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DUS II Soil Gas Sampling and Air Injection Test Results

J. V. Noonkester
D. G. Jackson
W. E. Jones
W. K. Hyde
J. L. Kohn
R. Walker

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Savannah River National Laboratory
Savannah River Nuclear Solutions
Aiken, SC 29808

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LIST OF ACRONYMS

AS	air sparging
ASVE	active soil vapor extraction
bgs	below ground surface
BTU	British thermal unit
° C	degrees Celsius
CCL4	carbon tetrachloride
C-DCE	cis-dichloroethane
cfm	cubic feet per minute
CHCL3	chloroform
CH4	methane
DUS	dynamic underground stripping
ERT	electrical resistance tomography
Hg	mercury
HPO	hydrous pyrolysis oxidation
ml	milliliter
PCE	tetrachloroethylene
ppmv	parts per million vapor
SCDHEC	South Carolina Department Health and Environmental Control
scfm	standard cubic feet minute
SRNL	Savannah River National Laboratory
SRNS	Savannah River Nuclear Solutions, LLC
SVE	soil vapor extraction
TCA	1,1,1, trichloroethane
TCE	trichloroethylene
TMP	thermal monitoring points
VEW	vapor extraction well
VOC	volatile organic compound

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1.0 SUMMARY

Soil vapor extraction (SVE) and air injection well testing was performed at the Dynamic Underground Stripping (DUS) site located near the M-Area Settling Basin (referred to as DUS II in this report). The objective of this testing was to determine the effectiveness of continued operation of these systems. Steam injection ended on September 19, 2009 and since this time the extraction operations have utilized residual heat that is present in the subsurface. The well testing campaign began on June 5, 2012 and was completed on June 25, 2012. Thirty-two (32) SVE wells were purged for 24 hours or longer using the active soil vapor extraction (ASVE) system at the DUS II site. During each test five or more soil gas samples were collected from each well and analyzed for target volatile organic compounds (VOCs). The DUS II site is divided into four parcels (see Figure 1) and soil gas sample results show the majority of residual VOC contamination remains in Parcel 1 with lesser amounts in the other three parcels. Several VOCs, including tetrachloroethylene (PCE) and trichloroethylene (TCE), were detected. PCE was the major VOC with lesser amounts of TCE. Most soil gas concentrations of PCE ranged from 0 to 60 ppmv with one well (VEW-22A) as high as 200 ppmv.

Air sparging (AS) generally involves the injection of air into the aquifer through either vertical or horizontal wells. AS is coupled with SVE systems when contaminant recovery is necessary. While traditional air sparging (AS) is not a primary component of the DUS process, following the cessation of steam injection, eight (8) of the sixty-three (63) steam injection wells were used to inject air. These wells were previously used for hydrous pyrolysis oxidation (HPO) as part of the DUS process. Air sparging is different from the HPO operations in that the air was injected at a higher rate (20 to 50 scfm) versus HPO (1 to 2 scfm). . At the DUS II site the air injection wells were tested to determine if air sparging affected VOC soil gas concentrations during ASVE. Five (5) SVE wells that were located closest to the air injection wells were used as monitoring points during the air sparging tests. The air sparging tests lasted 48 hours. Soil gas sample results indicate that sparging did not affect VOC concentrations in four of the five sparging wells, while results from one test did show an increase in soil gas concentrations.

2.0 PURPOSE

The purpose of this project was to collect soil gas samples from SVE wells and evaluate air injection effectiveness at the DUS II site in M Area (Figure 1). The results of the testing would be used to determine the wells that should continue to be used for ASVE and to identify extraction wells that can be transitioned from active to passive treatment systems. The data from these tests will be used to provide a technical basis to determine which components of the SVE and air sparging well infrastructure should remain for future corrective action activities. Testing began on June 5, 2012 and was completed on June 25, 2012.

2.1 Background

The steaming process for the DUS system operated from the summer 2005 to the fall 2009 and removed over 430,000 pounds of dissolved and pure phase VOC contamination (SRNS 2009). In October 2009, Savannah River Nuclear Solutions, LLC (SRNS) submitted to the South Carolina Department of Health and Environmental Control (SCDHEC) the technical basis for shutting down the steam at the Western Sector DUS project. The technical basis encompassed three criteria related to the following focus areas: (1) energy output, (2) target zone heating, and (3) contaminant concentrations.

The first criterion that the energy input into the subsurface was greater than the conceptual BTU load for heat-up of the target zone was met in August 2008. The total quantity of steam injected at the DUS site was over 340 million pounds.

The second criterion specified that the functional thermocouples [thermal monitoring points (TMPs)] in the target volume were at the target temperature (110°C ± 5°C) and that the Electrical Resistance Tomography (ERT) provided evidence to support that the steam front swept the entire target zone. According to collected TMP and ERT data, this criterion was fulfilled in 2006.

The third criterion stated the undiluted vapor concentrations for PCE at each wellhead needed to be less than 400 ppmv at an optimized flow rate (i.e., 500 scfm at 9 inches Hg vacuum) during continuous operation. Below this vapor concentration, dense non-aqueous phase liquid was considered to no longer be conclusively observed. Data collected in 2009 provided the evidence needed to satisfy this criterion. PCE concentrations in the wells were considered to be indicative of peak VOC rebound values and were expected to decrease with continued SVE operations.

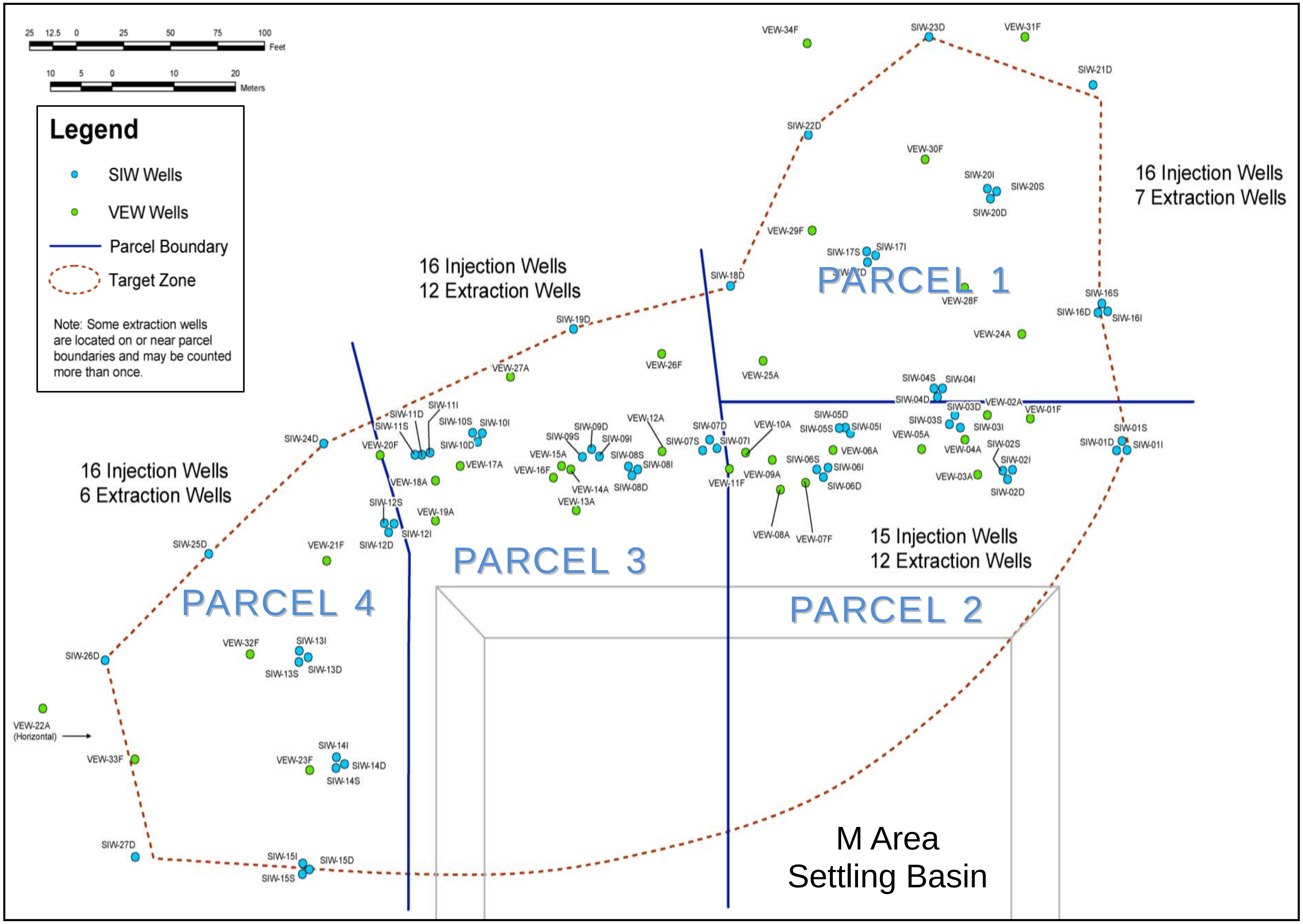

Figure 1. Location of Parcels and Soil Vapor Extraction Wells (VEW)

3.0 SOIL VAPOR EXTRACTION (SVE) WELL TESTING

There are thirty-two (32) SVE wells (well designation VEW) located at the DUS II project. The approach was to perform SVE tests on approximately four wells at a time by extracting from the wells using the DUS II ASVE system for a 24-hour period. The targeted wells were valved open to the ASVE system to perform purging. Each 24-hour test period started at approximately 10:00 AM. Tests that began on the last work day of a work week were allowed to continue over the weekend and were completed on the following Monday. The wells associated with tests that ran over a weekend were VEW-5A, 7F, 10A, 11F, 18A, 19A, 24A, 26F, and 34F.

Samples were collected at each wellhead using a handheld vacuum pump. A total of five sets of samples were collected during the 24-hour testing period. Soil gas samples were collected in both 20 ml headspace vials by using the headspace vial/ziploc method and in Tedlar bags. The 20 ml vials were analyzed on a gas chromatograph at the Savannah River National Laboratory (SRNL) and the following compounds are reported: PCE, TCE, 1,1,1-trichloroethane (TCA), cis-dichloroethane (C-DCE), carbon tetrachloride (CCL4), chloroform (CHCL3), and methane (CH4) . Other constituents of operational interest to DUS (i.e., mercury and polychlorinated biphenyl) were not within the scope of this investigation.

A photoacoustic analyzer (Bruel and Krull Model 1312A) was used in the field to analyze the gas samples collected in Tedlar bags. This instrument provides real-time results that allow concentration trends to be observed as testing progresses. This provided the ability to verify that 24-hours of ASVE were sufficient to establish a baseline VOC soil gas concentration. The objective was to determine if the concentration stabilized or trended up or down during the 24-hour test period. Two of the SVE wells (VEW-24A and VEW-25A) examined continued to trend upward during the 24-hour purging period. On the last day of testing, these wells were added to the schedule for an additional round of purging to see if concentrations would stabilize. After the additional purging period, concentrations did drop in both VEW-24A and VEW-25A.

Thirty-two (32) of the thirty-four (34) SVE wells were successfully tested. Table 1 provides a listing of the wells by parcel. The two wells that were not evaluated were VEW-13A and VEW-32F. VEW-13A was producing excessive amounts of condensate that oversaturated samples making them un-analyzable. VEW-32F had been capped off and was no longer piped to the system and was not tested because of functionality problems during ASVE.

3.1 Soil Gas Sample Results

PCE was the major compound that was detected with lesser amounts of TCE with several other compounds found in very low to trace amounts. Results for all compounds can be found in Appendix A. PCE results for each parcel are shown in Figures 2 through 5. No other compounds are illustrated in this report since all concentrations, except PCE, are too low to impact future decisions of the DUS II infrastructure.

The highest PCE soil gas concentrations were detected in VEW-22A (200 ppmv). VEW-22A is the only horizontal SVE well at DUS II and it runs underneath the basin. Parcel 1 had the most wells with significant concentrations as high as 60 ppmv.

TCE concentrations were very low in all of the wells. TCE concentrations were mostly less than 10 ppmv with the exception of VEW-22A where concentrations were as high as 113 ppmv.

The presence of C-DCE in low concentrations was detected in VEW-7F, -11F, -22A and -24A. High methane results were also detected in these wells. This may indicate some anaerobic activity is occurring near these four wells. VEW-22A had the highest methane concentrations at 1,896 ppmv.

Table 1. Listing of Wells in Each Parcel

Parcel 1	Parcel 2	Parcel 3	Parcel 4
VEW24A	VEW01F	VEW12A	VEW20F
VEW25A	VEW02A	VEW13A*	VEW22A
VEW28F	VEW03A	VEW14A	VEW-33F
VEW29F	VEW04A	VEW15A	VEW-23F
VEW30F	VEW05A	VEW17A	VEW-32F*
VEW31F	VEW06A	VEW18A	VEW-21F
VEW34F	VEW07F	VEW19A	
	VEW08A	VEW26F	
	VEW09A	VEW27A	
	VEW10A	VEW-16A	
	VEW11A		

*These wells were not tested. Refer to Section 3.0 for additional information.

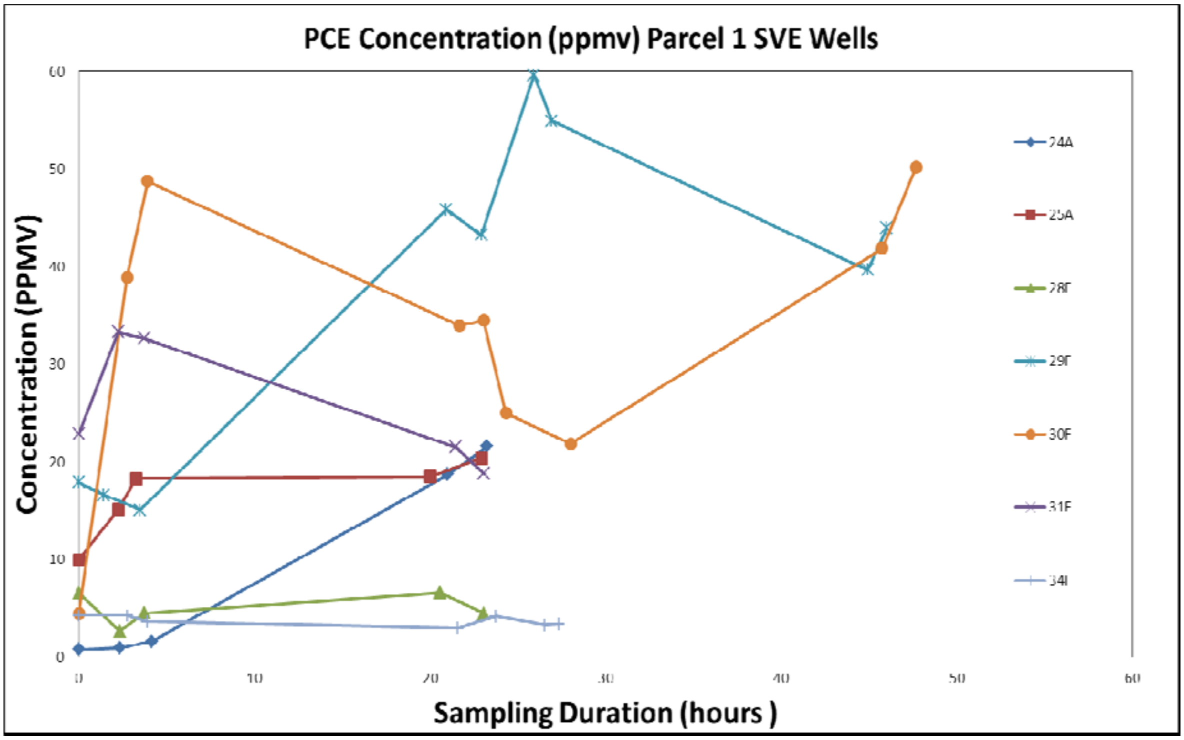

Figure 2. Parcel 1 Soil Gas Sample Results for PCE

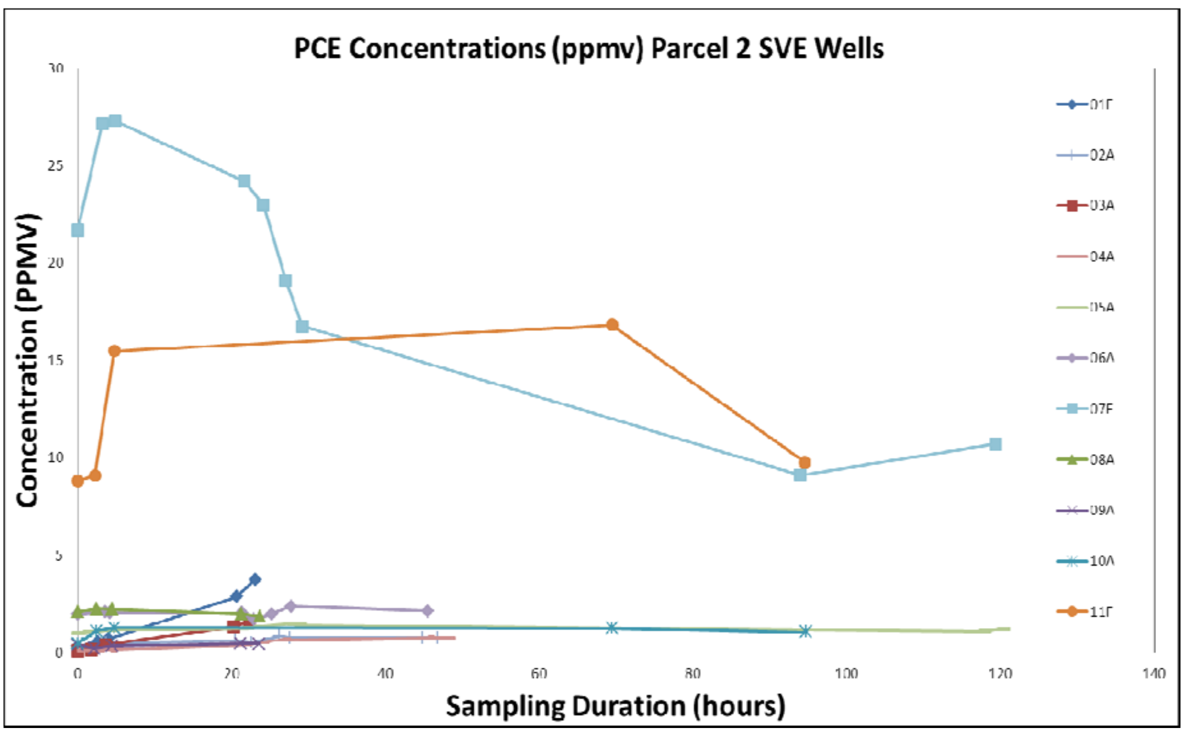

Figure 3. Parcel 2 Soil Gas Sample Results for PCE

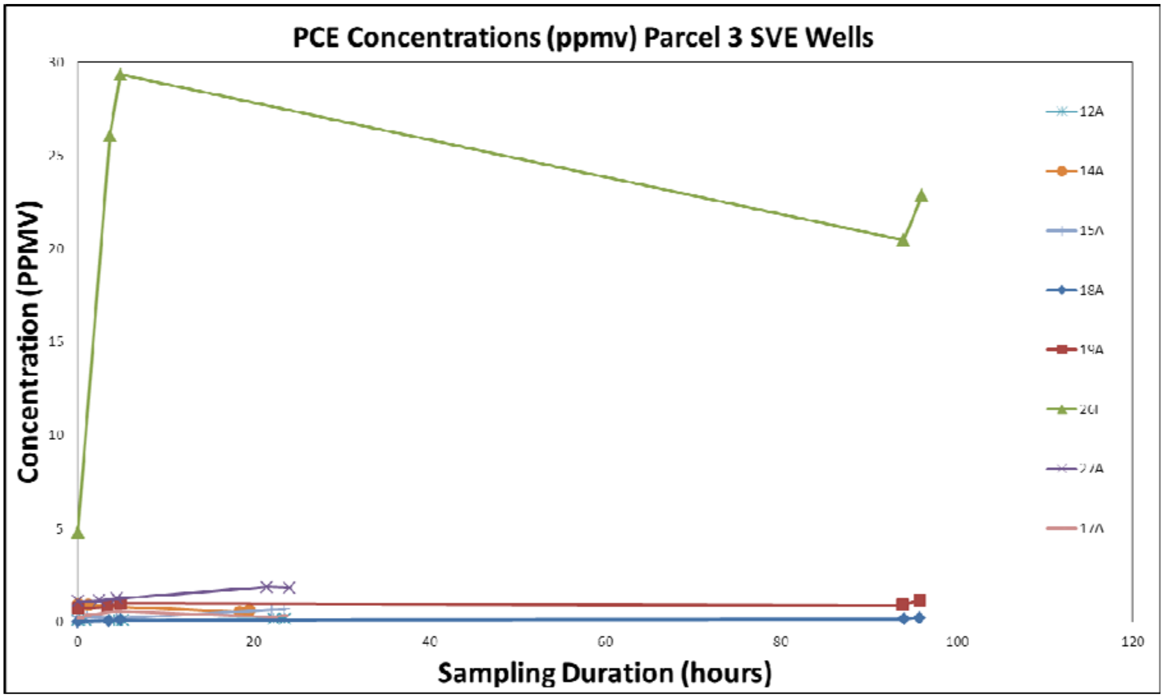

Figure 4. Parcel 3 Soil Gas Sample Results for PCE

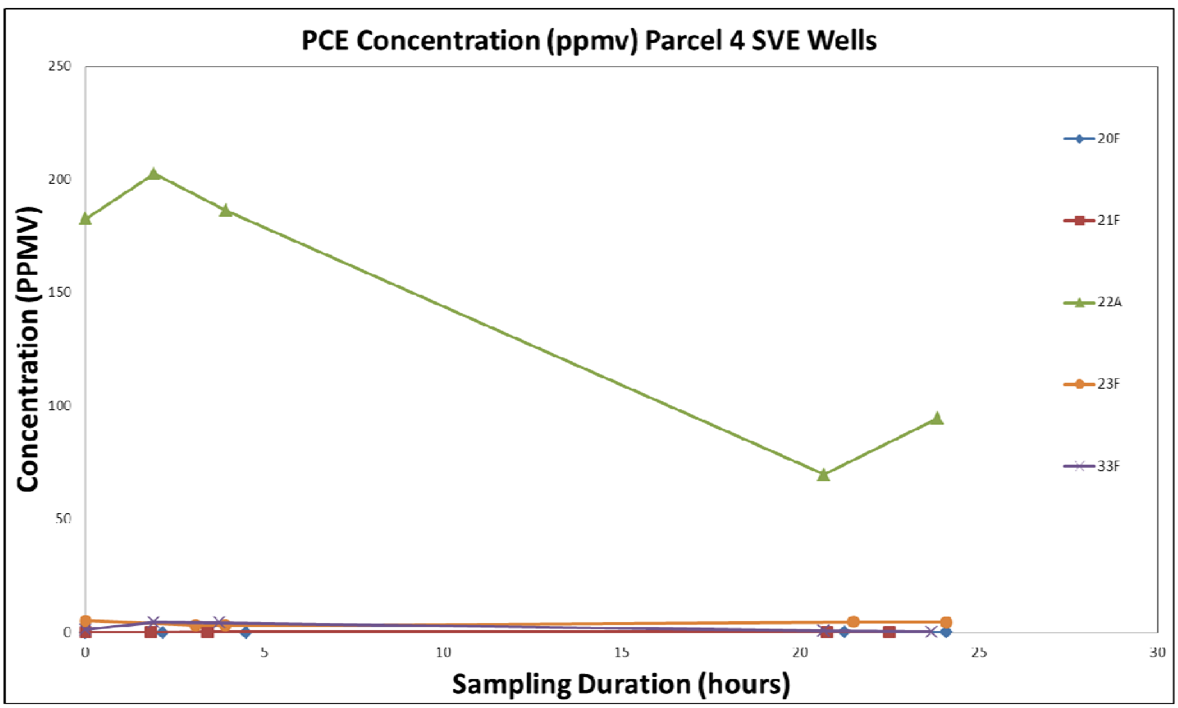

Figure 5. Parcel 4 Soil Gas Sample Results for PCE

Field Parameters

Field parameters collected at each wellhead during SVE well testing included soil gas temperature, vacuum, and volume flow rate. The intention was to use existing installed instrumentation at each wellhead to measure these parameters. During testing it was discovered that the flow meters in approximately two thirds of the wells were inoperable. In the wells with inoperable flow meters, a handheld insertion flow meter (ALNOR, model AVM 430) was used at each wellhead. Flow observations from these wells are suspect because of the location of the port that was used to insert the handheld meter. The port was located in a 90 degree elbow, which is not the appropriate use of this type of instrument due to air flow disruption. The installed flow rate instrument provided the most accurate flow rate results. The results varied from 100 cfm to 440 cfm in the wells that had working instruments. Vacuum readings varied from 2.8 inches Hg to 8.0 inches Hg. Soil gas temperatures varied from a low of 80 degrees Fahrenheit (VEW-22A) to a high of 160 degrees Fahrenheit (VEW-09A). See Appendix B for complete set of field parameter data.

4.0 AIR INJECTION/SPARGING WELL TESTING

Testing of the air injection wells was performed to determine if air affects the VOC soil gas concentrations during ASVE. Traditional air sparging was not a component of the original DUS process. The air injection system was installed to promote a hydrolysis pyrolysis reaction as an integral component of DUS heating. This reaction has been identified as degrading volatile organics under the pressures and temperatures associated with DUS. A necessary component of this reaction is oxygen. During active steam injection, compressed air was injected using the deepest injection wells to promote this degradation reaction. It is important to recognize that conventional air sparging must be coupled with vapor extraction in the vadose zone immediately above the phreatic surface of the sparge zone. Failure to have adequate extraction results in a volatilization and condensation cycle of the volatile constituents out of and back into the saturated zone.

The DUS II site has eight former steam injection wells (i.e., SIW-2D, SIW-3D, SIW-4D, SIW-5D, SIW-6D, SIW-17D, SIW-20D, and SIW-23D) that are configured and approved by SCDHEC for air injection. The location and depth of the injection wells were evaluated against the proximity of the existing vapor extraction wells to identify which extraction well would likely be influenced by air injection and would provide adequate capture of any sparged vapors.

Five SVE wells that were located closest to the air injection wells were used as monitoring points during the air injection tests. Air injection tests lasted 48 hours. During the first 24 hours, the SVE well was pumped and sampled as described in Section 3.0. At the end of the first 24 hours of the test, air injection at the target SIW was initiated and the SVE well continued to be pumped and sampled for the final 24 hours. A total of nine soil gas samples were collected during each air injection test. The tests were discontinued at three of the air injection wells (SIW-4D, SIW-5D, and SIW-17D) because they were non-operational. Non-operational status was recognized by high pressures and no flow. Table 2 provides a list of the air injection wells that were successfully tested. Two of the air injection well tests (i.e., SIW-3D and SIW-23D) extended over the weekend; , therefore, these tests lasted longer than the planned 24 hour duration. Results associated with the air injection phase are incorporated within the results presented in Appendix A for specific extraction wells.

Soil gas sample results indicate that air injection was not effective at significantly increasing VOC concentrations in four (i.e., SIW-2D, SIW-3D, SIW-6D, and SIW-23D) of the five injection wells (Figure 6). In the remaining air injection well (i.e., SIW-20D) the results are considered to be inconclusive. Prior to air injection at SIW-20D, the PCE vapor concentration observed at well VEW-30F peaked at approximately 50 ppmv and then had decreased to 35 ppmv when air injection was initiated. Following air injection, the PCE concentration continued to decrease over the next 24-hours to a minimum value of 22 ppmv. Over the following 20-hours, the PCE concentration increased to 50 ppmv. While the fluctuations in PCE concentrations observed in VEW-30F may be attributed to air injection at SIW-20D, other likely possibilities include variations in the zone of capture of VEW-30F caused by other SVE wells being shut down and others being turned on. When SIW-20D was activated, SVE well VEW-31F was started and VEW-32F was shut down. These activities would have affected the zone of capture of VEW-30F. To know for certain if air injection at well SIW-20D impacts VOC concentration in the vadose zone, a test should be performed with more controlled conditions. As the maximum values observed from VEW-30F with and without air injection were both on the order of 50 ppmv and no enhancement was observed using the four other injection wells, SRNL's recommendation is to abandon future air injection operations.

Table 2. List of Sparging Wells and SVE Sampling Wells

Air Sparging Well	SVE Sampling Well
SIW-2D	VEW-2A
SIW-3D	VEW-5A
SIW-6D	VEW-6A
SIW-20D	VEW-30F
SIW-23D	VEW-34F

Note: Wells SIW-4D, SIW-5D, and SIW-17D were found to be non-operational.

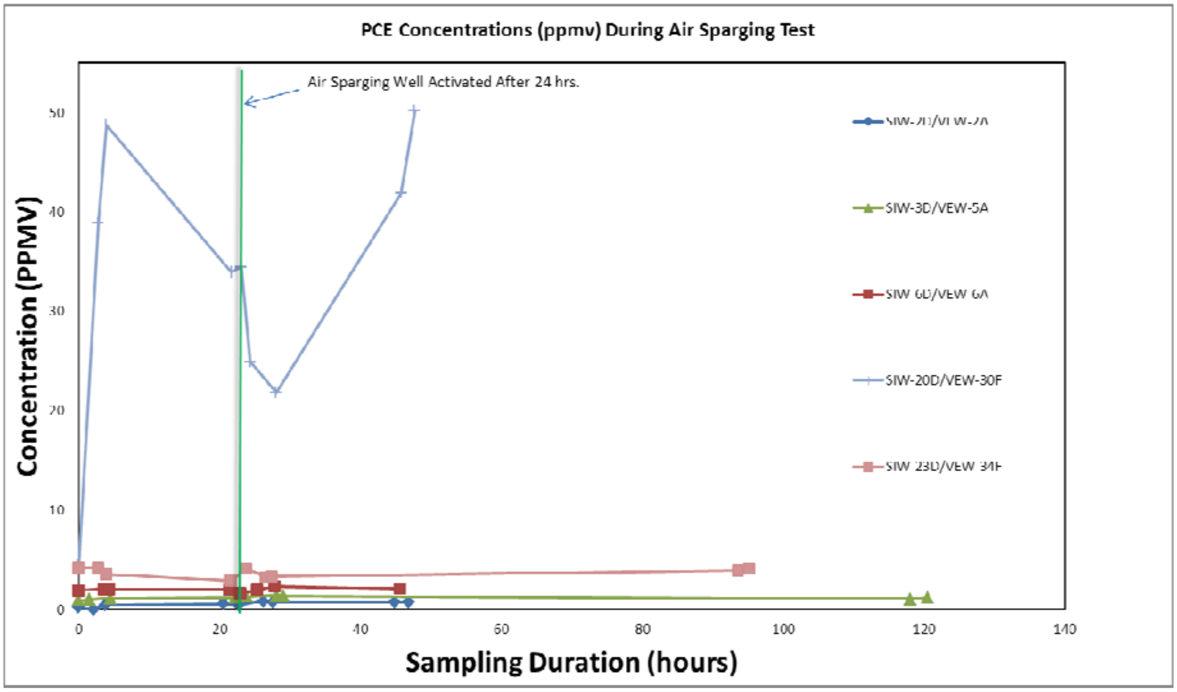

Figure 6. PCE Concentration during Sparging Tests

5.0 RECOMMENDATIONS

The results from sampling of DUS II vapor extraction wells indicate that some residual VOC source remains at the site. The major compound observed was PCE, which when present was significantly higher than other DUS II target compounds (e.g., TCE and 1,1,1-TCA). High concentrations of PCE was observed at most of the extraction wells (5 of 7) located in Parcel 1, two extraction wells in Parcel 2, and one extraction well in both Parcel 3 and in Parcel 4. These wells are identified in Table 3 and should be the primary focus of ASVE activities. Continued operation of the active vapor extraction system with these wells will capitalize use of the thermal energy that remains in the subsurface. ASVE should incorporate periodic monitoring of vapor concentration, flow rate, and gas temperature as these parameters are key components of determining mass extraction rate from each well. As extraction performance and thermal energy (temperature) decrease, then the wells can be transitioned to passive SVE. Flow meters that are non-operational on the identified wells should be repaired or replaced with operational components. As previously discussed, no significant performance was associated with air injection operations.

Table 3. DUS II Extraction Wells that Should Be Targeted for ASVE

Parcel 1	Parcel 2	Parcel 3	Parcel 4
VEW24A	VEW07F	VEW26F	VEW22A
VEW25A	VEW11A		
VEW29F			
VEW30F			
VEW31F			

Definitive depth-discrete soil sampling is the preferred method to vertically delineate residual source material. Without this information, SRNL advocates that any recalcitrant source will be located in the interbedded fine grain sediments. Known intervals of fine-grained materials within the M-Area vadose zone include 90 – 120 feet bgs and, to a lesser degree, in other fine grain sediment through the 130 feet thick vadose zone. These “tight zones” may continue to provide a source for groundwater contamination. These intervals will be difficult to remediate because the material is considered to be diffusion rate limited. Effective remediation and protection of deeper groundwater may be achieved by converting the remaining vapor extraction wells to the passive extraction process using either MicroBlowers™ or BaroBalls™.

SRNL recommends caution when deciding on a strategy for which wells to decommission. At this stage, SRNL would not recommend the abandonment and removal of any of the remaining vapor extraction wells. Operation of the ASVE system will produce vapor drawdown in the subsurface that will inhibit the performance of any passive technology. Passive technology should be selectively implemented first in Parcel 3 and Parcel 4, then in Parcel 2, and finally in Parcel 1. Implementation should be such to ensure that active extraction does not hinder operation of the passive system.

Another important consideration in the decision should be the limited zone of capture of passive technology. The SVE at the DUS II site have long screen zones that are located in the permeable portion of the vadose zone. The conventional configuration of MicroBlowers™ is intended for shorter screen lengths. Proper evaluation and selection of blower capacity is warranted when transitioning to passive remedies. The more wells that are utilized, the more effective the passive technology will be in extraction of residual contaminants prior to impacting the groundwater.

6.0 REFERENCES

SRNS, 2009. *Technical Basis for Steam Shut Down at the M-Area Settling Basin Dynamic Underground Stripping (DUS) Facility*, ERD-EN-2009-0108, October 2009, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

Appendix A. Complete List of Soil Gas Sample Results

Note: Blank cells indicates a non-detect result

Well Name/Sample Duration (hrs)	CCL4	C-DCE	CH4	CHCL3	PCE	TCA	TCE
VEW-01F							
0			79.3		0.3		
3			76.7		0.6		0.4
4			85.3		0.7		0.4
21			172.4		2.9		0.7
23			185.0		3.7		0.8
VEW-02A							
0			39.7		0.3		
2					0.1		
4			32.5		0.5		0.2
20			20.9		0.6		0.3
23			21.9		0.5		0.2
Injection of Air at SIW-2D: 24							
26			24.0		0.9		0.4
28			22.6		0.8		0.4
45			13.2		0.8		0.5
47			12.4		0.8		0.5
VEW-03A							
0			43.6		0.1		
2			44.0		0.2		
4			53.6		0.4		0.1
20			92.2		1.3		0.5
22			92.2		1.6		0.6
VEW-04A							
0			10.6		0.1		
3			7.6		0.1		
4			6.7		0.1		
22			9.6		0.4		0.3
24			10.5		0.5		0.3
27			9.7		0.7		0.3
28			9.9		0.6		0.3
46			12.0		0.8		0.4
48			12.5		0.8		0.4

Complete List of Soil Gas Sample Results (cont'd)

Well Name/Sample Duration (hrs)	CCL4	C-DCE	CH4	CHCL3	PCE	TCA	TCE
VEW-05A							
0					1.0		0.8
2					1.0		0.8
5					1.1		0.8
14			11.8		1.2		0.8
Injection of Air at SIW-3D: 24			12.4		1.3		0.7
28			13.8		1.5		0.6
29			12.4		1.4		0.7
118			12.9		1.1		0.5
120			12.8		1.2		0.6
VEW-06A							
0			55.6		2.0		0.3
4			61.5		2.1		0.3
4			61.8		2.1		0.3
21			67.2		2.0		0.5
23			66.6		1.7		0.5
Injection of Air at SIW-6D: 24							
25			73.7		2.0		0.4
28			77.5		2.4		0.4
46			75.6		2.1		0.4
VEW-07F							
0		3.2	1526.5		21.7		5.5
3		3.3	1375.9		27.1		6.1
5		3.3	1297.5		27.3		5.8
22		2.4	809.0		24.2		4.0
24		2.2	784.7		23.0		3.8
27		1.9	569.0		19.1		3.6
29		1.7	520.6		16.8		3.2
94		1.6	236.1		9.1		1.9
119		1.7	176.2		10.7		1.7
VEW-08A							
0			65.7		2.1		1.1
2			84.3		2.2		1.3
5			68.0		2.2		1.3
21			68.9		2.0		0.9
24			71.1		1.9		0.9

Complete List of Soil Gas Sample Results (cont'd)

Well Name/Sample Duration (hrs)	CCL4	C-DCE	CH4	CHCL3	PCE	TCA	TCE
VEW-09A							
0			25.3		0.4		
2			12.2		0.2		
5			18.4		0.3		
21			14.4		0.4		
24			12.7		0.4		
VEW-10A							
0			44.7		0.4		0.2
2			83.8		1.1		0.6
5			92.3		1.3		0.7
70			178.9		1.2		0.7
95			146.3		1.1		0.6
VEW-11F							
0		1.2	951.3		8.8		3.0
2		1.2	1014.2		9.1		2.9
5		1.7	1308.6		15.5		2.9
70		2.7	850.9		16.8		2.4
95		2.4	667.9		9.8		2.2
VEW-12A							
0					0.1		
1					0.1		
4					0.1		
5					0.1		
22			8.8		0.2		
24			9.0		0.2		
VEW-14A							
0					0.9		0.2
1					0.9		0.2
18					0.5		0.1
20					0.6		
VEW-15A							
0					0.3		0.2
1					0.3		0.2
4					0.2		0.2
22			19.6		0.6		0.5
24			20.3		0.7		0.5

Complete List of Soil Gas Sample Results (cont'd)

Well Name/Sample Duration (hrs)	CCL4	C-DCE	CH4	CHCL3	PCE	TCA	TCE
VEW-17A							
0					0.2		
1					0.3		
4					0.6		0.1
22					0.3		
23					0.3		
VEW-18A							
0							
3					0.1		
5					0.1		
94					0.1		
96					0.2		
VEW-19A							
0					0.7		
3					0.8		
5					1.0		
94					0.9		0.2
96					1.2		0.3
VEW-20F							
0					0.1		
2					0.1		
5					0.1		
21					0.1		
24					0.2		
VEW-21F							
0					0.2		
2					0.2		
3					0.3		
21			3.9		0.3		0.1
23			4.2		0.3		
VEW-22A							
0		1.8	1644.7		182.7		102.3
2		2.0	1747.4		202.8		113.1
4		2.3	1896.0		186.3		100.5
21			7.4		69.9		36.6
24			395.3		94.6		68.8

Complete List of Soil Gas Sample Results (cont'd)

Well Name/Sample Duration (hrs)	CCL4	C-DCE	CH4	CHCL3	PCE	TCA	TCE
VEW-23F							
0					5.3		1.9
3					3.3		1.3
4					3.1		1.2
22					4.8		1.9
24					4.6		2.0
VEW-24A							
0			377.5		0.8		
1			4.4		0.1		
2			459.2		0.9		
3			4.1		0.1		
4			522.8		1.6		
21			337.1		18.7		0.7
23			343.7		21.6		0.9
69		1.6	401.0		8.4		0.9
71		1.5	411.9		9.3		1.0
VEW-25A							
0		1.3	629.2		10.0		4.8
1			421.7		18.2		7.2
2			443.7		13.9		4.6
2.5			397.0		15.1		6.4
3			424.6		21.5		5.8
20			665.2		18.5		7.3
23			630.2		20.4		7.8
69			325.7		6.1		3.3
71			329.1		6.4		3.4
VEW-26F							
0					4.8		0.2
4			11.7		26.1		0.3
5			33.8		29.3		0.4
94			170.7		20.5		1.0
96			170.8		22.9		1.0
VEW-27A							
0			3.2		1.1		1.1
2			2.7		1.1		1.2
4			2.8		1.2		1.2
22			6.8		1.9		1.7
24			7.1		1.8		1.7

Complete List of Soil Gas Sample Results (cont'd)

Well Name/Sample Duration (hrs)	CCL4	C-DCE	CH4	CHCL3	PCE	TCA	TCE
VEW-28F							
0			436.3		6.5		1.2
2			198.9		2.6		0.7
4			223.0		4.5		1.0
21			185.7		6.6		1.1
23			170.9		4.5		0.9
VEW-29F							
0					17.9		1.8
1					16.6		1.6
3			3.2		15.1		1.5
21			5.7		45.8		1.3
23			6.4		43.2		1.2
26			13.0		59.6		1.3
27			13.9		54.9		1.1
45			26.4		39.6		0.8
46			27.3		44.0		0.8
VEW-30F							
0			4.4		4.4		0.7
3			3.7		38.9		1.0
4			3.9		48.7		1.2
22			3.3		33.9		1.2
23			3.1		34.5		1.2
Injection of Air at SIW-20D: 24			3.3		25.0		1.1
28			3.6		21.8		1.2
46			14.9		41.9		1.0
48			16.4		50.2		1.0
VEW-31F							
0					22.8		1.2
2					33.3		1.0
4					32.6		0.9
21					21.5		1.0
23					18.8		1.0
VEW-33F							
0					1.4		
2					4.6		
4					4.5		
21					0.8		
24					0.4		

Complete List of Soil Gas Sample Results (cont'd)

Well Name/Sample Duration (hrs)	CCL4	C-DCE	CH4	CHCL3	PCE	TCA	TCE
VEW-34F							
0			7.4		4.2		0.6
3			7.2		4.2		0.5
4			7.5		3.6		0.4
22			14.7		2.9		0.4
Injection of Air at SIW-23D: 24			18.4		4.1		0.4
26			16.4		3.3		0.4
27			16.3		3.3		0.4
94			15.5		4.0		0.7
95			15.7		4.1		0.7

Appendix B. Field Parameters

Note: Blank cells indicate data was not collected

Well Name	Date/Time	Wellhead Temp. (F)	Well Vac. (in. Hg)	Installed Flow (CFM)	Insert Flow (CFM)
VEW-01F	6/6/12 10:55	131	6.4		
VEW-01F	6/6/12 13:35	136	6		305
VEW-01F	6/6/12 14:55	136	6		
VEW-01F	6/7/12 7:35	135	7.5	228	
VEW-01F	6/7/12 10:00	138	7.3	440	
VEW-02A	6/6/12 11:15	141	4		
VEW-02A	6/6/12 13:25	146	5		360
VEW-02A	6/6/12 15:00	146	5.2		
VEW-02A	6/7/12 7:45	144	6		
VEW-02A	6/7/12 9:55	144	5.8	220	
VEW-02A	6/7/12 13:30	148	4.2		284
VEW-02A	6/7/12 14:50	148	4.2		
VEW-02A	6/8/12 8:05	158	4.9		
VEW-02A	6/8/12 10:05	146	4.2		
VEW-03A	6/6/12 11:30	147	6.2		
VEW-03A	6/6/12 13:15	141	5.8		210
VEW-03A	6/6/12 15:05	142	7		
VEW-03A	6/7/12 7:50	141	7.4		
VEW-03A	6/7/12 9:50	142	7.2		
VEW-04A	6/18/12 10:35	126	4.8	140	
VEW-04A	6/18/12 13:20	130	5.4	140	379
VEW-04A	6/18/12 15:00	130	5.4	140	
VEW-04A	6/19/12 8:25	128	6.2	138	
VEW-04A	6/19/12 10:40	130	6	124	402
VEW-04A	6/19/12 13:30	130	5.6	131	368
VEW-04A	6/19/12 14:55	130	5.8	128	
VEW-04A	6/19/12 15:05	138	7.6		
VEW-04A	6/20/12 10:55	131	5.2	157	
VEW-05A	6/13/12 9:55	145	5.8		
VEW-05A	6/13/12 11:25	150	5.4		214
VEW-05A	6/13/12 14:25	150	5.2		
VEW-05A	6/14/12 8:05	150	6		
VEW-05A	6/14/12 9:45	149	6.5		
VEW-05A	6/14/12 14:00	148	7.1		
VEW-05A	6/14/12 14:55	148	7.2		

Field Parameters (cont'd)

Well Name	Date/Time	Wellhead Temp. (F)	Well Vac. (in. Hg)	Installed Flow (CFM)	Insert Flow (CFM)
VEW-05A	6/18/12 7:55	147	7.7		
VEW-05A	6/18/12 10:20	146	7.6		282
VEW-06A	6/12/12 10:45	140	6		112
VEW-06A	6/12/12 14:10	143	6.1		
VEW-06A	6/12/12 14:50	143	6.1		
VEW-06A	6/13/12 7:55	143	6.8		103
VEW-06A	6/13/12 9:30	143	6.6		
VEW-06A	6/13/12 11:30	134	5		
VEW-06A	6/13/12 14:20	144	5.4		87
VEW-06A	6/14/12 8:10	142	6		97
VEW-07F	6/7/12 10:30	150	6.2		
VEW-07F	6/7/12 13:20	153	5.1	323	515
VEW-07F	6/7/12 15:00	153	5.1	321	
VEW-07F	6/8/12 7:45	151	5.8	365	
VEW-07F	6/8/12 10:15	151	5.6	340	
VEW-07F	6/8/12 13:10	151	4.8	275	456
VEW-07F	6/8/12 15:20	150	4.9	279	
VEW-07F	6/11/12 8:05	150	5.2	349	
VEW-07F	6/12/12 9:30	151	4.9	341	520
VEW-08A	6/7/12 10:40	144	5.6		
VEW-08A	6/7/12 13:10	151	4.8		88
VEW-08A	6/7/12 15:10	151	4.6		
VEW-08A	6/8/12 7:55	150	5		
VEW-08A	6/8/12 10:20	150	5.2		
VEW-09A	6/7/12 10:50	154	5		
VEW-09A	6/7/12 13:00	160	4.9		181
VEW-09A	6/7/12 15:20	160	4.9		
VEW-09A	6/8/12 8:00	160	5.1		
VEW-09A	6/8/12 10:25	155	4.6		
VEW-10A	6/8/12 10:40	126	5		
VEW-10A	6/8/12 13:05	130	5		151
VEW-10A	6/8/12 15:25	132	5		
VEW-10A	6/11/12 8:10	132	5.2		
VEW-10A	6/12/12 9:25	131	4.9		160
VEW-11F	6/8/12 10:45	138	4.8	180	
VEW-11F	6/8/12 13:00	144	4.8	150	500
VEW-11F	6/8/12 15:30	143	4.7	150	
VEW-11F	6/11/12 8:15	147	5.1	298	

Field Parameters (cont'd)

Well Name	Date/Time	Wellhead Temp. (F)	Well Vac. (in. Hg)	Installed Flow (CFM)	Insert Flow (CFM)
VEW-11F	6/12/12 9:20	148	5	293	485
VEW-12A	6/12/12 9:50	139	5.4	228	
VEW-12A	6/12/12 10:40	123	5.2	278	
VEW-12A	6/12/12 14:00	140	5.3	292	
VEW-12A	6/12/12 14:55	141	5.9	296	
VEW-12A	6/13/12 8:10	138	6.2		408
VEW-12A	6/13/12 9:25	138	6.2		
VEW-14A	6/12/12 13:50	150	3		over range
VEW-14A	6/12/12 15:00	150	3.3		
VEW-14A	6/13/12 8:15	150	5.6		124
VEW-14A	6/13/12 9:20	150	5.2		
VEW-15A	6/13/12 10:10	126	7.2	147	
VEW-15A	6/13/12 11:15	130	5.6	175	468
VEW-15A	6/13/12 14:35	131	5.8		
VEW-15A	6/14/12 8:15	130	6.3		
VEW-15A	6/14/12 9:40	128	6.8	170	504
VEW-17A	6/13/12 10:30	120	4.8	192	
VEW-17A	6/13/12 11:10	127	5.2	206	270
VEW-17A	6/13/12 14:40	128	5.2		
VEW-17A	6/14/12 8:25	128	5.8		
VEW-17A	6/14/12 9:35	128	6.3		325
VEW-18A	6/14/12 10:15	118	7.8		
VEW-18A	6/14/12 13:45	130	7		110
VEW-18A	6/14/12 15:05	130	7		
VEW-18A	6/18/12 8:15	127	7.5		
VEW-18A	6/18/12 10:00	129	7.2		81
VEW-19A	6/14/12 10:20	96	7.2		
VEW-19A	6/14/12 13:40	107	7.2		4
VEW-19A	6/14/12 15:10	108	7.2		
VEW-19A	6/18/12 8:10	80	8		
VEW-19A	6/18/12 10:05	100	7.6		4
VEW-20F	6/18/12 10:50	102	5	305	
VEW-20F	6/18/12 13:00	102	5.6	305	over range
VEW-20F	6/18/12 15:20	104	5.6	302	
VEW-20F	6/19/12 8:05	104	6	339	
VEW-20F	6/19/12 10:55	104	5.8	312	over range
VEW-21F	6/20/12 11:25	120	4.3		
VEW-21F	6/20/12 13:15	125	3.8		

Field Parameters (cont'd)

Well Name	Date/Time	Wellhead Temp. (F)	Well Vac. (in. Hg)	Installed Flow (CFM)	Insert Flow (CFM)
VEW-21F	6/20/12 14:50	128	3.8		
VEW-21F	6/21/12 8:10	128	4.4		
VEW-21F	6/21/12 9:55	128	4.2		
VEW-22A	6/19/12 11:20	84	2.8		
VEW-22A	6/19/12 13:15	100	4.8		238
VEW-22A	6/19/12 15:16	98	4.2		
VEW-22A	6/20/12 8:00	72	6		
VEW-22A	6/20/12 11:10	80	7.8		
VEW-23F	6/21/12 10:35	94	10.2		
VEW-23F	6/21/12 13:40	101	4.6		
VEW-23F	6/21/12 14:30	102	4.8		
VEW-23F	6/22/12 8:05	103	5.1		
VEW-23F	6/22/12 10:40	104	3		
VEW-24A	6/5/12 11:10	104	6	145	
VEW-24A	6/25/12 10:05	116	7.2	135	349
VEW-24A	6/5/12 13:30	119	5.8	148.8	205
VEW-24A	6/5/12 15:20	120	5.5	142	
VEW-24A	6/6/12 8:10	117	5.9	126	
VEW-24A	6/6/12 10:25	118	6	122	177
VEW-24A	6/22/12 11:10	115	4.4	136	
VEW-24A	6/22/12 12:55	118	6.8	160	427.6
VEW-24A	6/22/12 14:25	119	6.4	159	
VEW-24A	6/25/12 7:55	116	7.4	136	
VEW-25A	6/5/12 11:45	130	5	320	
VEW-25A	6/25/12 10:10	136	6.6	410	over range
VEW-25A	6/5/12 14:00	140	5.2	332	over range
VEW-25A	6/5/12 15:00	139	5.1	322	
VEW-25A	6/6/12 7:45	137	5.4	351	
VEW-25A	6/6/12 10:40	137	5.2	361	
VEW-25A	6/22/12 11:00	134	5		
VEW-25A	6/22/12 13:00	135	6	358	1116
VEW-25A	6/22/12 14:15	136	5.8	351	
VEW-25A	6/25/12 8:05	134	6.8	421	
VEW-26F	6/14/12 10:10	134	7		
VEW-26F	6/14/12 13:50	143	7.2		61
VEW-26F	6/14/12 15:00	144	7.2		
VEW-26F	6/18/12 8:05	141	7.9		

Field Parameters (cont'd)

Well Name	Date/Time	Wellhead Temp. (F)	Well Vac. (in. Hg)	Installed Flow (CFM)	Insert Flow (CFM)
VEW-26F	6/18/12 10:10	140	7.6		240
VEW-27A	6/18/12 10:45	106	5	0	
VEW-27A	6/18/12 13:10	116	5.7	0	5
VEW-27A	6/18/12 15:10	116	5.6	0	
VEW-27A	6/19/12 8:15	88	6.7	0	
VEW-27A	6/19/12 10:50	100	6.2	0	5.2
VEW-28F	6/5/12 11:25	140	5		
VEW-28F	6/5/12 13:45	148	5		340
VEW-28F	6/5/12 15:10	150	4.9		
VEW-28F	6/6/12 8:00	149	5		
VEW-28F	6/6/12 10:30	148	4.2		375
VEW-29F	6/19/12 11:35	128	4.8		
VEW-29F	6/19/12 13:00	138	5.8		
VEW-29F	6/19/12 15:05	140	6.2		
VEW-29F	6/20/12 8:30	140	7.4	100	
VEW-29F	6/20/12 10:30	140	7.2		
VEW-29F	6/20/12 13:30	140	4.1		
VEW-29F	6/20/12 14:30	140	4.2		
VEW-29F	6/21/12 8:30	141	4.7		
VEW-29F	6/21/12 9:35	142	4.6		
VEW-30F	6/20/12 10:40	139	5		
VEW-30F	6/20/12 13:25	140	3.7		145
VEW-30F	6/20/12 14:35	140	3.8		
VEW-30F	6/21/12 8:20	142	4		
VEW-30F	6/21/12 9:45	142	3.9		159
VEW-30F	6/21/12 10:55	142	5		
VEW-30F	6/21/12 14:45	142	5		
VEW-30F	6/22/12 8:25	140	5.2		
VEW-30F	6/22/12 10:20	142	5.2		230
VEW-31F	6/21/12 11:05	104	4.2		
VEW-31F	6/21/12 13:20	109	4.5		
VEW-31F	6/21/12 14:50	108	4.6		
VEW-31F	6/22/12 8:35	104	5		
VEW-31F	6/22/12 10:10	108	4.8		
VEW-33F	6/19/12 11:25	88	2.8		
VEW-33F	6/19/12 13:20	90	4		82
VEW-33F	6/19/12 15:10	92	4		
VEW-33F	6/20/12 8:05	81	6.2		

Field Parameters (cont'd)

Well Name	Date/Time	Wellhead Temp. (F)	Well Vac. (in. Hg)	Installed Flow (CFM)	Insert Flow (CFM)
VEW-33F	6/20/12 11:05	90	7.2		
VEW-34F	6/21/12 10:45	94	5		
VEW-34F	6/21/12 13:30	104	4.8		81
VEW-34F	6/21/12 14:40	101	4.6		
VEW-34F	6/22/12 8:20	97	5.2		
VEW-34F	6/22/12 10:30	98	5		
VEW-34F	6/22/12 13:15	104	6		76
VEW-34F	6/22/12 14:05	104	5.8		
VEW-34F	6/25/12 8:15	98	7.4		
VEW-34F	6/25/12 9:55	98	7.3		101