and small bubbles were noted in some upper saturated zone wells located nearby to AS-2; however, most of the air appeared to still be within the lower saturated zone. During the AS test into the lower saturated zone, PID readings from SVE-1 remained relatively similar to concentrations from the SVE test.

Some questions raised during this pilot test that may need to be answered to accurately assess the efficacy of an AS/SVE system at the site and may be important for design and implementation. These include, but are not limited to:

- How do tidal fluctuations influence the ability to inject air into the lower saturated zone?

- Where is air in the lower saturated zone going? What is the ROI in the lower saturated zone vs. the ROI in the upper saturated zone from sparging in the lower saturated zone? During sparging into the lower saturated zone, bubbles were observed in wells screened in the lower saturated zone, approximately 35 feet away from the sparge well. Small bubbles, but not of the same volume, were observed in closer wells screened in the upper saturated zone.

- Is air within the lower saturated zone traveling along preferential pathways, e.g. the utility corridor?

- Is air traveling along the bottom of the semi-confining layer rather than being released to the upper saturated zone? If so, what are the expected directions of travel and ROI of this air based on the elevation of the confining layer?

Enclosure(s) (3)

Attachment A: Photo log from 1 May 2019
Attachment B: Photo log from 2 May 2019
Attachment C: Photo log from 3 May 2019

***Photo #1**:* Soil Vapor Extraction (SVE) system set up at well SVE-1. SVE system set up to extract from SVE-1 with manifold with several flow meters in order to conduct a step test. Extracted vapor will be run through GAC canister (drum in background).

***Photo #2**:* Measuring vacuum at wells prior to startup of the SVE system.

***Photo #3**:*

System startup of the SVE system. Opening the valves on part of the manifold. Operating at 100% dilution.

***Photo #4**:*

Collecting SVE system sample in a tedlar bag. Sample collected from the SVE system prior to going through the manifold. Sample being drawn through the vacuum pump.

Photo #5:

Measuring concentrations in air leaving the GAC canister using a photoionization detector (PID) measuring in ppm. Low concentrations in air after going through GAC.

Photo #6:

Measuring vacuum in shallow wells during operation of the SVE system. Vacuum observed in nearby shallow wells.

***Photo #7*:**

Measuring vacuum in shallow well MW-26S during operation of the SVE system. Traffic control set up direct traffic around the well.

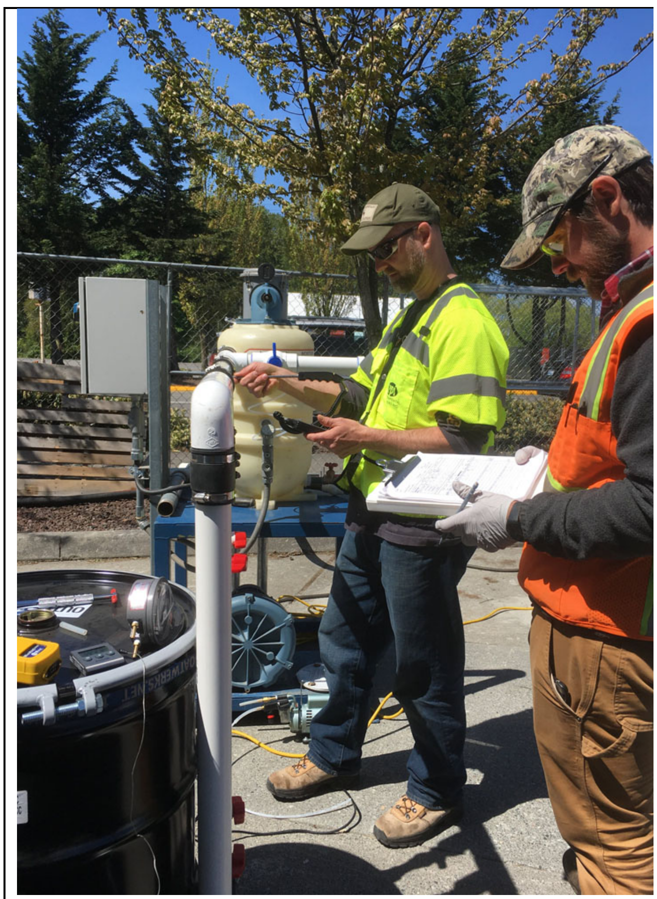

***Photo #8*:**

Measuring airflow between well SVE-1 and the moisture separator with a hot wire anemometer. Flow within the manifold was limited by the flow meters, so one section was changed out for blank PVC with no flow meter (closest upright in picture), and the airflow was measured by hot wire anemometer instead.

***Photo #1**:* Setting up visqueen on gravel area adjacent to AS-1 prior to operation of the air sparge (AS) system.

***Photo #2**:*

Completed setup of visqueen on gravel area adjacent to AS-1. Edge secured with sandbags, and duct taped around trees and visqueen seams.

***Photo #3**:*

SVE setup at well SVE-1, measuring pressure in SVE-1 prior to startup of AS system.

***Photo #4**:*

Collecting an air sample for PID testing from SVE-1. Using a vacuum chamber so that the sample does not go through the vacuum pump. Sample collected prior to going through the manifold.

Photo #5:

Measuring flow in the GAC outflow pipe to compare to flow near SVE-1.

Photo #6:

Setting up for injection into the shallow zone at well AS-1. SVE in operation.

***Photo #7*:**

Using a well camera paired with a phone to inspect shallow well MW-26S for bubbles prior to startup of the AS system.

***Photo #8*:** Initiating startup of the AS system, to blow into shallow well AS-1. AS-1 is located beneath the yellow jacket; concerns were raised about pressurizing PVC so a jacket was placed over the well attachment to protect personnel from PVC pieces in the event that the PVC

***Photo #9**:*

Ground near AS-1 and AS-2 wetted to inspect the surface for bubbles. No bubbles were observed.

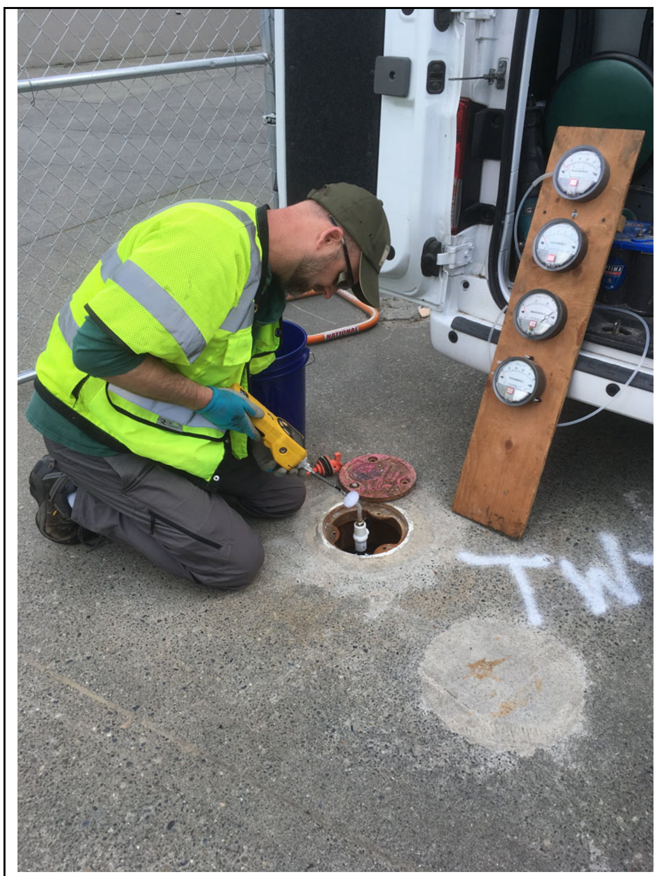

***Photo #10**:*

Measuring well head space with a PID while AS (shallow) and SVE systems operating.

Photo #11*:*

AS system gauges. Injecting into AS-1 at highest measurable flow rate (right gauge at 10 SCFM).

Photo #12*:* Well attachment at AS-1 with two pressure gauges attached.

***Photo #13**:* Measuring airspace beneath the visqueen near AS-1 with a PID. Readings beneath the visqueen were similar to ambient.

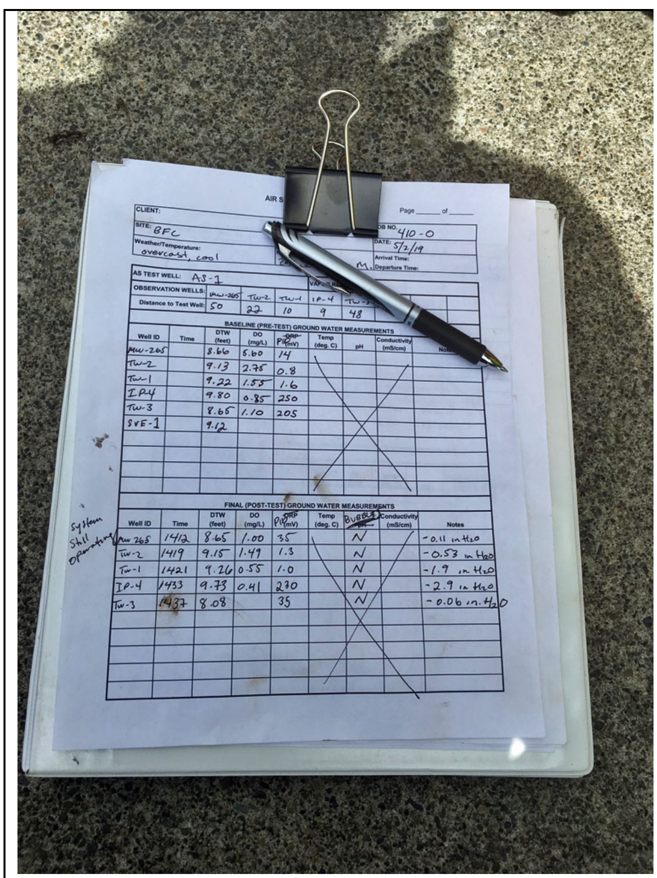

***Photo #14**:*

Data collection sheets for baseline (pre-test) and final (near the end of test) groundwater readings in monitoring wells. Vacuum measured in most shallow wells; DO after operation of AS and SVE systems lower than initial. PID readings generally a similar order of magnitude.

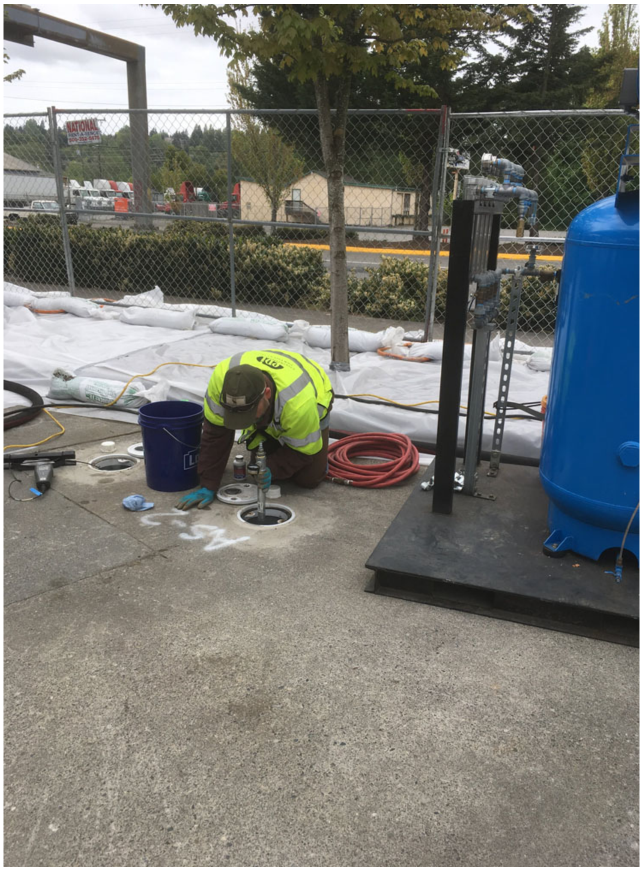

Photo #1:

Setting up steel well attachments for sparging at deep well AS-2.

Photo #2:

Measuring headspace in well IP-4 using a PID.

Photo #3:

Collecting a vapor sample from SVE-1 using a vacuum chamber prior to startup of sparging into AS-2.

Photo #4:

Field screening air extracted from well SVE-1 using a PID and tedlar bag. Concentrations measured with a PID did not change significantly while sparging compared to just soil vapor extraction.

***Photo #5**:*

Measuring pressure/vacuum in each well prior to startup of the AS system in the deep zone.

***Photo #6**:*

Measuring well headspace with a PID at deep well IP-5.

Photo #7:

System startup, sparging into deep well AS-2.

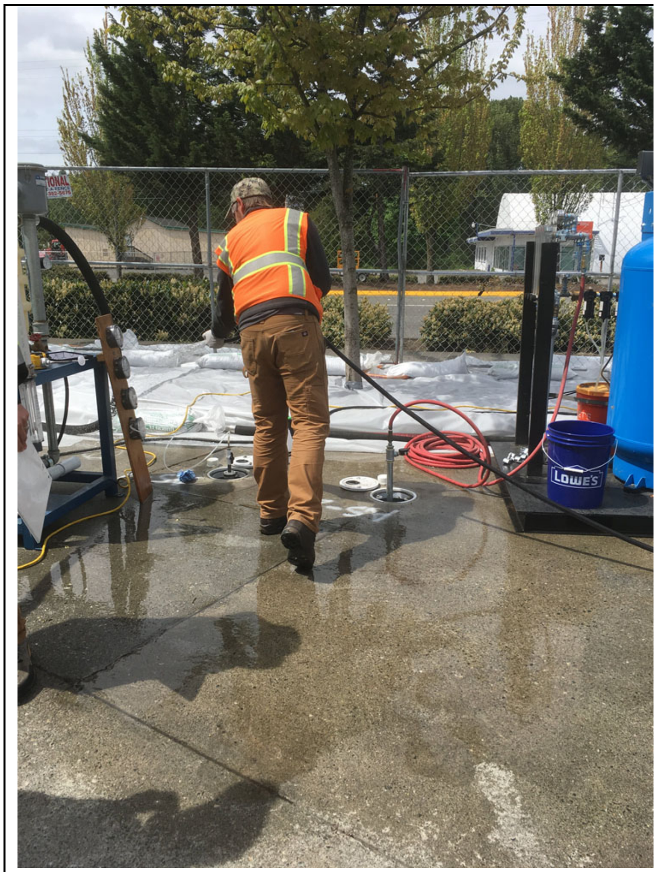

Photo #8:

Wetting down pavement near AS-1 and AS-2 to check for bubbles in the pavement.

Photo #9*:* Inspecting wet ground for bubbles near IP-5 and SVE-1.

Photo #10:

Using a well camera paired with a phone to inspect well MW-28D for bubbles while sparging into the lower zone and extracting from the upper zone.

Photo #11:

Measuring well headspace in well MW-26D while sparging into the lower zone and extracting from the upper zone.