

Notes: Pie chart diameters are relative to total load.

Figure 184. Relative Average Annual Total U Loads from Former IA Drainages and WWTP

3.1.5 Groundwater Data Interpretation and Evaluation

This section provides a summary of groundwater monitoring performed in 2014. A discussion of groundwater conditions during 2014, focusing on the most important water-quality aspects in the areas of interest (i.e., the main contaminant plumes), is then presented.

3.1.5.1 RFLMA Groundwater Monitoring Activities of 2014

Routine activities of the groundwater monitoring program in 2014 included sample collection, water-level measurement, groundwater treatment system maintenance, and well maintenance. “Groundwater” monitoring also includes monitoring activities at several surface-water locations, as well as at some locations that may not clearly belong to either category. (Examples of the former include Surface Water Support location SW018 and treatment system-related performance monitoring locations; examples of the latter include locations monitoring effluent from a treatment system before it is discharged.) However, because all of these locations support

groundwater monitoring objectives, the data collected from them in support of these objectives are included as part of the groundwater discussion.

Special, non-RFLMA monitoring (i.e., monitoring not required by the RFLMA) was also performed in 2014 to support various objectives. This is summarized in Section 3.1.5.2. The majority of this monitoring focused on the MSPTS, ETPTS, and SPPTS. Validated analytical data and other information generated via RFLMA (i.e., routine) and non-RFLMA (i.e., nonroutine) sampling have been reported in the corresponding quarterly reports for 2014 (DOE 2014d, 2014e, 2015) and are included in Appendix B for the fourth quarter of CY 2014. Unvalidated data are not reported but are summarized in this document.

There was one change to the network of groundwater monitoring locations during 2014. During the second quarter, the subsurface PVC well casing of Sentinel well 88104 was found to be kinked at a depth of approximately 10 feet below ground surface, and the well began to fill with sand (filter pack from the annulus) that entered through the breached casing. As this well is redundant (because Evaluation well 88205 is upgradient and also monitors former B881, and Sentinel well 00797 is downgradient and has the same objectives), discussions with the regulators led to the conclusion that well 88104 could be deleted from the network. This discussion is summarized in Contact Record 2014-07. The samples collected in the second quarter of 2014 are the last to be collected from this well. (Associated data were included in the corresponding quarterly report [DOE 2014e].)

The groundwater monitoring network set forth in RFLMA is subdivided and categorized as shown in Table 70.

Table 70. RFLMA Monitoring Classifications for the Groundwater Monitoring Network

Well Classification^a	General Objective	Number of Wells^{a,b}	Monitoring Frequency
AOC	Monitor groundwater quality and water levels in a drainage downgradient of a contaminant plume or group of plumes	9	Semiannual (2x/year)
Sentinel	Monitor groundwater quality and water levels near contaminant plume edges and in drainages	27	Semiannual (2x/year)
Evaluation	Monitor groundwater quality and water levels in or near contaminant source areas and in the former IA	42	Biennial (1x/every 2 years)
RCRA	Monitor groundwater quality and water levels upgradient and downgradient of the PLF and the OLF	10	Quarterly (4x/year)
Treatment System ^{c,d}	Monitor quality of groundwater treatment system influent, effluent, and downgradient surface water	9	Semiannual (2x/year)
Surface-Water Support ^c	Monitor quality of surface water downgradient of contaminant plume	1	Semiannual (2x/year)

Notes:

^a Locations are referred to as “wells” for convenience even if they do not represent wells, as is the case with treatment system and surface water locations.

^b The numbers of locations listed were current as of the end of 2014.

^c Treatment system and surface-water support locations are not monitoring wells but are included for completeness.

^d Locations associated with the PLFTS are discussed separately.

Table 71 presents the full 2014 schedule for RFLMA-required groundwater sample collection, a subset of which is summarized in Table 72 as those scheduled samples that were not successfully collected (e.g., due to dry conditions). Corresponding analytical results are published in the associated quarterly reports (DOE 2014d, 2014e, 2015) and Appendix B.

Table 71. Summary of Scheduled RFLMA-Required Groundwater Sampling in CY 2014 (by Quarter)

Area	Classification or Type	Location ID	Analytes					
			VOCs	U	Nitrate	Metals	Pu/Am	SVOCs
Present Landfill	RCRA	70193	1,2,3,4			1,2,3,4		
	RCRA	70393	1,2,3,4			1,2,3,4		
	RCRA	70693	1,2,3,4			1,2,3,4		
	RCRA	73005	1,2,3,4			1,2,3,4		
	RCRA	73105	1,2,3,4			1,2,3,4		
	RCRA	73205	1,2,3,4			1,2,3,4		
	AOC	4087	2,4	2,4	2,4			
	AOC	B206989	2,4	2,4	2,4			
Original Landfill	RCRA	P416589	1,2,3,4			1,2,3,4		1,2,3,4
	RCRA	80005	1,2,3,4			1,2,3,4		1,2,3,4
	RCRA	80105	1,2,3,4			1,2,3,4		1,2,3,4
	RCRA	80205	1,2,3,4			1,2,3,4		1,2,3,4
	AOC	11104	2,4	2,4				
MSPTS	E	00897	2					
	S	15699	2,4					
	TS	MOUND R1-0	2,4					
	TS	MOUND R2-E	2,4					
	TS	GS10	2,4					
ETPTS	E	3687	2					
	E	05691	2					
	E	03991	2					
	S	04091	2,4					
	S	95099	2,4					
	S	95199	2,4					
	S	95299	2,4					
	S	23296	2,4	2,4				
	TS	ET INFLUENT	2,4					
	TS	ET EFFLUENT	2,4					
TS	POM2	2,4						
SPPTS	E	P210189	2	2	2			
	E	79102	2	2	2			
	E	79202	2	2	2			
	E	P208989	2	2	2			
	E	79302		2	2			
	E	79402		2	2			
	E	79502		2	2			
	E	79605		2	2			
	E	00203	2	2	2			
	E	22205	2	2	2			
	S	P210089	2,4	2,4	2,4			
	S	70099		2,4	2,4			
	TS	SPIN		2,4	2,4			
	TS	SPOUT		2,4	2,4			
	TS	GS13		2,4	2,4			
	E	B210489		2	2			
E	51605		2	2				

Table 71 (continued). Summary of Scheduled RFLMA-Required Groundwater Sampling in CY 2014
(by Quarter)

Area	Classification or Type	Location ID	Analytes					
			VOCs	U	Nitrate	Metals	Pu/Am	SVOCs
Drainages Below Impacted Areas	AOC	10594	2,4	2,4	2,4			
	AOC	00997	2,4	2,4	2,4			
	AOC	00193	2,4	2,4				
Former B371/374	S	37405	2,4	2,4	2,4		2,4	
	S	37505	2,4	2,4	2,4			
	S	37705	2,4	2,4	2,4		2,4	
Former B771/774	S	20205	2,4	2,4			2,4	
	S	20505	2,4	2,4			2,4	
	S	20705	2,4	2,4	2,4		2,4	
Former North-Central IA	E	P114689	2					
	E	P115589	2					
	E	70705	2	2				
	E	33905	2					
	E	21505	2					
	S	52505	2,4					
	E	20902	2					
Former B559	AOC	42505	2,4					
	E	55905	2	2	2			
Former IHSS 118.1	E	56305	2	2	2			
	E	18199	2					
Former B444 Complex	SS	SW018	2,4					
	E	40005	2	2				
	E	40205	2	2				
	E	P419689	2	2				
	E	P416889	2	2				
	S	11502	2,4	2,4				
Former B881	S	40305	2,4	2,4				
	E	88205	2	2				
	S	00797	2,4	2,4				
Former B886	S	88104	2	2				
	E	22996	2	2				
Former B991	S	99305	2,4	2,4	2,4			
	S	99405	2,4	2,4	2,4			
	S	91305	2,4	2,4	2,4			
Former Oil Burn Pit No. 1	E	33502	2					
	E	33604	2					
	S	33711	2,4					
Former Oil Burn Pit No. 2	E	91105	2					
	S	91203	2,4					
Former SW056	S	45608	2,4					
OU 1 Plume	E	891WEL	2					
	AOC	89104	2,4					

Table 71 (continued). Summary of Scheduled RFLMA-Required Groundwater Sampling in CY 2014
(by Quarter)

Area	Classification or Type	Location ID	Analytes					
			VOCs	U	Nitrate	Metals	Pu/Am	SVOCs
903 Pad/Ryan's Pit Plume	E	00191	2					
	E	50299	2					
	E	90402	2					
	E	00491	2					
	E	07391	2	2				
	E	90804	2					
	S	90299	2,4					
	S	90399	2,4					
	AOC	10304	2,4	2,4	2,4			
PU&D Yard Plume	E	30900	2					
	S	30002	2,4					

Notes: In an analyte column, a numeral (e.g., 2) indicates the 2014 quarter in which sampling of that analyte was requested. If a cell in an analyte column is blank, sampling of that analyte was not requested.

Abbreviations:

ID = Identification (name) of well/sampling location

Location classifications: AOC = Area of Concern, E = Evaluation, RCRA = Resource Conservation and Recovery Act, S = Sentinel, SS = Surface Water Support, TS = Treatment System. (All but SS and TS are groundwater monitoring wells.)

SVOCs = semivolatile organic compounds.

Table 72. Summary of RFLMA-Required Groundwater Samples Not Successfully Collected in 2014
(by Quarter)

Location		Analytes						Comments
ID	Classification	VOCs	U	Nitrate	Metals	Pu/Am	SVOCs	
95299	S	2, 4						Dry well

Notes: In an analyte column, a numeral (e.g., 2) indicates the 2014 quarter in which sampling of that analyte was requested. If a cell in an analyte column is blank, sampling of that analyte was not requested.

3.1.5.2 Additional Groundwater Monitoring Activities of 2014

Groundwater monitoring beyond that required by the RFLMA (i.e., nonroutine monitoring) was performed in 2014 in support of several data needs. This is occasionally referred to as “non-RFLMA-required” monitoring, and generally falls within the following two categories:

- Investigative sampling
- Performance sampling

Table 73 summarizes the extra/nonroutine groundwater sample collection performed in 2014. In addition to this summary of the nonroutine sampling, additional monitoring was performed through the sitewide measurement of water levels as discussed in Section 3.1.3.

As in recent years, much of the extra monitoring performed in 2014 was focused on the SPPTS. Most of the additional analytical data collected for the SPPTS were generated by an in-house laboratory and cannot be validated. This topic is discussed in Section 3.1.2.8.

Table 73. Summary of Non-RFLMA-Required Groundwater Samples Collected in CY 2014 (by Quarter)

Area	Location ID	Analytes ^a													
		VOCs	U	Nitrate	Nitrites	NH3-N	NH3/NH4	U isotopes	SO4	TOC	Ca	Fe	DN-BART	Other	
SPPTS ^b	SPIN		1(10), 2(6), 3(8), 4(5)	1(6), 2(8), 3(8), 4(5)	1(3), 2(5)		2(5)			1, 2					
	SPOUT		1(7), 2(8), 3(9), 4(5)	1(7), 2(8), 3(9), 4(5)	3					1			P: 1(2), 2(4), 3(3), 4(3)		
	SPZE			1(10), 2(13), 3(11), 4(9)	1(10), 2(13), 3(11), 4(9)		1(10), 2(13), 3(11), 4(9)		2(9), 3(11), 4(9)	1(10), 2(13), 3(11), 4(9)	3(11), 4(9)	3(11), 4(9)	1(11), 2(3)		
	ITSE		1	1						1					
	ITSW		1	1						1					
	SPPDISCHARGE GALLERY		2, 4	2, 4											
	GS13		1(6), 2(7), 3(7), 4(5)	1(7), 2(7), 3(7), 4(5)										Hardness: 1(6), 2(4) Alk-Tot, TDS: 1(6), 2(4)	
	Lagoon Testing														
	SPCAE				1(16), 2(20), 3(19), 4(16)	1(10), 2(13), 3(13), 4(9)	1(10), 2(14), 3(13), 4(9)	1(10), 2(13), 3(13), 4(9)		2(10), 3(13), 4(9)	1(10), 2(19), 3(14), 4(9)	3(13), 4(9)	3(13), 4(9)	1(11), 2(3)	P: 1(3), 2(4), 3(3), 4(4) TSS: 3(9), 4(9) DOC: 1(10), 2(19), 3(14), 4(9)
	SPCAMID				1(10), 2(13), 3(13), 4(9)	1(10), 2(13), 3(13), 4(9)	1(11), 2(14), 3(13), 4(9)	1(10), 2(13), 3(13), 4(9)			1(10), 2(13), 3(13), 4(9)			1(11), 2(3)	
	SPCABOT				1(10), 2(13)	1(10), 2(13)	1(11), 2(14)	1(10), 2(13)			1(10), 2(19)			1(11), 2(3)	
	SPCBE				1(16), 2(20), 3(19), 4(16)	1(10), 2(13), 3(13), 4(9)	1(11), 2(14), 3(13), 4(9)	1(10), 2(13), 3(13), 4(9)		3(13), 4(9)	1(10), 2(19), 3(14), 4(9)	3(13), 4(9)	3(13), 4(9)	1(11), 2(3)	P: 1(3), 2(4), 3(3), 4(4) TSS: 3(9), 4(9) DOC: 1(10), 2(6), 3(14), 4(9)
	SPCBMID				1(10), 2(13), 3(13), 4(9)	1(10), 2(13), 3(13), 4(9)	1(11), 2(14), 3(13), 4(9)	1(10), 2(13), 3(13), 4(9)			1(10), 2(13), 3(13), 4(9)			1(11), 2(3)	
	SPCBBOT				1(10), 2(13)	1(10), 2(13)	1(11), 2(14)	1(10), 2(13)			1(10), 2(19)			1(11), 2(3)	
	Bench Test ^c			3	3	3		3		3	3	3	3		TSS: 3 DOC: 3
	ZVI Microcell Testing														
		MICROCELLZVI2H		1(3)											
		MICROCELLZVI2I		1(13)											
		MICROCELLZVI2J		1(10)											
		MICROCELLZVI2K		1(21)											
	MICROCELLZVI2M		2(7)												
	MICROCELLZVI2N		2(15)												
	MICROCELLZVI2P		3(26)												
	MICROCELLZVI2Q		3(23)												
	MICROCELLZVI2R		4(16)												
	MICROCELLZVI2S		4(5)												
	MICROCELLZVI2T		4(13)												
	MICROCELLZVI2U		4(3)												

Table 73 (continued). Summary of Non-RFLMA-Required Groundwater Samples Collected in CY 2014 (by Quarter)

Area	Location ID	Analytes ^a												
		VOCs	U	Nitrate	Nitrites	NH3-N	NH3/NH4	U isotopes	SO4	TOC	Ca	Fe	DN-BART	Other
ETPTS	ET EFFLUENT	1(1), 3	2											
	ET INFLUENT	1(1), 3	2											
	ETASEF	1, 2, 3												
	ETASH													
MSPTS	ASHINF	1(2), 2(3), 4												
	MOUND R1-0	1(2), 2(2)												
	MOUND R2-E	1(2), 2(2)												
	MOUND-FD	1(2), 2(3)												
	GS10	2, 4	1(6), 2(7), 3(7), 4(5)					2, 3, 4						Hardness: 1(6) Alk-Tot, TDS: 1(6), 2(4)
U Geochemistry Evaluation	GEOA1								2(2)			2(2)		H2S: 2(2)
	GEOA1INF			1(6), 2(7), 3(7), 4(4)					2(2)			2(2)		H2S: 2(2)
	GEOA3EFF								2(2)			2(2)		H2S: 2(2)
	GEOA3INF								2(2)			2(2)		H2S: 2(2)
	GEOB1INF								2(2)			2(2)		H2S: 2(2)
	GEOB4								2			2		H2S: 2
	GEOB5INF								2(2)			2(2)		H2S: 2(2)

Notes:

^a In an analyte column, a numeral (e.g., 2) indicates the 2014 quarter in which sampling of that analyte was requested. If a cell in an analyte column is blank, sampling of that analyte was not requested. For those locations where more than one non-RFLMA-required sample was collected in the indicated quarter(s), the total number of non-RFLMA-required samples collected is indicated in parentheses.

^b The Solar Ponds Plume Discharge Gallery (SPPDischargeGallery) is sampled in accordance with the RFSOG (DOE 2013b). Locations SPIN, SPOUT, SPCAE, SPZE, SPCAMID, SPCABOT, SPCBMID, and SPCBBOT are associated with various SPPTS components and were sampled to support ongoing testing. Similarly, all locations with location IDs starting with "MICROCELL" are associated with ongoing microcell tests.

^c Refer to text on lagoon tests for information and discussion on this bench test.

Abbreviations:

- Alk-Tot = total alkalinity
- Ca = calcium
- DOC = dissolved organic carbon
- Fe = iron
- H₂S = hydrogen sulfide
- ID = Identification (name) of well/sampling location
- NH₃-N = ammonia (as nitrogen)
- NH₃ = ammonia
- P = phosphorous
- Pu/Am = plutonium/ameridium
- SO₄ = sulfate
- TDS = total dissolved solids
- TOC = total organic carbon
- TSS = total suspended solids
- DN-BART = test for presence of denitrifying bacteria

Monitoring beyond RFLMA requirements was also performed in 2014 for the MSPTS and ETPTS air strippers. Most of these samples were submitted to contract laboratories and validated as if they were RFLMA data; a few samples from the ETPTS were analyzed by the in-house laboratory for evaluations of water hardness. These contract-lab data have been reported in previous quarterly and annual reports, but are summarized and discussed at greater length in the text focusing on those groundwater treatment systems in the next section.

Unlike 2013, no extra samples were collected from monitoring wells in 2014. This is because as an even-numbered year, all wells were scheduled for sampling this year. This was not the case in 2013, when no Evaluation wells were scheduled for routine monitoring but several were visited due to the relatively wet conditions that year.

3.1.5.3 Groundwater at the Rocky Flats Site: Discussion and Interpretations

This section presents a summary evaluation of groundwater quality at the Site during 2014, and it also provides descriptions of special studies and activities. Included in the discussion of water quality are descriptions of the behavior of and any notable activities at the groundwater treatment systems during 2014.

Groundwater quality data were obtained for all monitored areas in 2014. Analytical data have been published in quarterly reports issued for 2014 (DOE 2014d, 2014e, 2015), plus Appendix B, and will not be duplicated here.

Groundwater quality at the Site in 2014 was largely consistent with data reported in prior years. Generally speaking, groundwater quality within plumes that were identified and characterized through the decades of pre-closure groundwater monitoring at the Site has not changed much over the years since the Site was closed.

Trend Plots

Numerous statistical calculations were completed for this report in accordance with the RFLMA using analytical data collected from Sentinel and RCRA wells (see Sections 3.1.2.6 and 3.1.2.7 for discussion of RCRA wells). In addition, statistical calculations were performed for selected AOC wells and constituents, as well as Evaluation wells and selected treatment system locations. The statistical trending performed for upgradient RCRA wells, selected AOC wells and constituents, and groundwater treatment system locations is not required by the RFLMA but was completed for information purposes. Trend plots and corresponding summary tables are presented in Appendix B. In addition to these statistical trend plots, many time-series plots were prepared and are included in this report.

The Sanitas software package (version 9.4.32; Sanitas Technologies 2013) was used for statistical calculations, including ANOVA analyses and construction of statistical trend plots. (This is noted for the purpose of completeness only; this report does not make software recommendations.) For simplicity, trend calculations performed for all wells (except for RCRA wells) assign the given well a downgradient position. This is appropriate because the fundamental objective of the non-RCRA wells is related to detection monitoring or the exit strategy. No interwell statistics were planned for these other classes of wells; instead, only intrawell assessments of the trend of analyte concentrations over time are performed for each given well. Therefore, only RCRA wells were assigned either upgradient or downgradient

positions to support the related statistical evaluations, as described in Section 3.1.2.6 and Section 3.1.2.7.

Analytical data are handled as described in Section 3.1.1.2. Trends for wells sampled more than once a year are calculated and plotted using the S-K statistical method. This method was identified as most appropriate for Rocky Flats groundwater data after tests of various statistical methods (K-H 2004a), and therefore is specified in the RFSOG (DOE 2013b). Trends calculated for wells that are sampled less than twice per year (which removes aspects of seasonality) employ the Mann-Kendall (M-K) statistical method. S-K trends are plotted only where they are calculated to be at least 80 percent significant, and M-K trends are plotted only where they are calculated to be at least 95 percent significant.

A summary of these trends for 2014 is provided in Table 74. Only increasing and decreasing trends calculated to be at least 80 percent significant using the S-K test (or, for Evaluation wells, at least 95 percent significant using the M-K test) are included in this table. Therefore, trends with zero slope are not included, even if they are 95 percent significant. Monitoring well classifications that require statistical evaluation of concentration trends according to RFLMA (i.e., Sentinel, Evaluation, and downgradient RCRA wells) are included. In addition, trend calculations for upgradient RCRA wells, selected AOC wells and constituents, and influent to the MSPTS, ETPTS, and SPPTS are also included though they are not required. Refer to Appendix B for the trend plots and associated summary tables, and refer to Figure 2 for well locations. Significant trends for selected analytes and locations are discussed later in this section in the context of their respective groundwater contaminant plumes.

Table 74. Summary of Statistical Trend Calculations Through 2014 by Location

Well	Analyte	Trend	Significant at 95%?
Sentinel Wells			
00797	Uranium	Increasing	Yes
04091	Carbon tetrachloride	Decreasing	Yes ^c
11502	PCE	Decreasing	Yes
15699	1,1-DCE	Decreasing	Yes
	Chloroform	Decreasing	Yes ^c
	PCE	Decreasing	Yes
	TCE	Decreasing	Yes
	<i>trans</i> -1,2-DCE	Increasing	Yes ^c
	Vinyl chloride	Increasing	Yes ^c
20205	PCE	Increasing	No ^c
	Uranium	Increasing	Yes
20505	<i>cis</i> -1,2-DCE	Decreasing	Yes
	TCE	Decreasing	Yes
	Uranium	Decreasing	Yes
20705	Am-241	Decreasing	Yes ^{c,d,e}
	<i>cis</i> -1,2-DCE	Increasing	Yes ^b
	Uranium	Increasing	Yes
	Vinyl chloride	Increasing	No ^c

Table 74 (continued). Summary of Statistical Trend Calculations Through 2014 by Location

Well	Analyte	Trend	Significant at 95%?
23296	1,1-DCE	Increasing	Yes ^c
	Carbon tetrachloride	Decreasing	Yes ^c
	<i>cis</i> -1,2-DCE	Increasing	Yes
	Uranium	Decreasing	Yes
	Vinyl chloride	Increasing	Yes ^c
33711	Chlorobenzene	Decreasing	Yes ^d
	<i>cis</i> -1,2-DCE	Increasing	Yes
	<i>trans</i> -1,2-DCE	Increasing	Yes ^c
	Vinyl chloride	Increasing	Yes ^{c,d}
37405	Nitrate	Increasing	Yes
	Uranium	Decreasing	Yes ^d
37505	Uranium	Increasing	Yes
37705	Uranium	Decreasing	No
40305	<i>cis</i> -1,2-DCE	Decreasing	No ^c
	Uranium	Increasing	No
45608	1,1-DCE	Decreasing	No
	<i>cis</i> -1,2-DCE	Decreasing	Yes ^b
	PCE	Decreasing	Yes ^b
	TCE	Decreasing	Yes ^a
	<i>trans</i> -1,2-DCE	Decreasing	Yes
	Vinyl chloride	Decreasing	Yes
52505	<i>cis</i> -1,2-DCE	Increasing	Yes ^c
70099	Nitrate	Decreasing	Yes
88104	Uranium	Increasing	Yes ^b
90299	Carbon tetrachloride	Decreasing	Yes ^c
	Chloroform	Decreasing	Yes
	TCE	Decreasing	Yes
90399	1,1-DCE	Increasing	No
	<i>cis</i> -1,2-DCE	Increasing	Yes
	PCE	Increasing	Yes
	TCE	Increasing	Yes
91203	1,1,1-TCA	Increasing	Yes ^{b,c}
	1,1-DCE	Increasing	Yes
	<i>cis</i> -1,2-DCE	Increasing	Yes
	PCE	Increasing	Yes ^b
	TCE	Increasing	Yes ^b
91305	<i>cis</i> -1,2-DCE	Decreasing	Yes
	Uranium	Decreasing	Yes
95199	1,1-DCE	Increasing	Yes
	<i>cis</i> -1,2-DCE	Increasing	Yes
	PCE	Increasing	Yes
	TCE	Increasing	Yes
99305	<i>cis</i> -1,2-DCE	Increasing	Yes
	PCE	Increasing	Yes ^d
	TCE	Increasing	Yes ^d
	<i>trans</i> -1,2-DCE	Increasing	Yes ^{a,c}
	Uranium	Increasing	Yes ^{b,d}
99405	<i>cis</i> -1,2-DCE	Increasing	No
	Uranium	Decreasing	Yes ^d

Table 74 (continued). Summary of Statistical Trend Calculations Through 2014 by Location

Well	Analyte	Trend	Significant at 95%?
P210089	Nitrate	Increasing	Yes
	Uranium	Increasing	Yes
RCRA Wells			
70193	Boron	Increasing	Yes ^b
70393	1,1,1-TCA	Decreasing	Yes
	1,1-DCE	Decreasing	Yes
	PCE	Decreasing	Yes
	TCE	Decreasing	Yes
70693	1,1,1-TCA	Decreasing	Yes
	1,1-DCE	Decreasing	Yes
	Boron	Increasing	Yes ^b
	Carbon tetrachloride	Decreasing	Yes ^c
	Chloroform	Decreasing	Yes ^c
	PCE	Decreasing	Yes
73005	TCE	Decreasing	Yes
	Boron	Increasing	Yes
	Chromium	Increasing	Yes ^c
73105	Uranium	Increasing	Yes ^b
	Boron	Increasing	Yes
73205	Nickel	Increasing	Yes ^c
	Boron	Increasing	No
80005	Nickel	Increasing	Yes ^{b,c}
	Boron	Decreasing	Yes
80105	Uranium	Increasing	Yes ^{b,c}
	Uranium	Decreasing	No
80205	Boron	Increasing	Yes
	Nickel	Increasing	Yes ^{b,c}
	Uranium	Decreasing	Yes
P416589	Boron	Increasing	No ^c
	Uranium	Increasing	No ^c
Evaluation Wells			
00191	1,1-DCE	Decreasing	Yes ^f
00491	Chloroform	Decreasing	Yes
	TCE	Decreasing	Yes ^f
00897	PCE	Decreasing	Yes ^f
	TCE	Decreasing	Yes
03991	Carbon tetrachloride	Decreasing	Yes
	Chloroform	Decreasing	Yes ^c
	PCE	Decreasing	Yes
	TCE	Decreasing	Yes
05691	Carbon tetrachloride	Decreasing	Yes
	Chloroform	Decreasing	Yes
	cis-1,2-DCE	Decreasing	Yes
	PCE	Decreasing	Yes
	TCE	Decreasing	Yes
07391	Chloroform	Decreasing	Yes
	cis-1,2-DCE	Increasing	Yes ^c
	Uranium	Decreasing	Yes

Table 74 (continued). Summary of Statistical Trend Calculations Through 2014 by Location

Well	Analyte	Trend	Significant at 95%?
3687	1,1-DCE	Increasing	Yes ^f
	<i>cis</i> -1,2-DCE	Increasing	Yes
18199	Carbon tetrachloride	Decreasing	Yes
	Chloroform	Decreasing	Yes
	PCE	Decreasing	Yes
21505	PCE	Decreasing	Yes ^d
	TCE	Decreasing	Yes ^d
22205	Nitrate	Increasing	Yes
30900	1,1,1-TCA	Decreasing	Yes ^c
	<i>cis</i> -1,2-DCE	Increasing	Yes
	PCE	Decreasing	Yes ^f
33502	1,2,4-TCB	Decreasing	Yes ^c
33604	PCE	Decreasing	Yes ^d
	TCE	Decreasing	Yes ^d
33905	1,1-DCE	Decreasing	Yes ^{d,t}
	PCE	Decreasing	Yes ^{d,f}
40005	TCE	Increasing	Yes ^{d,f}
	Uranium	Increasing	Yes
40205	1,1-DCE	Decreasing	Yes
	<i>cis</i> -1,2-DCE	Decreasing	Yes
	PCE	Decreasing	Yes ^d
50299	<i>cis</i> -1,2-DCE	Decreasing	Yes ^f
55905	PCE	Increasing	Yes ^{d,f}
56305	PCE	Increasing	Yes ^d
	TCE	Increasing	Yes ^{d,f}
70705	Carbon tetrachloride	Increasing	Yes ^{c,d,f}
	Chloroform	Increasing	Yes ^{c,d}
	<i>cis</i> -1,2-DCE	Increasing	Yes ^{c,d,f}
	PCE	Increasing	Yes ^{c,d}
	TCE	Increasing	Yes ^{c,d,t}
	Uranium	Increasing	Yes ^{d,f}
79202	Carbon tetrachloride	Decreasing	Yes
	Chloroform	Decreasing	Yes
	PCE	Decreasing	Yes
	TCE	Decreasing	Yes
	Uranium	Increasing	Yes
79302	Nitrate	Increasing	Yes
	Uranium	Increasing	Yes
79502	Nitrate	Decreasing	Yes
	Uranium	Decreasing	Yes
79602	Uranium	Increasing	Yes ^{d,f}
88205	Toluene	Increasing	Yes ^{c,t}
	Total Xylenes	Increasing	Yes ^{c,d}
	TCE	Increasing	Yes ^{c,d,f}
	Uranium	Decreasing	Yes ^{c,d,t}
891WEL	Chloroform	Increasing	Yes
	<i>cis</i> -1,2-DCE	Increasing	Yes ^c
	TCE	Decreasing	Yes ^f

Table 74 (continued). Summary of Statistical Trend Calculations Through 2014 by Location

Well	Analyte	Trend	Significant at 95%?
91105	1,1,1-TCA	Decreasing	Yes
	<i>cis</i> -1,2-DCE	Decreasing	Yes
	TCE	Increasing	Yes
P114689	Carbon tetrachloride	Decreasing	Yes
	PCE	Increasing	Yes ^f
	TCE	Increasing	Yes
P115589	1,1,1-TCA	Decreasing	Yes ^{c,f}
	1,1,2-TCA	Decreasing	Yes ^{c,f}
	1,1-DCE	Decreasing	Yes ^f
	<i>cis</i> -1,2-DCE	Decreasing	Yes ^f
	TCE	Decreasing	Yes ^f
	Vinyl chloride	Decreasing	Yes ^{c,t}
P208989	Chloroform	Increasing	Yes ^c
	Nitrate	Decreasing	Yes ^f
	TCE	Increasing	Yes ^c
P210189	Carbon tetrachloride	Decreasing	Yes
	Chloroform	Decreasing	Yes
	<i>cis</i> -1,2-DCE	Decreasing	Yes
	Nitrate	Increasing	Yes ^f
	PCE	Decreasing	Yes ^f
	TCE	Decreasing	Yes
	Uranium	Increasing	Yes
P416889	<i>cis</i> -1,2-DCE	Decreasing	Yes
	PCE	Decreasing	Yes ^f
	TCE	Decreasing	Yes ^f
	Uranium	Increasing	Yes ^f
P419689	Uranium	Decreasing	Yes ^t
Selected AOC Wells & Constituents*			
00997	Uranium	Increasing	No
10304	Uranium	Increasing	Yes
10594	Uranium	Decreasing	Yes
11104	Uranium	Decreasing	Yes
B206989	Nitrate	Decreasing	Yes
Treatment System Influent*			
2000 through 2014			
MSPTS	1,1,1-TCA	Increasing	Yes
	1,1-DCE	Increasing	Yes
	Carbon tetrachloride	Decreasing	Yes
	Chloroform	Increasing	No
	<i>cis</i> -1,2-DCE	Increasing	Yes
	PCE	Increasing	Yes
	TCE	Increasing	Yes
	<i>trans</i> -1,2-DCE	Increasing	Yes ^c
	Vinyl chloride	Increasing	Yes ^c
	ETPTS	1,1-DCE	Increasing
Carbon tetrachloride		Decreasing	No
Chloroform		Increasing	Yes
<i>cis</i> -1,2-DCE		Increasing	Yes
PCE		Decreasing	No
	TCE	Increasing	Yes

Table 74 (continued). Summary of Statistical Trend Calculations Through 2014 by Location

Well	Analyte	Trend	Significant at 95%?
SPPTS	Nitrate	Increasing	Yes
	Uranium	Increasing	Yes

Notes: Only increasing and decreasing trends are included; indeterminate and zero-slope trends are not. Trends are listed if at least 80 percent statistically significant; any decisions that might be made would be based on trends having at least a 95 percent significance. Only those increasing trends having a 95 percent significance were assessed for applicability of the footnotes below.

* Calculating trends is not required by RFLMA, but is provided for informational purposes.

^a Trend was not calculated to be significant at 80% level in previous report, but with 2014 data is now 95% significant.

^b Trend was calculated to be significant in previous report, but at less than a 95% significance; it now meets the 95% level of significance.

^c Trend calculated at 95% significant might not be valid because 25 percent or more of the analytical data used to calculate this trend are nondetects (which in some cases have changed markedly over the period of record).

See Section 3.1.1.2 for discussion of how nondetects were handled in trending calculations.

^d Although the trend is calculated to have a 95% significance, the data used to calculate this trend may be affected by well replacement. Results for this constituent in samples from the original well are markedly different from those from the replacement well. These data sets might be separated in the future, rather than being pooled, as additional data are collected from the replacement well and are sufficient for trending separately.

^e Samples collected in 2005 were affected by very high turbidity (i.e., muddy water) immediately following installation of the replacement well. Thorough redevelopment reduced the turbidity and, therefore, the Am-241 as well.

^f Trend was not found to be 95% significant in previous report. (Applies to Evaluation wells, which are evaluated only for 95% significance, not for the 80% or greater significance employed for wells of other classifications. Note that this comparison may be with statistics developed for the annual report from the year before last, due to the every-other-year routine sampling frequency for Evaluation wells.)

Abbreviations:

- DCE = dichloroethene
- PCE = tetrachloroethene
- TCA = trichloroethane
- TCB = trichlorobenzene
- TCE = trichloroethene

Additional data will be collected in accordance with RFLMA and will further refine the concentration trends. Given that much of the analytical data used in trend calculations were collected before the Site was closed, and in many cases are from wells that were replaced as Site closure proceeded, some instances of slope change due to well replacement, rather than changes in groundwater quality, are to be expected. Replacement of a well can impact analytical and water elevation data.

Several previous annual reports have noted potential discontinuities in the data resulting from well replacement. The 2013 report made some adjustments to reduce these artificial effects, and this 2014 report retains those adjustments. Specifically, the analytical data sets used in statistical calculations for three wells (Sentinel wells 45608 and 88104, and Evaluation well 91105) now omit data from their predecessors due to discontinuities in these data. Note that the full data sets were not censored in this manner, only the data sets used for statistical calculations. In addition, those full data sets are typically used to create time-series plots included in this report. Results summarized in Table 74 reflect statistical calculations performed following these changes. In each of these cases, removal of the predecessor-well data allows a better understanding of conditions and trends that apply to groundwater monitored by the existing well.

(Note: Well 88104 has been deleted from the monitoring network, as discussed above, and will no longer be discussed after this 2014 report.)

For a cross-walk of closure-era original and replacement wells, refer to the *Rocky Flats Site 2006 Integrated Monitoring Plan Background Document*, also known as the 2006 IMP (DOE 2006c, Appendix B, Table B-4). Since 2006, the only well replacements completed have been the abandonment of wells 45605 and 33703 and their replacement with wells 45608 and 33711, respectively.

Calculations of statistical trends may also be affected by changes to detection limits (also discussed in a different context in Section 3.1.1.2). For example, this appears to be a significant factor in the statistical calculations for certain metals in downgradient wells at the PLF and OLF. With respect to Cr (the subject of Figure 4) and Ni, data reported before mid-2008 reflected higher detection limits than are now used. These constituents were often not detected with the higher detection limits, but may now be detected at lower concentrations. Due to data replacement of nondetects (i.e., wherein the reported value, which is equivalent to the detection limit, is replaced with a value of 0.001), the overall appearance is one in which the concentration is increasing—changing from a steady “concentration” of 0.001 to the reported detections. At some point these early data may be omitted from the calculations in order to remove this artifact; or, these earlier data may be allowed to gradually be overwhelmed by the quantity of newer data, yielding more reliable calculations of trend.

Groundwater Plumes with Treatment Systems

This section describes the general groundwater quality in 2014 at the three main groundwater contaminant plume treatment systems (MSPTS, ETPTS, and SPPTS) and the associated plumes these systems are designed to treat.

Mound Plume, OBP #2 Plume, and MSPTS

The Mound Plume (also called the Mound Site Plume) is located north of the former 903 Pad. The source of the plume is a former drum storage area (“the Mound”, previously referred to as IHSS 113) that was in use in the 1950s. Some of the drums leaked, resulting in a groundwater contaminant plume extending north toward South Walnut Creek (now part of the FC-4 segment). The drums were removed in 1970, and contaminated soils were removed in 1997. A groundwater treatment system was installed in 1998 to intercept and treat contaminated groundwater before it reaches the creek.

OBP #2 (previously IHSS 153) was located just west of the Mound source area, at the southeast corner of the former Protected Area fence. Characterization and groundwater monitoring of OBP #2 was not feasible due to security infrastructure until the Protected Area was decommissioned. Groundwater and soil were subsequently sampled, and elevated concentrations of VOCs were detected. This led to a source removal action in 2005 that addressed elevated concentrations in the soils. Supplemental carbon (in the form of HRC-X, an extended-release amendment similar to Hydrogen Release Compound [HRC]) was added to the backfill as electron donor material, to stimulate naturally occurring bacteria and enhance biodegradation of residual VOCs. (This action and its corresponding effects on groundwater quality are referenced and discussed in the text below.) Because the flow path for the OBP #2 Plume is toward FC-4 to the north, generally parallel to the flow direction of the nearby Mound Plume and potentially along the preferential pathway provided by a utility corridor left by a former storm drain, a gravel drain was installed in 2005 as part of the OBP #2 remediation. This gravel drain intercepts

and directs groundwater flowing northward from the OBP #2 source area to the MSPTS intercept trench. This combined flow is then directed to the MSPTS for treatment.

The following paragraphs describe these plumes and the MSPTS.

Mound Plume and OBP #2 Plume

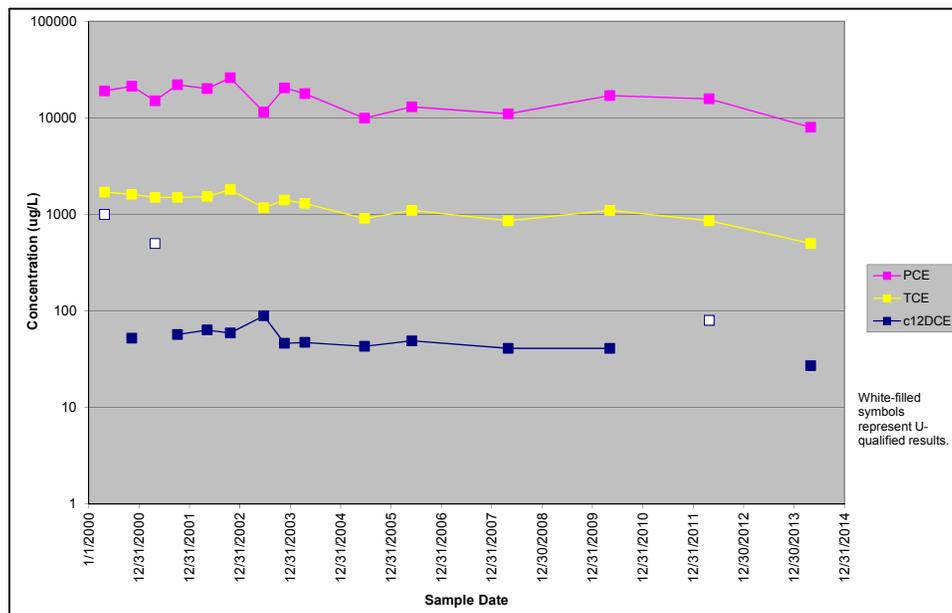
Annual reports for 2006 and 2007 (DOE 2007b, 2008) provide separate discussions of the Mound Plume and the nearby OBP #2 Plume. As described above, because groundwater flow from the Mound Plume as well as the OBP #2 Plume is captured and treated by the MSPTS, the two plumes have since been discussed as a group. Refer to previous reports for additional detail on closure-era activities in these areas and their impacts on the local groundwater.

Consistent with the technical design of the groundwater monitoring network at the Rocky Flats Site (RFS), the two source-area wells, 00897 (Mound) and 91105 (OBP #2), are Evaluation wells that are scheduled for routine monitoring every other year, in the second quarter of even-numbered years. For 2014, both of these wells were scheduled for routine RFLMA sampling. Well 00897 was sampled on April 30, and well 91105 was sampled on April 24, 2014.

The Mound Plume source area is characterized by elevated concentrations of tetrachloroethene (PCE) and trichloroethene (TCE). Conversely, groundwater in the OBP #2 source area was originally characterized by elevated concentrations of 1,1,1-trichloroethane (TCA), PCE, TCE, and 1,1-dichloroethene (DCE). This difference in contaminant distribution allows the impacts of the OBP #2 remedial action and the associated groundwater to be distinguished from Mound Plume water in the MSPTS influent, as discussed in greater detail below.

Analytical results from well 00897 in 2014 were generally consistent with previous data. The primary contaminants in groundwater sampled at this well remain PCE and TCE, both of which are present at concentrations exceeding their respective RFLMA Table 1 values. The daughter product *cis*-1,2-DCE is also typically detected, but at concentrations below its Table 1 value. Concentrations reported in 2014 for these three constituents were each at their lowest levels since 2000 (Figure 185). Whether the result in 2014 reflects an impact from the heavy precipitation in 2013 is not known, but the figure shows that overall concentrations have been gradually decreasing over the period of record. Concentrations of PCE and TCE are still well above Table 1 values, reported at 8,000 µg/L (RFLMA value = 5 µg/L) and 500 µg/L (RFLMA value = 2.5 µg/L) respectively in the 2014 sample; *cis*-1,2-DCE was reported at 27 µg/L (RFLMA value = 70 µg/L). As discussed below in the text on the MSPTS, contaminant concentrations in the influent to that treatment system were relatively consistent until the OBP #2 flow was directed to the system. Since that time, distributions of VOCs in the influent have been much more erratic.

Constituents for which statistical trends have been calculated to have a 95 percent significance at well 00897 include PCE and TCE (Table 74). Both are calculated to be on a decreasing concentration trend.



Notes:

Constituents and their respective RFLMA Table 1 values (µg/L): PCE, 5; TCE, 2.5; c12DCE = *cis*-1,2-DCE, 70.

Several detections are qualified, but for simplicity are not shown differently.

Nondetects for *cis*-1,2-DCE are not connected to detections so as to provide a more appropriate visual representation.

Note logarithmic concentration scale.

Figure 185. Primary VOCs in Mound Plume Source-Area Well 00897

Well 91105 is the third to monitor the OBP #2 source area; its two predecessors (91103 and 91104) were installed prior to remediation and directly within the contaminated soils, while the current well is on the downgradient edge of the backfilled source-removal excavation. The two predecessor wells therefore produced samples with substantially higher concentrations of VOCs than does the current monitoring well. Following the OBP #2 source removal and addition of electron donor material to the backfill to enhance biodegradation of residual VOCs, concentrations of some parent compounds, such as carbon tetrachloride, PCE, and TCE, decreased sharply as concentrations of some corresponding daughter products (such as *cis*-1,2-DCE and VC) increased. In fact, until 2014 concentrations of carbon tetrachloride had decreased to the point that this constituent was no longer detected in samples from well 91105. The sample collected in April reported the first detection of this constituent (estimated at 36 µg/L) since January 2005, though detection limits have varied and been as high as 76 µg/L. Chloroform, which is the primary daughter product from reductive dechlorination of carbon tetrachloride, initially increased in concentration and has since leveled off. (Other areas at the Site underwent a similar source removal activity and addition of electron donor material, but the contaminant distributions often illustrate a different pattern. This is the case at IHSS 118.1, for example, discussed later in this section.) More recently, concentrations of the parent compounds PCE and TCE in samples from well 91105 have rebounded. In fact, concentrations of PCE in 2014 were the highest ever reported in this replacement well, at 8,200 µg/L. (Note that this is well below levels reported prior to remediation in a predecessor well, where the highest concentration was 76,200 µg/L.) While still much higher than in 2008 (61 µg/L), concentrations of TCE in 2014 were lower than in recent years (12,000 µg/L vs. 18,000 µg/L in 2013).

Figure 186 provides a graphical representation of the concentrations of primary VOCs and daughter products at Evaluation well 91105 and its predecessors. The top portion of the figure presents the eight chlorinated VOCs that have exceeded RFLMA Table 1 values over the life of this monitoring location (whether in samples from the existing well or its predecessors). A linear scale is used in this upper portion of the figure to provide perspective on the varying concentrations of each compound, while the two lower charts use a logarithmic concentration scale and split the compounds among the two charts for easier visualization.

The middle portion of Figure 186 illustrates concentrations of PCE, TCE, and their dechlorination daughter products *cis*-1,2-DCE and VC; the sharp initial decrease in parent PCE and TCE concentrations in response to the well's new, downgradient location and the source removal is evident, as is the increase in daughter product concentrations. However, as noted in previous annual reports (e.g., DOE 2011, 2012, 2013a, 2014c), concentrations of these daughter products have recently decreased, while those of TCE and PCE have rebounded somewhat. Concentrations of TCE in 2014 were 12,000 µg/L at well 91105, still much lower than pre-remedial concentrations that were up to 84,800 µg/L, and also lower than the 16,000 µg/L to 18,000 µg/L concentrations consistently reported since 2011. The gradual, post-remedial increase in parent compounds and decrease in daughter products suggests residual effects of the electron donor material added during remediation are waning, at least for the PCE/TCE group of VOCs.

The lower portion of Figure 186 illustrates concentrations of 1,1,1-TCA and its dechlorination byproduct 1,1-DCE, and carbon tetrachloride and its primary byproduct chloroform. As previously noted, carbon tetrachloride was not detected following remediation of the source area, until 2014; whether this most recent detection is representative of a trend—i.e., a rebound in concentrations such as that apparent for PCE and TCE—remains to be seen. However, concentrations of chloroform that increased after the source removal activity have since remained relatively uniform save for a slight apparent decrease. Concentrations of 1,1,1-TCA and 1,1-DCE vary similarly to each other, with an initial decrease after remediation followed by a fairly uniform and gradual decrease that is similar to that of chloroform.

Constituents for which statistical trends have been calculated to have a 95 percent significance (using only data from replacement well 91105) include 1,1,1-TCA, *cis*-1,2-DCE, and TCE. The trend is decreasing for the first two constituents and increasing for TCE, as is visually evident on Figure 186. Refer to Table 74 and Appendix B for additional information on these results.

The extent to which the heavy precipitation in September 2013 and its associated groundwater recharge event have affected contaminant concentrations observed in either well 00897 or 91105 is not clear. Relatively higher water levels and groundwater discharge to the drainages was apparent for much of 2014. Data collected in future years may help to illustrate any longer-term effects of this extreme event on concentrations.

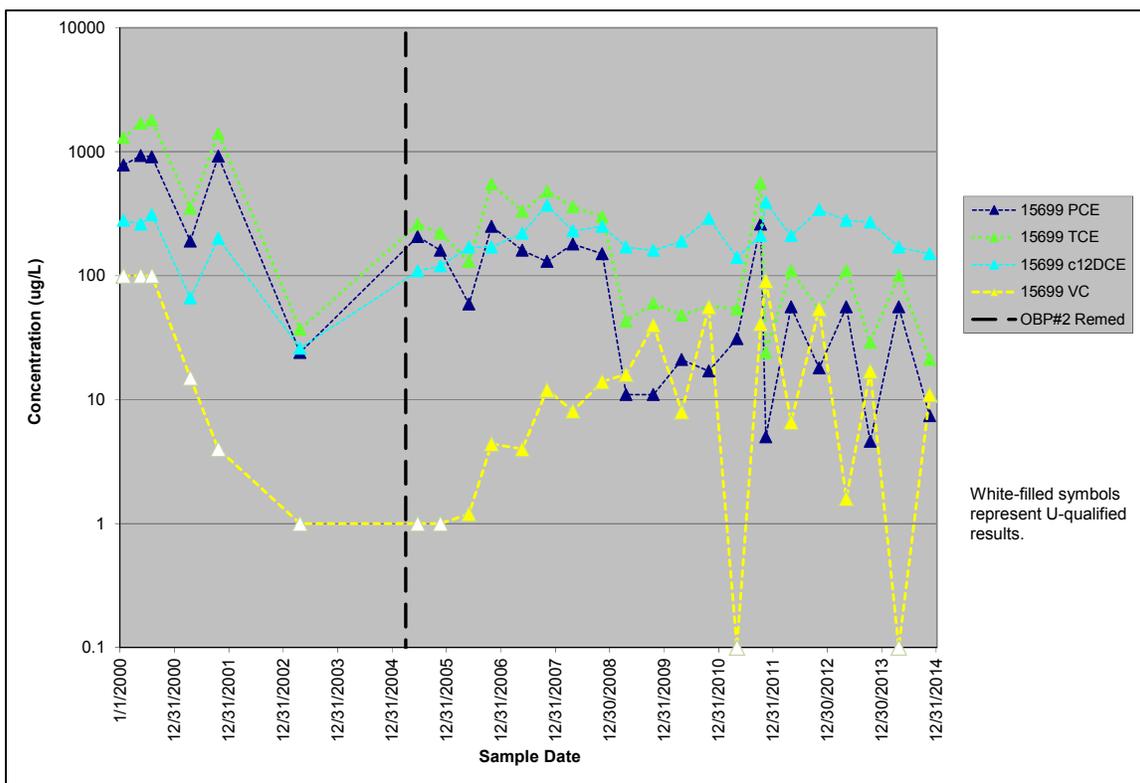


Notes:
 Constituents and RFLMA Table 1 values (µg/L): 111TCA = 1,1,1-TCA, 200; 11DCE = 1,1-DCE, 7; CT = carbon tetrachloride, 1; CF = chloroform, 3.4; PCE, 5; TCE, 2.5 ; c12DCE = cis-1,2-DCE, 70; VC, 0.2.
 “91103 Repl” and “91104 Repl” are dates on which those wells were abandoned and replaced by the next well, ultimately the current well, 91105.
 Several detections are qualified, but for simplicity are not shown differently.
 Note that the upper chart uses linear concentration scale, while the lower two use logarithmic scales.

Figure 186. Primary VOCs in OBP #2 Source Area Well 91105 (and Predecessors)

The Mound and OBP #2 Plumes are also monitored by Sentinel wells positioned along flow paths to surface water. Sentinel well 15699 is located directly downgradient of the Mound source area, but also downgradient of the unlined MSPTS intercept trench; as a result, contaminants in the well are expected to reflect a mix of Mound and OBP #2 Plume conditions. Sentinel well 91203 is located west of the gravel drain that was installed to route OBP #2 groundwater to the MSPTS intercept trench, and as such is actually sidegradient rather than downgradient of the OBP #2 source area.

Well 15699 produces groundwater with elevated concentrations of parent and daughter products—primarily PCE, TCE, *cis*-1,2-DCE, and VC (Figure 187). The effects from redirecting OBP #2 groundwater to the MSPTS trench are evident from about late 2006 on, especially through the relatively higher concentrations of *cis*-1,2-DCE and VC.



Notes:

Constituents and RFLMA Table 1 values (µg/L): PCE, 5; TCE, 2.5 ; c12DCE = *cis*-1,2-DCE, 70; VC, 0.2. “OBP#2 Remed” indicates when that source area was remediated and flow was directed to the MSPTS groundwater intercept trench. Several detections are qualified, but for simplicity are not shown differently. Note use of logarithmic concentration scale.

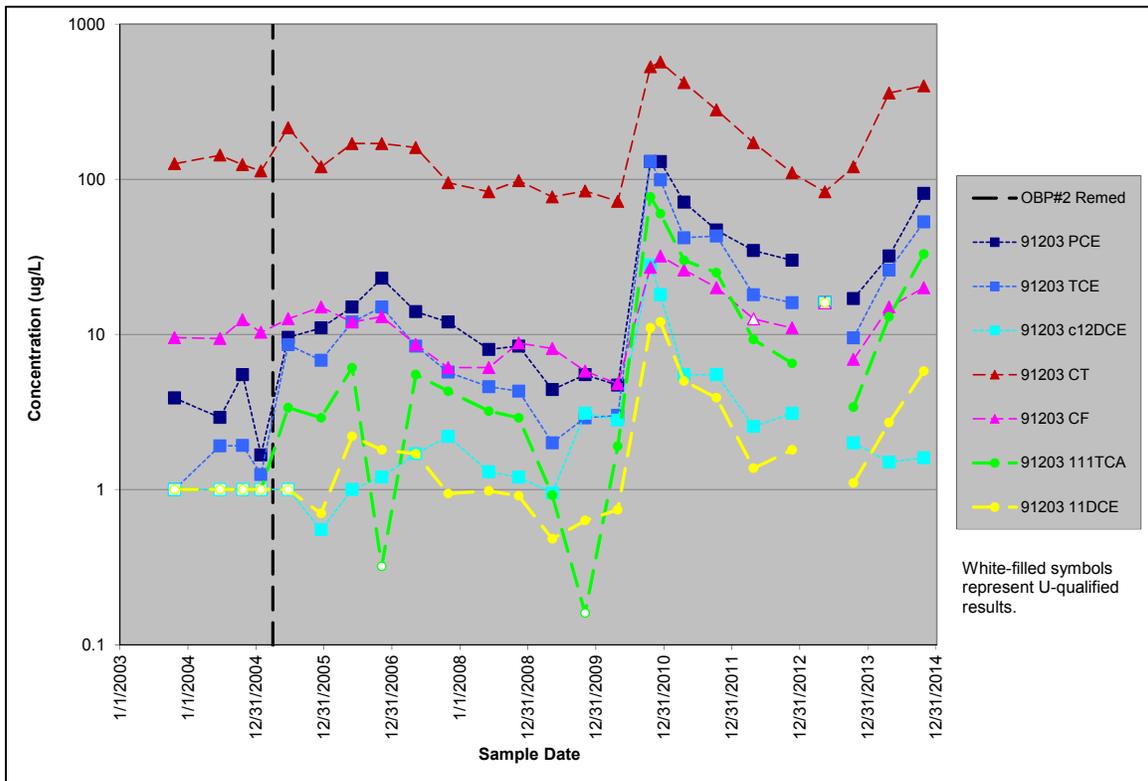
Figure 187. Primary VOCs in Downgradient Mound/MSPTS Well 15699

Similar to observations in the source-area wells, effects of the high precipitation in September 2013 are not readily apparent in the concentrations of the primary VOCs at well 15699. However, a cyclical variation in concentrations of PCE, TCE, and VC is apparent starting around 2011, with fourth-quarter concentrations of the parent products (PCE, TCE) being relatively lower while concentrations of a daughter product (VC) are relatively higher. This may relate to a seasonal variation in biologically mediated reductive dechlorination of the

parent compounds, since this mechanism is favored under lower dissolved-oxygen concentrations that may be more common in the drier fourth quarters than in the second quarters. Additional data will be collected in accordance with the RFLMA and may help to confirm any longer-term patterns such as these. More broadly, concentration trends having a statistical significance of 95 percent are calculated for 1,1-DCE, chloroform, PCE, and TCE (all decreasing), and *trans*-1,2-DCE and VC (both increasing). The trends for chloroform, *trans*-1,2-DCE, and VC are based on data including a large number of nondetects, and therefore may not be viable. Refer to Table 74 and Appendix B for additional statistical information.

Groundwater at Sentinel well 91203 is significantly different in contaminant distribution from that reported at well 15699 and at well 91105, indicating the contaminants reported at 91203 are probably not sourced directly by the Mound Plume or OBP #2 Plume. This is most obvious for the Mound Plume, given that well 91203 is clearly not downgradient of the source area, but the proximity and location of the OBP #2 source area has led to some question in the past as to whether it was responsible for the contamination reported in groundwater at well 91203.

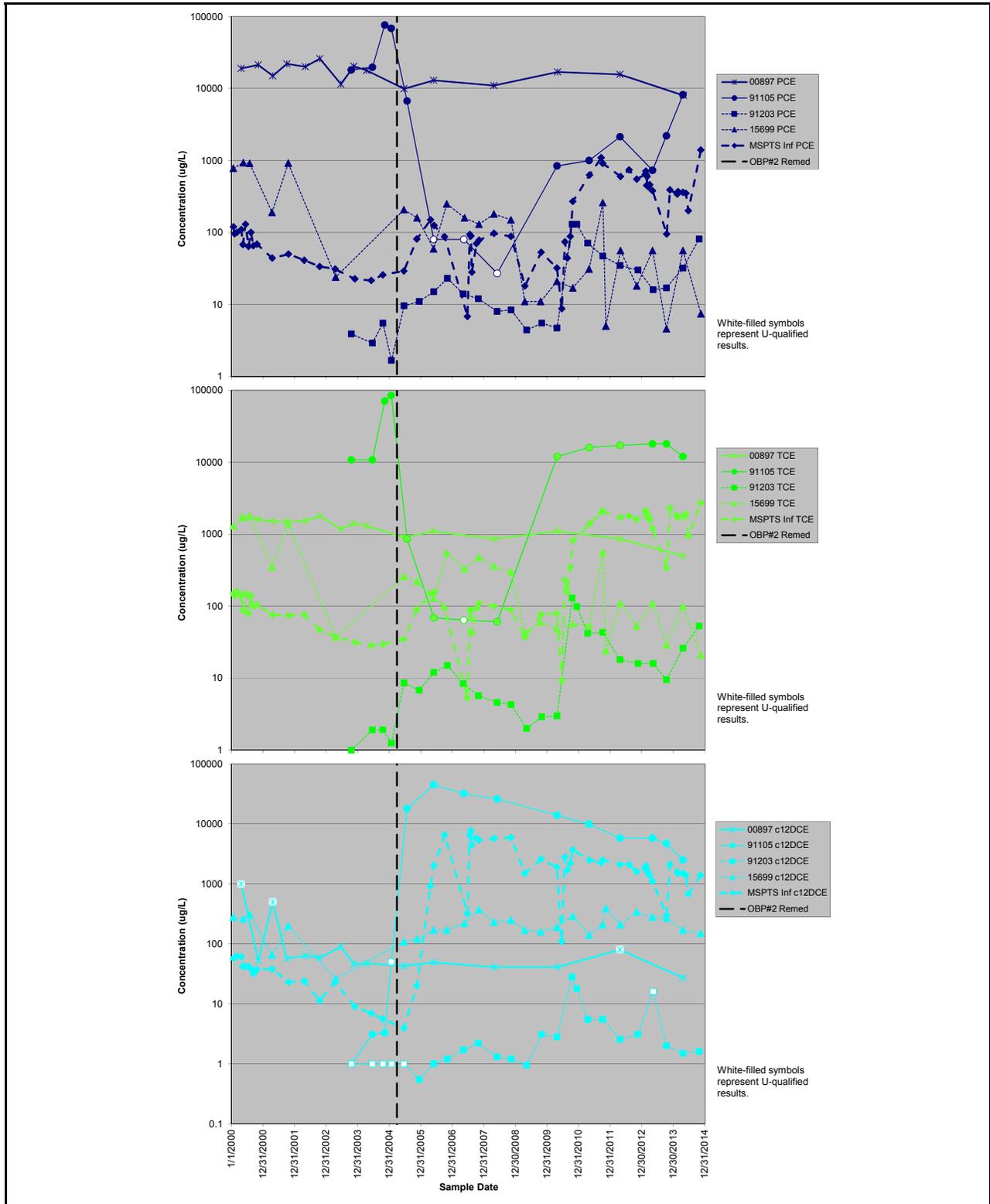
The contaminant that is consistently present at the highest concentrations in samples from well 91203 is carbon tetrachloride (Figure 188). Its primary daughter product, chloroform, is present at lower concentrations that vary uniformly with those of the parent product. The PCE/TCE/*cis*-1,2-DCE family is also represented in samples from this well, though VC has never been detected. 1,1,1-TCA and 1,1-DCE are also both present. All of these VOCs vary more or less uniformly with one another, but slightly differently from the carbon tetrachloride/chloroform pair, at least until about 2010. Each of these constituents shows a relatively higher concentration in (and after) the wet year of 2010, and the data collected following the September 2013 storms suggest a similar effect may now be underway, as discussed in the 2013 Annual Report (DOE 2014c; see also related discussion in the 2012 report [DOE 2013a]). The higher water levels following these recharge events may have mobilized residual contaminants present higher in a normally dry portion of the soil column. Concentrations of *cis*-1,2-DCE in samples from well 91203 do not follow as closely the patterns displayed by other contaminants (Figure 188), most notably in the 2004–2008 time frame and in 2014. Additional data should help to clarify longer-term patterns.



Notes: Constituents and RFLMA Table 1 values (µg/L): PCE, 5; TCE, 2.5; c12DCE = *cis*-1,2-DCE, 70; CT = carbon tetrachloride, 1; CF = chloroform, 3.4; 111TCA = 1,1,1-TCA, 200; 11DCE = 1,1-DCE, 7. OBP #2 Remed indicates when that source area was remediated and flow directed to the MSPTS groundwater intercept trench. Several detections are qualified, but for simplicity are not shown differently. Results for the sample collected May 14, 2013, were all nondetects except for CT; the associated results are shown separated from the other data because linking these particular nondetects would not aid visual presentation of the data. Note use of logarithmic concentration scale.

Figure 188. Primary VOCs in Sentinel Well 91203

Figure 189 displays reported concentrations of PCE, TCE, and *cis*-1,2-DCE in samples from Mound and OBP #2 source-area Evaluation wells 00897 and 91105, respectively; Sentinel wells 91203 and 15699; and influent to the MSPTS. The different portions of this figure illustrate the general similarity in concentration variations at Mound source-area well 00897 and MSPTS influent prior to the OBP #2 remediation work (which included routing OBP #2-area groundwater to the MSPTS groundwater intercept trench and was completed on April 1, 2005). Following completion of this work, the MSPTS influent concentrations began to more closely resemble OBP #2 groundwater reported at corresponding source-area well 91105. As noted above, contaminant distributions in samples from well 91203 do not closely resemble either source area (nor MSPTS influent).



Notes: Top portion represents PCE, middle shows TCE, and bottom shows *cis*-1,2-DCE in samples from source-area wells 00897 and 91105, more distant wells 91203 and 15699, and MSPTS influent. “OBP#2 Remed” refers to completion of that activity. Constituents and RFLMA Table 1 values ($\mu\text{g/L}$): PCE, 5; TCE, 2.5; c12DCE = *cis*-1,2-DCE, 70. Several detections are qualified, but for simplicity are not shown differently. Note logarithmic concentration scales, and that the scale for *cis*-1,2-DCE starts at a lower value.

Figure 189. PCE, TCE, and *cis*-1,2-DCE in Wells Near the MSPTS and in MSPTS Influent

The distribution of contaminants evident in well 15699 (Figure 189), which is located a short distance downgradient of the MSPTS groundwater intercept trench, is also dissimilar to that in source-area wells and in MSPTS influent. Some hydraulic communication is indicated, however. As noted above, well 15699 exhibits a delayed response to the concentration variations in MSPTS influent, such as a general increase in *cis*-1,2-DCE concentrations in the 2007 time frame following the 2006 spike in the concentrations of this contaminant in MSPTS influent. Perhaps more clearly indicative of this communication is the appearance of VC in samples from the well, as shown above in Figure 187. However, while concentrations of PCE and TCE in this well have continued to vary similarly to one another, they also have decreased compared with pre-closure levels. This is not the case in MSPTS influent (Figure 189), where PCE and TCE are elevated compared with their pre-closure concentrations.

Given that the MSPTS trench is not lined—it has an impermeable barrier on the downgradient edge and a clay layer in the bottom, but is otherwise an earthen trench—if significant bypass or leakage from the trench was taking place, the groundwater in well 15699 would be a good place to detect it. Instead, the patterns seen in these contaminant data suggest substantial groundwater leakage or bypass in this area is not occurring.

Several statistical trends calculated to have a 95 percent level of significance were calculated in the wells monitoring the Mound and OBP #2 area. With respect to the source-area wells, decreasing trends in both PCE and TCE are calculated for Evaluation well 00897; decreasing trends in 1,1,1-TCA and *cis*-1,2-DCE and an increasing trend in TCE are calculated at Evaluation well 91105. (As a reminder, these calculations at well 91105 are based only on data from that well, not its predecessors, as noted previously and discussed in the annual report for 2013 [DOE 2014c].) Trends having this significance in the sidegradient Sentinel well 91203 include increasing 1,1,1-TCA, 1,1-DCE, PCE, TCE, and *cis*-1,2-DCE. These trends in the parent compounds (1,1,1-TCA, PCE, and TCE) are newly identified in this 2014 report. While the concentrations of these constituents have varied over the years by orders of magnitude (see Figure 188), an overall increase is visually apparent. Sentinel well 15699 is represented by four decreasing and two increasing trends having a statistical significance of 95 percent: parent compounds PCE and TCE and daughter products chloroform and 1,1-DCE are calculated to be decreasing, and the daughter products *trans*-1,2-DCE and VC are calculated to be increasing. Note that some of these calculated trends are complicated by the presence of numerous nondetects (particularly with respect to the trends calculated for 1,1,1-TCA at well 91203, and for chloroform, *trans*-1,2-DCE, and VC at well 15699). Refer to Table 74 for a summary of all statistically significant trends calculated for 2014, and to Appendix B for the associated summary information and plots.

Mound Site Plume Treatment System

The MSPTS was the first groundwater intercept/treatment system installed at the Site to incorporate ZVI, and is actually among the first of its type in the world. It was installed in 1998. The first media replacement activity was conducted in the summer of 2006, and the media was replaced again in 2011. As a part of this second replacement activity, a small, prototype air stripper was installed in the effluent manhole to polish the effluent (see DOE 2012, the 2011 Annual Report and especially Appendix F to that report, for additional detail on the MSPTS prototype air stripper). In 2013, this prototype was replaced with a larger, full-time air stripper

(refer to DOE 2014c for more detail). Section 2.4 discusses routine maintenance activities performed at the MSPTS in 2014, much of which focused on the new air stripper.

As with all years from 2005 on, flow rates through the MSPTS in 2014 were well above pre-2005 levels. This is due to the intentional routing of groundwater from the OBP #2 area into the MSPTS intercept trench. (For additional background, see the 2005 Annual Report, DOE 2006d.) Table 75 provides annual estimates of the volume of water treated by the MSPTS, which in 2014 was approximately 689,000 gallons. This is by far the highest volume treated by this system in any single calendar year, and shows the continuing effects of the extreme precipitation event of September 2013. This volume is also more than 50 percent higher than the average post-closure annual volume treated by this system and is nearly six times the average volume treated over the period 2000 through 2004 (Table 76). (A pre-closure volume average that omits 2005 flows is included in this table because the volume treated in that year was abnormally high, not representative of typical pre-closure conditions.) The data in this table clearly show the effects of the 2013 flood as well as completion of the OBP #2 connection.

Table 75. Estimated Volumes of Water Treated by the MSPTS

Calendar Year	Annual Estimates of Volume Treated (gallons)	Estimated Cumulative Volume Treated (gallons)
2000	258,000	660,000
2001	119,000	780,300
2002	53,000	833,000
2003	82,000	915,000
2004	86,000	1,001,000
2005	506,000	1,507,000
2006	430,000	1,937,000
2007	326,000	2,263,000
2008	358,000	2,621,000
2009	287,000	2,908,000
2010	420,000	3,328,000
2011	546,000	3,874,000
2012	461,000	4,335,000
2013	422,000	4,757,000
2014	689,000	5,446,000

Notes:

Cumulative volume shown for 2000 includes water treated since system installation in 1998. Estimates for years 2000 through 2004 are compiled from Kaiser-Hill Company LLC (K-H) documents (K-H 2000a, K-H 2000b, K-H 2000c, K-H 2000d, K-H 2002b, K-H 2003, K-H 2005a, K-H 2005b).

Table 76. Average Volumes Treated by the MSPTS

Time Period	Average Volume Treated Per Year (gallons)
Pre-closure, 2000–2005	184,000
Pre-closure, 2000–2004	119,600
Post-closure, 2006–2014	438,000

Notes: Average volumes are rounded and based on volumes presented in Table 75. Time periods shown include complete years, and do not correspond to exact date of closure; for example, the pre-closure estimate for the 2000–2005 period spans January 1, 2000, through December 31, 2005, and the post-closure period used for this table begins January 1, 2006.

Figure 190 presents a hydrograph illustrating flows from January 1, 2000, through the end of 2014, and Figure 191 provides a hydrograph focusing on CY 2014. Mean daily flows in 2014 appear comparatively uniform as well as elevated compared with conditions prior to mid-2010. The extremely high precipitation in September 2013 is muted on Figure 190, but this is probably artificial: the influent valves were only partly open to help even the distribution to the two treatment cells. These metered flows also helped to smooth the hydrograph shown in Figure 191 and likely resulted in better VOC treatment than would have occurred had the influent been able to flow through the system as quickly as it collected in the trench, because during peak-flow periods the water would have been in contact with the treatment media for longer than might otherwise have been the case if the valves had been wide open.

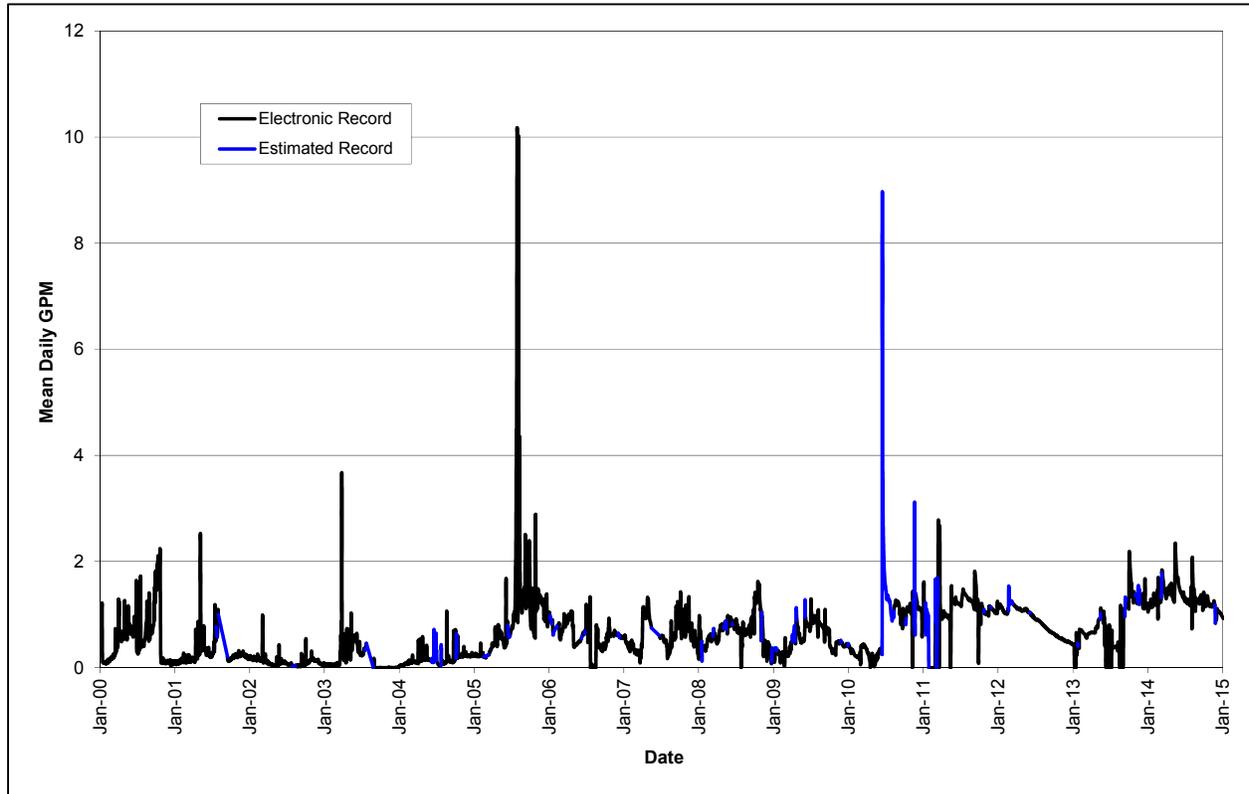


Figure 190. Hydrograph for MSPTS from 2000 Through 2014

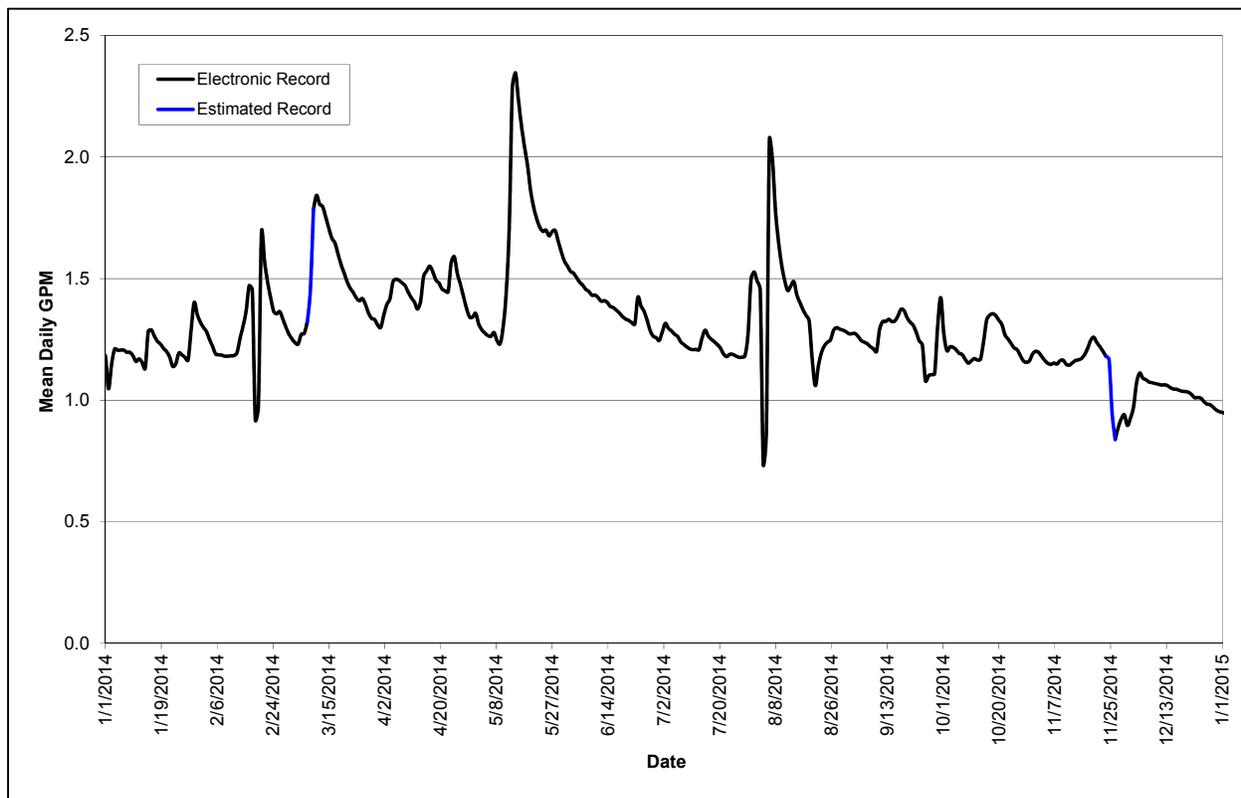
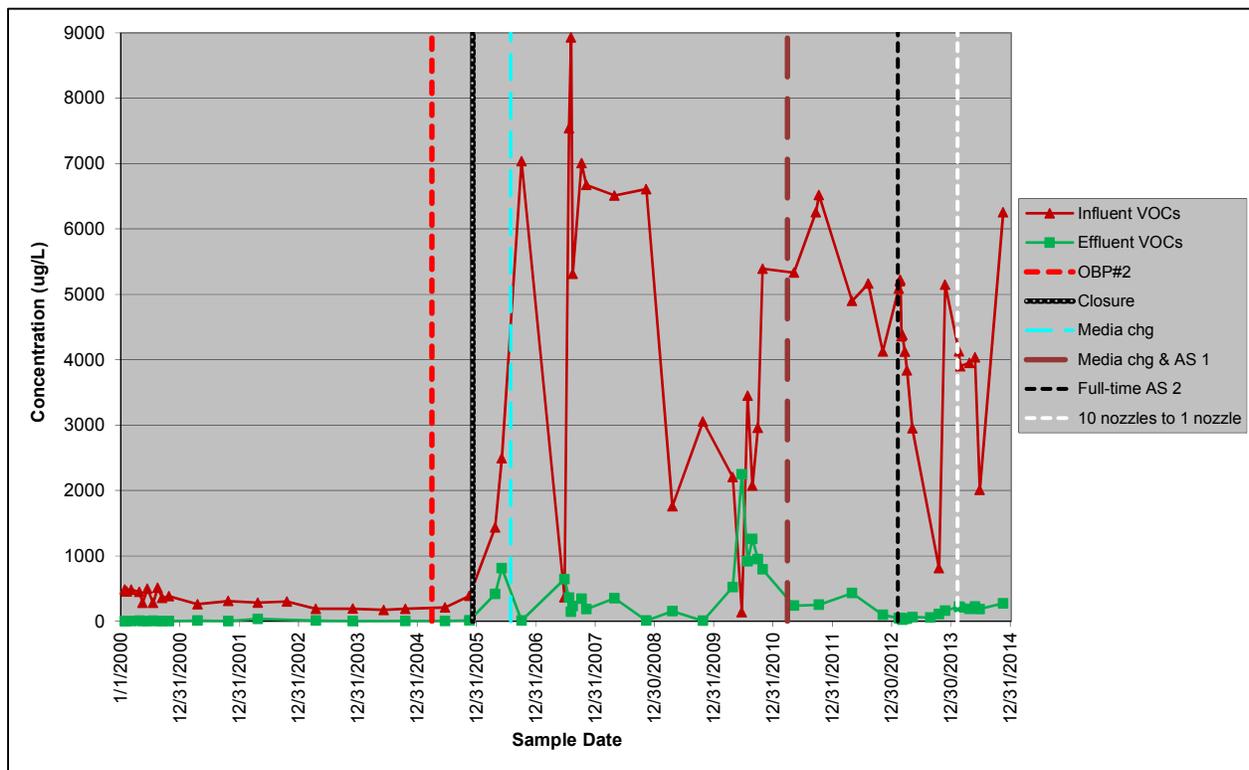


Figure 191. Hydrograph for MSPTS for CY 2014

The MSPTS was sampled twice in 2014 (May and November) in accordance with the RFLMA. In addition, the MSPTS was sampled four additional times (twice in February and once each in April and June) in order to assess and refine the operation and performance of the air stripper installed in 2013, and to support confirmatory sampling at surface water performance location GS10 as discussed further below. Two of the extra sampling events excluded GS10 because these events focused on the effectiveness of the air stripper.

Analytical data representing MSPTS influent and effluent continue to illustrate the dramatic effect the addition of OBP #2-related groundwater has on the system (Figure 192). These data also show that the treatment system continues to demonstrate its effectiveness in reducing VOC loads, and the air stripper installed in 2013 improves overall performance significantly.



Notes:

VOC data shown represent all results at locations MOUND R1-0 (influent) and MOUND R2-E (effluent) that represent validated detections. Many results are qualified otherwise (e.g., J, B) but are incorporated at face value. “OBP#2” = date on which remediation of Oil Burn Pit #2 was completed. “Closure” = date of Site closure. “Media chg” = first instance in which the ZVI treatment media was replaced. “Media chg & AS 1” = second time the media was replaced, with a prototype air stripper that operated part-time also installed. “Full-time AS 2” = date on which a larger air stripper operating full-time was installed. Also shown is the date on which the array of ten nozzles in the air stripper was replaced with a single nozzle.

Figure 192. Total VOCs in MSPTS Influent and Effluent, 2000 Through 2014

Table 77 summarizes MSPTS influent and effluent analytical data for selected constituents. Refer to the quarterly reports (DOE 2014d, 2014e, 2015) and Appendix B for additional 2014 water-quality data for the MSPTS. As can be surmised from Figure 192, data representing MSPTS influent clearly show the impact of closure activities performed upgradient of the system, particularly the installation of the engineered preferential pathway (the backfilled storm drain corridor and associated cross-cutting gravel drain) that now routes groundwater impacted by the OBP #2 into the MSPTS groundwater intercept trench. (For more information on this feature, see K-H 2005c.)

As indicated in Table 77, from a mass-based concentration perspective the primary contaminants in MSPTS influent are TCE and *cis*-1,2-DCE. PCE is also present in significant concentrations, typically in the 200–400 µg/L range, but the sample collected in November 2014 reported a concentration that was as high as that of *cis*-1,2-DCE, at 1,400 µg/L. This is the highest concentration of PCE in the MSPTS influent period of record (since January 1, 2000). The unusually high PCE concentration in the November 2014 sample is also reflected in the relatively higher concentrations of other constituents, such as TCE (also highest ever, at 2,700 µg/L), carbon tetrachloride, chloroform, 1,1,1-TCA, and 1,1-DCE. The cause of these higher than normal concentrations is not known, but may relate to the anomalously high

groundwater recharge resulting from the September 2013 floods, which may have flushed residual contamination from higher in the soil column. Refer to Section 3.1.3.5 for additional discussion of the lingering effects of that precipitation event on groundwater at Rocky Flats in 2014. (Note that the explanation for the anomalously low concentrations reported in MSPTS influent in the June 26 sample is also not known.)

Eight VOCs were detected in 2014 in MSPTS influent at concentrations exceeding their respective RFLMA Table 1 levels: 1,1,1-TCA, 1,1-DCE, carbon tetrachloride, chloroform, *cis*-1,2-DCE, PCE, TCE, and VC. This is nearly the same group of VOCs that was elevated in 2013, but lacks the 1,2-DCA reported that year. As previously noted, the presence of 1,1,1-TCA in MSPTS influent at concentrations as high as the RFLMA Table 1 standard was unknown until 2007 and represents a primary contaminant from the OBP #2 source area.

In 2014, six VOCs were detected in MSPTS treated effluent at concentrations exceeding RFLMA Table 1 values: carbon tetrachloride, chloroform, *cis*-1,2-DCE, PCE, TCE, and VC. This represents two more VOCs than were reported at levels above their RFLMA values in the effluent in 2013; carbon tetrachloride and chloroform did not exceed those values in 2013 data. Several factors may be responsible. The relatively higher flows in 2014 caused by the heavy September 2013 precipitation were almost certainly a factor, as higher flows in turn cause shorter residence time within the treatment system. The higher influent concentrations reported in late 2014 could also contribute to an overall reduction in treatment effectiveness; note that it was this November effluent sample that exceeded the RFLMA standard for chloroform. In addition, some of the constituents remaining at elevated levels in the effluent are more recalcitrant; the reductive dechlorination of polychlorinated constituents (such as PCE, TCE, and carbon tetrachloride) occurs more readily than for mono- and dichlorinated compounds (e.g., *cis*-1,2-DCE, VC) (EPA 2000). Therefore, these partially chlorinated daughter products require a greater residence time within the ZVI media for adequate treatment to be accomplished. However, when flow rates are higher (as has been the case since Site closure, and more so since the 2013 floods), the residence time instead decreases. Finally, the ZVI media within the MSPTS is increasingly passivated over time, and thus the amount of fresh ZVI with which the contaminants are able to come into contact is also waning. Contaminants that move through the media without contacting sufficient fresh ZVI will not be adequately dechlorinated; the air stripper in the effluent manhole may not be able to completely treat all residual VOCs in effluent from the treatment cells.

The aforementioned effects of the OBP #2 remediation on MSPTS influent are clearly evident in the time-series plots of Figure 192 and Figure 193. As illustrated on the latter figure, system influent contained decreasing concentrations of *cis*-1,2-DCE until shortly after that remediation activity was complete, when concentrations of this constituent began a sharp increase of over three orders of magnitude (from less than 10 µg/L to nearly 8,000 µg/L). Since 2007, *cis*-1,2-DCE concentrations have been gradually decreasing while (more recently) those of PCE and TCE have rebounded. Although it is crowded, the chart in the upper portion of Figure 193 shows that only carbon tetrachloride is present in MSPTS influent at levels roughly equivalent to those prior to closure. All other VOCs in MSPTS influent illustrated on Figure 193 (including 1,1,1-TCA; 1,1-DCE; *cis*-1,2-DCE; PCE, TCE, and VC) are present at concentrations that are at least one to two orders of magnitude higher than they were in 2000. This confirms that the MSPTS is capturing and treating significantly more contaminant load than was present in its influent prior to closure. Refer also to Table 77 for evidence of this fact.

Table 77. Summary of VOC Data (µg/L) for MSPTS Influent and Effluent

DATE	1,1,1-TCA		1,1-DCE		CT		CF		cis-1,2-DCE		MCI		PCE		TCE		VC	
	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E
1/27/2000	8 (J)	1 (U)	10	1 (U)	110	1 (U)	25	1 (U)	57	1	5 (BJ)	1 (B)	120	0.1 (J)	150	1 (U)	10 (U)	1 (U)
2/8/2000	9 (J)	1 (U)	10	1 (U)	110	1 (U)	25	1 (U)	59	2	6 (JB)	2 (B)	96	1 (U)	140	1 (U)	10 (U)	0.1 (J)
3/7/2000	9 (J)	1 (U)	12	1 (U)	110	1 (U)	26	1 (U)	62	2	14 (B)	0.9 (JB)	100	1 (U)	160	1 (U)	10 (U)	1 (U)
4/26/2000	7 (J)	1 (U)	10	1 (U)	96	1 (U)	24	1 (U)	61	4	20 (B)	0.8 (JB)	110	1 (U)	140	1 (U)	10 (U)	0.2 (J)
5/15/2000	6	1 (U)	8	1 (U)	49 (D)	1 (U)	19	1 (U)	42 (D)	3	0.1 (JB)	0.7 (BJ)	68 (D)	1 (U)	87 (D)	1 (U)	0.3 (J)	1 (U)
6/14/2000	8	1 (U)	10	1 (U)	130	1 (U)	24	1 (U)	42	1	3 (BJ)	0.2 (BJ)	130	1 (U)	150	1 (U)	10 (U)	1 (U)
7/19/2000	4 (J)	1 (U)	6	1 (U)	63	1 (U)	12	1 (U)	42	2	4 (JB)	0.9 (JB)	64	1 (U)	79	1 (U)	5 (U)	1 (U)
8/16/2000	10 (J)	1 (U)	10 (J)	1	180	1 (U)	31	1 (U)	39	1 (J)	23 (B)	0.3 (BJ)	100	1 (U)	140	1 (U)	10 (U)	1 (U)
9/13/2000	5.9	0.5 (U)	7	0.5 (U)	122	0.5 (U)	25.4	0.5 (U)	32.1	0.74	1 (U)	0.57	65.3	0.5 (U)	99.9	0.5 (U)	1 (U)	0.5 (U)
10/25/2000	6.3	0.5 (U)	8	0.5 (U)	133	0.5 (U)	25.6	0.5 (U)	37.3	0.69	1 (U)	0.5 (U)	68.7	0.33 (J)	104	0.5 (U)	1 (U)	0.5 (U)
4/19/2001	4 (D)	1 (U)	5 (D)	1 (U)	73 (D)	1 (U)	20 (D)	0.6 (J)	38 (D)	3	2 (U)	6	44 (D)	1 (U)	76 (D)	1 (U)	2 (U)	1 (U)
10/25/2001	3.4	1 (U)	5.1	1 (U)	130	1 (U)	23	1 (U)	23	0.9 (J)	1 (U)	1 (U)	50	1 (U)	74	1 (U)	1 (U)	1 (U)
4/25/2002	2.9	1 (U)	4.5	1 (U)	110	1 (U)	26	1 (U)	24	1.8	1 (U)	1 (U)	41	1 (U)	76	1 (U)	1 (U)	1 (U)
10/21/2002	2.6	1 (U)	1.06	1 (U)	155	1 (U)	27.5	1 (U)	11.3	1 (U)	1 (U)	1 (U)	33.6	1 (U)	46.8	1 (U)	1 (U)	1 (U)
4/17/2003	2.8	1 (U)	2.5	0.23 (J)	73	1 (U)	19	0.93 (J)	23	4.4	1 (U)	3.5 (B)	31	0.38 (J)	38	0.31 (J)	0.81 (J)	1 (U)
12/1/2003	2	1 (U)	2	1 (U)	104 (D)	1 (U)	21.4	1 (U)	9	1	1 (U)	1 (U)	22.6	1 (U)	31.4	1 (U)	1 (U)	1 (U)
6/9/2004	1.34	1 (U)	1.49	1 (U)	91.9	1 (U)	22.4	1 (U)	6.98	1 (U)	1 (U)	1 (U)	21.5	1 (U)	28.3	1 (U)	1 (U)	1 (U)
10/20/2004	2.07	1 (U)	2.47	1 (U)	100	1 (U)	24.6	1 (U)	5.59	0.83 (J)	1 (U)	1 (U)	25.7	0.72 (J)	29.4	2.74	1 (U)	1 (U)
6/21/2005	1 (U)	1 (U)	1.58	1 (U)	110	1 (U)	30.4	0.48 (J)	3.93	2.04	0.74 (J)	1 (U)	29.1	1.66	34.9	1.28	1 (U)	1 (U)
11/18/2005	11 (J)	1 (U)	5.2	0.67 (J)	150	1 (U)	31	0.42 (J)	20	6.3	1 (U)	1 (U)	81	4.5	90	1.6	1 (U)	1 (U)
4/25/2006	35	0.16 (U)	18	4.8	81	0.19 (U)	56	0.16 (U)	920	390	20	1.7	150	5.7	150	7.6	0.68 (U)	5.6
6/5/2006	27.4	1 (U)	1 (U)	1 (U)	60.1	1 (U)	45	1 (U)	2040 (D)	793 (D)	27.2	1 (U)	125 (D)	3	158 (D)	4.6	6	8.6
10/5/2006	53.3	1 (U)	73.1	1 (U)	60.1	1 (U)	45.1	1 (U)	6580 (D)	0.78 (J)	6.9	7.3	87.2	1 (U)	93.7	1 (U)	26.1	1 (U)
6/26/2007	11	0.43 (U)	5.2	1.4 (J)	3.4 (J)	0.51 (U)	4.1	0.43 (U)	320	590	0.32 (U)	2.6 (J)	6.8	0.53 (U)	5.3	0.43 (U)	12	48
7/24/2007	290	0.32 (U)	95	0.52 (J)	48 (J)	0.38 (U)	77	0.32 (U)	6500	330	21 (U)	6.7	94	0.4 (U)	88	0.32 (U)	350	18
8/6/2007	370	0.16 (U)	99	0.35 (J)	58	0.19 (U)	99	0.16 (U)	7700	130	8.5 (U)	3.3	89	0.2 (U)	88	0.16 (U)	420	8.6
8/16/2007	180	0.32 (U)	47	0.4 (J)	24	0.38 (U)	67	0.32 (U)	4500	190	4.1 (U)	5.4 (U)	28	0.4 (U)	42	0.32 (U)	420	34
10/9/2007	300	0.16 (U)	93	0.44 (J)	42	0.19 (U)	88	0.16 (U)	5800	300	13 (U)	4.8	70	0.2 (U)	93	0.16 (U)	470	36
11/8/2007	270	0.16 (U)	94	0.5 (J)	40	0.19 (U)	85	0.16 (U)	5400	140	13 (U)	4.7	78	0.2 (U)	110	0.16 (U)	590	36
4/29/2008	340	0.16 (U)	94 (J)	1.3 (J)	30	0.19 (U)	100	0.45 (J)	5700	310	6.4 (J)	6.2 (J)	97	0.32 (J)	100	0.56 (J)	44	28
11/11/2008	310	0.16 (U)	71	0.14 (U)	35	0.19 (U)	80	0.16 (U)	5900	2.2	9.2 (U)	1.3 (U)	88	0.2 (U)	89	0.17 (J)	32 (J)	4.2 (J)
4/21/2009	45	0.16 (U)	27	1.6	7.2	0.19 (U)	8.6	0.16 (U)	1500	95	1.6 (U)	4.1 (B)	18	0.53 (J)	37	1.9	92	47
10/26/2009	110	0.16 (U)	36	0.14 (U)	27	0.19 (U)	19	0.16 (U)	2600	1.8	1.6 (U)	0.46 (J)	53	0.2 (U)	77	0.58 (J)	130 (J)	1.5 (J)
4/27/2010	75	0.16 (U)	25	5.6	3.3	0.19 (U)	6.3	0.16 (U)	1900	360	2.1	0.82 (J)	32	0.2 (U)	79	3.5	79	150
6/22/2010	6	35	2.2	24	0.4	1.3 (U)	0.46	9.9	110	1800	0.39	5.6 (U)	8.7	29	9.3	77	0.4	270
7/28/2010	190	15	42	8.5	11	0.76 (U)	22	3.3 (J)	2800	790	7.7	6.4	74	11	230	40	70	40
8/26/2010	120	12	22	12	9.7	0.38 (U)	15	3.5	1700	960	3.1	4.3 (B)	44	20	160	84	2	160
9/29/2010	220	8.3	43	10	19	0.38 (U)	27	3	2200	690	1.6	0.64 (U)	88	11	350	93	9	130
10/28/2010	400	9.7	68	7.5	27	0.38 (U)	49	3.4	3700	590	3.2	2.2 (U)	270	6.5	810	100	64	75
5/9/2011	450	0.16 (U)	90	1.9	120	0.19 (U)	130	0.3 (J)	2500	210	1.8 (U)	9.7	630	5.5	1400	6.6	8.4	3.3
9/21/2011	516	NA	79.4	NA	146	NA	128	NA	2260	NA	0.25 (U)	NA	1090	NA	2000	NA	29.4	NA
10/10/2011	580	0.16 (U)	76	0.33 (J)	180	0.19 (U)	150	3.5	2500	240	3.2 (U)	4.9	910	0.34 (J)	2100	0.29 (J)	19	2.3

Table 77 (continued). Summary of VOC Data (µg/L) for MSPTS Influent and Effluent

DATE	1,1,1-TCA		1,1-DCE		CT		CF		cis-1,2-DCE		MCI		PCE		TCE		VC	
	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E	R1-0	R2-E
5/1/2012	300	0.16 (U)	46	1.8	93	0.19 (U)	52	5.7	2100	410	3.2 (U)	1.9	600	3.6	1700	4.7	8 (J)	2.3
8/9/2012	330	NA	49	NA	87	NA	47	NA	2100	NA	2.2 (U)	NA	740	NA	1800	NA	7.4	NA
11/6/2012	220	0.16 (U)	46	0.47 (J)	64	0.19 (U)	39	0.34 (J)	1600	90	1.3 (U)	0.32 (U)	550	.81 (J)	1600	0.53 (J)	3.5 (J)	4.5
2/12/2013	250	0.16 (U)	58	0.23 (U)	82	0.19 (U)	43	0.16 (U)	1900	46	1.6 (U)	0.32 (U)	640	0.48 (J)	2100	0.97 (J)	12	1.2
2/19/2013	270	0.16 (U)	78	0.23 (U)	87 (J)	0.19 (U)	44	0.16 (U)	1900	43	8 (U)	0.32 (U)	710	0.66 (J)	2100	1.2	11 (J)	1.2
2/22/2013	270 (J)	0.16 (U)	67	0.23 (U)	93 (J)	0.19 (U)	43	0.16 (U)	2000	42	3.2 (U)	0.32 (U)	640	0.48 (J)	2100	0.83 (J)	8.1 (J)	1.4
3/1/2013	230	0.16 (U)	48	0.23 (U)	80	0.19 (U)	40	0.16 (U)	1700	37	3.2 (U)	0.32 (U)	450	0.3 (J)	1800	0.66 (J)	6.4 (J)	0.91 (J)
3/7/2013	270	0.16 (U)	64 (J)	0.23 (U)	100 (J)	0.19 (U)	42	0.16 (U)	1600	24	1.6 (U)	0.32 (U)	600	0.27 (J)	1700	0.51 (J)	0.5 (U)	0.85 (J)
3/22/2013	220 (J)	0.16 (U)	40 (J)	0.23 (U)	87 (J)	0.19 (U)	39 (J)	0.16 (U)	1500	37	3.2 (U)	0.32 (U)	430 (J)	0.25 (J)	1800	0.78 (J)	4.7 (J)	0.95 (J)
4/4/2013	200	0.16 (U)	53	0.23 (U)	83	0.19 (U)	34	0.16 (U)	1400	38	1.6 (U)	0.32 (U)	460	0.4 (J)	1600	0.73 (J)	5	1.7
5/7/2013	140	0.16 (U)	33	0.37 (J)	63 (J)	0.19 (U)	28	0.25 (J)	1100	60	3.2 (U)	0.32 (U)	380	0.9 (J)	1200	1.6	7 (J)	2.2
8/26/2013	NA	0.16 (U)	NA	0.24 (J)	NA	0.19 (U)	NA	0.46 (J)	NA	50	NA	0.32 (U)	NA	1.8	NA	2.2	NA	2.8
10/18/2013	39	0.57 (J)	11	0.84 (J)	14 (J)	0.19 (U)	7.7	0.63 (J)	300	87	0.32 (U)	0.32 (U)	95	5.4	340	7.9	5	6.3
11/25/2013	180	1.3	40	0.83 (J)	66	0.32 (J)	38	0.9 (J)	2100	130	3.2 (U)	0.32 (U)	390	4.8	2300	18	32	5.4
2/18/2014	210	5.3	47 (J)	2.4 (J)	68 (J)	1.6 (J)	30	1.4	1600	140	3.2 (U)	0.32 (U)	340	11	1800	53	31	8.7
2/26/2014	180	4.1	47	1.9	57	1.1	23	1.1	1500	130	3.8 (U)	0.32 (U)	370	11	1700	55	21	5.7
4/24/2014	170	3.8	43	1.4	43	0.84 (J)	20	1.1	1500	120	4.9 (U)	0.32 (U)	360	9.6	1800	47	13	4.1
5/28/2014	230	6.5	42	2.1	61	1.3	29	1.6	1400	130	3.2 (U)	0.32 (U)	350	15	1900	65	19	4.7
6/26/2014	110	4.3	22	1.6	31	0.73 (J)	15 (J)	1.5 (J)	680	120	2.9 (U)	0.32 (U)	200	8.8	950	45	0.5 (U)	4.2
11/17/2014	460	15	71	3.1	140	3.3	69	4	1400	96 (J)	3.2 (U)	0.32 (U)	1400	45	2700	100 (J)	12	7.9

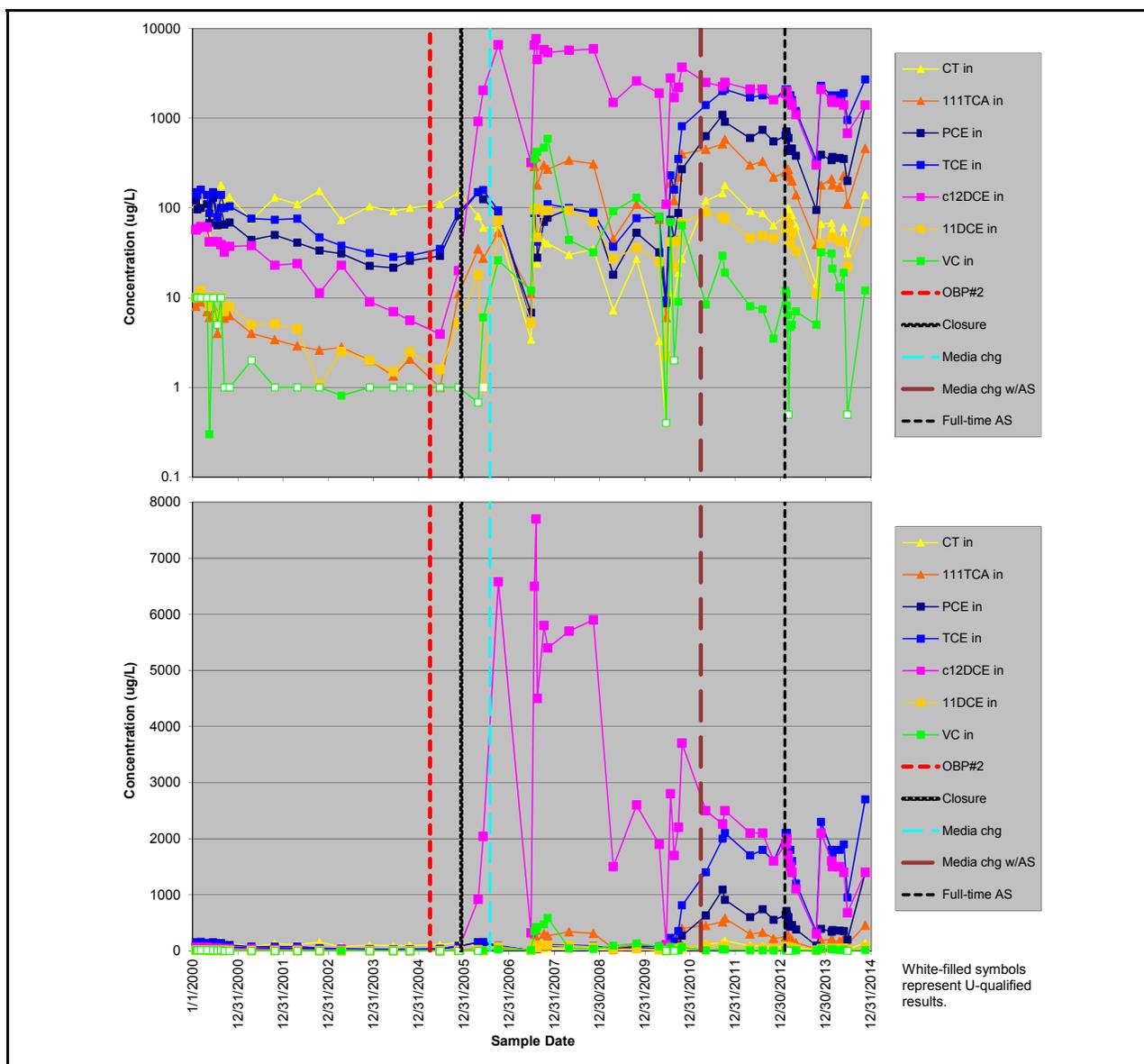
Notes: Constituents and their respective RFLMA values (all in µg/L): 1,1,1-TCA (200); 1,1-DCE (7); CT = carbon tetrachloride (1); CF = chloroform (3.4) ; cis-1,2-DCE (70); MCI = methylene chloride (4.6); PCE (5); TCE (2.5); VC (0.2).
R1-0 = influent, R2-E = effluent.

Formal RFLMA sampling location names are MOUND R1-0 and MOUND R2-E.

A shaded cell with bold font indicates that a detected concentration exceeds corresponding applicable level stipulated in RFLMA Attachment 2, Table 1 (CDPHE et al. 2012). If a detection limit exceeded that concentration and the constituent was qualified as a nondetect, then the result is not highlighted as an exceedance.

Laboratory and validation qualifiers (wherein the validation qualifier supersedes the lab qualifier if they differ): J = result is estimated below the sample quantitation limit; U = analyte not detected at the indicated concentration; B = constituent was also detected in the blank; D = analysis was performed at a dilution.

NA = location not sampled on the given date.



Notes:

All data represent MSPTS influent; upper plot uses logarithmic concentration scale to illustrate distribution of VOCs, and lower plot uses linear scale to better illustrate their relative concentrations. Several events are noted but not all affect MSPTS influent; they are shown to provide context.

“OBP#2” indicates the date of OBP #2 source removal and backfilling. “Closure” indicates when the Site closed.

“Media chg” shows the first time the ZVI was replaced. “Media chg w/AS” indicates when the ZVI was replaced a second time and a prototype air stripper was installed. “Full-time AS” shows when the prototype air stripper was replaced with a full-time unit.

Constituents and their RFLMA values (ug/L): CT = carbon tetrachloride, 1; 111TCA = 1,1,1-TCA, 200; PCE, 5; TCE, 2.5; c12DCE = *cis*-1,2-DCE, 70; 11DCE = 1,1-DCE, 7; VC, 0.2.

In addition to the nondetects, several results are qualified, but for simplicity are not shown differently.

Figure 193. Concentrations of Primary VOCs in MSPTS Influent

The impact on water quality related to the addition of OBP #2 flow is more concisely summarized in Table 78, which presents average MSPTS influent concentrations generally prior to and following the diversion of OBP #2 water to MSPTS influent. (Note that these averages incorporate all results—even nondetects—at face value, regardless of qualifiers. Therefore, the

pre-closure average concentrations shown for constituents that were not consistently detected—which can be seen in Table 77—are actually overestimated compared to what these averages would be if the actual concentrations were known.) With the exception of carbon tetrachloride, all constituents shown in this table increased in concentration following OBP #2 remediation. The average concentrations of chloroform and methylene chloride, both daughter products of carbon tetrachloride degradation, appeared to increase relatively little, while the concentrations of the other constituents summarized here increased from one to two orders of magnitude. However, these average values for some constituents, such as methylene chloride, are based largely on nondetects (as noted above and individually itemized in Table 77) and for this summary simply incorporate the associated detection limits. For this reason, the average values should be compared with data provided in Table 77 before they are considered as representative of actual water quality. As an example, VC was generally not detected prior to the impact from OBP #2, reporting only two detections, both less than 1 µg/L (Table 77); therefore, the average value shown in Table 78, 3.9 µg/L, is biased high due to the face-value incorporation of the associated detection limits. Comparison with the averages calculated for and provided in the 2011, 2012, and 2013 Annual Reports (DOE 2012, 2013a, 2014c) shows the post-closure average concentrations of several constituents changing markedly. In particular, the average post-closure PCE and TCE concentrations have sharply increased, from the 2011 values of 187.8 µg/L (PCE) and 375.9 µg/L (TCE) to the 2014 values of 337.5 µg/L and 1,006.3 µg/L, respectively. This demonstrates the rebounding concentrations of parent compounds mentioned previously. Concentrations of their daughter products, *cis*-1,2-DCE and VC, are decreasing (*cis*-1,2-DCE from 3,415 µg/L in 2011 to 2,549.0 µg/L, and VC from 130.6 µg/L to 75.1 µg/L) but still remain elevated with respect to pre-closure conditions. The average post-closure concentrations of other constituents did not change as much from 2011 to 2014.

Table 78. Average Contaminant Concentrations in MSPTS Influent, Pre- vs. Post-Closure, in µg/L

	111TCA	11DCE	CT	CF	c12DCE	MCI	PCE	TCE	VC
Through 2005	5.3	6.1	110.0	24.1	31.9	4.4	65.1	88.7	3.9
Since 2005	223.8	51.4	59.3	48.4	2549.0	5.2	337.5	1006.3	75.1

Notes: Pre-closure averages include data from January 1, 2000, through December 31, 2005; post-closure averages include data collected from January 1, 2006, through the end of 2014. To calculate these averages, all data, including nondetects, were taken at face value regardless of qualifier. Constituents and RFLMA Table 1 values (µg/L): 111TCA = 1,1,1-TCA, 200; 11DCE = 1,1-DCE, 7; CT = carbon tetrachloride, 1; CF = chloroform, 3.4; c12DCE = *cis*-1,2-DCE, 70; MCI = methylene chloride, 4.6; PCE, 5; TCE, 2.5; VC, 0.2.

A critical point is that the addition of electron donor material to the OBP #2 source area excavation, and the resulting stimulation of biodegradation of residual chlorinated VOCs, led to concentrations of daughter products (such as *cis*-1,2-DCE and VC) in MSPTS influent increasing more than did those of their parent compounds. While a larger increase in daughter products relative to parent compounds is indicative of desirable dechlorination, as explained above these two daughter products represent some of the more recalcitrant constituents.

Finally, although not required by the RFLMA, S-K trend calculations were performed for MSPTS influent. The data evaluated included all influent from January 2000 through the end of 2014. The trend calculations identify several represented by a statistical confidence of 95 percent (Table 74; see also the trend plots in Appendix B). As expected, these trends are affected by the addition of OBP #2 flow. Trends at this level of significance include some affected by a

consistent record of nondetects prior to the OBP #2 work (increasing 1,1,1-TCA, VC, and both *cis*- and *trans*-1,2-DCE) but which can be accepted as generally valid given that these constituents were either not detected or present at lower levels than has been the case since closure. Others include increasing 1,1-DCE, chloroform, TCE, and PCE; and decreasing carbon tetrachloride.

No VOCs other than those summarized in Table 77 were detected in 2014 in MSPTS effluent at concentrations exceeding the RFLMA standards.

Four grab samples for the analysis of VOCs were collected in 2014 at the surface-water performance location for the MSPTS, surface-water station GS10. Two of these sampling events were routine RFLMA events (April and November), and the extra two events (June and December) were completed to confirm VOC detections reported in the previous samples. Low concentrations of VOCs were detected in each of the four events (Table 79). TCE concentrations reported in the April and November samples exceeded the RFLMA Table 1 value of 2.5 µg/L. The follow-up samples reported concentrations of TCE that were lower than the RFLMA value. None of the other VOCs detected at GS10 exceeded the corresponding RFLMA standards. However, the number of VOCs detected in 2014 at GS10 is greater than in most years. VOCs detected most commonly at location GS10 are *cis*-1,2-DCE and TCE. 1,1,1-TCA and chloroform have only been detected here in 2010 and 2014, both higher-flow years. Therefore, the high flows in 2014 resulting from heavy 2013 precipitation, and the consequentially reduced residence time for influent within the treatment system, may have contributed to the elevated concentrations of TCE and the greater number of VOCs reported at GS10 this year.

Table 79. Summary of VOCs Detected in 2014 at GS10

Date	Constituent	Result (µg/L)	Qualifier
4/24/2014	1,1,1-TCA	0.18	J
4/24/2014	<i>cis</i> -1,2-DCE	6.7	
4/24/2014	PCE	0.45	J
4/24/2014	TCE	2.8	
6/26/2014	<i>cis</i> -1,2-DCE	4.3	
6/26/2014	PCE	0.36	J
6/26/2014	TCE	1.7	
11/17/2014	1,1,1-TCA	0.85	J
11/17/2014	Chloroform	0.37	J
11/17/2014	<i>cis</i> -1,2-DCE	6.5	
11/17/2014	PCE	2.4	
11/17/2014	TCE	6.3	
12/9/2014	1,1,1-TCA	0.17	J
12/9/2014	<i>cis</i> -1,2-DCE	3	
12/9/2014	PCE	0.68	J
12/9/2014	TCE	1.6	

Notes:

RFLMA Table 1 value for 1,1,1-TCA is 200 µg/L, for *cis*-1,2-DCE is 70 µg/L, for PCE is 5 µg/L, and for TCE is 2.5 µg/L.

Italicized, bold, larger-font entries represent concentrations that exceed the corresponding RFLMA values.

MSPTS Effluent Polishing Component: Air Stripper

The 2010 and 2011 Annual Reports (DOE 2011 and 2012, respectively) introduce and provide discussion of the decision to install an effluent polishing component at the MSPTS, as well as initial results of testing. The 2012 Annual Report (DOE 2013a) further describes and summarizes the results of the prototype unit installed in 2011, which operated 12 hours per day. The 2013 report (DOE 2014c) provides discussion of the full-time air stripper installed that year within the effluent manhole, the same location in which the previous units had been installed.

The 2012 Annual Report (DOE 2013a) describes the establishment of special monitoring to support evaluation of the air stripper's effectiveness. The location ASHINF (which stands for "air stripper housing influent") represents water that has been treated by the ZVI-filled treatment cells—the original treatment components of the MSPTS—but has not yet passed through the air stripper. This location was sampled in 2014 to continue this evaluation.

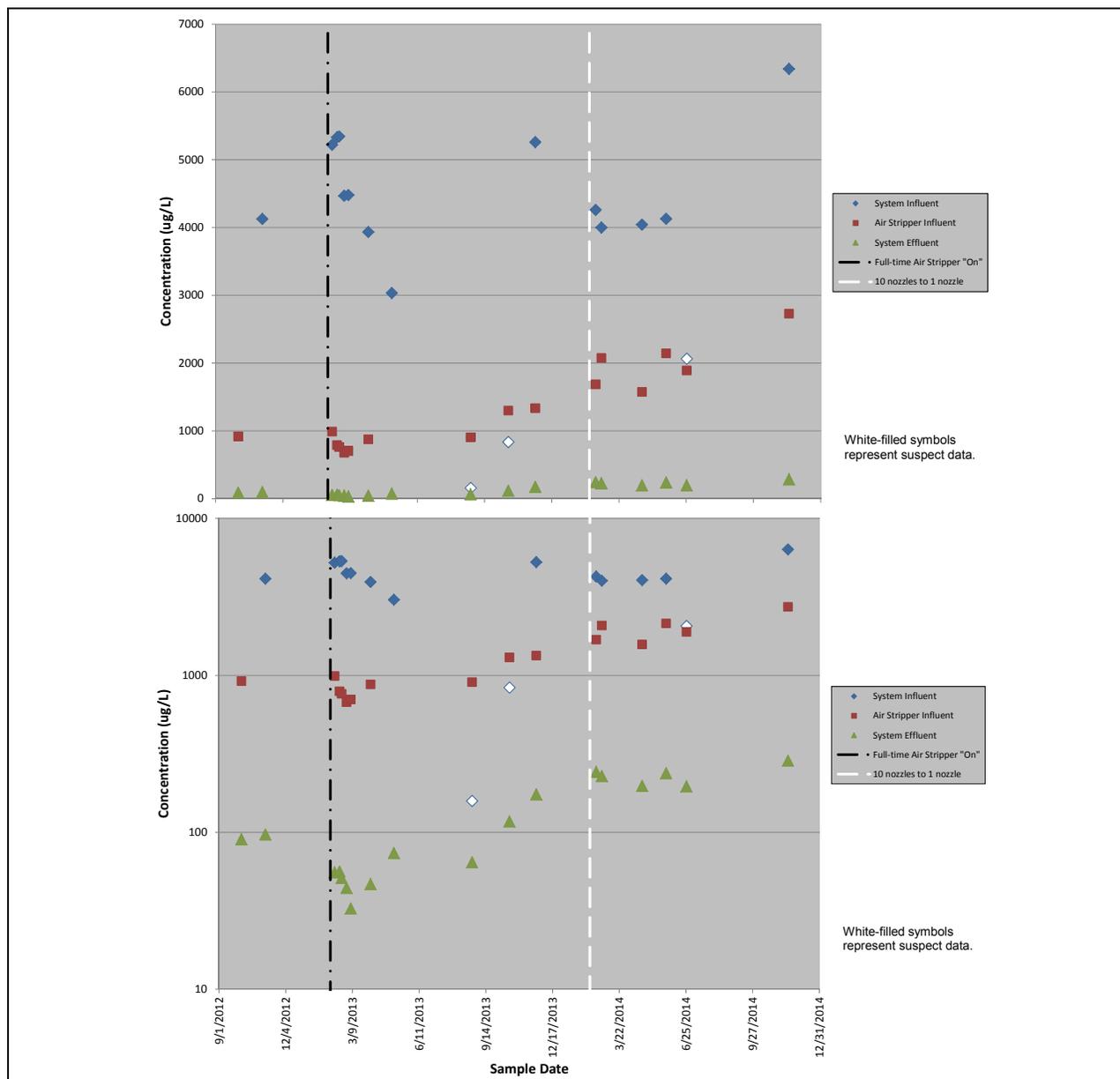
Concentrations of VOCs detected at location ASHINF have generally increased since the air stripper was installed in 2013. This is probably due to two main factors, both of which have been mentioned above: the treatment effectiveness of the ZVI is decreasing over time, and the higher influent flow rates observed since fall 2013 have translated to water being treated for a shorter time within that ZVI. This latter factor, which was noted in the 2013 report (DOE 2014c), also impacts the effectiveness of the air stripper, because the effluent manhole (a.k.a., air stripper housing) operates as a purely flow-through component: the faster water enters, the faster it must exit this manhole. To put it another way, the higher the influent flow rate, the less time this water is in contact with the ZVI and the less it is processed by the air stripper, and therefore the less total treatment it receives.

Figure 194 illustrates total VOCs (i.e., a sum of all VOCs detected) at three MSPTS monitoring locations: system influent (RFLMA location MOUND R1-0), system effluent (RFLMA location MOUND R2-E), and the previously described non-RFLMA-required location ASHINF. This figure focuses on the air stripper installed in 2013. (Refer to the annual reports for 2011, 2012, and 2013 [DOE 2012, 2013a, and 2014c, respectively] for additional information on the preceding air stripper components.)

Not shown on Figure 194 are data from the small, vertical French drain into which system effluent is routed before it flows to the larger subsurface discharge gallery. The 2013 Annual Report (DOE 2014c) discusses this location, which more accurately represents true MSPTS effluent than water still within the manhole that houses the active air stripper. However, following the successes in reconfiguring the ETPTS (discussed below) to eliminate ZVI from the process and its associated costs and wastes, a similar effort is planned for the MSPTS. Formally establishing this French drain as a new effluent monitoring location in light of this planned change is not necessary.

Figure 194 shows the wide variability in VOC concentrations of MSPTS influent; this is particularly evident in the upper portion of the figure. Ignoring the two suspect datapoints in late 2013 and the one in mid-2014, total VOCs in MSPTS influent over just the short period of time illustrated in this figure ranged from approximately 3,000 µg/L to over 6,300 µg/L. This presents a challenge to the system, which is magnified when higher concentrations coincide with higher

flow rates, as was the case beginning in the latter portion of 2013 as a result of the extremely heavy precipitation that September.



Notes:

Upper and lower portions show the same data, but linear concentration scale is used in upper chart, logarithmic scale is used in lower chart.

“System Influent” refers to samples collected at location MOUND R1-0. “Air Stripper Influent” refers to samples from location ASHINF (effluent from ZVI-filled treatment cells before it enters manhole housing air stripper). “System Effluent” represents location MOUND R2-E (water just prior to leaving the manhole in which the air stripper is installed).

“Full-time Air Stripper ‘On’” shows when the prototype air stripper was replaced with larger, full-time unit. “10 nozzles to 1 nozzle” indicates when the array of small nozzles was replaced with a single, larger-bore nozzle.

Causes for the outliers indicated as “suspect” data are not known.

Figure 194. Concentrations of Total Detected VOCs at MSPTS Locations

The VOC that most consistently reports the highest concentrations in samples collected from location ASHINF is *cis*-1,2-DCE. This constituent, a recalcitrant daughter product of the PCE-TCE family, typically exceeds 500 µg/L in the effluent from the ZVI-filled treatment cells. Of the 15 samples collected over the period illustrated in Figure 194, it exceeded that concentration 13 times, ranging from 490 µg/L to 1,000 µg/L. Other VOCs reported at ASHINF at concentrations exceeding 500 µg/L over this period include PCE (once, at 700 µg/L) and TCE (three times, once as high as 1,100 µg/L—the November 2014 sample event in which the MSPTS influent contained unusually high concentrations of several VOCs). Note that *cis*-1,2-DCE can be created via partial dechlorination of PCE or TCE, so it is not necessarily true that some of this constituent that is entering the ZVI is leaving without being treated. It could be that all the *cis*-1,2-DCE entering the ZVI is treated (or further dechlorinated to VC), but some of the PCE/TCE is only partially dechlorinated to yield the resulting concentrations of *cis*-1,2-DCE reported at ASHINF.

No constituents were reported at such high levels in MSPTS effluent during the period shown in Figure 194. However, *cis*-1,2-DCE was again the constituent that was most often present at the highest concentrations in system effluent, exceeding 100 µg/L in six of the samples. The other VOC present at this level was TCE at 100 µg/L (estimated; again, this sample is from the November 2014 event).

Figure 194 also illustrates when the original array of 10 smaller nozzles was replaced with a single, larger-diameter nozzle. Analytical data following this change do not clearly indicate which nozzle arrangement provides more effective treatment. The upper portion of the figure suggests the single nozzle may be better, but that is not necessarily the case even though the flow rates were higher during the operation of this single nozzle. Based on the good treatment effectiveness and the significantly reduced maintenance required by the larger nozzle, the single nozzle configuration is currently being retained. Other efforts to optimize treatment, such as keeping the pumps and nozzle/piping clean, and keeping the powered ventilation operable and clear of obstructions, are the primary goals until the MSPTS can be reconfigured as noted above. Refer to Section 2.4.1.3 for additional information on MSPTS maintenance.

East Trenches Plume and Treatment System

The East Trenches Plume is an area of groundwater contamination named after several buried disposal trenches. These trenches are located on the pediment south of South Walnut Creek, in former OU 2. The source of this plume is residual VOC contamination associated predominantly with Trenches T-3 and T-4, which were remediated in 1996. In addition, a portion of the 903 Pad Plume flows from its source area toward the northeast and merges with the East Trenches Plume. Following the successful installation and testing of the MSPTS in the late 1990s, a similar treatment system (the ETPTS) was designed and installed in 1999 to intercept and treat contaminated groundwater flowing toward the B-Series Ponds and South Walnut Creek.

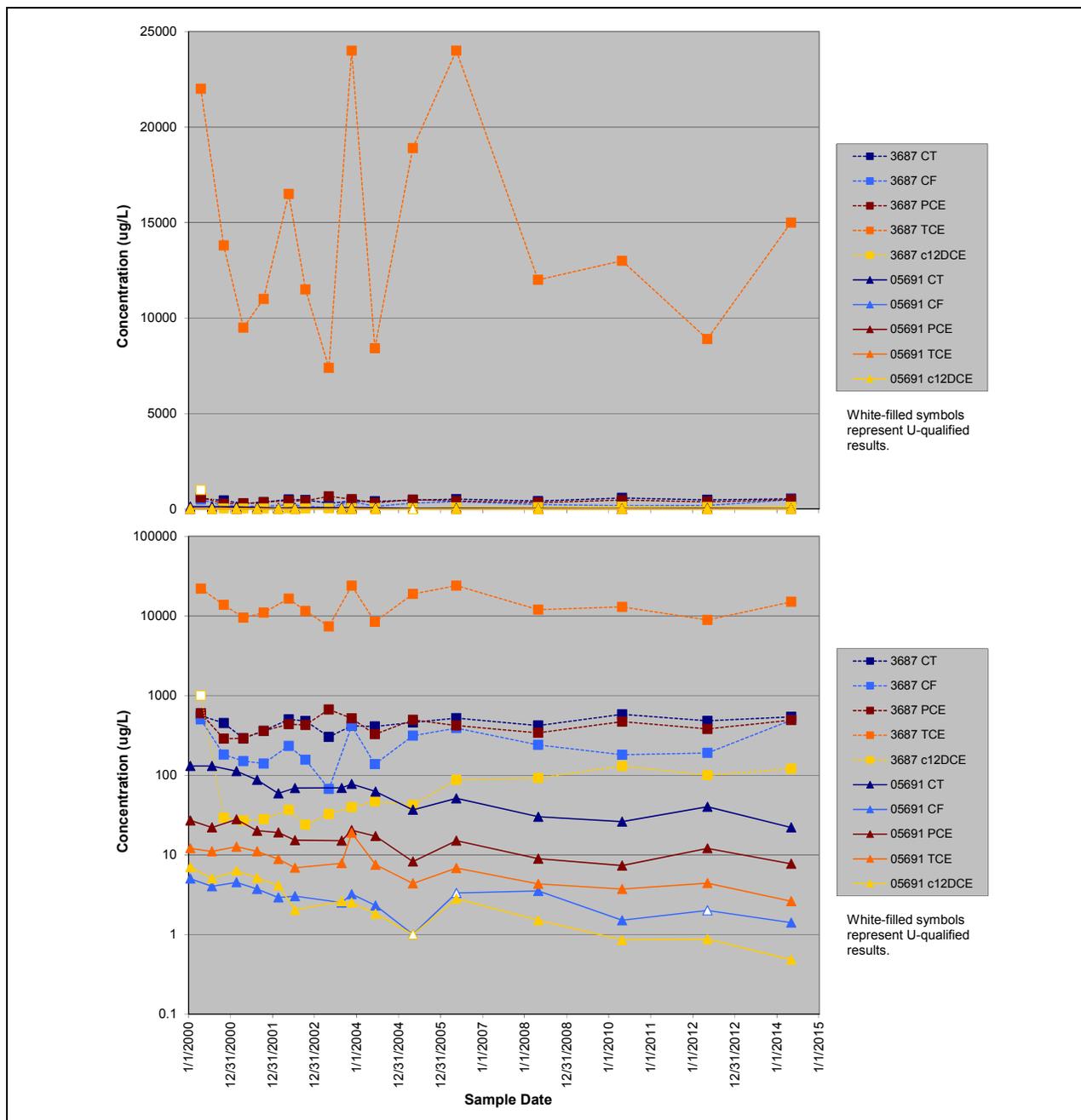
East Trenches Plume

Evaluation wells 3687 and 05691 monitor the primary source areas of the East Trenches Plume, Trenches T-3 and T-4, respectively. More distal portions of the plume are monitored by Evaluation well 03991 and Sentinel well 04091 to the east-northeast. Sentinel wells 95099, 95199, 95299, and 23296 monitor the ETPTS and downgradient portions of the plume along

South Walnut Creek. AOC well 00997, situated at the mouth of Pond B-5 in the South Walnut Creek drainage, also supports monitoring of this plume (as well as the Mound Plume, which is farther upgradient—west—of the East Trenches Plume). Well 00191 monitors groundwater closest to the source area of the 903 Pad Plume (a portion of which joins the East Trenches Plume) and is discussed in the context of the 903 Pad/Ryan's Pit Plume later in this section.

All of the East Trenches Plume Evaluation wells were scheduled for RFLMA sampling in 2014, as were the Sentinel wells and the AOC well. Source-area wells 3687 and 05691 were both sampled on May 6, 2014. Concentrations of the primary VOCs detected at these locations were consistent with historic results (Figure 195). Well 3687 continues to produce groundwater with higher concentrations of VOCs than does well 05691, and the TCE reported at the former well is present at much higher concentrations than any other VOC reported at either location (upper portion of Figure 195). Furthermore, when viewed using a logarithmic scale (lower portion of this figure), concentrations in well 3687 appear to be relatively stable or rising, while those in the latter well generally appear to be decreasing. These visual suggestions are confirmed by statistical calculations (Table 74): at well 3687, concentrations of 1,1-DCE and *cis*-1,2-DCE are on an increasing trend with a 95 percent level of statistical significance; at well 05691, decreasing trends of the same significance are calculated for carbon tetrachloride, chloroform, *cis*-1,2-DCE, PCE, and TCE. Data for 1,1-DCE are not illustrated on Figure 195 but can be seen on the statistical trend plots provided in Appendix B, along with all other trend plots and statistical summaries.

Evaluation well 03991 is located farther to the east (Figure 2), on the margin of the East Trenches Plume, and reports much lower concentrations of VOCs than are indicated in the source-area wells. The constituents most commonly detected are carbon tetrachloride, chloroform, PCE, and TCE. Concentrations reported in the sample collected in May 2014 were somewhat lower than usual, but still within the normal ranges at this well. The VOC reporting the highest concentration in this sampling event was carbon tetrachloride, at 3.7 µg/L. Since 2000, the only constituent to report concentrations exceeding 5 µg/L is carbon tetrachloride. Statistical trending calculations indicate decreasing trends having a 95 percent level of confidence for carbon tetrachloride, chloroform, PCE, and TCE. (The trend for chloroform is based on a dataset containing numerous nondetects, and might not be valid.) Refer to Table 74 for a summary of statistical trend results, and to Appendix B for the associated trend plots and statistical details.



Notes:

Upper and lower portions show same data, but upper portion uses linear concentration scale and lower uses logarithmic scale.

CT = carbon tetrachloride (RFLMA Table 1 standard = 1 µg/L); CF = chloroform (3.4 µg/L); PCE (5 µg/L); TCE (2.5 µg/L); c12DCE = cis-1,2-DCE (70 µg/L).

Figure 195. Concentrations of Primary VOCs in East Trenches Plume Source-Area Wells

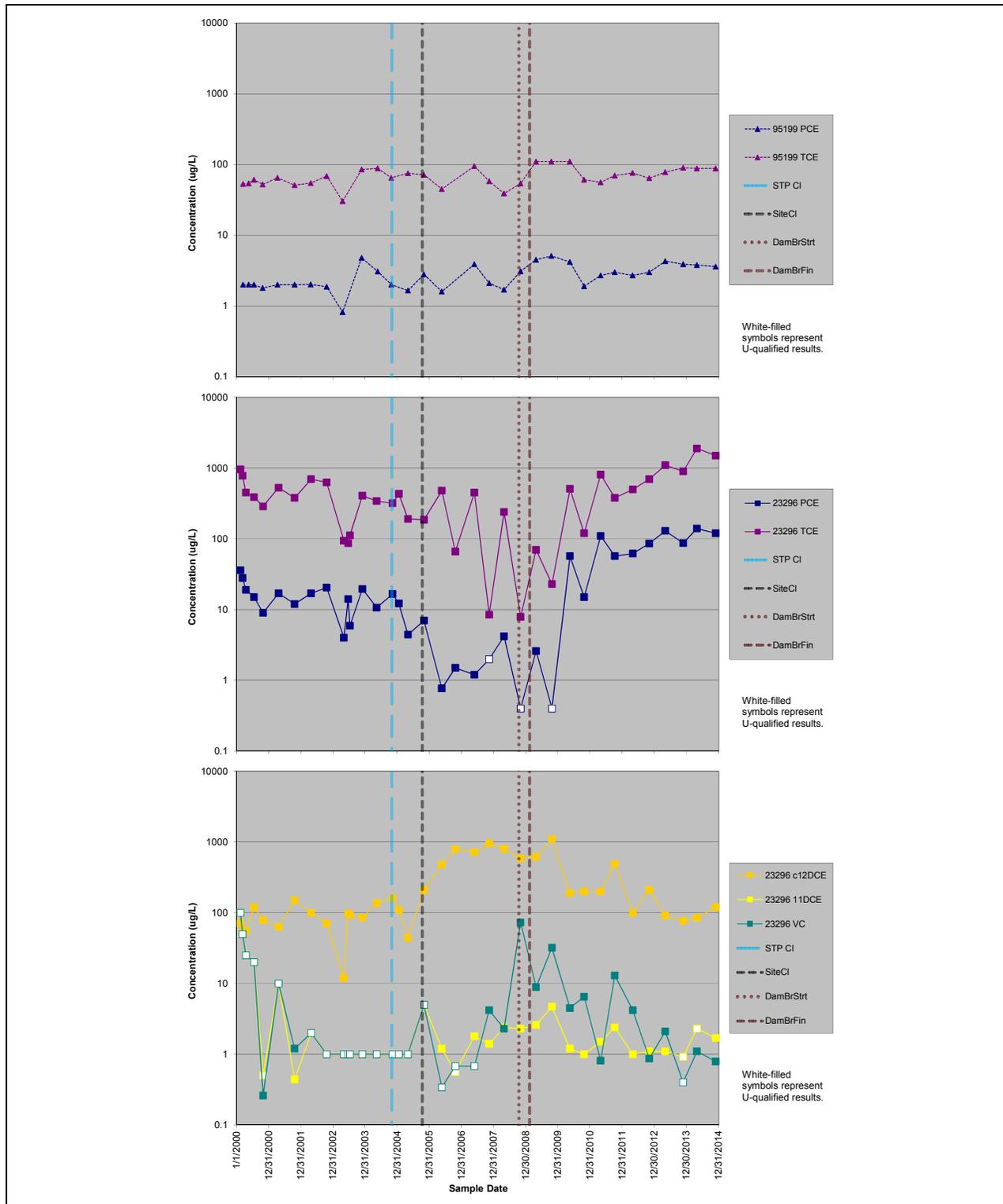
Sentinel well 04091 is located on the pediment edge farther to the east of the source area, and was sampled in May and December 2014. This well typically reports very low (<1 µg/L) concentrations of VOCs, most often carbon tetrachloride. No detections above RFLMA Table 1 values have been reported in the period of record (since January 1, 2000). The only VOC detected in the samples collected in 2014 was carbon tetrachloride, reported at estimated

(J-qualified) concentrations of 0.23 µg/L (May) and 0.21 µg/L (December). Until mid-2007, PCE was also detected here fairly regularly, also at very low (estimated) concentrations, but it has not been reported since May of that year. A decreasing trend having a 95 percent statistical significance is calculated for carbon tetrachloride at this well, but is based on a dataset containing numerous nondetects (and many estimated values) and therefore might not be valid. It remains to be seen whether the heavy precipitation of September 2013 will affect VOC concentrations reported at well 04091 and elsewhere in the East Trenches Plume (such as well 03991, discussed in the preceding paragraph).

The Sentinel wells sampled along South Walnut Creek in support of the East Trenches Plume and ETPTS showed water quality in 2014 that was fairly consistent with previous years but, as has been the case in recent years, included suggestions of patterns with uncertain causes. Well 95299, which is located near the western end of the ETPTS groundwater intercept trench, was dry; this has been the case for the entire period of record (since January 1, 2000) except for one occasion in 2006. (Even the floods of September 2013 did not translate to measurable water in this well.) RFLMA Table 1 standards were exceeded in samples from wells 23296 and 95199. As in previous years, the highest concentrations of VOCs were reported at well 23296.

Figure 196 displays several VOCs that are commonly detected in one or both of wells 23296 and 95199 at concentrations exceeding the corresponding RFLMA Table 1 standards: PCE, TCE, *cis*-1,2-DCE, 1,1-DCE, and VC. Concentrations of TCE and PCE at well 23296 in 2014 were the highest over the period of record (beginning in 2000); this had been the case with the results reported in the second quarter of 2013, but concentrations in second-quarter 2014 were higher yet. TCE was reported in the May sample at 1,900 µg/L and PCE in the same sample was at 140 µg/L. As shown on the figure, the second-quarter sample tends to contain a higher concentration than the fourth-quarter sample, and this has usually been the case since 2006, particularly for TCE. This may relate to closure of the Sewage Treatment Plant (STP) and removal from upper South Walnut Creek of the associated continuous water supply, which was replaced by natural flows of variably oxygenated waters as discussed in previous annual reports (e.g., DOE 2013a and 2014c).

The partially dechlorinated degradation byproducts, *cis*-1,2-DCE, VC, and 1,1-DCE, all appear to show occasional but inconsistent seasonal behavior in samples from well 23296. From about 2007 on, VC has shown generally higher concentrations in the fourth quarters, but that reversed in 2012. Concentrations of 1,1-DCE appear more randomly variable, as do those of *cis*-1,2-DCE.



Notes: Constituents and their respective, applicable RFLMA Table 1 values (ug/L; CDPHE et al. 2012): PCE, 5; TCE, 2.5; c12DCE = *cis*-1,2-DCE, 70; 1,1-DCE, 7; VC, 0.2. Several detections are qualified but for simplicity are not shown differently. Note use of logarithmic concentration scales. DamBrStrt and DamBrFin = start and finish, respectively, of the project that breached the B-1, B-2, B-3, and B-4 dams on South Walnut Creek. Site CI = closure of the Site. STP CI = approximate closure date of former Building 995, the Sewage Treatment Plant (STP).

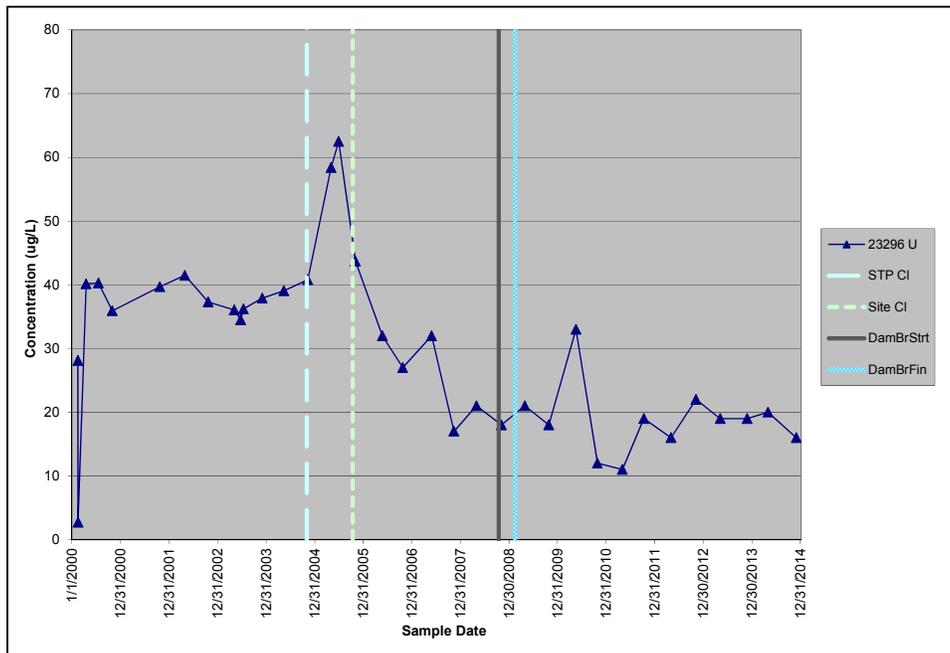
Figure 196. Most Commonly Detected VOCs in Sentinel Wells Downgradient of the ETPTS

The central portion of Figure 196 shows that variable but generally lower concentrations of parent VOCs (PCE and TCE) were detected at well 23296 between closure of the STP and shortly after the dam breaches were completed. Since then, PCE and TCE concentrations have been more consistent and have increased to the point that both are now detected at concentrations above those prior to closure. Concentrations of the daughter products have generally showed less variability, and with respect to *cis*-1,2-DCE were higher during the period between removal of the STP and completion of the dam breach activities. The concentrations of other daughter products, 1,1-DCE and VC, appear to have increased erratically over the period of record. These latter two constituents were not often detected prior to Site closure, but have been detected fairly consistently since then. Changes to the detection limits challenge this interpretation, given that the detection limit for 1,1-DCE has decreased from 100 µg/L in 2000 (the first point on Figure 196, a nondetect) to less than 1 µg/L most often in recent years. The highest reported detection of this constituent was measured at 4.7 µg/L in late 2009, and it was detected only once before the site closed (0.44 µg/L in late 2001). The same issue applies to the data for VC. Since the B-Pond dams were breached in winter 2008–2009, an apparent relationship has existed between the concentrations of parent compounds PCE and TCE, which have been increasing, and those of daughter products *cis*-1,2-DCE and VC, which have been decreasing. This suggests a slowing of VOC degradation since that time, but other mechanisms may be involved. Well 23296 will continue to be monitored, and with additional data any broader patterns may become more clear.

At well 95199, only PCE and TCE are detected at elevated concentrations (top portion of Figure 196). As in previous years, in 2014 only TCE exceeded its RFLMA value at this location, being reported at 88 µg/L in both the May and December samples. *cis*-1,2-DCE is consistently detected in samples from well 95199, but at much lower concentrations that are well under the RFLMA Table 1 value of 70 µg/L. Even so, concentrations of this constituent are increasing, and the highest in the period of record was reported in the fourth quarter of 2014, 6.5 µg/L.

Refer to the 2013 Annual Report (DOE 2014c) for additional discussion of these two wells and possible mechanisms related to the variations seen in VOC concentrations.

Samples collected from well 23296 are also analyzed for uranium. A time-series plot of this constituent is provided below as Figure 197. The available data suggest a fairly uniform concentration of uranium prior to closure of the STP (aside from an early outlier), with concentrations generally in the mid-30 to 40 µg/L range. Concentrations peaked immediately after the STP was removed, then decreased following Site closure and appear to have stabilized in recent years in the 10–20 µg/L range. More data will be required to determine whether this truly represents stabilization of uranium concentrations at this location.



Notes:

Applicable RFLMA value for uranium (µg/L; CDPHE et al. 2012) is the groundwater threshold of 120 µg/L.

STP CI = approximate closure date of former Building 995, the Sewage Treatment Plant (STP). Site CI = closure of the Site. DamBrStrt and DamBrFin = start and finish, respectively, of the project that breached the B-1, B-2, B-3, and B-4 dams on South Walnut Creek.

Figure 197. Concentrations of Uranium in Samples from Well 23296

As noted above, *cis*-1,2-DCE is increasing at well 95199. This trend is calculated to have a statistical significance of 95 percent, as do increasing trends in 1,1-DCE, PCE, and TCE at this well. Roughly three quarters of the detections of 1,1-DCE are J-qualified (estimated concentrations), and several nondetects are also present in the dataset. Additional, unqualified data would help to confirm the validity of this trend. The trend plots and summary statistical information are provided in Appendix B.

Concentration trends having a statistical significance of 95 percent are also calculated for well 23296. Increasing trends are calculated for 1,1-DCE, *cis*-1,2-DCE, and VC; and decreasing trends are calculated for carbon tetrachloride and uranium. Note that the trends for 1,1-DCE, carbon tetrachloride, and VC are based on datasets containing numerous nondetects, and therefore the corresponding trends may not be valid.

AOC well 00997 is located near the inlet to Pond B-5. This well was sampled twice in 2014 (May and December). All constituents were below their respective RFLMA values. Two VOCs were detected in the May sample: 1,3-dichlorobenzene (1,3-DCB) at an estimated (J-qualified) concentration of 0.13 µg/L, and chloroform at an estimated concentration of 0.27 µg/L. The May sample also reported 3.8 mg/L nitrate, while the December sample contained 0.52 mg/L. U was reported at concentrations of 36 µg/L in May and 30 µg/L in December. While U at this location has been reported at concentrations as high as 46.5 µg/L (2005), this constituent is usually reported at about half the 2014 concentrations. The relatively higher concentrations detected in

2014 may be a result of the extreme precipitation in September 2013. This event provided an unusually large volume of recharge to the groundwater regime, and led to a prolonged and higher-volume period of groundwater discharging to the surface water. As the site groundwater tends to contain higher concentrations of uranium than surface water, this discharge also contributed more uranium to the surface water. A report on the recent geochemistry study is being produced and predicts just such a response.

East Trenches Plume groundwater will continue to be monitored in accordance with RFLMA. As more data are collected, additional patterns and significant trends should become evident.

East Trenches Plume Treatment System

The ETPTS was installed in 1999. Its design is very similar to that of the MSPTS, but the intercept trench for the ETPTS is 1,200 feet long, compared to the 220-foot-long MSPTS trench. The longer trench is required to intercept the broader East Trenches Plume as it flows toward South Walnut Creek and the former B-Series Ponds.

The ETPTS treated approximately 1,298,000 gallons of water in 2014. This is more than twice the volume of 2013 and only the second time since closure the system has treated more than 1 million gallons in a calendar year (Table 80). Similar to the volume treated in 2014 at the MSPTS, this is roughly half again as much as the annual post-closure average volume treated (Table 81).

Figure 198 presents a hydrograph showing ETPTS flow estimates since January 2000. (Refer to the 2009 Annual Report [DOE 2010a] for information on correction of anomalous flows previously reported for the year 2006). The higher flows in 2010, and the return to more typical flows in mid-2011, are clearly evident on this figure. So too are the lower flows in 2012, which continued through much of 2013. Only in late 2013, in response to the extreme precipitation that September, did flows increase, and those relatively higher flows persisted throughout 2014.

Figure 199 provides a hydrograph for CY 2014 for the ETPTS. This hydrograph clearly shows the continuing effects of the heavy rains the previous September.

The ETPTS influent and effluent locations were sampled four times in 2014: twice for routine RFLMA requirements (May and December), together with surface water performance location POM2, and two additional times (February and July) to check operation and effectiveness of the air stripper installed in 2013. This frequency was significantly reduced compared to 2013, when the ETPTS was sampled 22 times, because the decision had been made to replace the original air stripper via the ETPTS Reconfiguration Project. This project is discussed in greater detail below.

Table 80. Estimated Volumes of Water Treated by the ETPTS

Calendar Year	Annual Estimates of Volume Treated (gallons)	Estimated Cumulative Volume Treated (gallons)
2000	1,633,000	2,800,000
2001	1,900,000	4,700,000
2002	≤1,000,000	5,700,000
2003	2,100,000	7,800,000
2004	1,500,000	9,300,000
2005	1,800,000	11,100,000
2006	675,000	11,775,000
2007	951,000	12,726,000
2008	629,000	13,355,000
2009	406,000	13,761,000
2010	1,606,000	15,367,000
2011	890,000	16,257,000
2012	622,000	16,879,000
2013	604,000	17,483,000
2014	1,298,000	18,781,000

Notes:

Cumulative volume shown for 2000 includes water treated since system installation in 1999. Estimates for years 2000 through 2004 are compiled from K-H (2000a, 2000b, 2000c, 2000d, 2002b, 2003, 2005a, 2005b). Volumes are rounded.

Table 81. Average Volumes Treated by the ETPTS

Time Period	Average Volume Treated Per Year
Pre-closure, 2000–2005	1,655,500
Post-closure, 2006–2014	853,500

Notes:

Average volumes are rounded, and are based on estimates of volumes treated. Time periods shown include complete years, and do not correspond to exact date of closure: the pre-closure estimate spans January 1, 2000, through December 31, 2005, and the post-closure period begins January 1, 2006.

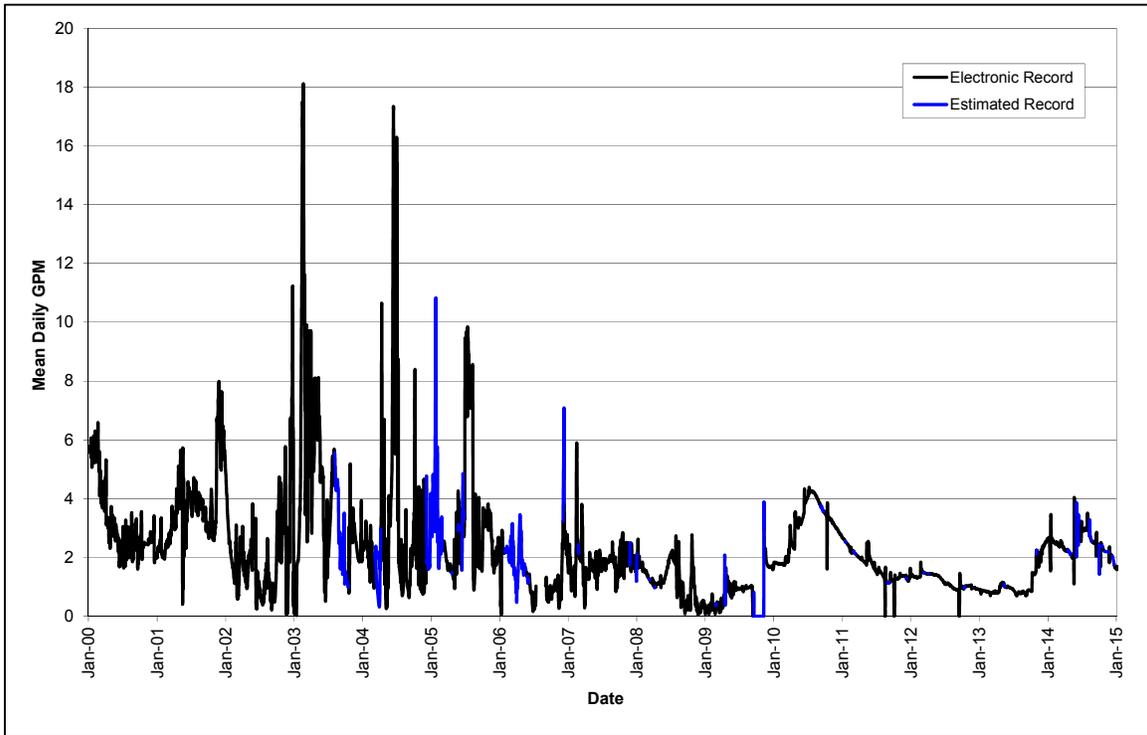


Figure 198. Hydrograph for ETPTS from 2000 Through 2014

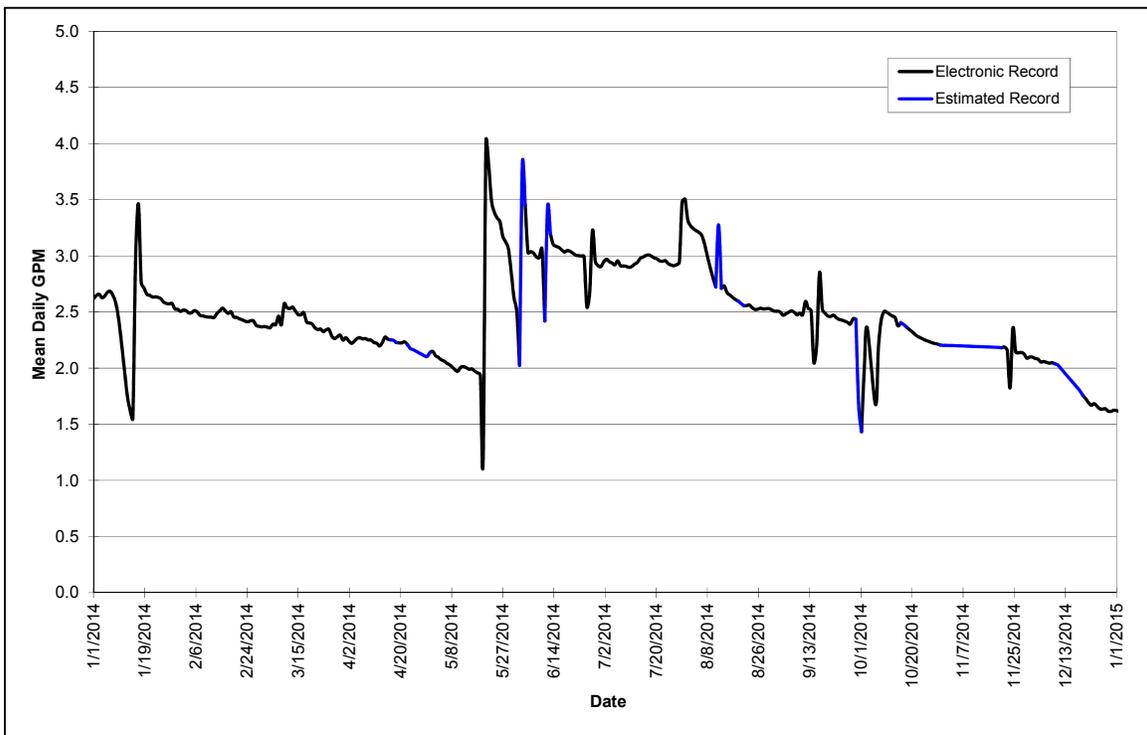


Figure 199. Hydrograph for ETPTS for CY 2014

ETPTS effluent water quality in 2014 continued to reflect a dramatic reduction in VOC load. However, VOCs were detected in the effluent, including some present at concentrations exceeding the respective RFLMA Table 1 values. This is consistent with the past performance of the ETPTS. VOCs have been routinely detected in ETPTS effluent since the system was installed in 1999 and have been reported and discussed as the data are issued. As discussed in the 2013 Annual Report (DOE 2014c), replacement of the ZVI media had been tentatively scheduled for the 2012–2013 time frame but was postponed in order to test air stripping at the ETPTS following successful early results at the MSPTS. Additional system reconfiguration planning at the ETPTS superseded any further ZVI media replacement activities. However, the condition of the ZVI media during this period was continually degrading and losing its treatment effectiveness.

A summary of the VOCs that most commonly exceed RFLMA Table 1 values in system influent, plus *cis*-1,2-DCE and VC as dechlorination-related constituents, is presented in Table 82; refer to quarterly reports (DOE 2014d, 2014e, 2015) and Appendix B.6 for additional analytical data from 2014. As with the MSPTS, S-K trending was used to evaluate ETPTS influent data; this is not required by RFLMA, but was conducted for informational purposes. Results having a 95 percent level of statistical significance (Table 74) for the entire period include increasing 1,1-DCE, *cis*-1,2-DCE, chloroform, and TCE. Decreasing trends in carbon tetrachloride and PCE are also suggested, but at less than 95 percent statistical significance. Refer to Appendix B for additional information and the trend plots.

As shown in Table 82, TCE is the VOC with the highest concentrations in ETPTS influent (and often in the effluent as well). Figure 200 illustrates this clearly, showing the primary VOCs in system influent and effluent in the upper portion, a sum of the concentrations of all detected VOCs in the middle portion (both on a linear concentration scale to provide perspective), and only TCE in the lower portion (using a logarithmic scale).

The top and bottom portions of Figure 200 show how variable influent concentrations of TCE can be, even over a very short period of time (see data for 2013 in particular; this is also evident on Table 82). Note also that in two of the samples collected in 2014 (May and December), influent concentrations of TCE were higher than ever before, except for a single anomalous result in 2004. Although the ETPTS continued to consistently remove the bulk of the VOCs from the influent, system reconfiguration began in 2014 to achieve better treatment and minimize wastes and long-term costs. One of the first activities in this project was to drain and remove the ZVI from the treatment cells; the start of this task is shown on the figure. After that point, treatment was performed only by the air stripper in the influent manhole. Refer to Section 2.4.2 for additional discussion on operation and maintenance of this system, and the separate discussion below on the ETPTS Reconfiguration Project.

Table 82. Summary of VOC Data (µg/L) for ETPTS Influent and Effluent

Date	CT		CF		MCI		PCE		TCE		cis-1,2-DCE		VC	
	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef
1/18/2000	200	2 (U)	110	15	48 (JB)	12 (B)	320	2 (U)	3500 (D)	1 (J)	29 (J)	32	100 (U)	0.9 (J)
2/9/2000	240	1 (U)	140	16	88 (JB)	19 (B)	360	0.3 (J)	3900 (D)	0.9 (J)	38 (J)	35 (E)	100 (U)	1
3/16/2000	250	1 (U)	130	6	75 (JB)	9 (B)	380	0.1 (J)	3300 (D)	0.3 (J)	36 (J)	12	100 (U)	1 (U)
4/17/2000	200	0.3 (J)	100	18	270 (B)	24 (B)	370	1	3000 (D)	2	27 (J)		100 (U)	1
5/17/2000	130 (J)	1 (U)	88 (J)	4	470 (B)	8	290	0.3 (J)	2800	0.3 (J)	24 (J)	10	200 (U)	1 (U)
6/13/2000	230	1 (U)	110	2	25 (BJ)	17 (B)	490	2	2700 (D)	1 (U)	30 (J)	17	100 (U)	0.8 (J)
7/18/2000	180	1 (U)	82	0.5 (J)	6 (BJ)	17 (B)	320	1	3000 (D)	0.3 (J)	23	11	20 (U)	0.6 (J)
8/8/2000	190	1 (U)	98 (J)	1 (U)	330 (B)	10 (B)	390	1	2900 (D)	1	26 (J)	8	100 (U)	0.5 (J)
9/22/2000	197 (D)	0.5 (U)	96.9	0.5 (U)	0.5 (U)	10.5	370 (D)	0.82	3230 (D)	1.1	29.3	5.5	0.5 (U)	0.5 (U)
10/25/2000	138 (D)	0.5 (U)	-N/A-	0.5 (U)	0.5 (U)	3.9	300 (D)	0.77	911 (E)	1.8	26.6	5.5	0.5 (U)	0.5 (U)
4/18/2001	160 (D)	1 (U)	79 (JD)	1 (U)	100 (U)	15	240 (D)	0.6 (J)	2900 (D)	1 (U)	100 (U)	5	100 (U)	1 (U)
10/25/2001	160	1 (U)	84	1 (U)	10 (U)	1 (U)	350	5.3	2500	0.66 (J)	32	6.6	10 (U)	1 (U)
4/24/2002	200	1 (U)	88	1 (U)	10 (U)	1 (U)	280	12	3200	3.9	35	20	10 (U)	1 (U)
10/22/2002	151	1 (U)	61.2	1 (U)	1 (U)	1 (U)	367 (D)	1.45	1880 (D)	1.02	20.1	0.34 (J)	1 (U)	1 (U)
4/17/2003	120	1 (U)	68	7.1	10 (U)	6.4 (B)	290	19	2000	60	28	36	10 (U)	1 (U)
9/3/2003	-N/A-	1 (U)	-N/A-	20	-N/A-	19 (B)	-N/A-	73	-N/A-	200	-N/A-	46	-N/A-	1 (U)
9/22/2003	-N/A-	0.561 (U)	-N/A-	7.53	-N/A-	11.7	-N/A-	57.3	-N/A-	77.4	-N/A-	32.3	-N/A-	1.4 (U)
11/13/2003	-N/A-	0.561 (U)	-N/A-	0.428 (U)	-N/A-	15.7	-N/A-	1 (J)	-N/A-	4.62	-N/A-	2.82	-N/A-	1.4 (U)
11/20/2003	160	1 (U)	73	1 (U)	6.7 (U)	17	380	1.3	2700	5.7	33	4.5	6.7 (U)	1 (U)
1/28/2004	130	1 (U)	71	1.1	5 (U)	20	290	0.93 (J)	2300	1.8	40	9.5	5 (U)	1 (U)
2/25/2004	150	1 (U)	71	1.4	2.7 (JB)	19 (B)	270	1.1	2400	2.5	40	10	10 (U)	1 (U)
3/22/2004	180	1 (U)	71	1	2.6 (JB)	21	270	1.2	2400	1.8	39	9.7	6.7 (U)	0.39 (J)
5/26/2004	216	1 (U)	65.1	1 (U)	1 (U)	17	618 (D)	3.38	5510 (D)	6.36	28	11.5	1 (U)	1 (U)
6/22/2004	130	1 (U)	59	1 (U)	6.7 (JB)	14 (B)	240	1.9	1900	1.8	29	8	10 (U)	1 (U)
7/29/2004	142 (D)	1 (U)	54.1	1 (U)	2.3	14.1 (B)	354 (D)	1.8	1960 (D)	0.69 (J)	29.4	7.7	1 (U)	1 (U)
8/19/2004	68.1	1 (U)	26.6	1 (U)	1 (U)	13.7	137 (D)	1.2	774 (D)	0.55 (J)	13.3	7.4	1 (U)	1 (U)

Table 82 (continued). Summary of VOC Data (µg/L) for ETPTS Influent and Effluent

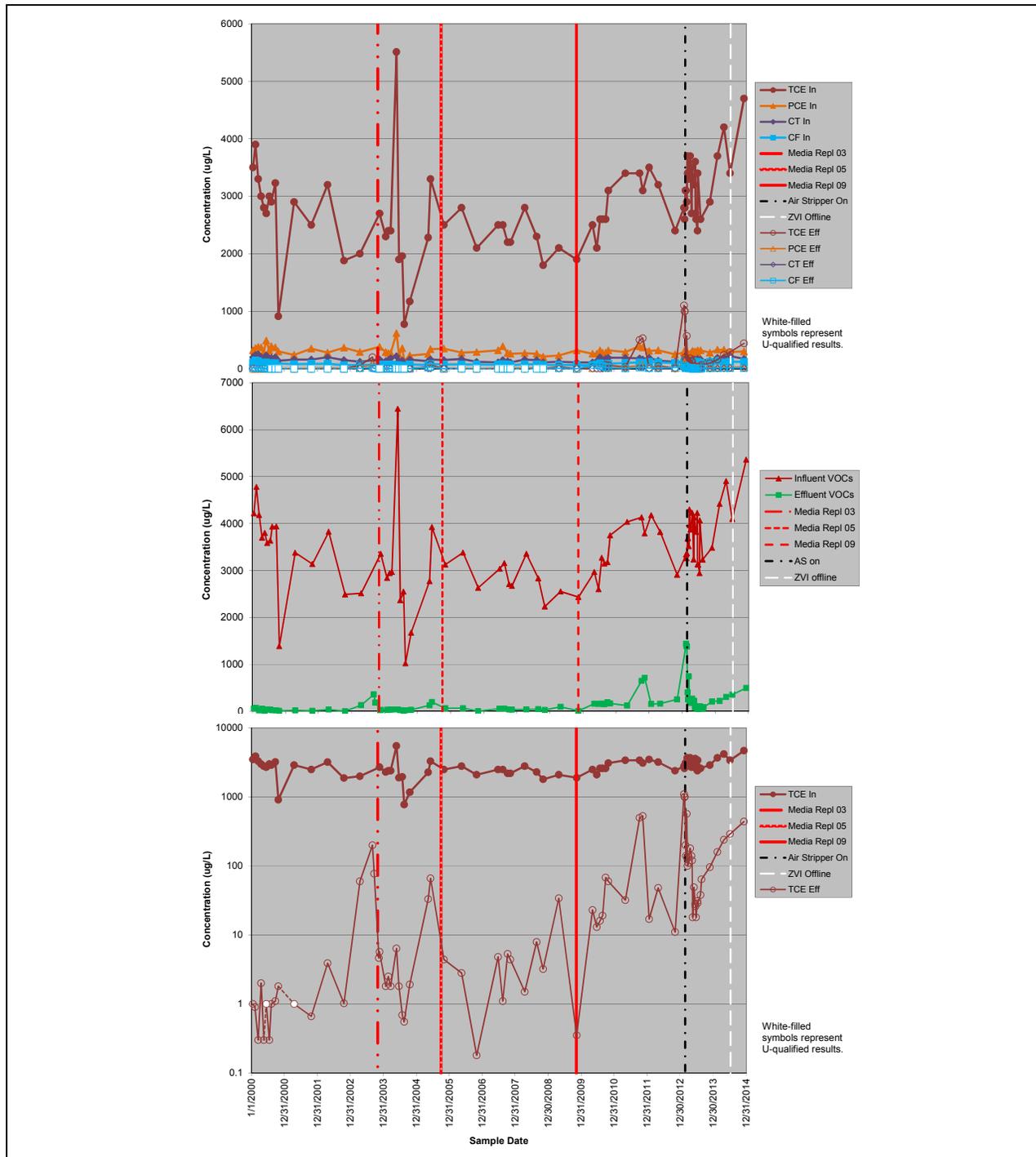
Date	CT		CF		MCI		PCE		TCE		cis-1,2-DCE		VC	
	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef
10/20/2004	160	1 (U)	72.9	2.56	1 (U)	15.6	230 (D)	2.13	1170 (D)	1.91	32.6	11.3	1 (U)	1 (U)
5/12/2005	131	1 (U)	66	22.2	1 (U)	14.6	256 (D)	21.9	2280 (D)	33.1	30.4	36.4	1 (U)	1 (U)
6/7/2005	160	1 (U)	81	30	10 (U)	22 (B)	340	36	3300	66	33	44	10 (U)	1 (U)
11/2/2005	151	1 (U)	74.8	0.73 (J)	250 (U)	18.2	350	1 (U)	2500	4.4	50.7	39.6	50 (U)	1.2
5/17/2006	170	0.23 (J)	75 (J)	1.9	0.32 (U)	32	280	4.1	2800	2.8	46	27	0.17 (U)	0.77 (J)
10/31/2006	120	0.19 (U)	75	0.16 (U)	6.4 (U)	0.32 (U)	290	0.85 (J)	2100	0.18 (J)	40 (J)	4.3 (J)	3.4 (U)	0.17 (U)
6/26/2007	110	0.19 (U)	70	0.16 (U)	1.6 (U)	0.32 (U)	320	9.7	2500	4.8	30	40	0.85 (U)	1.2
8/16/2007	150	0.19 (U)	81	0.16 (U)	8 (JB)	0.73 (JB)	390	4.4	2500	1.1	32	51	2.7 (U)	1.7
10/9/2007	130	0.19 (U)	71	0.25 (J)	3.2 (U)	1.7	270	9.5	2200	5.3	34	22	1.7 (U)	0.43 (J)
11/8/2007	110	0.19 (U)	64	0.16 (U)	3.2 (U)	0.32 (U)	260	9.1	2200	4.4	32	21	1.7 (U)	0.46 (J)
4/16/2008	160	0.19 (U)	78	0.16 (U)	36 (B)	1.5 (B)	270	7.3	2800	1.5	43	30	7.6 (U)	1
8/25/2008	150	0.19 (U)	77	0.16 (U)	1.6 (U)	0.89 (J)	260	17	2300	7.9	42	20	1.9 (U)	0.38 (U)
11/5/2008	110	0.19 (U)	66	0.16 (U)	9.7 (J)	0.88 (J)	210	10	1800	3.2	31	16	3.8 (U)	0.5 (J)
4/28/2009	120	0.19 (U)	68	6.7 (J)	8.9 (U)	4.5 (U)	230	11 (J)	2100	34	30	45	3.8 (U)	0.38 (U)
11/12/2009	110	0.19 (U)	63 (J)	0.23 (J)	0.32 (U)	6.3 (J)	320	0.2 (U)	1900	0.35 (J)	36	0.3 (J)	0.4 (U)	0.4 (U)
5/6/2010	110	0.19 (U)	62	63	2.3 (U)	8.2 (B)	260	10	2500	23	30	57	2 (U)	0.4 (U)
6/22/2010	130	0.19 (U)	70	64	2.1 (U)	8.4 (B)	260	14	2100	13	34	55	2.7 (U)	0.4 (U)
7/28/2010	200	0.19 (U)	95	57	3.7 (J)	15	320	20	2600	16	43	55	4 (U)	0.76 (J)
8/26/2010	140	0.35 (J)	78	39	5.8 (JB)	19 (B)	280	18	2600	19	37	56	4 (U)	0.4 (U)
9/29/2010	170	8.8	79	23	1.6 (U)	14	280	27	2600	68	39	50	2 (U)	0.4 (U)
10/28/2010	190	2.5	87	17	1.3 (U)	11	320 (*)	17	3100	60	44 (J)	59	1.6 (U)	0.84 (J)
5/5/2011	190	1.2	100	4.5	4.5 (JB)	1.6 (B)	290	27	3400	32	48	56	1 (U)	1.2
10/10/2011	180	21	110	23	3.2 (U)	3.9	390	56	3400	500	45	42	1 (U)	0.46 (J)
11/14/2011	160	21	100	21	3.2 (U)	5.7	370	63	3100	530	51	69	1 (U)	0.83 (J)
1/24/2012	190	0.19 (U)	120	12	6.7 (U)	8.5 (B)	310 (J)	22 (J)	3500	17	49	94	1 (U)	0.1 (U)
5/3/2012	140	1.3	110	7	3.2 (U)	2.3	320	27	3200	48	42	76	1 (U)	1.1
11/6/2012	120	0.19 (U)	100	22	3.2 (U)	2.3	250	7.4	2400	11	36	210	1 (U)	0.69 (J)
2/13/2013	110	36	100	41	1.6 (U)	1.8 (J)	280	95	2800	1100	43	160	0.5 (U)	1.6 (J)

Table 82 (continued). Summary of VOC Data (µg/L) for ETPTS Influent and Effluent

Date	CT		CF		MCI		PCE		TCE		cis-1,2-DCE		VC	
	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef	ET In	ET Ef
2/19/2013	160 (J)	50 (J)	130	49	3.2 (U)	2.1 (J)	310	110	2600	1000	50	180	1 (U)	2.2 (J)
2/22/2013	140 (J)	45 (J)	110	47	6.4 (U)	2.6 (J)	270	110	2800	1000	42	170	2 (U)	2 (J)
3/1/2013	130	5.1	120	15	3.2 (U)	2.3	270	28	3100	200	50	150	1 (U)	2.3
3/7/2013	130	3	110	9.9	3.2 (U)	0.65 (J)	290	17	3100	140	49	85	1 (U)	1.2
3/15/2013	150	23	120	24	1.6 (U)	0.99 (J)	290	53	2900	570	45	68	0.5 (U)	1.4
3/22/2013	170	3.4	120	8.8	3.2 (U)	1.2 (J)	250 (J)	14 (J)	3700	130	49	85	1 (U)	1.1
3/25/2013	130	2.6	100	7.4	3.2 (U)	0.32 (U)	280	16	3400	100	46	68	1 (U)	0.92 (J)
4/4/2013	150	2.4	120	7.4	3.2 (U)	0.32 (U)	250	11	3300	110	48	45	1 (U)	0.1 (U)
4/22/2013	120	3.8	100	11	3.2 (U)	0.73 (J)	260 (J)	17 (J)	3700	180	40	57	1 (U)	0.49 (J)
5/7/2013	120 (J)	3.5 (J)	100	9.2	6.4 (U)	0.46 (J)	270	15	2700	140	42	49	2 (U)	0.49 (J)
5/14/2013	150	3.8	120	9.8 (J)	0.32 (U)	2.3 (U)	300	19 (J)	3500	120	48	69	0.1 (U)	1.4
5/20/2013	150	0.26 (J)	120	1.8	6.4 (U)	1.6	310	7.4 (J)	3300	18 (J)	43	49	2 (U)	1.4
6/3/2013	160	0.19 (U)	120	0.38 (J)	3.2 (U)	0.32 (U)	290	18	3200	49	44	43	1 (U)	0.63 (J)
6/17/2013	150	0.19 (U)	120	0.4 (J)	3.2 (U)	0.43 (J)	300	16 (J)	3600	28	48	17	1 (U)	0.1 (U)
6/20/2013	95	0.19 (U)	100	0.37 (J)	6.4 (U)	0.32 (U)	200	15 (J)	2700	26	36	15	2 (U)	0.1 (U)
6/27/2013	110	0.19 (U)	90	0.54 (J)	3.2 (U)	1.4	270	13	2600	18 (J)	42	13	1 (U)	0.1 (U)
7/12/2013	120 (J)	0.19 (U)	91	5.6	6.4 (U)	11	290	19	2400	31	38	29	2 (U)	0.33 (J)
7/15/2013	170	0.19 (U)	120	4.3	3.2 (U)	13	320	19	3400	29 (J)	47	37	1 (U)	0.1 (U)
8/15/2013	160	0.78 (J)	100	2.5	3.2 (U)	0.32 (U)	320	6.5	2600	38	44	6.1	1 (U)	0.1 (U)
8/26/2013	-N/A-	2.6	-N/A-	4.1	-N/A-	0.32 (U)	-N/A-	12	-N/A-	64	-N/A-	5.7	-N/A-	0.1 (U)
11/26/2013	140	2.2	120	5.9	3.2 (U)	1	280	23	2900	96	37	80	1 (U)	0.49 (J)
2/18/2014	190 (J)	2.6	140	11	6.4 (U)	0.32 (U)	330	21	3700 (J)	160	47	29	2 (U)	0.43 (J)
5/1/2014	200 (J)	7.7	120	15	20 (U)	0.32 (U)	330	25	4200	240	44	19	1 (U)	0.1 (U)
7/8/2014	220	12	120	14	3.2 (U)	0.32 (U)	290	24	3400	290	54	16	1 (U)	0.1 (U)
12/9/2014	170	12	120	13	3.2 (U)	0.32 (U)	300	26	4700	440	62	6.5	1 (U)	0.1 (U)

Notes:

Constituents and their respective, applicable RFLMA levels (µg/L; CDPHE et al. 2012): CT = carbon tetrachloride, 1; CF = chloroform, 3.4; MCI = methylene chloride, 4.6; PCE, 5; TCE, 2.5; cis-1,2-DCE, 70; VC, 0.2. ET In = influent (ET INFLUENT), ET Ef = effluent (ET EFFLUENT). Shaded, bold value indicates detected concentration exceeds corresponding RFLMA standard. Lab qualifiers: J = estimated value; U = analyte not detected at the indicated concentration; B = constituent was also detected in the blank; D = analysis was performed at a dilution (a qualifier no longer used). N/A = data not available or acceptable (rejected).



Notes:

Top portion shows primary VOCs and the middle portion shows all detected VOCs in ETPTS influent and effluent, with both charts using a linear concentration scale. Bottom portion illustrates TCE only using a logarithmic scale.

Constituents and their respective, applicable RFLMA levels (µg/L; CDPHE et al. 2012): TCE, 2.5; PCE, 5; CT = carbon tetrachloride, 1; CF = chloroform, 3.4. “In” after a constituent denotes this is the concentration in ETPTS influent, “Eff” indicates it is in the effluent. “Media Repl <year abbreviation>” = year in which complete media replacement was performed. Other attempts to restore media effectiveness prior to closure are not illustrated; see previous annual reports (e.g., DOE 2011) and treatment system reports (e.g., K-H 2005b) for related information. “Air Stripper On” indicates when that component was activated in the influent manhole. “ZVI Offline” indicates when the ZVI-filled treatment cells began to be taken offline. Several detections are qualified but are not shown differently for the sake of simplicity.

Figure 200. VOCs in ETPTS Influent and Effluent

The performance monitoring location for the ETPTS is POM2, which is located in former Pond B-4. Sampling at this location in support of the ETPTS began in 2005. The location was visited twice in 2014 for sampling, in May and December. *cis*-1,2-DCE and TCE were detected in one or both sampling events (Table 83), but none of the results exceeded the corresponding RFLMA Table 1 values. Each of these constituents has been detected in the past, as has chloroform. No VOCs have ever been measured at concentrations exceeding their respective RFLMA standards at POM2.

Table 83. Summary of VOCs Detected in 2014 at POM2

Date	Constituent	Result (µg/L)	Qualifier
5/2/2014	TCE	0.23	J
12/9/2014	<i>cis</i> -1,2-DCE	1.2	
12/9/2014	TCE	1.2	

Notes: RFLMA Table 1 value for *cis*-1,2-DCE is 70 µg/L and for TCE is 2.5 µg/L.

East Trenches Plume Treatment System Reconfiguration Project

This section describes the ETPTS Reconfiguration Project first introduced in the 2013 Annual Report (DOE 2014c). Following discussion of this project, a summary of data from the former air stripper, installed in the ETPTS influent manhole in 2013, is provided.

Reconfiguration of the ETPTS came about following installation and testing of the air stripper built within the influent manhole in 2013, which was based on a similar unit installed within the effluent manhole at the MSPTS. However, accumulations of hard-water scale in the pump, piping, and nozzles required frequent and extensive maintenance to keep this ETPTS unit operating properly. (This is not the case with the MSPTS unit, since it is situated downstream of the ZVI-based treatment, which removes the bulk of the ions associated with hard-water scale.) Despite efforts to mitigate the effects of the hard water and reduce maintenance, for example by incorporating pumps that are more capable of handling solids (such as hardened fragments of scale precipitates) and spray nozzles with larger orifices to allow solids to pass, processing the very hard groundwater continued to cause clogging that could only be addressed via extensive and difficult maintenance. (Addition of a sequestering agent to chelate dissolved ions such as calcium and magnesium, thereby reducing or eliminating the associated precipitates, was considered but not tested. Using these chemical additives would represent additional cost, complexity, maintenance, and environmental effects—all of which might be successfully overcome, but the goal was to identify a simpler approach, if possible.)

While these hard-water issues posed significant problems to the air stripper, one of the primary objectives for this unit was to support the evaluation of whether air stripping might be a feasible long-term alternative to ZVI-based treatment. Analytical data and other information indicated the answer was yes, air stripping alone might be a feasible alternative.

The analytical data supporting this determination was collected from monitoring locations supporting the air stripper within the ETPTS influent manhole. Other critical information was provided by vendors of commercially available air strippers.

One of the most critical factors in the consideration of commercial air strippers—if not the most critical—is the fact that line power is not available at Rocky Flats. This has been pointed out in the past, but bears repeating as it represents a constraint that renders impossible many otherwise attractive off-the-shelf approaches to water treatment. Anything that requires electrical power to operate must be adapted to solar/battery power or a generator. (Wind energy is sometimes suggested, but winds at the site are erratic and not suited to reliable power generation.) Using a generator to operate a treatment system would not be optimal due to the need to refuel and maintain the generator and equip it with sufficient secondary systems to prevent or minimize problems in the event of mishap, whether fuel leaks or malfunction.

Installing a full-scale, commercial air stripper that operates “off the grid” using only solar/battery power was feasible because the ETPTS influent flow rate is very low (the overall, multi-year average since closure has averaged in the 1.5 gpm to 2 gpm range), the cost of solar power has dropped sharply in recent years, and the manufacturer of the selected air stripper was willing and able to provide design adjustments to fit the Rocky Flats application. The low flow rate enables the air stripper to operate in batch mode, rather than continuously. Continuous operation would require so much more power than is currently available at the ETPTS that even with today’s lower cost for solar photovoltaic (PV) equipment it would not be feasible. In addition, the expertise required to assess the appropriateness of, and adapt, an “off-the-shelf” air stripper to the Rocky Flats application was substantial, requiring evaluation of water flow rates, influent concentrations of VOCs and hardness-related constituents, site altitude, temperature variability, spatial constraints, electrical and energy constraints, budgetary constraints, required accessories (e.g., pumps), desired automation features, and more. Requests for interest were distributed to various manufacturers of commercial air strippers, and of the few that responded favorably only one was able to confirm their equipment could be adapted to the ETPTS application. This firm then supported the reconfiguration project by working closely with the project team to refine the design of the air stripper itself so that it could be used in this application.

As described in the 2013 Annual Report (DOE 2014c), design of the reconfigured ETPTS was begun in late CY 2013. The design was completed in late January 2014. Following procurement of the air stripper and, separately, a construction subcontractor, field work began on August 19, 2014. Several adjustments to the design were made, most notably to address poor-quality soils that would not provide adequate structural support to the enclosure that would house the commercial air stripper. The end result was to remove the pre-existing vault on which the enclosure was to be built, overexcavate in the immediate area of the structure, construct a more appropriate sub-grade using structural fill, and build a simpler and shallower foundation for the enclosure. In addition, because shallow groundwater entering the excavation caused some of these issues for a short time, a drainage collection pipe and riser were installed to allow the excavation to be dewatered to support construction. This groundwater was no longer present even before the collection pipe and riser were installed, but the collection components were retained—and are still present—in case they are needed in the future for some reason. These soil-related adjustments (including overexcavation, structural fill, drainage collection features, and foundation revisions) were made at the recommendation of and in consultation with a qualified geotechnical engineer to ensure the finished product is robust and long-lived.

These design adjustments prolonged the construction effort. Originally scheduled to be completed in CY 2014, the reconstruction project was instead completed in January 2015.

Although that technically falls outside the scope of this 2014 Annual Report, some early information from the operation of this reconfigured system is provided in this section.

Reconfiguration of the ETPTS did not affect the groundwater intercept trench located generally west of the influent manhole. The manhole itself was also unaffected, except for the removal of the previous air stripper and related items (e.g., pump and powered ventilation). Similarly, the effluent manhole was not affected by this project, nor was the discharge gallery.

Most of the work comprising the ETPTS Reconfiguration Project focused on the former treatment cells (Cell 1 and Cell 2), the former “metering vault,” the piping in the immediate vicinity of these components (including that within the “flow configuration vault”), and the solar/battery power facility (the “solar conex”).

- All ZVI was removed from the two treatment cells. This material was sampled to support waste disposal decisions and packaged for later disposition.
- Cell 1 was adapted to act as—and is now referred to as—the Influent Tank.
- Cell 2 was similarly adapted and renamed the Effluent Tank.
- Both tanks were stabilized and strengthened to resist shifting (e.g., due to buoyancy) and deformation (due to their high-density polyethylene [HDPE] construction). Primary methods included constructing reinforced concrete floors in each, with a welded HDPE liner within the floors to further resist leakage; and construction of galvanized steel support structures that line the walls within each tank. The concrete floors act as ballast as well as protect the HDPE bottoms of the tanks, and the steel structures help keep the walls of these plastic tanks from collapsing.
- The metering vault was removed, as noted above.
- The flow configuration vault was left in place. This vault holds piping and flow meters that support operation of the system.
- The influent line from the groundwater intercept trench was cut where unnecessary 90-degree bends were present immediately south of the Influent Tank, and a more direct line was installed.
- Additional solar PV capacity was installed adjacent to the solar conex, and comprises the four PV panels installed at the MSPTS in 2011 for the prototype air stripper that operated part-time. These four panels were mounted on a pole and the electricity generated is fed to the solar conex.
- The power that is available from the solar conex was revised from 72 volts direct current (72V DC) to the three-phase, 208V AC required to run the commercial air stripper. A portion of the 208V alternating current (AC) is transformed back to 12V and 48V DC at the enclosure to power monitoring and telemetry equipment.
- A power-input connection was installed on an outside wall of the solar conex to allow a generator (of suitable three-phase, AC power configuration) to be connected to the power supply conex in case additional power is required. (For example, if existing power was unable to operate the air stripper for long enough to treat available groundwater, a generator could be rented and plugged in to the solar conex to boost available power.)

- A shallow trench was dug along the existing dirt road, and conduit was laid from the solar conex to the new enclosure. Power and data lines were fished through the conduit. Pull boxes were installed in case troubleshooting or line addition/replacement is required.

During construction of the project, there was an extended time during which water was not routed through ZVI for treatment because that ZVI had been removed from the treatment cells and would not be replaced. However, the air stripper in the influent manhole remained in operation. This component treated collected influent throughout the construction effort, with the exception of a few instances in which flow was either stopped and stored in the trench or was directed to the effluent manhole without treatment. These latter instances were minimized through careful management of the construction schedule, in accordance with Contact Record 2014-04.

At the end of CY 2014, the ETPTS Reconfiguration Project was almost finished. Formal completion was achieved on January 23, 2015, with receipt of analytical data showing the air stripper met all RFLMA water quality targets. In all, three sets of influent and effluent samples were collected before completion was declared. The first set, collected on January 14, 2015, reported effluent containing 2.8 µg/L TCE (the RFLMA Table 1 standard is 2.5 µg/L). Minor adjustments were made and a second set was collected on January 21, 2015, but concentrations of TCE in this sample still exceeded the RFLMA value. The blower speed was then increased (resulting in a higher air flow rate through the air stripper trays) and another set of samples was collected later on January 21, 2015. The concentration of TCE in the effluent in this third set was reported at 2.0 µg/L. All other Table 1 constituents analyzed in the three effluent samples met the associated RFLMA standards. The blower speed was left at the higher setting and the system has been operating automatically since then. (Although the ETPTS is not scheduled for routine RFLMA monitoring until the second quarter of 2015, a subsequent round of samples was collected in February 2015 that confirmed all standards were still being met.)

Minor activities remained to be completed following the receipt of the January 2015 sample data, such as finalizing erosion controls and revegetation, and addressing remaining punch-list items.

The overall operation of the reconfigured ETPTS is relatively straightforward. Groundwater that is intercepted by the ETPTS groundwater intercept trench is piped to the Influent Tank. The untreated water accumulates in this tank. Once conditions are met—including (a) sufficient power, (b) sufficient water, (c) temperatures within nominal operating range, and (d) timer setting allows operation—the air stripper begins its startup process (pre-warming the blower motor and control panel) and then water treatment begins. A pump within the Influent Tank delivers water to the air stripper at approximately 13.6 gpm; the air stripper treats this water, which then drains to the Effluent Tank. The air stripper continues to operate until any of the four listed conditions is no longer met, and then the unit begins its shutdown process and deactivates. Meanwhile, when conditions are met in the Effluent Tank—(a) sufficient power and (b) sufficient water—the effluent pump activates and discharges water to the subsurface discharge gallery via the effluent manhole. This pump operates at approximately 5 gpm, which is more appropriate for the discharge gallery than the 13.6 gpm flow rate of the influent pump. During its first few weeks of operation, these various constraints combined with groundwater availability in winter 2014–2015 led to the system treating volumes of approximately 2,400 to 2,800 gallons per day. The influent pump and air stripper were active over these first weeks for about 3 hours, from 10 a.m. until about 1 p.m., and the effluent pump operated from about

11:30 a.m. or noon until around 11 p.m. or midnight. As groundwater flows vary, the volume of water that is treated each day and the duration each pump operates will vary as well.

The power facility has sufficient capacity to activate and run the air stripper and associated components even during cloudy or dark conditions. However, the timer is currently set to activate the unit only during daylight hours (currently, 10 a.m. until the water level falls to the low-level switch) to take advantage of the solar conditions. This can be adjusted, as can the levels of the various switches within the Influent and Effluent Tanks. As operating experience is gained, these settings will be optimized as necessary.

The temperature settings can be more relaxed, because the thermal capacity of water is so much greater than that of air. Even if the temperature of the air blowing through the air stripper is well below freezing, the relatively warmer groundwater (which remains fairly constant and is typically in the range of about 50 to 55 °F) will not freeze during its pass through the air stripper. Even so, to help minimize the potential for freezing conditions, two solar thermal panels were installed on the roof of the air stripper enclosure to help condition the air temperature within the structure. This structure was also designed to passively benefit from geothermal heat through its open floor.

The system incorporates additional automation relating to upset or anomalous conditions. This includes shutoffs that would be triggered under certain conditions. For example, if water in the Influent Tank reaches a level that is too high, an automatic valve on the influent line will shut and influent will then be stored within the groundwater intercept trench until the air stripper has processed the influent held in the tank. The same occurs if the Effluent Tank water level reaches a similarly high level, so that the tank will not overflow. In case this automatic valve fails to activate, an emergency overflow drain is present to route water to the discharge gallery. If power levels are insufficient to operate the air stripper, it will not run. The tanks have sufficient volume to accommodate more than one day's influent (depending on influent flow rates), and because various data are available via telemetry (including water levels in the tanks and influent flow rate), personnel have time to respond to such conditions—for example, by plugging a generator into the solar conex to boost available power. The air stripper will shut down if back pressure reaches a sufficiently high level, indicating the trays are clogged (e.g., with scale). So far, scale formation related to the hard water has not posed problems, but routine maintenance activities will include checking and cleaning (if necessary). Various upset conditions can trigger delivery of an “alarm” text to staff, alerting them to the need to respond to the ETPTS for urgent troubleshooting or maintenance.

Samples for analysis to evaluate air stripper performance can be collected from the influent and the effluent pipes at the air stripper. Samples can also be collected within the flow configuration vault (farther from the air stripper; the influent water would be the same as that collected at the air stripper, but the effluent would represent a composite of the water in the Effluent Tank). RFMLA-required samples will continue to be collected from the influent and effluent manholes (locations ET INFLUENT and ET EFFLUENT, respectively).

Figure 201 illustrates the evolution of the air stripper approach to treating the VOC-contaminated groundwater at the ETPTS. Figure 202 provides several before/after photographs from the ETPTS Reconfiguration Project, and Figure 203 focuses on different aspects of the project.



Notes:

Clockwise from top left: (1) Initial field test in 2010 at the MSPTS used a handheld photoionization detector to determine whether VOCs moved from the liquid phase (MSPTS influent) to the air phase within a plastic tub, using a landscaping mist nozzle and a garden-fountain pump to perform the aeration; (2) initial spray-aeration testing in the MSPTS effluent manhole before the prototype unit was installed in 2011; (3) the “medusa” array of ten spray nozzles mounted in the ETPTS influent manhole in 2013; and (4) the enclosure housing a commercial air stripper, the primary and most visible component of the ETPTS Reconfiguration Project. Refer to previous annual reports (i.e., DOE 2011, 2012, 2013a, 2014c) for additional information on these successive developments.

Figure 201. Evolution of the Air Stripper Approach at Rocky Flats



Notes:

Top and middle left show the ETPTS treatment cells, vaults, and effluent manhole prior to the reconfiguration project; top and middle right show the same areas after the project was completed (except for minor punchlist items). The bottom photo shows the same features as the middle-right photo, but with the enclosure doors open to show the new air stripper.

Figure 202. ETPTS Reconfiguration Project: Before and After Photographs



Notes:

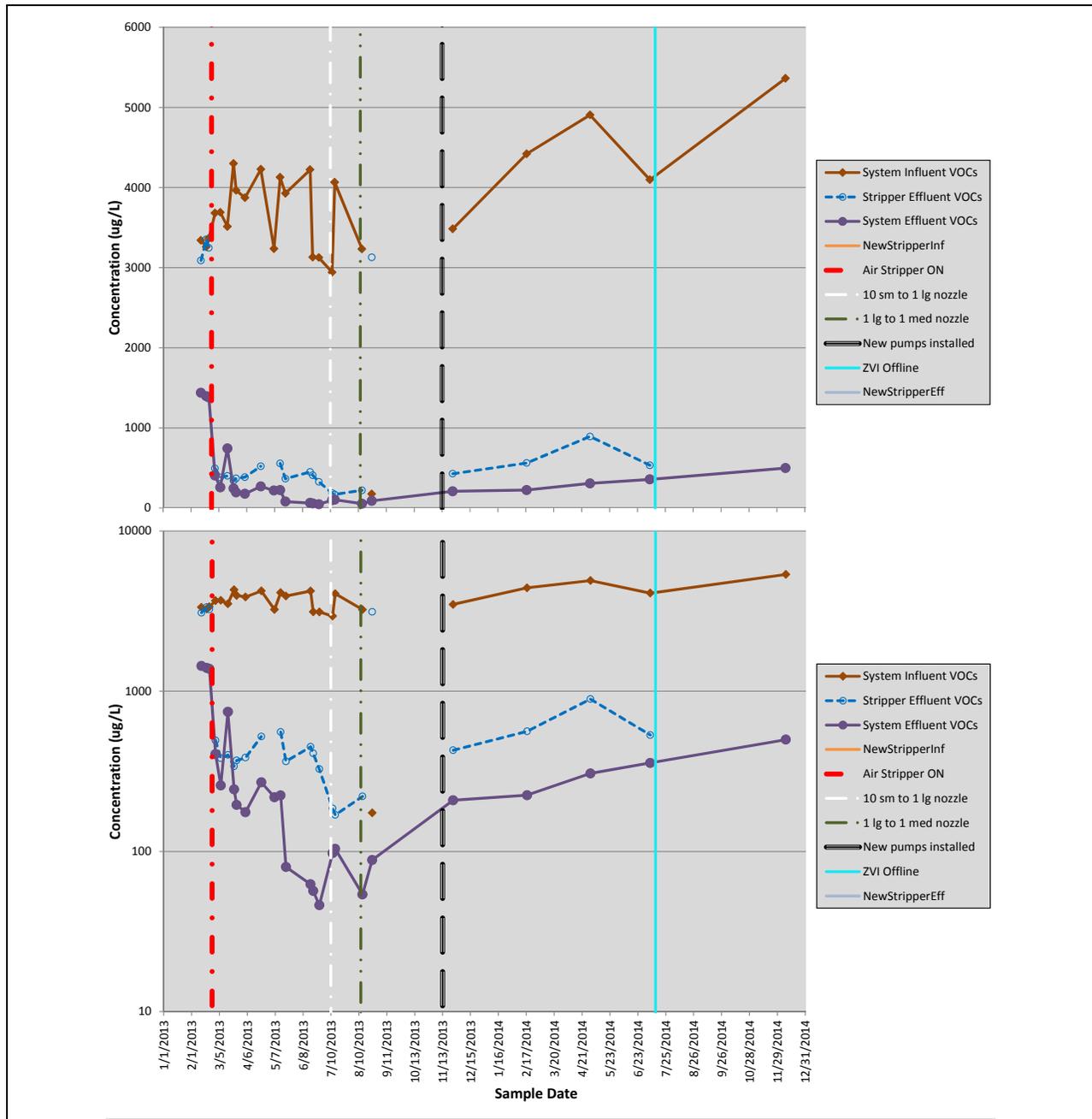
Top and second row, left to right: Rebar installed in bottom of emptied HDPE tank (former ZVI-filled treatment cell); first pour of concrete in HDPE tank; rebar constructed over HDPE liner that was welded to the interior of the tank, above the first concrete pour; second pour of concrete; structural steel framework being constructed within the tank to help the walls resist collapse from sidewall forces; the final constructed framework and water starting to collect in bottom of Influent Tank, with pump and several float switches waiting to be placed in operational positions. **Third row, left:** Foundation of air stripper enclosure completed, following extensive redesign (including removal of the pre-existing vault) due to poor-quality subsurface soils. A groundwater drain and collection system was installed (pipe rising vertically in lower left portion of photo) in case saturated conditions continued to cause construction problems; they did not, but this feature was retained in case of future need. **Third row, right:** the air stripper enclosure being framed, with south-facing (left side) roof angled for better solar exposure. **Bottom row, left:** the solar/battery conex after completion, with small pole-mounted array that was added to bolster available power. **Bottom row, right:** Waste ZVI from the two treatment cells. This amount of waste was previously generated approximately every three to four years (and had to be replaced with an equivalent amount of fresh ZVI), but will no longer be generated at the ETPTS.

Figure 203. ETPTS Reconfiguration Project: Photographs Showing Selected Components

The annual report for 2013 (DOE 2014c) provides extended discussion, along with photographs and time-series plots of analytical data, related to the air stripper installed that year in the influent manhole. This air stripper continued to be maintained and operated (as summarized in Section 2.4.2) throughout 2014, and assisted the aging ZVI in treating VOCs in the ETPTS influent.

As described in that 2013 report, this “original” air stripper posed significant maintenance challenges due to the very hard water at Rocky Flats (a natural condition having nothing to do with the former weapons-related mission). Maintenance efforts at the ETPTS were essentially all directed at removing hard-water scale or trying to reduce its impacts on various components. These efforts included using a single, large-orifice spray nozzle instead of ten narrow-orifice nozzles, thereby reducing the potential for the nozzle component to clog with scale particles. Two variants of these single nozzles were tested separately. Another change made for the same reason was to replace the centrifugal pump, which had been selected because of its successful operation at the MSPTS, with a helical pump that would more easily pass particulates (e.g., scale). The helical pumps produced lower flows, so two were installed in place of the single centrifugal pump. Both of these changes helped to reduce maintenance, but not significantly; the scale that was forming was so abundant as to nearly completely clog 2-inch-diameter hoses and pipes, and to do so repeatedly, requiring periodic disassembly and acid baths to clear the clogs.

Figure 204 illustrates the final data from the “original” air stripper installed in the ETPTS influent manhole. The data on the far left in these time-series plots represent samples collected prior to the installation of the air stripper. Comparing these “baseline” data with those collected after the air stripper was installed allows one to assess treatment improvements related to addition of this component. The most recent data points shown on this figure represent samples collected in December 2014, when only the original air stripper was operating to treat water (see Contact Record 2014-04 for details on water management during the Reconfiguration Project). In fact, one of the two helical pumps malfunctioned in November, so the air stripper at the time of this sample was only operating at about half its former capacity. Despite the lack of ZVI, the treatment effectiveness using only the air stripper in December 2014 was better than it had been before the air stripper was installed in 2013 using only ZVI. This is a further indication of the effects of passivation on the treatment effectiveness of ZVI.



Notes:

Upper and lower portions show same data, but upper portion uses linear concentration scale and lower uses logarithmic scale. Data represent sum of detected concentrations for ETPTS influent (location ET INFLUENT), water that has been treated by the air stripper (shown as Stripper Effluent and formally representing location ETASEF), and ETPTS effluent (ET EFFLUENT). "Air Stripper ON" indicates when the ETPTS air stripper was activated; "New pumps installed" shows the timing of replacement of malfunctioning centrifugal pump with two helical pumps; "ZVI Offline" shows when the ZVI-filled treatment cells began to be drained and emptied. Also indicated are nozzle changes, from ten small- to one large-orifice nozzle, and from that nozzle to one with a slightly smaller orifice. Two outlier points are included (shortly after the final nozzle change indicated), one each for system influent and stripper effluent, but are not connected to other points in the same series because these data are suspect.

Figure 204. Effect of ETPTS Air Stripper on VOC Concentrations

Solar Ponds Plume and Treatment System

The SPP is an area of elevated nitrate and U concentrations in groundwater. (Note: The analytical data report concentrations of nitrate+nitrite as nitrogen; this is referred to in this document simply as nitrate.) Liquid wastes generated during the production era at Rocky Flats were stored in the former Solar Evaporation Ponds (SEPs), which were located on the pediment in the northeastern portion of the former IA. Leakage from these ponds over the years is the source of the groundwater plume. The following paragraphs describe the plume, the treatment system installed to address this contamination, and activities conducted in 2014 at this system; see also Section 2.4 for information on operation and maintenance activities.

Solar Ponds Plume

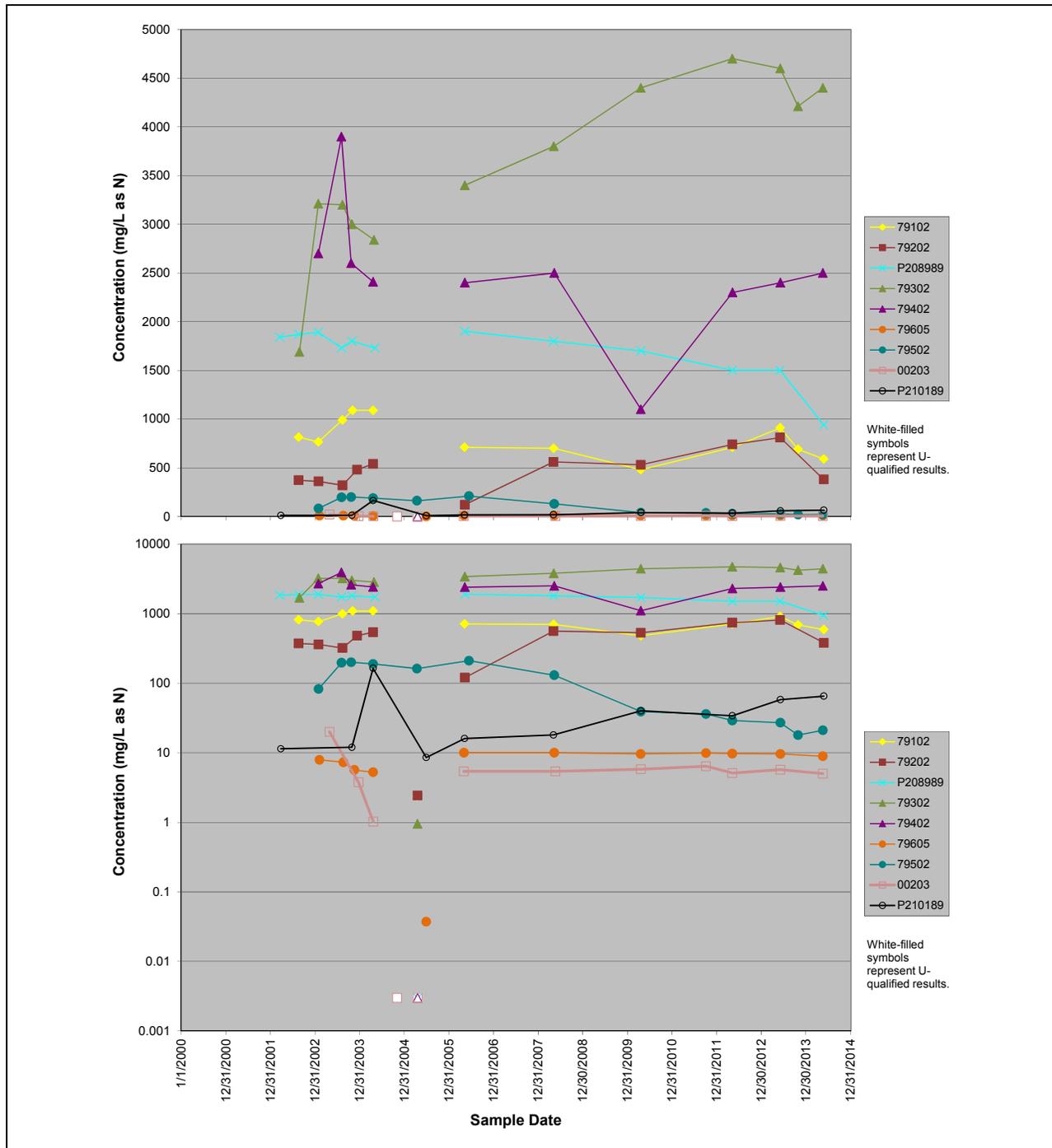
Groundwater in the SEP area is contaminated with nitrate and U. Groundwater in the westernmost portion of this area, generally coinciding with the location of former Pond 207C, is also contaminated with VOCs. However, due to the more localized distribution of VOC contamination, it is not considered part of the SPP, but rather as a separate plume.

The source area of the SPP (the former SEPs) is monitored by eight Evaluation wells installed immediately downgradient of the SEPs (along the north, east, and south sides of the former SEPs). A ninth Evaluation well is positioned at the south edge of former Pond 207C, in the vicinity of the VOC source area. This distribution effectively monitors groundwater flowing north/northeastward, the primary contaminant flow path; it also monitors potential eastward and southeastward migration of contaminants, which are (at most) much less significant flow paths.

Additional wells monitoring the SPP are located at greater distances from the source. This includes Evaluation wells situated both upgradient and downgradient of the SPPTS groundwater intercept trench as well as along North Walnut Creek, Sentinel wells adjacent to that trench and along South Walnut Creek near former B991, and an AOC well in North Walnut Creek near former Pond A-1 (well 10594). Another AOC well in South Walnut Creek supports monitoring of any southeastward contaminant migration from the SEPs; conditions at this well (well 00997) were summarized above in the text on the East Trenches Plume.

All of the Evaluation wells supporting the SPP and SPPTS were scheduled for routine RFLMA sampling in 2014, which was performed in May. The Sentinel and AOC wells were also sampled, twice each.

In keeping with recent years, the highest concentration of nitrate reported in the vicinity of the former SEPs was in a sample collected from Evaluation well 79302. This well reported a concentration of 4,400 mg/L nitrate (again, as N) in the sample collected in May. This and two other wells—79402 and P208989—typically report concentrations of nitrate exceeding 1,000 mg/L, and all are situated near the northeastern corner of the former SEPs (see Figure 2 for well locations). In the sample collected at well P208989 in May, however, the concentration had decreased slightly to 940 mg/L. These data are illustrated below in Figure 205, which incorporates logarithmic as well as linear concentration scales to provide perspective.



Notes: Top and bottom portion of the figure incorporate same data, but top uses a linear scale and the bottom uses a logarithmic concentration scale. RFLMA Table 1 value for nitrate (reported by the laboratory as nitrate+nitrite as nitrogen) is 10 mg/L (CDPHE et al. 2012). Refer to the 2006 Annual Report (DOE 2007b) for discussion of the discontinuous data in 2005. Several results are qualified but are not shown differently for the sake of simplicity. Note that data shown as representing well 79605 in 2003 and 2004 are actually from predecessor well P207989.

Figure 205. Concentrations of Nitrate in SPP Source-Area Evaluation Wells

Several of these Evaluation wells were sampled in 2013, in some cases more than once, due to wetter conditions in 2013. The 2014 sampling event produced results that are not dramatically different than data preceding 2013. Minor variations are evident (Figure 205), but natural

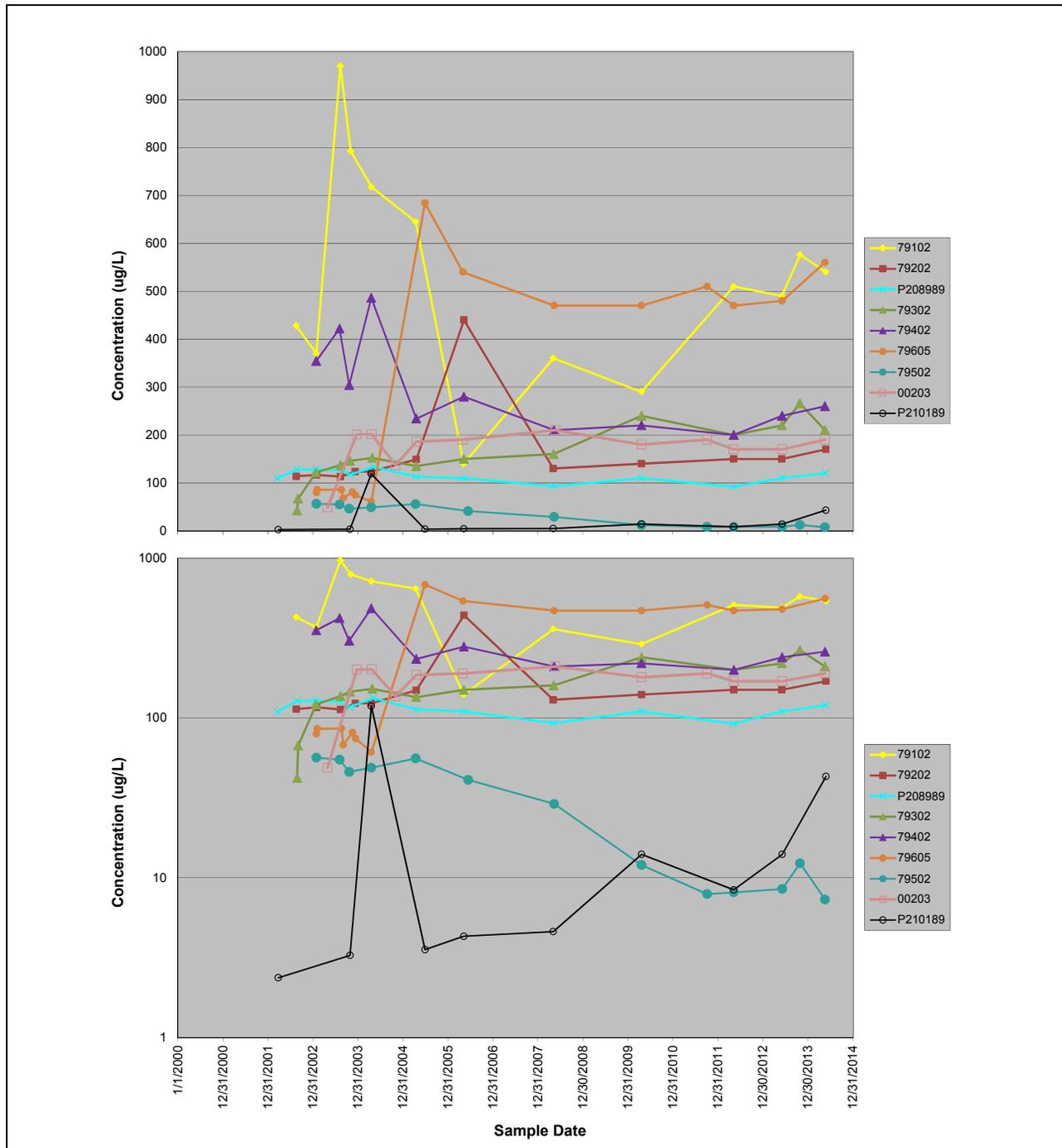
variability is to be expected irrespective of the occurrence of floods and droughts. The lower nitrate concentration in 2014 at well P208989 represents the lowest result for this well in the period of record (since January 2000), but concentrations had been decreasing here before the climatic events of 2013. The same can be said for nitrate in well 79502, which is located off the southeastern corner of the former SEPs. The concentration in 2014 is lower than in the second quarter of 2013 but slightly higher than in the fourth quarter of that year, and concentrations in samples from this well have been decreasing for several years. As discussed in previous reports, this suggests that a southeastern pathway for SEP-related contaminants to reach South Walnut Creek is not meaningful. Additional data will be required to assess whether the floods of 2013, in particular, affected nitrate concentrations in the source area over the longer term.

Nitrate concentrations in wells 79605 and 00203 (eastern and southern sides of the former SEPs; see Figure 2) remain consistently at or below the RFLMA value of 10 mg/L. As with well 79502, noted above, this is further indication that a southern/southeastern pathway is not significant.

Mann-Kendall statistical trends having a 95 percent level of confidence were calculated for nitrate in some SPP source-area Evaluation wells, including increasing trends at 79302 and P210189, and decreasing trends at 79502 and P208989. Refer to Appendix B for the trend plots and statistical summaries, and Table 74 for a summary of trends for 2014. Each of these is visually apparent on Figure 205.

The SPP also includes elevated concentrations of uranium, as noted above. Time-series plots of uranium concentrations in the source-area wells are provided below in Figure 206. Similar to the data reported for nitrate, concentrations of uranium in the Evaluation wells nearest the source area are consistent with past results. The highest concentration of uranium in these wells in 2014 was reported at well 79605 (560 µg/L). Of the wells monitoring the SEP source area, this well produced samples with the highest concentrations of U from 2005 through 2011. Before 2005 and after 2011, well 79102 has reported higher concentrations of uranium. Direct comparison of those earlier results is misleading, however, because they represent the predecessor to well 79605, P207989. As noted in the 2013 report (DOE 2014c), well P207989 was located less than 5 feet from the replacement well 79605. The original well also had a shorter screened interval than well 79605, and whereas the current well's screen extends above the bedrock contact the original well's screen was entirely within the weathered bedrock. Most importantly, given the consistent and relatively low concentrations of nitrate at well 79605 (Figure 205), it is not likely that this uranium represents SPP-related contamination, but rather natural uranium.

The data included on Figure 206 do not suggest that a strong effect has been imposed on uranium distribution and concentrations in this area as a result of the floods of 2013. As with nitrate in these wells, illustrated above on Figure 205, some relatively smaller-scale variation is evident in the results obtained in 2014. Examples include the increasing concentration of U at well P210189 and decreasing nitrate at well 79202. Larger-scale changes, such as the uranium and nitrate pulse apparent at well 79102 in 2003 that continued into 2005, or the short-lived "spike" in both constituents reported in 2004 at well P210189, are not apparent in the data collected through 2014.



Notes:
 Top and bottom portion of the figure incorporate same data, but top uses linear concentration scale and bottom uses logarithmic scale. Several results are qualified but are not shown differently for the sake of simplicity.
 RFLMA U threshold value is 120 µg/L.
 Note that data shown as representing well 79605 in 2003 and 2004 are actually from predecessor well P207989.

Figure 206. Concentrations of Uranium in SPP Source-Area Evaluation Wells

The 2012 and 2013 Annual Reports (DOE 2013a and 2014c, respectively) included high-resolution isotopic analytical results for samples from wells 79102 (collected in May 2012), 79302, and 79502 (both collected in October 2013). These three wells were selected as they

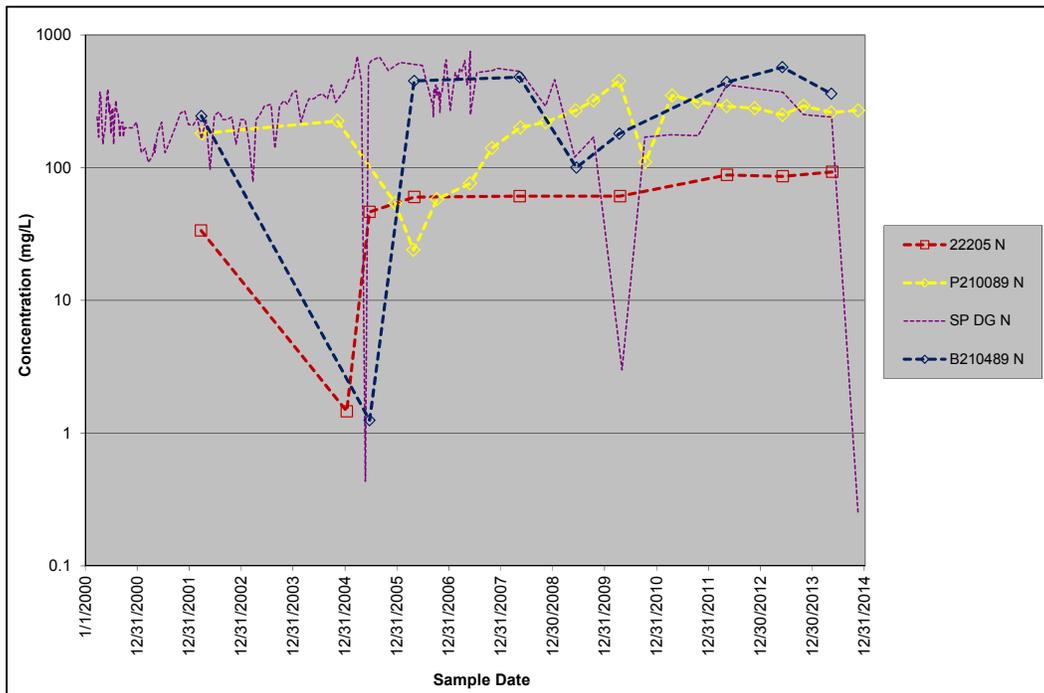
essentially demarcate the downgradient corners of the former SEPs, with well 79102 on the northwestern corner, well 79302 on the northeastern corner, and well 79502 on the southeastern corner. The 510 µg/L total uranium concentration reported for well 79102 was found to be 100 percent anthropogenic (depleted), while the 266 µg/L uranium sample from well 79302 was over 87 percent natural (over 12 percent of the rest being depleted), and the 12.30 µg/L sample from well 79502 was found to be almost 97 percent natural. This result for well 79502 may serve as additional evidence for the relative insignificance of a southeastern migratory pathway for SPP-contaminated groundwater to reach the South Walnut Creek drainage.

Trends are visually apparent in the concentrations of uranium from some of these wells (Figure 206), and some also support trends calculated using the Mann-Kendall approach to have a statistical significance of at least 95 percent. Trends of this significance are calculated for uranium at wells P210189, 79202, and 79302 (all increasing); and for well 79502 (decreasing). An increasing trend is also calculated for well 79605, but this is affected by the inclusion of data from the original well P207989. Future reports may exclude those earlier data from the statistical calculations.

Several wells monitor for SPP-related constituents farther downgradient from the SPP source area. These include, from nearer to farther from the source area, Evaluation well 22205 on the hillside between the source area and the SPPTS; Sentinel wells P210089 adjacent to the southwestern end of the SPPTS groundwater intercept trench and 70099 just north of this end of the trench; Evaluation well B210489 in North Walnut Creek just east of the SPPTS Discharge Gallery; Evaluation well 51605 by surface water location GS13; and AOC well 10594 between former Ponds A-1 and A-2. This roughly northeastern-oriented transect represents the most meaningful flow direction for the uranium- and nitrate-contaminated groundwater of the SPP.

Figure 207 displays concentrations of nitrate (where it is meaningful) from these wells and from the sampling location associated with the SPPTS Discharge Gallery. (The SPPTS is discussed in greater detail below; data from this location are included here for purposes of comparison.) Of the wells listed above, locations that produce samples consistently lacking significant nitrate concentrations include Sentinel well 70099, Evaluation well 51605, and AOC well 10594. The average nitrate concentrations at these locations are all well below the associated RFLMA Table 1 value of 10 mg/L. Of those three wells, the highest average nitrate is found at the well closest to the treatment system, 70099, where nitrate averages approximately 1.3 mg/L.

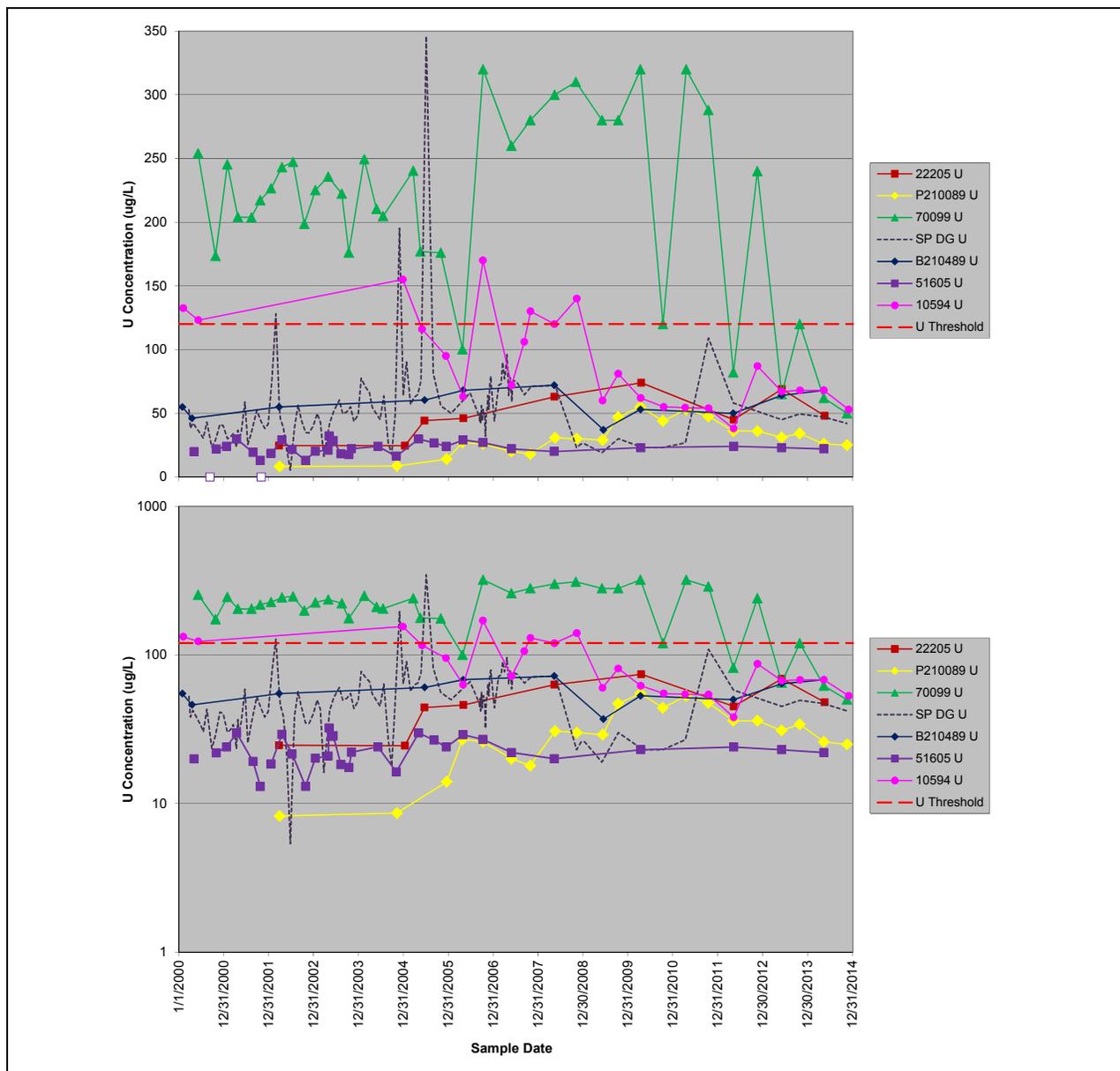
As can be seen on Figure 207, concentrations of nitrate reported in 2014 from groundwater wells are consistent with previous data. No strong effects from the 2013 floods are yet suggested, despite the proximity of well B210489 to the North Walnut Creek drainage (Figure 2) and the location of well P210089 approximately within the floodplain. In addition, proximity to the source of nitrate contamination, the SEPs, does not appear to be relevant, though the impacts of historic and SPPTS-related infrastructure are expected to exert strong controls. At the SPPTS Discharge Gallery, the sharp drop in nitrate in late 2014 corresponds to a period in which the treatment system was undergoing maintenance, resulting in extra residence time for the water subsequently sampled at the Discharge Gallery.



Notes:
 N = nitrate+nitrite as nitrogen. RFLMA value is 10 mg/L. The locations are listed in the legend in order of increasing distance from the former SEPs (the source area). "SP DG" refers to the SPPTS Discharge Gallery sampling location. Note logarithmic concentration scale.

Figure 207. Nitrate Concentrations Downgradient of the Former SEPs

Concentrations of uranium are yet more complicated. This is attributed to the presence of natural uranium (as opposed to Site-related anthropogenic uranium) in groundwater in this area, which allows the wells excluded from the nitrate-focused Figure 207 to be included in a uranium-focused version below (Figure 208). As shown in this figure, Sentinel well 70099 has consistently displayed the highest concentrations of uranium, and AOC well 10594 has often produced the second-highest uranium values of these wells. In 2014, concentrations of uranium in well 70099 continued their recent episodic decrease and fell slightly beneath those reported at well 10594. Note that uranium in samples from both of these wells has previously been characterized (using high-resolution isotopic methods) as approximately 97–100 percent natural; therefore, these variations are attributed to natural variability, not Site-related uranium contamination.



Notes:

Top and bottom portions present the same uranium (U) data, but top uses a linear scale and bottom uses a logarithmic scale. However, two U nondetects at well 51605 (representing April 2000 and May 2001) are omitted from the bottom (logarithmic) time-series plot due to their discontinuous nature.

The locations are listed in the legend in order of increasing distance from the former SEPs (the source area).

“SP DG” refers to the SPPTS Discharge Gallery sampling location.

RFLMA U threshold is 120 µg/L.

Figure 208. Uranium Concentrations Downgradient of the Former SEPs

The very strong, apparently cyclical variations in uranium concentrations reported at well 70099 are not consistent with climatic seasons: concentrations are lowest in the fourth quarter of 2010, but are then lowest in the second quarters of 2012 and 2013 (and 2006), with the two results from 2014 not dramatically different from one another (62 µg/L and 50 µg/L for second and fourth quarter samples, respectively). Note that the fourth-quarter 2014 result is the lowest uranium concentration in the period of record. The cause for this variability is not certain.

However, an overall decrease in uranium concentrations at well 70099 is suggested, as is a similar decrease at well 10594.

Concentrations of uranium at the other locations displayed on Figure 208 do not show the wide variations that mark the last few years at well 70099. Uranium concentrations at Evaluation well 51605 (located adjacent to surface water monitoring location GS13) have been the most consistent of this group of locations since Site closure, never falling outside the range of 20 µg/L to 30 µg/L (upper portion of Figure 208). Similar concentrations are most recently reported at Sentinel well P210089. This follows a several-year period of higher concentrations of around 50 µg/L from about 2009 through 2011, with more recent results suggesting a steadily decreasing uranium content. Concentrations reported at Evaluation wells 22205 (nearest the SEPs) and B210489 (nearest the Discharge Gallery) have varied substantially over the years, but not as much as at 70099. Samples from the SPPTS Discharge Gallery have varied sharply in uranium content, which is due to activities and behavior at the SPPTS as well as buried infrastructure such as the Interceptor Trench System in the subsurface of the hillside south and west of the Discharge Gallery.

Calculated nitrate and uranium trends having a 95 percent level of confidence are reported for several of these wells (see summary in Table 74 and trend plots and reports in Appendix B), some of which are readily apparent on Figure 207 or Figure 208. With respect to nitrate, increasing trends of this statistical significance are calculated for wells 22205 and P210089, and a decreasing trend is calculated for well 70099 (not illustrated above due to its consistently low concentrations; refer to the trend plots in Appendix B). Uranium is calculated to be increasing at well P210089 and decreasing at well 10594. Data from Evaluation wells B210489 and 51605 do not support significant trends.

These wells will continue to be monitored and evaluated for trends and other patterns.

As described above, Sentinel wells 99305 and 99405, both located in the South Walnut Creek drainage adjacent to former B991, are monitored to evaluate a potential southeastern flow path for SPP groundwater. Water quality at these wells is discussed in greater detail later in this report, but with respect to the SPP, nitrate concentrations in samples collected in 2014 were consistent with previous data and do not suggest a southern/southeasterly flow path for the SPP is meaningful. The highest concentration reported in 2014 at well 99305 was 0.49 mg/L (in the sample collected in April) and at well 99405 was 1.4 mg/L (October sample). As with previous conditions, uranium concentrations are very consistent and lower at well 99305, while they have been more variable and substantially higher at nearby well 99405. Both have been characterized as producing groundwater with uranium that is 100 percent natural.

Solar Ponds-Area VOC Plume

All of the Evaluation wells designated to monitor the VOC plume in the western SEP area were scheduled for regular RFLMA sampling in 2014. These wells include P210189 on the southern edge of former Pond 207C and in the vicinity of the VOC source area; wells 79102, 79202, and P208989 to the north, along the pathway to the North Walnut Creek drainage; well 22205 about halfway between the source area and the drainage; and well 00203 on the southern side of the former SEPs. Sentinel well P210089, which is located north of the SEPs at the western end of the SPPTS intercept trench, is also monitored for VOCs. Of these, Evaluation wells P208989

(located just east of well 79202) and 00203, as well as Sentinel well P210089, report few VOC detections, and none above RFLMA Table 1 values. Evaluation well 22205 also reports few VOC detections, and none above the RFLMA values since before Site closure.

As defined by conditions at well P210189, this plume is characterized predominantly by elevated concentrations of carbon tetrachloride, as well as elevated concentrations of TCE and chloroform. Several other VOCs are also detected in samples from this well. This includes 1,1-DCE and PCE at levels below RFLMA values since before closure, and 1,2-DCA typically in the 1 µg/L to 2 µg/L range (above its RFLMA value of 1 µg/L).

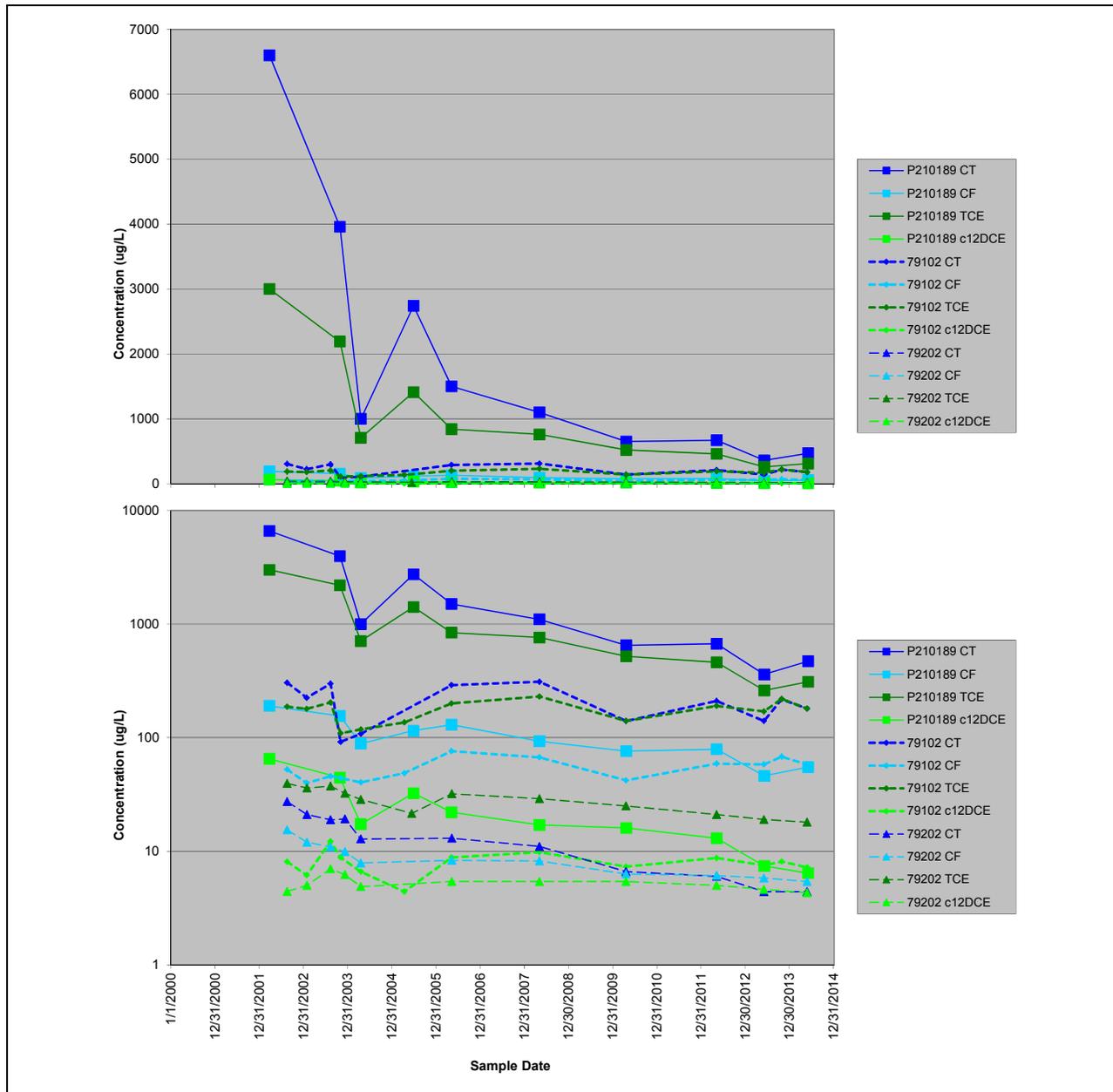
Data reported for samples collected from these wells in 2014 were generally consistent with past results. As previously reported (e.g., DOE 2013a), decreasing trends are evident in several cases (Figure 209). These trends are especially evident for each of these three VOCs at well P210189. The nearest downgradient well, 79102, does not show similar decreases. However, data for well 79202, also downgradient but monitoring water with lower concentrations of VOCs, indicate some constituents are decreasing. As noted previously for other constituents, the floods of 2013 do not appear to have strongly impacted pre-existing trends.

Several VOCs were also detected in SEP-area Evaluation wells other than those depicted in Figure 209. Well P208989, located north of the SEPs and representing the next well east of 79202, the easternmost downgradient well included in the figure, reported detections of chloroform, PCE, and TCE, all J-qualified (estimated) at concentrations below 1 µg/L (and below their corresponding RFLMA levels). Well 00203, on the southern edge of the former SEPs, reported a detection of 1,3-DCB at an estimated concentration less than 1 µg/L and also below its RFLMA value. This is not a primary constituent in the plume, but it was also detected in well 79102 at sub-1 µg/L estimated concentrations in second-quarter samples collected in 2013 and in 2014.

Farther downgradient, conditions at Evaluation well 22205 in 2014 with respect to VOCs were consistent with those in previous years. There is no strong suggestion of the VOC plume migrating toward the North Walnut Creek drainage. Chloroform, TCE, and 1,3-DCB were each detected in 2014 at very low, estimated (J-qualified) concentrations of less than 1 µg/L.

No VOCs were detected in Sentinel well P210089, located farther downgradient and next to the SPPTS groundwater intercept trench. However, 1,3-DCB was detected in the sample collected in May from AOC well 10594. This constituent has been reported previously at this well—in 2009 and 2013, each time in the second quarter—and as in those cases was reported at a very low, estimated concentration well below 1 µg/L.

Statistical calculations indicate that in well P210189, decreasing trends in carbon tetrachloride, chloroform, *cis*-1,2-DCE, PCE, and TCE now rise to the 95 percent level of significance. Several of these constituents are included on Figure 209, and their trends are visually apparent. Decreasing trends of this significance are also calculated for carbon tetrachloride, chloroform, TCE, and PCE at well 79202. Finally, well P208989 reports an increasing trend in chloroform of this statistical significance, but the data set contains numerous nondetects suggesting the trend may not be viable. No trends of this level of statistical significance are calculated for VOCs at wells 79102, 22205, 00203, or P210089.



Notes:

Top and bottom incorporate the same data, but top portion uses linear concentration scale, bottom uses logarithmic scale. Constituents and their respective, applicable RFLMA Table 1 standards (µg/L; CDPHE et al. 2012): CT = carbon tetrachloride, 1; CF = chloroform, 3.4; TCE, 2.5; c12DCE = *cis*-1,2-DCE, 70. Several detections are qualified but are not shown differently for the sake of simplicity.

Figure 209. Primary VOCs in SEP VOC Plume Wells

Solar Ponds Plume Treatment System

Like the ETPTS, the SPPTS was installed in 1999. In basic design, the system is very similar to the MSPTS and ETPTS, with a groundwater intercept trench (1,100 feet long) and two original treatment cells. However, unlike the ETPTS and MSPTS, this system is designed to treat water with elevated concentrations of nitrate and U rather than VOCs. As such, the treatment media in the original SPPTS treatment cells differs from the ZVI media in the MSPTS and (prior to being

reconfigured in 2014) ETPTS treatment cells. The treatment media in these SPPTS cells consists of organic material (sawdust) with a small fraction of ZVI in the first cell, and ZVI with pea gravel in the second cell. Also, the treatment media in the original SPPTS treatment cells is buried under approximately 10–12 feet of overburden, and is therefore difficult to access.

Unlike the gravity-flow operation of the MSPTS and ETPTS, water that collects in the SPPTS intercept trench must be actively pumped into the treatment cells. This is accomplished using a solar-charged, battery-powered pump system. This component of the SPPTS, together with the collection well that houses the pump and is installed within the trench, was completed as the first system upgrade in 2002.

As described in previous annual reports (especially DOE 2007b, 2008, 2009c, 2010a), the SPPTS has been the focus of extensive study and modification over the past several years, particularly since the site closed. The primary objective has been to improve collection and treatment of contaminated groundwater, and has included repairs, subsurface exploration, treatability studies (laboratory, bench-scale, and pilot-scale), and the design and construction of system upgrades. Several factors drove these efforts, including:

- (1) Historically, concentrations of nitrate and uranium measured at the sampling location associated with the subsurface effluent discharge gallery (formally referred to as SPPDISCHARGEGALLERY, but often shortened to Discharge Gallery or DG) usually exceeded those in untreated influent to the system, even though this is where effluent confirmed to be adequately treated contributes to a pool of water on the ground surface.
- (2) Accessing and maintaining the treatment media and plumbing within the original structure is costly and difficult.
- (3) The original treatment media is not optimal over the long term.

More recent annual reports (DOE 2011, 2012, 2013a, 2014c) have presented and discussed further efforts to optimize the effectiveness of this system, focusing on the performance of bench-scale to pilot-scale treatability studies.

Critical to understanding the difficulties that face optimization of the SPPTS is a recognition of a fundamental challenge to achieving consistently reliable treatment by this system: the lack of electrical power. Although it supports a number of tools and critical components, the several kilowatts of solar-based power installed in 2009 cannot substitute for full-time, on-demand line power. In addition, the capital costs associated with solar power are high; when coupled with installation of a battery bank to ensure full-time operation, and the recurring needs for maintenance to address various needs of treatment media and active components and piping, costs increase.

Maintenance and optimization activities were conducted at the SPPTS throughout 2014 and are reported in Section 2.4. The text below provides a summary of the results related to water treatment, as well as a discussion of ongoing tests.

The SPPTS treated approximately 591,000 gallons of groundwater in 2014, about 100,000 gallons more than in each of the two previous years (Table 84). This is the second-highest volume treated in any calendar year, and continues to reflect the effects of the Phase I upgrades installed in late 2008. (The Phase I upgrades collect additional contaminated

groundwater and route it through the SPPTS for treatment; see annual reports for 2008 and 2009 [DOE 2009c and 2010a, respectively].) Figure 210 presents a hydrograph showing flow from January 2000 through the end of 2014. Clearly evident is the effect of the Phase I upgrades on the total volume treated by the SPPTS. The hydrograph for CY 2014 is presented as Figure 211.

Table 84. Estimated Volumes of Water Treated by the SPPTS

Calendar Year	Annual Estimates of Volume Treated (gallons)	Estimated Cumulative Volume Treated (gallons)
2000 ^a	64,000	64,000
2001 ^a	424,000	452,700
2002	5,600 ^b	458,000
2003	340,000	797,000
2004	230,000	1,027,000
2005	140,000	1,167,000
2006	251,000	1,418,000
2007	244,000	1,662,000
2008	280,000	1,942,000
2009	524,000	2,466,000
2010	738,000	3,204,000
2011	507,000	3,711,000
2012	498,000	4,209,000
2013	498,000	4,707,000
2014	591,000	5,298,000

Notes:

^a Annual and cumulative volume estimates for 2000 and 2001 are suspect, as a sum of the volumes presented in each of the quarterly reports for 2000 and statements regarding the volume for 2001 disagree by approximately 35,000 gallons.

^b Most of this volume was from the former Modular Storage Tanks (K-H 2003). Estimates for years 2000 through 2004 are compiled from K-H (2000a, 2000b, 2000c, 2000d, 2002b, 2003, 2005a, 2005b).

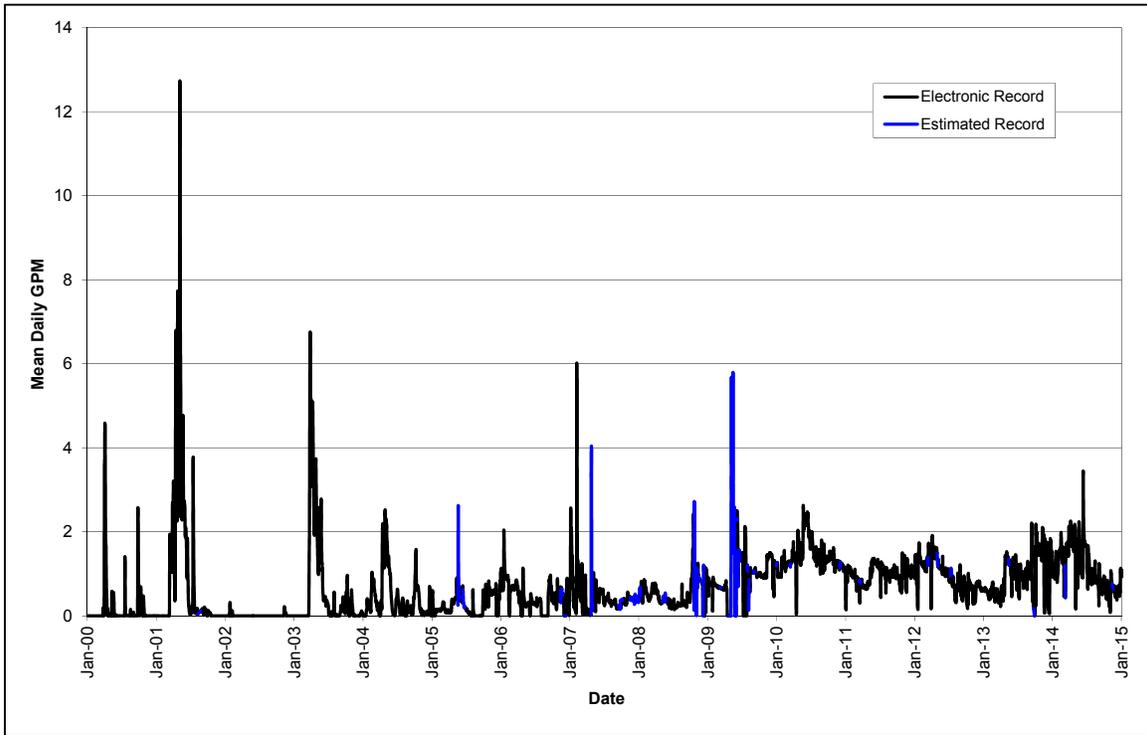


Figure 210. Hydrograph for SPPTS from 2000 Through 2014

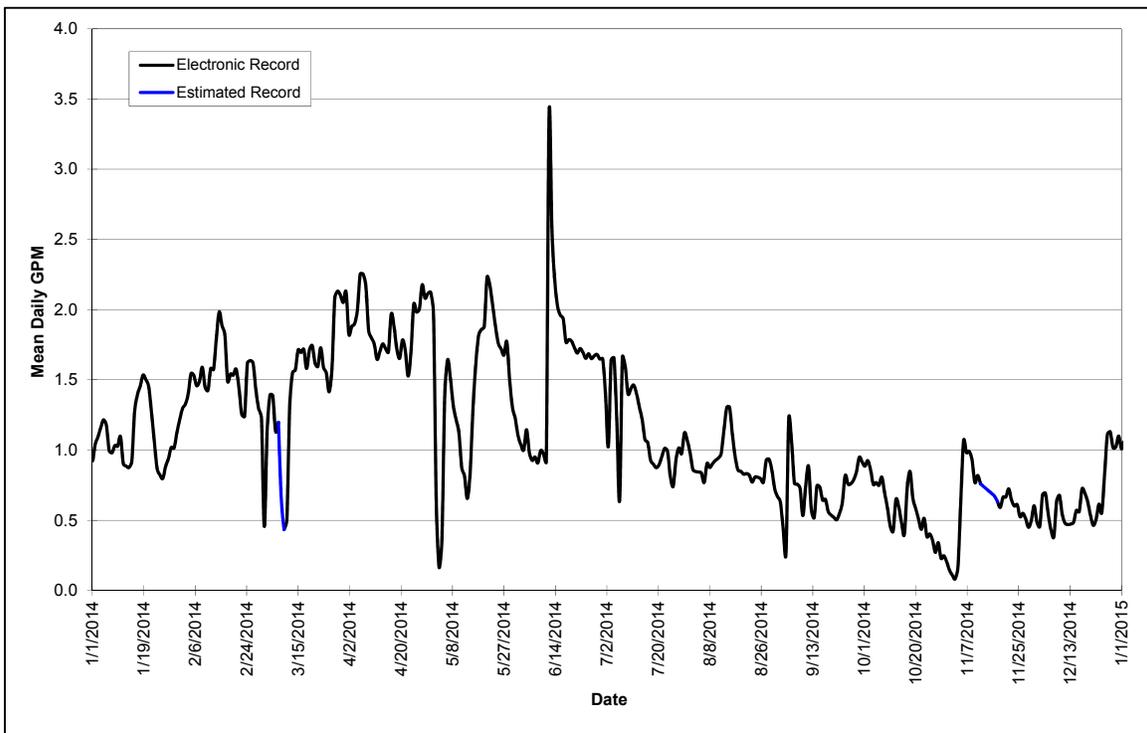


Figure 211. Hydrograph for SPPTS for CY 2014

On average, the SPPTS has treated about 353,000 gallons per year since January 1, 2000 (Table 85). However, this average flow may be misleading: from Table 84, it is evident that significant changes have occurred. The most significant of these are a result of the 2002 installation of a pump to deliver influent from the collection trench to the treatment cells; as is visually evident on Figure 210, flow was irregular until after this pump was added. The late-2008 installation of the Phase I upgrades represents another significant factor in the volumes of water treated by the SPPTS.

Table 85. Average Volumes Treated by the SPPTS

Time Period	Average Volume Treated Per Year (Gallons)
Overall since January 1, 2000	353,000
Pre-closure, 2000–2005	195,000
Post-closure, 2006–2014	459,000
Pre-Phase I upgrades, 2000–2008	216,000
Post-Phase I upgrades, 2009–2014	559,000

Notes:

Average volumes are rounded to the nearest 1000 gallons and are based on estimates of volumes treated, as presented in Table 84.

Time periods shown include complete years, and do not correspond to exact dates of closure and Phase I upgrades: the pre-closure estimate for the 2000–2005 period spans January 1, 2000, through December 31, 2005; the post-closure period begins January 1, 2006; and the post-Phase I period begins January 1, 2009.

Site closure appears to have had a relatively minor effect on the volume of flow treated by the SPPTS, as suggested by the volumes for the couple of years preceding and following that event. About 195,000 gallons per year were treated from 2000 through 2005 (Table 85), assuming the volumes for 2000 through 2002 are accurate. (The year 2005 is included with the pre-closure average.) Several years after closure, however, average annual flows through the system more than doubled following installation of the Phase I upgrades in late October, 2008. Averaging the volumes treated from 2000 through 2008 gives a pre-Phase I average of approximately 216,000 gallons per year, while the post-Phase I average is well over twice that, at about 559,000 gallons per year. Even so, this higher average volume amounts to an average flow rate through the SPPTS of only about 1.06 gpm.

Summary of SPPTS Upgrades

As noted above, several upgrades have been made to the SPPTS since Site closure. These upgrades have been discussed in greater detail in previous annual reports (particularly DOE 2009c, 2010a, and 2011) and are summarized below in Table 86. Refer to Section 2.4 for information on operation and maintenance in 2014.

Table 86. Summary of SPPTS Construction and Upgrades

Upgrade Phase (Year Installed)	Summary Description	Summary of Associated Features and Nomenclature
"Phase 0" (1999)	Original SPPTS constructed. Groundwater intercept trench bisects previously installed French drain network called the Interceptor Trench System, or ITS, and feeds collected water by gravity through two cells operated in series: Cell 1 contains sawdust plus 10% ZVI for nitrate treatment; Cell 2 contains pea gravel and 15% ZVI for U treatment. Effluent is routed into a downgradient limb of the ITS and thence to a line to the subsurface discharge gallery.	SPPMM02 = "influent" location accessed at piezometer a.k.a. 71099 SPPMM01 = effluent location accessed in manhole SPP Discharge Gallery in valley bottom GS13 = surface water performance at mouth of Pond A-1
"Phase 0.1" (2002)	Collection well equipped with solar-powered pump is installed to deliver collected groundwater to cells.	SPIN (name later assigned to influent flow from this pump)
Phase I (2008)	Collection sump and gravel drain installed at terminal points of ITS, adjacent to location of former Interceptor Trench Pump House.	ITSS = Intercept Trench System Sump, the constructed sump that receives water collected by the upgrade ITSE = east ITS line where it empties into ITSS ITSW = west ITS line where it empties into ITSS
	Piping installed to transfer water from ITSS to SPIN, and to discharge treated system effluent from effluent manhole to Discharge Gallery; SPIN vault provides access point to flows from the former, and ITSS vault provides access to flows from the latter.	SPOUT = effluent location accessed in ITSS vault
Phase II (2009)	Easily accessible cell installed to treat U upstream of nitrate treatment.	SPZE = effluent from Phase II cell
Phase III ^a (2009)	Installed: two pilot-scale nitrate treatment cells to evaluate alternative treatment approaches; associated vault to house carbon supply (added to one of the Phase III cells); vault to allow flow configuration, control, dosing, monitoring, programming, and telemetry infrastructure; associated water storage sump to provide influent in the event of dry conditions; and solar power and plumbing infrastructure to support all of this.	Cell A = pilot-scale nitrate treatment cell using inert media dosed with liquid carbon Cell B = pilot-scale nitrate treatment cell using organic (reactive) corn stover media SPILCA = dosed influent to Cell A SPCAE = effluent from Cell A SPCBE = effluent from Cell B
Phase III, Part 2 ^a (2012)	Reconfigured Phase III cells described above to allow testing of lagoon-style approach to nitrate treatment. See text for information.	Cell A = pilot-scale nitrate treatment cell using inert media dosed with liquid carbon; initially (through late January 2013) equipped with recirculation pump Cell B = pilot-scale nitrate treatment cell using inert media dosed with liquid carbon, no recirculation pump SPCAE = effluent from Cell A SPCBE = effluent from Cell B
Phase IV (to be determined)	Install full-scale nitrate treatment component, integrated with uranium treatment component, developed via testing and results.	To be determined

Notes:

^a Phase III cells were cleaned out in 2012 and modified to support different pilot-scale testing. See DOE 2013a for details.

Abbreviations:

ITS = Interceptor Trench System

Summary of SPPTS Treatment

The SPPTS through 2014 was the subject of continuing testing to identify methods by which uranium and nitrate treatment could be improved for the long term. Although simply replacing the media in the treatment cells would improve treatment over the short term, that improvement would be inadequate and the associated costs to complete the media replacement activity would be high. Replacing like for like would guarantee the necessity of managing and dispositioning the full quantity of existing media and overburden wastes as well as a second, equivalent quantity in a few years. With respect to nitrate treatment, replacing the media in the original Cell 1 with similar sawdust and ZVI media would not provide adequate treatment because the system receives much higher flows and nitrate loads than when this media was performing adequately. As soon as the Phase I upgrades were put online, SPPTS effluent no longer met target concentrations, although water quality at the DG improved dramatically (DOE 2009c).

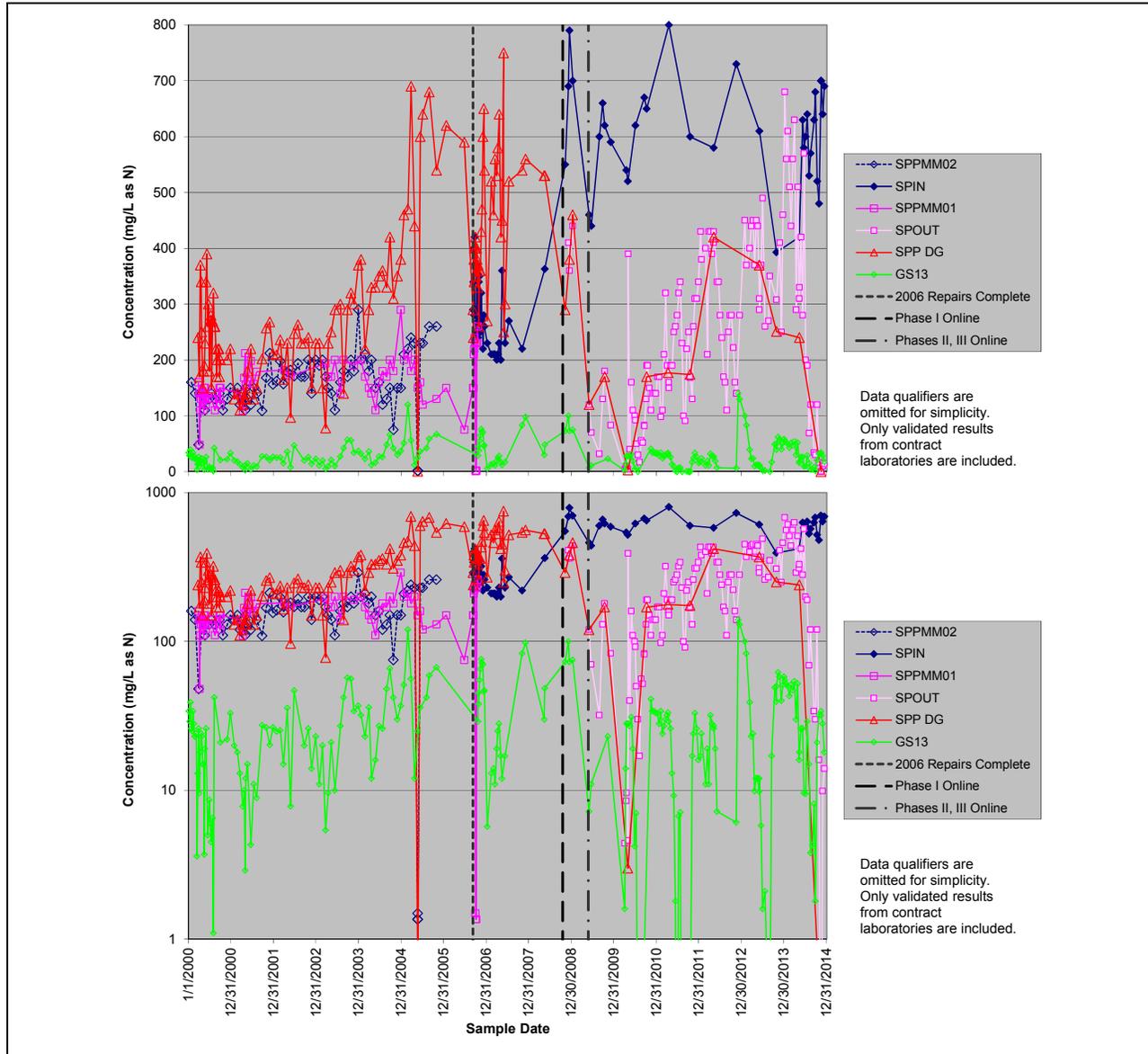
Influent concentrations of nitrate that were reported prior to Site closure ranged from 1.36 mg/L to 290 mg/L, with an arithmetic average of about 160 mg/L; since the Phase I upgrades were completed in late 2008, nitrate in system influent has ranged from 393 mg/L to 800 mg/L, and averages over 600 mg/L. The uranium concentrations prior to closure averaged 53 µg/L, and since Phase I have averaged over 70 µg/L. This roughly four-fold increase in nitrate and 30 percent increase in uranium concentrations has come with a doubling to tripling of the flow rate (Table 85). Expecting the original media design to perform effectively under these conditions would not be logical or realistic.

The operation and maintenance costs associated with the system as originally (and currently) configured are not sustainable; a new treatment approach is needed in order to effectively manage and treat the influent at a reasonable cost. Therefore, because work continues to focus on identifying a more appropriate long-term system configuration and treatment approach, effluent conditions in 2014 were generally not improved over those in recent years.

RFLMA monitoring locations supporting the SPPTS were sampled in 2014 much more frequently than semiannually, with the influent location (SPIN) sampled 15 times for nitrate and 16 times for uranium; the effluent location (SPOUT) sampled 26 times for each of these constituents; and the surface water performance location (GS13) sampled 28 times for nitrate and 11 times for uranium. (Differences in numbers of samples reflect the use of these data for various objectives, including the Adaptive Management Plan, surface water objectives, and treatment system objectives. They also reflect differences in collection methods at GS13—grab sampling for nitrate, flow-paced composite sampling for uranium.) In addition, numerous samples were collected for analysis by the Environmental Sciences Laboratory (ESL) in Grand Junction, Colorado, which is operated for DOE. The results from the ESL cannot be validated and are not used for compliance purposes; instead, these samples are collected and corresponding data used to support treatment studies.

Figure 212 presents concentrations of nitrate at various system locations, using a linear scale in the upper portion and a logarithmic scale in the lower portion. Effluent concentrations of nitrate have been substantially higher over the recent past, again due to ongoing focus on developing better approaches to nitrate treatment. This is especially evident on the linear portion of Figure 212. The continuing higher flow rates resulting from the 2013 floods exacerbated this situation, as the elevated flows again translated to reduced residence time within the treatment media. However, effluent (and Discharge Gallery) nitrate in the latter part of 2014 was

significantly lower due to the extended residence time resulting from operational and maintenance efforts described above in Section 2.4.3.



Notes:
 Top and bottom portions display the same data, but top uses linear scale and bottom uses logarithmic scale, and values less than 1 mg/L are omitted from the lower chart to allow the other data to show more clearly.
 SPPMM02 = original system “influent”; SPIN = true system influent; SPPMM01 = original system effluent; SPOUT = current system effluent location; SPP DG = SPP Discharge Gallery; GS13 = surface water performance location.
 Refer to previous annual reports (DOE 2007b, 2008, 2009c, 2010a, and 2011) for more information on events related to system repairs and modifications, including Phases I, II, and III.
 Some data are qualified but are not displayed differently for simplicity.

Figure 212. Concentrations of Nitrate at Selected SPPTS Monitoring Locations

The operation of the Phase III cells (see Table 86; discussed in greater detail below) continued to remove nitrate in 2014, but only a small portion of the total flow is routed through these pilot-scale lagoons. For part of the year the original treatment cell structure constructed in 1999 acted

as another lagoon: the media, overburden, and plumbing in original Cell 1 is increasingly clogged but cannot be easily accessed to clear the blockage. As a result, water now pools on the surface of the overburden. This pooled water contains a rich bacterial population as well as carbon nutrients and nitrate, and therefore can be expected to contribute to overall nitrate treatment at the SPPTS.

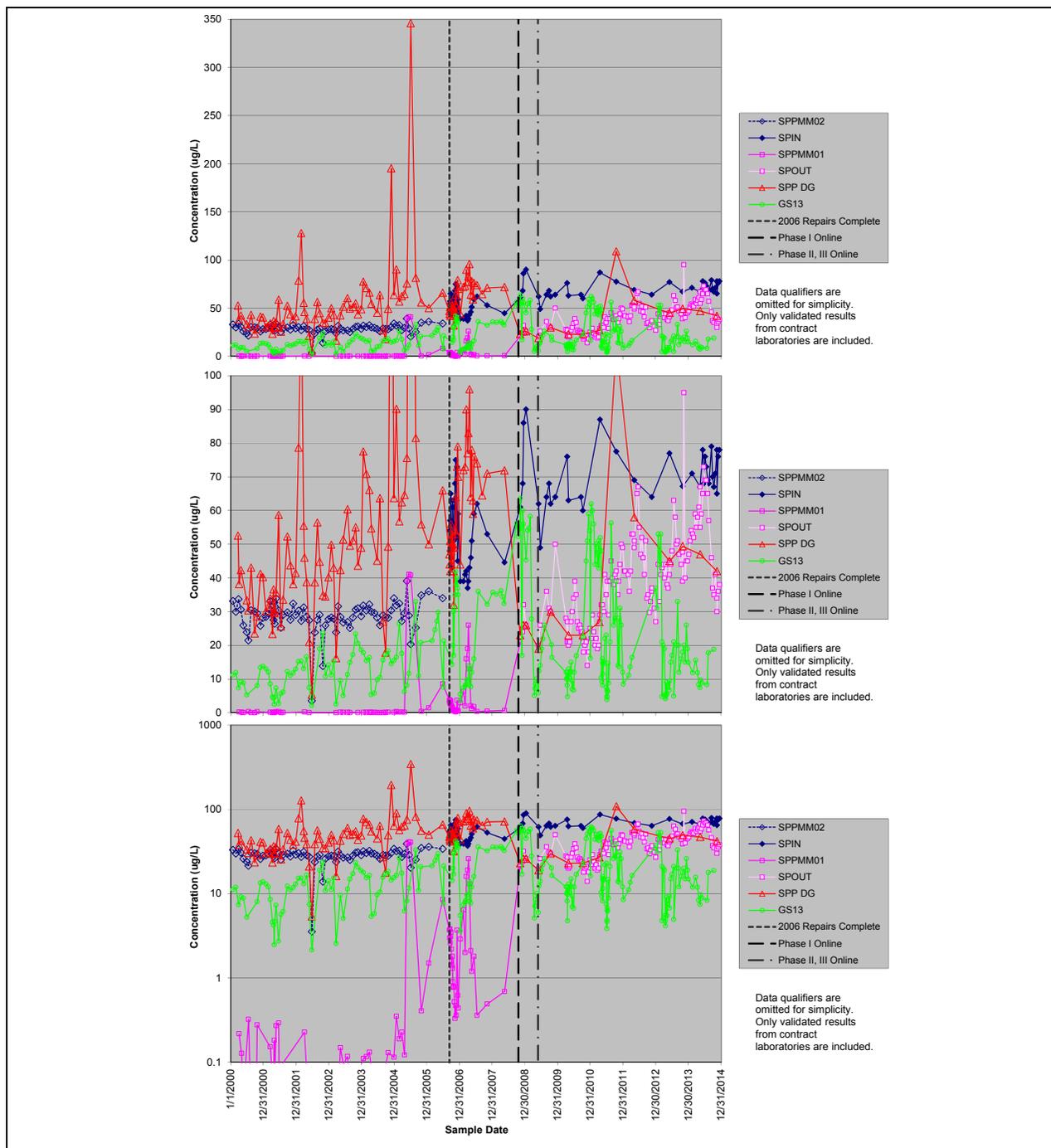
Nitrate concentrations reported at surface water performance location GS13 in 2014 ranged from 1.8 mg/L to 58 mg/L, with an arithmetic average of approximately 29 mg/L.

As stated above, uranium in system influent has also increased (Figure 213). Similar to nitrate conditions, system effluent monitored at SPOUT in 2014 continued to contain elevated concentrations of uranium. The effects of the floods of 2013 are especially evident on the top and middle parts of this figure, which display the data using a linear scale. Improved treatment in the latter portion of 2014 is evident, and again is due to the extended residence time resulting from maintenance activities as well as the valve adjustment described previously.

The system continues to remove uranium, as can be seen in Figure 213. However, the Phase II cell is of little benefit because its ZVI-based treatment media has been passivated with the high concentrations of nitrate. Original Cell 2, designed to remove uranium, is also unable to remove sufficient uranium to meet treatment targets. Tests of ZVI-containing microcells continued through 2014 and were generally very effective, but like the pilot-scale lagoons these tests treat only a small portion of the overall SPPTS flow. (Microcells are discussed in additional detail below.)

Uranium concentrations measured in flow-paced composite samples collected from surface water performance location GS13 were generally consistent with previous data. The highest uranium concentration was 18.8 µg/L, and the arithmetic average was about 12 µg/L, both lower than in 2013 but within historic ranges.

S-K trend calculations were performed for SPPTS influent. This is not required by RFLMA, but can help to identify long-term trends in concentrations. The results of these calculations (Table 74) are obvious without the benefit of statistical analysis: Nitrate and uranium are both found to be on increasing trends with a 95 percent level of significance in system influent. Influent concentrations have been affected by two primary events that have been discussed in this and previous reports. The first, which took place in 2006, was reassignment of the influent monitoring location from a trench piezometer (sampled as SPPMM02, but also referred to as piezometer 71099) to SPIN. The effect of this was an immediate increase in both nitrate and uranium concentrations of about 20 percent; refer to the annual report for 2006 (DOE 2007b) for more information on this change. The second event affecting influent water quality had a much greater effect: this was the completion of the Phase I upgrades in late 2008, as discussed in previous annual reports (for example, DOE 2009c and 2012). Note that while both of these changes affected influent data, only the latter truly affected influent water quality; the change in sampling location did not represent an actual change in water quality, only where it was measured. For the trend calculations, results for both locations—SPPMM02 and SPIN—were grouped and evaluated as a single data set. Refer to Table 74 for summary information on these statistical results, and Appendix B for details and the trend plots.



Notes:

Top, middle, and bottom portions display the same data, but top and middle use a linear scale (with middle portion focusing on data between 0 and 100 $\mu\text{g/L}$) and bottom uses logarithmic scale (and omits values less than 0.1 $\mu\text{g/L}$ to allow the other data to show more clearly). SPPMM02 = original system “influent”; SPIN = true system influent; SPPMM01 = original system effluent; SPOUT = current system effluent location; SPP DG = SPP Discharge Gallery; GS13 = surface water performance location. Refer to previous annual reports (DOE 2007b, 2008, 2009c, 2010a, and 2011) for more information on events related to system repairs and modifications, including Phases I, II, and III. Some data are qualified but are not displayed differently for simplicity.

Figure 213. Concentrations of Uranium at Selected SPPTS Monitoring Locations

Uranium Microcell Testing and Development

The 2012 Annual Report (DOE 2013a) introduced and described the topic of uranium treatment using microcells based on ZVI, and the 2014 Report (DOE 2014c) provides a generalized design sketch of a microcell and a summary of the procedure used in these tests.

Several different combinations of ZVI and filler materials have been explored over the past few years, incorporating materials such as sand, sawdust, and steel wool. The addition of filler material decreases the overall treatment capacity of the cell because the surface area of the reactive media is reduced, but can improve performance by delaying or limiting the development of clogs. Coarse ZVI can also act as a filler material, as it can enhance media permeability while also providing some limited uranium treatment.

Microcell tests continued through 2014. In all cases, microcells operated in an upflow configuration. The focus remained on a ZVI-based media for uranium treatment. Several tests were run using coarser ZVI in the bottom (upstream) portion of the microcell and finer ZVI in the upper portion. The intent of this design was to use the coarser material to gradually “condition” the water by removing some of the excess oxygen and major ions such as calcium and bicarbonate, before that water contacted the finer ZVI. Several other tests focused on a mixture comprising roughly equal volumes of ZVI and sawdust, with the sawdust added to help cushion the crystal growth forces exerted by the oxidizing ZVI and formation of chemical precipitates so that the microcells would not clog as quickly. Testing also included experimenting with vessels that could be used repeatedly rather than disposed after a single use.

Maintaining desired flow rates through each microcell has been a challenge. Because the ZVI gradually clogs, water must be pumped through the microcell at increasingly higher pressures in order to maintain a relatively uniform flow rate. This is achieved by manually adjusting valves or the voltage of the main SPIN pump to divert more flow to the microcell, something that is not automated but rather relies on staff availability and schedules. Through the course of a microcell test, flow rates and pressures are monitored and adjusted as warranted and as feasible. (Different types of pumps are available that are designed to maintain uniform flow, as are other alternatives to the current manual approach. However, these are expensive and represent additional power demand. Therefore, tests are being conducted using existing equipment.) Eventually the water pressure in the line feeding the microcell, or uranium concentrations in the effluent, increase sufficiently that the test is concluded and the microcell is taken offline. This generally occurs after approximately 1 to 3 weeks of operation.

Microcell tests in 2014 focused in part on trying to achieve relatively consistent, repeatable treatment effectiveness using a given media fill, and exploring those media designs that appeared to show promise in terms of combined treatment and longevity. However, achieving repeatability has been difficult. Reasons for variations in treatment effectiveness can include one or, more likely, a mix of operational and media factors. Operational factors include such aspects as variations in SPIN pump flow rates, valve settings, and electrical power from full-sun daytime to nighttime. Media-related factors include ZVI packing (tight vs. loose), ZVI mesh size, whether the fill represents settled fines from the given mesh or a representative mix of the stated mesh sizes, quantity and distribution of ZVI vs. filler material, composition of the filler material, presence of trapped gas bubbles within the media, degree of media clogging and oxidation

(which increases with exposure to the influent water), whether preferential flow is present and meaningful, variations in influent concentrations of U/nitrate/dissolved oxygen/major ions, impurities in the ZVI (such as dust, trace metals, and so on), and other factors. Automatic system shutdowns due to groundwater entering the open-bottomed flow configuration vault—largely a lingering result of the heavy precipitation in September 2013—and planned shutdowns for electrical work to streamline the system and to replace the batteries, and to address flow conditions in the “big box”, interfered with ongoing microcell tests. (Refer to Section 2.4.3 for additional discussion.)

Details on microcells tested in 2014 are summarized below in Table 87. Data collected for microcells from the start of these tests through the spring of 2014 were compiled and evaluated over the summer to assist in refining media designs. The results were mixed, but they confirmed that the design incorporating a coarser ZVI followed by a finer ZVI performed among the best. Other top performers included (1) those filled entirely with the finer ZVI, despite clogging issues, and (2) a mixture of finer ZVI with sand. At the time this evaluation was conducted, no tests using a mixture of ZVI with sawdust had been completed. However, results from these later tests have been very favorable.

Table 87. Summary of Microcells Tested in 2014

Microcell	Media and Grain Size Description	Reusable/ Disposable Vessel	Start Date	Duration of Test (days)	Uranium Removed by Microcell (mg/L)
2H	2 layers (from base to top): 50% Peerless -4/+8 ZVI + 50% Peerless 8/50 ZVI	Disposable	1/2/2014	6	256.93
2I	3 layers (from base to top): one third Grade #1 Steel Wool + one third Peerless -4/+8 ZVI + one third Hepure 20/60 ZVI	Disposable	1/9/2014	12	505.61
2J	2 layers (from base to top): 50% Peerless -4/+8 ZVI + 50% Hepure 20/60 ZVI	Disposable + Liner	1/22/2014	16	543.12
2K	2 layers (from base to top): 50% Peerless -4/+8 ZVI + 50% Hepure 20/60 ZVI	Disposable + Liner	2/17/2014	20	973.40
2L	2 layers (from base to top): 50% Peerless -4/+8 ZVI + 50% Peerless 8/50 ZVI	Reusable	3/17/2014	0	Microcell leaked
2M	2 layers (from base to top): 50% Peerless -4/+8 ZVI + 50% Peerless 8/50 ZVI	Reusable	4/1/2014	8	454.92
2N	2 layers (from base to top): 50% Peerless -4/+8 ZVI + 50% Hepure 20/60 ZVI	Reusable	4/17/2014	14	516.63
2O	2 layers (from base to top): 50% Peerless -4/+8 ZVI + 50% Hepure 20/60 ZVI	Reusable (was 2M)	7/7/2014	13	Sampler malfunctioned
2P	Mixture of Peerless 8/50 ZVI and sawdust	Reusable (was 2L)	7/20/2014	24	1,204.65
2Q	Mixture of Peerless 8/50 ZVI and sawdust	Disposable	8/28/2014	23	1,629.33
2R	Mixture of Peerless 8/50 ZVI and sawdust	Disposable	10/8/2014	14	1,565.31
2S	Mixture of Peerless 8/50 ZVI and sawdust	Disposable	11/20/2014	19	335.76
2T	Mixture of Peerless 8/50 ZVI and sawdust	Disposable	12/9/2014	13	452.46

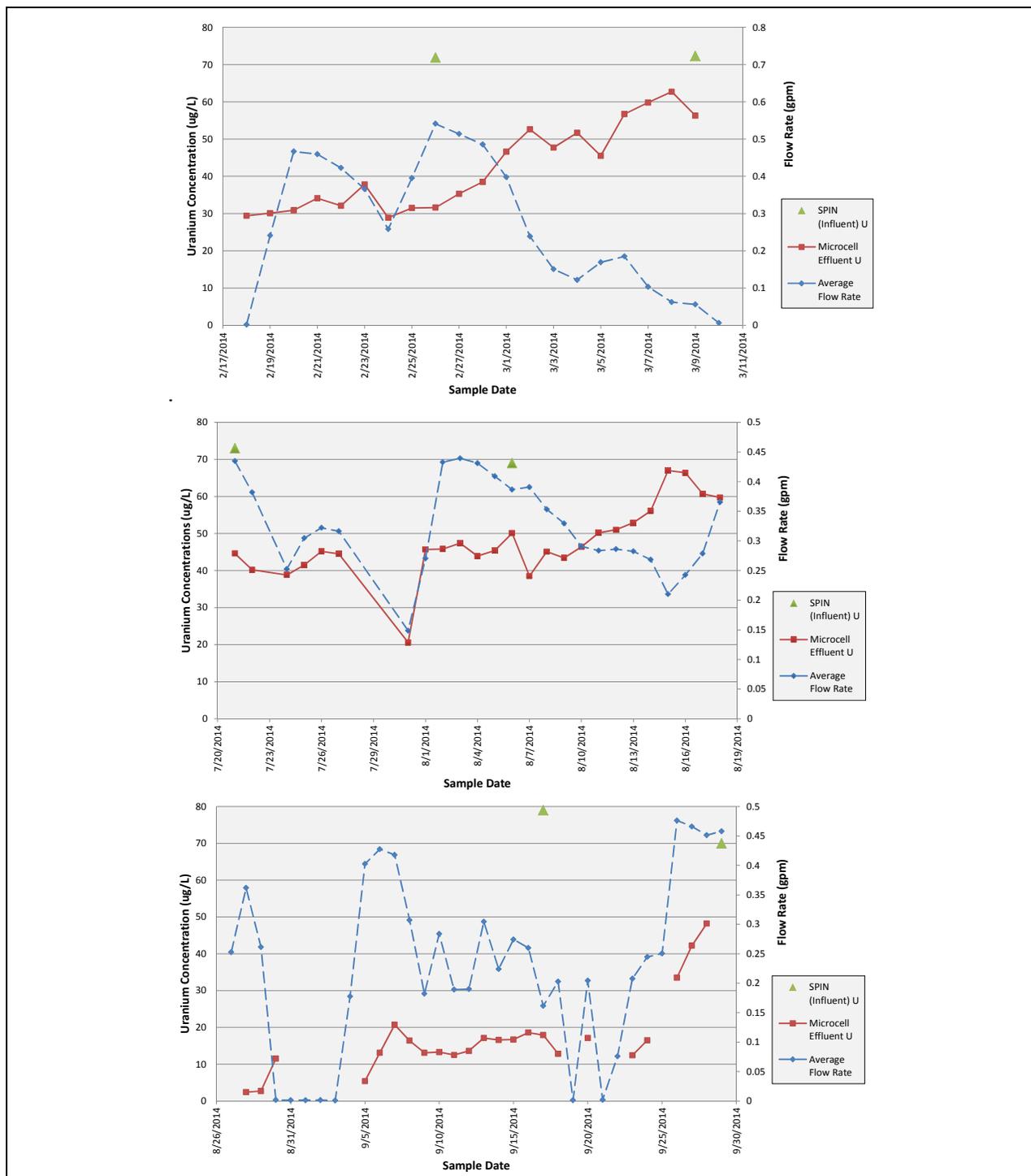
Notes:

Average uranium removed is based on data from the ESL in Grand Junction, Colorado. Microcells were all oriented vertically and configured for upflow operation. Standard U.S. mesh sizes are provided; ZVI mesh sizes were not tested but are listed as reported by vendors (Peerless and Hepure). Steel wool manufactured by Rhondes American.

Experiments with a reusable microcell were begun in the second quarter of 2014. This effort is designed to reduce costs and labor associated with microcell materials and wastes. Microcell dimensions and design are essentially the same as described in the 2013 Annual Report (DOE 2014c), but for these tests a plastic liner was placed inside the reusable microcell, between the interior walls of the microcell and the treatment media within, to aid in removing the spent ZVI-based media. After each use, the media and liner were removed, a new liner was installed, and the microcell was refilled with media. The microcell was then ready to be placed back online. The testing of these microcells continued through second quarter.

Figure 214 displays uranium concentrations and flow data for three selected microcells: one (microcell 2K in Table 87) filled with coarser and finer ZVI, and two (2P and 2Q) containing the finer ZVI/sawdust mixture. Each of these charts demonstrates the correlation among flow rate and uranium concentration in microcell effluent: As with other treatment system components discussed in this report (whether at the MSPTS, ETPTS, or SPPTS), a slower influent flow rate translates to an extended residence time for the influent within the treatment media, and a corresponding increase in treatment effectiveness. As the flow rate increases, uranium concentrations in microcell effluent often increase as well. While the ZVI within the microcell is still relatively fresh and not yet oxidized or fouled with chemical precipitates, the media is better able to treat even under conditions of higher flow. The reactive nature of the media is reduced with continued use, and at some point is no longer adequate. In addition, the media can become increasingly clogged, causing flow rates to wane; this is especially evident in the chart for microcell 2K (top of Figure 214), which used coarser ZVI in the bottom half and finer ZVI in the upper half of the microcell. (Note that, by design, clogging does not appear to be as big an issue with the ZVI/sawdust media.) These charts show that achieving adequate treatment at a sufficiently high flow rate and for a useful period of time is a balancing act regardless of which of these two media types is in use.

Although constructed to be equivalent, the effectiveness of the two ZVI/sawdust microcells varied sharply. Operational variations, particularly with respect to flow rates, are clearly factors in these differences, as the SPIN pump was deactivated in late August to support maintenance performed on the “big box” in early September, as described in Section 2.4.3. This, together with lower flow rates, affected performance of microcell 2Q (bottom chart in Figure 214).



Notes:

Top shows microcell 2K; middle, microcell 2P; bottom, microcell 2Q. Data point for 2P on July 31, 2014, represents a period of no flow (extended residence time) and is therefore not representative of microcell performance. Similarly, 2Q experienced several instances of no flow as shown on the corresponding chart. In all 2014 tests, flow direction has been upward through the microcell. Refer to text and Table 87 for details. Analytical data are from ESL, flow data are from a meter attached to microcell influent line. Some data may be qualified but are not shown differently for simplicity.

Figure 214. Example Microcell Uranium Treatment Performance Charts

Several tests were conducted in 2014 to evaluate whether there were substantial differences in treatment effectiveness among two brands of ZVI that have significant cost differences. (These are listed in Table 87 as Peerless, short for Peerless Metal Powders and Abrasive; and Hepure, for Hepure Technologies Inc. This report does not recommend any particular product, vendor, or manufacturer; this information is only provided for completeness.) The grain size ranges for the ZVI media obtained from these sources are not identical, but both were readily available and the size ranges are fairly similar. The 8/50 mesh product is technically coarser (from 0.0937 inch to 0.0117 inch) than the 20/60 mesh product (from 0.0331 inch to 0.0098 inch), though there is a large degree of overlap. While results for the several microcells using the same media mix were not consistent, this lack of repeatability did not appear related to ZVI source, nor was a strong improvement in uranium removal observed with ZVI from one source compared to ZVI from the other. Differences in treatment effectiveness may be present, but would require the tests be conducted under conditions that are much more tightly controlled than is feasible at the SPPTS. Therefore, given that any differences are slight and the cost differences are more meaningful, further testing was based on the less-expensive alternative.

Longer treatment was achieved with some designs in 2014, most particularly the mixtures of ZVI with sawdust. These microcells tended to perform better than microcells incorporating other media designs. As 2014 ended, tests of microcells continued to focus on mixtures of ZVI and sawdust. These will continue in 2014, as will tests of reusable vessels.

Phase III Pilot Studies: Lagoon Treatment

A lagoon-style approach to nitrate treatment is being pursued because not only does it have a successful long-term record of water treatment dating back thousands of years (Montana Water Center 2005), but it should require minimal maintenance to achieve effective and reliable treatment. In particular, the lagoon approach avoids the need to periodically excavate and replace treatment media, as would be the case using an organic material such as that within the original treatment Cell 1. It also avoids a prime challenge of the initial Phase III pilot-scale studies: biomass-related clogging and the related, extensive maintenance requirements. This is not to say a lagoon approach would require no maintenance, but maintenance efforts should be sharply reduced compared to these other options.

The 2012 Annual Report (DOE 2013a) summarized the design, performance, and results of bench-scale lagoon tests, successes from which led to the design of pilot-scale lagoons reported in the 2013 Annual Report (DOE 2014c). Refer to the latter report for operational details and other information.

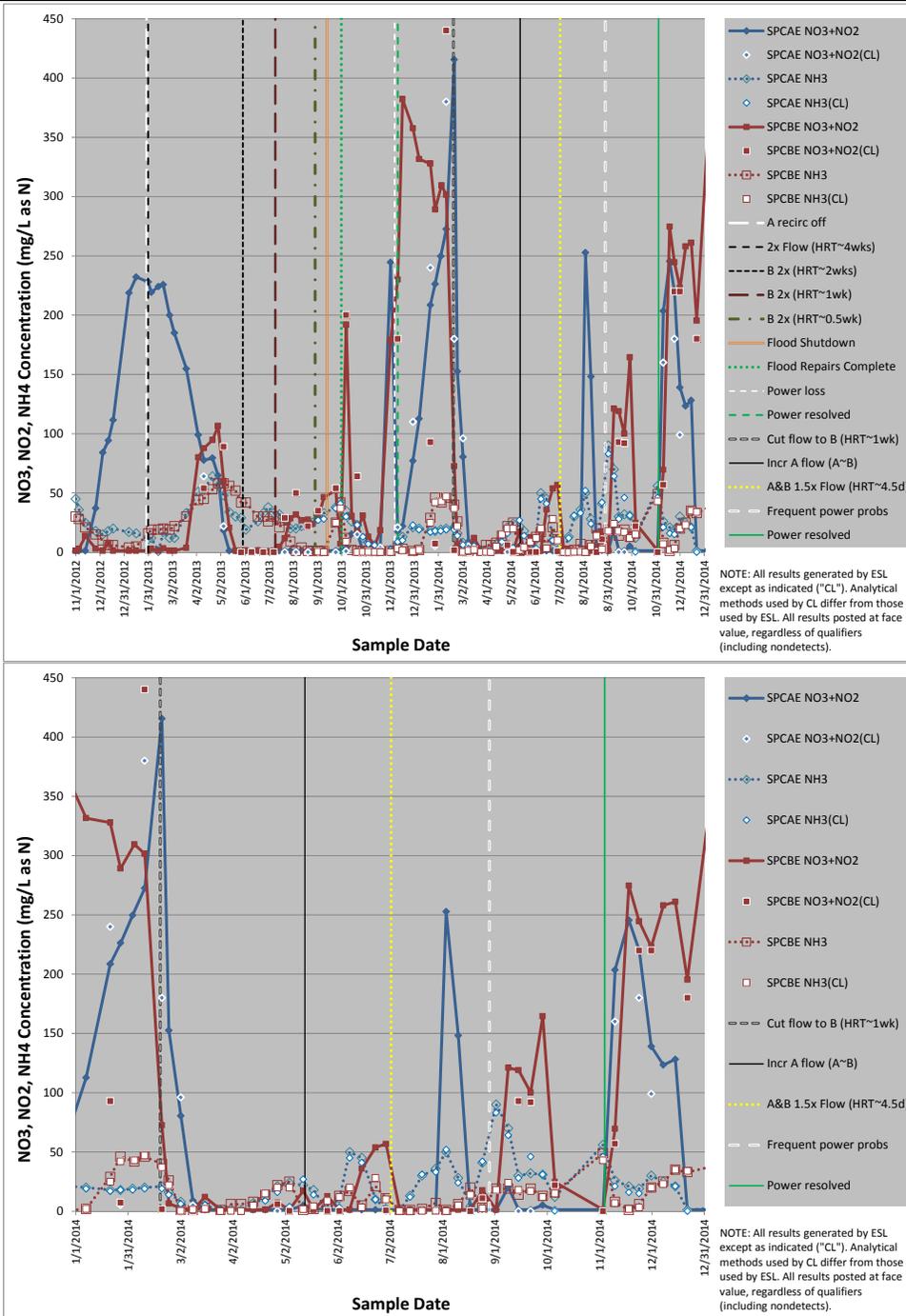
Initially, both pilot lagoons were operating at the same flow rate, based on an estimated hydraulic residence time (HRT) within the original concrete structure if its entire volume—i.e., including original treatment Cells 1 and 2 and the volume currently occupied by the associated overburden—was converted to a single lagoon. (See the 2012 Annual Report [DOE 2013a] for additional detail.) The water within one of the two pilot lagoons was also recirculated to assess the need for this in a larger-scale lagoon, and showed recirculation did not provide meaningful benefit and might actually be detrimental (DOE 2014c).

Flows were then adjusted, with the pilot-scale lagoon in Cell A remaining at the original flow rate while flows in Cell B were periodically adjusted. This is discussed at length in the 2013 Annual Report (DOE 2014c).

Throughout these tests, the same proprietary liquid carbon has been dosed to lagoon influent. This solution, which is manufactured by Environmental Operating Systems, was previously marketed as MicroCg but has since been renamed MicroC 4125; in addition, the material used in these studies contains custom-added phosphorus, the need for and concentrations of which are based on treatability studies performed using influent from the SPPTS in previous years (DOE 2010a, 2011). (Note that this report does not recommend any particular product, vendor, or manufacturer; this information is only provided for completeness.)

Efforts in 2014 were mainly focused on reducing treatment variability and understanding related maintenance requirements. Treatment effectiveness can relate to such factors as operational aspects (e.g., flow rates and nutrient dose rates), as well as by environmental conditions (including concentrations of various constituents in the influent, and climate). Many more variables can also play a part, such as the oxygen content of the water, presence of competing organisms in addition to the denitrifying bacteria, presence of toxins, and so on. Consideration was also given in 2014 to whether and how the accumulating biomass sludge in the bottom of each lagoon might be removed, and to testing microcells using effluent from the lagoons. Plans were developed for removing the sludge, but were not implemented as no ill effects were observed. Specialized plumbing was designed and installed (see Contact Record 2014-08) to support future tests of microcells using lagoon effluent as the influent to those tests. This would allow an evaluation of whether the ZVI-based treatment media would be effective in treating uranium for a substantially longer period if influent to the microcell had lower concentrations of nitrate. Additional discussion of this subject is presented later in this section.

The flow rates at the start of 2014 targeted HRTs of roughly 20–25 days in Cell A and 3–4 days in Cell B. In February 2014 the flow rate to Cell B was reduced so that the target HRT increased to approximately one week. The 1-week HRT provided improved treatment in this lagoon, as shown on Figure 215. In May flows to Cell A were increased to be equivalent to those to Cell B, and then in early July flows to both cells were increased slightly, targeting a 4.5 day HRT. (Note that flows to each cell are delivered in pulses and controlled by valves. Setting the valves to be equivalent, and to achieve the desired HRT, can be a difficult, iterative process. Actual average flow rates and HRTs can vary from the target values significantly as a result, and are fine-tuned over a period of days to weeks.) Dosing throughout this process remained uniform, at 15 mL of the liquid carbon nutrient to each gallon of influent. Although both cells were being operated the same—same flow rates and dosing—Figure 215 shows that nitrate treatment was not equivalent.



Notes:

Top illustrates entire duration of Phase III lagoon operation, bottom focuses on 2014.

SPCAE = Cell A effluent; SPCBE = Cell B effluent.

CL = contract lab; all other data from ESL in Grand Junction, Colorado. Data for NO3+NO2 from ESL are plotted as arithmetic sums of the individual results. Events related to Cell A are summarized as “A,” in Cell B are summarized as “B”; for example, “A recirc off” indicates when the Cell A recirculation pump stopped. HRT = hydraulic residence time; changes are shown as “2x” indicating doubling of flow, or halving of HRT, the result of which is listed as approximate number of weeks or days.

Not all operational events are shown, such as instances of system shutdown due to high water levels or shorter-term power losses. Some data are qualified but are not displayed differently.

Figure 215. Overall Treatment Performance of SPPTS Phase III Pilot-Scale Lagoons

As with other treatment testing, such as the microcells discussed above, evaluating and improving the consistency and reliability of lagoon-based nitrate treatment was made more difficult due to operational issues in 2014. The already-high groundwater levels resulting from the flood of 2013 combined with winter snowmelt and spring moisture to enter the open-bottomed metering vault in which the electrical controls of the SPPTS are situated, triggering automated shutdowns of the system. (This has occurred in previous years as well, but the unusually high groundwater levels in 2014 increased the frequency of these events.) Later, power failures of an unrelated nature began to occur and led to electrical work and replacement of the batteries, as discussed in Section 2.4.3. While each of these conditions in all instances was successfully remedied, during the interim the lagoons did not receive flow. These unplanned events did not help treatment effectiveness nor contribute to improvements in treatment reliability (Figure 215). The two lagoons—despite being operated the same and suffering the same upsets—performed differently with respect to nitrate treatment over the course of the year. The general condition of the water in each lagoon varied remarkably over this period, producing smells, foam, higher-viscosity fluid, and clots of biomass that had been different or uncommon before. However, neither lagoon suffered an upset that would require re-establishing the bacterial population, and shortly after each upset the treatment improved.

As can be seen on Figure 215, treatment has suffered during periods of extreme cold each winter. The temperature of the groundwater itself remains fairly uniform over the course of a year, but heat can be lost through system piping and treatment cells. Adding insulation (such as concrete blankets over the tops of the lagoons, pipe insulation on pipes within vaults, and so forth) has helped to reduce these variations, but is not entirely successful. Excess power is not available to add heat, such as via heat tape. As 2014 came to a close, a different type of insulation—insulated covers manufactured for hot tubs—were on order for further testing.

As noted above, one of the main improvements lagoon-based treatment offers is the lack of a substrate that would otherwise be susceptible to clogging. The plastic media that was present in the original configuration of Phase III Cell A became extremely clogged with biomass and led to the rejection of this treatment approach. However, the Phase III lagoons still depend upon denitrifying bacteria to treat the influent, and visual observations have shown that biomass is abundant in the water. Attempts were made in 2014 to gauge the quantity of biomass that might be accumulating as a layer of sludge on the bottom of each cell. A small, waterproof camera and flashlight were attached to a rod, and a Secchi disc was set a few inches from the camera lens and within the beam of the flashlight. This assembly was slowly lowered to the bottom each cell, with video collected throughout the process. Even though the disc was only about 6 inches from the lenses of the camera and flashlight, the black and white pattern was no longer visible after being lowered only a foot or so into the lagoon. In the shallowest interval of each lagoon where sunlight penetrated, clots of biomass could be seen passing in front of the lens. Below a depth of about 2 to 3 feet the water was too turbid—the flashlight did not provide enough illumination to allow inspection, and the sludge layer at the bottom of each cell could not be visually distinguished.

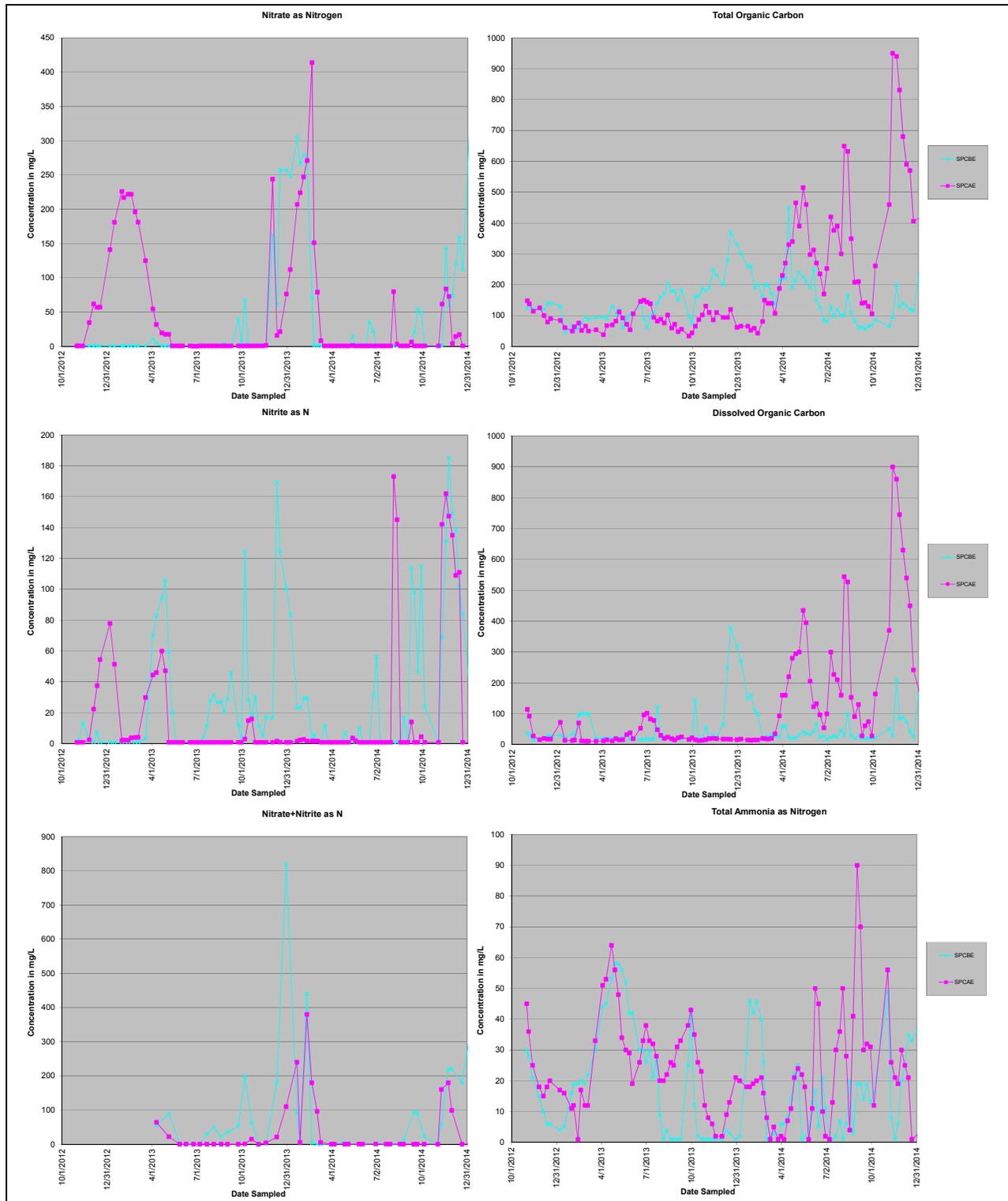
Several charts are included that focus on individual nitrogen-containing constituents (nitrate as N, nitrite as N, ammonia as N) and other parameters of interest (total organic carbon or TOC, dissolved organic carbon or DOC). These charts are grouped together and provided below as Figure 216. (**Note:** Most of the data presented in Figure 215 and all data in Figure 216 are

generated by the ESL in Grand Junction. This laboratory is operated for DOE and results cannot be validated. However, instrumentation and analytical methods used are sound, and the data for nitrogen constituents are occasionally checked by submitting split samples to EPA-certified contract laboratories, as shown on Figure 215.)

Lagoon-based treatment in late 2014 was not optimal, as can be seen on both of these figures. Flow interruptions discussed previously represented difficulties. By early November these issues had been resolved, but an early cold snap contributed to the reduced treatment effectiveness evident in November and December. (This cold snap contributed to the damage or loss of many trees across the Front Range, as temperatures dropped very quickly from the 60 °F range to below 0 °F and remained in the 0–10 °F range for several days.) The water in the cells does not freeze, but it does get colder than is optimal for the denitrifying bacteria.

These operational issues were expressed via reduced treatment effectiveness as well as the aforementioned changes to the appearance of the water in the lagoons. These changes in appearance or consistency were not uniform among the two cells, though both cells eventually exhibited essentially all characteristics observed. Conditions that were observed included thick foam layers over the water surface, lasting longer in Cell A, but varying in color from nearly white to brown. Particulates, ranging from black chunks to sugary crusts to brown or black “pudding skin” to fleshy chunks, were evident in one or both cells at various times. The viscosity of the water increased and at times was similar to mucous. The lagoons began to emit different odors. Over time and with continued operation conditions began to gradually improve. Addition of insulating covers over the lagoons in late November helped, as did resumption of continuous operation.

As the year ended, system operations were back to normal and treatment was beginning to improve. It was clear that concrete blankets were not ideal for insulating covers, both because they are difficult to manage when sampling weekly and because they may not offer the best insulation. Special hot-tub covers with high R-values (i.e., better insulation efficiency) were ordered and installed in early 2015, but early results suggest these may not be adequate either. This underscores the importance of considering heat loss in a full-scale lagoon design, and may indicate some form of low-energy heat addition (e.g., via solar thermal) is required. While a full-scale lagoon would represent a very high thermal capacity and might remain warm enough despite cold winter temperatures, any heat lost would be difficult to replace.



Notes:

SPCAE = Cell A effluent; SPCBE = Cell B effluent.

All data except Nitrate + Nitrite as N are from the ESL in Grand Junction, Colorado; chart for Nitrate + Nitrite as N is based on results from a contract laboratory.

Some data are qualified—including as nondetects—but are not displayed differently for simplicity.

Figure 216. Charts of Various Parameters in SPPTS Phase III Lagoons

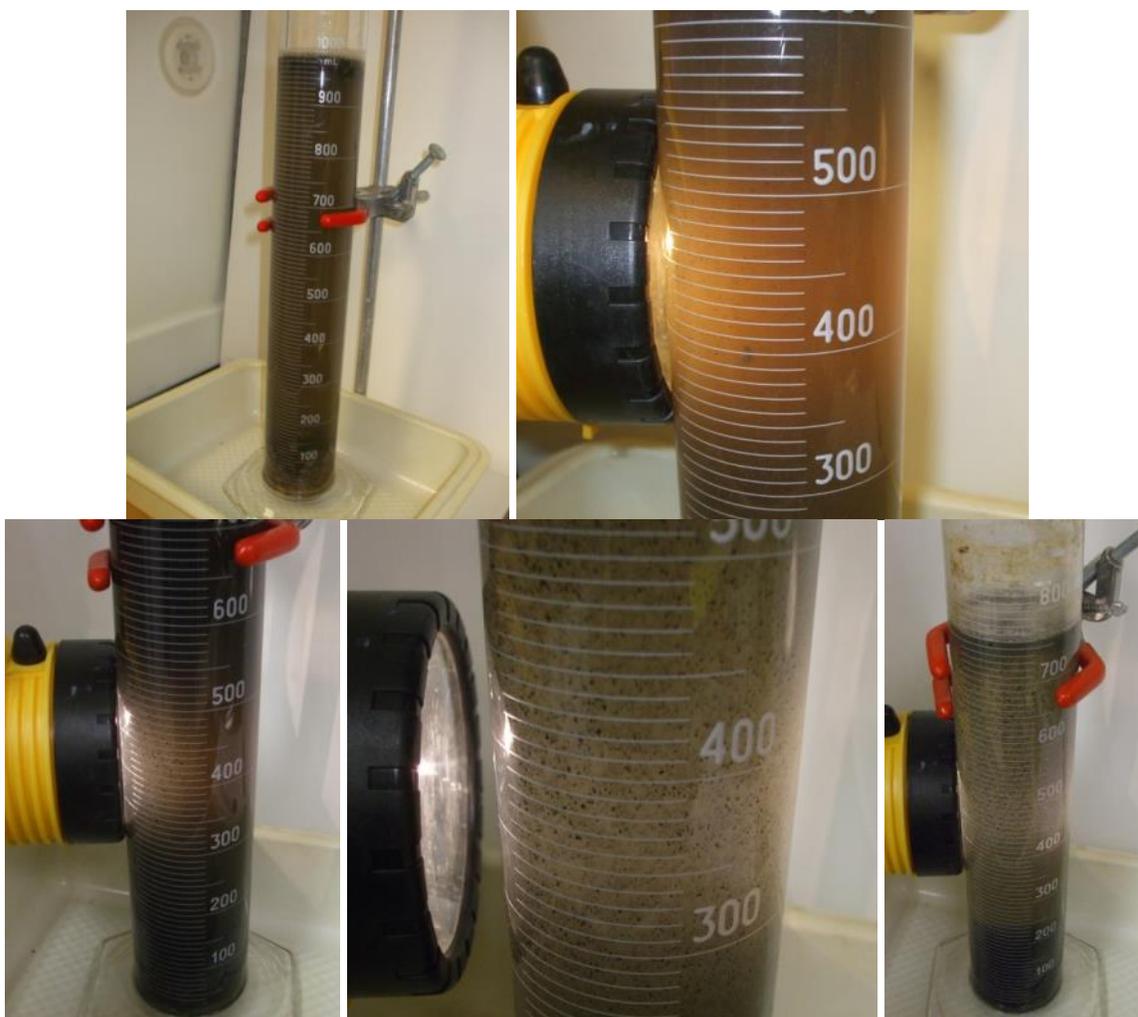
A bench test was designed and performed in 2014 to examine potential methods of clarifying lagoon effluent. The abundant biomass in this liquid may contribute to system clogging if not reduced adequately. In a full-scale application, that could impact the ability of the subsurface Discharge Gallery to release treated effluent at the necessary rate, and could also lead to clogging in the pipes leading to the Discharge Gallery. In addition, testing of microcells using denitrified water—i.e., lagoon effluent—is planned, as discussed above in the text on microcells. To this end, plumbing was installed in 2014 for future use. However, a ZVI-based microcell such as those currently being tested would quickly clog with biomass if raw lagoon effluent was pumped through it. This also applies to any larger-scale ZVI treatment component receiving effluent from a lagoon.

The initial bench test performed in 2014 was simple: Approximately equal aliquots of effluent were collected from Cells A and B and placed in a single graduated cylinder. This filled container was allowed to rest, undisturbed and uncapped, for several weeks. Photographs were taken and observations were recorded each workday, and turbidity was measured periodically.

Results of this test showed biomass in the effluent settled fairly readily and without any external influences. The fluid was initially roiling with chunks of biomass that floated to the top, released bubbles of gas, and sank back to the bottom. (Similar behavior is observed in the Phase III lagoons.) Within one day in the graduated cylinder, this level of activity was reduced, and within two days the water was noticeably clearer. The effluent stratified over several days to form a floating layer of scum and a bottom layer of sludge, with the middle portion relatively clear. Although the changes that were observed took place very gradually, after about 2 weeks the water had almost finished clarifying (Figure 217). The turbidity levels over this time period decreased sharply, from an initial value of approximately 700 nephelometric turbidity units (NTU) to about 40 NTU.

Additional bench tests of this type are planned for 2015. All are based on low-energy methods, which means they also tend to be time-consuming. In addition to simple settling such as was performed in this initial test, sand filters and bag filters will be tested. Results will be summarized and discussed in the 2015 Annual Report.

Operation of the pilot-scale lagoons will continue in 2015 and maintenance needs will continue to be assessed. Other tests may also be identified to support conceptualization and design of a full-scale nitrate treatment lagoon facility.



Notes: Top row, left to right: Filled cylinder on first day (July 8, 2014); close-up on same date. Bottom row, left to right: Conditions on July 9, 2014 (day 2), July 21, 2014 (day 14), and August 7, 2014 (day 31). Test was concluded on August 13, 2014 (day 37).

Figure 217. Photographs Showing Lagoon Effluent Conditions During Clarifying Test

Other Plumes

In accordance with RFLMA, other groundwater contaminant plumes at Rocky Flats were also monitored during 2014. Contaminant source areas (monitored by Evaluation wells) and downgradient contaminant migration pathways (monitored by Sentinel and AOC wells) were all scheduled for routine monitoring in 2014.

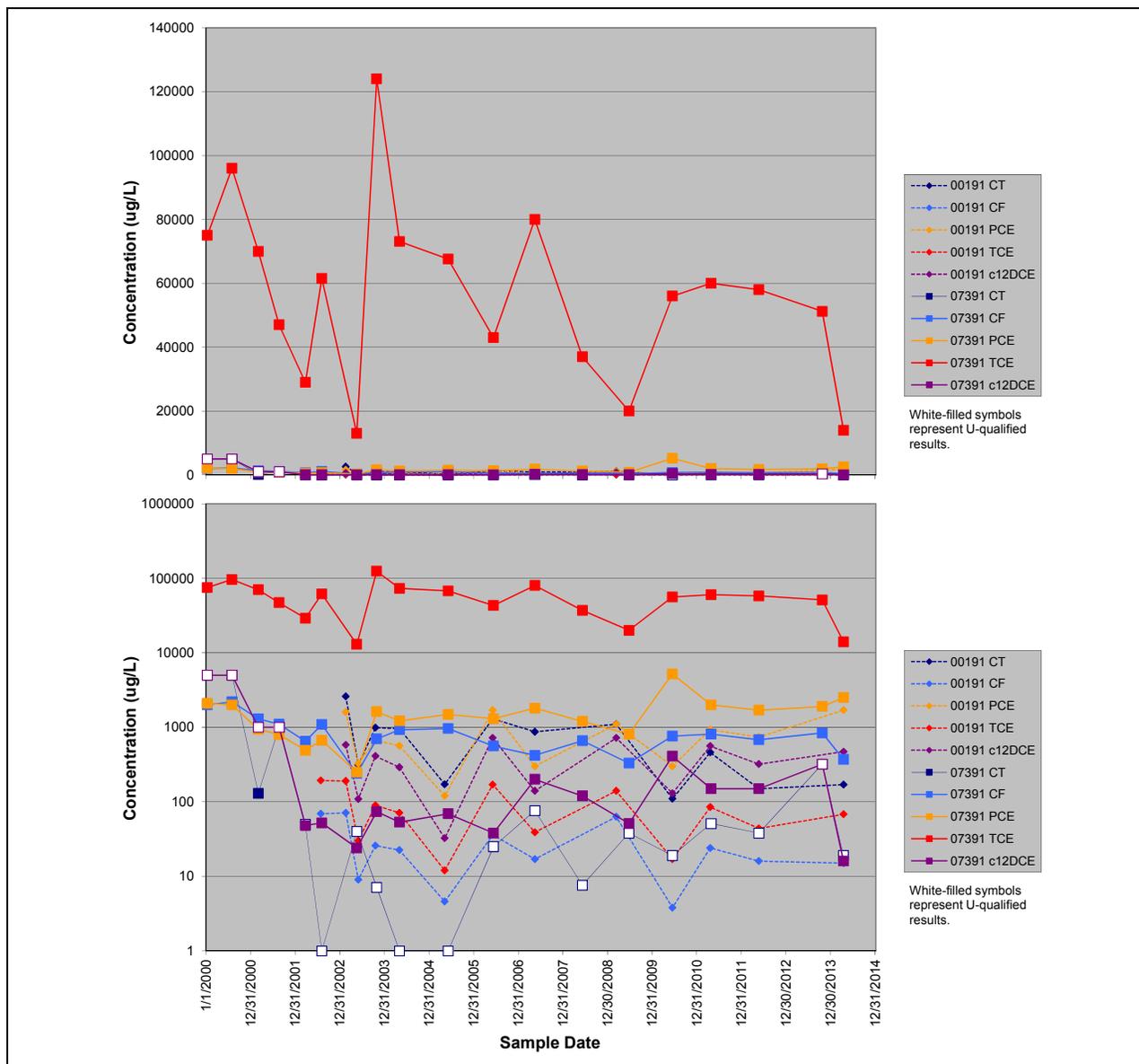
This section presents a summary discussion of data collected in 2014 from wells monitoring several plumes and areas of interest. These include source and distal locations for the 903 Pad/Ryan's Pit Plume, the collection of small plumes collectively referred to as the IA Plume, the VC Plume (or OBP #1 Plume) located south of the former Building 371 (B371) complex, the IHSS 118.1 Plume (also called the Carbon Tetrachloride Plume) located between former Building 776 and B771, the PU&D Yard Plume, the OU1 Plume, and other locations of special interest.

903 Pad/Ryan's Pit Plume

All of the Evaluation wells monitoring the 903 Pad/Ryan's Pit Plume source areas were sampled in 2014, including source-area wells 00191 (903 Pad) and 07301 (Ryan's Pit), and the hillside wells 90402, 50299, 00491, and 90804. All Sentinel and AOC wells were also sampled, including hillside/SID Sentinel wells 90299 and 90399, and Woman Creek valley AOC wells 10304 and 00193. The Evaluation wells were sampled in April, and the Sentinel and AOC wells were sampled in April and October. Refer to Figure 2 for an illustration showing the locations of these wells.

Analytical results in samples collected in 2014 from this area were generally consistent with previous data. Source-area well 07391, located just south of former Ryan's Pit, continued to produce samples with the highest overall concentrations of contaminants. Concentrations of TCE from well 07391 are consistently reported at much higher concentrations (by typically 1 to 2 orders of magnitude) than any other VOCs in this well or in 903 Pad source-area well 00191. This is clearly evident on Figure 218, which includes a time-series plot using a linear concentration scale at the top for perspective. Although carbon tetrachloride is a primary constituent at the 903 Pad and is the parent compound for chloroform, it continues to be undetected in samples from Ryan's Pit well 07391 while chloroform is detected at elevated concentrations. Chloroform was also used in the production era at Rocky Flats (ChemRisk 1992), which explains why it could occur without detectable levels of carbon tetrachloride at Ryan's Pit. (It should also be noted that the detection limits for carbon tetrachloride are fairly high due to the high concentrations of other VOCs in samples from well 07391. The detection limit for this constituent in 2014 was reported at 19 µg/L, while in 2013 it was 320 µg/L, the highest it has been since 2001.)

Compared with those at well 07391, overall concentrations of the primary VOCs detected in well 00191 have been varying much more similarly for the period of record (since January 2000): generally speaking, when concentrations of one increase, so too do the others. However, the order in which the concentrations of PCE, carbon tetrachloride, and *cis*-1,2-DCE are ranked has varied. Since 2010, the concentration of PCE has been higher than the others; prior to that, carbon tetrachloride was most often present at the highest concentration. Also since 2010, the concentration of *cis*-1,2-TCE has been higher than carbon tetrachloride. As mentioned above and illustrated on Figure 218, the concentrations of VOCs in samples from this well are much lower than those of TCE in well 07391.



Notes:

Top and bottom portions display the same data, but the top portion uses a linear concentration scale and the bottom uses a logarithmic scale.

Constituents and RFLMA Table 1 values: CT = carbon tetrachloride, 1 µg/L; CF = chloroform, 3.4 µg/L; PCE, 5 µg/L; TCE, 2.5 µg/L; c12DCE = *cis*-1,2-DCE, 70 µg/L.

Several detections are qualified but for simplicity are not shown differently.

Figure 218. Primary VOCs in 903 Pad/Ryan's Pit Plume Source-Area Wells

An inverse relationship between concentrations of VOCs in samples from these two wells has been previously suggested (DOE 2012), but this does not appear to hold true for 2014 data. The primary VOCs in well 00191 generally reported about the same (carbon tetrachloride, chloroform) or slightly higher (PCE, TCE, *cis*-1,2-DCE) concentrations in 2014 compared with results from 2012 (Figure 218). Concentrations of some VOCs increased at well 07391 (PCE, *cis*-1,2-DCE), while others decreased (TCE, chloroform).

Electron donor material was applied to the subsurface in both source areas shortly prior to Site closure (K-H 2005d, DOE 2006d). Effects of this activity on VOCs reported in wells 07391 and 00191 are not clear (for example, as they are in OBP #2 source-area Evaluation well 91105, discussed above).

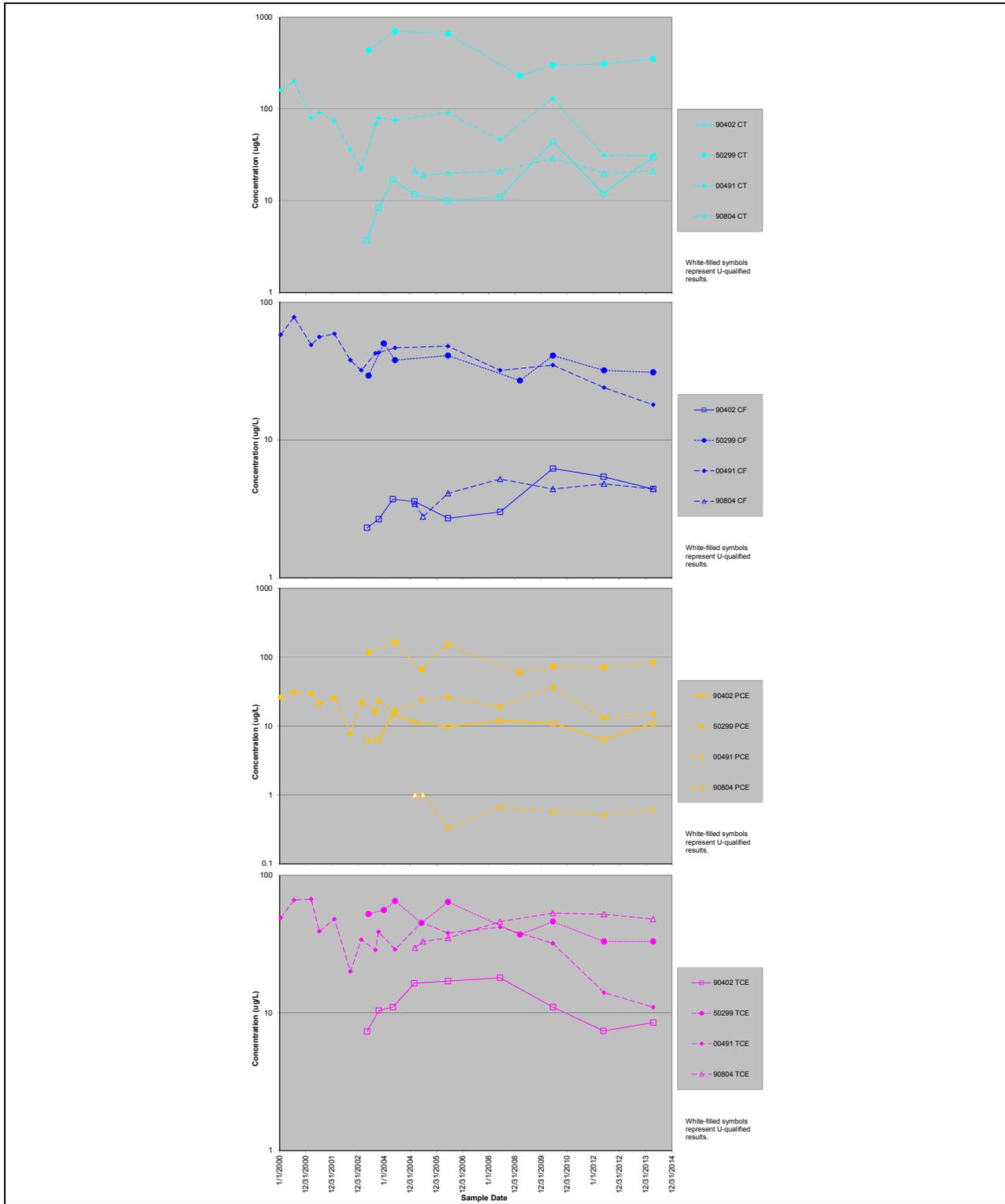
Elsewhere on this hillside, the four Evaluation wells monitoring the 903 Pad/Ryan's Pit Plume (90402, 50299, 00491, and 90804) reported concentrations of VOCs that are consistent with previous data. The VOCs displayed above in Figure 218 are also displayed for these four hillside wells as Figure 219, except for *cis*-1,2-DCE, which is not a meaningful constituent in samples from wells 90402 and 90804.

Defining a pattern among these constituents in the four wells is difficult, as they appear to vary somewhat randomly. Well 90402 is closest to both source areas, but is only downgradient of the 903 Pad. Even so, overall this well reports lower concentrations of VOCs than the other three wells; the most consistent exception is PCE, which is routinely higher in well 90402 than in well 90804. This latter well, 90804, is screened within materials beneath a slump block. It is the only one of the four to be downgradient of the Ryan's Pit source area; as a result, since 2008 this well has presented the highest concentrations of TCE of any of these wells. Well 50299 is located near a marshy area east of Ryan's Pit, and well 00491 is a short distance south and downgradient of the former well (Figure 2). Their similarity in chloroform concentrations perhaps reflects this proximity; however, they typically differ markedly in the concentrations of the other three constituents displayed on Figure 219. As additional data are collected in accordance with the RFLMA, clearer patterns among the VOCs detected in these wells may become evident.

Perhaps showing its proximity to the 903 Pad source area, concentrations of carbon tetrachloride and PCE historically were the most similar in samples from well 90402. However, since 2008 these constituents are no longer detected at roughly equivalent concentrations; concentrations of PCE are now well below those of carbon tetrachloride, and are more similar to those of TCE.

Concentrations of these four VOCs in samples from well 90804 vary as little as do the water levels in this well (see hydrograph in Appendix A). Compared to their concentrations in the other wells illustrated in Figure 219, those at well 90804 are much more consistent. TCE is present at the highest concentrations, followed by carbon tetrachloride, illustrating the effective commingling of contaminants from the two source areas.

As of the second quarter of 2014, contaminant concentrations at these four Evaluation wells showed little if any response to the heavy precipitation in September 2013. Some increases are evident, such as for carbon tetrachloride and PCE reported at well 90402 (the closest of these four wells to the 903 Pad), and for these same VOCs at well 50299 and for PCE at well 00491. However, the concentrations of the various VOCs are seen to vary naturally over the period of record; the relatively minor increases and decreases seen in 2014 may not be linked to the heavy rains. With additional data in future years, clearer causal relationships among constituent concentrations and that major precipitation event may become more apparent.



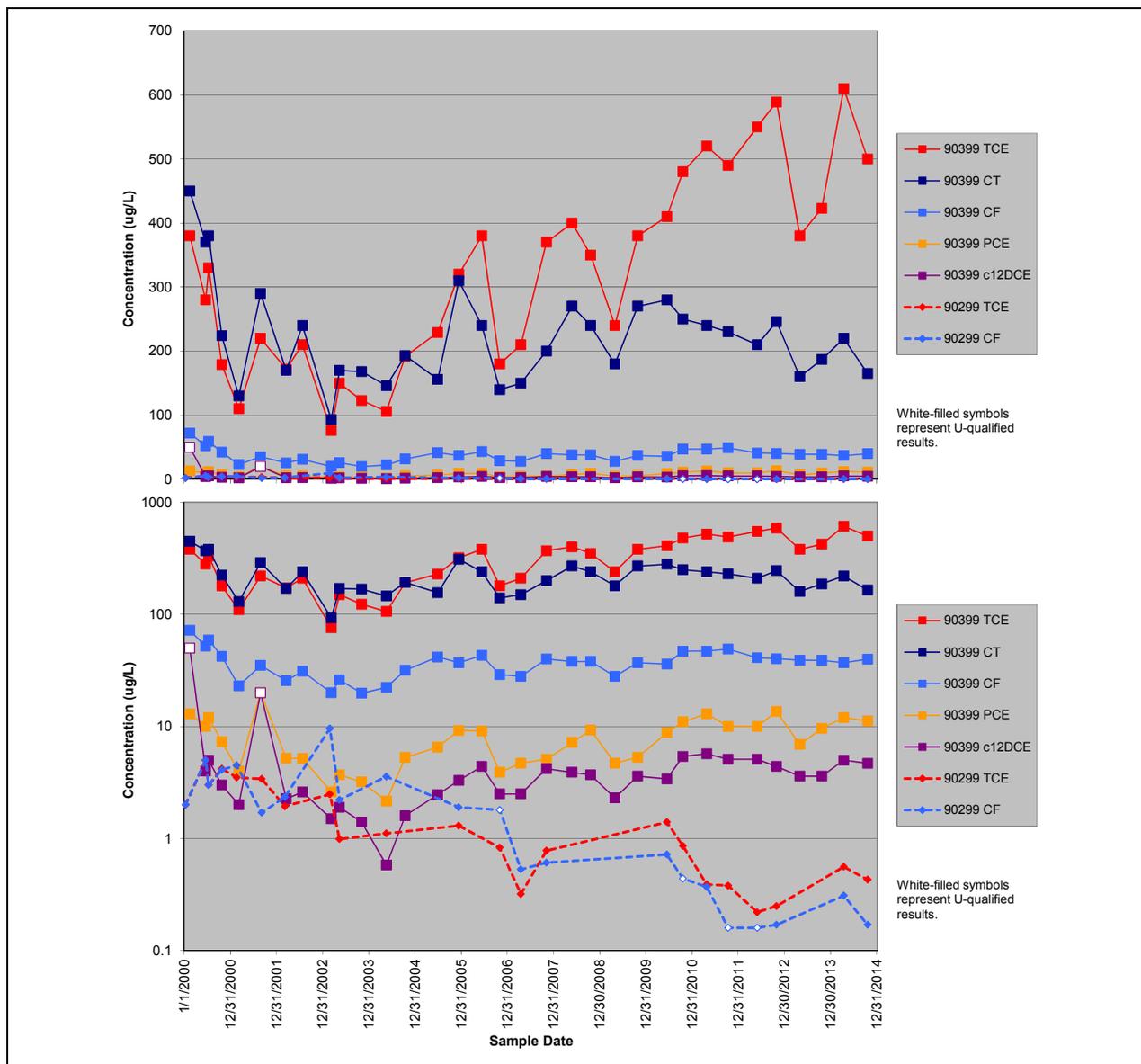
Notes: Constituents and RFLMA Table 1 values (µg/L): CT = carbon tetrachloride, 1; CF = chloroform, 3.4; PCE, 5; TCE, 2.5. Several detections are qualified but for simplicity are not shown differently. Note logarithmic concentration scales, which vary in magnitude depending on the VOC concentrations being displayed.

Figure 219. Primary VOCs in 903 Hillside Evaluation Wells

Two Sentinel wells—90299 and 90399—monitor this plume at locations farther downgradient from the source areas than the four Evaluation wells discussed above. Both are located on the north side of the SID, near the Woman Creek valley bottom. Although near each other and similarly constructed, well 90399 produces water reliably and 90299 often is dry; in addition, concentrations of VOCs in samples from well 90399 are consistently much higher than are those in samples from well 90299. Following the extreme recharge event in 2013, well 90299 produced samples in both the second and fourth quarters of 2014.

Figure 220 provides time-series plots of several constituents in these two Sentinel wells, with both linear and logarithmic concentration scales to provide additional perspective. Included for well 90399 are the primary contaminants from the 903 Pad and Ryan's Pit source areas illustrated on the time-series plots above, and well 90299 is represented by a subset of these VOCs because the others are not detected. As in previous years, well 90399 continues to report concentrations of contaminants that exceed those at some wells nearer the source areas. The concentrations of TCE reported in samples from this well are typically second in this area only to those reported at Ryan's Pit source-area well 07391. Concentrations of carbon tetrachloride in well 90399 in 2014 were similar to those reported for the 903 Pad source area well 00191 (220 µg/L and 165 µg/L in second and fourth quarters at well 90399, compared with 170 µg/L in the second quarter at well 00191). Concentrations of TCE and carbon tetrachloride at well 90399, once present in roughly equivalent concentrations, have continued to diverge. TCE is now reported at concentrations that are significantly higher than those of carbon tetrachloride (Figure 220), and this separation has continued following the relatively lower 2013 concentrations of both constituents. Results reported in 2014 include the highest concentration of TCE in the period of record during the second quarter. Variations in TCE concentrations are large compared to those of other constituents detected at 90399, such as carbon tetrachloride, PCE, *cis*-1,2-DCE, and chloroform. Overall, it appears that TCE is generally increasing while concentrations of the other VOCs remain fairly uniform or are increasing more slightly. At well 90299, concentrations of TCE and chloroform both appear to be gradually decreasing (Figure 220).

As noted above for the Evaluation wells, it is not yet certain whether the heavy rains of 2013 had any marked effect on contaminant behavior in these Sentinel wells, and the same applies to the 903 Pad/Ryan's Pit Plume as a whole. That heavy recharge event may have acted to flush residual contaminants from the vadose zone, which could lead to increasing concentrations over time as these constituents reach the various monitoring points. Previous studies indicating the presence of a bedrock paleoridge between the 903 Pad source area and the wells farther down the hillside (EG&G 1995b) have suggested that only during periods of high water is groundwater from the 903 Pad area able to "spill over" and migrate down this south-facing hillside. The extremely heavy September 2013 rains, which resulted in significant recharge across the site, could have activated this migration pathway, in which case 903 Pad waters and contaminants might flush through this hillside in the coming years. Additional data from each of these wells will continue to be evaluated for such a signal.



Notes: Top and bottom portions display the same data, but the top portion uses a linear concentration scale and the bottom uses a logarithmic scale.

Constituents and RFLMA Table 1 values: CT = carbon tetrachloride, 1 µg/L; CF = chloroform, 3.4 µg/L; PCE, 5 µg/L; TCE, 2.5 µg/L; c12DCE = *cis*-1,2-DCE, 70 µg/L.

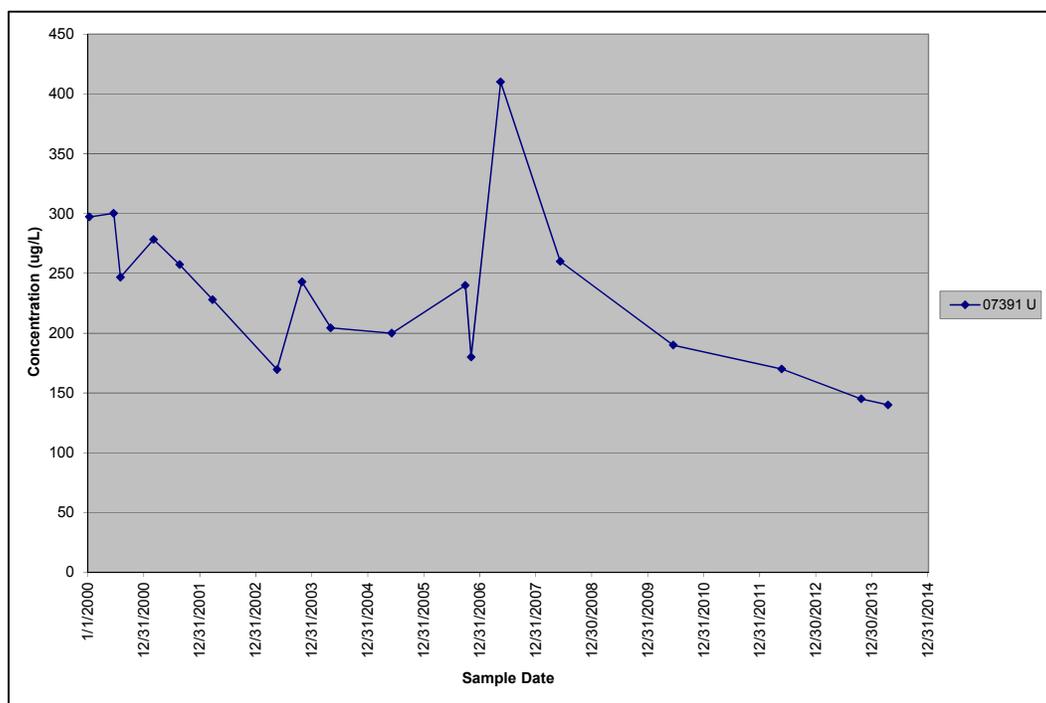
Several detections are qualified but for simplicity are not shown differently.

Figure 220. Primary VOCs in 903 Pad/Ryan's Pit Plume Sentinel Wells 90299 and 90399

Calculated concentration trends having a statistical significance of 95 percent are indicated for several analyte/well pairs. Data from source-area well 00191 are calculated to be on a decreasing trend for 1,1-DCE. Source-area well 07391 shows a decreasing trend in chloroform and an increasing trend in *cis*-1,2-DCE, but this latter trend may not be viable due to the many nondetects in the data set. On the hillside, well 50299 shows a decreasing trend in *cis*-1,2-DCE, and data from nearby well 00491 support decreasing trends in chloroform and TCE. Evaluation wells 90402 and 90804 do not support any trends at this level of statistical significance, but Sentinel wells 90299 and 90399 each show several such trends. Data for carbon tetrachloride, chloroform, and TCE from well 90299 are calculated to be decreasing (but carbon tetrachloride

is represented by many nondetects, so this trend may not be viable); and increasing trends in *cis*-1,2-DCE, PCE, and TCE are indicated – and visually evident on the figure above—at well 90399. Refer to Appendix B for the statistical summaries and trend plots, and refer to Table 74 for a list of the statistically significant trends identified for 2014.

Source-area Evaluation well 07391 is also monitored for uranium. The results are displayed in a time-series plot on Figure 221. A clear decreasing trend is evident in these data, though a single relatively high result reported in 2007 is an outlier. This visually apparent trend is also calculated to have a 95 percent level of statistical significance.



Notes: RFLMA Table 1 threshold value for uranium is 120 µg/L.

Figure 221. Concentrations of Uranium at Ryan’s Pit Source-Area Well 07391

AOC well 10304, which is located on the northern bank of and along the 903 Pad/Ryan’s Pit Plume flow path to Woman Creek, directly south of Sentinel well 90399, was also sampled twice in 2014 in accordance with the RFLMA. TCE was detected in both samples, at a concentration of 1.3 µg/L in April and an estimated (J-qualified) concentration of 0.72 µg/L in October (RFLMA value is 2.5 µg/L). TCE has been detected occasionally at this well since 2007. Uranium concentrations reported in 2014 were 27 µg/L in April and 10.7 µg/L in October. The April results for TCE and uranium are both the highest in the period of record at this location, potentially reflecting effects of the September 2013 precipitation event. Nitrate was detected in both samples at concentrations of less than 0.1 mg/L.

AOC well 00193, located at the mouth of Pond C-2, also supports the monitoring of the 903 Pad/Ryan’s Pit Plume. No VOCs were detected in samples collected at this location in 2014. Concentrations of uranium reported in these samples were within their historic range; the April result was 73 µg/L, and the October result was 79.4 µg/L. This well has been characterized as producing samples with 99.2 percent to 100 percent natural U.

IA Plume

The IA Plume (named for the former Industrial Area) is actually a collection of several small areas of groundwater contaminated with VOCs. These are grouped together for convenience and, in some cases, because of uncertainties regarding specific sources. This discussion addresses the IA Plume in terms of three loosely defined segments: the South, Central, and North IA Plumes. In accordance with RFLMA, each of the Evaluation wells was scheduled for routine sampling once in 2014, and the AOC and Sentinel wells were sampled twice.

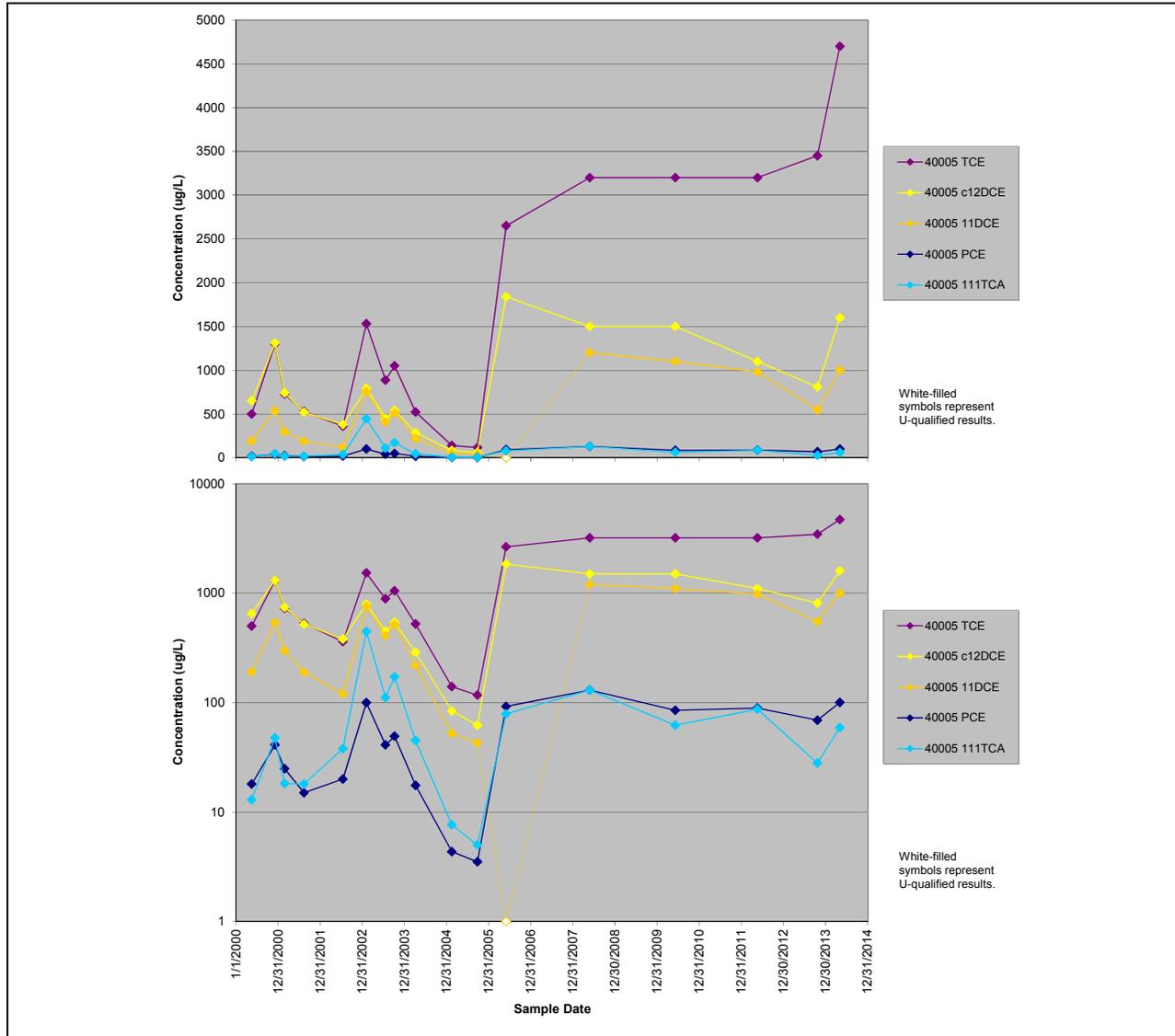
The pathway to surface water for the southern portion of the IA Plume is monitored by AOC well 11104, which was sampled in June and November 2014. No VOCs were detected. Concentrations of U in 2014, which is analyzed to support monitoring of the OLF and former B444, were consistent with previous results at this location (25 µg/L and 22 µg/L, respectively) and remained well below the applicable RFLMA value.

Upgradient of AOC well 11104, wells monitoring the South IA Plume include Evaluation wells 40005, 40205, P419689, and P416889, and Sentinel wells 11502 and 40305. Analytical results from these wells in 2014 were generally consistent with past data, although the results from well 40005 show some increase in VOC concentrations relative to those reported in recent years. This well consistently reports the highest concentrations of VOCs of any of the South IA Plume wells (see Figure 222 and compare it with Figure 223). The concentration of TCE reported in 2014 in well 40005, 4,700 µg/L, was the highest TCE result in the period of record for this location (since January 2000, including predecessor well 40099). Located between former B444 and B460, the exact source of this VOC contamination is not certain. (For additional discussion of this topic and historical information on this area, see Safe Sites 2002.)

Concentrations of the constituents included on Figure 222 increased in 2014. In most cases these results are well within the recent range of concentrations for the corresponding constituents. However, the increase for TCE is different: the concentration in 2014 was more than 35 percent higher than what had been the highest concentration reported here. The heavy September 2013 rains may have flushed residual contaminants that were then detected in samples collected at well 40005, but additional data will be required to confirm any longer-term patterns.

Comparing Figure 222, which focuses on well 40005, with Figure 223, which provides data on more distant wells, shows how localized are the higher concentrations of VOCs. However, concentrations of PCE do exceed the RFLMA level (5 µg/L) in some of these outlying wells, as indicated in the uppermost portion of Figure 223. PCE concentrations from 2014 exceed the RFLMA level at wells P416889, P419689, and 40205 (as well as 40005). The well farthest downgradient of this group, 11502, reports a concentration of PCE that is lower than the RFLMA value, as does the slightly sidegradient Sentinel well 40305. Several other VOCs are detected at one or more of these wells besides 40005, but PCE is present at the highest concentrations. Partially dechlorinated constituents are reported in source-area well 40005 as well as more distal wells in the South IA Plume, including VC (which is consistently detected at well 40205 above the RFLMA value, the PQL of 0.2 µg/L). This may suggest VOCs in this area are degrading without biostimulation efforts, such as were conducted at other locations across the site. These efforts were conducted via subsurface application of electron donor material at the

PU&D Yard Plume, IHSS 118.1, OBP #2, 903 Pad, and Ryan's Pit, but not in the B444/South IA Plume area.



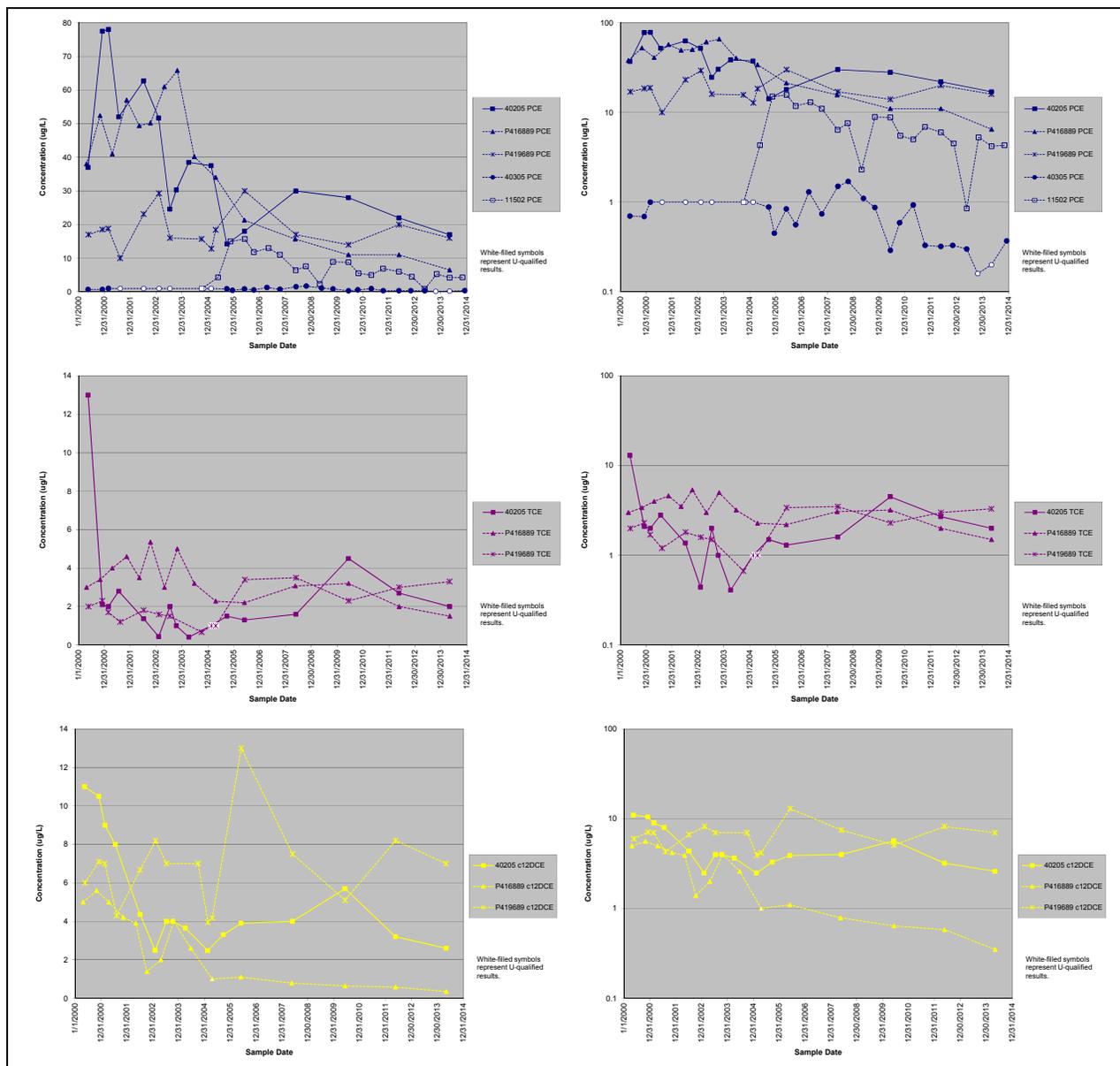
Notes:

Top and bottom portions display the same data, but the top uses a linear concentration scale and the bottom uses a logarithmic scale.

Applicable RFLMA Table 1 values (ug/L): 1,1,1-TCA, 200; PCE, 5; TCE, 2.5; *cis*-1,2-DCE, 70; 1,1-DCE, 7.

Several detections were qualified but for simplicity are not shown differently.

Figure 222. Concentrations of VOCs in South IA Plume Source-Area Well 40005



Notes:

Left and right portions display the same data, but the left portions use a linear concentration scale and the right portions use a logarithmic scale.

Applicable RFLMA Table 1 value (µg/L) (CDPHE et al. 2012): PCE, 5; TCE, 2.5; *cis*-1,2-DCE, 70.

Several detections were qualified but for simplicity are not shown differently.

Figure 223. Concentrations of VOCs in Other South IA Plume Wells

Because of the production-era mission of former B444, uranium is also analyzed in groundwater samples from this area. The highest result of any of these Evaluation and Sentinel wells in 2014 was 3.4 µg/L in well P416889. This does not suggest the presence of significant uranium contamination in groundwater of the South IA Plume.

Calculated statistical trends having a 95 percent level of statistical significance at these wells (Table 74) include increasing TCE and uranium at well 40005; decreasing 1,1-DCE, *cis*-1,2-DCE, and PCE at well 40205; decreasing *cis*-1,2-DCE and increasing uranium at

well 40305 (although the dataset for the former contains many nondetects); decreasing PCE at well 11502; decreasing uranium at P419689; and decreasing *cis*-1,2-DCE, PCE, and TCE and increasing uranium at well P416889. Data from AOC well 11104 were also evaluated for statistical trends, although this is not RFLMA requirement; uranium was calculated to be on a decreasing trend (at this level of statistical significance). Statistical results are summarized and trend plots are provided in Appendix B.

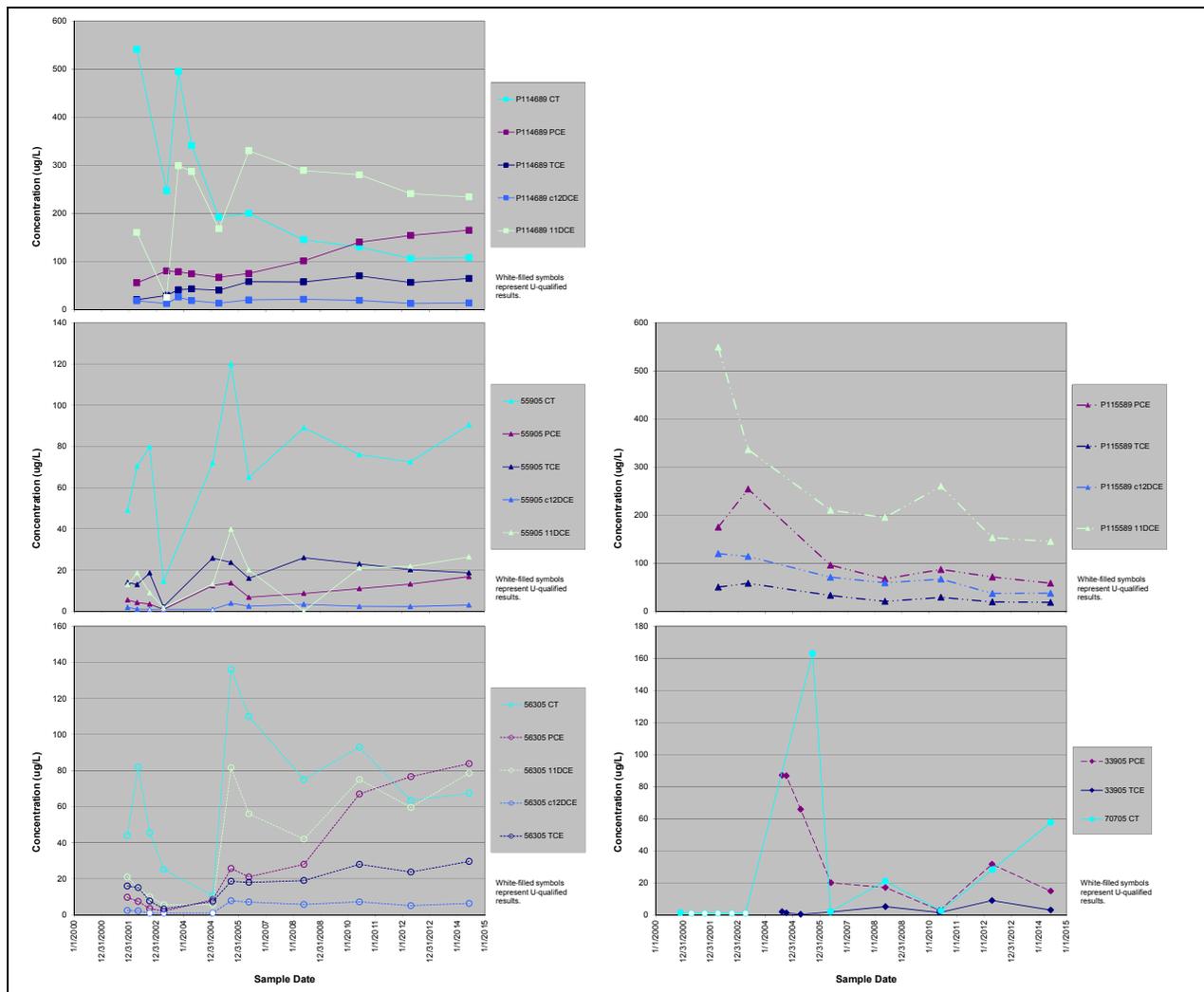
The central portion of the IA Plume, for the purposes of this report, is monitored by Evaluation wells P115589, P114689, 70705, 33905, 55905, and 56305 (see Figure 2 for a map that includes these locations). Each of these wells was scheduled for routine RFLMA sampling in 2014. The highest concentrations of VOCs in the Central IA Plume are reported at wells P114689 and P115589 (Figure 224), where the dechlorination byproduct 1,1-DCE is reported at higher concentrations than other VOCs. Also present at elevated concentrations are PCE, TCE, and *cis*-1,2-DCE. Carbon tetrachloride concentrations are also elevated at well P114689, and prior to closure they were as high as those of 1,1-DCE, but this constituent is not detected at well P115589.

A short distance northeast of well P114689 are wells 55905 and 56305, both installed to monitor groundwater downgradient of former B559. There are some similarities in how VOC concentrations vary among these three wells. The two B559 wells are especially similar, which is to be expected given their close proximity to one another. Concentrations of VOCs at well P115589 do not follow the same pattern, nor do those at well 33905 or 70705.

Several of these Central IA Plume wells are also monitored for uranium, including 55905, 56305, and 70705. Concentrations of uranium in samples from these wells have been consistently low and fairly uniform since before Site closure (Figure 225). In 2014, each of the three wells reported a concentration below 5 µg/L.

The two wells monitoring former B559 are also monitored for nitrate. Concentrations reported in 2014 were consistent with previous results, and were both below 5 mg/L.

Several VOCs in Central IA Plume Evaluation wells support increasing or decreasing trends at a 95 percent level of significance. (Refer to Appendix B for the associated trend plots and statistical summaries, and Table 74 for a summary.) Well P114689 is represented by a decreasing trend in carbon tetrachloride and increasing trends in PCE and TCE, each of which is visually apparent on Figure 224. At well P115589, six decreasing trends are calculated but three of the corresponding datasets contain numerous nondetects and may not be viable. Those that appear reliable (and are clearly evident on the figure) are for 1,1-DCE, *cis*-1,2-DCE, and TCE; the less-reliable trends are calculated for 1,1,1-TCA, 1,1,2-TCA, and VC. For the two wells monitoring former B559, increasing trends are calculated for PCE at 55905, and PCE and TCE at 56305; each of these may be affected by well replacement, when these wells were installed following abandonment of their predecessors and closure of the building in 2004. Trends calculated for well 33905 may be similarly affected, and include decreasing concentrations of 1,1-DCE and PCE. Finally, well 70705 is represented by six increasing trends calculated at a 95 percent level of confidence, all of which may be affected by well replacement and all but one of the corresponding data sets include numerous nondetects. The trend that is not based on many nondetects is for uranium; the others are carbon tetrachloride, chloroform, *cis*-1,2-DCE, PCE, and TCE.



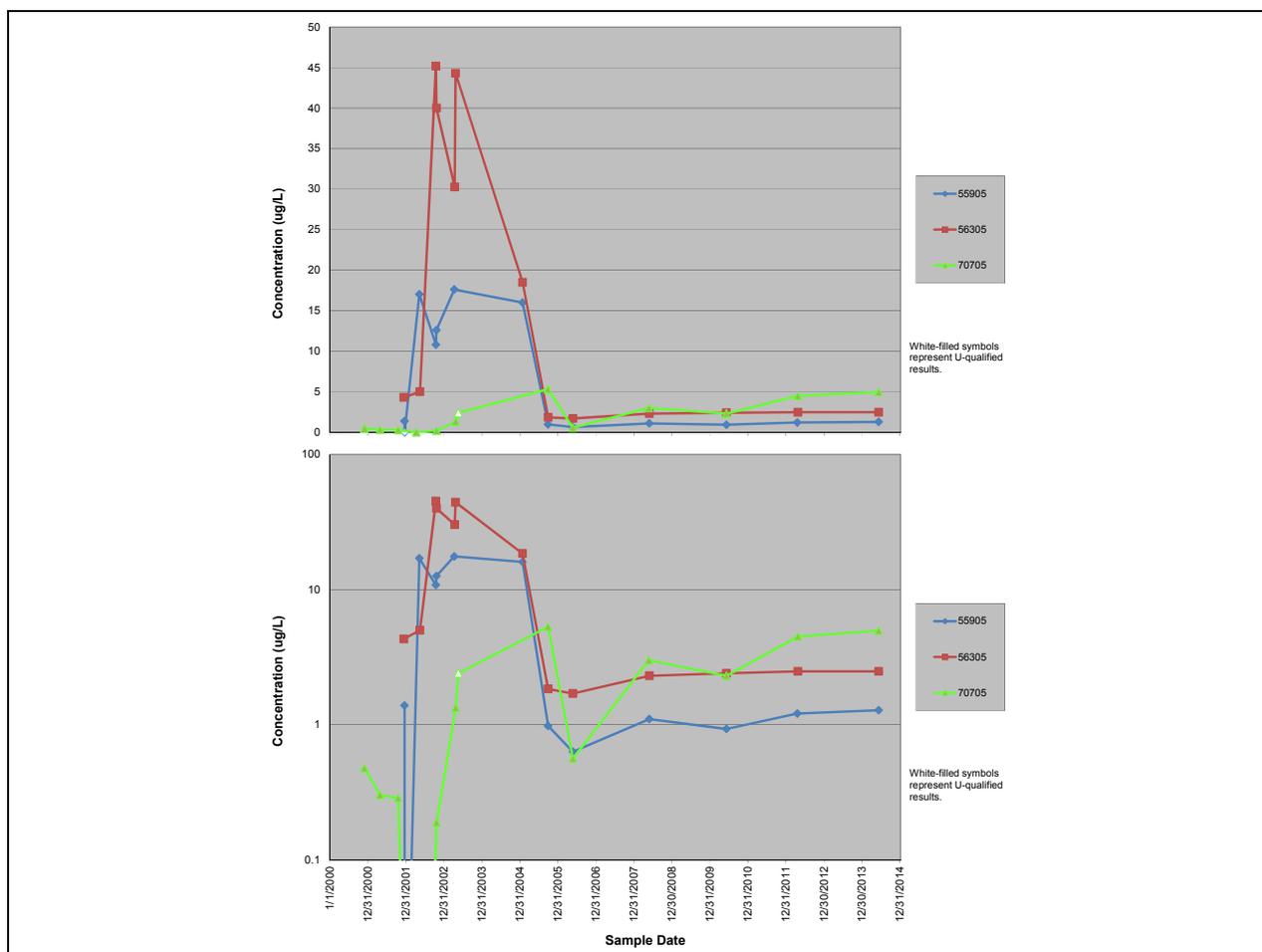
Notes:

Time-series plots for wells P114689, 55905, and 56305 are aligned vertically on the left side due to some similarities; those for wells P115589 and (combined) 33905 and 70705 are aligned vertically on the right side of the figure. All use a linear scale, but the scales vary to allow changes in concentrations to be more easily visible.

Applicable RFLMA Table 1 values (ug/L) (CDPHE et al. 2012): carbon tetrachloride, 1; PCE, 5; TCE, 2.5; cis-1,2-DCE, 70; and 1,1-DCE, 7.

Several detections were qualified but for simplicity are not shown differently.

Figure 224. Concentrations of VOCs in Central IA Plume Wells



Notes:

Top and bottom portions display the same data, but the top portion uses a linear concentration scale and the bottom portion uses a logarithmic scale and omits two data points that are below 0.01 µg/L (one for the predecessor to well 55905 in 2001, one for the predecessor to well 70705 in 2002).

The RFLMA uranium threshold is 120 µg/L.

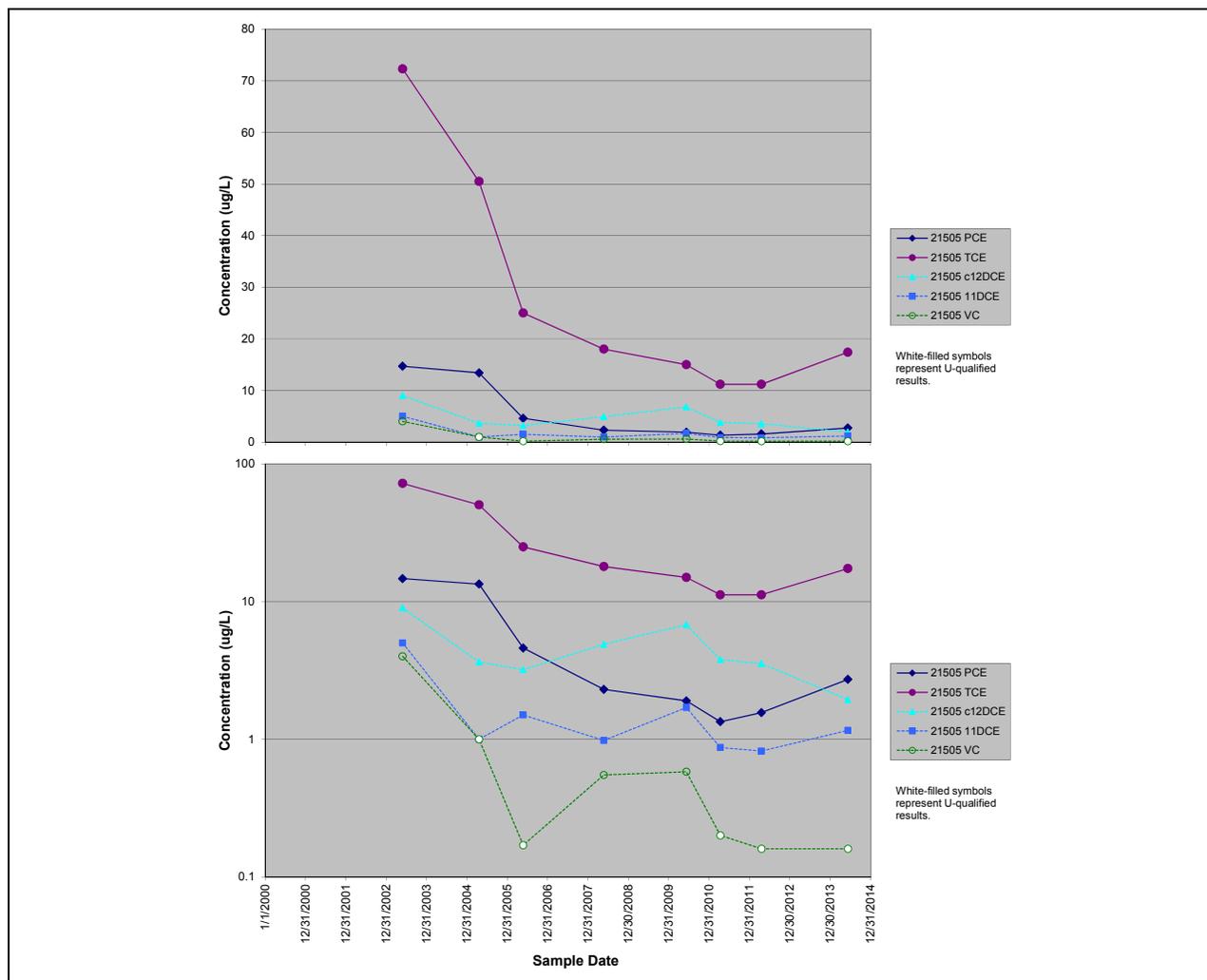
Several detections were qualified but for simplicity are not shown differently.

Figure 225. Concentrations of Uranium in Central IA Plume Wells

Wells monitoring the North IA Plume include Evaluation well 21505 and Sentinel well 52505 along FC-2, and AOC well 42505 at the terminus of FC-2 at North Walnut Creek. Each of these was sampled in 2014. (Although they also monitor the North IA Plume, wells 18199, 20902, 20705, 20505, and 20205 are discussed below in the context of the IHSS 118.1 Plume; farther to the west, wells 33502, 33604, and 33703 are discussed in the section on the VC Plume.)

Data from Evaluation well 21505 in 2014 were consistent with previous results and included several detections of VOCs. Concentrations of TCE were higher than the other VOCs, as in past sample data. Time-series plots for the primary VOCs are displayed in Figure 226. A relatively slight increase in concentrations of PCE, TCE, and 1,1-DCE is evident in the 2014 results compared with data collected over the past few years from well 21505. These increases may be attributable to contaminant flushing caused by the heavy rains of September 2013, as discussed below for well 52505, but more data will be required to confirm any longer-term patterns. In addition, the relatively slight increases shown at this well may pre-date the floods; for example,

PCE began to increase in 2012. Also, concentrations reported in 2014 are well within the historic ranges for these constituents, and therefore may not have any relationship to the 2013 storms.



Notes:
 Top and bottom portions display the same data, but the top portion uses a linear concentration scale and the bottom uses a logarithmic scale.
 Applicable RFLMA Table 1 values (µg/L) (CDPHE et al. 2012): PCE, 5; TCE, 2.5; *cis*-1,2-DCE, 70; 1,1-DCE, 7; and VC, 0.2.
 Several detections were qualified but for simplicity are not shown differently.

Figure 226. Concentrations of VOCs in North IA Plume Well 21505

The terminal end of the North IA Plume is monitored by Sentinel well 52505, nearby Surface Water Support location SW018, and AOC well 42505. Both of the wells and the surface-water location were sampled twice in 2014 (May and October). Well 52505 commonly reports very low detections of *cis*-1,2-DCE, and has also reported other VOCs in the past. The results from 2014 included detections of *cis*-1,2-DCE in both samples, and a detection of TCE in the May sample. This was the first detection of TCE at this location for the period of record (since January 2000), given as an estimated (J-qualified) concentration of 0.17 µg/L. (The RFLMA Table 1 value is 2.5 µg/L.) Both samples collected in 2014 reported concentrations of *cis*-1,2-DCE that were above their normal range at this location: typically present at

concentrations below 2 µg/L, the May sample contained 3.6 µg/L and the October sample 3.33 µg/L of this constituent (which has a RFLMA value of 70 µg/L). It is not certain whether these results reflect effects of the flood of September 2013, though well 52505 is situated in the valley bottom, downstream and downgradient of the North IA Plume and the VC Plume.

Surface Water Support location SW018 also reported very low concentrations of *cis*-1,2-DCE and TCE in the sample collected in May. VOCs are often detected here, and these constituents have been reported in previous samples. Consistent with past data, both results were assigned J qualifiers (estimated values), and the concentrations were 0.23 µg/L for *cis*-1,2-DCE and 0.16 µg/L for TCE, both well below their respective RFLMA Table 1 values and also within their historic ranges at this location.

AOC well 42505 reported similar low, J-qualified detections of *cis*-1,2-DCE in both samples collected in 2014. The May sample contained an estimated concentration of 0.81 µg/L, while the October sample contained 0.45 µg/L (also estimated).

Vinyl Chloride Plume

The source of the VC Plume is one or more former, collocated IHSSs including IHSS 128 (Oil Burn Pit #1), IHSS 134(N) (Lithium Metal Destruction Site), and IHSS 171 (Solvent Burning Ground). Refer to the Historical Release Report (e.g., DOE 1992b, the first of these documents) for additional information on these potential source areas. For convenience, the source of the plume has been informally referred to as OBP #1, though any of these three IHSSs may be contributing groundwater contamination.

These IHSSs were located on what was originally the southern/southeastern margin of a valley that was filled during construction of the B371 complex and later became the site of Sage Avenue and the Portal 2 parking lots, among other facilities (Figure 227). The contaminated groundwater plume referred to as the VC Plume is present within this buried valley, and groundwater flow appears to be controlled by that feature. This is the only Rocky Flats area where VC is confirmed to be naturally present at such elevated concentrations (not as a result of biostimulation, such as at OBP #2 through the addition of electron donor material). These high concentrations are taken as an indication that active biodegradation is occurring here. This is also the only area where chlorobenzenes are reported at elevated levels, as discussed below.

The VC Plume is monitored by two source-area Evaluation wells and one Sentinel well. Evaluation well 33502 is located in the immediate vicinity of OBP #1. Approximately 175 feet generally downgradient (northeast) is Evaluation well 33604, and Sentinel well 33711 is about 110 feet downgradient (north) of 33604. This Sentinel well developed a kink in its subsurface PVC casing and was replaced in 2011 (see DOE 2012 for additional information, including a discussion of water quality changes potentially related to well replacement). Each of these wells was scheduled for routine RFLMA sampling in 2014.



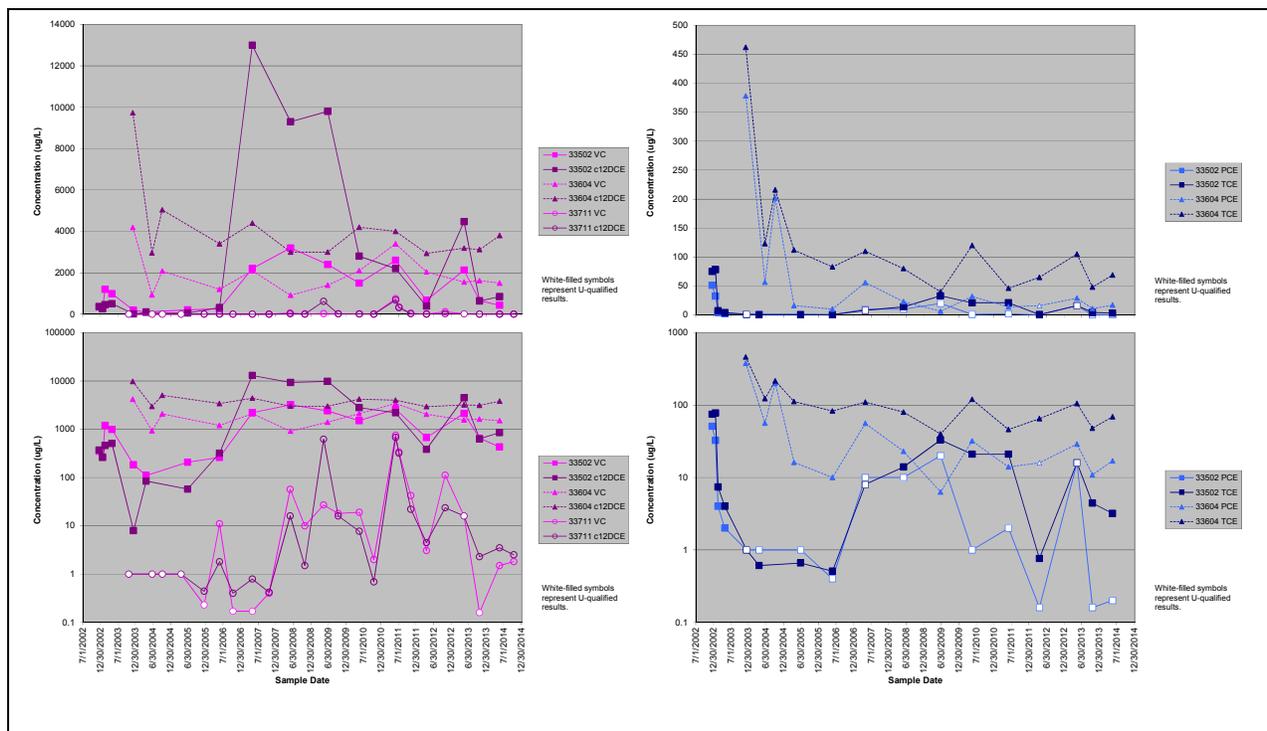
Notes:

Top photo from October 1964; middle photo from the 1970s; bottom photo from 2001. A valley extends across the middle of the top photo; in the middle photo, this valley has been infilled and Building 371 is being constructed; in the bottom photo, the area is completely developed. The areas represented in the photos are approximately equivalent. The source area may be visible on the southern edge of the valley in the lower-left quadrant of the top photo, as a dark spot with white strip (indicated by white arrow).

Figure 227. Photographs Showing Evolution of Vinyl Chloride Plume Source Area

Well 33502 is one of only two locations where strong evidence for biodegradation was found at the Site (K-H 2004c); the second location identified in that report was well 1986, the predecessor to well 52505, which is discussed above in the context of the north IA Plume. (If it had existed at the time of that study, well 33604 almost certainly would have provided similarly strong evidence for biodegradation, and very likely 33711 as well.) This is taken as an explanation for both the high concentrations of VC and *cis*-1,2-DCE as well as the extremely limited aerial extent over which these concentrations have been observed. The active biodegradation here is attributed to the buried soil and decomposing organic remains of vegetation that once grew within the now-filled valley shown on the top photo in Figure 227; these wells monitor groundwater within that feature. This decomposition process would consume oxygen, promoting anaerobic conditions, and the organic debris would represent a carbon source for the naturally occurring bacteria that perform reductive dechlorination of solvents including those most commonly found at the Site. Parent compounds, including PCE and TCE, are also detected in the groundwater in this area but at much lower concentrations than those of their partially dechlorinated byproducts. While VC and *cis*-1,2-DCE are reported in groundwater samples from source-area wells 33502 and 33604 at concentrations in the hundreds to thousands of micrograms per liter, PCE and TCE are typically reported in the tens to hundreds (and PCE has not been detected in samples from well 33502 since late 2003). Similarly, although concentrations are highly variable, Sentinel well 33711 in the past has reported concentrations of these daughter products at tens to hundreds of micrograms per liter but PCE is rarely detected and TCE is typically either not detected or is reported at concentrations of less than 1 µg/L.

A time-series plot of the concentrations of primary parent and daughter compounds in source-area Evaluation wells 33502 and 33604 is presented as Figure 228, which displays these constituents using a linear concentration scale in the upper portion, and a logarithmic scale in the lower portion. Concentrations of the daughter products in samples from well 33711 are also provided in this figure. The general decrease in daughter-product (*cis*-1,2-DCE and VC) concentrations evident at well 33502 over the past several years continues, while concentrations of these constituents at well 33604 remain more uniform. With respect to the parent compounds PCE and TCE (right side portion of Figure 228), a similar pattern is evident: concentrations appear more uniform in well 33604 than in 33502, although as noted above, PCE is consistently not detected at well 33502.



Notes:

Top left and bottom left display the same data, as do top right and bottom right, but the top two plots use a linear concentration scale and the bottom two use a logarithmic scale.

c12DCE = *cis*-1,2-DCE. Applicable RFLMA surface water action levels for these constituents (µg/L)

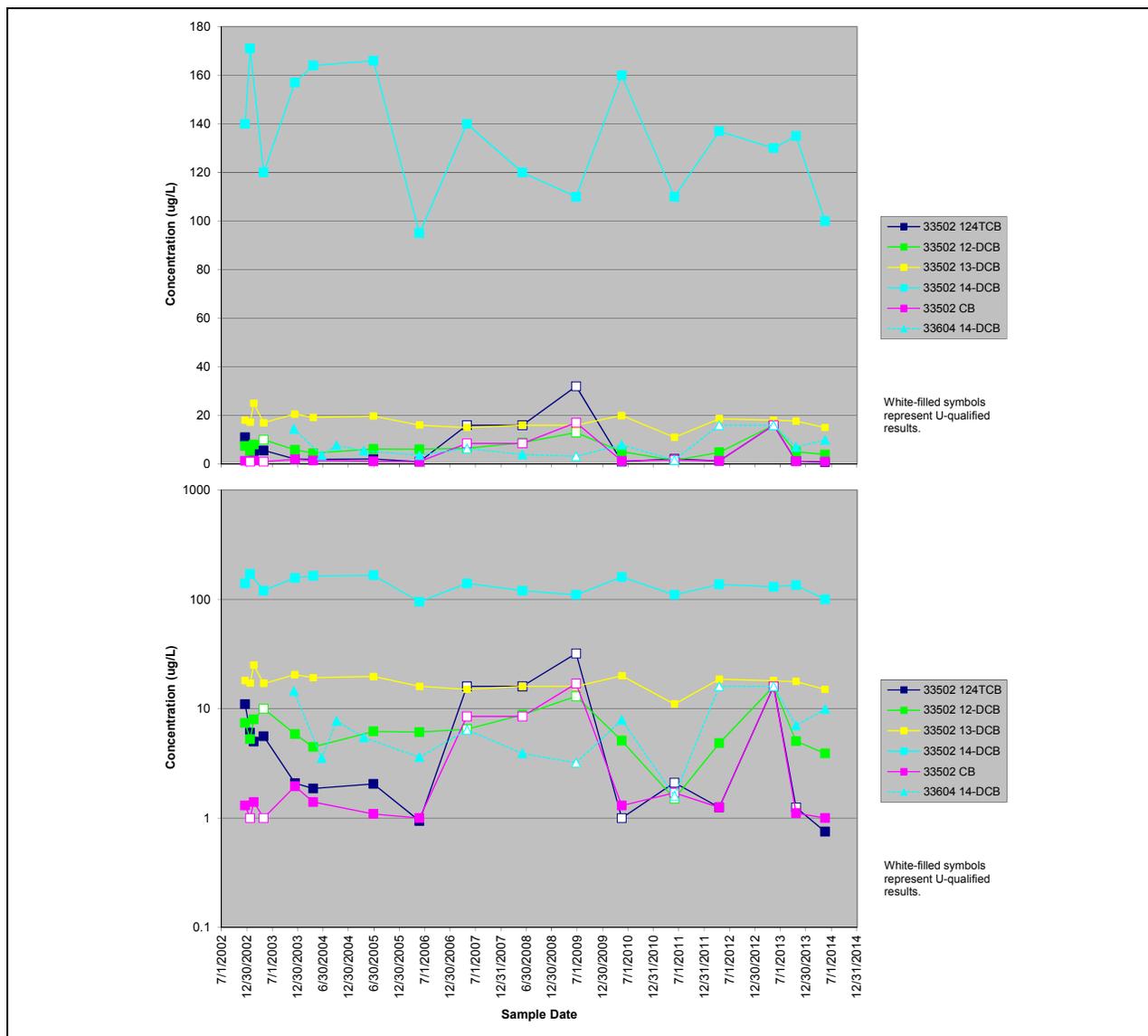
(CDPHE et al. 2012): VC, 0.2; *cis*-1,2-DCE, 70; PCE, 5; TCE, 2.5.

Data for PCE and TCE at well 33711 are not included because they are mostly nondetects and estimated quantities. In addition to the nondetects (U-qualified results), several detections were qualified but for simplicity are not shown differently. Note logarithmic concentration scales.

Figure 228. Primary VOCs in the VC Plume Evaluation and Sentinel Wells

Concentrations of *cis*-1,2-DCE and vinyl chloride at Sentinel well 33711 are extremely variable, as can be seen in the lower left portion of Figure 228. Concentrations of these daughter products at this location have historically ranged from not detected (at detection limits below 1 µg/L) to over 600 µg/L. Data collected in 2014 are more uniform and all below 5 µg/L, but whether this signals a change to more consistent concentrations of these VOCs remains to be seen.

Concentrations of several chlorinated benzenes are also detected in samples from VC Plume wells. These most commonly include one or more of the following: 1,2,4-trichlorobenzene (TCB), 1,2-DCB, 1,3-DCB, 1,4-DCB, and chlorobenzene. These compounds are industrial and agricultural chemicals; primary uses for several are as pesticides or insecticides, but they may also be used as solvents. 1,2,4-TCB can be degraded anaerobically to 1,2-DCB, 1,3-DCB, and (or) 1,4-DCB, which then can degrade to chlorobenzene (Adrian and Gorisch 2002; USGS 2006). Therefore, similar to the chlorinated ethenes in this area, near-complete degradation of 1,2,4-TCB may explain its rare detection and may also be a factor in the presence of 1,2-DCB, 1,3-DCB, 1,4-DCB, and (occasionally) chlorobenzene in samples from well 33502 (Figure 229). Of these constituents, 1,4-DCB is present in well 33502 at levels exceeding its RFLMA standard.



Notes: Top and bottom plots display the same data, but the top uses a linear concentration scale and the bottom uses a logarithmic scale. Applicable RFLMA Table 1 values (µg/L): 1,2,4 TCB (trichlorobenzene), 35; 1,2-DCB, 420; 1,3-DCB, 94; 1,4-DCB, 63; CB (chlorobenzene), 100. In addition to the nondetects (U-qualified results), several other results were qualified but for simplicity are not shown differently.

Figure 229. Chlorinated Benzene Compounds in Samples from VC Plume Evaluation Wells

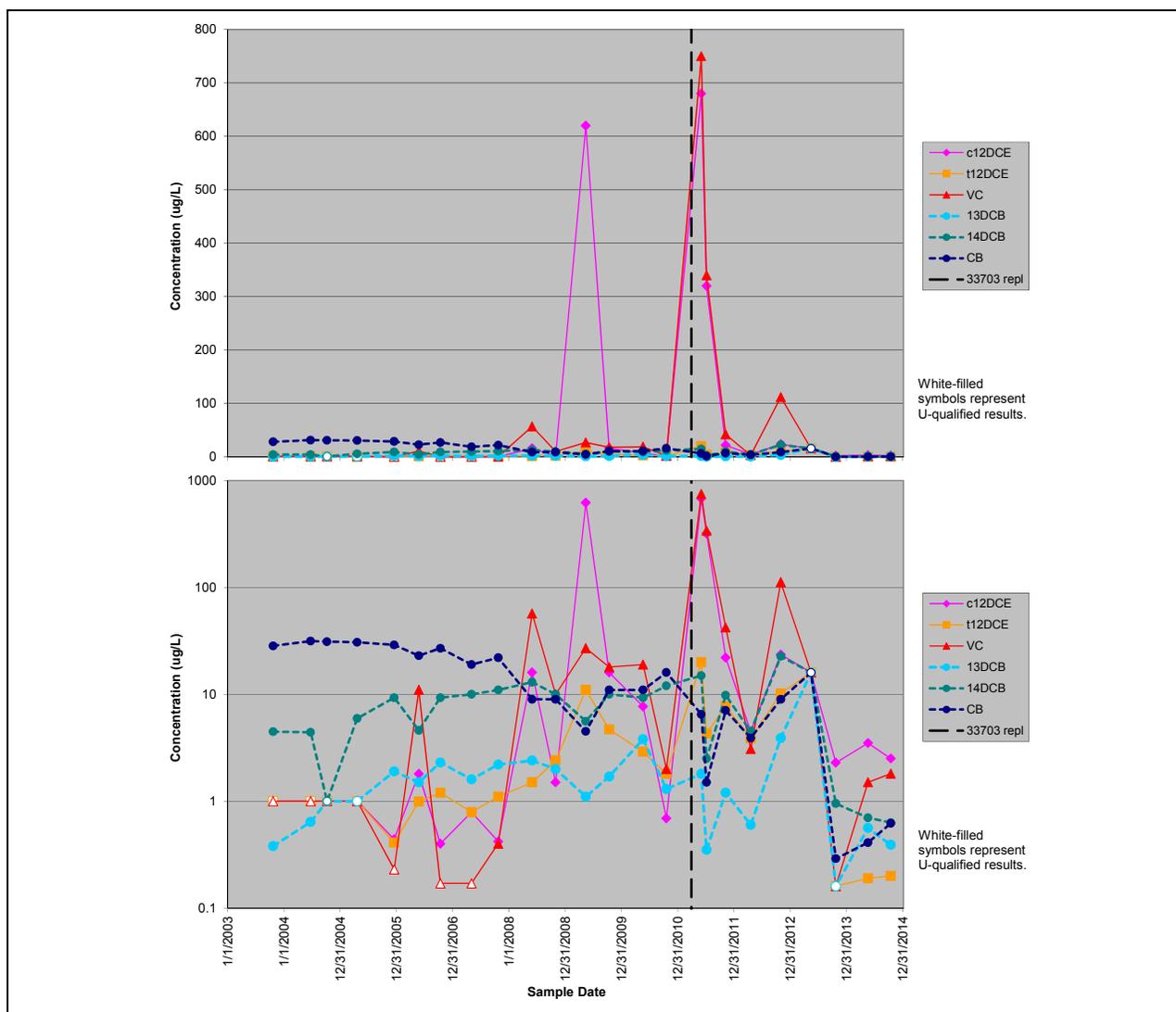
Before 2013, Evaluation well 33604 had not reported any detections of chlorinated benzenes since 2010. However, in 2013 there were detections of 1,2-DCB, 1,3-DCB, 1,4-DCB, and chlorobenzene—all in the sample collected from this well following the heavy September rains (and none in the second-quarter 2013 sample). Two of these compounds, 1,3-DCB and 1,4-DCB, were detected in the sample collected in 2014 at well 33604. Whether the heavy rains of September 2013 might be a factor in those fourth-quarter 2013 detections is not yet certain. Both of the chlorinated benzenes detected in 2014 have been detected at this location on several previous sampling events over the years; the anomalous 2013 detections were of 1,2-DCB

(only detected once, in that October 2013 sample) and chlorobenzene (detected twice, once in 2003 and the second time in October 2013).

The text above regarding chlorinated ethenes in this area notes that some of these constituents have also been detected in Sentinel well 33711, and the same applies to chlorinated benzenes. As discussed in the 2011 Annual Report (DOE 2012), the predecessor to well 33711 (33703) was replaced that year. When replacement well 33711 finally produced sufficient water for sampling, the concentrations of *cis*-1,2-DCE and (especially) VC were unusually elevated. The highly variable concentrations of these two constituents are included on the left portion of Figure 228, and they are also illustrated on Figure 230 along with the chlorinated benzenes typically detected at 33711.

Data from the May and October 2014 samples collected at well 33711 are relatively uniform and of lower concentration compared with results obtained over the past several years. While much lower than the several hundred microgram per liter concentrations reported in the recent past, results for VC in 2014 remain above the RFLMA Table 1 value (the PQL of 0.2 µg/L), being reported at 1.5 µg/L and 1.81 µg/L in the second and fourth quarter samples, respectively. Concentrations of the chlorinated benzenes also are lower than their typical range. Whether the lower and more uniform concentrations of these chlorinated ethenes and benzenes in 2014 is coincidental or related to the heavy precipitation in late 2013 is not known. This well will continue to be monitored in accordance with the RFLMA, and the additional data may help to clarify any patterns.

Calculated trends having a 95 percent level of confidence are identified for several constituents in wells monitoring the VC Plume. In the source-area Evaluation wells, decreasing trends are calculated (Table 74; Appendix B) at this level of significance for 1,2,4-TCB at well 33502, and for PCE and TCE at well 33604. The trend at well 33502 is based on a dataset that contains numerous nondetects, and therefore may not be valid. A decreasing trend in chlorobenzene is calculated for downgradient Sentinel well 33711, as are increasing trends in *cis*-1,2-DCE, *trans*-1,2-DCE, and VC. The two 1,2-DCE isomers are represented by datasets containing numerous nondetects, and as a result those trends might not be viable.



Notes:

Top and bottom plots display the same data, but the top uses a linear concentration scale and the bottom uses a logarithmic scale. Applicable RFLMA Table 1 values (µg/L) (CDPHE et al. 2012): *cis*-1,2-DCE, 70; *trans*-1,2-DCE, 100; VC, 0.2; 1,2,4 TCB (trichlorobenzene), 35; 1,2-DCB, 420; 1,3-DCB, 94; 1,4-DCB, 63; CB (chlorobenzene), 100. In addition to the nondetects (U-qualified results), several other results were qualified but for simplicity are not shown differently.

Figure 230. Chlorinated Compounds in Samples from VC Plume Sentinel Well 33711

IHSS 118.1 (Carbon Tetrachloride) Plume

Former IHSS 118.1 is the source of a plume of groundwater contaminated with carbon tetrachloride and its primary daughter product, chloroform. In late 2004, dense, nonaqueous phase liquid (DNAPL) source material was removed along with an adjacent subsurface tank group referred to as Building 730. Electron donor material was added to the backfill material to enhance biodegradation of residual contamination.

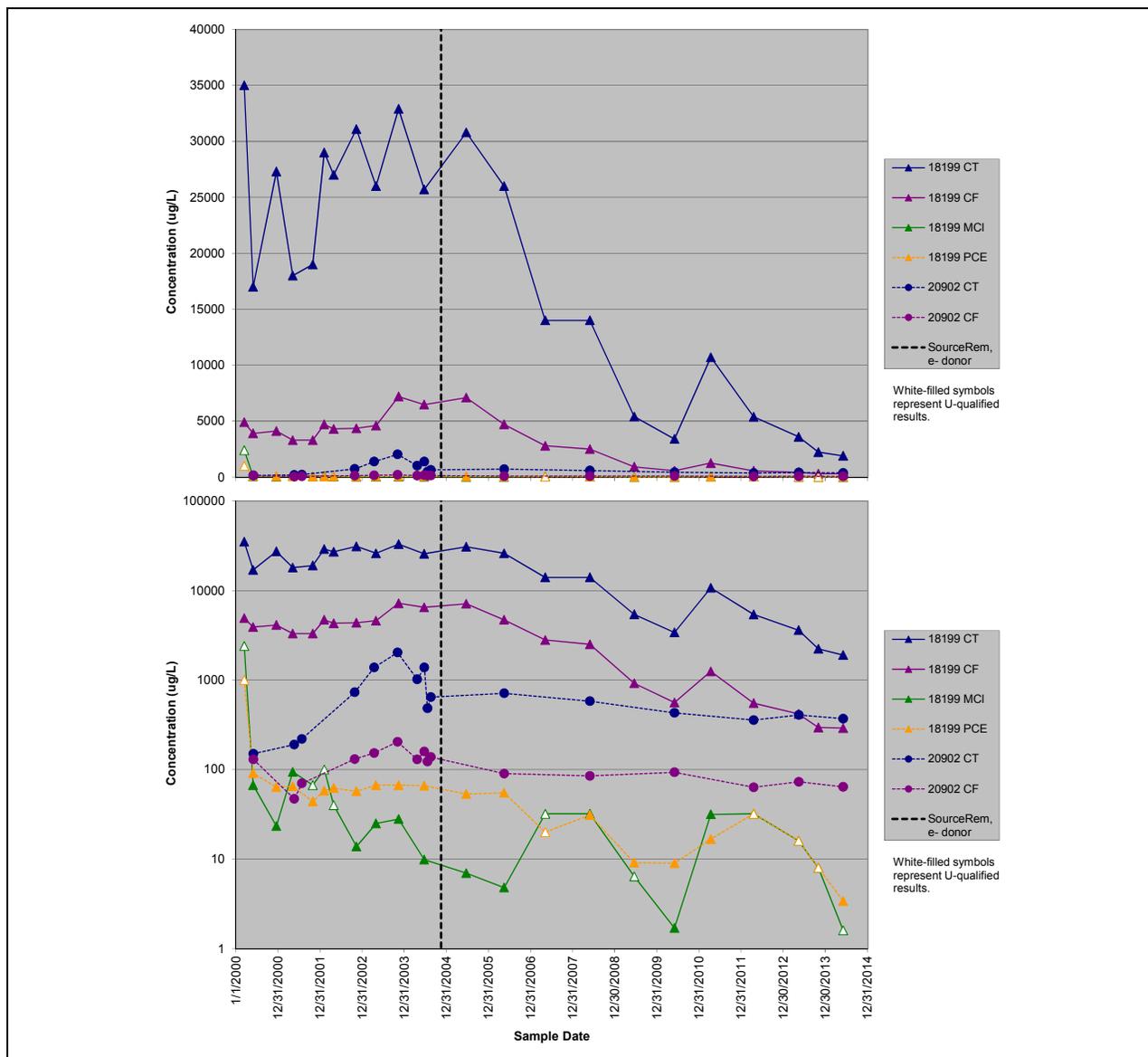
Evaluation well 18199 is one of several installed in 1999 to support further characterization of the source area following several previous contaminant characterization projects focused on this

IHSS. This well is located immediately north of the former IHSS, roughly 80 to 90 feet north-northwest of the area in which free-phase carbon tetrachloride was present and perhaps 30 feet north of the source-removal excavation boundaries. The plume has been mapped to extend to Evaluation well 20902, located approximately 350 feet to the northwest. Both of these Evaluation wells were scheduled for routine RFLMA monitoring in 2014.

Several Sentinel wells also support evaluation of this plume. Three of these—20705, 20505, and 20205—are located generally north of the source area, along the northern side of the former B771 complex, and support the evaluation of a more northerly groundwater flow path from the IHSS 118.1 source area. (With the closure of B771 and disruption of the associated foundation drain system, the anticipated flow path for this plume was more northerly than it had been prior to closure). In addition, Sentinel well 52505, Surface Water Support location SW018, and AOC well 42505 support the evaluation of this plume. These latter three locations are discussed above in the context of the North IA Plume and will not be addressed here, except to summarize that none of these produced samples suggesting impacts from former IHSS 118.1.

Concentrations of carbon tetrachloride and its primary daughter product, chloroform, in 2014 were reported at the lowest concentrations yet from source-area Evaluation well 18199 (1,900 µg/L and 290 µg/L, respectively; see Figure 231). Methylene chloride was not detected (at a detection limit of 1.6 µg/L), but PCE was detected at a low, estimated (J-qualified) concentration of 3.4 µg/L. Other constituents in the PCE family are similarly minor or absent; TCE and *cis*-1,2-DCE have not been detected since 2011. Decreasing concentrations of the primary contaminants at this location has been apparent for some time, aside from a brief interruption in 2011. The cause of the change in that year remains uncertain. The 2013 Annual Report (DOE 2014c) postulated that the wetter conditions of 2010 might have flushed residual contaminants from higher in the soil column, with those contaminants detected at well 18199 a year later, in which case a similar pattern might follow the late-2013 floods and be evident in the 2014 data. However, such a response was not evident in the second-quarter 2014 results. Similarly, whether the overall decrease in primary contaminant concentrations is related to the biostimulation that was performed as part of the source-removal action, or simply from removal of the DNAPL source material, is not known.

Carbon tetrachloride concentrations at downgradient Evaluation well 20902 do not suggest an obvious or significant decreasing trend; levels are much more consistent, and the same applies to chloroform at this location (Figure 231). Carbon tetrachloride in 2014 was reported at a concentration of 370 µg/L in well 20902, and chloroform was reported at 64 µg/L. Both of these results are very similar to those of the past few years.



Notes:

Top and bottom plots display the same data, but the top uses a linear concentration scale and the bottom uses a logarithmic scale.

CT = carbon tetrachloride; CF = chloroform; MCl = methylene chloride; Source Rem, HRC = date on which source removal and backfilling with soil and HRC was completed. Applicable RFLMA surface-water action levels for these constituents (µg/L) (CDPHE et al. 2012): CT, 1; CF, 3.4; MCl, 4.6; PCE, 5.

Several results were qualified but are not shown differently for simplicity.

Note logarithmic concentration scale.

Figure 231. Concentrations of VOCs in the IHSS 118.1 Plume

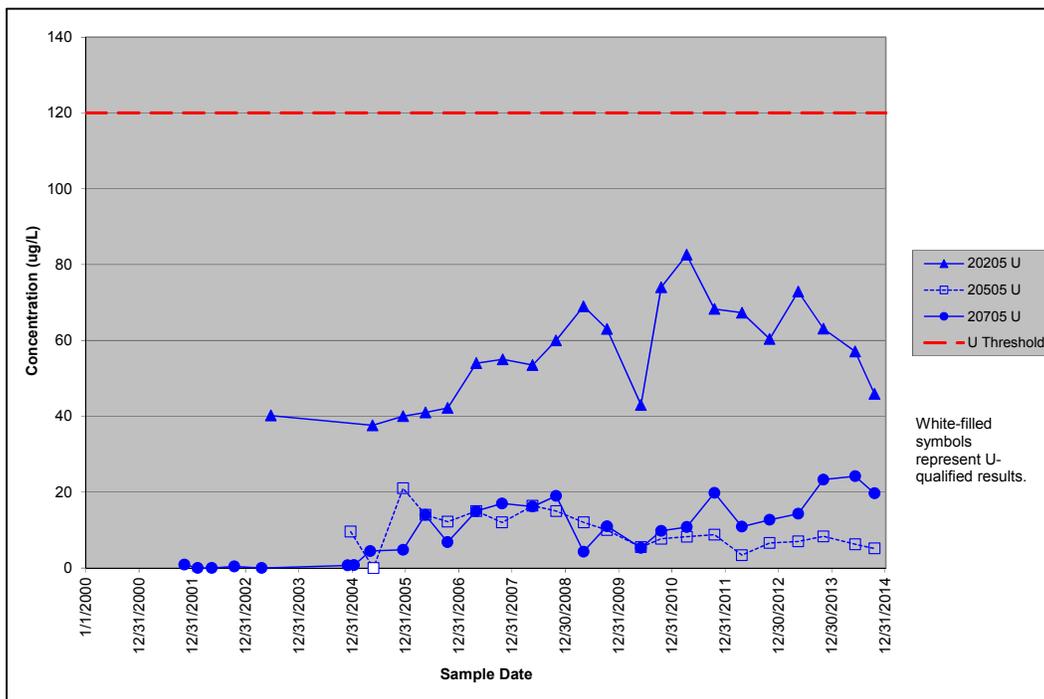
Decreasing trends in carbon tetrachloride, chloroform, and PCE are calculated at the 95 percent level of significance (Table 74; Appendix B) at well 18199. As previously suggested (e.g., DOE 2013a) and in contrast to the behavior evident in the OBP #2-impacted groundwater discussed above, these decreasing trends may be related more to removal of the DNAPL source material than the subsequent application of electron donor material. Well 20902 does not support any increasing or decreasing statistical trends of this level of significance.

Sentinel wells 20205, 20505, and 20705, all of which are located generally north of IHSS 118.1 and the former B771 complex, are monitored to evaluate the effects on groundwater of the closure of B771 and to determine whether a more northerly groundwater flow path from the IHSS 118.1 source area is indicated. These wells were sampled in June and October, 2014. Detections of carbon tetrachloride as well as chloroform—both primary contaminants from the IHSS 118.1 source area—were reported at well 20205 in both samples. This well is located at the eastern end of this line of three wells, just north (downgradient) of former Bowman’s Pond and Building 774, the eastern member of the B771 complex. Both constituents have been previously detected here, and these detections in well 20205 were the only ones in 2014 for the carbon tetrachloride family (i.e., this parent compound and its partially dechlorinated byproducts). Although carbon tetrachloride has not been detected in the other two wells (20505, 20705), past data from well 20705 include detections of chloroform as well as methylene chloride and chloromethane, also daughter products from the dechlorination of carbon tetrachloride. Well 20505, located between the other two wells (Figure 2), has not reported any detections of carbon tetrachloride or its dechlorination byproducts. Other VOCs detected in this area in 2014 included 1,1-DCE, *cis*-1,2-DCE, PCE, TCE, and VC.

The results for chloroform in both samples from well 20205 exceed the corresponding RFLMA Table 1 value, with the second and fourth-quarter samples reporting concentrations of 6.81 µg/L and 6.14 µg/L, respectively (the RFLMA value is 3.4 µg/L). In addition, the three detections of VC reported in 2014 exceed its RFLMA value of 0.2 µg/L: the second-quarter sample from well 20505 was reported at 0.87 µg/L (estimated, J-qualified); and the two samples collected from well 20705 contained 0.78 µg/L (estimated) and 2.18 µg/L, respectively. However, none of these results—whether from Sentinel or previously discussed AOC wells—suggest a strong northerly flow component from the IHSS 118.1 Plume source area.

Seepage velocities summarized in Table 35 are similar to those calculated in previous years and suggest that contaminants in the groundwater migrating from source area well 18199 to downgradient well 20505 could have been detected in this downgradient well as early as 2006. The velocities calculated using 2014 water level data again lead to travel times of slightly more than one year. (As previously explained, this estimated velocity applies to pure water, not to dissolved contaminants.) Based on the analytical data collected through 2014, elevated levels of IHSS 118.1 contaminants have still not reached this particular downgradient well (20505), or others in its vicinity (20205, 20705). While it would take some time for groundwater to saturate the backfill of the former B771 area, observations of seeps on this hillside in previous years (see DOE 2011 and 2012) suggest that has been completed. Wells monitoring former IHSS 118.1 will continue to be sampled and the data assessed to evaluate the potential for contaminant migration from that source area as well as the IA Plume and former B771.

Each of these B771-area Sentinel wells is also monitored for uranium, plutonium, and americium, and well 20705 is sampled for nitrate. (Discussion of plutonium and americium is provided in a separate section below.) Time-series plots of uranium in samples from all three of these wells are provided below in Figure 232. From this figure, it can be seen that concentrations of uranium in samples from wells 20505 and 20705 are fairly similar, while those from well 20205 are higher—though still well below the applicable RFLMA value. Nitrate was not detected in either sample collected in 2014 from well 20705.



Notes:

U = uranium. Applicable RFLMA value is 120 µg/L.
 Several results were qualified but are not shown differently for simplicity.

Figure 232. U in Groundwater Along North Side of Former B771

Several trends were calculated for the three Sentinel wells monitoring B771 (Table 74; Appendix B). Those with a 95 percent level of statistical significance include decreasing *cis*-1,2-DCE and TCE at well 20505, and increasing *cis*-1,2-DCE at well 20705. Trends of this significance are also identified for uranium, which is calculated to be increasing at wells 20205 and 20705 and decreasing at well 20505. Finally, americium (discussed in more detail separately below) is calculated to be decreasing at well 20705, but there are several reasons to question the viability of this result: The dataset includes numerous nondetects, is potentially affected by well replacement, and reflects now-resolved borehole artifacts. (For additional discussion of this topic, refer to the annual report for 2005, DOE 2006d.)

Each of these wells will continue to be monitored and the data evaluated in accordance with RFLMA.

PU&D Yard Plume

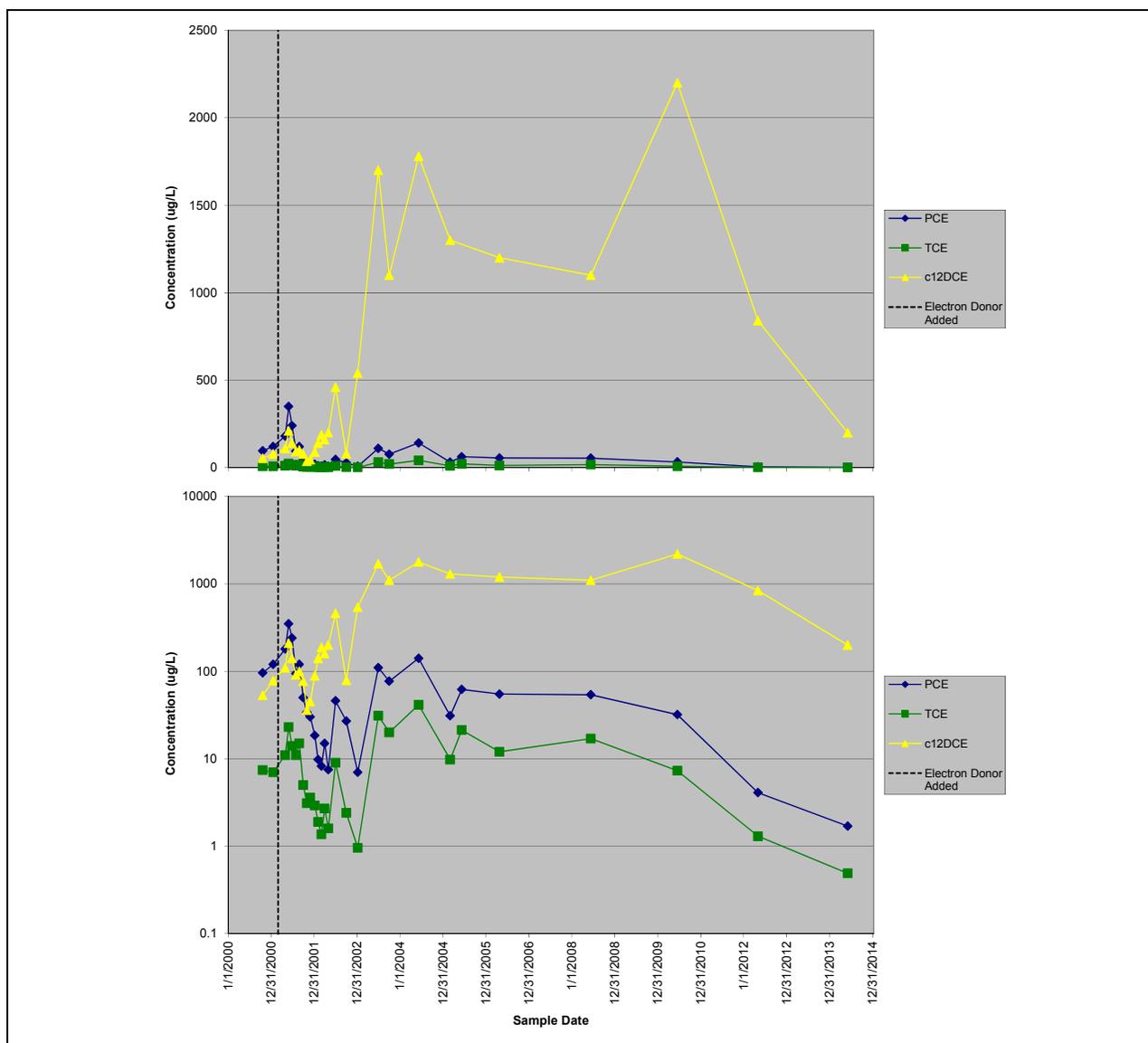
The PU&D Yard Plume is an area of groundwater with low concentrations of primarily PCE-family VOCs (PCE, TCE, and *cis*-1,2-DCE). This area was the site of the first application at Rocky Flats of electron donor material, in which a proprietary carbon source (HRC) was tested in a treatability study begun in early 2001 (K-H 2001, 2002b; see K-H 2005b for a final summary report on this study). This plume is monitored by Evaluation well 30900 in the source area and Sentinel well 30002 downgradient to the east, at the north edge of North Walnut Creek. In addition, upgradient PLF RCRA wells 70393 and 70693 monitor the plume as it flows toward the PLF (Figure 2). Each of these wells was monitored in 2014 in accordance with the RFLMA;

the Evaluation well was sampled in the second quarter, the Sentinel well was sampled in the second and fourth quarters, and the RCRA wells were sampled all four quarters.

Source-area well 30900 continues to produce groundwater containing elevated concentrations of chlorinated ethenes, primarily PCE, TCE, and *cis*-1,2-DCE (Figure 233). Other constituents have also been detected in the past; those that have been detected more than once include 1,1,1-TCA, 1,1-DCE, 1,3-DCB (also detected in 2014), 1,4-DCB, chloroform, methylene chloride, toluene, *trans*-1,2-DCE, and VC (also detected in 2014). Of these, data for VC may be most unusual. VC has only been detected three times at well 30900: 0.21 µg/L in 2001, then 360 µg/L in 2012, and 110 µg/L in 2014. (For perspective, on Figure 233 the values for *cis*-1,2-DCE in those two later sampling events were 840 µg/L and 200 µg/L, respectively.) Combined with the decreasing concentrations of the more chlorinated constituents of the PCE family (PCE, TCE, *cis*-1,2-DCE), these recent detections of VC may signify a corresponding boost in reductive dechlorination of the compounds shown on the figure, perhaps stimulated by higher groundwater levels in 2010 and 2014.

Downgradient Sentinel well 30002 reported no detections of VOCs in either sample collected in 2014 (June, October). This is not unusual; over the history of this well, there have been only four validated detections of VOCs—three for 1,3-DCB and one for toluene, all J-qualified at estimated concentrations below 1 µg/L, and the most recent was in 2012.

Consistent with past results, two of the upgradient RCRA wells reported low concentrations of VOCs in 2014. Those wells most affected by the PU&D Yard Plume are 70393 and 70693. Commonly detected VOCs at these wells include PCE, TCE, 1,1,1-TCA, and 1,1-DCE. Time-series plots of these constituents in wells 70393 and 70693 are presented as Figure 234, which shows asymptotic decay curves for concentrations of each of these constituents. As illustrated, concentrations of each of these compounds generally have been gradually decreasing since 2000. Even so, TCE continues to be detected—consistently at well 70393 and frequently at well 70693—at concentrations exceeding the RFLMA Table 1 value of 2.5 µg/L; none of the other reported VOCs exceed their RFLMA values. TCE is a daughter product of PCE as well as being used itself during the production era at Rocky Flats. 1,1-DCE is a daughter product of PCE, TCE, and 1,1,1-TCA dechlorination. There is no apparent relative increase in daughter products with respect to the parent products. The highest concentration reported in 2014 for TCE in well 70393 was 9 µg/L, and in well 70693 was 2.8 µg/L.



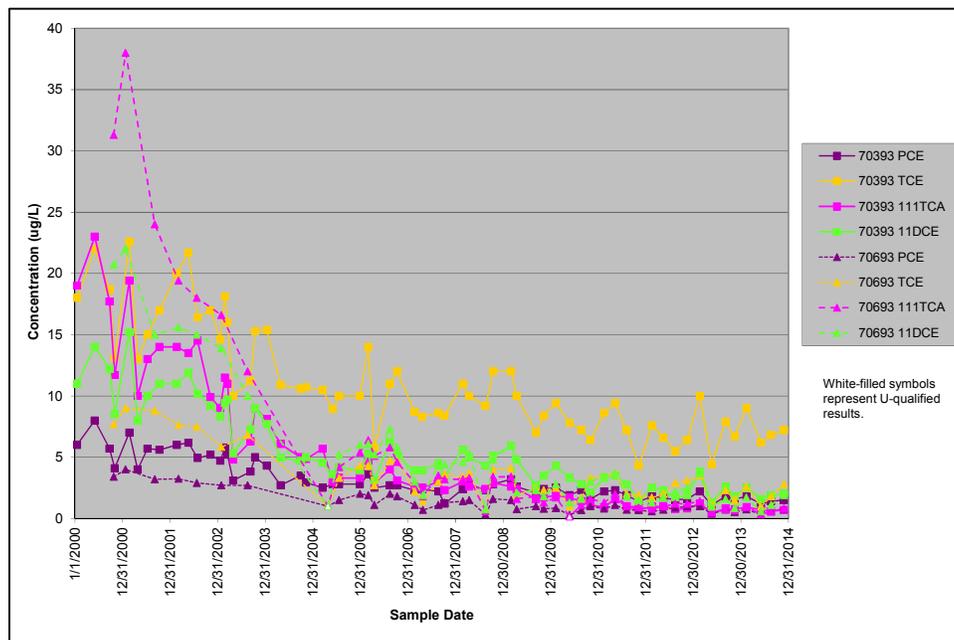
Notes:

Top and bottom plots display the same data, but the top uses a linear concentration scale and the bottom uses a logarithmic scale.

Applicable RFLMA Table 1 values (µg/L) (CDPHE et al. 2012): PCE, 5; TCE, 2.5; cis-1,2-DCE, 70.

Several detections were qualified but for simplicity are not shown differently.

Figure 233. Concentrations of Primary PU&D Yard Plume VOCs in Source-Area Evaluation Well 30900



Notes:

Applicable RFLMA surface-water action levels for these constituents (µg/L) (CDPHE et al. 2012): PCE, 5; TCE, 2.5; 1,1,1-TCA, 200; 1,1-DCE, 7.

Several detections were qualified but for simplicity are not shown differently.

Figure 234. Concentrations of Primary PU&D Yard Plume VOCs in Upgradient PLF RCRA Wells

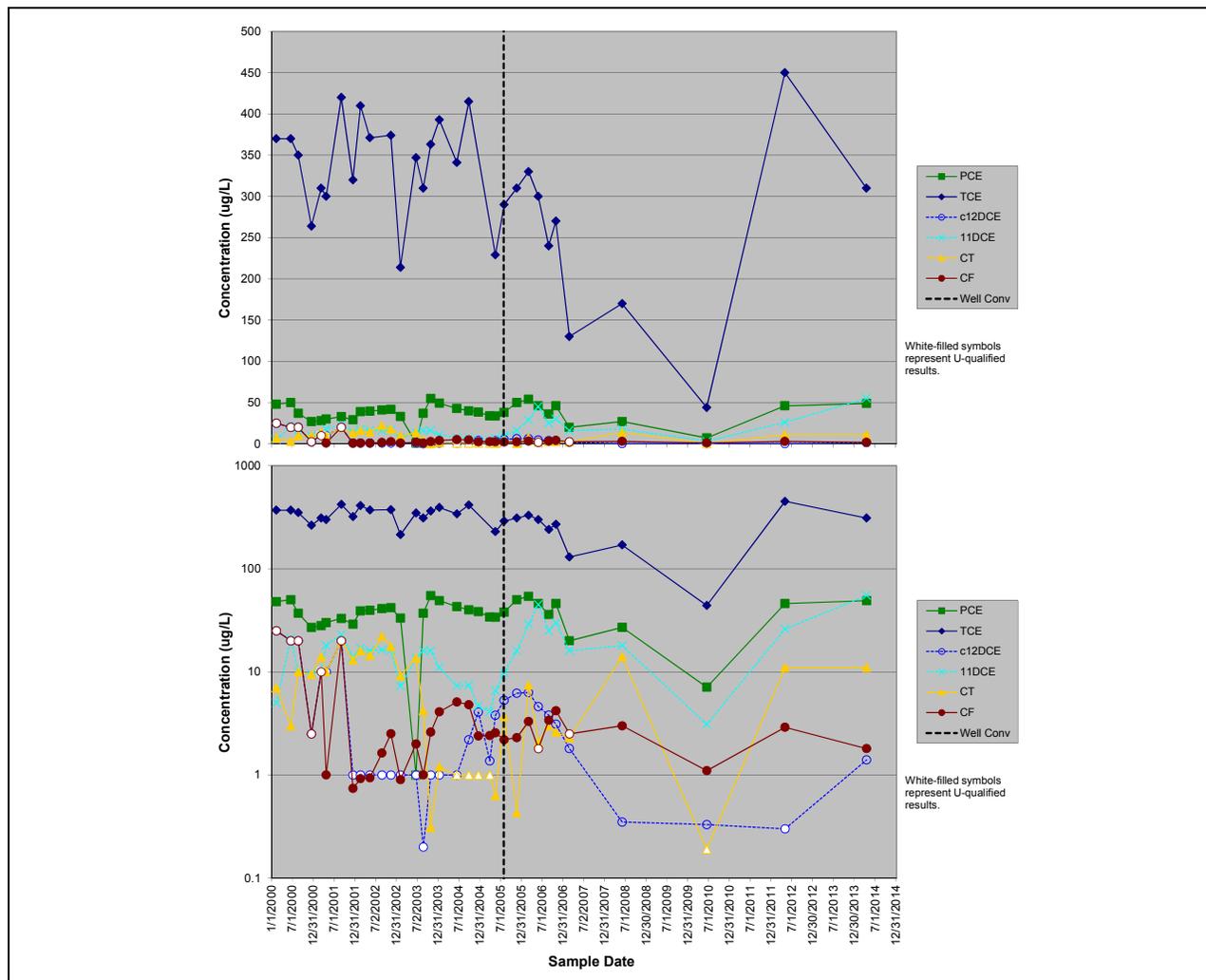
Statistical trends calculated to have a 95 percent level of significance at source-area Evaluation well 30900 include decreasing 1,1,1-TCA and PCE, and increasing *cis*-1,2-DCE; however, the trend for 1,1,1-TCA is based on a dataset that contains many nondetects, and therefore this trend may not be viable. Downgradient of the source area, trends of this significance include decreasing 1,1,1-TCA, 1,1-DCE, PCE, and TCE at both wells 70393 and 70693 (Table 74; Appendix B). In addition, decreasing trends with this significance are calculated for carbon tetrachloride and chloroform at well 70693, though the corresponding data sets contain many nondetects and therefore these trends may not be valid. No increasing or decreasing trends are calculated at downgradient Sentinel well 30002, since VOCs are typically not detected here.

OU 1 Plume

The OU 1 Plume is located on the 881 Hillside, east of former B881 and immediately south of the former Contractor Yard. Its source area, former IHSS 119.1, was a drum and scrap metal storage area. This source area is monitored by Evaluation well 891WEL (the modification of which, in 2005, has been detailed in previous documents, e.g., DOE 2006c), and the pathway to surface water is monitored by AOC well 89104, located to the south adjacent to Woman Creek (Figure 2). Each of these wells was sampled in accordance with the RFLMA in 2014.

Results from source-area well 891WEL in 2014 are generally consistent with previous data. TCE continues to be present at the highest concentration, and in 2014 was more similar to the range of concentrations that applied up until about 2007 rather than more recent results (Figure 235). The same applies to the result for PCE. Results for *cis*-1,2-DCE, carbon tetrachloride, and chloroform have shown significant variability over the years but their concentrations in 2014 were within

their historic ranges. In contrast, the result for 1,1-DCE was the highest in the period of record (since January 2000), measuring 55 $\mu\text{g/L}$ (RFLMA Table 1 value is 7 $\mu\text{g/L}$). Causes for the strong variations in VOC concentrations at 891WEL are not known.



Notes:

Top and bottom plots display the same data, but the top uses a linear concentration scale and the bottom uses a logarithmic scale.

Applicable RFLMA Table 1 values ($\mu\text{g/L}$) (CDPHE et al. 2012): PCE, 5; TCE, 2.5; *cis*-1,2-DCE, 70; 1,1-DCE, 7; CT (carbon tetrachloride), 1; CF (chloroform), 3.4.

Several detections were qualified but for simplicity are not shown differently.

Figure 235. Concentrations of VOCs in OU-1 Source-Area Evaluation Well

Downgradient AOC well 89104 was sampled twice, in April and October 2014. No VOCs were detected.

Other Areas

In addition to the major plumes discussed above, other areas are discussed below because they may be of interest.

AOC Well B206989: This well is located immediately east of the former Landfill Pond dam, which was breached in early 2012. Refer to previous annual reports (e.g., DOE 2012) for information on and discussion of the reportable condition for nitrate, which was fully expected and was proactively initiated in 2007; see also the related Contact Record 2007-06. That reportable condition is the only one pertaining to groundwater at AOC wells since the Site closed. For this reason, the corresponding well has been given focused attention in each annual report since then. Future annual reports may omit this text given the water quality that has prevailed at this well since 2010.

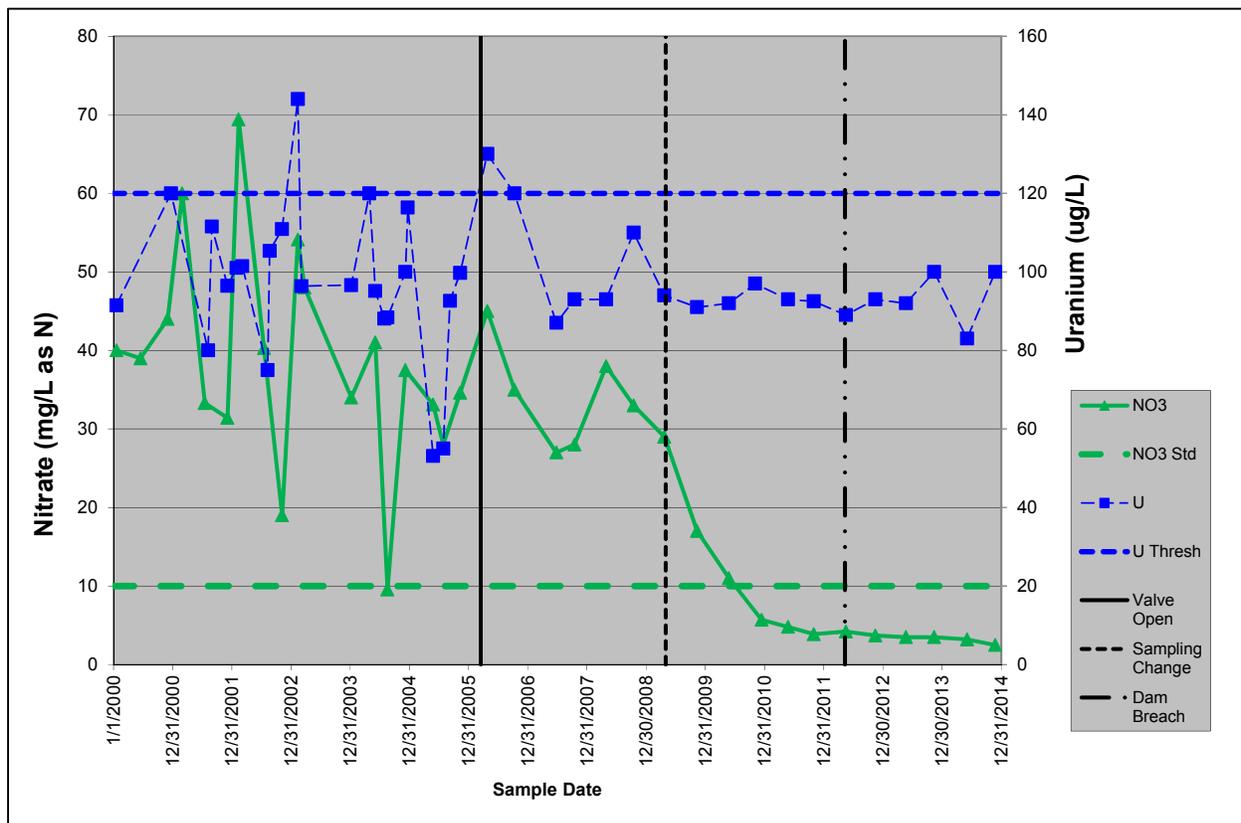
Annual reports issued since the report for 2008 (DOE 2009c) have noted the calculation of a decreasing trend in nitrate, with the associated level of statistical confidence reaching 95 percent in the 2009 report (DOE 2010a). Data collected since then, including those from 2014, continue to support this trend (see Table 74 and Appendix B.3). Nitrate results from samples collected in 2014 continued to be well below the applicable 10 mg/L standard and were actually the lowest yet. The concentration in the June sample was reported at 3.2 mg/L, and that in the November sample was 2.5 mg/L.

At the same time, concentrations of U in groundwater samples from well B206989 have not exceeded the 120 µg/L total U threshold since 2006. Concentrations of this analyte stabilized around 2007 compared to data from prior years, appearing to have leveled off at around 90 µg/L to 100 µg/L. The highest concentration of uranium reported in 2014 was 100 µg/L, as was the case in 2013.

Both of these constituents (nitrate and U) are illustrated in time-series plots on Figure 236. As noted above, a decreasing trend in nitrate is calculated to be 95 percent significant; a trend of this significance for uranium is not identified.

This well is also sampled for VOCs. As with most years, none were detected in the samples collected in 2014.

AOC well 4087 is also located in this area, and is sampled for the same suite at the same frequency. This well consistently reports lower concentrations than are present in samples from well B206989. No VOCs were detected here in 2014.

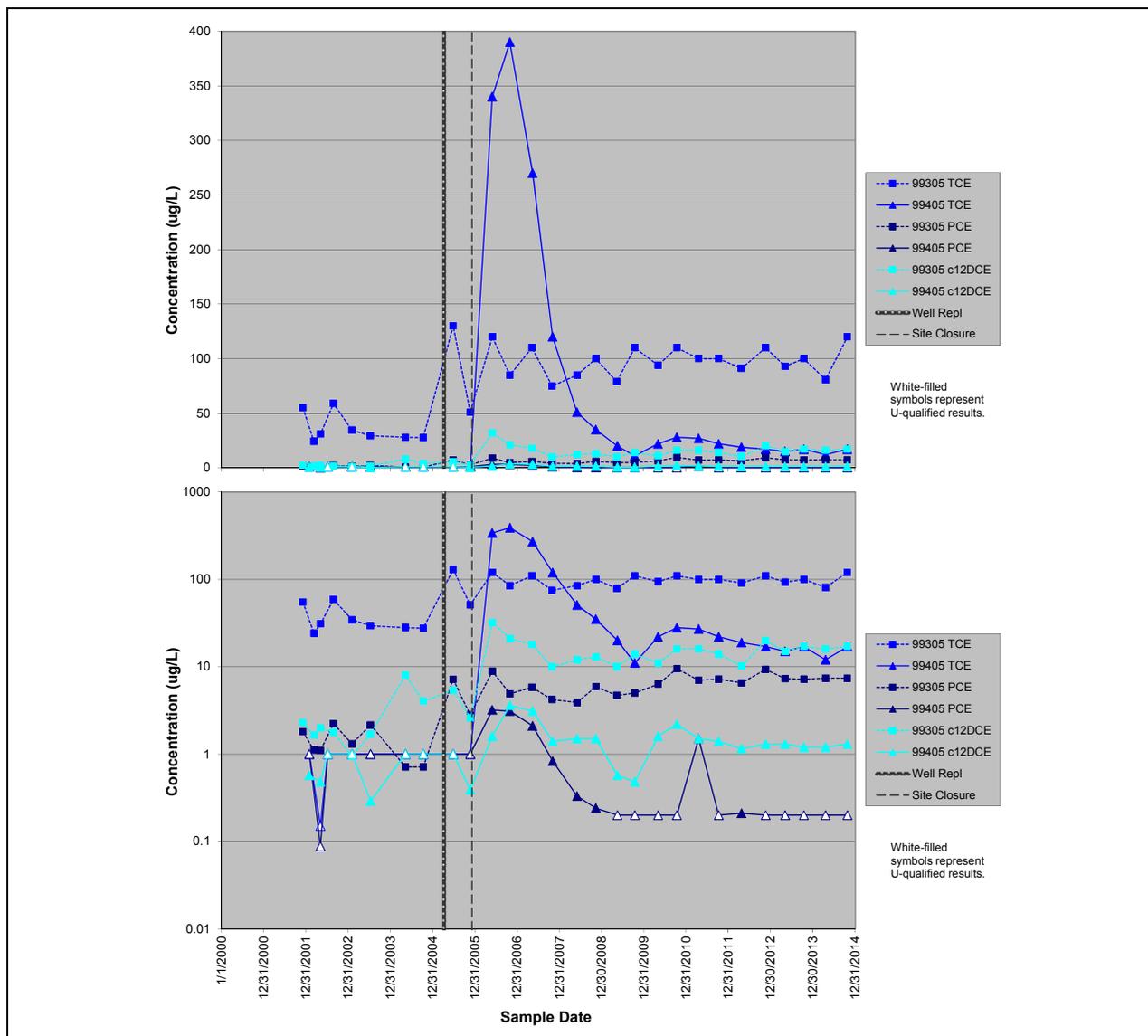


Notes:
 NO3 = nitrate (reported as nitrate + nitrite as N); NO3 Std = RFLMA Table 1 value for nitrate (10 mg/L); U = uranium; U Thresh = uranium threshold (120 µg/L). Note the use of two y axes to help illustrate the concentrations of the different constituents. Dates pertaining to dam operation and sampling methods are as indicated, and are discussed in previous annual reports (e.g., DOE 2012).

Figure 236. Concentrations of Nitrate and U in Groundwater Samples from AOC Well B206989

Former B991: Groundwater samples from wells 99305 and 99405 are monitored for VOCs, nitrate, and U. Both of these wells are located near the eastern edge of former B991, with well 99405 positioned at what was the east loading dock area, slightly southwest of well 99305 and closer to FC-4 and the valley bottom. Samples collected in April and October 2014 continued the post-closure pattern of higher concentrations of VOCs than were typical prior to closure. Noteworthy constituents continue to include PCE, TCE, and *cis*-1,2-DCE.

Figure 237 illustrates results for these VOCs in both wells, and indicates when the wells were replaced (when 99305 replaced 99301, and 99405 replaced 99401) and when the Site closed. The original wells were abandoned on the same date prior to building demolition, and the replacement wells were installed after building closure and hillside grading had been completed. That is, B991 demolition and closure was completed between the last data points from the original wells—in late 2004—and the indicated April 2005 well replacement date. Well 99305 was drilled approximately 3.4 feet from where 99301 had been, and well 99405 was drilled approximately 1.7 feet from the location of 99401. The screened intervals of the replacement wells are very similar to those of the original wells.



Notes:

Top and bottom plots display the same data, but the top uses a linear concentration scale and the bottom uses a logarithmic scale.

c12DCE = *cis*-1,2-DCE; Well Repl = well replacement. Applicable RFLMA Table 1 values (µg/L) (CDPHE et al. 2012): PCE, 5; TCE, 2.5; *cis*-1,2-DCE, 70.

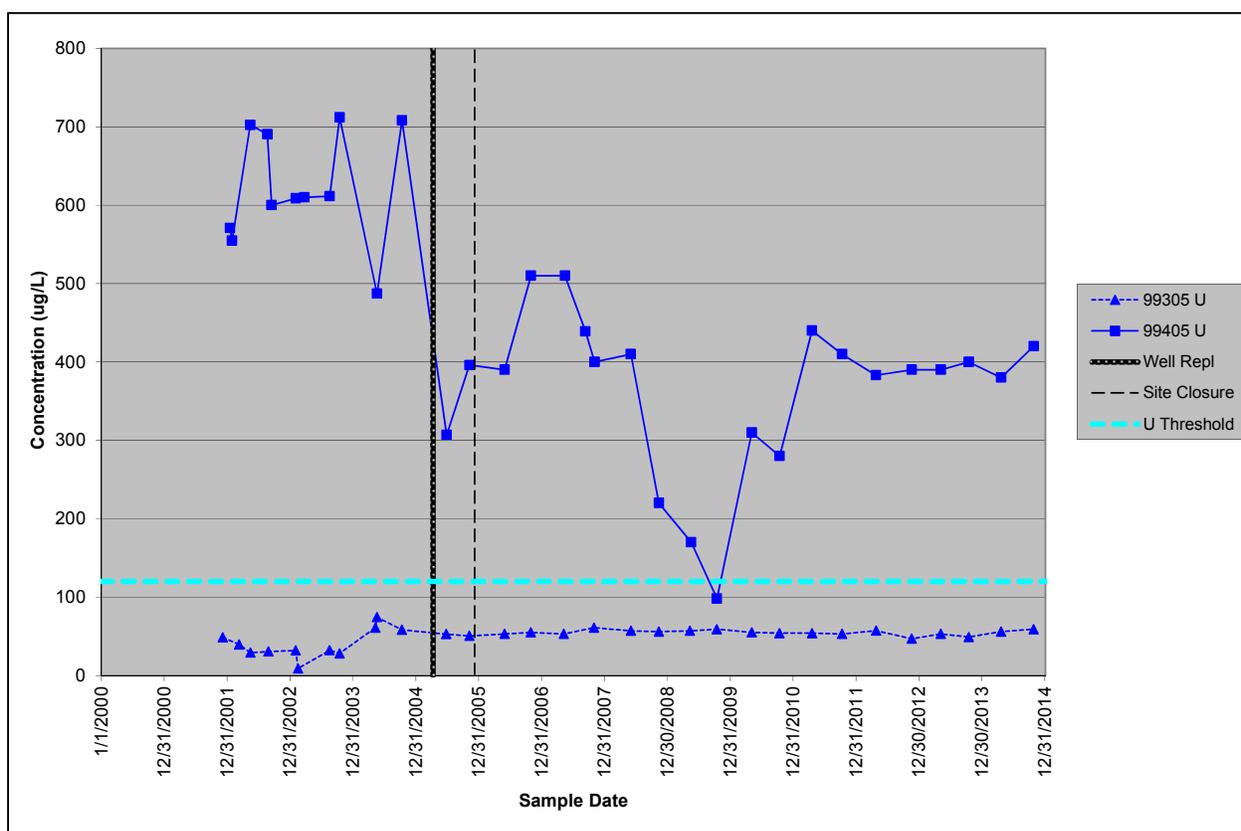
In addition to the nondetects (U-qualified results), several other results were qualified but are not shown differently for simplicity.

Figure 237. Concentrations of Primary VOCs in B991-Area Groundwater

As shown on Figure 237, water quality changes with respect to these three constituents occurred suddenly at well 99405, and appear to coincide with Site closure rather than B991 demolition. These changes are less marked in samples from well 99305, and suggest an earlier mechanism timed with well replacement, at least for PCE and TCE—changes in the concentrations of *cis*-1,2-DCE occur in two pulses, the first before building demolition and the last after Site closure. Since shortly after these initial increases in VOC concentrations, they have been reported at fairly uniform levels. No obvious effects are evident from the floods of September 2013. Those exceeding the RFLMA Table 1 values include TCE at both wells and

PCE at well 99305. In addition, more recently there have been repeated detections of vinyl chloride at well 99305. The first such detection occurred in 2006, and was only sporadically detected from then until 2011; since that year, vinyl chloride has been detected at least once each year, and in 2014 was reported in both samples. The highest reported concentration of VC in 2014 was estimated (J-qualified) at 0.88 $\mu\text{g/L}$, the same as the fourth-quarter 2012 result. Refer to previous annual reports (e.g., DOE 2014c) for a more detailed discussion of the concentration patterns of constituents illustrated in Figure 237.

These two B991 wells are also monitored for uranium. More so than with the VOCs depicted above in Figure 237, uranium concentrations at these two wells (Figure 238) are very different. This is despite the fact that the wells are located only about 115 feet apart, and multiple samples from each of these wells have been analyzed using high-resolution isotopic methods that have characterized the uranium content as 100 percent natural.



Notes:

Applicable RFLMA uranium (U) threshold ($\mu\text{g/L}$; CDPHE et al. 2012), 120. Analytical data include results for uranium as mass-based concentrations and converted from isotopic activities. Several detections were qualified but for simplicity are not shown differently.

Figure 238. Concentrations of U in B991 Sentinel Wells

Uranium in well 99305 continues to be reported at concentrations that are very consistent from sample to sample; results in 2014 were 56 $\mu\text{g/L}$ (April) and 59 $\mu\text{g/L}$ (October). Concentrations of uranium at nearby well 99405 have become more consistent than they were in the original well and between 2008 and 2010, when concentrations could vary by more than 200 $\mu\text{g/L}$ from one sample to the next. Since 2011, concentrations of uranium in samples collected from well 99405

have consistently ranged between 380 µg/L and 440 µg/L, with those collected in 2014 reported at 380 µg/L (April) and 420 µg/L (October). Reasons for this transition to relatively uniform uranium concentrations at well 99405 are not known; possible factors are noted in the annual report for 2013 (DOE 2014c).

As discussed above in the context of the SPP and SPPTS, prior to Site closure the SPP was described as having a southeast-trending groundwater pathway for associated contaminants. Because it represents a primary constituent of SPP contamination, nitrate is analyzed in samples from wells 99305 and 99405 to assess the relative importance of such a pathway. The maximum concentration of nitrate in 2014 at well 99305 was 0.49 mg/L, and in well 99405 was 1.4 mg/L, both of which are lower than in 2013 but consistent with past data. Therefore, as in previous years, these data continue to indicate a southeastern flow path is not effective for migration of SPP constituents. The fact that the uranium in groundwater at these wells has consistently been analyzed as natural further supports this conclusion.

Statistical trends with a 95 percent level of significance apply to several constituents detected at these wells. Well 99405 only supports one such trend, decreasing uranium, but this may be affected by the well replacement completed in 2004. Five trends of this significance are calculated for well 99305, all increasing: *cis*-1,2-DCE, *trans*-1,2-DCE, PCE, TCE, and uranium. The trends for all but *cis*-1,2-DCE may be affected by artifacts within the datasets, such as numerous nondetects (*trans*-1,2-DCE) or well replacement (PCE, TCE, uranium). Except for the trend in *trans*-1,2-DCE concentrations, each of these trends is visually apparent on Figure 237 or Figure 238. Refer to Table 74 for a summary of statistical trends, and Appendix B for the associated trend plots.

Former B881 and 800 Area: This area has been monitored by Evaluation wells 88205 and 22996, and Sentinel wells 88104 and 00797. Each of these wells was scheduled for RFLMA sampling in 2014. During the second-quarter sampling event at well 88104, the previously recognized damage to the subsurface PVC well casing was found to have worsened considerably. The casing had breached approximately 10 feet below ground surface and sand from the filter pack had entered through the breach and filled the lower portion of the well, compromising the filter and preventing access to the full depth of the well. Representatives of the regulatory agencies were consulted and the final consensus, documented in Contact Record 2014-07, was to remove this monitoring location from the network and not replace the well. Factors supporting this decision include the fact that this location is essentially redundant with Sentinel well 00797 and Evaluation well 88205; well 88104 consistently produces water having no constituents above their corresponding RFLMA levels (including in the second-quarter 2014 samples); uranium at this location has been characterized as 100 percent natural; there is no suggestion of environmental impacts from the primary monitoring objective of this well (former B881); replacing the well would consume resources and would damage the reclaimed and revegetated area; and the remaining members of the well network would continue to effectively monitor groundwater downgradient of former B881 if well 88104 was abandoned and not replaced. Therefore, this 2014 Annual Report will be the last to summarize current conditions at that well; the analytical data collected in the second quarter were provided as part of the associated quarterly report (DOE 2014e).

Results from the samples collected from these wells in 2014 were generally consistent with previous data. Well 88205 reported several detections of VOCs, none above their corresponding

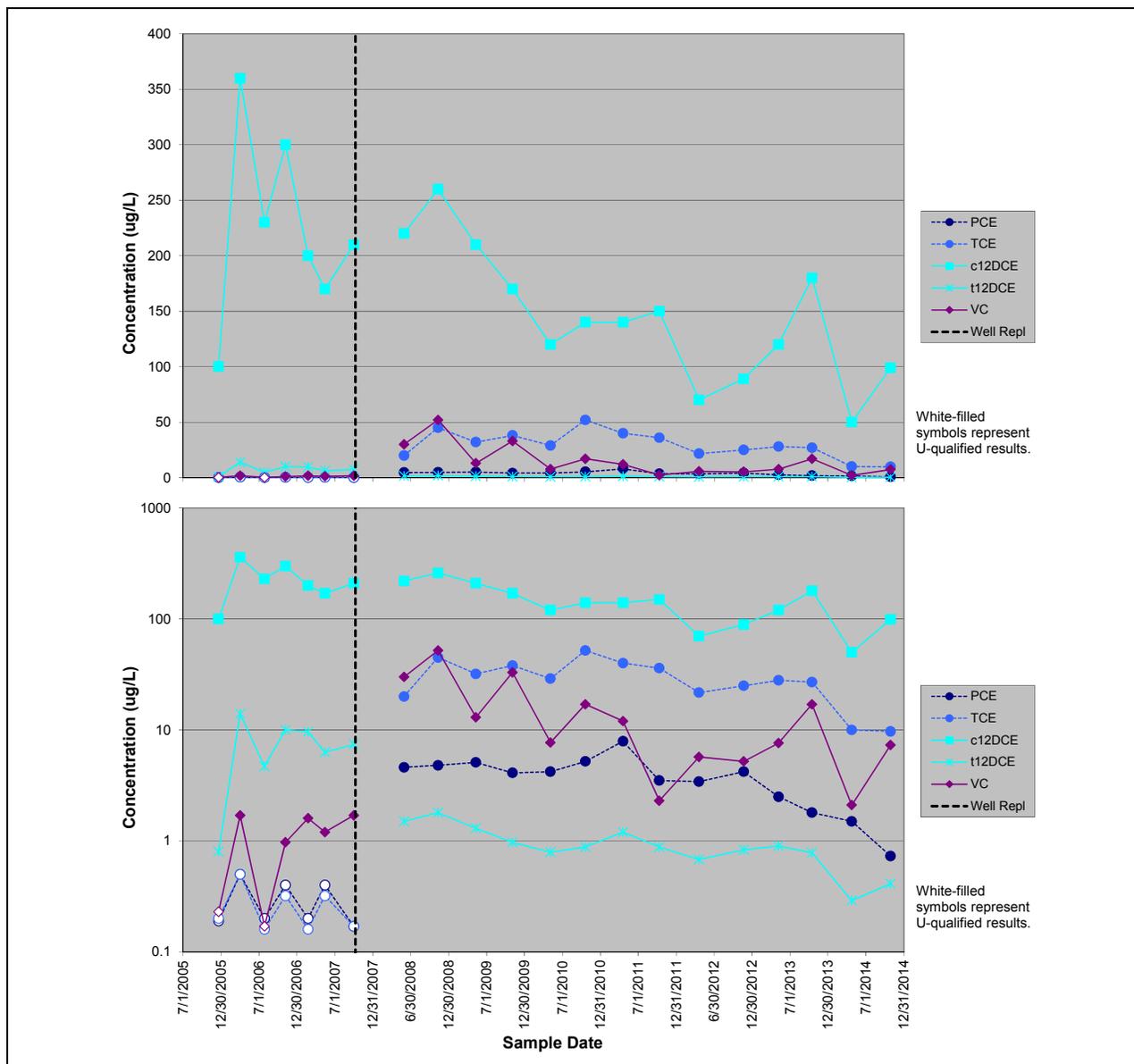
RFLMA Table 1 values, and well 88104 reported one VOC detection, also well under the RFLMA value. Uranium concentrations in 2014 at these wells were all well below the uranium threshold and fairly consistent with their historic ranges, though both Sentinel wells reported slightly higher concentrations than has been the case since January 2000. Well 00797 reported a concentration in fourth-quarter 2014 of 34.7 µg/L (previous high was 34 µg/L in the second quarter of 2012), and well 88104 reported 77 µg/L in the second quarter (previous high was 74 µg/L, also second quarter 2012). Uranium was not detected in the sample collected from Evaluation well 88205, which is also consistent with previous data: since this replacement well was installed in 2005, only one sample has contained a confirmed detection of uranium (second quarter 2006, 0.19 µg/L).

Several trends having a statistical significance of 95 percent are calculated from the data for these three B881 wells. Four such trends are calculated for well 88205, but each one is based on a dataset containing numerous nondetects and the data also may be affected by well replacement; therefore, these trends may not be viable. They include increasing toluene, total xylenes, and TCE; and decreasing uranium. Increasing trends of this statistical significance are also calculated for uranium in wells 00797 and 88104. Refer to Table 74 for a list of increasing and decreasing trends calculated in 2014, and to Appendix B for the trend plots and additional statistical results.

Elsewhere in the former 800 Area, Evaluation well 22996 monitors groundwater downgradient of former B886 and other 800-Area buildings (such as B865 and B883). The sample collected here in the second quarter of 2014 reported one VOC detection, for 1,3-DCB at an estimated (J-qualified) concentration of 0.34 µg/L. The RFLMA Table 1 value for this constituent is 94 µg/L. The uranium concentration reported here in 2014 was 11 µg/L, which is within its normal range at this location.

Hillside South of Former B991: The north-facing hillside south of former B991 contains the remains of a French drain that was installed during the construction of this artificial hillside to stabilize it. Because the drain outfall (former surface water location SW056) produced water containing VOCs, prior to closure the outfall from this drain was removed, the drain itself was interrupted, and electron donor material was added to the backfill to enhance biodegradation of VOCs. Sentinel well 45605 was installed to monitor groundwater adjacent to the drain interruption, but because the French drain no longer had an outlet for collected water, the hillside slumped. Well 45605 was properly abandoned, the area was regraded, and Sentinel well 45608 was installed to replace 45605. For more detail on the hillside and French drain, see the 2006 Annual Report (DOE 2007b); for information on the well abandonment and hillside regrading, see the 2007 and 2008 Annual Reports (DOE 2008, 2009c). Refer to the 2010 Annual Report (DOE 2011) for a discussion of potential well replacement-related effects on contaminant concentrations.

Well 45608 was sampled twice in 2014 (April, October). The continuing detections of *cis*-1,2-DCE and VC are an indication that reductive dechlorination is still occurring upgradient of the well. The extent to which this is related to placement of the electron donor material in 2005 is not known. Figure 239 illustrates time-series plots of several VOCs at this well, with the upper portion of the figure using a linear scale to provide perspective on the relative concentrations, and the lower portion using a logarithmic scale to more clearly display each constituent.



Notes:

Top and bottom portion incorporate the same data, but top portion uses linear concentration scale, bottom uses logarithmic scale.

c12DCE = *cis*-1,2-DCE; t2DCE = *trans*-1,2-DCE; Well Repl = date on which well 45605 was abandoned, with subsequent samples collected from its replacement, well 45608. RFLMA Table 1 values (µg/L) (CDPHE et al. 2012): PCE, 5; TCE, 2.5; *cis*-1,2-DCE, 70; *trans*-1,2-DCE, 100; VC, 0.2.

In addition to the nondetects (U-qualified results), several detections were qualified but are not shown differently for simplicity.

Figure 239. Concentrations of VOCs in Sentinel Well 45608, South of Former B991

From 2008 through about 2012, concentrations of VC were clearly (but erratically) decreasing. Concentrations of VC increased in 2013 (Figure 239) and through 2014 had not yet stabilized, perhaps in response to the floods of September 2013; a similar pattern is evident for *cis*-1,2-DCE. Concentrations of TCE in both samples collected in 2014 were substantially lower than in 2013, as were concentrations of PCE. These patterns could signify both flushing and degradation of the parent compounds into their partially dechlorinated daughter products. As

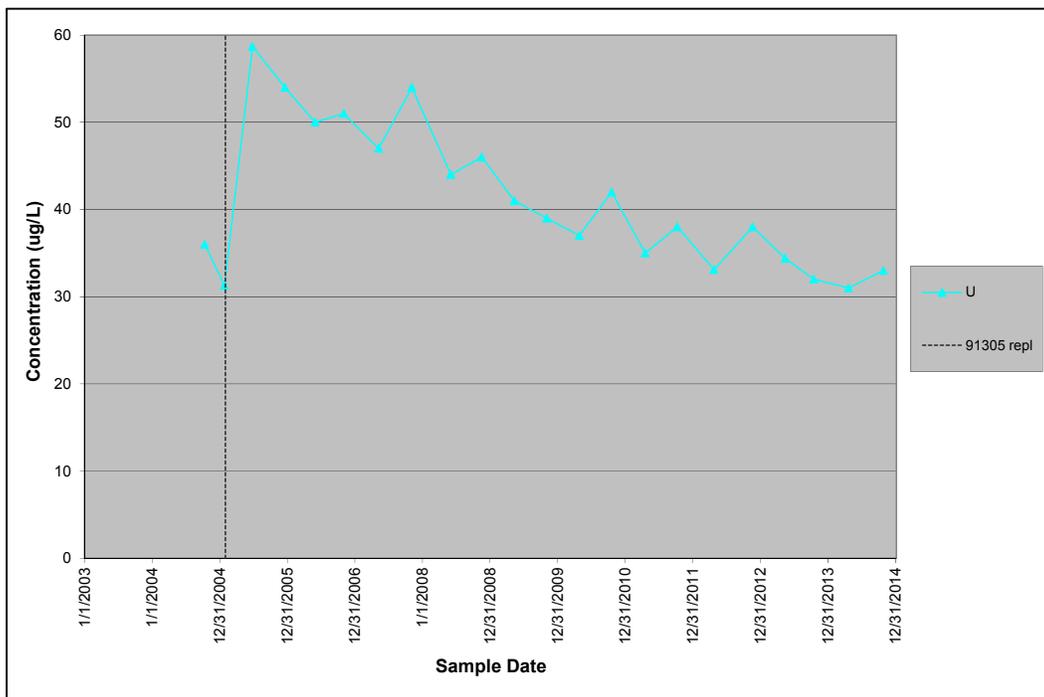
trans-1,2-DCE is not a favored metabolic byproduct from the breakdown of TCE (e.g., ITRC 1998; Leeson et al. 2004; K-H 2004c; USGS 2006), the more consistent concentrations of this constituent (with only one exception, below 1 µg/L since 2009) are not surprising. While the true cause(s) of these changes might never be clear, additional data may help to define any longer-term trends.

Several statistical trends are calculated to have a 95 percent level of confidence at well 45608. As explained in the 2013 Annual Report (DOE 2014c), the dataset on which these statistical calculations is based represents only the existing well, 45608. Data from its predecessor, 45605, are no longer included in these calculations due to the discontinuities in data discussed in previous reports. Significant trends calculated in 2014 are all decreasing and include PCE, TCE, both isomers of 1,2-DCE, and VC. As noted in Table 74, the decreasing trend for TCE is new as of 2014.

Sentinel well 91305 is also located in this area, west of well 91203 (discussed above in the context of the OBP #2/Mound Plumes) and adjacent to FC-4. As with other Sentinel wells, it was sampled in the second and fourth quarters of 2014 (in the case of this well, in April and October). Concentrations of VOCs in samples from well 91305 remain low, with *cis*-1,2-DCE most commonly detected (highest 2014 concentration: 3.3 µg/L). The only other VOC detected in 2014 was VC (fourth quarter only), at an estimated concentration of 0.18 µg/L, which is less than the corresponding RFLMA value (PQL of 0.2 µg/L). The only VOC to have been reported at this location at concentrations above the corresponding RFLMA value is VC, and the last time this took place was in the fourth quarter of 2012.

Well 91305 is also monitored for nitrate and uranium, again to support the evaluation of a potential southeastern pathway for the SPP to reach surface water. Nitrate was detected in both samples at very low concentrations, consistent with previous data: the highest concentration reported in 2014 was 0.17 mg/L. Uranium concentrations were also consistent with past data, with the April sample at 31 µg/L and the October sample reported at 33 µg/L. Concentrations of uranium at this location have not exceeded the uranium threshold, but have been as high as the upper 50 µg/L range. As is clearly evident on Figure 240, uranium concentrations at well 91305 are decreasing. Refer to previous annual reports (e.g., DOE 2014c) for discussion of the apparent jump in uranium concentrations from the levels reported for the original well, abandoned in January 2005, and the first samples collected from well 91305 in June 2005.

Two statistical trends having a 95 percent level of significance are calculated for well 91305 (Table 74 and trend plots in Appendix B). Both are decreasing, and represent concentrations of *cis*-1,2-DCE and of uranium.



Notes:
 "91305 repl" indicates the date when original well 2187 was abandoned; replacement well 91305 was installed 3 months later, roughly 2 months before the first 2005 sample was collected here. U = uranium. The RFLMA uranium threshold is 120 µg/L.

Figure 240. Concentrations of Uranium in Samples from Sentinel Well 91305

Former B371: Groundwater at the former B371 complex is sampled at three Sentinel wells. Each of these wells was sampled twice in 2014 (June, October), in accordance with the RFLMA. These samples are analyzed for VOCs, nitrate, and U. (Samples from two of the wells are also analyzed for plutonium and americium, as discussed in a separate section below.)

The VOC most commonly detected in this area is PCE in samples collected from well 37505. Concentrations of PCE here do not exceed the RFLMA Table 1 value (5 µg/L), instead consistently being reported at J-qualified concentrations below 1 µg/L. In 2014, PCE was the only VOC detected at any of the three wells (37405, 37505, 37705), where it was detected in both samples collected from well 37505. The highest concentration was estimated (J-qualified) at 0.42 µg/L.

Consistent with previous years, nitrate was detected in all samples collected in 2014 from the wells monitoring former B371. All results were below the 10 mg/L RFLMA Table 1 value. The highest concentration reported this year was 5.9 mg/L at well 37405.

Uranium concentrations in groundwater at the B371 monitoring wells are consistently well below the applicable RFLMA value. The highest concentration reported in 2014 was in a sample from well 37505, with a value of 14.7 µg/L.

S-K trending results (Table 74) indicate an increasing trend meeting the 95 percent level of confidence for nitrate in samples from well 37405 and for U in samples from well 37505, and a

decreasing trend of the same significance for uranium at well 37405. The associated trend plots are provided in Appendix B.

Areas Monitored for Plutonium and Americium: Groundwater immediately downgradient of the former B371 and B771 complexes is monitored for Pu and Am. Abundant technical research (much of which focused specifically on Rocky Flats) indicated that the groundwater regime does not constitute a meaningful migration pathway for these constituents at Rocky Flats. Therefore, as in previous years, it is not surprising that the groundwater monitoring wells that are sampled for Pu and Am consistently report results for these constituents that are qualified by the analytical laboratory as nondetects. Despite a lack of technical justification for these analyses, due to the production-era missions of these buildings and to provide stakeholder assurance, Pu and Am were included in the RFLMA monitoring for these wells.

In 2014, just as in previous years, the five wells monitored for Pu and Am (Sentinel wells 20205, 20505, and 20705 at former B771; and 37405 and 37705 at former B371) only reported values qualified as nondetects for these radionuclides. The RFLMA value is 0.15 pCi/L, and reported values in 2014 ranged from -0.0123 pCi/L to 0.0177 pCi/L, again all qualified as nondetects. (As an activity-based analysis that is compared against the activity in a laboratory blank, the analysis always generates a number.) In fact, the only Pu or Am results reported since Site closure that are not qualified as nondetects have been three J-qualified results in samples collected in December 2005, the highest activity of which was 0.0238 pCi/L (representing Am in a sample from well 20705).

3.1.6 High-Resolution Uranium Isotopic Analyses

Previous reports have presented data summaries and discussions of specialized uranium analyses performed on selected samples. These high-resolution isotopic analyses are performed by experts who then use the data to estimate the relative fraction of the uranium in a sample that represents naturally occurring uranium vs. anthropogenic uranium. This distinction is important because the former Rocky Flats Plant only worked with anthropogenic (depleted and enriched) uranium, not natural uranium. Therefore, if uranium in a given sample is natural, it does not represent Site-related uranium contamination.

The annual report for 2013 (DOE 2014c) described the change in service providers for this type of analysis. The Lawrence Berkeley National Laboratory (LBNL) now performs these analyses for Rocky Flats, and uses the same model that was used by the Los Alamos National Laboratory (LANL), the previous provider of this service) to estimate natural vs. anthropogenic content.

Three batches of surface water samples were submitted to LBNL in 2014 for high-resolution uranium analysis. These samples were selected to support the geochemistry study, and include many from WALPOC as well as locations farther upstream on North and South Walnut Creeks. As noted in the 2013 Annual Report (DOE 2014c), a batch of samples was being identified for LBNL analysis as 2013 ended. The data provided here and the corresponding reports from LBNL, attached in Appendix F, include two samples that date to 2013. These results were not available for inclusion in the annual report for that year.