

Figure 3-177. Relative Average Annual Total U Loads from Major COU Drainages and Former WWTP

3.1.5 Groundwater Data Interpretation and Evaluation

This section provides a summary of groundwater monitoring performed in 2009, separated into RFLMA-required and non-RFLMA-required. A discussion of groundwater conditions during 2009, focusing on the most important water-quality aspects in the areas of interest (i.e., the main plumes), is then presented.

3.1.5.1 RFLMA Groundwater Monitoring Activities of 2009

Routine activities of the groundwater monitoring program in 2009 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 groundwater treatment system-related performance monitoring locations within streams and ponds; examples of the latter include locations monitoring effluent from a treatment system.) 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 was also performed in 2009 to support various objectives. This is discussed in Section 3.1.5.2. The majority of this monitoring focused on the 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 2009 (DOE 2009e, 2009d, 2010c) and are included in Appendix B for the fourth quarter of CY 2009. Unvalidated data are not reported but are summarized in this document.

There were no changes to the network of groundwater monitoring locations during 2009. The groundwater monitoring network set forth in RFLMA is subdivided and categorized as shown in Table 3–75.

Table 3–75. RFLMA Monitoring Classifications for the Groundwater Monitoring Network

Well Classification	General Objective	Number of Wells^a	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)
Boundary	Monitor groundwater quality and water levels in Woman Creek and Walnut Creek drainages at eastern (downgradient) Site boundary	2	Annual (1x/year)
Sentinel	Monitor groundwater quality and water levels near contaminant plume edges and in drainages	28	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 ^{b, c}	Monitor quality of groundwater treatment system influent, effluent, and downgradient surface water	9	Semiannual (2x/year)
Surface-Water Support ^b	Monitor quality of surface water downgradient of contaminant plume	1	Semiannual (2x/year)

^aThe numbers of locations listed are current through 2009.

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

^cThe PLFTS is discussed separately.

Table 3–76 presents the full 2009 schedule for RFLMA groundwater sample collection, a subset of which is summarized in Table 3–77 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 2008f, 2008e, 2009f) and Appendix B.

Table 3–76. Summary of Scheduled RFLMA-Required Groundwater Sampling in CY 2009 (by Quarter)

Area	Classification	Location ID	Analytes					
			VOCs	U	Nitrate	Metals	Pu/Am	SVOCs
Boundary Wells	B	10394	2	2	2			
	B	41691	2	2	2			
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	S	15699	2,4					
	TS	MOUND R1-0	2,4					
	TS	MOUND R2-E	2,4					
	TS	GS10	2,4					
ETPTS	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	S	P210089	2,4	2,4	2,4			
	S	70099		2,4	2,4			
	TS	SPIN		2,4	2,4			
	TS	SPOUT ^a		2,4	2,4			
	TS	GS13		2,4	2,4			
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	S	52505	2,4					
	AOC	42505	2,4					
Former IHSS 118.1	SW	SW018	2,4					

Table 3-76 (continued). Summary of Scheduled RFLMA-Required Groundwater Sampling in CY 2009
(by Quarter)

Area	Classification	Location ID	Analytes					
			VOCs	U	Nitrate	Metals	Pu/Am	SVOCs
Former B444 Complex	S	11502	2,4	2,4				
	S	40305	2,4	2,4				
Former B881	S	00797	2,4	2,4				
	S	88104	2,4	2,4				
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	S	33703	2,4					
Former Oil Burn Pit No. 2	S	91203	2,4					
Former SW056	S	45608 ^b	2,4					
OU1 Plume	AOC	89104	2,4					
903 Pad/Ryan's Pit Plume	S	90299	2,4					
	S	90399	2,4					
	AOC	10304	2,4	2,4	2,4			
PU&D Yard Plume	S	30002	2,4					

Notes: ID = Identification (name) of well/sampling location
 Location classifications: AOC = Area of Concern, B = Boundary, S = Sentinel, DD = Decision Document, E = Evaluation, RCRA = Resource Conservation and Recovery Act, TS = Treatment System, SS = Surface Water Support
 SVOCs = semivolatile organic compounds
 2 (or other numeral) = Analyte requested for that quarter; if blank, analyte not requested
^aLocation replaces former location SPPMM01
^bLocation replaces well 45605.

Table 3–77. Summary of RFLMA-Required Groundwater Samples Not Successfully Collected in 2009

Location		Analytes						Comments
ID	Classification	VOCs	U	Nitrate	Metals	Pu/Am	SVOCs	
90299	S	2, 4						Dry well
95299	S	2, 4						Dry well

Notes: ID = Identification (name) of well/sampling location
 RFLMA classifications: AOC = Area of Concern, B = Boundary, S = Sentinel, E = Evaluation,
 RCRA = Resource Conservation and Recovery Act, TS = Treatment System, SS = Surface Water Support
 SVOCs = semivolatile organic compounds
 2 (or other numeral) in analyte column = Corresponding analyte requested in the indicated calendar quarter of 2009; if blank, analyte not requested

3.1.5.2 Non-RFLMA Groundwater Monitoring Activities of 2009

Non-RFLMA (i.e., nonroutine) groundwater monitoring was performed in 2009 in support of several data needs, which generally fall within the following two categories:

- Investigative sampling; and
- Performance sampling.

Table 3–78 summarizes all non-RFLMA sample collection performed in 2009. In addition to this non-RFLMA sampling, additional non-RFLMA monitoring was performed through the sitewide measurement of water levels as discussed in Section 3.1.3.5.

In 2009, as in recent years, most of the non-RFLMA monitoring 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. Due to the significant effort and unusual events related to that treatment system, this topic is discussed separately in Section 3.1.2.10.

Table 3–78. Summary of Non-RFLMA-Required Groundwater Monitoring Performed in 2009

Area	Location ID	Analytes ^{a,b}					
		VOCs	U	Nitrate	Nitrite	NH ₃ -N	Other
SPPTS	GS13		1(5), 2	1(6), 2 (includes 1 set of split samples collected in 1st quarter)	1		
	ITSE ^c		1(3) (includes 1 set of split samples collected in 1st quarter)	1(3) (includes 1 set of split samples collected in 1st quarter)			
	ITSS ^c		1(4) (includes 1 set of split samples collected in 1st quarter)	1(4) (includes 1 set of split samples collected in 1st quarter)			
	ITSW ^c		1(3) (includes 1 set of split samples collected in 1st quarter)	1(3) (includes 1 set of split samples collected in 1st quarter)			

Table 3-78 (continued). Summary of Non-RFLMA-Required Groundwater Monitoring Performed in 2009

Area	Location ID	Analytes ^{a,b}					
		VOCs	U	Nitrate	Nitrite	NH ₃ -N	Other
SPPTS	SPIN		1(5), 2, 3(2), 4 (includes 1 set of split samples collected in 1st quarter)	1(5), 2, 3(2), 4 (includes 1 set of split samples collected in 1st quarter)		3	Se 3
	SPOUT		1(6), 2, 3(2), 4 (includes 1 set of split samples collected in 1st quarter)	1(6), 2, 3(2), 4 (includes 1 set of split samples collected in 1st quarter)	1	3	Se 3,4
	SPP Discharge Gallery ^c		1(5), 2, 4 (includes 1 set of split samples collected in 1st quarter)	1(5), 2, 4 (includes 1 set of split samples collected in 1st quarter)			Se 3
	SW093			1(6) (includes 1 set of split samples collected in 1st quarter)	1		
	SPCAE ^c		2, 3(2), 4	2, 3(2), 4		3	P 3
	SPCBE ^c		2, 3(2), 4	2, 3(2), 4		3	P 3
	SPZE ^c		2, 3(2), 4	2, 3(2), 4		3	P 3
	SPILCA ^c		3(2)	3(2)		3	P 3
	SPVL ^c		3	3			
	1786		2	2			
B210489		2	2				
Former B771/774	20205			4 ^d			
	20505			4 ^d			
Former IHSS 118.1	18199	2					
Former Oil Burn Pit No. 1	33502	2					
	33604	2					
903 Pad/Ryan's Pit Plume	00191	1					
	50299	1					
	07391	2					

Notes: ^aThe numeral in the "analyte" column (e.g., 2) indicates the 2009 quarter in which the analyte was requested; if blank, analyte 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 samples collected is indicated in parentheses.

^bSeveral split samples were collected at locations associated with the SPPTS; one set was sent to a contract laboratory and the other to the ESL for analysis.

^cThe Solar Ponds Plume Discharge Gallery (SPDischargeGallery) is sampled in accordance with the RFSOG (DOE). Locations ITSW, ITSE, and ITSS are associated with the Phase I upgrades to the SPPTS and were sampled to evaluate system effectiveness (i.e., quality of additional water being captured by the Phase I upgrades). Locations SPCAE, SPCBE, SPZE, SPILCA, and SPVL are associated with the Phase II/III upgrades to the system and were sampled to evaluate the system effectiveness.

^dDuring fourth quarter, samples were inadvertently analyzed for nitrate from wells 20205 and 20505.

ID = Identification (name) of well/sampling location

NH₃-N = ammonia reported as nitrogen

P = phosphate

Se = selenium

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 2009. Groundwater quality is addressed first, followed by 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 2009.

Trend Plots

Numerous statistical trend plots were constructed for this report using analytical data collected from Sentinel, Evaluation, and RCRA wells (see Sections 3.1.2.8 and 3.1.2.9 for discussion of RCRA wells). Although not required by RFLMA, trend plots were also constructed for selected constituents in several AOC wells. Trend plots and corresponding summary tables are presented in Appendix B. In addition to these statistical trend plots, many nonstatistical time-series plots were prepared and are included in this report.

The Sanitas software package (version 9.0; Sanitas Technologies 2009) was used for statistical calculations, including the ANOVA analyses and construction of trend plots. (This is noted for the purpose of completeness only; this report does not make software recommendations.) For simplicity, trend calculations performed for any but RCRA wells assign the given well a downgradient position. This is appropriate because the fundamental objective of the other wells is related to detection monitoring or the exit strategy; no interwell statistics were planned for these classes of wells (only intrawell assessment of the trend of an analyte over time at each given well). Only RCRA wells were assigned either upgradient or downgradient positions to support the related statistical evaluations, as described in Section 3.1.2.8 and Section 3.1.2.9.

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, as recommended for Rocky Flats groundwater data (K-H 2004a) and in accordance with the RFSOG (DOE 2010a). Trends calculated for wells that are sampled less than twice per year, removing aspects of seasonality, employ the Mann-Kendall (M-K) statistical method. S-K trends are only plotted where they are calculated to be at least 80 percent significant, and M-K trends are plotted if at least 95 percent significant.

Table 3–79 summarizes the results of these trend calculations. Only increasing and decreasing trends calculated to be at least 80 percent significant using the S-K test are included in this table. (Therefore, even if 95 percent significant, trends with zero slope are not included.) Monitoring well classifications that require statistical evaluation of concentration trends according to RFLMA (i.e., Sentinel and downgradient RCRA wells) are included, as are calculations for selected analytes from selected AOC wells. As noted above, this is the first time trends can be calculated using the S-K method for the downgradient RCRA wells. Refer to Appendix B for the plots and associated summary tables, and Figure 3–1 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 3–79. Summary of Statistical Trend Calculations

Well	General Location	Analyte	Trend	Significant at 95%?
<i>Sentinel Wells</i>				
15699	MSPTS	1,1,1-TCA	Decreasing	Yes^a
45608	Hillside south of B991	1,1,1-TCA	Increasing	No ^{c,d}
15699	MSPTS	1,1-DCE	Decreasing	Yes^a
23296	ETPTS	1,1-DCE	Increasing	Yes^a
45608	Hillside south of B991	1,1-DCE	Increasing	No ^d
33703	OBP#1	1,2-DCB	Increasing	No ^c
15699	MSPTS	1,2-DCA	Increasing	No
33703	OBP#1	1,3-DCB	Increasing	No
33703	OBP#1	1,4-DCB	Increasing	Yes
04091	East Trenches Plume	Carbon tet	Decreasing	Yes^c
23296	ETPTS	Carbon tet	Decreasing	Yes^c
90299*	903 Pad/Ryan's Pit Plume-SID	Carbon tet	Decreasing	Yes^c
91203	OBP#2	Carbon tet	Decreasing	Yes^a
33703	OBP#1	Chlorobenzene	Decreasing	Yes
15699	MSPTS	Chloroform	Decreasing	Yes^{b,c}
23296	ETPTS	Chloroform	Decreasing	Yes
90299*	903 Pad/Ryan's Pit Plume-SID	Chloroform	Decreasing	No
91203	OBP#2	Chloroform	Decreasing	No
20505	B771	<i>cis</i> -1,2-DCE	Decreasing	No
20705	B771	<i>cis</i>-1,2-DCE	Increasing	Yes^c
23296	ETPTS	<i>cis</i>-1,2-DCE	Increasing	Yes
33703	OBP#1	<i>cis</i>-1,2-DCE	Increasing	Yes
90399	903 Pad/Ryan's Pit Plume-SID	<i>cis</i> -1,2-DCE	Increasing	No
91203	OBP#2	<i>cis</i>-1,2-DCE	Increasing	Yes^c
99305	B991	<i>cis</i>-1,2-DCE	Increasing	Yes
99405	B991	<i>cis</i> -1,2-DCE	Increasing	No ^c
90299*	903 Pad/Ryan's Pit Plume-SID	Methylene Chloride	Decreasing	Yes^{a,c}
95199	ETPTS	PCE	Increasing	Yes^b
99305	B991	PCE	Increasing	Yes
04091	East Trenches Plume	PCE	Decreasing	Yes^c
15699	MSPTS	PCE	Decreasing	Yes
23296	ETPTS	PCE	Decreasing	Yes
40305	B444	PCE	Increasing	Yes^c
45608	Hillside south of B991	PCE	Increasing	Yes^{b,c,d}
99305	B991	<i>trans</i>-1,2-DCE	Increasing	Yes^{a,c}
15699	MSPTS	<i>trans</i>-1,2-DCE	Increasing	Yes^c
23296	ETPTS	<i>trans</i>-1,2-DCE	Increasing	Yes
33703	OBP#1	<i>trans</i>-1,2-DCE	Increasing	Yes
45608	Hillside south of B991	<i>trans</i> -1,2-DCE	Decreasing	No
15699	MSPTS	TCE	Decreasing	Yes
23296	ETPTS	TCE	Decreasing	Yes
45608	Hillside south of B991	TCE	Increasing	Yes^{c,d}
90299*	903 Pad/Ryan's Pit Plume-SID	TCE	Decreasing	Yes
90399	903 Pad/Ryan's Pit Plume-SID	TCE	Increasing	No
91305	OBP#2 / B991	TCE	Increasing	Yes^c
95199	ETPTS	TCE	Increasing	No
99305	B991	TCE	Increasing	Yes

Table 3-79 (continued). Summary of Statistical Trend Calculations

Well	General Location	Analyte	Trend	Significant at 95%?
99405	B991	TCE	Increasing	Yes^c
15699	MSPTS	VC	Increasing	Yes^c
20505	B771	VC	Decreasing	No ^c
20705	B771	VC	Increasing	No
33703	OBP#1	VC	Increasing	Yes^c
45608	Hillside south of B991	VC	Increasing	Yes^d
00797	B881	U	Increasing	Yes
20205	B771	U	Increasing	Yes
20705	B771	U	Increasing	Yes^d
23296	ETPTS	U	Decreasing	No
37505	B371	U	Increasing	Yes^b
70099	SPPTS	U	Increasing	No
88104	B881	U	Decreasing	Yes^d
99305	B991	U	Increasing	Yes
99405	B991	U	Decreasing	Yes
P210089	SEP/SPPTS	U	Increasing	Yes
37405	B371	Nitrate	Increasing	No
37705	B371	Nitrate	Increasing	Yes^c
70099	SPPTS	Nitrate	Decreasing	Yes
P210089	SPPTS	Nitrate	Increasing	No
20705	B771	Am-241	Decreasing	Yes^{d,e}
RCRA Wells				
73105	PLF	Boron	Increasing	Yes^a
73205	PLF	Boron	Increasing	No ^a
80005	OLF	Boron	Decreasing	Yes^a
80205	OLF	Boron	Increasing	No ^a
80205	OLF	Nickel	Decreasing	No ^{a,c}
80205	OLF	Selenium	Increasing	Yes^{a,c}
Selected AOC Wells				
00193	Woman Ck. at Pond C-2	Uranium	Decreasing	No ^f
00997	S. Walnut Ck. at Pond B-5	Uranium	Increasing	No ^f
4087	Landfill Pond Dam	Uranium	Decreasing	No ^f
10304	Woman Ck. at Pond C-1	Uranium	Increasing	No
10594	N. Walnut Ck. at Pond A-2	Uranium	Decreasing	No
11104	Woman Ck. below OLF	Uranium	Decreasing	No
B206989	Landfill Pond Dam	Uranium	Decreasing	No ^f
B206989	Landfill Pond Dam	Nitrate	Decreasing	Yes

Notes: Only increasing and decreasing trends are included; indeterminate and zero-slope trends are not. Trends are listed if there is an 80 percent statistical significance; any decisions that may be made would be based on trends having a 95 percent significance. **Bold** entries designate those trends having a 95 percent significance; only these trends were assessed for applicability of the footnotes below.

DCA = dichloroethane; DCE = dichloroethene; DCB = dichlorobenzene; OBP = Oil Burn Pit; PCE = tetrachloroethene; TCB = trichlorobenzene

* Well was dry in 2009 – trend does not reflect any new data

^aTrend was not calculated to be significant at 80% level in previous (2008) report, but with 2009 data is now 95% significant.

^bTrend was calculated to be significant in previous (2008) report, but at less than a 95% significance; it now meets the 95% level of significance.

^cTrend may not be valid even though it is calculated to have a 95 percent significance, because 25 percent or more of the analytical data used to calculate this trend are nondetects. See Section 3.1.1.2 for discussion of how nondetects were handled in trending calculations.

Table 3–79 (continued). Summary of Statistical Trend Calculations

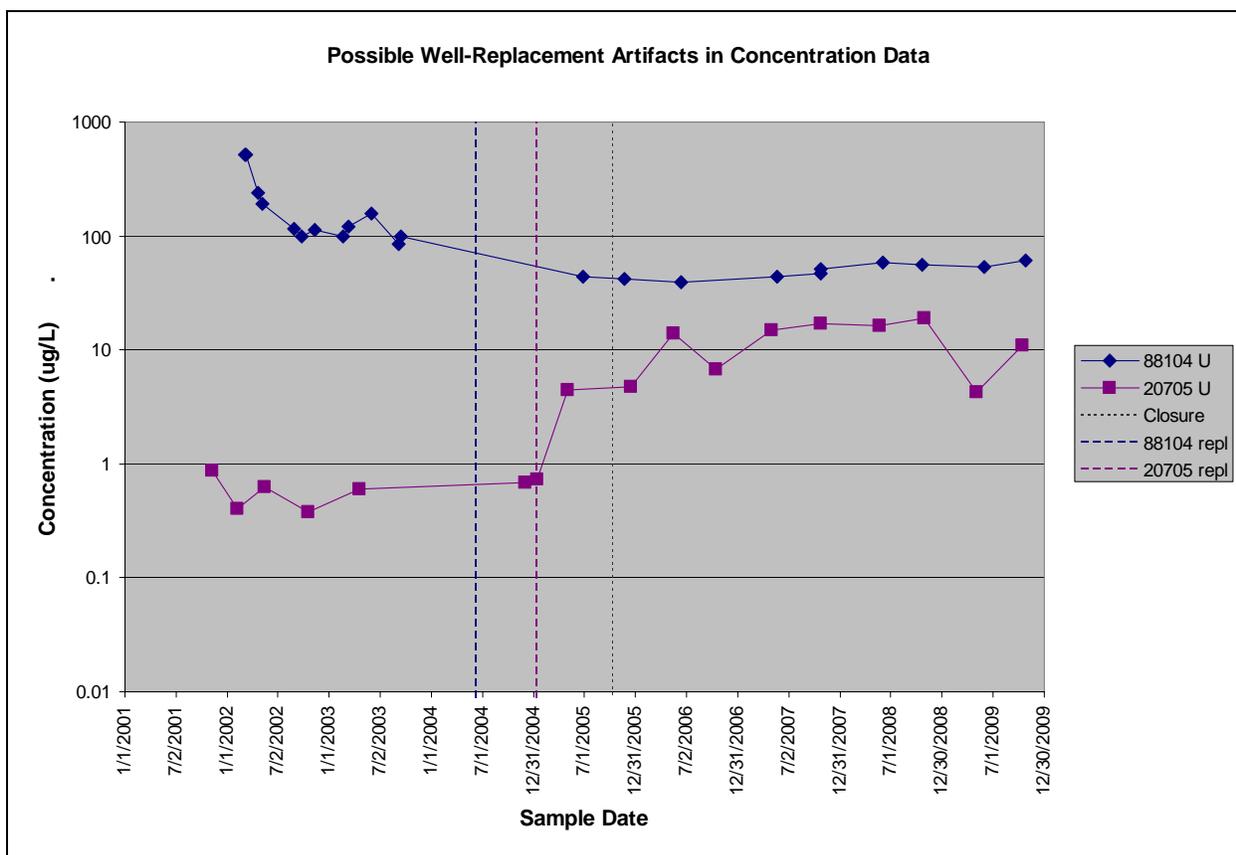
^dAlthough the trend is calculated to have a 95% significance, the data used to calculate this trend may be affected by well replacement. Results for this constituent in samples from the original well are markedly different from those from the replacement well. These data sets may be separated in the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

^eSamples 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.

^fTrend was not calculated to be significant at 80% level but is listed for informational purposes (AOC wells only).

Comparing the results of trend calculations for Sentinel and RCRA wells reported in the 2008 Annual Report (DOE 2009g) with those presented above shows very few changes from one year to the next. There are a few instances in which a concentration trend did not meet the 95 percent level of significance using 2008 data, but with 2009 data that level was attained; these instances are identified in the table. There are also instances in which a trend that had been calculated to be significant no longer met that test when 2009 data were included in the calculation. Of the trends in Sentinel and RCRA wells that meet the 95 percent level of significance, 21 are decreasing and 31 are increasing.

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 have since been replaced, some instances of slope change due to well replacement are to be expected. This may impact analytical as well as water elevation data. Figure 3–178 is an example of data that appear (even on a logarithmic concentration scale) to be strongly impacted by well replacements, as noted in the summary of calculated trends above. For a cross-walk of closure-era original and replacement wells, refer to the *Rocky Flats Site 2006 Integrated Monitoring Plan Background Document* (2006 IMP) (DOE 2006c, Appendix B, Table B-4); since that date, the only well replacement was the abandonment of well 45605 and its replacement with well 45608.



Notes: Well 88104 is located immediately south of former B881, and well 20705 is located immediately north of former B771.
 “Repl” = replacement; “Closure” = Site closure date (in this case, declaration).
 The date of well replacement is represented by the date the original well was abandoned, because this is the last possible date on which samples from the original location could have been collected.

Figure 3–178. Time-Series Plot of Discontinuous U Concentrations from Selected Wells

Groundwater Plumes with Treatment Systems

Groundwater quality data were obtained for all monitored areas in 2009, but as noted above, Evaluation wells—which include wells in contaminant source areas—were not scheduled for routine monitoring in this period. Analytical data have been published in quarterly reports issued for 2009 (DOE 2009e, 2009d, 2010c), plus Appendix B, and will not be duplicated here. Appendix B also includes S-K trend plots for CY 2009.

Groundwater quality at the Site in 2009 was largely consistent with data reported in prior years (as can be deduced from the summary of statistical trends presented in Table 3–79). Generally, groundwater quality within plumes that were identified and characterized through the decades of pre-closure groundwater monitoring at the Site have not changed much over the years since the Site was closed.

This section describes the general groundwater quality in various areas of interest across the Site, beginning with descriptions of conditions in 2009 at the three main groundwater contaminant plume treatment systems (MSPTS, ETPTS, and SPPTS).

Mound Plume, Oil Burn Pit #2 (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”) that was in use in the 1950s. Some of the drums leaked, creating a groundwater contaminant plume extending north toward South Walnut Creek. 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 was located just west of the Mound source area, at the southeast corner of the former Protected Area fence. 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 observed. This led to a source removal action in 2005 that addressed elevated concentrations in the soils. Supplemental carbon (in the form of Hydrogen Release Compound, HRC) was added to the backfill to enhance biodegradation of residual VOCs. Because the flow path for the OBP#2 Plume is 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 to intercept and direct this flow into the MSPTS intercept trench, from which it is directed to the MSPTS for treatment.

The following paragraphs describe these plumes and the MSPTS.

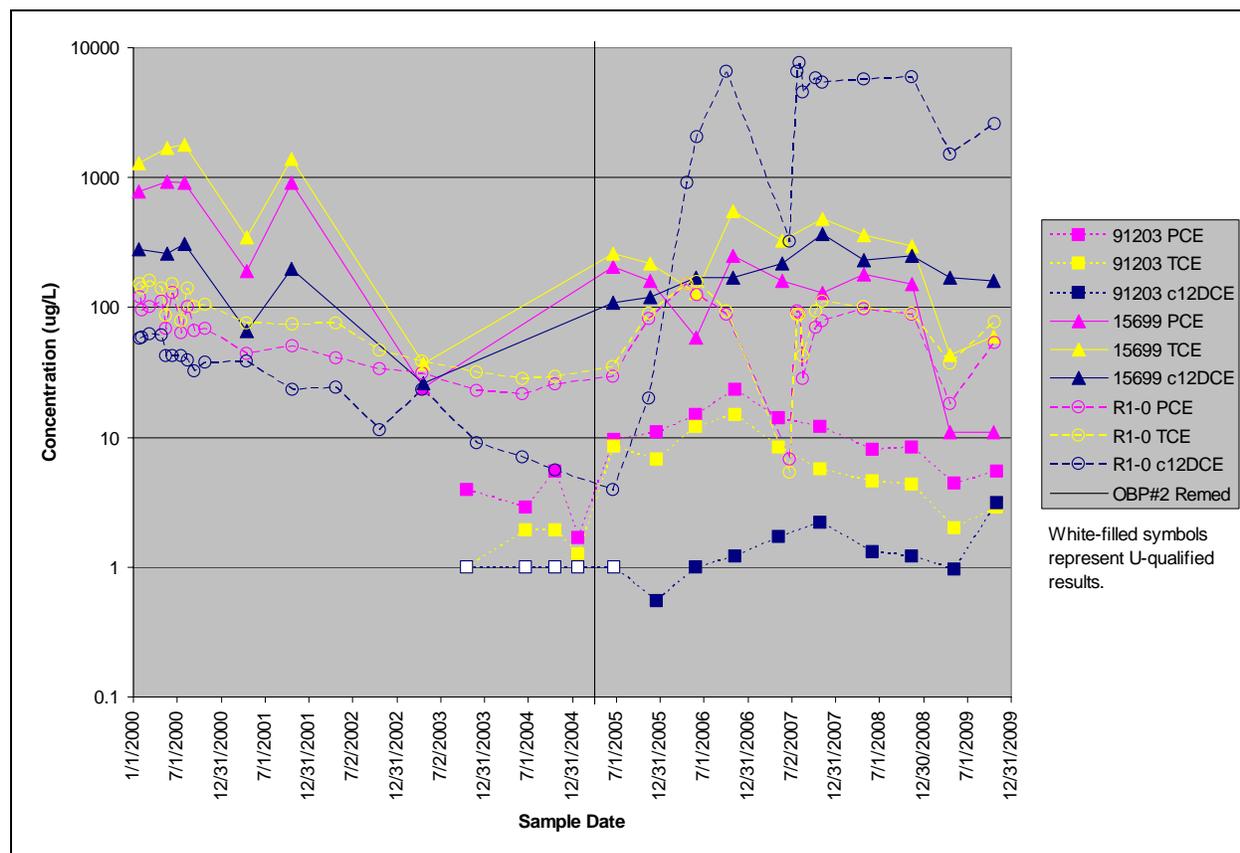
Mound Plume and OBP#2 Plume

Previous annual reports (e.g., DOE 2007f, 2008d) provide separate discussions of the Mound Plume and the nearby OBP#2 Plume. However, 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.

At its source area, the Mound Plume is characterized by elevated concentrations of tetrachloroethene (PCE) and TCE. 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), but since the source removal and addition of HRC to the backfill, concentrations of *cis*-1,2-DCE and other metabolic byproducts have increased sharply in samples from the OBP#2 source-area well. This well, 91105, is the third to monitor the OBP#2 source area; the previous two (91103, 91104) were installed within the contaminated soils, and the current well is on the downgradient edge of the backfilled source-removal excavation.

Consistent with the technical design of the groundwater monitoring network at the RFS, the two source-area wells, 00897 (Mound) and 91105 (OBP#2), are Evaluation wells that are scheduled for routine monitoring every other year. They were not sampled in 2009. Therefore, no additional data are available to update conditions reported for 2008 (DOE 2009g). Both wells are scheduled for sampling in CY 2010, and source-area conditions will be reported in the corresponding annual report.

The OBP#2 and Mound Plumes are also monitored by Sentinel wells positioned downgradient of the source areas, along flowpaths to surface water. Figure 3–179 displays reported concentrations of PCE, TCE, and *cis*-1,2-DCE in samples from Sentinel wells 91203 (downgradient of OBP#2) and 15699 (downgradient of the Mound and MSPTS groundwater intercept trench), as well as from the influent sampling location for the MSPTS, R1-0. Samples from well 91203 show an increase in the concentrations of some VOCs that generally coincides with the disruption associated with remediation of OBP#2 completed on April 1, 2005. These concentration increases have since leveled off and begun to decrease and approach pre-closure levels, although the sample collected in November 2009 reflects minor increases in concentrations of the main parent products detected here (PCE and TCE) and a sharper increase in the metabolic byproduct *cis*-1,2-DCE. This general pattern and the magnitude of the increase in concentrations suggests that groundwater at well 91203 is impacted by the OBP#2 source area, but not strongly.



Notes: R1-0 represents the influent sampling location for the MSPTS. OBP#2 Remed indicates the date on which source removal and backfilling of the OBP#2 was completed (April 1, 2005). Applicable RFLMA surface-water action levels for these constituents ($\mu\text{g/L}$; DOE 2007a): PCE, 5; TCE, 5; *cis*-1,2-DCE (*c*12DCE in the figure above), 70. Several results are qualified (“J,” “D”), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 3–179. VOC Concentrations in Samples from Mound Plume and OBP#2 Plume Downgradient Wells 15699 and 91203

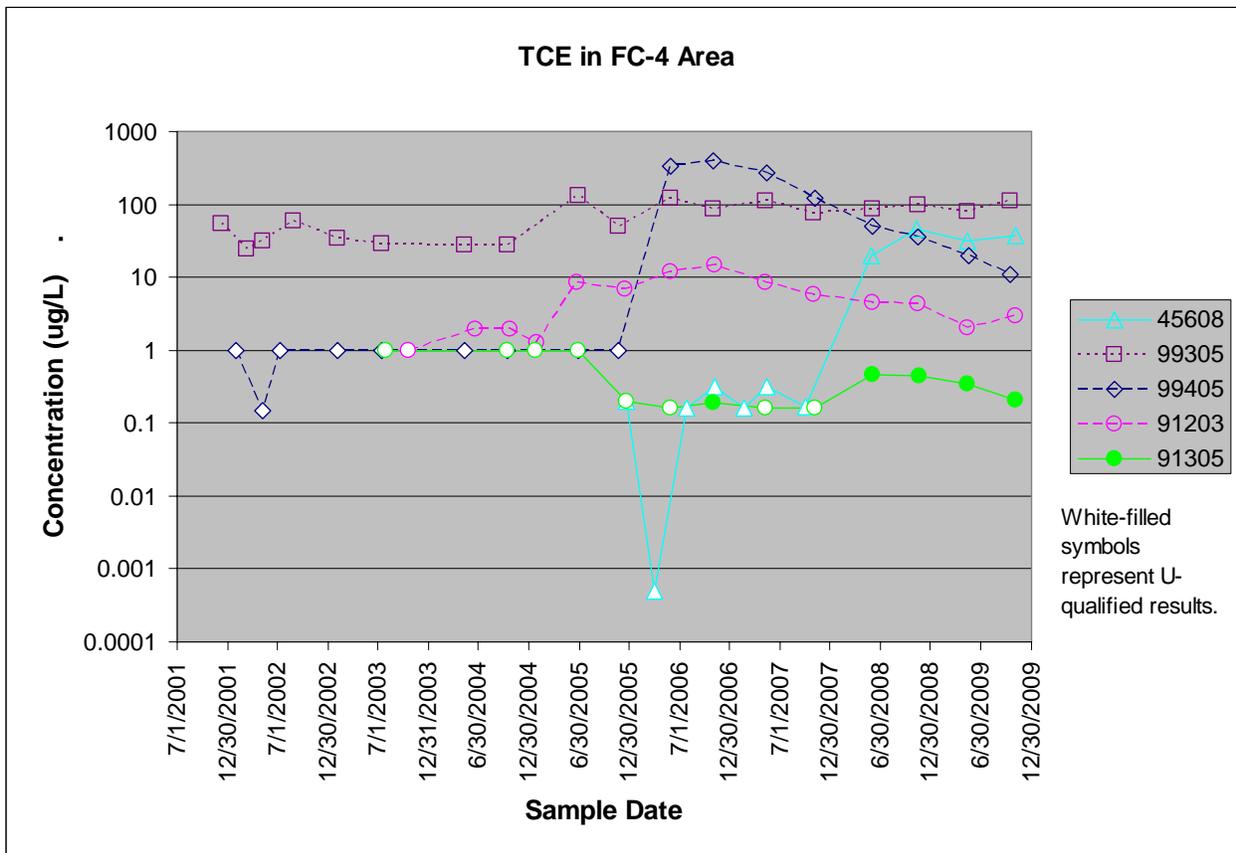
The concentrations of these constituents in samples from well 15699 that were collected prior to closure show fairly close correlation, with the relative concentration of each mirroring its position in the degradation pathway of PCE. (With successive dechlorination, PCE is transformed to TCE and then to *cis*-1,2-DCE, 1,1-DCE, and VC [K-H 2004d, ATSDR 2007].)

However, since mid-2006, concentrations of these constituents have varied erratically. Since 2007, *cis*-1,2-DCE concentrations exceeded those of the fully-chlorinated parent, PCE, and in 2009, concentrations of *cis*-1,2-DCE in samples from this well exceeded both parent compounds. This is interpreted to be an indication of the increased biodegradation of parent compounds in the OBP#2 source area following the addition of HRC to the backfill after source removal activities, and the installation of a gravel drain that routes flow from OBP#2 to the MSPTS.

Figure 3–179 also includes data from MSPTS location R1-0, the monitoring point for system influent. These data show a rapid and sharp response to OBP#2 remediation, particularly in the relative abundance of *cis*-1,2-DCE compared to PCE and TCE. Concentrations of the latter two compounds have been very similar for the past several years, particularly since closure, until diverging in 2009 when concentrations of TCE were higher than those of PCE, much like in the early 2000s. Conversely, concentrations of *cis*-1,2-DCE in samples from R1-0 increased sharply in late 2005/early 2006, again reflecting the additional biodegradation taking place since the addition of the HRC carbon source, and have remained high through 2009.

S-K trend calculations indicate the concentration of *cis*-1,2-DCE in samples from Sentinel well 91203 (Table 3–79) is on an increasing trend at a 95 percent confidence level. Although there are numerous nondetects in the data set, from a purely visual perspective this trend appears reasonable. S-K trend plots for well 15699 show a statistically significant (95 percent) decreasing trend for PCE, and similarly significant increasing trends in *trans*-1,2-DCE and VC concentrations. The latter two trends may not be valid, however, because most of the data for these constituents from 2000 through closure are reported as nondetects with elevated detection limits (e.g., 100 µg/L). Refer to Appendix B for S-K plots and detailed summary tables.

Data from well 91305, located in the FC-4 valley bottom west of well 91203, suggest this well monitors a mix of waters. Comparisons of degradation byproducts and parent compounds suggest the primary source of the low concentrations of contaminants reported in well 91305 is either the French-drain-affected hillside south of former B991 (located west-southwest of well 91305), or the B991 hillside itself (due west of the well). Additional contributions may be received from the OBP#2 source area to the south/southeast of well 91305. Figure 3–180 illustrates concentrations of TCE in samples from wells in this area, including 45608 (on the hillside south of B991), 99305 and 99405 (on the 991 hillside), 91203 (downgradient to side-gradient of OBP#2), and 91305. With the exception of well 91203, each of these has produced samples containing levels of TCE that are calculated to be on an increasing trend at the 95 percent level of statistical significance (Table 3–79). As shown on Figure 3–180, the increasing concentrations seen in samples from well 91305 resemble those reported in wells 45608 and 99405. The increase at 91305 occurs simultaneously with that at 45608 and is delayed by some 2 years after well 99405. A simultaneous change at 91305 and 45605 is unlikely: it would require that both wells be fed by the same source area and receive this input essentially simultaneously, yet TCE concentrations in well 91305 are about 2 orders of magnitude lower than those in well 45608. In addition, degradation byproducts reported for the two wells do not reflect the same pattern, and the increase at 45608 coincides with this well's replacement in 2008. (Water quality at well 45608 is discussed further in the section on other plumes below.) Degradation byproducts in well 99405 are too scarce to support either argument. The extensive reworking of the entire area as a part of closure precludes definitive explanation. Much more detailed study (e.g., via modeling, isotopics/tracer testing) would need to be conducted, and at this time it is not warranted.



Notes: FC-4 is Functional Channel 4; see map of well locations. Applicable RFLMA surface-water action level for TCE: 5 µg/L (DOE 2007a). Several results are estimated (“J”-qualified), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 3–180. Concentrations of TCE in Samples from Wells near FC-4 Constructed Wetland

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. This work was completed in 1998. The first media replacement activity was conducted in the summer of 2006. Routine maintenance activities performed at the MSPTS in 2009 are discussed in Section 2.5.1.

As with all years from 2005 on, flow rates through the MSPTS in 2009 were above pre-2005 levels. This is due to the routing of groundwater flow from the OBP#2 area into the MSPTS intercept trench. (For additional background, see the 2005 Annual Report, DOE 2006d.) However, the volume treated in 2009 is fairly similar to that treated in 2000. Table 3–80 provides annual estimates of the volume of water treated by the MSPTS, which in 2009 is estimated at approximately 287,000 gallons. This continues a general decline in MSPTS volumes that has been apparent since 2005. Closure-related activities in 2005 followed by gradual dewatering of the area to more stabilized levels may be the cause of this pattern. Figure 3–181 presents the corresponding hydrograph, and Figure 3–182 provides a hydrograph for CY 2009.

Table 3–80. 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

Note: Estimates for years 2000 through 2004 are compiled from K-H (2000a, 2000b, 2000c, 2000d, 2002, 2003, 2005b, 2005c).

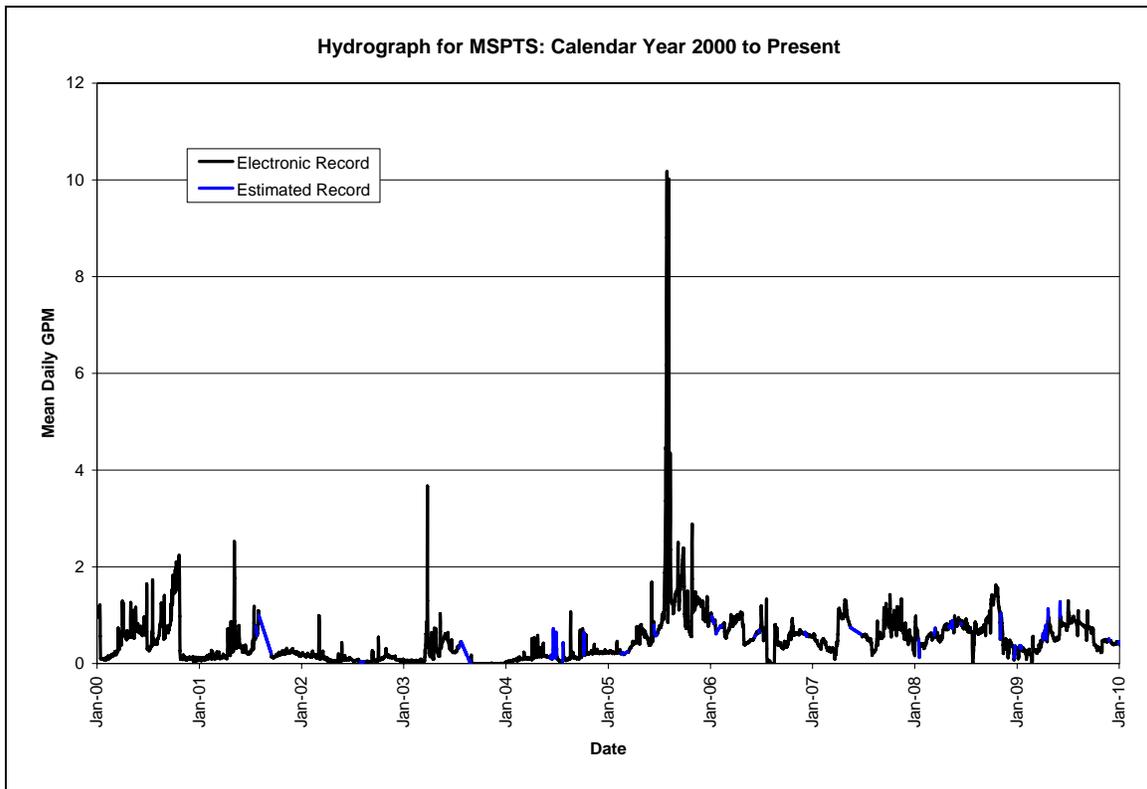


Figure 3–181. Hydrograph for MSPTS from 2000 through 2009

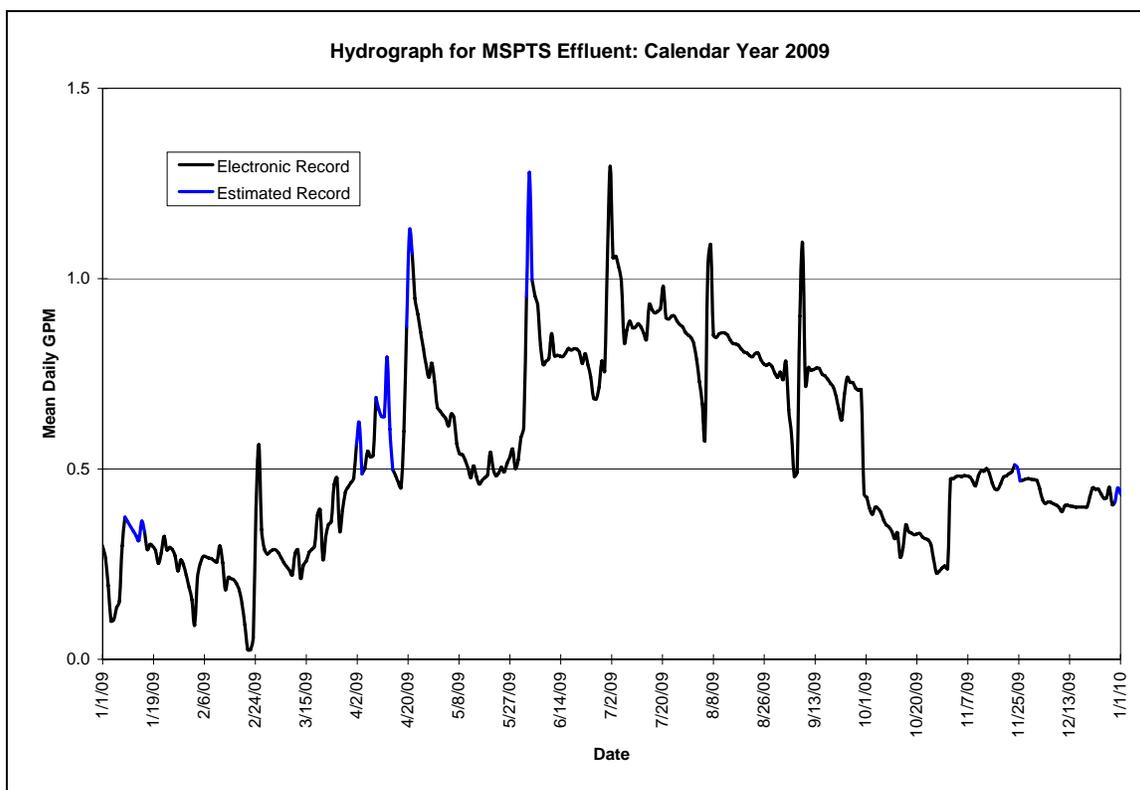


Figure 3–182. Hydrograph for MSPTS for CY 2009

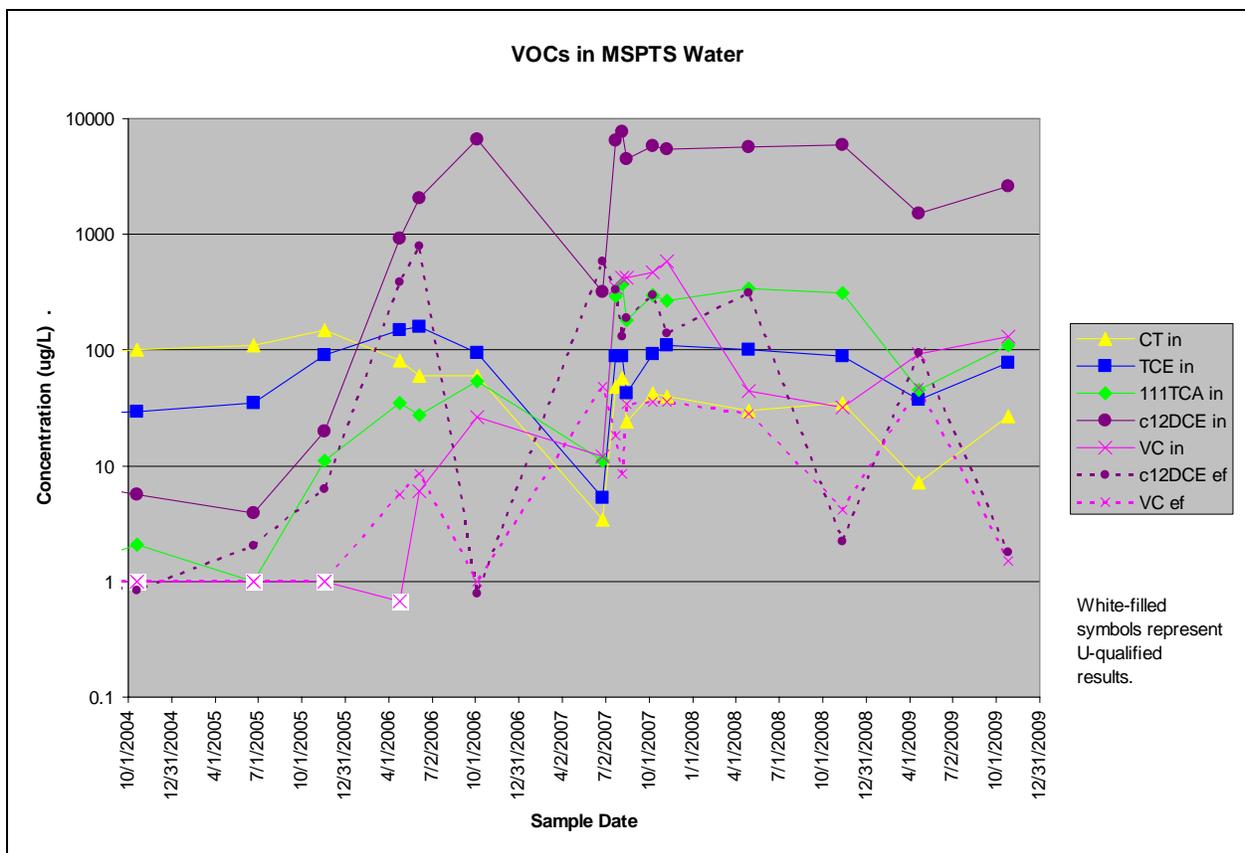
The MSPTS was sampled twice in 2009 (April, October) in accordance with RFLMA. Seven VOCs were detected in 2009 in MSPTS influent at concentrations exceeding their respective Table 1 levels (DOE 2007a): 1,1-DCE, carbon tetrachloride, chloroform, *cis*-1,2-DCE, PCE, TCE, and VC. The same seven constituents exceeded these levels in 2007 and 2008, but in those prior years 1,1,1-TCA also exceeded RFLMA levels. The presence of 1,1,1-TCA in MSPTS influent was not prevalent until 2007 and represents a primary contaminant from the OBP#2 source area; the decreasing concentrations of this contaminant in 2009 may be evidence for degradation of the residual source material, variations related to climate and groundwater availability, or factors related to the gravel drain routing groundwater from the OBP#2 area to the MSPTS intercept trench. Additional monitoring data from 2010 and future years will help to clarify the dominant processes.

Two VOCs were detected in MSPTS treated effluent in 2009 at concentrations exceeding RFLMA Table 1 values: *cis*-1,2-DCE and VC. These compounds were also detected in 2007 and 2008 in system effluent at concentrations exceeding Table 1 values, although in those years methylene chloride also exceeded RFLMA values. These represent some of the more recalcitrant compounds.

Table 3–81 summarizes MSPTS influent and effluent analytical data. Refer to the quarterly reports (DOE 2009e, 2009d, 2010c) and Appendix B for additional water-quality data for the MSPTS. As discussed above, data from samples of MSPTS influent show the influence of closure activities performed upgradient of the system, particularly the installation of an engineered preferential pathway (the backfilled storm drain corridor) that now routes groundwater impacted by the OBP#2 into the MSPTS groundwater intercept trench. (For more

information on this feature, see K-H 2005d) Because the OBP#2 source area was remediated and HRC was added to the backfill to stimulate biodegradation of residual VOCs, the concentrations of daughter products *cis*-1,2-DCE, 1,1-DCE, and VC in MSPTS influent have increased, as noted above in the discussion of this plume. The decreased influent concentrations of VC reported for 2008 (DOE 2009g), relative to those detected in the latter half of 2007, continued in 2009, although concentrations increased toward late-2007 levels.

Figure 3–183 illustrates how concentrations of some VOCs in MSPTS influent and effluent were affected by closure activities. The figure encompasses the period from immediately prior to the OBP#2 remediation (completed April 1, 2005) to the end of 2009. As shown, the concentration of carbon tetrachloride in system influent has decreased over this period, while influent concentrations of TCE (which appear similar to those of PCE at this scale; refer to Table 3–81) generally increased, and those of 1,1,1-TCA and daughter products from the biodegradation of these constituents increased more sharply. These patterns reflect the increased volume of water reaching the MSPTS from the OBP#2 area subsequent to the remediation of that source area; and the addition of HRC to the associated backfill to enhance bioremediation. The sharp decreases in effluent concentrations of *cis*-1,2-DCE and VC for fourth-quarter 2008 and 2009 may relate to the generally lower flows present during this time of year: lower flow rates through the system result in a longer residence time within the treatment media.



Notes: Constituents and their respective, applicable RFLMA Table 1 standards (µg/L; DOE 2007a): CT = carbon tetrachloride, 5; TCE, 5; 1,1,1-TCA, 200; *cis*-1,2-DCE, 70; VC, 0.2; in = influent (Mound R1-0); ef = effluent (Mound R2-E). Lab qualifiers not indicated except for U (analyte not detected at the indicated concentration); other qualified data plotted at reported value for simplicity. Note logarithmic concentration scale.

Figure 3–183. Recent Concentrations of Selected VOCs in MSPTS Influent and Effluent

Table 3–81. Selected VOC Data (µg/L) from 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)

Notes: 1,1,1-TCA = 1,1,1-trichloroethane; 1,1-DCE = 1,1-dichloroethene; CT = carbon tetrachloride; CF = chloroform; cis-1,2-DCE = cis-1,2-dichloroethene; MCI = methylene chloride; PCE = tetrachloroethene; TCE = trichloroethene; VC = vinyl chloride. R1-0 = influent, R2-E = effluent; formal sampling location names are Mound R1-0 and Mound R2-E. Shaded, bold value indicates detected concentration exceeds corresponding applicable level stipulated in RFLMA Attachment 2, Table 1 (DOE 2007a); if detection limit exceeded that concentration and constituent was qualified as nondetect, result is not highlighted as an exceedence. Lab 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 = chemical was also detected in the blank; D = analysis was performed at a dilution.

This page intentionally left blank

In addition to the constituents summarized in Table 3–81, other VOCs were detected in MSPTS effluent in 2009 (see DOE 2009e, 2009d, 2010c and Appendix B.6 for the data). None of those other constituents were reported at a level exceeding the applicable RFLMA Table 1 concentration.

Two grab samples for the analysis of VOCs were collected in 2009 at the performance monitoring location for the MSPTS, surface-water station GS10. As in prior years, VOC detections were reported (Table 3–82), but in 2009 only *cis*-1,2-DCE was detected. On both occasions the reported concentration was well below the corresponding surface-water action level. In 2008, this constituent and 1,2-DCA were detected; and in 2007, both of those constituents plus TCE were detected.

Table 3–82. Summary of VOCs Detected in 2009 at GS10

Date	Constituent	Result (µg/L)	Qualifier
4/21/2009	<i>cis</i> -1,2-DCE	1.6	
10/19/2009	<i>cis</i> -1,2-DCE	0.3	J

East Trenches Plume and Treatment System

The East Trenches Plume is an area of groundwater contamination named after several buried disposal trenches that contribute VOCs to groundwater. These trenches are located on the pediment south of South Walnut Creek, in former OU 2. The source of this plume is predominantly 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 joins the East Trenches Plume. A treatment system (the ETPTS) was installed in 1999 to intercept and treat contaminated groundwater flowing toward the B-series ponds and South Walnut Creek.

East Trenches Plume

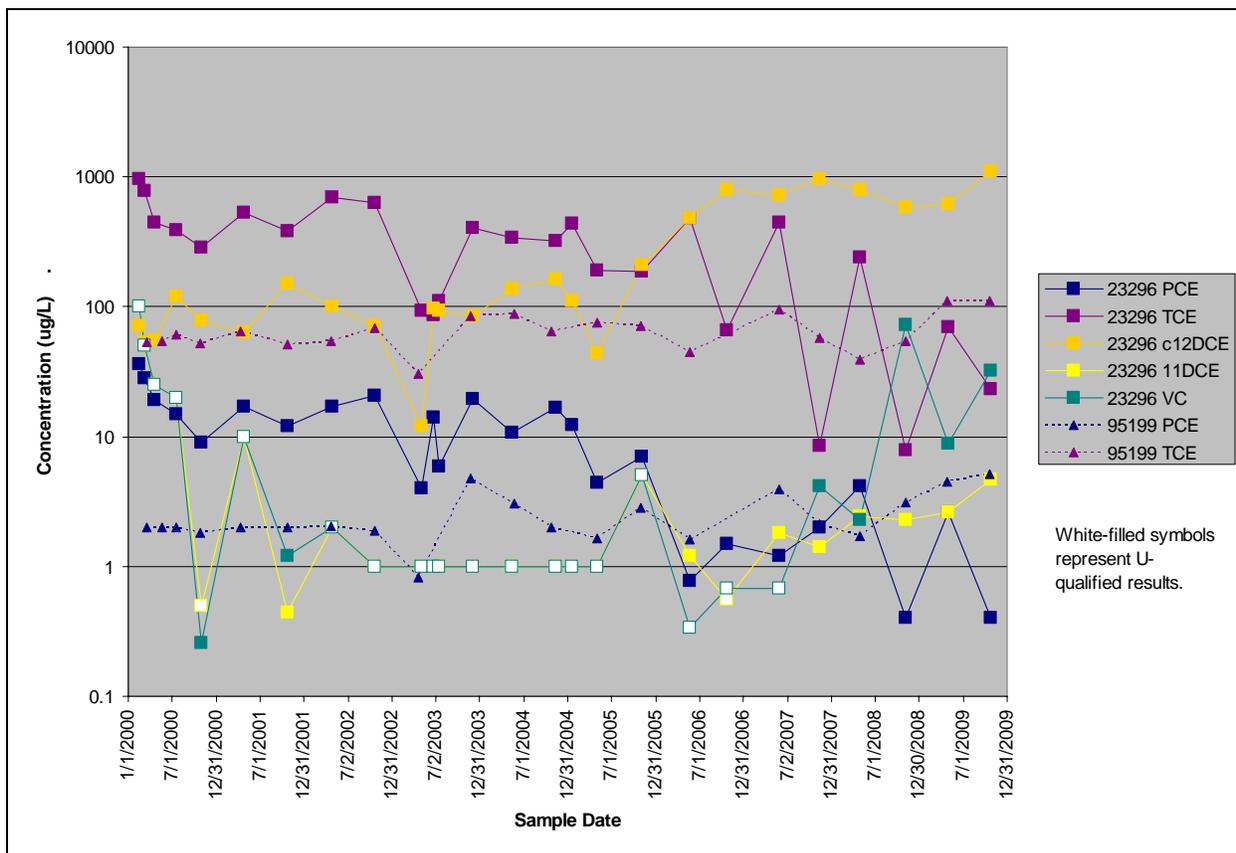
Evaluation wells 3687 and 05691 monitor the primary source areas of the East Trenches Plume, Trenches T-3 and T-4, respectively. More distal portions of the plume are monitored by Evaluation well 03991 and Sentinel well 04091 to the east-northeast. Sentinel wells 95099, 95199, 95299, and 23296 monitor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

None of the East Trenches Plume Evaluation wells were sampled in 2009. All Sentinel wells supporting the East Trenches Plume/ETPTS, and the AOC well at Pond B-5, were sampled twice in 2009. Analytical data for these wells in 2009 were generally consistent with those from recent years.

Of the wells sampled along South Walnut Creek in support of the East Trenches Plume, well 95299 was dry, and RFLMA Table 1 standards were exceeded in samples from wells 23296 and 95199. This is consistent with past conditions, as is the fact that samples from well 23296 contained the highest concentrations of VOCs of this group of wells. Figure 3–184 displays the three VOCs that, since 2007, have been most commonly detected in one or both of these wells at concentrations exceeding the corresponding RFLMA action level: TCE, *cis*-1,2-DCE, and VC.

Also displayed are PCE and 1,1-DCE in well 23296, and PCE in well 95199. Concentrations of *cis*-1,2-DCE in samples from well 23296 show a fairly gradual increase at this logarithmic scale; a similar pattern is also evident in concentrations of 1,1-DCE from the same well for the past couple of years. Conversely, over the same period concentrations of TCE, PCE, and VC have varied sharply from sample to sample. Concentrations of VC are seen to vary inversely with those of PCE and TCE: concentrations of TCE and PCE are relatively higher, and concentrations of VC are relatively lower in the second calendar quarters, and then in the fourth quarters VC is relatively higher and TCE and PCE are lower. This may be attributed to seasonal effects on biodegradation, wherein the fourth quarter allows waters to become more locally reducing, given that this period is typically drier and therefore features reduced infiltration of fresh water; these geochemical conditions would be expected to promote increased levels of reductive dehalogenation of parent compounds. The second quarter, being marked by more frequent precipitation and consequently greater amounts of oxygenated surface water, would act to reduce this dehalogenation. However, given that *cis*-1,2-DCE and 1,1-DCE are intermediate byproducts between the parent compounds (PCE and TCE) and the final chlorinated byproduct (VC), one might expect those intermediate constituents to reflect a pattern more similar to that of VC than the steady, gradual increase shown. Additional factors, therefore, must be affecting the concentrations reported in samples from well 23296.

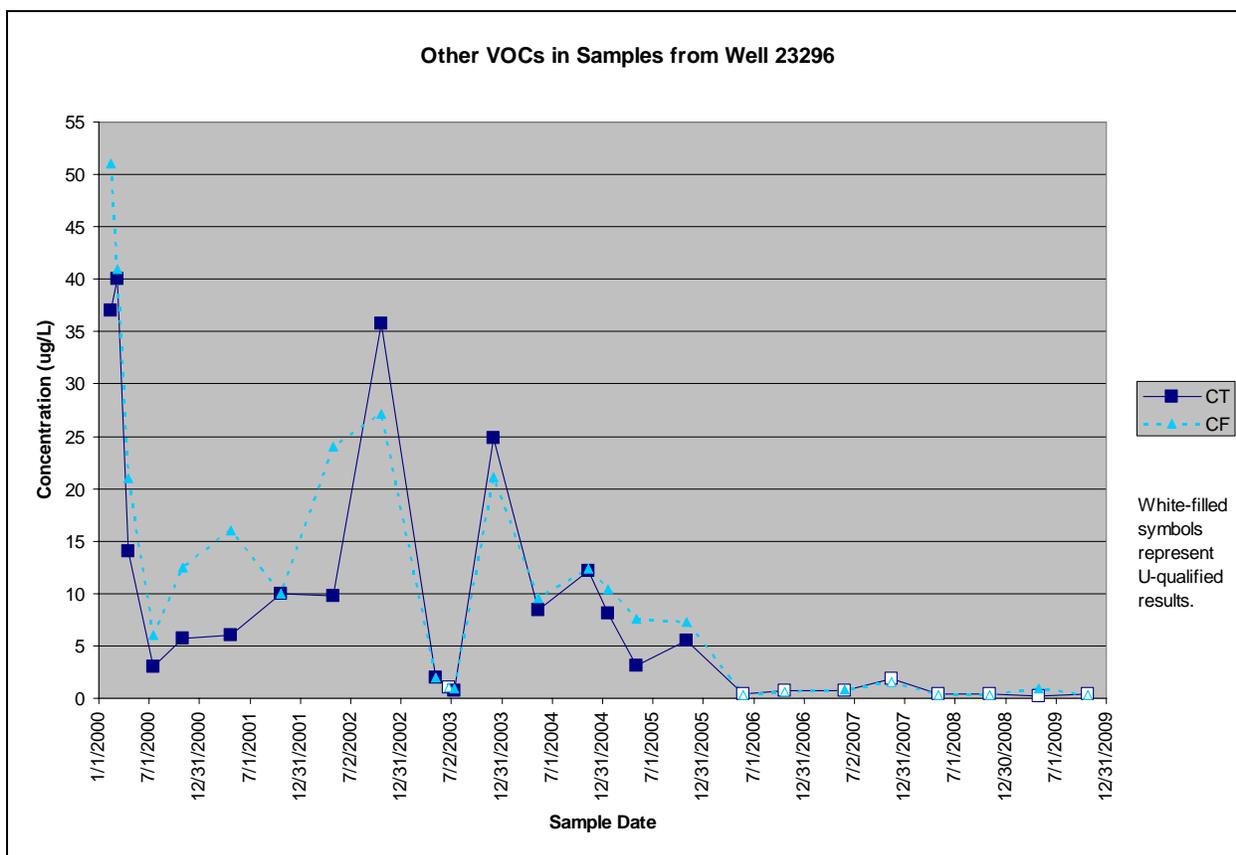
Concentrations of PCE and TCE in samples from well 95199 have been much more uniform than the constituents discussed above in well 23296. Little *cis*-1,2-DCE, 1,1-DCE, VC, or other metabolic byproducts from the degradation of PCE and TCE are reported in samples from well 95199. This well is deeper than well 23296, and although both are screened in unconsolidated surficial materials, this physical separation from the more sharply varying near-surface conditions—plus the location of 23296 right at the valley bottom, where additional organic carbon may be present in the subsurface muds—may help to limit reductive dechlorination in groundwater monitored at 95199 relative to that at 23296.



Notes: Constituents and their respective, applicable RFLMA Table 1 standards ($\mu\text{g/L}$; DOE 2007a): PCE, 5; TCE, 5; c12DCE = *cis*-1,2-DCE, 70; 1,1-DCE = 7. In addition to nondetects (U-qualified results), several other results were qualified (D, J), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 3–184. Most Commonly Detected VOCs in Sentinel Wells Downgradient of the ETPTS

S-K trend plots (Appendix B.3, and summarized above in Table 3–79) indicate 95 percent significant trends for several constituents monitored in East Trenches Plume wells. At well 23296, these included decreasing trends for carbon tetrachloride, chloroform, PCE, and TCE; and increasing trends for 1,1-DCE and both isomers of 1,2-DCE. At well 95199, an increasing trend was calculated for PCE. The decreasing trend for carbon tetrachloride at well 23296 may not be valid given the high frequency of nondetects, including every result since site closure. However, this fact and the time-series plot presented as Figure 3–185 suggest this trend may be real. The pattern of trends suggests a general reduction in the residual mass of the parent compounds as biodegradation proceeds. Conversely, the increasing trend in concentrations of PCE at well 95199 suggests a lower rate of biodegradation at this location.



Notes: Constituents and their respective, applicable RFLMA Table 1 standards (µg/L; DOE 2007a): CT = carbon tetrachloride, 5; CF = chloroform, 3.4. In addition to nondetects (U-qualified results), several other results were qualified (J), but are not shown differently for the sake of simplicity.

Figure 3-185. Carbon Tetrachloride and Chloroform in Well 23296

Sentinel well 04091 is located on the eastern edge of the East Trenches Plume and was sampled twice in 2009. Samples from this well are represented by significant (at the 95 percent confidence level) decreasing trends for carbon tetrachloride and PCE. However, these data contain abundant nondetects, rendering the calculated trends unreliable.

AOC well 00997 is located near the inlet to Pond B-5. This well was sampled twice in 2009 (June and October). All constituents were below the RFLMA Table 1 levels. No VOCs were detected. U was detected at concentrations of 12 µg/L in June and 14 µg/L in October, which is within the typical range at this well.

Wells monitoring the East Trenches Plume will continue to be monitored in accordance with RFLMA. As more data are collected, additional 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. However, 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 B-series ponds.

The ETPTS treated approximately 406,000 gallons of water in 2009, a significant decrease from the volume treated in previous years (Table 3–83). This volume continues the pattern observed since closure, when flow to the system was reduced by a factor of two to three. Figure 3–186 presents a hydrograph showing ETPTS flow estimates since January 2000. Note that anomalous flows reported for the year 2006 have been revised in this figure. Previous versions of this hydrograph (e.g., see DOE 2008d and 2009g) included flows in the summer of 2006 that were above 10 gallons per minute (gpm) for over a month, at one point exceeding 60 gpm. This is not reasonable; Figure 3–186 presents a revision with those anomalous flows omitted.

Figure 3–187 provides a hydrograph for CY 2009 at the ETPTS. The period of no flow from mid-September to early November corresponds to the period of time over which the treatment media was replaced and plumbing upgrades were installed, as discussed in greater detail below.

Table 3–83. 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

Note: Estimates for years 2000 through 2004 are compiled from K-H (2000a, 2000b, 2000c, 2000d, 2002, 2003, 2005b, 2005c).

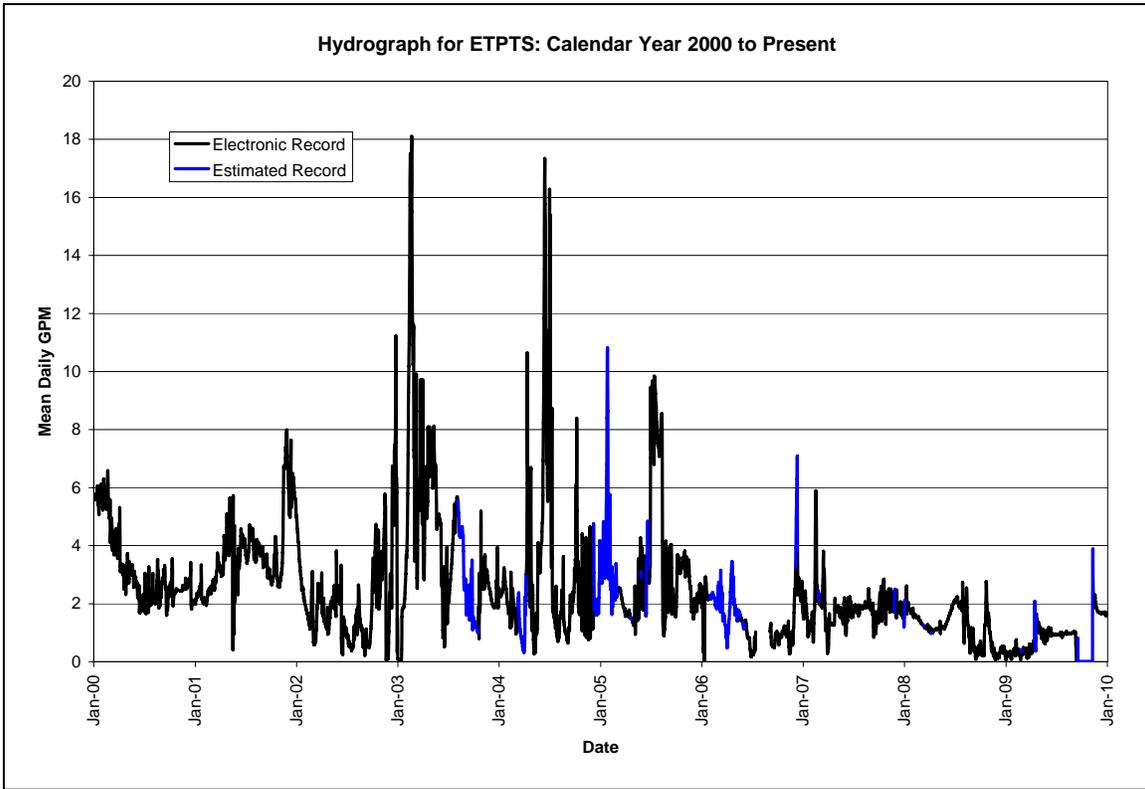


Figure 3–186. Hydrograph for ETPTS from 2000 through 2009

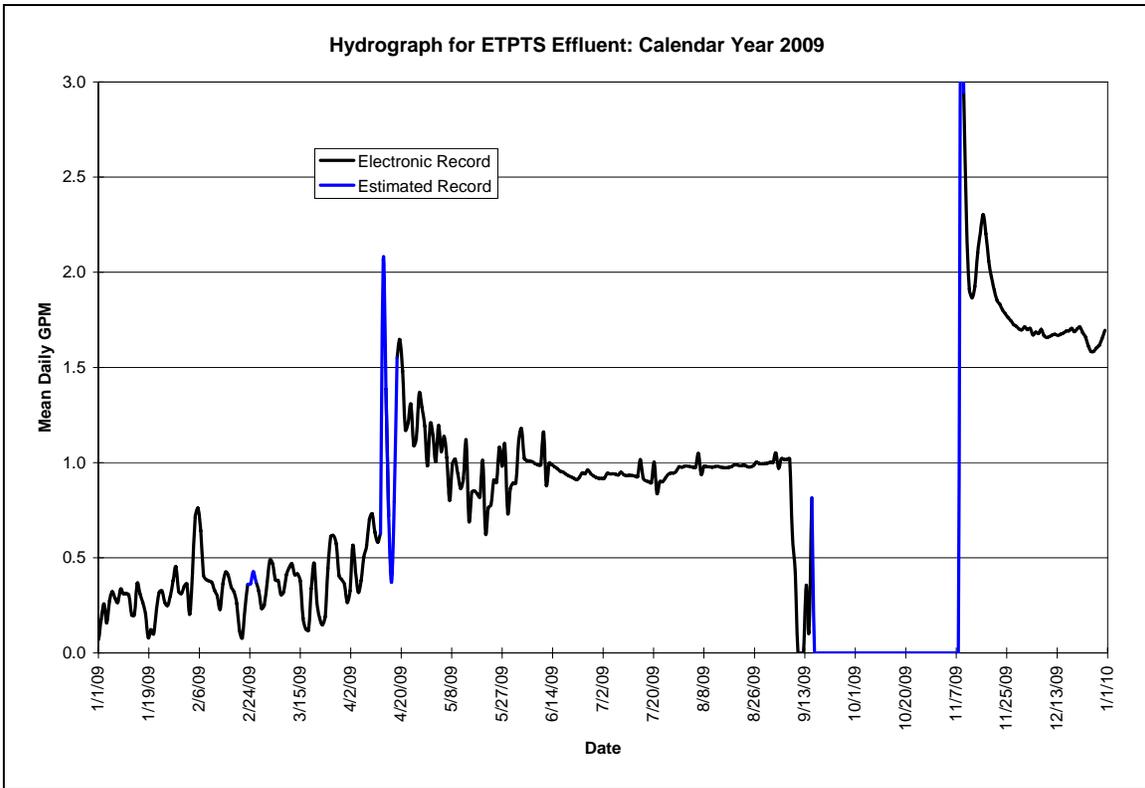


Figure 3–187. Hydrograph for ETPTS for CY 2009

Routine maintenance activities at the ETPTS were conducted through most of 2009, and in the latter part of the year the media was replaced and several upgrades were installed. Routine maintenance is discussed in Section 2.5.2, and the media replacement and system upgrades are discussed below.

The ETPTS was sampled twice in 2009 (April and November). Despite the increased maintenance performed in 2009, treatment of groundwater by the ETPTS in this year was generally consistent with previous years in which the media was not replaced. Effluent water quality reflected a dramatic reduction in VOC load, but as in other years some VOCs were detected in the effluent. This condition was improved by the media replacement, which was completed in early November 2009. 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 constituents, is presented in Table 3–84; refer to quarterly reports (DOE 2009e, 2009d, 2010c) and Appendix B.6 for additional data from 2009.

Table 3–84. Summary of Recent VOC Data from 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
1/28/2004	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)
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)

Notes: Constituents and their respective, applicable RFLMA levels (µg/L; DOE 2007a): CT = carbon tetrachloride, 5; CF = chloroform, 3.4; MCI = methylene chloride, 4.6; PCE, 5; TCE, 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 = chemical was also detected in the blank; D = analysis was performed at a dilution.

In addition to the constituents summarized in Table 3–84, other VOCs were detected in system effluent in 2009 (see DOE 2009e, 2009d, 2010c and Appendix B.6 for the data). None of those other constituents were reported at a level exceeding the applicable RFLMA Table 1 concentration.

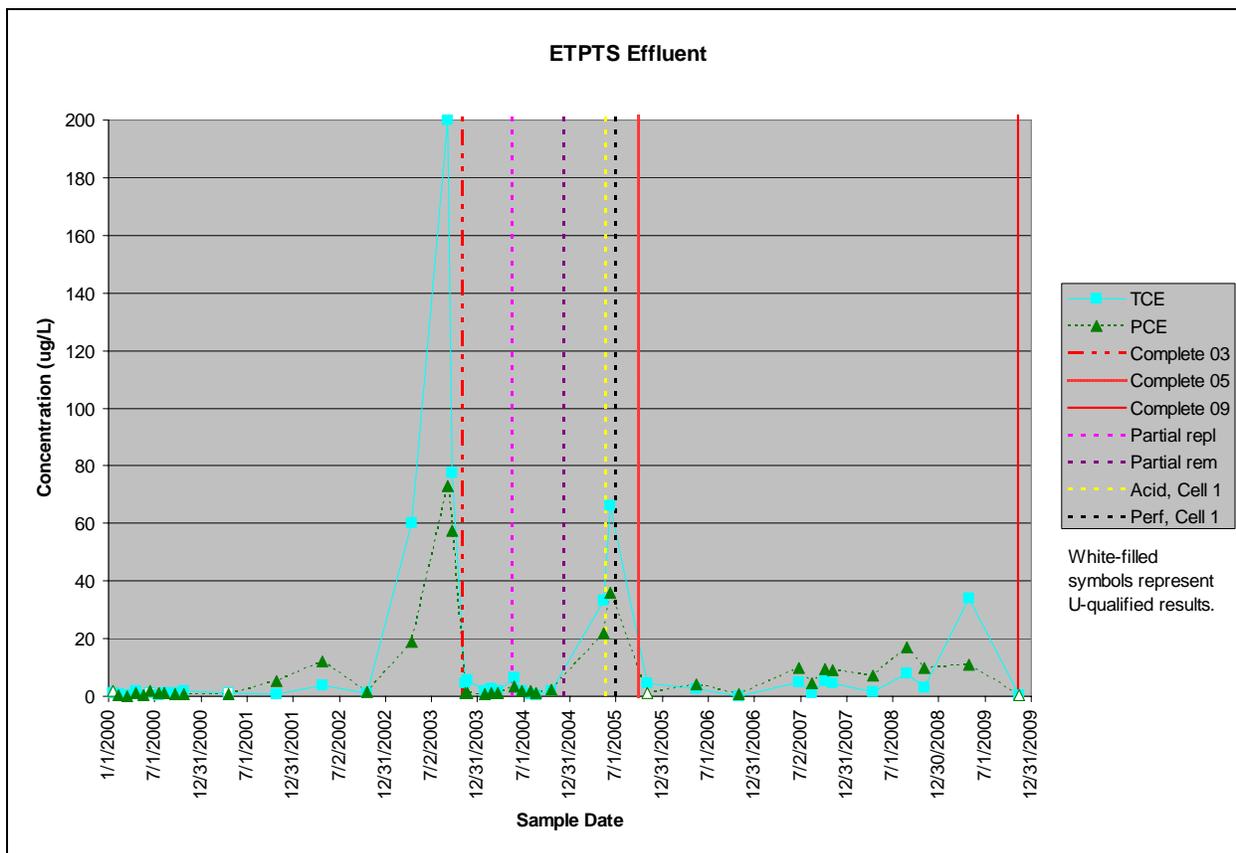
The performance monitoring location for the ETPTS is POM2, which is located in Pond B-4. Sampling in support of the ETPTS began at this location in 2005. Grab samples were collected from POM2 in April and November 2009. Each sample reported two detections of VOCs (Table 3–85), and in all cases the concentrations were J-qualified (estimated) and below the applicable RFLMA Table 1 levels.

Table 3–85. Summary of VOCs Detected in 2009 at POM2

Date	Constituent	Result (µg/L)	Qualifier
4/28/2009	<i>cis</i> -1,2-DCE	0.64	J
4/28/2009	TCE	0.24	J
11/12/2009	<i>cis</i> -1,2-DCE	0.23	J
11/12/2009	TCE	0.25	J

East Trenches Media Replacement and Upgrades

Flow through the ETPTS media was observed over the recent past to be increasingly restricted due to the accumulation of media-clogging precipitates. This indicated the media would soon need to be replaced, even though effluent water quality in 2008 was not significantly different from previous years. The possible exceptions to this statement are that effluent concentrations of TCE, and to a lesser extent PCE, had increased. Increasing concentrations of TCE in particular can serve as a signal for a media replacement. This is illustrated in Table 3–84 and Figure 3–188. This figure also shows when previous media work has been performed, including complete media replacements (in September–October 2003, September 2005, and in 2009), partial replacement (in May 2004), partial removal (December 2004), acid treatment of Cell 1 media (May 2005), and perforation of the Cell 1 crust (late June 2005).



Notes: Complete 03 = complete media replacement in 2003; Complete 05 = complete media replacement in 2005; Complete 09 = complete media replacement in 2009; Partial repl = partial media replacement in May 2004; Partial rem = partial media removal in December 2004; Acid, Cell 1 = acid treatment of Cell 1 media in May 2005; Perf, Cell 1 = perforation of Cell 1 media crust in June 2005. Dates shown for some activities are approximated, but the month is accurate. Constituents and their respective, applicable RFLMA Table 1 standards (ug/L; DOE 2007a): TCE and PCE, 5. In addition to nondetects (U-qualified results), several other results were J-qualified but are not shown differently for the sake of simplicity.

Figure 3–188. TCE and PCE in ETPTS Effluent

As a result of the flow restrictions and degrading effluent water quality, media replacement was planned. Several upgrades were also planned:

- Install piping that can be easily reconfigured from upflow to downflow, and parallel flow to series flow
- Simplify plumbing to reduce “spaghetti” and longer runs that can lead to clogging
- Eliminate buried valves that can malfunction
- Improve distribution of influent within treatment cells
- Improve media design (if warranted based on condition of media being replaced) to reduce clogging, enhance flow through the media
- Improve flow metering and adjustment

The ETPTS was originally designed to be operated in a series-flow, downflow configuration. Under such a configuration, water to be treated would enter near the top of Cell 1, flow down

through the media, and exit at the bottom of Cell 1; then rise to enter the top of Cell 2, flow down through the media, and exit that cell; and finally flow to the effluent manhole and be discharged. Several potential problems may result from such a configuration, as summarized below.

- Potential negative effects of series flow:
 - Cell 1 media clogs or becomes ineffective more rapidly and more thoroughly than Cell 2 media.
 - Cell 1 media replacement is required sooner.
 - Cell 2 media gets replaced before it is truly necessary based on flow restriction or water quality (due to cost efficiencies in mobilization/demobilization, labor, equipment, etc.).
- Potential negative effects of downflow:
 - Media more readily develops preferential pathways (water trickles downward with gravity assistance, rather than seeping upward against gravity).
 - Cannot push more water through the system than media permeability allows—water will simply overtop the cell because the ETPTS cell tops are not sealed.
 - Must replace media as dictated by media permeability (clogging) rather than by effluent water quality.

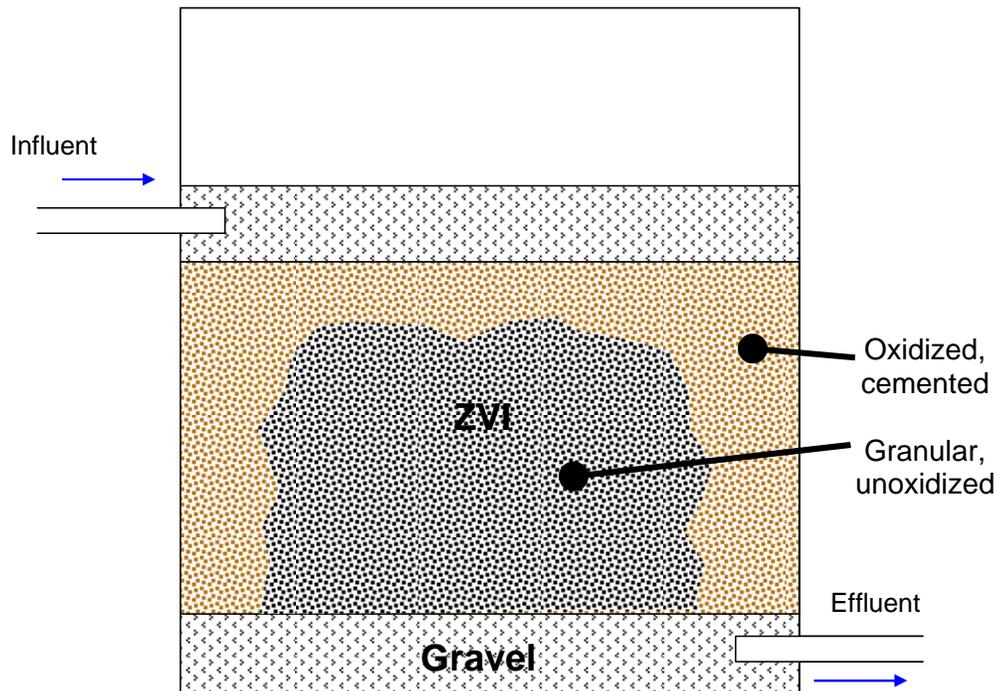
While some plumbing work was performed in 2006 to allow parallel flow and upflow, that earlier work did not completely optimize the plumbing configuration to reduce the potential for pipe clogging and make piping changes simple. One of the upgrades planned for 2009 was therefore to optimize the piping so that flow configurations could be easily changed, and most pipe clogging could be addressed easily and cost effectively (i.e., without requiring excavation). This was achieved by installing a new, flow-control vault between the two treatment cells and routing pipes that are downstream of a treatment cell (but upstream of the effluent manhole) through this vault. Pipes downstream of a treatment cell are most likely to become clogged, given that the clogging observed at some sites' ZVI-based treatment systems is typically due to accumulated iron oxides and oxyhydroxides from treatment by ZVI media. Routing the pipes through the flow control vault makes them accessible; enclosing these pipes in liners, eliminating buried valves, and utilizing new treatment cell entry and exit points allows the pipes to be exchanged during a routine media replacement activity, without need for excavation. (The effluent line leading to and exiting the manhole would have been replaced with larger-diameter pipe to reduce the potential for clogging, but concerns that the manhole might become unstable and shift or settle during or following the associated excavation work led to the decision to postpone this until necessary.)

The influent distribution piping that was initially present within the cells had a simple cross shape constructed of perforated PVC pipe. More thorough flow distribution can lead to enhanced treatment via more uniform contact with treatment media, and more uniform flow characteristics that can increase the longevity of the media by reducing pockets of oxidized/clogged media and associated preferential flowpaths. Similarly, if warranted based on observations of the media being removed, the design of the media itself—e.g., with respect to gravel and ZVI content and distribution—would be revised.

Finally, improved flow monitoring and control was desired to allow closer tracking of system operation and performance, and to ensure uniform flows through the two cells when operated in parallel.

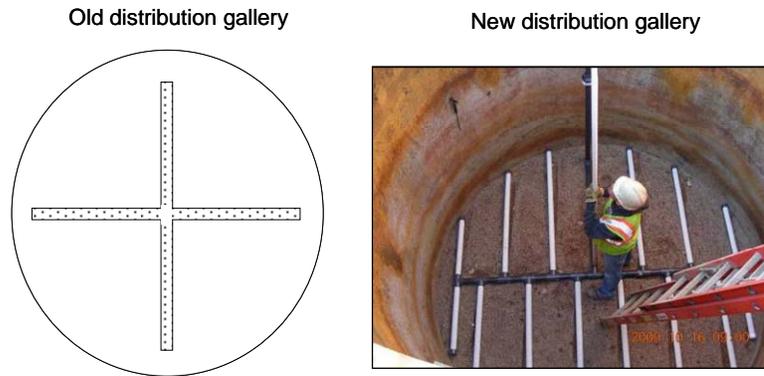
Fieldwork began on September 21, 2009, and was completed on November 9, 2009.

Excavation of the media revealed inconsistent flow patterns and media exposure in Cell 1, and reduced oxidation and precipitation within Cell 2. The pattern of oxidized media in Cell 1 indicated that an impermeable shell of oxidized and clogged media had formed over and around an internal core of relatively fresh, still-granular ZVI (see Figure 3–189). This is a result of preferential flow: the oxygenated influent contacted the surficial media first, eventually forming an impermeable crust that routed water downward along the cell edges, causing the material nearest the edge to also become clogged. The central mass of media was shielded from flow. Although some improvement to flow characteristics and media utilization would be expected due to the improved distribution gallery configuration (Figure 3–190) and operating under upflow conditions, changes to the media design were warranted and were implemented.



Note: Drawing not to scale; for illustration purposes only. Colored outer portion of media represents heavily oxidized, cemented ZVI media; uncolored central portion represents granular, relatively fresh ZVI media. Patterns depicting gravel vs. ZVI are as indicated.

Figure 3–189. Drawing Showing Partial Oxidation of ETPTS Cell 1 Media

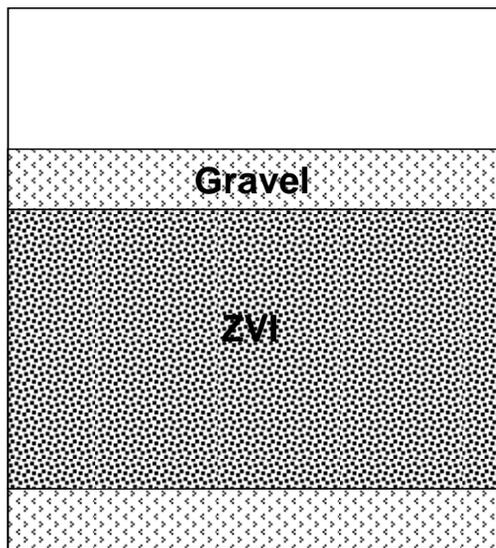


Note: Drawing not to scale; for illustration purposes only.

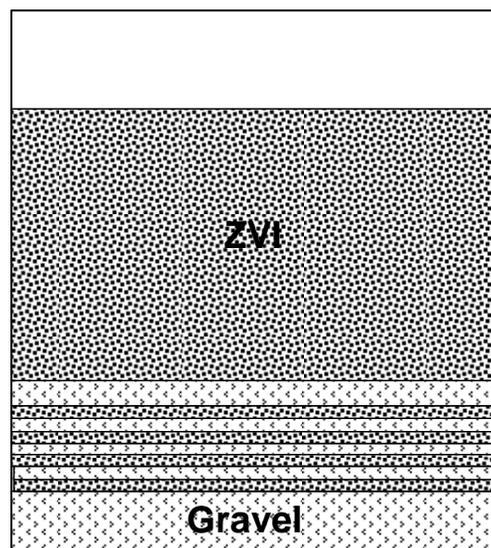
Figure 3-190. Previous vs. New Influent Distribution Gallery Configuration at the ETPTS

The intent of the media design that was ultimately selected is to maximize the utilization of the ZVI. It includes several feet (38–40 inches) of thin (typically 2–3 inches thick), alternating layers of pure ZVI and pure pea gravel as the first section of media that contacts the water (in upflow configuration). Water entering the cell through the improved distribution gallery, which is bedded in pea gravel, will flow upward and contact a layer of ZVI. This ZVI will start to condition the influent (i.e., remove some of the dissolved oxygen and constituents such as calcium and carbonate), becoming clogged as a result. The next layer, gravel, can act as an additional space in which precipitates can accumulate, and can also help to redistribute flow across the entire area of the cell if preferential pathways are starting to develop through the underlying layer of ZVI. The water will then rise through the next layer of ZVI for further conditioning, then the next layer of gravel for redistribution, and so on as it moves upward through the cell. Even if the ZVI settles into the underlying layer of gravel rather than remaining as distinct layers, as is expected to some degree, the additional porosity represented by such a mix should still act in a similar manner. The topmost layer of gravel in this interval is significantly thicker to allow a final repository of precipitates and redistribution of the water. While this design, which is presented as a generalized schematic drawing in Figure 3-191, has not been proven, the technical team supporting the media replacement and upgrades agreed it was logical and would likely lead to at least some improvement over previous conditions. Finally, the overall thickness of the media was also increased to take advantage of the available cell volume.

Old media design



New media design

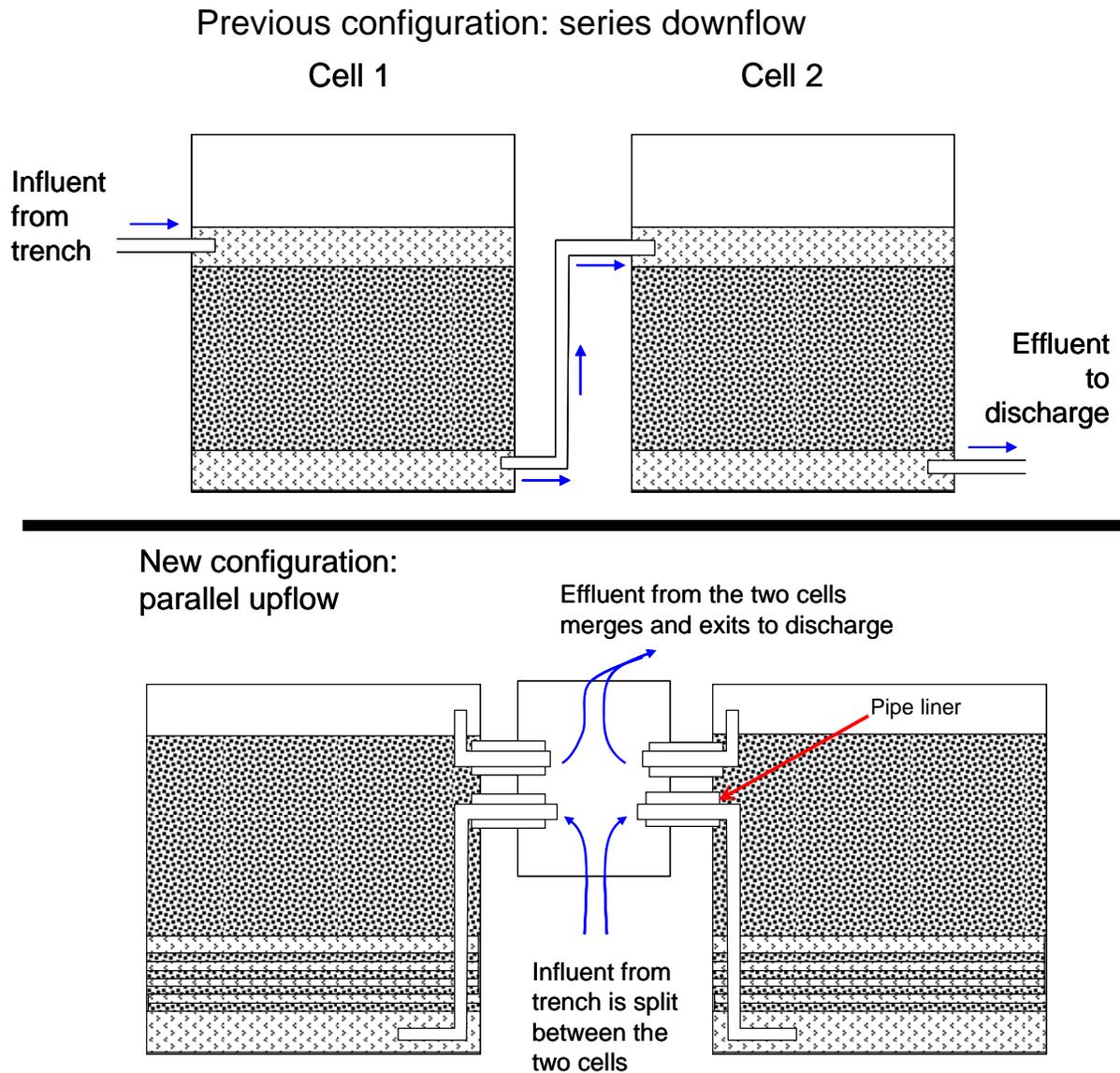


Note: Drawings not to scale; for illustration purposes only. Flow through old media (on left) was downward, and through the new media (on right) is upward. Patterns depicting gravel vs. ZVI are as indicated. Many more alternating layers of gravel and ZVI are present in the bottom portion of the media than are shown in the drawing on the right.

Figure 3–191. Previous vs. New Media Design in ETPTS Treatment Cells

As an additional improvement intended to assist the next media replacement at the ETPTS, thin HDPE sheeting was placed between the cell walls and the media fill. Previous media replacement efforts have encountered ZVI tightly adhering to the HDPE cell walls, which has required very careful removal using a manually-operated jack-hammer. By lining the cell walls with this plastic sheeting, the media cannot stick to the walls; media removal should be quicker and easier, with less risk of damage to the cells themselves.

Except for the plastic sheeting, these improvements to the ETPTS are summarized in the schematic drawings below (Figure 3–192).



Note: Drawings not to scale; for illustration purposes only. Patterns depicting gravel vs. ZVI are as indicated on previous figures. The new flow control vault is shown as a box between the cells in the lower portion of the figure, and one of the pipe liners is indicated. Many more alternating layers of gravel and ZVI are present in the bottom portion of the media than are shown in the lower drawings.

Figure 3–192. Summary of Upgrades to ETPTS Plumbing and Media Design.

Solar Ponds Plume and Treatment System

The Solar Ponds Plume (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 typically

referred to herein simply as nitrate.) Liquid wastes generated during the production era 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 work performed in 2009 on the system.

Solar Ponds Plume

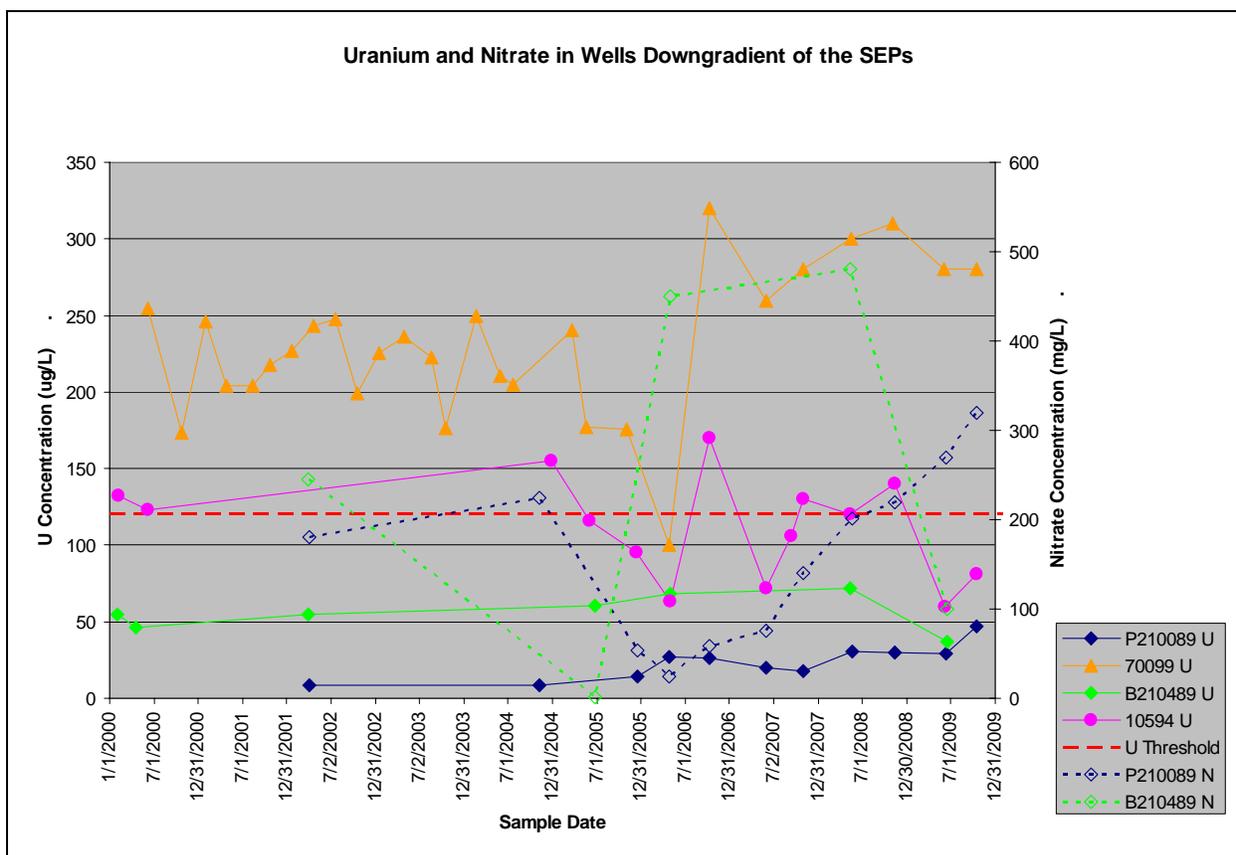
Groundwater in the SEP area is contaminated with nitrate and U. Groundwater in the westernmost portion of this area, generally coinciding with the location of former Pond 207C, is also contaminated with VOCs. However, due to the localized nature of VOC contamination, it is not considered part of the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

The source area of the SPP (the SEPs) is monitored by a line of eight Evaluation wells installed immediately downgradient of the SEPs (generally along the north, east, and south sides of the former SEPs), with additional wells located at greater distances from the source. Another Evaluation well is positioned at the south edge of former Pond 207-C, in the VOC source area. This distribution effectively monitors groundwater flowing north/northeastward, the primary contaminant flowpath, as well as eastward and southeastward, which are less-significant flowpaths.

None of these Evaluation wells was scheduled for sampling in 2009. (However, an Evaluation well located farther down in the North Walnut Creek drainage, well B210489, was sampled once in support of ongoing SPPTS work and is discussed below.) Sentinel wells P210089 and 70099 and AOC well 10594 were sampled twice in accordance with RFLMA.

Figure 3–193 displays U and nitrate concentrations from wells downgradient of the SEPs source area. With respect to the SPPTS, those shown include upgradient (P210089), sidegradient (70099), and downgradient (B210489, 10594) wells. Nitrate data for wells 70099 and 10594 are not included because concentrations are low (nondetect to low single-digit mg/L). Although several U results from AOC well 10594 have exceeded the 120- μ g/L threshold, since the signing of RFLMA, no two consecutive routine samples have exceeded that concentration; if and when that condition is met, a reportable condition as defined by RFLMA for AOC wells will exist at this well, and consultation with the regulators will follow. As has been reported previously (e.g., DOE 2008d), U in this well has been repeatedly characterized as 100 percent natural, most recently in September 2007.

The variable concentrations of nitrate and U in several of these wells is evident on Figure 3–193. The well nearest the source area (Sentinel well P210089) does not produce groundwater samples with the highest concentrations of U; rather, this is the case with samples from well 70099, located at the northwestern end of the SPPTS groundwater intercept trench. Of these wells, even most-distal well 10594 produces samples with higher concentrations of U than does well P210089. In contrast, concentrations of nitrate are highest in well P210089 and are uniformly low in wells 70099 and 10594. This further substantiates previous conclusions that U in groundwater samples from wells 70099 and 10594 is natural, and is not part of a plume of U and nitrate contamination. (Samples from well 70099 were characterized in 2002 as being 99.4 percent natural.)



Note: U = total uranium, N = nitrate+nitrite as nitrogen.

Figure 3-193. U and Nitrate Concentrations in Wells Downgradient of the Former SEPs

Figure 3-193 illustrates that concentrations of U in samples from wells 70099 and 10594, and concentrations of nitrate in samples from well P210089, decreased sharply beginning in late 2004. Concentrations of these constituents bottomed out in early 2006 and then rose. At well 70099, this rise was sudden and sharp, promptly leveling off above the previous range. At well 10594, U concentrations have since fluctuated fairly widely, from a high in 2006 of 170 $\mu\text{g/L}$ to a low in second-quarter 2009 of 60 $\mu\text{g/L}$. Conversely, concentrations of nitrate in samples from well P210089 have been rising steadily since 2006, in 2009 reaching new highs (320 mg/L in the fourth quarter sample). Concentrations of U in samples from P210089 show an increase in 2006, as the other decreases described above are reaching maximum, and have generally increased since; the concentration reported in fourth quarter of 2009 is the highest in the data set, 47 $\mu\text{g/L}$. These visual patterns are partially confirmed by statistical evaluations of trend. A statistically significant (at the 95 percent confidence level) increasing trend for U at well P210089 is confirmed (Table 3-79), while a decreasing trend in nitrate was calculated at well 70099 (not illustrated; concentrations have always been less than 3 mg/L as N). Although of insufficient statistical significance, increasing trends are suggested for uranium at well 70099 and nitrate at well P210089 (Table 3-79). The mechanism causing these patterns of behavior is not certain, but may relate to the application of dust suppression water during closure activities in the 700 Area and SEP area (where the B-Pond sediments were being staged and packaged for transportation off site).

Concentrations of U and nitrate in groundwater monitored by well B210489, an Evaluation well that was sampled in 2009 to support evaluations of the SPPTS upgrades, are also illustrated on Figure 3–193. The concentrations of U are seen to increase in a manner similar to that in well P210089 before decreasing in 2009, but the timing of these increases coincide with the decreases in the other wells. The reduced data set for this well does not help, nor does the unusually low concentration reported in 2005. The decreases in U and nitrate in 2009 at this well may relate to the additional contaminated groundwater being collected and treated by the SPPTS following installation of the Phase I upgrades. This well is located approximately 200 feet downgradient of the SPP Discharge Gallery, and therefore would be expected to monitor shallow groundwater discharged by that feature. Well B210489 will continue to be monitored to confirm longer-term concentration trends in U and nitrate.

The VOC plume in the western SEP area was not monitored in 2009. The Evaluation wells monitoring this plume will be sampled in 2010 along with all other Evaluation wells. VOCs were not detected in samples collected in 2009 from Sentinel well P210089, which is located north/northeast of the VOC source area.

Solar Ponds Plume Treatment System

Like the ETPTS, the SPPTS was installed in 1999. In basic terms, the system is very similar to the MSPTS and ETPTS, with an intercept trench (1,100 feet long) and two 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 ETPTS. The treatment media in these SPPTS cells consists of organic material (sawdust) and ZVI.

Another difference between the SPPTS and the other two systems is that the water collected in the intercept trench is actively pumped into the treatment cells, rather than flowing into the cells by gravity. 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 added in 2002.

Routine maintenance activities at the SPPTS were conducted throughout 2009, and are reported in Section 2.5.3. Important upgrades were also made to the system, building on improvement efforts begun in 2008 (Phase I, which focused on collecting significantly more contaminated groundwater and discharging it via new, unperforated discharge piping). The upgrades installed in 2009 included Phase II (a new treatment cell designed to remove U as the first treatment step) and Phase III (pilot-scale treatment cells to evaluate improved nitrate treatment methods). These new features are discussed in greater detail below.

Following installation of Phase I in 2008, treatment effectiveness of the SPPTS was reduced and system effluent water quality exceeded target concentrations of nitrate and U. While conditions improved in 2009, target concentrations in system effluent were not consistently met. The upgrades that were completed in late May 2009 continued to be optimized for the balance of the year, and these efforts will continue in 2010.

The SPPTS treated approximately 524,000 gallons in 2009. This is the highest volume ever treated by this system (Table 3–86). The increase in volume relative to previous years is due to

the installation of the Phase I groundwater collection sump and associated upgrades (see DOE 2009g). Figure 3–194 presents a hydrograph showing flow from January 2000 through the end of 2009. The hydrograph for CY 2009 was presented in Section 2.0 as Figure 2–5. Evident on the latter figure are periods of no flow in the spring, which correspond to the construction of the Phase II and III upgrades; and in the summer, which correspond to a malfunction in and associated repairs to those upgrades. Each of these subjects is discussed at length below.

Table 3–86. 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

Notes: Estimates for years 2000 through 2004 are compiled from K-H (2000a, 2000b, 2000c, 2000d, 2002, 2003, 2005b, 2005c).

^aAnnual 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.

^bMost of this volume was from the former Modular Storage Tanks (K-H 2003).

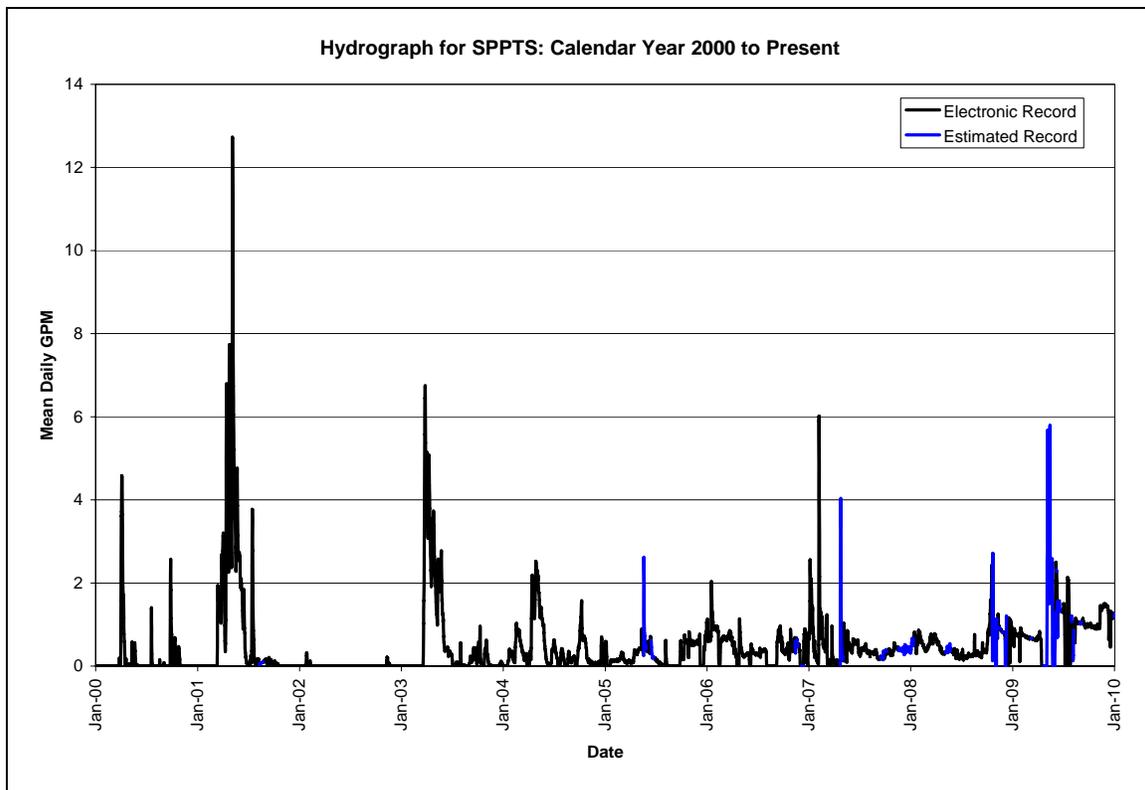
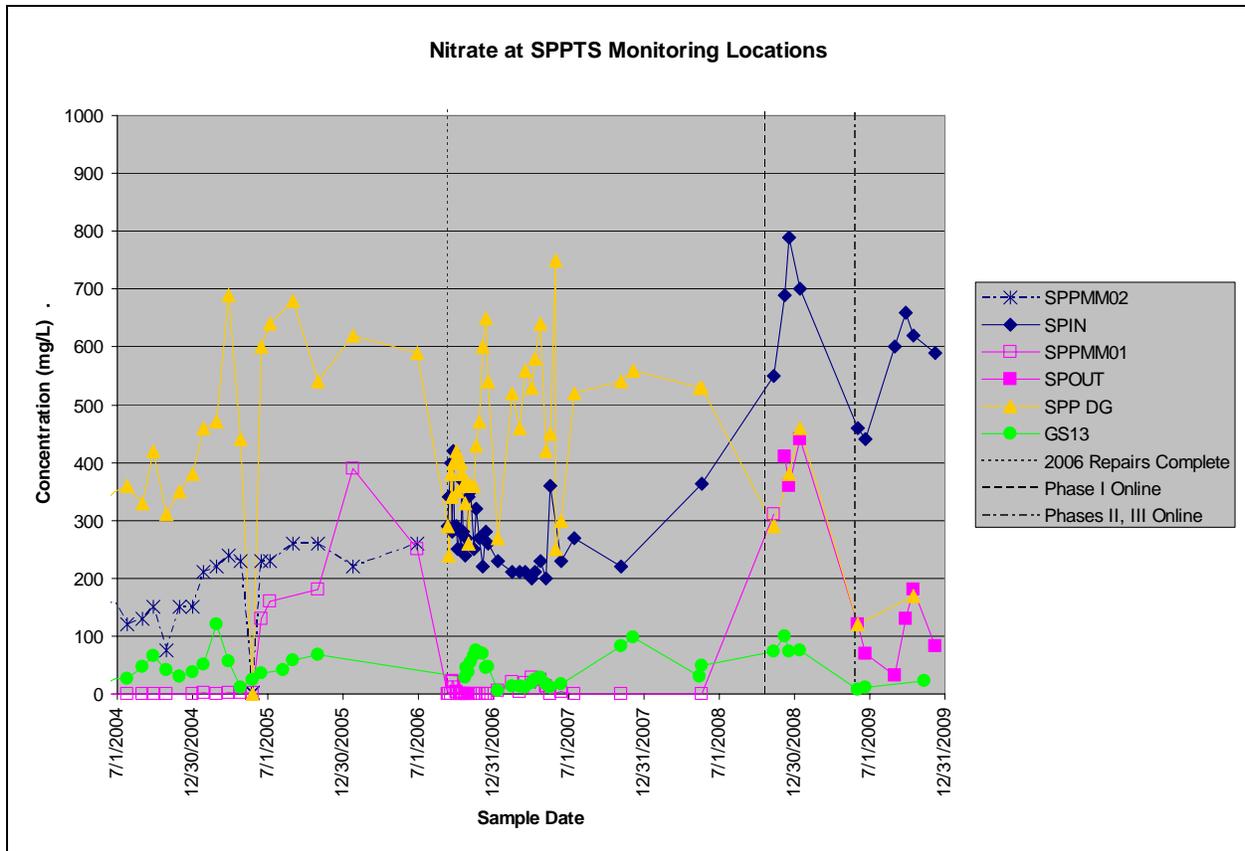


Figure 3–194. Hydrograph for SPPTS from 2000 through 2009

Figure 3–195 provides an illustration of nitrate concentrations in SPPTS monitoring locations since mid-2004; Figure 3–196 shows a similar graph for U concentrations. (Only validated results from contract laboratories are included in these figures, not the supporting data generated by the Environmental Sciences Laboratory, or ESL, in Grand Junction because those data cannot be validated. However, those data are useful and are displayed separately as discussed below.) In both figures, the effects of valve changes made in mid-2005 are obvious on concentrations of these constituents in the effluent, and to some degree at the SPP Discharge Gallery (informally referred to herein as the DG) and GS13 as well (see the 2006 Annual Report, DOE 2007f, for additional discussion of these events). The effects of the system repairs made in 2006 are also obvious on the nitrate graph (Figure 3–195; refer to the same Annual Report for additional information). More recently, the effects of the Phase I upgrades in late 2008 can be seen on both figures, with concentrations of nitrate and U in system influent increasing significantly as the elevated flow rates and concentrations overwhelmed the system’s capacity for effective treatment. While the system may have been able to treat these concentrations given sufficient residence time, the increased flow reduced residence time below that necessary to achieve satisfactory treatment. This in turn affected concentrations of nitrate and U reported at downgradient locations. The date of the most recent upgrades, completion of Phases II and III, is also indicated on both figures.

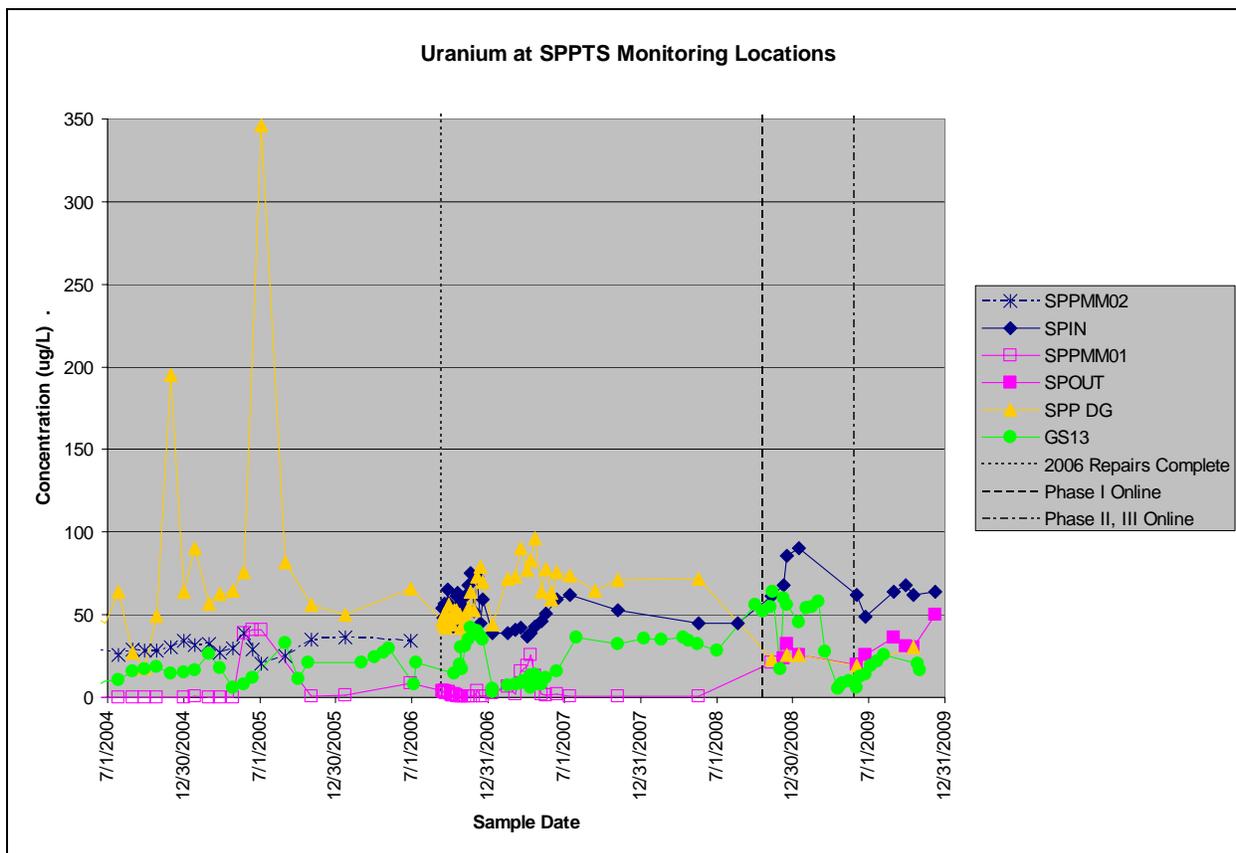
Following completion of Phases II and III, concentrations of nitrate and U at downgradient locations (SPOUT, the DG, and GS13) were somewhat reduced, as seen on these figures. However, concentrations were still well above effluent target levels, and therefore optimization

efforts continued on both of these upgrades. The isolated late-2004 and mid-2005 spikes in U concentration at the DG (Figure 3–196) are anomalous and inconsistent with other DG results. Concentrations of U at this location have consistently been less than 100 µg/L, except for three results of approximately 128 µg/L (2/28/2002), 195 µg/L (11/30/2004), and 346 µg/L (7/6/2005). None of the associated data were rejected during validation, but they are clearly outliers.



Notes: SPPMM02 = historical “influent” monitoring location; SPIN = true system influent (collection well); SPPMM01 = historical system effluent location, replaced in late 2008 with SPOUT; SPP DG = SPP Discharge Gallery; GS13 = surface water performance monitoring location. Analytical data from SPPMM02 and SPPMM01 are included for comparison only; these locations are no longer monitored. See the 2006 Annual Report (DOE 2007f) for a more detailed discussion of location SPPMM02, as well as a discussion of the activities responsible for the abrupt concentration changes seen in data for May 24, 2005; and see the 2008 Annual Report (DOE 2009g) for more information on SPOUT. Some data are qualified (e.g., U, B, J), but are not displayed differently for simplicity. All data are from contract laboratories (not the ESL).

Figure 3–195. Recent Concentrations of Nitrate in Samples from SPPTS Monitoring Locations



Notes: SPPMM02 = historical "influent" monitoring location; SPIN = true system influent (collection well); SPPMM01 = historical system effluent location, replaced in late 2008 with SPOUT; SPP DG = SPP Discharge Gallery; GS13 = surface water performance monitoring location. Analytical data from SPPMM02 and SPPMM01 are included for comparison only; these locations are no longer monitored. See the 2006 Annual Report (DOE 2007f) for a more detailed discussion of location SPPMM02, as well as a discussion of the activities responsible for the abrupt concentration changes seen in data for May 24, 2005; and see the 2008 Annual Report (DOE 2009g) for more information on SPOUT. Some data are qualified (e.g., U, B, J), but are not displayed differently for simplicity. All data are from contract laboratories (not the ESL).

Figure 3–196. Recent Concentrations of U in Samples from SPPTS Monitoring Locations

Table 3–87 presents summary statistics for concentrations of nitrate and U for the years 2000 through 2009 at several locations of interest. These statistics are shown when only results reported by contract laboratories (without ESL data) are used, and when ESL data are included. (Frequent sampling, and analysis by the ESL, was begun to track the effects of the Phase I, II, and III upgrades and optimization efforts focused on those components. Therefore, the data set is more robust if ESL data are also included.) These statistical results further confirm the patterns evident on Figure 3–195 and Figure 3–196. Concentrations of nitrate and U in system influent, as represented at SPIN, increased dramatically as a result of the Phase I upgrades, which focused on collecting additional contaminated groundwater. At the same time, despite the reduced treatment effectiveness documented at effluent monitoring locations SPPMM01 and SPOUT, relative to pre-Phase I levels the contaminant concentrations at the DG were greatly reduced. This is because the contaminated groundwater that had been issuing (untreated) at the DG was now being collected by Phase I and partially treated by the SPPTS, resulting in reduced contaminant loads at the DG. The effects of the Phase II and III upgrades can also be seen, as concentrations

of nitrate measured at SPOUT and the DG dropped sharply. This effect is also evident in the summary statistics for GS13, where SPPTS performance is measured.

Table 3–87. Summary Statistics for U and Nitrate Concentrations from 2000 through 2009 at Historical and Current SPPTS Monitoring Locations

SPIN	Nitrate			Uranium		
	Average	SD	Median	Average	SD	Median
Pre-closure	N/A	N/A	N/A	N/A	N/A	N/A
Post-closure, pre-Phase I	276.7	59.7	270.0	52.4	9.8	52.0
Post-Phase I	682.5	99.1	695.0	76.3	14.0	77.0
<i>with ESL data</i>	645.3	64.0	646.3	63.1	13.3	60.5
Post-Phase II, III	561.7	90.0	595.0	61.5	6.5	63.0
<i>with ESL data</i>	568.2	66.7	584.9	63.0	7.5	64.0
SPPMM02						
Pre-closure	160.7	45.9	156.0	28.4	4.6	28.8
Post-closure, pre-Phase I (n = 3)	246.7	23.1	260.0	35.0	1.0	34.9
Post-Phase I	N/A	N/A	N/A	N/A	N/A	N/A
SPOUT						
Pre-closure	N/A	N/A	N/A	N/A	N/A	N/A
Post-closure, pre-Phase I	N/A	N/A	N/A	N/A	N/A	N/A
Post-Phase I (n = 3)	403.3	40.4	410.0	27.3	4.2	26.0
<i>with ESL data</i>	393.5	100.6	421.0	20.3	5.5	20.0
Post-Phase II, III	102.5	51.9	101.5	32.2	10.2	30.5
<i>with ESL data</i>	103.5	63.2	88.9	30.6	6.6	30.3
SPPMM01						
Pre-closure	6.1	27.0	0.1	3.0	10.5	0.1
Post-closure, pre-Phase I	26.6	77.8	0.4	3.7	5.7	1.7
Post-Phase I (n = 1)	310.0	N/A	310.0	21.0	N/A	21.0
	283.0	112.8	329.2	16.7	3.0	15.5
SPP Discharge Gallery						
Pre-closure	259.9	123.2	233.0	52.8	44.7	43.3
Pre-closure without 3 U outliers	N/A	N/A	N/A	44.9	16.9	43.0
Post-closure, pre-Phase I	449.8	123.2	425.0	60.5	14.6	56.0
Post-Phase I (n = 3)	376.7	85.0	380.0	25.0	1.7	26.0
<i>with ESL data</i>	379.7	117.9	385.1	18.4	4.6	16.7
Post-Phase II, III (n = 2)	145.0	35.4	145.0	24.5	7.8	24.5
<i>with ESL data (U n = 3)</i>	88.1	69.0	78.9	25.5	5.8	27.5
GS13						
Pre-closure	24.9	17.6	23.0	12.1	6.1	11.8
Post-closure, pre-Phase I	41.2	26.2	38.0	23.0	13.1	21.4
Post-Phase I	80.3	13.2	74.0	38.3	22.6	52.3
<i>with ESL data</i>	88.5	61.4	75.0	36.1	18.7	38.1
Post-Phase II, III (nitrate n = 3)	13.7	8.2	11.0	17.0	6.2	17.7
<i>with ESL data</i>	15.5	10.3	13.1	17.1	7.4	18.2

Notes: SPIN = true system influent (collection well); SPPMM02 = historical “influent” monitoring location; SPPMM01 = historical system effluent location, replaced in late 2008 with SPOUT; GS13 = surface water performance monitoring location.

Table 3–87 (continued). Summary Statistics for U and Nitrate Concentrations from 2000 through 2009 at Historic and Current SPPTS Monitoring Locations

N/A indicates location was not monitored, or the indicated statistic cannot be calculated. Where three or fewer results form the basis for the statistics presented, the number of samples is indicated parenthetically (e.g., n = 3). Refer to report text for additional information on the outliers noted for the Discharge Gallery statistics.

Closure date used is October 2005; Phase I date used is October 20, 2008.

Analytical data from SPPMM02 and SPPMM01 are included for comparison only; these locations are no longer monitored. See the 2006 Annual Report (DOE 2007f) for a more detailed discussion of location SPPMM02, and see the 2008 Annual Report (DOE 2009g) for more information on SPOUT.

Data used to calculate the statistics were taken at face value, regardless of qualifier. This is largely irrelevant, but nitrate and U were frequently not detected prior to spring 2005 in effluent monitoring location SPPMM01, so the resulting statistically generated values would be expected to be biased high.

Data from ESL are not validated, but typically correspond very closely to results from split samples sent to contract labs. ESL results for “nitrate” used to calculate the statistics include those for nitrate only as well as for nitrate plus nitrite; the latter constituent is not usually present at significant concentrations.

Validated contract lab data indicate nitrate concentrations in 2009 at the performance monitoring location for the SPPTS, GS13, were within their typical range. None of the nitrate results exceeded the 100-mg/L TM stipulated in RFLMA. (Note that this limit was reduced to 10 mg/L when the TM expired at the end of CY 2009.) Concentrations of U were also within their typical range, though as seen on Table 3–87, the average and median concentrations were slightly higher prior to the installation of the Phase II and Phase III upgrades. Following that work, concentrations of U decreased significantly.

Summary of SPPTS Phases II and III

The SPPTS has been the subject of intense scrutiny and continuing study since Site closure in 2005. Several factors drove these efforts, including (1) concentrations of nitrate and uranium measured at the DG typically exceeded those in untreated influent to the system, even though this is where effluent confirmed to be adequately treated is discharged; (2) accessing and maintaining the treatment media and plumbing is costly and difficult; and (3) the original treatment media used may not be optimal over the long term. In addition, operational difficulties were experienced in the spring of 2005 that forced a more immediate response (see DOE 2007f for discussion). Previous annual reports have discussed various components of this post-closure work (DOE 2007f, 2008d, 2009g), which has included repairs, subsurface exploration, treatability studies, and the design and construction of system upgrades.

This section describes the activities performed in 2009 to upgrade the SPPTS, the effects of those upgrades on water quality, and the planned path forward for additional improvements. Phases II and III are discussed together because both phases rely on shared infrastructure and were constructed concurrently. Phase I, which was completed in 2008, is described in the corresponding annual report (DOE 2009g). Routine system maintenance is discussed in Section 2.5.3.

The Phase II upgrades focused on the installation of a new U treatment cell. The fundamental objectives of these upgrades are to (1) treat U as a first step in the water treatment process, rather than after nitrate is treated (as is the case with the original treatment cells), and (2) provide an easily-accessible U treatment cell. By removing U before nitrate, the downstream nitrate media should be disposable as a nonradioactive waste; and by being easily accessed, maintenance associated with the cell and related plumbing would be less costly, hazardous, and difficult. This

cell incorporates a ZVI-based treatment media, wherein the ZVI is mixed with varying amounts of pea gravel (to maintain porosity and permeability). This media is very similar to the ZVI-based media used in original SPPTS Cell 2.

The Phase III upgrades focused on the installation of two pilot-scale nitrate treatment cells. These cells are designed to test two different approaches to treatment: (1) inert media dosed with a high-quality liquid carbon source in a more active treatment setting in “Cell A”, and (2) organic media operated as a passive flow-through treatment cell in “Cell B,” similar to the existing nitrate treatment cell. Data and information collected through the operation and optimization of Phase III, together with the knowledge gained through previous years of operations at the SPPTS, will inform the design and construction of Phase IV, which is intended to be a full-scale nitrate treatment cell that incorporates a more effective and efficient treatment media and methodology. Cell A incorporates a high surface-area plastic substrate that goes by the trade name “Kontakt,” manufactured by Jaeger Environmental, in which the individual plastic pieces resemble spoked wagon wheels; and MicroCg, a liquid carbon source manufactured by EOS. Cell B uses a media composed of corn stover—essentially everything left in the corn field after the grain is harvested, so it is predominantly stalks and leaves, with some cobs—and a small amount of crushed limestone to reduce the potential for fermentation to develop. (Bacterial colonies involved in fermentation would be undesirable competitors with the denitrifying bacteria.)

Construction of the Phase II and III upgrades began on April 7, 2009, and was completed on May 28, 2009. Several delays were experienced during construction; the most significant were due to weather and the subsequent need to recover from the effects of the weather, but changes in key personnel also affected the pace of the work. As completion neared, 40 gallons of inoculum was prepared in 5-gallon buckets. Each bucket contained approximately 335 mL malt vinegar (carbon source), 40 mL molasses (carbon source), a pinch of Miracle Grow fertilizer (nutrients), water from SPIN (nitrate source), and a small amount of soil from the DG (bacteria source). This mixture was allowed to sit for approximately 2 weeks in covered buckets (to reduce oxygen content), by which time the fluid had a strong foul odor, brown coloration, and slimes and molds on the top surface. Then, as influent filled Cells A and B, half of this inoculum was added to each cell to provide the initial “seed colony” of denitrifying bacteria. The cells were then allowed to sit for several days while the bacteria in the inoculum multiplied and colonized the cell media. After this period, flow-through conditions were initiated.

The finished upgrades provide significant improvements in water treatment but are also complex due to the need to exert more control over system operations than was necessary in the past. Previous operation of the SPPTS utilized a single-speed pump in SPIN that cycled on and off depending on water availability in the collection sump within the collection trench. As a result, influent flows were variable, and could range from several days or more of no flow to a period of nearly continuous flow. However, the redox-sensitive nature of the ZVI media in the Phase II cell requires that flow be as continuous as is feasible so that air is not allowed to contact the media, causing it to oxidize. Further, the Phase III pilot-scale studies needed to be operated at consistent flow rates to allow the resulting data to be most useful. Therefore, a pump suitable for continuous operation, and which could support variable pumping rates, was needed for SPIN. Furthermore, given the existence of dry periods (i.e., no influent flow) in the past, the design needed to accommodate dry conditions by storing groundwater within the intercept trench and within system components so that it could be metered to the Phase II and III cells without interruption.

Innovative technologies and approaches to water treatment were incorporated in the design of these upgrades. The entire system has to be operated by gravity or solar-powered components; this includes the pumps, telemetry, monitoring instrumentation and probes, dataloggers, and various control components. Literature searches were conducted and bench tests were performed in the ESL to evaluate different U treatment media, carbon sources and media for nitrate treatment, and ways to extend the effective lifespan of media. The U treatment media that were evaluated included ion exchange resins, ferric oxides, and ZVI; of these, ZVI represented the best alternative. Carbon sources and media that were evaluated for nitrate treatment included several locally available types of brewery waste, vegetable oil and emulsified vegetable oil, the three EOS products MicroCm, MicroCglycerin, and MicroCg, and agriculturally related organic materials such as walnut shells, corn stover, alfalfa, sawdust, and mushroom compost. Although tests performed in the ESL led to the preliminary selection of a brewery waste as the liquid carbon source to be fed to Cell A, concerns about the uniformity and stability of such a material over time and temperature variations led to the selection of MicroCglycerin as the liquid carbon source. A sample of this material was analyzed and found to contain undesirable concentrations of selenium, so MicroCg (which was shown to have lower concentrations of selenium) was chosen as the liquid carbon source.

Of the organic media reviewed for Cell B, corn stover represents a desirable combination of attributes including rich and readily available carbon content, physical characteristics that would promote flow through the media, and low cost. The initial preference for walnut shells mixed with vegetable oil or emulsified vegetable oil did not perform favorably in laboratory testing, so the corn stover was selected. Those laboratory results also ended consideration of using these oils to rejuvenate the sawdust in Cell 1, a concept that had been studied as a temporary improvement to the SPPTS while the Phase III studies were underway.

Column tests were also performed in the ESL to investigate the potential for extending the effective life of ZVI-based media by chelating (i.e., binding and rendering unavailable for reactions) ions present in the influent. This concept was initially scoped as a possible method of reducing downstream clogging by chelating the dissolved iron issuing from a cell incorporating a ZVI-based media—that is, by adding it to the effluent from such a cell. However, it was found that by dosing the influent to the cell with a chelating agent, the accumulation of precipitates that render the ZVI particles unavailable for treatment is postponed, and the downstream benefits of the chelator are also realized. Following the success of lengthy laboratory tests using water from SPIN, sodium citrate (referred to herein as citrate) as a chelator, and media ranging from pure ZVI to ZVI mixed with sand (as an analog to pea gravel), the Phase II design incorporated citrate dosing of the influent to that cell.

Additional pumps were required to direct flow to the Phase III cells, dose the Phase II cell with citrate, and dose the Cell A flow with carbon. Furthermore, to ensure adequate water availability to the Phase III cells during dry periods that might be encountered during the Phase III effort, a water storage sump (the sump) was installed between the Phase II and Phase III cells. Concerns of water availability to the Phase II cell were addressed by plans to allow water in the intercept trench to accumulate in advance of traditionally dry times.

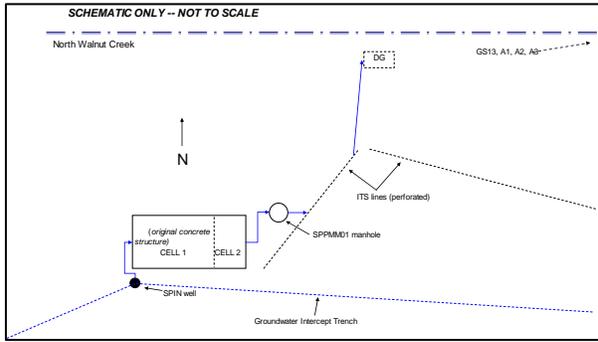
Water from SPIN is routed through a vault (the SPIN vault) for metering, through another vault (metering vault) for citrate dosing, and into the distribution gallery at the bottom of the Phase II cell. The water moves through the media in an upflow direction, then (prior to malfunctions in July) exited to the sump. From there, the appropriate portion was pumped back into the metering

vault and split among Cells A (influent to which is dosed with liquid carbon) and B to maintain the selected study flow rates, while the balance of the flow was routed from the sump around these Phase III cells. Effluent from Cells A and B then rejoin this bypassed water and enter original SPPTS Cell 1, then Cell 2, and finally pass through SPOUT and issue at the DG. Numerous parameters at different locations through the system (e.g., flow rates, pressures, temperatures, voltages, water levels) are measured, logged, and are available via telemetry to personnel at the Rocky Flats office. General operation of the various components is described in Section 2.5.3, and the evolution of the SPPTS and its various components is illustrated below.

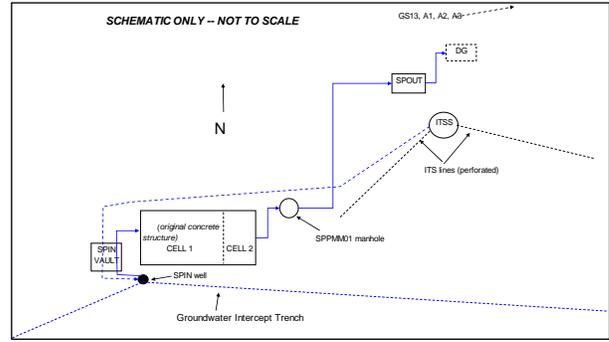
Operation and optimization of the completed system proceeded fairly smoothly until July 4, 2009, when the system automatically shut down due to low water levels in the sump. This occurred despite the availability of adequate groundwater; upon investigation, it was found that the sump had settled, creating a leak along the seam between the two sections of this concrete structure. That leak had further eroded the subsurface, causing an area of subsurface cavity development that was not apparent from the ground surface due to the thorough manual compaction performed during construction of the Phase II and III upgrades. For the next several weeks, conditions in the area were assessed, and a recovery plan was developed and implemented. During this period, different parts of the system were operated to manage and treat accumulating groundwater. Water was always routed through original Cells 1 and 2, at a minimum. The Phase II cell was online much of this time, Cell A received occasional batches of influent and doses of MicroCg, and Cell B received less-frequent batches of influent. The system was returned to full operation on August 6, 2009.

Removal of U via the Phase II cell, which incorporated the innovative citrate dosing, began well. However, after several weeks U was detected in the effluent from this cell. Because citrate dosing was still being optimized, in early August an attempt was made to promptly reverse the rising levels of U by doubling the citrate dose. The effluent concentrations of U that were reported from the next samples increased significantly, suggesting that unlike the results achieved in a laboratory setting, the effects of citrate dosing in this full-scale setting required additional testing. Citrate dosing was halted completely on August 26, 2009.

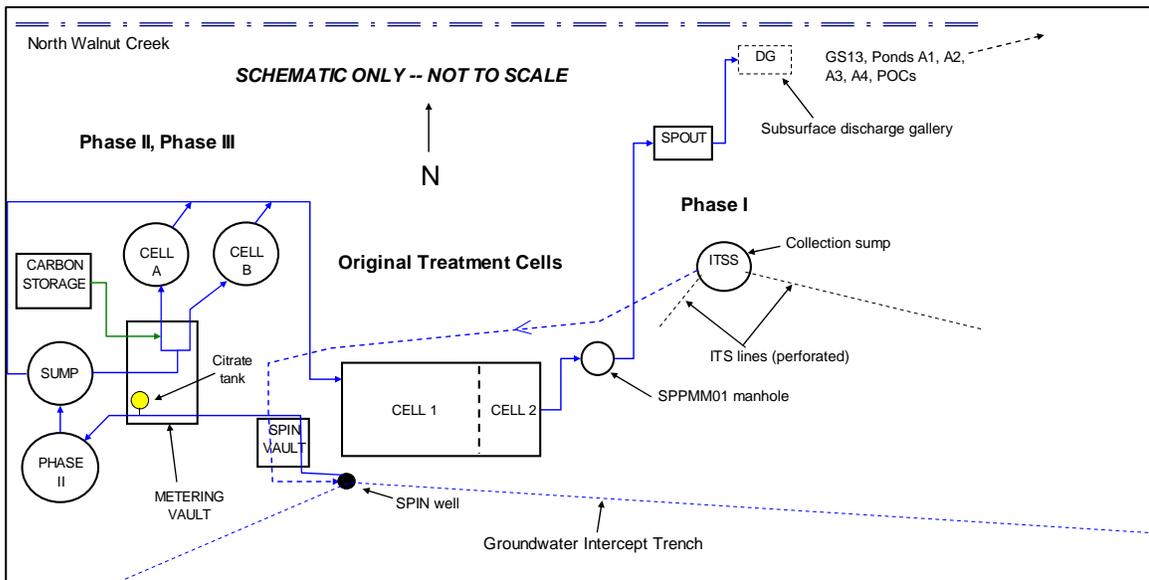
Figure 3–197 provides schematic drawings that illustrate the evolution of the SPPTS from Site closure through the end of 2009.



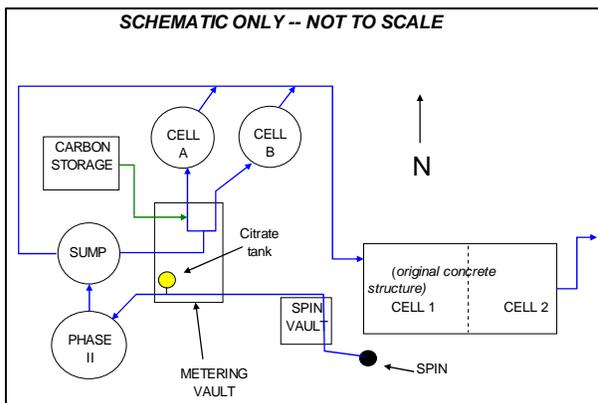
A. SPPTS at Site closure



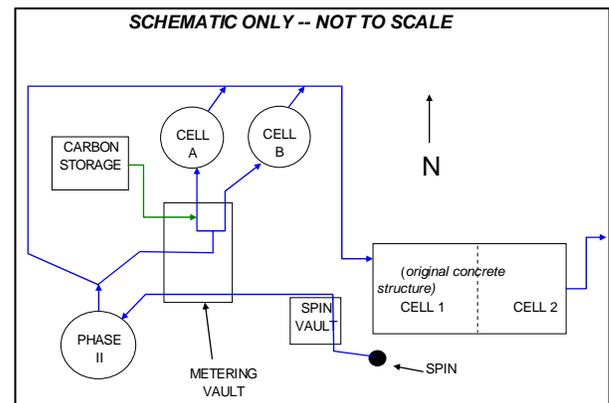
B. SPPTS with Phase I upgrades



C. SPPTS with completed Phase I, II, and III upgrades (Phase II and III as originally constructed)



D. Phases II and III as originally constructed



E. Phases II and III following repairs; through 2009

Figure 3-197. Evolution of SPPTS from Site Closure through Phases I, II, and III Upgrades

A geotechnical investigation of the Phase II/III area to define the cause of the settling and develop recommendations to prevent additional settling was performed in late July as the final step of the assessment of the subsidence event. This investigation included drilling six boreholes among and around the Phase II and III components, sampling the resulting subsurface materials, and performing geotechnical testing and analysis of the samples. The final *Rocky Flats SPPTS Geotechnical Investigation Report* was issued on October 8, 2009 (Appendix F). In summary, the geotechnical investigation could not definitively identify the cause of the observed subsidence, but factors leading or contributing to it included moisture (e.g., the heavy precipitation that occurred during construction of Phases II and III) and incomplete compaction of backfill (probably related to previous grading efforts, potentially including the closure-related removal of a large drain that had underlain the Phase II and Phase III area, closure-related road removal and backfilling, and/or relocation in the late 1970s of the North Walnut Creek drainage and construction of the hillside on which the SPPTS and associated components are situated). Recommendations from this geotechnical study included installing helical piers under the Phase II and Phase III components and injecting grout in the shallow subsurface of this area. However, it was noted that implementing these measures would represent a conservative approach and might not be truly necessary. Although the Phase II and III components, including the sump, had been designed and constructed with an eye toward possible future repurposing and use in the final system (Phase IV), the sump was removed and the Phase II cell outlet reconfigured so that this cell now doubles as a water storage component (though one with much less storage volume). The ground surface was regraded as necessary to improve drainage of precipitation away from the components. Installation of the additional stabilizing features (e.g., piers) will be considered during design of Phase IV.

Concurrently with and following the geotechnical evaluation and development of recommendations to stabilize the components, the operation of Phases II and III continued to be optimized. Various components or aspects that were studied, adjusted, revised, or reworked included valving to improve flow control, logic and electrical components to improve power characteristics and reliability, dose rates for MicroCg and phosphate (a critical nutrient for denitrifying bacteria that is not adequate in system influent or MicroCg, and thus must also be added to Cell A), influent flow rates (both via adjustments to pump rates and adjustments to valving), and others. Optimization efforts continued through the balance of 2009, and by the end of the year overall system performance was significantly improved (as indicated by Table 3–87), but much additional optimization remained to be completed. (Refer to Section 2.5.3 for additional discussion on system optimization.) At year's end, Cell A was still being optimized but was reducing influent nitrate concentrations by approximately one-half to two-thirds; and Cell B was reducing nitrate by approximately one-fifth to one-third. The Phase II cell was still not achieving treatment targets, reducing U by approximately one-fifth to one-third.

Four nonexclusive hypotheses, one physical and three chemical (based on passivation of the ZVI), were developed for the reduced effectiveness of the Phase II cell:

- Preferential flowpaths had developed.
- The high concentrations of nitrate promote formation of ferric oxyhydroxides on the ZVI grains.

- Dosing with citrate resulted in precipitates coating the ZVI grains.
- The nitrate and/or citrate accelerated weathering of feldspars in the granitic pea gravels to clays that coated the ZVI grains.

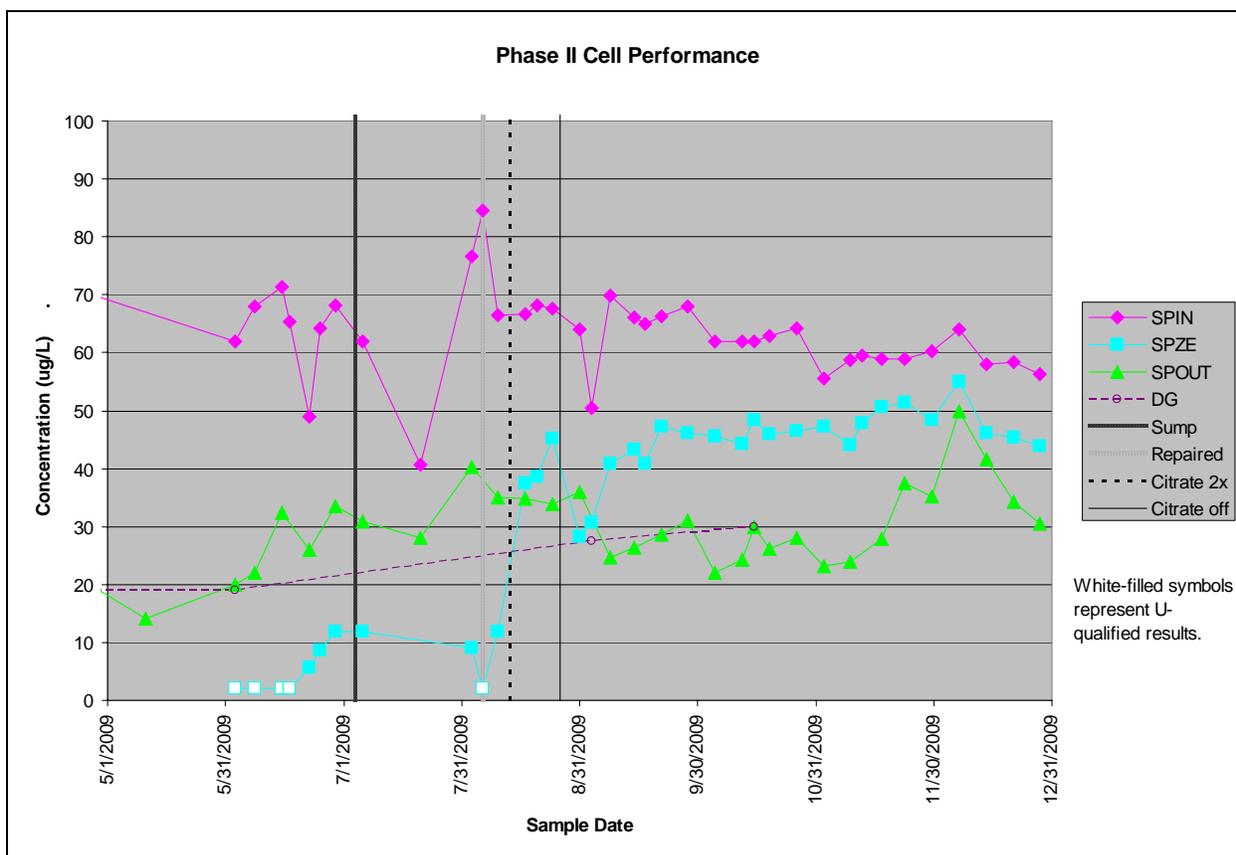
The first, purely physical hypothesis seemed unlikely given the newness of the installation, but was still possible. The second hypothesis seemed unlikely because raw SPIN waters had been used in laboratory column tests to determine the favored U treatment media, and nitrate interference had not been suggested during those tests. The third also seemed unlikely, again because laboratory testing had not yielded similar results under normal operating conditions. The fourth hypothesis represented an untested set of conditions, because the laboratory tests had used either pure ZVI or ZVI mixed with quartz sand as an analog to the pea gravels used in the full-scale system. Quartz is much more chemically resistant than feldspar.

A tracer test was designed to test the first hypothesis and was performed in October 2009. Although the results did not suggest the presence of preferential flow, neither were they conclusive. Another tracer test was planned for early 2010 to collect data that could definitively determine whether the explanation was purely physical, that is, due to faulty hydraulics.

Additional expertise was added to the technical team to assist in the geochemical studies. As of the end of 2009, planning was underway to collect and analyze samples of the Phase II media, following the conclusion of a successful second tracer test. In addition, extensive column testing was also under consideration should the media analyses not produce a definitive cause and solution to the observed reduction in U removal.

Figure 3–198 illustrates the concentrations of U at several important locations, as represented by both unvalidated ESL and validated contract laboratory data. The apparent response to increased citrate dose rates is clear. Efforts in the laboratory to duplicate reduced U removal were eventually successful, but in those tests, U removal rates were restored once citrate dosing was discontinued. A similar effect is not seen in the full-scale Phase II application, although a minor decrease in U concentrations has been observed into early 2010.

Also evident on Figure 3–198 is the response to the extended residence time that resulted from subsidence of the sump and the corresponding discontinuance of continuous flow through Phase II until repairs were completed. This suggests some ZVI was still available for treatment (i.e., was still in contact with the water). Concentrations of U at locations farther downstream (SPOUT and the DG) are included to illustrate that the original SPPTS treatment cells continued to remove some U, although treatment objectives were not being met.



NOTES: SPZE = sampling location for effluent from Phase II cell. Sump = date on which the water storage sump failed; Repaired = date on which system repairs were completed and the system was returned to operation; Citrate 2x = date on which the citrate dose rate was approximately doubled; Citrate off = date on which citrate dosing was discontinued. Data include both contract lab and ESL. Some results are qualified but are not shown differently for the sake of simplicity; only nondetects are shown differently.

Figure 3–198. Effectiveness of U Treatment by Phase II Cell

As noted above, optimization efforts and other studies will continue to focus on Phase II to determine the cause of and appropriate solution to the observed reduction in treatment effectiveness.

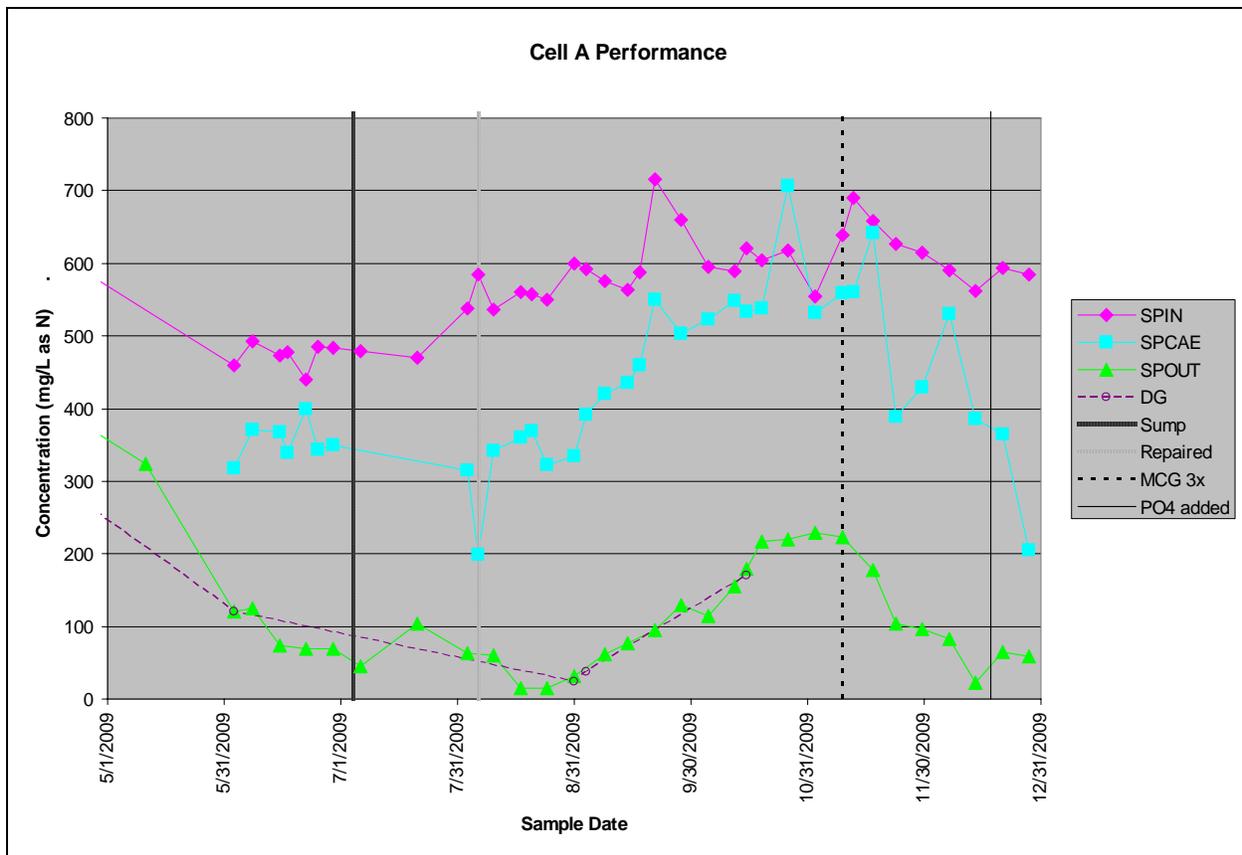
The effectiveness of nitrate treatment by the Phase III cells varied through late 2009 as changes in flow rates, carbon dosing (Cell A only), climate, and other factors influenced the performance of these components. One challenge foreseen for Cell A was the low flow rates planned for the pilot study. Active treatment systems such as this (i.e., employing inert media and a high-quality carbon source) typically are exposed to higher velocities of water with lower concentrations of nitrate. However, this requires electrical power that would exceed the reasonable capabilities of a solar-based system; furthermore, the higher concentrations of nitrate in the SPP require greater residence time to treat. Finally, given that this is a pilot-scale study, the cell size, configuration, and infrastructure had to be constrained, or construction and testing would not be practicable. To address these requirements, a pump was installed at the top of Cell A to recirculate the water at the top of the cell back to the bottom of the cell. Although only rated at 3 gpm, this represents a significant increase over the average influent flow rate to Cell A in 2009, which was generally in the 0.25–0.3 gpm range. The intake of this pump represents the highest-velocity conditions of

the entire cell, and therefore had to be guarded from biofouling with a filter basket. This component is cleaned when it becomes clogged with biofilm.

Nitrate removal rates in Cell A through 2009 did not achieve the target effluent concentration, but were improving following substantial increases in carbon dose rates and addition of phosphate to the carbon source. MicroCg is obtained in 237-gallon totes that are stored in the carbon storage vault (Figure 3–197) and connected directly to the system via a dosing port. The first tote of MicroCg used in the summer was modified by mixing in phosphate; this was then discontinued in an effort to “wean” the resident population of denitrifying bacteria off the added phosphorous. However, by late 2009 it was clear that additional nutrients were needed to develop the robust biofilms needed to treat the water. The rate of carbon dosing was sharply increased, and phosphate addition to this liquid was resumed. A second objective was also being targeted in this act: the addition of excess carbon that would flow downstream into the original Cell 1 sawdust-based media and promote nitrate treatment within that cell. This was successful but led to increasing biofouling within Cell 1. As the year ended, discussions were underway on addressing this biofouling. The improvements in nitrate removal seen in Cell A allowed the MicroCg dosing rate to be reduced as a part of the dose-optimization efforts underway before the end of 2009.

Figure 3–199 illustrates the nitrate treatment performance of Cell A through 2009, using both unvalidated ESL and validated contract laboratory data. Note that this includes a mix of results reported variously as nitrate + nitrite as N, and nitrate as N (omitting nitrite). Nitrite was monitored using field test kits (paper strips), and this constituent was detected using this method; assuming these test-strip results are accurate, up to approximately 24 mg/L nitrite as N was present in Cell A effluent. However, the reliability of these field data for nitrite is questionable; concentrations of nitrite will be determined analytically in 2010 to confirm treatment effectiveness.

As shown on Figure 3–199, treatment effectiveness worsened into the fall of 2009, but when the MicroCg dose rate was increased, treatment improvements resulted. These improvements are also evident at SPOUT, since an excess of carbon was being added to Cell A by design in an effort to promote nitrate treatment by Cell 1. Adding phosphorous to the MicroCg to ensure an adequate supply of this required nutrient further improved treatment in Cell A. Optimization efforts will continue in 2010.



NOTES: SPCAE = sampling location for effluent from Cell A. Sump = date on which the water storage sump failed; Repaired = date on which system repairs were completed and the system was returned to operation; MCG 3x = date on which the dose rate for MicroCg was approximately tripled; PO4 added = date on which phosphate was added to the MicroCg. Data include both contract lab and ESL. Some results are qualified but are not shown differently for the sake of simplicity.

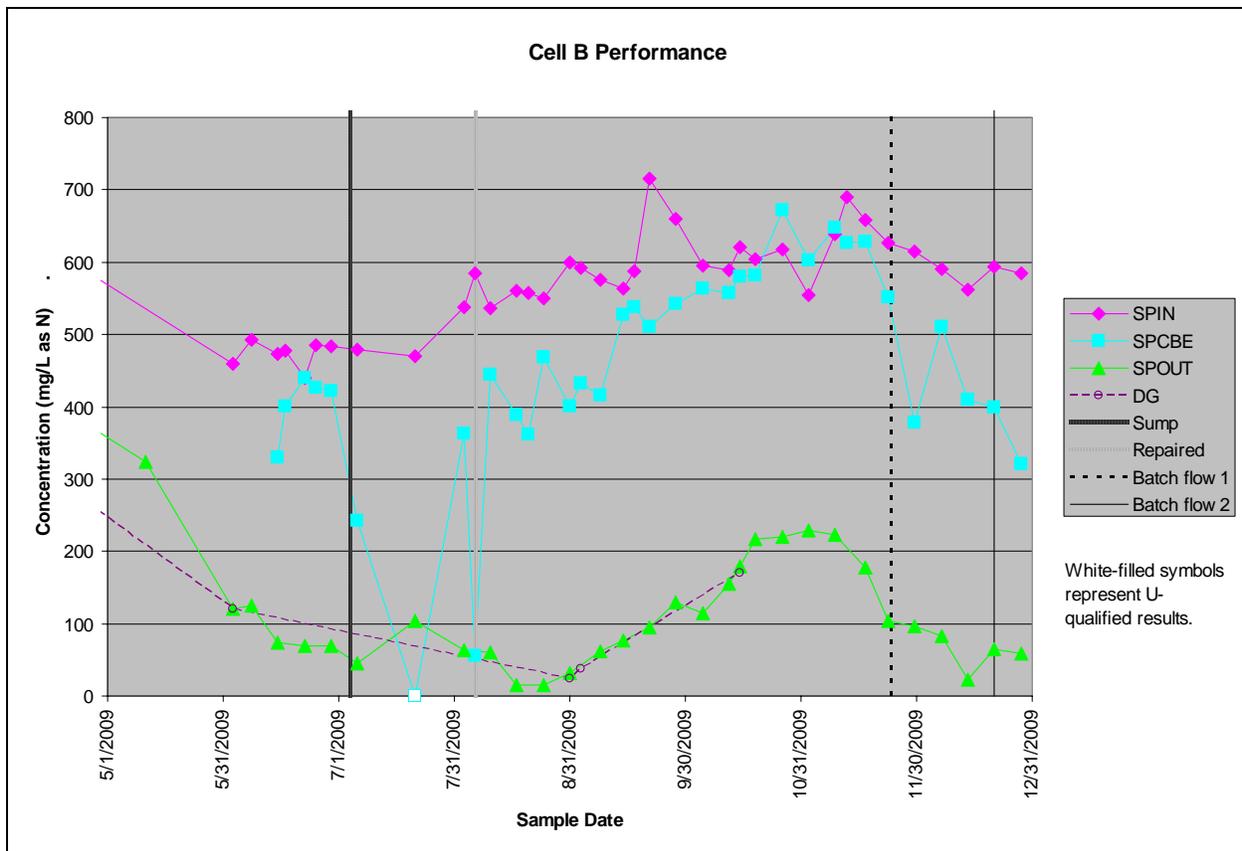
Figure 3-199. Effectiveness of Nitrate Treatment by Cell A

Cell B performance was also challenged, mainly by the fundamental limitations imposed by this type of treatment and by climatic conditions. Given the much lower treatment efficiency of a passive, flow-through system based on a natural organic media, compared to an active system such as Cell A, a much larger volume of media would be required to treat the same high-nitrate flow passing through Cell A. Alternatively, rather than increasing the volume of media, the residence time within the media could be increased (i.e., via lower flow rates). Therefore, after several months of operation at similar flow rates as Cell A, flows to Cell B were reduced. In late November, the flow rate was reduced from about 0.25–0.3 gpm to about 0.01 gpm. The pumps and valving used in the system are not able to control to such a low flow rate, so flows were added in four batches of 15 or 30 gallons per week. When this change was first implemented, table salt was added to the influent in an effort to use conductivity measurements conducted during each flow addition to track flow of this salty water through the cell—that is, a simple tracer test. However, the conductivity data were too erratic, and the hydraulic residence time within the cell could not be well established.

The effort required to perform four additions of water per week in winter conditions at Rocky Flats led to a revision of this practice in December, after which 52 gallons were added twice

weekly. In late December, this flow rate was further reduced to 52 gallons per week (2 batches of 26 gallons each), which averages to approximately 0.005 gpm. Under such low average flow rates as these batched additions represent, improvements in nitrate removal were anticipated. However, reducing the flow of relatively warmer groundwater to the uninsulated Cell B caused water temperatures within that uninsulated cell to drop as winter progressed. (Cell A was not as strongly affected because its flow rate remained the same and this cell incorporates a recirculation pump, as described above.) Insulation was added to cell and vault lids in November and December, and sheet insulation was floated on the water surface in the Phase II cell. These modifications helped to reduce heat loss, but were not sufficient. At year's end, methods of adding more insulation to Cell B in an effort to further reduce heat loss were being considered. Heating the cell would accomplish the same goals, but the power requirements are significant; this option has not been pursued.

Figure 3–200 illustrates the nitrate treatment performance of Cell B through 2009. The effects of reducing the flow rate—equivalent to extending the residence time—are indicated by the improved nitrate treatment that followed. This effect is also evident over the period in which the cell was not operating due to the subsidence of the sump (i.e., between July 4 and August 6, 2009); during this period, the cell received only one addition of untreated water (80 gallons on July 20). A similar effect is apparent in Cell A but is reduced because untreated water was added to Cell A on three separate occasions through this period (219 gallons on July 14, 85 gallons on July 16, and 150 gallons on July 20). This cumulative addition of 454 gallons, averaged over a month (approximately the time the system was down), gives an average flow rate in Cell A during this period of about 0.01 gpm; for Cell B, the single batch added yields an approximate flow rate of 0.002 gpm.



NOTES: SPCBE = sampling location for effluent from Cell B. Sump = date on which the water storage sump failed; Repaired = date on which system repairs were completed and the system was returned to operation; Batch flow 1 = date on which continuous flow was halted and flow was added in multiple batches per week, amounting to 104–105 gallons per week or an average of approximately 0.01 gpm; Batch flow 2 = date on which the batch flow was halved to 52 gallons per week or an average of approximately 0.005 gpm. Data include both contract lab and ESL. Some results are qualified but are not shown differently for the sake of simplicity; only nondetects are shown differently.

Figure 3–200. Effectiveness of Nitrate Treatment by Cell B

Phase III optimization did not progress as rapidly as was initially envisioned, and this has been aggravated by the subsidence of the sump. Cells A and B will continue to be operated and optimized in 2010. Once complete, the information gathered through this effort will be used to develop the Phase IV upgrades. Phase IV is envisioned as a full-scale renovation of the existing nitrate treatment and may utilize all, part, or none of the Phase III components and existing SPPTS Cells 1 and 2. Phase IV will be designed starting in 2010, and construction of this phase is anticipated in 2011.

Other Plumes

In accordance with RFLMA, the downgradient contaminant migration pathways for other groundwater contaminant plumes at Rocky Flats were monitored during 2009. On the whole, source areas were not monitored because the associated wells (Evaluation wells) are scheduled for routine monitoring in even-numbered years. However, a few source-area wells were sampled and will be discussed where appropriate.

This section presents a summary discussion of data collected in 2009 from 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 former B371, the IHSS 118.1 Plume (also called the carbon tetrachloride plume) located north-northwest of former B776, the PU&D Yard Plume, and the OU 1 Plume. A short summary of data from other locations of special interest is then presented.

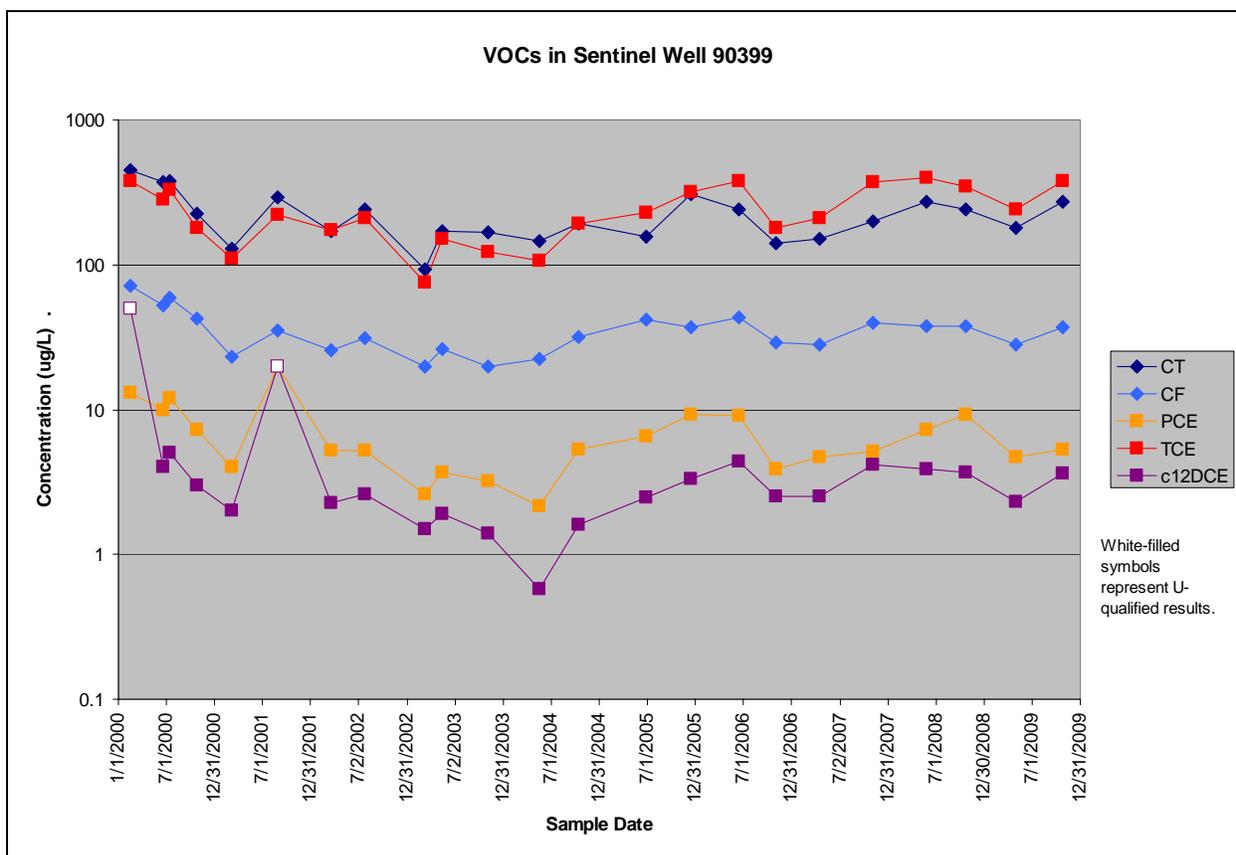
903 Pad/Ryan's Pit Plume

Downgradient portions of the 903 Pad/Ryan's Pit Plume were monitored in 2009. In addition, as noted in the 2008 Annual Report (DOE 2009g), two Evaluation wells supporting this plume were monitored in March 2009 because they had been inadvertently missed during scheduled routine monitoring in 2008. Those wells are 00191 and 50299, summary information for which was reported in the 2008 report. As noted in that document, water quality in those two wells was generally consistent with previous data, although concentrations of carbon tetrachloride in the sample from well 50299 was lower than normal. Sampling of all Evaluation wells is planned for 2010, and the resulting annual report will include updates to these data.

Ryan's Pit source-area well 07391 was sampled in June 2009. The concentration of PCE was within the normal range for this well (it was reported at 810 µg/L, and the normal range is 250 µg/L to 2,100 µg/L), but the concentration of TCE was reduced relative to most previous years. TCE was reported at a concentration of 20,000 µg/L, which is the second-lowest concentration reported since 2000 (it was reported at 13,000 µg/L in May 2003; the other results range from 29,000 µg/L to 124,000 µg/L). However, given that PCE did not show a similar decrease, nor did *cis*-1,2-DCE (the primary metabolic byproduct of TCE dechlorination) increase, this may not signify an increase in reductive dechlorination of the residual source material.

Downgradient Sentinel well 90299 continued to be dry through 2009, which is consistent with its typical condition (see associated hydrograph in Appendix A). Concentrations of VOCs in downgradient well 90399 in 2009 were consistent with previous data. The S-K calculations for well 90399 did not identify any increasing or decreasing trends at a 95 percent confidence level.

The main VOCs present in samples from well 90399 are displayed on Figure 3-201, which illustrates how consistent concentrations of these constituents have remained over the past several years. As shown, concentrations of carbon tetrachloride and TCE—the two dominant VOCs in the two source areas for the 903 Pad/Ryan's Pit Plume—are very similar, hence the conclusion that both source areas contribute to the contamination reported in samples from this well. While biodegradation of the PCE to TCE may also be contributing to the higher TCE concentrations, previous reports (K-H 2004d; ATSDR 2007) suggest this mechanism would be of minor importance in this area.



Notes: Applicable RFLMA surface-water action levels for these constituents ($\mu\text{g/L}$; DOE 2007a): CT, 5; CF, 3.4; PCE, 5; TCE, 5; *cis*-1,2-DCE, 70. In addition to the nondetects ("U"-qualified results), several other results were qualified (D, J), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

Figure 3–201. VOCs in Downgradient 903 Pad/Ryan’s Pit Plume Well 90399

AOC well 10304 also monitors the pathway to surface water of the 903 Pad/Ryan’s Pit Plume. This well was sampled twice in 2009 (May, November). Constituents that are consistent with this plume were not detected in either sample. As reported in 2007 (DOE 2008d), TCE was detected in this well at an estimated (J-qualified) concentration of $0.17 \mu\text{g/L}$; TCE has not been detected in any subsequent sample. The May sample did report a detection of 1,3-dichlorobenzene (DCB) (J-qualified, $0.39 \mu\text{g/L}$), similar to the detection reported in November 2007 ($0.43 \mu\text{g/L}$, J-qualified). This constituent is not detected in the source area wells, but has been detected infrequently in samples from well 90399 (also at very low, estimated concentrations). These results appear to be anomalous and not indicative of the behavior or status of this plume.

IA Plume

The IA Plume is actually a collection of several small VOC plumes grouped together for convenience and, in some cases, because of uncertainties regarding specific sources. This document presents discussions of the IA Plume as three segments: the South, Central, and North IA Plumes.

The pathway to surface water for the South IA Plume is monitored by AOC well 11104. One VOC detection was reported in the May 2009 sample, and none were detected in the November 2009 sample. The May sample reported an estimated (J-qualified) concentration of 1,3-DCB of 0.42 µg/L (RFLMA Table 1 standard is 94 µg/L). Concentrations of U, samples for which are collected because of the proximity of the OLF and former B444, continue to be well below the U threshold of 120 µg/L; the highest concentration in 2009 was reported at 23 µg/L.

Upgradient of well 11104, wells monitoring the South IA Plume include Sentinel wells 11502 and 40305, and Evaluation wells 40005, 40205, P419689, and P416889. Each of the Sentinel and none of the Evaluation wells was sampled in 2009. Results are consistent with past samples.

Data for PCE concentrations in samples from Sentinel well 40305 had an increasing trend that is statistically significant at the 95 percent confidence level (Table 3–79). However, of the 19 data points for PCE in the period of record for this well, 6 are qualified as nondetects and 11 as estimated values (J qualifier)—only 2 results represent unqualified detections (the highest being 1.5 µg/L). Therefore, the validity of this trend is suspect. Sentinel well 11502, located on Cactus Road near Evaluation well P416889, is not represented by any trends at a 95 percent level of significance. Although not required, U data for AOC well 11104 were also evaluated using the S-K trending method. This evaluation indicated there is a decreasing trend in U concentrations, but the statistical significance of this trend is less than 95 percent.

The central portion of the IA Plume is monitored primarily by Evaluation wells P114689 and P115589, neither of which was sampled in 2009. Similarly, the Evaluation wells that monitor the North IA Plume—33905, 55905, 56305, 70705, and 21505—were not sampled in 2009.

The terminal end of the North IA Plume is monitored by Sentinel well 52505 and AOC well 42505. To some extent, Sentinel wells 20705, 20505, and 20205 also monitor this plume, but being situated on the north side of former B771, their primary objectives are to monitor for effects from that facility and for carbon tetrachloride from former IHSS 118.1; these wells are discussed below in the context of IHSS 118.1.

Wells 52505 and 42505 were sampled twice in 2009 (May and October). Concentrations of VOCs at well 52505 remain very low, and most of the reported concentrations were estimated; in 2009, reported detections included *cis*-1,2-DCE (0.34 µg/L, J-qualified; RFLMA standard is 70 µg/L), ethylbenzene (0.21 µg/L, J-qualified; RFLMA standard is 530 µg/L), and total xylenes (1.1 µg/L; RFLMA standard is 10,000 µg/L). Detections of VC reported in samples from this well in fourth-quarter 2007 and 2008 were not repeated in 2009. Similarly, VOC detections in samples from well 42505 also remain very low, and all were estimated; they included chloroform (0.22 µg/L; RFLMA standard is 3.4 µg/L), *cis*-1,2-DCE (0.76 µg/L), and TCE (0.62 µg/L; applicable RFLMA standard is 5 µg/L).

In accordance with RFLMA requirements, analytical data from Sentinel well 52505 were analyzed for trend. No statistically-significant trend was determined.

VC Plume

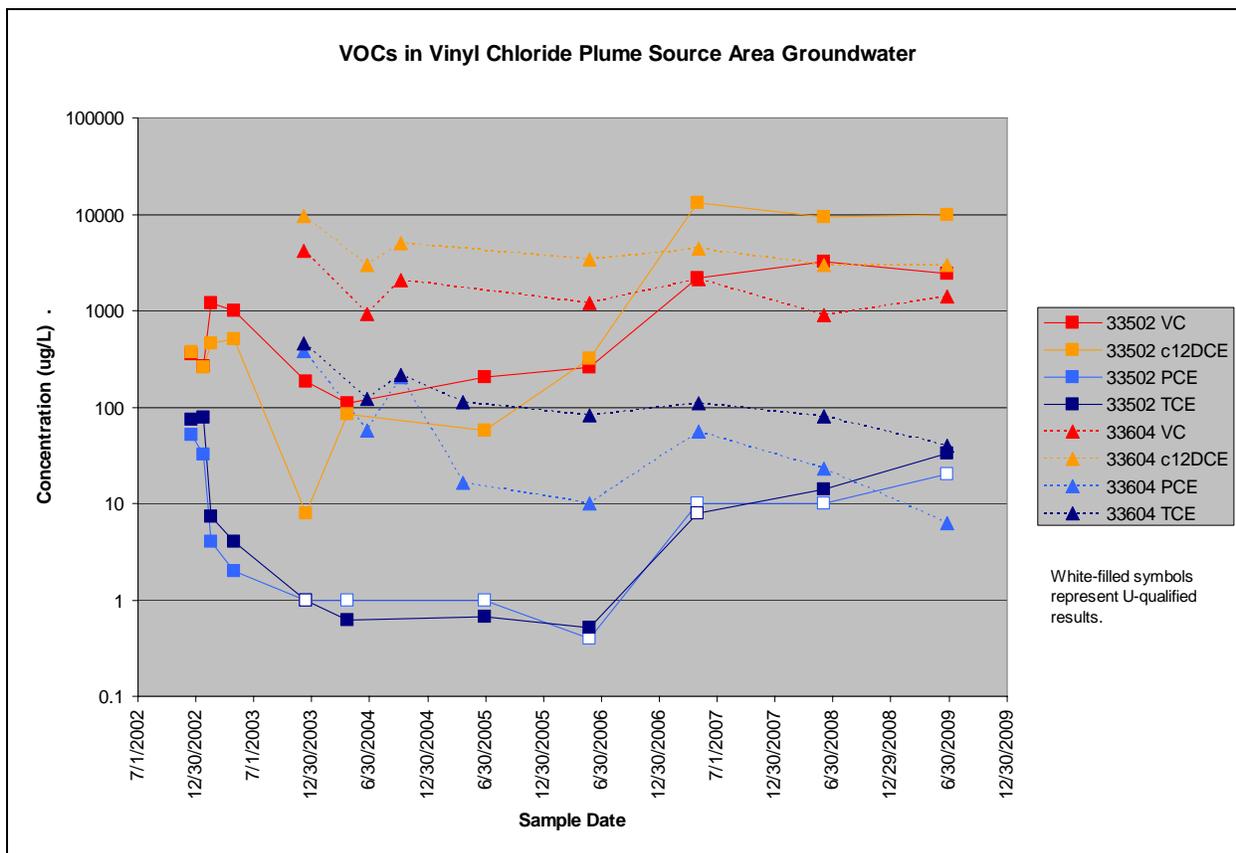
The VC Plume emanates from OBP#1 and nearby metal disposal/destruction sites. These source areas were on the margin of a valley that was buried during construction of B371 and became the

site of Sage Avenue and the Portal 2 parking lots, among other facilities. The plume resides within and groundwater flow appears to be routed by that buried valley. This is the only Rocky Flats area where VC is known to be present at such elevated concentrations.

The VC Plume is monitored by source-area Evaluation wells 33502 and 33604 and more distal Sentinel well 33703. Sentinel well 33703 was scheduled for RFLMA monitoring in May and October 2009. To collect data reflecting the moist spring conditions in this buried valley, source-area wells 33502 and 33604 were also sampled, in June.

Well 33502 is one of only two locations where strong evidence for biodegradation has been found (K-H 2004d); the second location identified in that report is well 1986, the predecessor to well 52505, discussed above. This is a likely 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. This biodegradation is probably a result of the slowly decomposing organic matter remaining from the vegetation that once grew within the now-buried valley. This process would consume oxygen, providing an anaerobic environment and carbon source suitable for the bacteria that perform reductive dechlorination of the chlorinated solvents 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 compared with those of the metabolic 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 is frequently not detected in well 33502, as has been the case since late 2003, including the sample collected in 2009).

A time-series plot of the concentrations of primary parent and daughter compounds in wells 33502 and 33604 is presented as Figure 3–202. This figure illustrates that since 2006, concentrations in samples from well 33502 of the parent compound TCE have increased even as concentrations of the metabolic byproducts, *cis*-1,2-DCE and VC, have also increased. This may indicate an increase in the rate of contaminant flux from residual contamination that is sorbed to soils, to dissolved constituents in the groundwater. Such a change could result from the removal of impermeable surfaces over this area, which would increase the amount of direct groundwater recharge from surface-water precipitation. These patterns also suggest that the resulting increase in infiltrating precipitation has not caused a sharp reduction in the rates of reductive dechlorination. The grading and filling activity performed in this area in 2007 to reduce ponding and encourage runoff of precipitation may have helped to maintain the healthy biodegradation evident in this area. This flushing effect is either reduced or not relevant at nearby well 33604, where concentrations of parent compounds recently have been generally stable or decreasing slightly as those of byproducts remain fairly constant, again indicating biodegradation has not been adversely affected.



Notes: VC = vinyl chloride; c12DCE = *cis*-1,2-DCE. Applicable RFLMA surface-water action levels for these constituents (µg/L; DOE 2007a): VC, 0.2; *cis*-1,2-DCE, 70; PCE, 5; TCE, 5. In addition to the nondetects ("U"-qualified results), several other results were qualified (J, D), but are not shown differently for the sake of simplicity. Note logarithmic concentration scale.

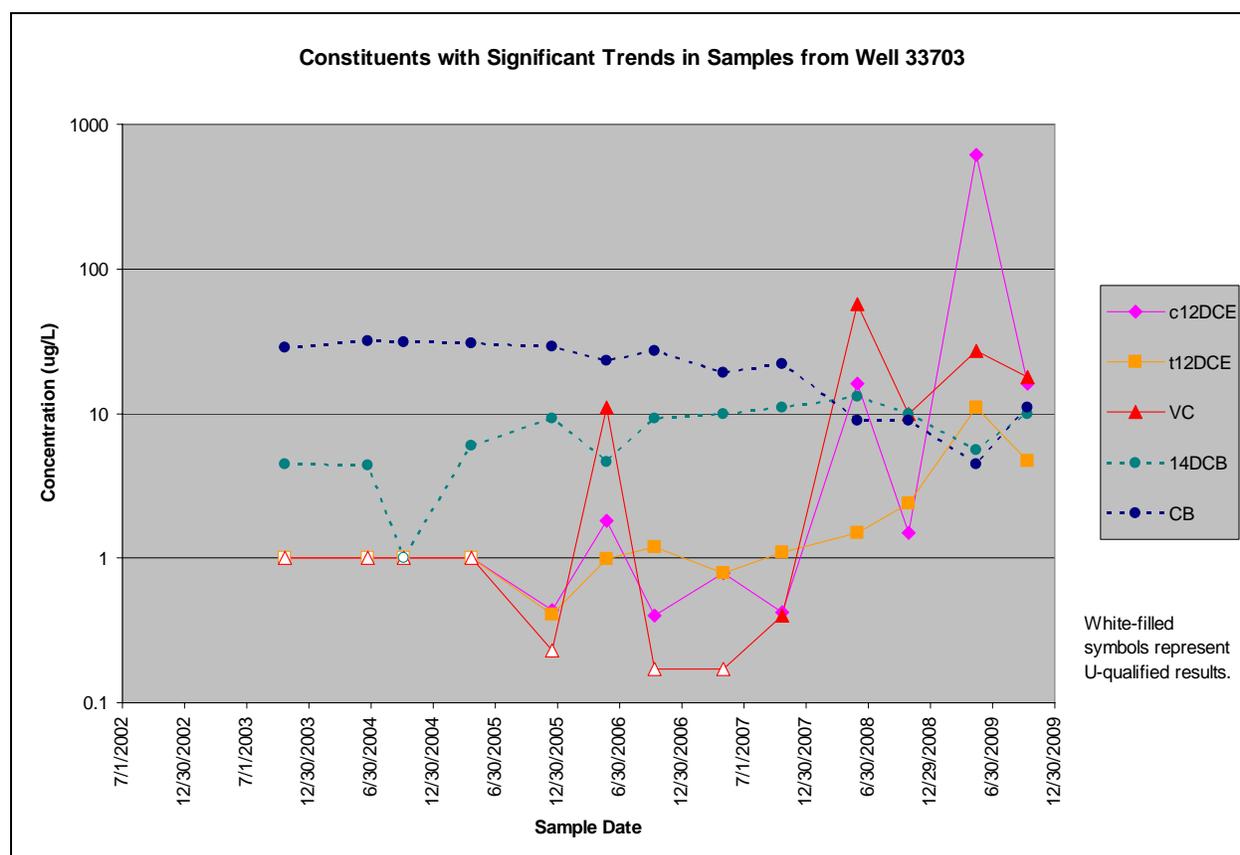
Figure 3–202. VOCs Present in the VC Plume Source Area

Downgradient Sentinel well 33703 produced samples in 2009 that continued some of the unusual characteristics for this location that were reported in 2008. Concentrations of VC and *cis*-1,2-DCE were unusually high in 2008, particularly in the second quarter sample. Before that year, concentrations of these constituents were consistently below 1 µg/L, and were often reported as nondetect, with one exception: the May 2006 sample reported a concentration of VC of 11 µg/L and *cis*-1,2-DCE of 1.8 µg/L. In May 2008, the reported concentration of *cis*-1,2-DCE rose to 16 µg/L, and in May 2009 this increased to 620 µg/L. The fourth quarter samples showed much lower concentrations of 1.5 µg/L and 16 µg/L, respectively. While concentrations of VC also increased in 2008, the concentrations in 2009 did not continue this pattern: in second and fourth quarters 2008, results were 57 µg/L and 10 µg/L, respectively; in 2009, they were 27 µg/L and 18 µg/L, respectively. Concentrations of *trans*-1,2-DCE also showed an increase, though much smaller. As noted in the 2008 Annual Report (DOE 2009g), while still orders of magnitude below the concentrations in the nearby wells 33502 and 33604, these increases may signal downgradient expansion of the plume of contaminated groundwater. This is one logical effect of removing the impermeable surfaces that once covered the source area of the VC Plume, and allowing incident precipitation to recharge groundwater in this area directly. Furthermore, as the plume is dominated by partially dechlorinated metabolic byproducts rather than the parent products (such as PCE and TCE), it is reasonable to expect that a spreading

plume would consist primarily of these byproducts, and that the effects on water quality would be more noticeable in the traditionally wetter second quarter than the normally drier fourth quarter.

The 2009 results for well 33703 are consistent with past data in that PCE was not detected. However, TCE was detected at a reported concentration of 7 µg/L in the second quarter of 2009, and an estimated 0.8 µg/L in the fourth quarter of 2009. These represent the first detections of TCE in the data set for this well. Additional monitoring will be conducted in accordance with RFLMA to further define any longer-term change in groundwater conditions at this location.

S-K statistical trending (Table 3–79) indicates that significant (at the 95 percent confidence level) increasing trends are present in samples from well 33703 for both isomers of 1,2-DCE as well as VC and 1,4-DCB; concentrations of chlorobenzene are calculated to be on a statistically significant decreasing trend. However, the trend for VC is questionable given the numerous nondetects in the data set, and those for the DCE isomers contain several nondetects and estimated concentrations. Time-series plots for these constituents are presented as Figure 3–203 and clearly illustrate the second-quarter pattern of increased concentrations described above. Refer to Appendix B for statistical trend plots.



Notes: c12DCE = *cis*-1,2-DCE; t12DCE = *trans*-1,2-DCE; VC = vinyl chloride; 14DCB = 1,4-DCB; CB = chlorobenzene. In addition to the nondetects ("U"-qualified results), several other results were qualified (J, D), but are not shown differently for simplicity. Note logarithmic concentration scale.

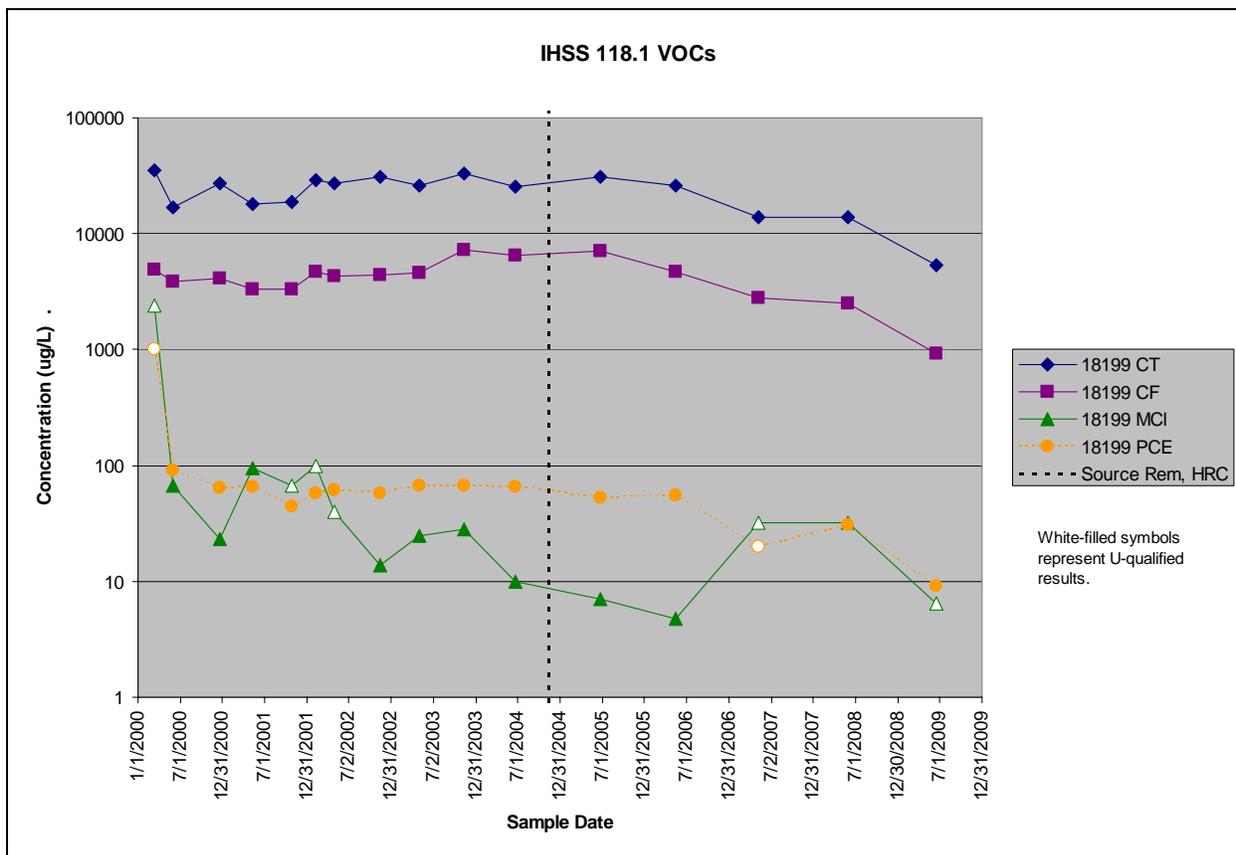
Figure 3–203. Constituents with Statistically Significant Trends in Samples from Sentinel Well 33703

IHSS 118.1 (Carbon Tetrachloride) Plume

The area referred to as former IHSS 118.1 is the source of a plume of groundwater contaminated with carbon tetrachloride. In late 2004, dense, nonaqueous phase liquid source material was removed along with an adjacent subsurface tank group referred to as B730. The carbon source HRC was added to the backfill material to enhance biodegradation of residual contamination.

Evaluation well 18199 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 well 20902, located approximately 350 feet to the northwest. Neither of these wells were scheduled for RFLMA sampling in 2009, but source-area well 18199 was sampled in June 2009 to gather additional data on the effects of the moist spring and the potential for contaminant biodegradation.

Data from samples collected in 2009 from well 18199 suggest that concentrations of carbon tetrachloride and chloroform, the primary contaminants in this plume, appear to be decreasing in groundwater in the source area (Figure 3–204). These data were not tested for trend in 2009, but increased rates of biodegradation are not apparent in these data: there are no evident increasing trends in the concentrations of the principal carbon tetrachloride daughter products, chloroform, methylene chloride, and chloromethane (the terminal daughter products, methane and CO₂, are not analyzed), together with decreases in carbon tetrachloride concentrations. Data for the other daughter products do not show apparent increases in concentration, and because many are not detected, only chloroform and methylene chloride are shown. PCE concentrations are also displayed on this figure, and show a decrease since approximately 2006 that is similar in overall shape to the curves for carbon tetrachloride and chloroform. TCE is not shown because the most common result for TCE is nondetect, as was the case in 2009. Additional samples will be required to confirm the presence of any longer-term trends in contaminant concentrations.



Notes: CT = carbon tetrachloride; CF = chloroform; MCI = 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; DOE 2007a): CT, 5; CF, 3.4. Several results were qualified (J, D, E, and – for methylene chloride in particular – B), but are not shown differently for simplicity. Note logarithmic concentration scale.

Figure 3–204. Concentrations of Primary and Secondary VOCs in IHSS 118.1 Source Area Well

Wells 20705, 20505, and 20205, 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. (With the closure of B771 and abandonment of the associated foundation drain system, the anticipated flow path for this plume was more northerly, toward well 20505; hence, the well pairing provided in Table 3–40.) Such a path is not suggested by analytical data collected in 2009, which are generally consistent with pre-closure results. Carbon tetrachloride was detected in only one sample from these three wells: well 20205 produced a sample in May 2009 with a J-qualified (estimated) concentration of 0.2 µg/L. Chloroform, methylene chloride, and chloromethane, all of which are metabolic byproducts of the dechlorination of carbon tetrachloride, were not detected in any of the samples from these wells. Consistent with past data, including much of that collected prior to closure, several constituents in the PCE-TCE chain were detected. The reported concentrations are also generally consistent with prior data, although concentrations of *cis*-1,2-DCE in samples from well 20505 appear to be decreasing. This apparent decrease trend is confirmed, but at a significance that is less than 95 percent.

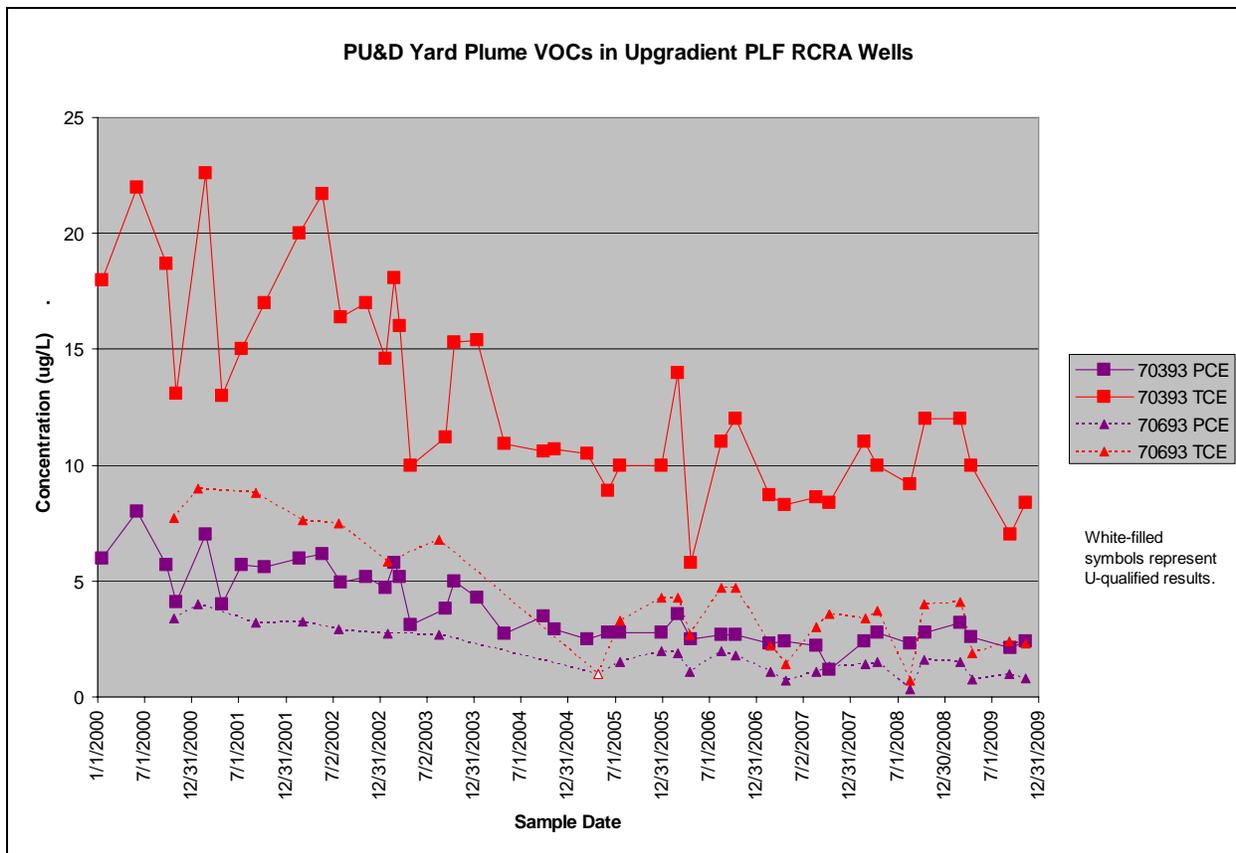
Statistically-significant (at the 95 percent confidence level) trends in constituent concentrations were identified for *cis*-1,2-DCE in samples from well 20705 (reported as increasing; however, data from the period of record include a large number of nondetects and estimated values), U in samples from wells 20205 and 20705 (both increasing, but potentially affected by well replacement at the latter location), and americium-241 in samples from well 20705 (decreasing; however, well replacement, issues of high turbidity in the early samples from the replacement well, and the geochemistry of americium render this trend unreliable). U concentrations reported in wells 20205 and 20705 remain well below the U threshold (120 µg/L; see DOE 2007a). Results for 2009 in samples from well 20205 were 69 µg/L (second quarter; the highest concentration yet observed at this location) and 63 (fourth quarter); in well 20705, results were 4.3 µg/L and 11 µg/L, respectively (both of which are within the historical range at this location). See Table 3–79 and Appendix B for additional information on the results of S-K trending.

These wells will continue to be monitored, and the data will be 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 of the proprietary carbon source HRC performed at Rocky Flats, which took the form of a treatability study begun in early 2001 (K-H 2001, 2002; see K-H 2005c for a final summary report on this study). This plume is monitored by Evaluation well 30900 in the source area and Sentinel well 30002 to the east, at the margin of North Walnut Creek. In addition, upgradient PLF RCRA wells 70393 and 70693 monitor the plume as it flows toward the PLF. The source-area Evaluation well was not monitored in 2009, but the Sentinel well was sampled twice and the RCRA wells four times in 2009.

No VOCs were detected in 2009 in samples from Sentinel well 30002, which were collected in May and October. Both RCRA wells, which are sampled quarterly, continue to be impacted by the PU&D Yard Plume. Time-series plots of PCE and TCE in these RCRA wells is presented as Figure 3–205. Detections of *cis*-1,2-DCE are infrequent. As has become the rule since 2003, only TCE concentrations in samples from well 70393 exceeded the applicable RFLMA Table 1 standards (5 µg/L for TCE; DOE 2007a). Concentrations of TCE were very similar in 2009 to those reported in 2008 and ranged from 7 µg/L to 12 µg/L in the four samples collected. There is an apparent decreasing trend in the concentration of both of these analytes at both wells. (As upgradient RCRA wells, trending is not required. However, trending performed in 2008 to supplement results of trending of data from source-area Evaluation well 30900 indicated that each of these apparent trends in the two RCRA wells was significant.) Whether application of HRC to the source area has contributed to these apparent declining concentrations is not known, but the infrequency with which the metabolic byproducts of PCE are detected suggests its effects are minimal at this distance from the point of application.



Notes: Several results were qualified as estimated (J), but are not shown differently for the sake of simplicity.

Figure 3–205. Concentrations of Primary PU&D Yard Plume Source Area VOCs in Upgradient PLF RCRA Wells

OU 1 Plume

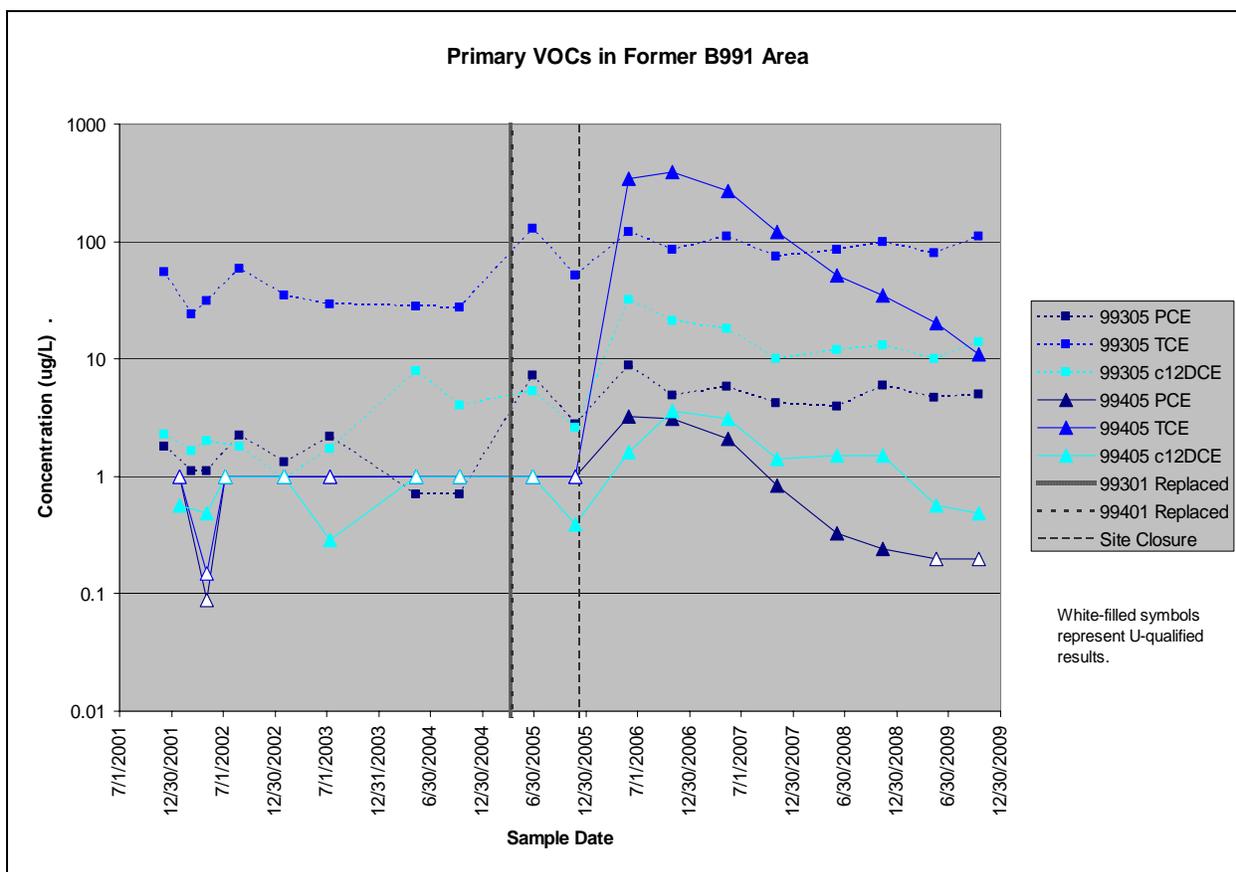
The OU 1 Plume is located on the 881 Hillside, immediately south of the former Contractor Yard portion of the IA. Its source area, former IHSS 119.1, was a drum and scrap metal storage area. This source area is monitored by Evaluation well 891WEL (the modification of which has been detailed in previous 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 3–1).

Evaluation well 891WEL was not scheduled for RFLMA sampling. AOC well 89104 was sampled twice in 2009, once in May and once in October. Results include one VOC detection: 1,3-DCB was detected at an estimated concentration of 0.52 µg/L (applicable RFLMA standard is 94 µg/L). This represents the first detection of this constituent in samples from this well. As there have been no detections of this constituent in samples from source-area well 891WEL for the period of record, this result may be anomalous and not representative of OU1 groundwater contamination. The OU1 Plume will continue to be monitored in accordance with RFLMA.

Other Areas

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

Former B991: Groundwater samples from wells 99305 and 99405 are monitored for VOCs, nitrate, and U. Both of these wells were located near the eastern edge of B991, with well 99405 positioned in the east loading dock area. Samples collected in May and October 2009 continued the post-closure pattern of higher concentrations of VOCs than were typical prior to closure. The noteworthy constituents include PCE, TCE, and *cis*-1,2-DCE, although concentrations of PCE and *cis*-1,2-DCE are frequently estimated or nondetect values in samples from well 99405. Figure 3–206 illustrates results for these constituents in both wells, together with the dates of well replacements (when 99305 replaced 99301 and 99405 replaced 99401) and site closure. As shown on this figure, VOC-related water quality changes occurred suddenly and uniformly for these three constituents at well 99405. Conversely, at well 99305 these constituents appear to have started to increase earlier, but their increase was not as sharp and was not followed by steady declines. Since 2006, VOC concentrations in samples from well 99405 are clearly decreasing, but this is not apparent for well 99305. The dates of well replacement do not appear to be a factor in the water quality illustrated for well 99405; the observed changes instead relate to other activities performed to close the Site. Conversely, well replacement appears to coincide with the changes observed at well 99305, although the increases in *cis*-1,2-DCE concentrations appear to occur over two distinct steps. The mechanism for these increases is not known, but greater impacts would be expected at that location from B991 D&D than from well replacement. VOC concentrations in samples from downgradient surface-water location GS10, which are all below applicable RFLMA standards, indicate that the increased concentrations of VOCs seen in samples from wells 99305 and 99405 have not impacted surface water quality.



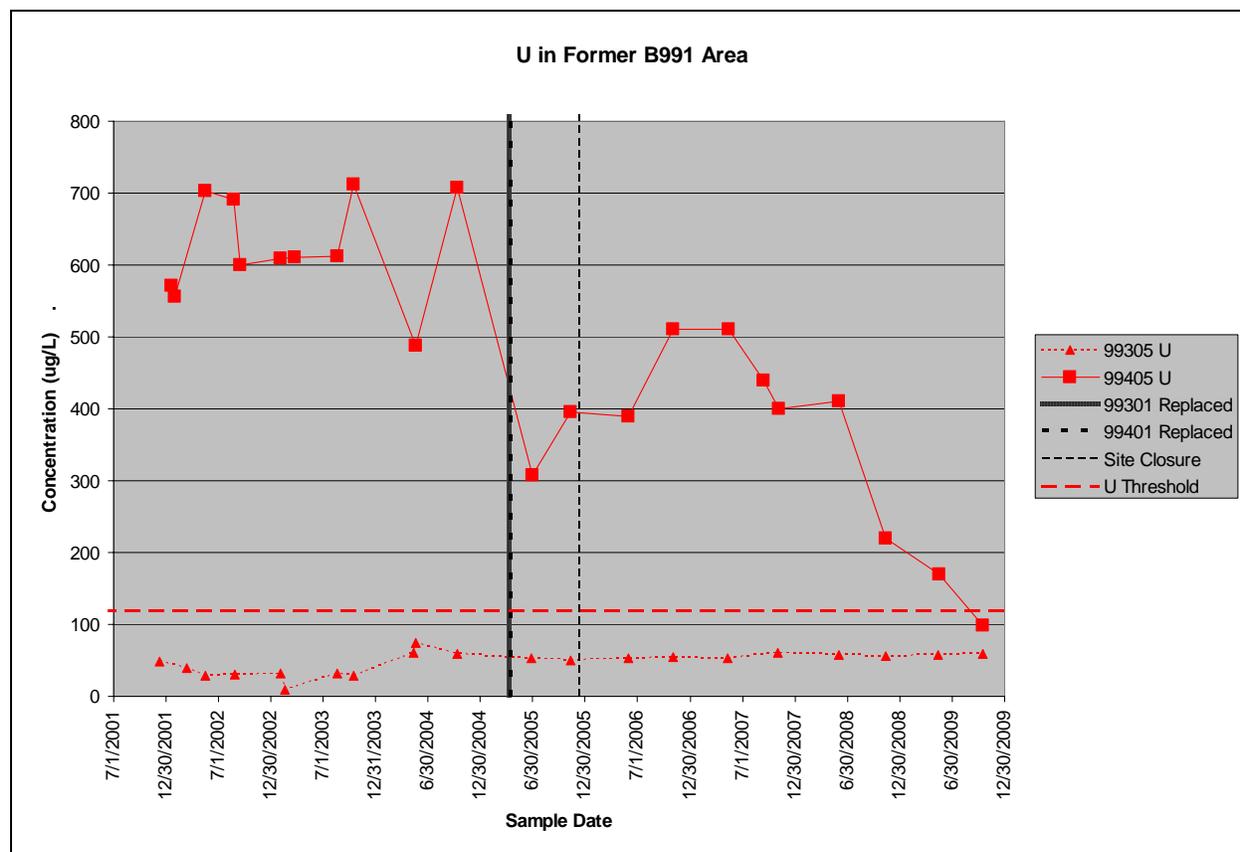
Notes: c12DCE = *cis*-1,2-DCE. Applicable RFLMA action levels for these constituents (µg/L; DOE 2007a): PCE, 5; TCE, 5; *cis*-1,2-DCE, 70. In addition to the nondetects (“U”-qualified results), several other results were qualified (J), but are not shown differently for simplicity. Note logarithmic concentration scale.

Figure 3–206. Concentrations of Primary VOCs in B991 Sentinel Wells

Concentrations of U in samples from well 99405 display a remarkable decrease (Figure 3–207). The two samples collected in 2009 returned the lowest concentrations of U yet measured in samples from this well. Previous samples have reported U concentrations exceeding 700 µg/L, and until late 2008 the concentration of U in samples from this well averaged over 500 µg/L. The results received in 2009 were 170 µg/L (May) and 98 µg/L (October). This location has been analyzed on multiple occasions for signs of U contamination through high-resolution isotopic analyses, and in each instance the results have shown the U to be 100 percent natural—i.e., there has been no site-related U contamination in the samples. The mechanism for the observed decrease in U concentrations is not known but may relate to hydrologic and geochemical changes that have occurred as a result of Site closure (for example, removal of the water supply, associated leakage, and chlorinated water; removal of impermeable surfaces and resumption of direct recharge of groundwater by precipitation; removal of foundation drains; and so on, with possible changes in redox conditions as a result of some of these factors). Concentrations of U at nearby well 99305 have always been much lower, despite the fact that these wells are only 115 feet apart; results in 2009 are consistent with previous data, which are comparatively uniform over the entire data set.

S-K trend plots show 95 percent confidence in several calculated trends at these wells (Table 3–79). Samples from well 99305 show increasing trends in both isomers of 1,2-DCE, as

well as PCE, TCE, and U. Well 99405 shows similarly significant trends in concentrations of TCE (increasing) and U (decreasing). Note that the trends calculated for *trans*-1,2-DCE in well 99305 and TCE in well 99405 are suspect, due to the large number of nondetects in the corresponding data sets. The same concern applies to the increasing trend (of less than 95 percent significance) in concentrations of *cis*-1,2-DCE calculated for samples from well 99405. Refer to Appendix B for plots of statistically-calculated trends.



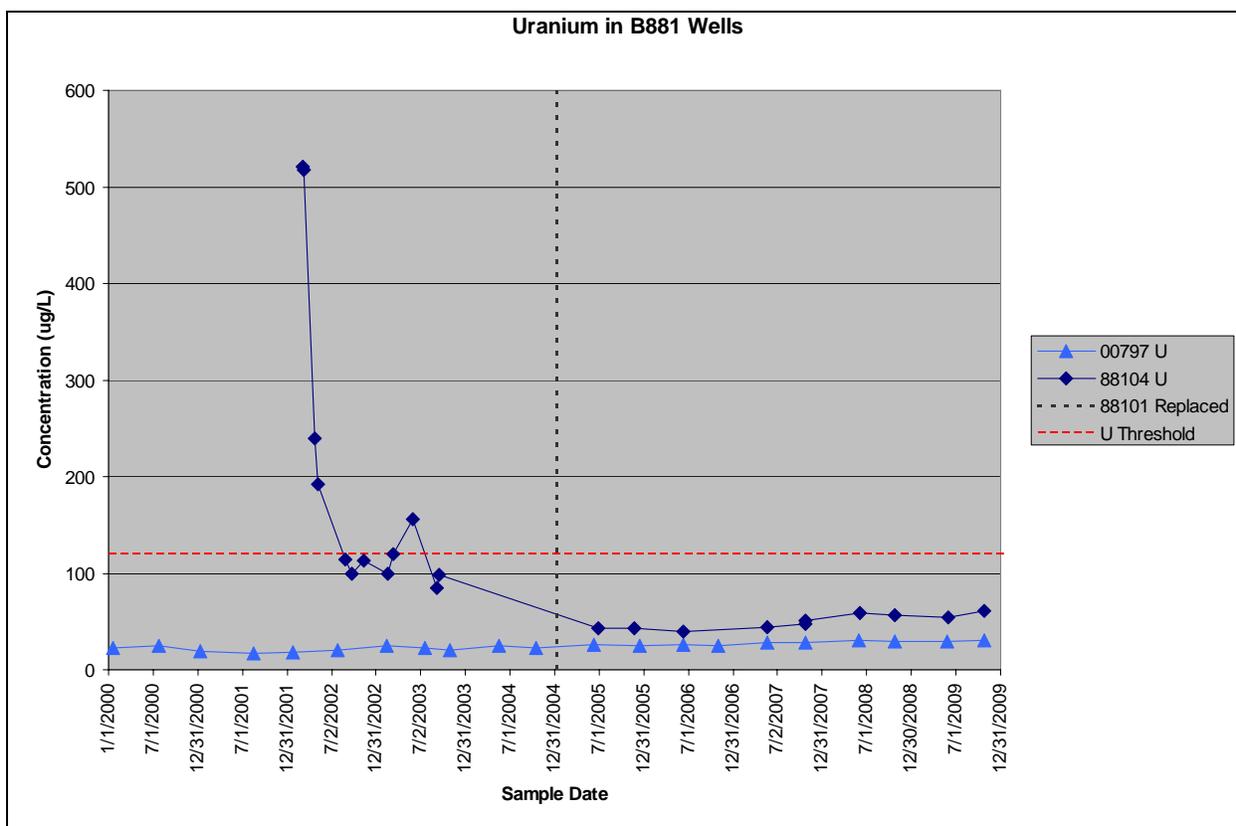
Notes: Applicable RFLMA action level ($\mu\text{g/L}$; DOE 2007a) for U (threshold), 120. U data include results for U-mass and converted isotopic activities. Several results were qualified (J, B, N, and, for two U-235 results, U) but are not shown differently for the sake of simplicity.

Figure 3-207. Concentrations of U in B991 Sentinel Wells

Both of the B991 wells are also monitored for nitrate to evaluate the potential for migration of the SPP toward South Walnut Creek. Concentrations of nitrate reported for samples from these wells continue to indicate this is not an effective pathway for migration of the SPP constituents. The samples collected in 2009 gave results that were consistent with previous data; the highest concentration reported was 2 mg/L.

Former B881: Consistent with recent annual reports (e.g., DOE 2007f, 2008d, 2009g), S-K calculations indicate there is a statistically significant (at the 95 percent confidence level) decreasing trend for U in well 88104, while in well 00797 the trend for this analyte is increasing (Table 3-79). The trend calculated for well 88104 is complicated by the well replacement performed in 2004, when well 88101 was replaced with well 88104, the latter of which is located approximately 110 feet south of the original location, which was adjacent to the southern side of

the building. Concentrations of U in the original well (88101) had decreased significantly between the installation and final sampling of that well (from a maximum concentration of approximately 521 µg/L in March 2001, to approximately 85 µg/L in September 2003). Figure 3–208 illustrates U concentrations in these two wells since 2000 and clearly shows the difference in U concentrations between the original well and replacement wells. Also evident are the comparatively uniform concentrations of U in groundwater samples from well 00797, which is located farther south, roughly between well 88104 and the SID. The increasing trend calculated for well 00797 has a very slight positive slope, as expected given the time-series plot. (Refer to the S-K plots and summary tables in Appendix B.3.) Note that concentrations of U in both wells are and have been below the RFLMA U threshold of 120 µg/L (DOE 2007a) since before B881 was demolished in 2004.

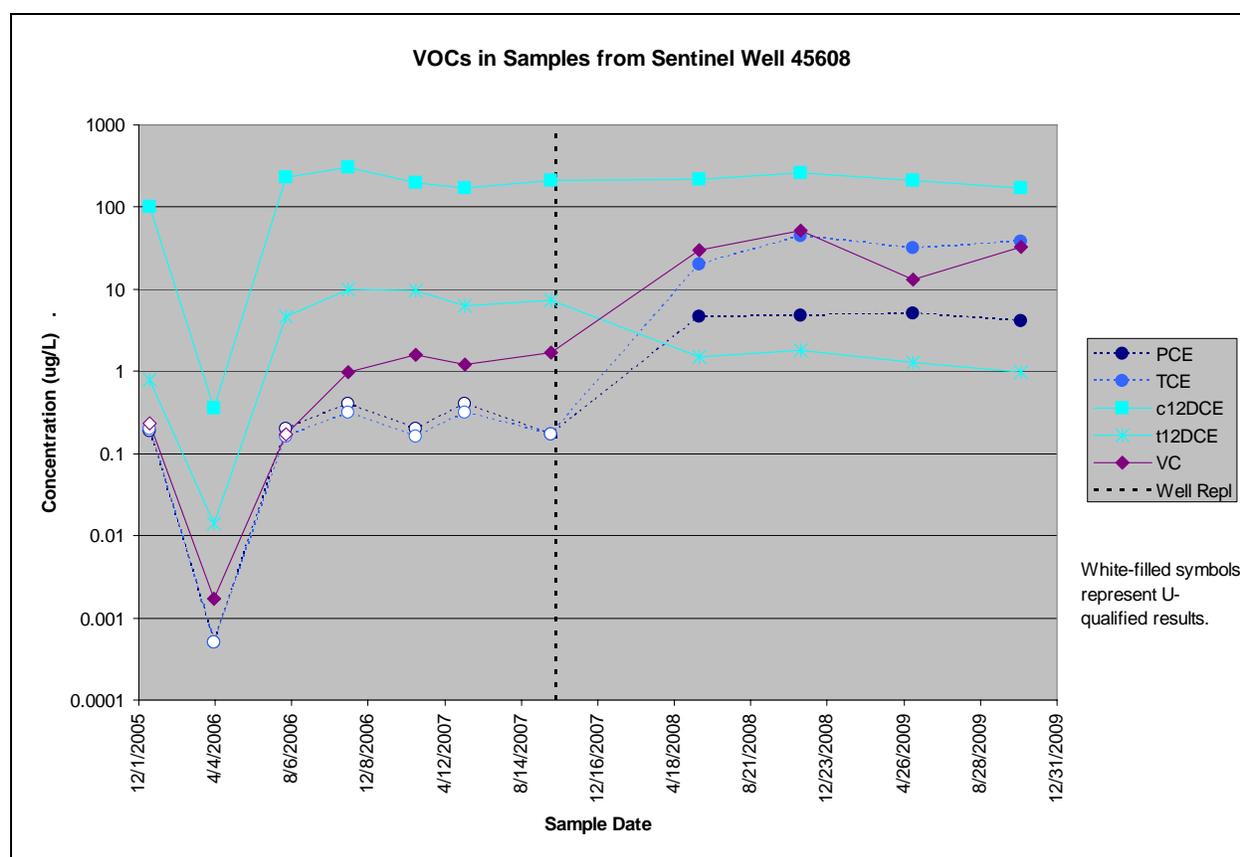


Notes: Applicable RFLMA action level (µg/L; DOE 2007a) for U (threshold), 120. U data include results for U-mass and converted isotopic activities. Several results were qualified (J, B, N, and, for two U-235 results, U) but are not shown differently for simplicity.

Figure 3–208. Concentrations of U in B881 Sentinel Wells

Hillside south of former B991: The constructed hillside south of former B991 contains the remains of a French drain that was installed to stabilize this hillside. The outfall from this drain was removed, and the drain was interrupted prior to closure because the outfall produced water containing VOCs. Sentinel well 45605 was installed to monitor groundwater adjacent to the drain interruption, but the hillside slumped. The area was regraded, and Sentinel well 45608 was installed to replace the abandoned 45605. For more detail on the hillside and French drain, see the 2006 Annual Report (DOE 2007f); for information on the well abandonment and hillside regrading, see the 2007 and 2008 Annual Reports (DOE 2008d, 2009g).

Well 45608 was sampled twice in 2009 (May, November). The continuing detections of 1,2-DCE and VC are an indication that biodegradation is still occurring. Water quality at this location changed in late 2007 (Figure 3–209). Well replacement, reconfiguration of the hillside during the regrading performed in 2007, and/or consumption of the HRC added to backfill following removal of the drain outfall may be factors in the changes visible on this figure. PCE and TCE were not detected in samples collected before 2008 from the original well but have been consistently detected in samples collected since that date from the replacement well. At the same time, concentrations of VC increased by an order of magnitude, and those of *trans*-1,2-DCE decreased overall by almost as much. These constituents, including PCE and TCE, were consistently detected in samples collected from the original drain outfall, SW056; the concentrations of PCE and TCE prior to the drain’s removal were consistent with the results for well 45608 in 2008 and 2009 (see DOE 2005b for tabulated data). Well 45608 will continue to be monitored according to RFLMA.



Notes: 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. In addition to the nondetects (“U”-qualified results), several other results were qualified (J, D), but are not shown differently for simplicity. Note logarithmic concentration scale.

Figure 3–209. Concentrations of VOCs in Sentinel Well 45608 Monitoring Hillside South of Former B991

AOC well B206989: This well is located east of the Landfill Pond dam. Well B206989 entered a reportable condition in 2007 due to concentrations of nitrate that exceeded the applicable RFLMA Table 1 standard for that location, 10 mg/L. (The TM of 100 mg/L nitrate, effective

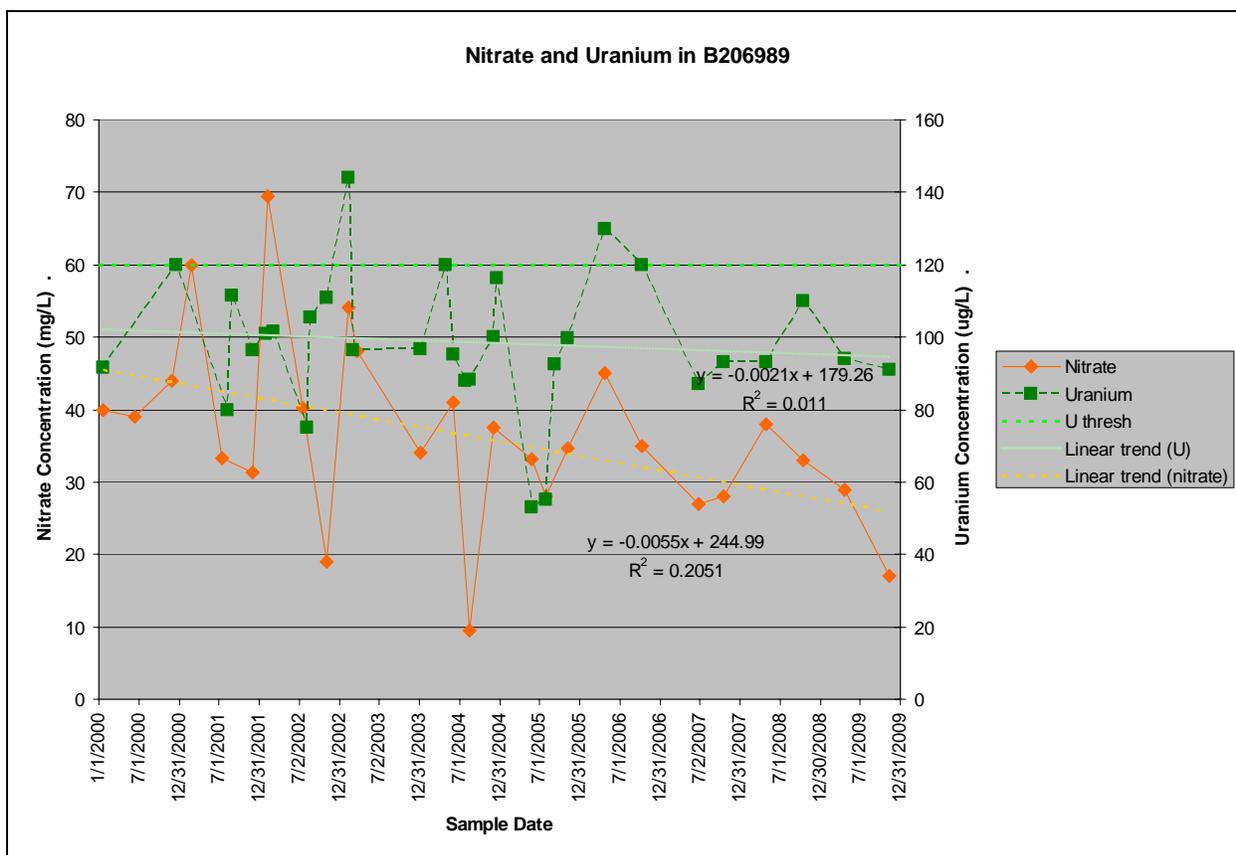
through the end of CY 2009, did not apply to the No Name Gulch drainage.) Concentrations of nitrate that exceeded 10 mg/L in samples from this well were neither new nor unexpected; instead, the reportable condition was set up by the well being reclassified via the signing of RFLMA from a Sentinel well to an AOC well. (The former classification has no reportable conditions, while the latter does.) When the first results were received after RFLMA went into effect, and those concentrations exceeded the applicable RFLMA standard, discussions were held with the CDPHE, and Contact Record 2007-06 was issued to document the resulting agreement.

As reported in the 2008 Annual Report (DOE 2009g), concentrations of nitrate in the well had met the 80 percent level of significance for a decreasing trend. Additional discussions were held with CDPHE. As a result, on May 6, 2009, surface water was sampled at two locations in No Name Gulch downstream of the well. One location was new, the second corresponded to pre-closure location GS56. These samples were analyzed for nitrate. The results for both were nondetect, with a reported detection limit of 0.01 mg/L.

The result of this effort is that the well continues to be monitored according to RFLMA, but results above 10 mg/L are not considered reportable because they are expected. With the data collected in 2009, the decreasing trend meets the 95 percent level of significance (see Table 3-79 and Appendix B.3). However, as expected, the results received in 2009—29 mg/L and 17 mg/L—still exceed the RFLMA standard.

Concentrations of U in groundwater samples from well B206989 have not exceeded the 120 µg/L total U threshold since 2006, and a reportable condition for U at this location has not yet existed. S-K trending for U (Appendix B.3) indicates the data show a decreasing trend, but at a significance that is below 80 percent.

Figure 3-210 provides updated time-series plots of nitrate and U in groundwater samples collected through the end of 2007 from well B206989. The trend lines shown for each constituent are simple regression curves; the associated negative slopes indicate the general trends are decreasing, but the low R^2 values for each of these trend lines confirm the data are widely variable.



Notes: The applicable action level for nitrate is 10 mg/L; that for U is 120 µg/L (DOE 2007a). Simple linear regression trend lines are shown for each, together with the corresponding equation and correlation coefficient. Note the use of two axes to help illustrate the concentrations of the different constituents.

Figure 3-210. Concentrations of Nitrate and U in Groundwater Samples from AOC Well B206989

East Government property boundary (former RFETS boundary): Boundary wells 10394 (Woman Creek and Indiana Street) and 41691 (Walnut Creek and Indiana Street) are located far outside the DOE-controlled area of the Central OU, on refuge lands managed by the US Fish and Wildlife Service. Monitoring these wells is not required to support the remedy, and the associated groundwater data do not support technical objectives of the RFS monitoring network. Nonetheless, they are monitored to meet operational requirements stipulated in RFLMA.

These wells were each sampled once in 2009 (April). Results included detection of 1,3-DCB, an insecticide that is also used to make herbicides, at both wells, a condition that also existed in 2006. The applicable RFLMA standard for this constituent is 94 µg/L, and the reported concentrations in the April 2009 samples were 1.8 µg/L at well 10394 and 1.9 µg/L at well 41691. The lack of consistent detections of 1,3-DCB suggests these results may be anomalous and not representative of groundwater at the Site. (At these concentrations, no action would indicated even if the detections were consistent.) Concentrations of nitrate and U were within their typical ranges at these locations (less than 1 mg/L at both wells, and 6.5–6.7 µg/L, respectively).