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Revision 1

Fiscal Year 2003 Environmental Monitoring Report for the Radioactive Waste Management Complex

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April 2004

Idaho Completion Project

Bechtel BWXT Idaho, LLC

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ABSTRACT

This report summarizes data resulting from monitoring the air, waste zone, vadose zone, and aquifer in and around the Radioactive Waste Management Complex within the Idaho National Engineering and Environmental Laboratory. This report is a joint publication of the Clean/Close Radioactive Waste Management Complex Project and the Landfills and Waste Disposal Project, and the results summarized here are used to satisfy several requirements and needs. The Landfills and Waste Disposal Project uses the results to comply with requirements of U.S. Department of Energy Order 435.1, "Radioactive Waste Management," Chapter IV, and the associated implementation manual and guidance, which require monitoring of low-level radioactive waste disposal facilities. The Clean/Close Radioactive Waste Management Complex Project uses the monitoring results to support activities associated with the ongoing Comprehensive Environmental Response, Compensation, and Liability Act risk assessment for Waste Area Group 7, which comprises the Radioactive Waste Management Complex.

Data from Fiscal Year 2003 are presented in detail, and historical aquifer data from Fiscal Years 1997–2003 are summarized to facilitate evaluation of temporal and spatial trends. Organic contaminants are shown to be declining in the soil gas because of ongoing vapor-vacuum extraction efforts in the vadose zone. Anion, cation, and metal contaminants are widespread in the vadose zone and are mostly attributable to magnesium chloride brine applied to roads within the Subsurface Disposal Area many years ago as a dust suppressant. Nitrate is not associated with the brine; it has relatively high and increasing concentrations that could provide data for model calibration. Radionuclide detections are evaluated over time and within the context of disposals to determine whether there are any candidate nuclides for model calibration efforts. Technetium-99, C-14, and H-3 are detected regularly at one or more locations, but the detections do not correlate well with the disposal locations. Trends in uranium detections correlate with the disposal locations and could be useful for validating some modeling assumptions. Detections are sporadic for Am-241, Cs-137, Cl-36, I-129, Np-237, plutonium, and Sr-90. Soil gas and atmospheric data collected near Soil Vault Rows 12 and 20 suggest that C-14 and H-3 are migrating from disposals of beryllium blocks and activated metal.

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ACRONYMS

bls	below land surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
CPP	Chemical Processing Plant
CY	calendar year
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FY	fiscal year
GC/MS	gas chromatography/mass spectrometry
GSP	gas sampling port
HDPE	high-density polyethylene
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
MCL	maximum contaminant level
MDA	minimum detectable activity
OCVZ	organic contamination in the vadose zone
OU	operable unit
PA/CA	performance assessment and composite analysis
PCE	tetrachloroethene
RBC	risk-based concentration
RFP	Rocky Flats Plant
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
SRPA	Snake River Plain Aquifer

SVR	soil vault row
TCA	trichloroethane
TCE	trichloroethene
TRA	Test Reactor Area
TRU	transuranic
USC	United States Code
USGS	United States Geological Survey
VOC	volatile organic compound
VVET	vapor vacuum extraction with treatment
WAG	waste area group

Fiscal Year 2003 Environmental Monitoring Report for the Radioactive Waste Management Complex

1. INTRODUCTION

The Radioactive Waste Management Complex (RWMC) at the Idaho National Engineering and Environmental Laboratory (INEEL) has been used for waste disposal operations since the 1950s. The RWMC occupies about 177 acres (71.6 ha) in the southwestern quadrant of the INEEL (see Figure 1-1), and it is divided into three areas: (1) the Subsurface Disposal Area (SDA), where radioactive and hazardous waste has been disposed of; (2) the Transuranic Storage Area; and (3) the administration and operations area. Contaminant concentrations are monitored routinely within and around the RWMC in soil gas, soil moisture, and the Snake River Plain Aquifer (SRPA) to determine whether waste buried in the SDA is impacting the environment. In addition, special studies are conducted to determine whether contaminants can be detected in the atmosphere and other media. Results from these hydrological monitoring activities are used to support the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC § 9601 et seq.) risk assessment in the Clean/Close RWMC Project and the Performance Assessment and Composite Analysis (PA/CA) Monitoring Program in the Landfills and Waste Disposal Project.

This report is a joint effort of the Clean/Close RWMC Project and the Landfills and Waste Disposal Project to compile environmental monitoring results for the RWMC from Fiscal Year (FY) 1997 through FY 2003, with emphasis on recent results. Data prior to FY 2003 are presented to evaluate the presence or absence of contaminant trends.

1.1 Purpose and Scope

Monitoring results summarized in this report are used to satisfy several requirements and needs. The Landfills and Waste Disposal Project uses the results to comply with requirements of U.S. Department of Energy (DOE) Order 435.1, “Radioactive Waste Management,” Chapter IV, and the associated implementation manual and guidance, which require monitoring of low-level radioactive waste disposal facilities. In particular, the following requirements of DOE Order 435.1 must be addressed:

- Site-specific PA/CA will be used to determine the media, locations, radionuclides, and other substances to be monitored.

- The environmental monitoring program will be designed to include measuring and evaluating releases and migration of radionuclides.

- The environmental monitoring program will be capable of detecting changing trends in performance to allow application of necessary corrective action before exceeding the performance assessment objectives. The performance objectives (i.e., action levels) for FY 2002 are discussed and compared with monitoring results in the PA/CA annual review (Parsons, McCarthy, and Seitz 2003).

The Clean/Close RWMC Program uses the monitoring results to support activities associated with the ongoing CERCLA risk assessment for Waste Area Group (WAG) 7, which comprises the RWMC. Operable Unit (OU) 7-13/14 is the designation for the comprehensive operable unit for WAG 7 recognized under the *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory* (DOE-ID 1991) and CERCLA (42 USC § 9601 et seq.).

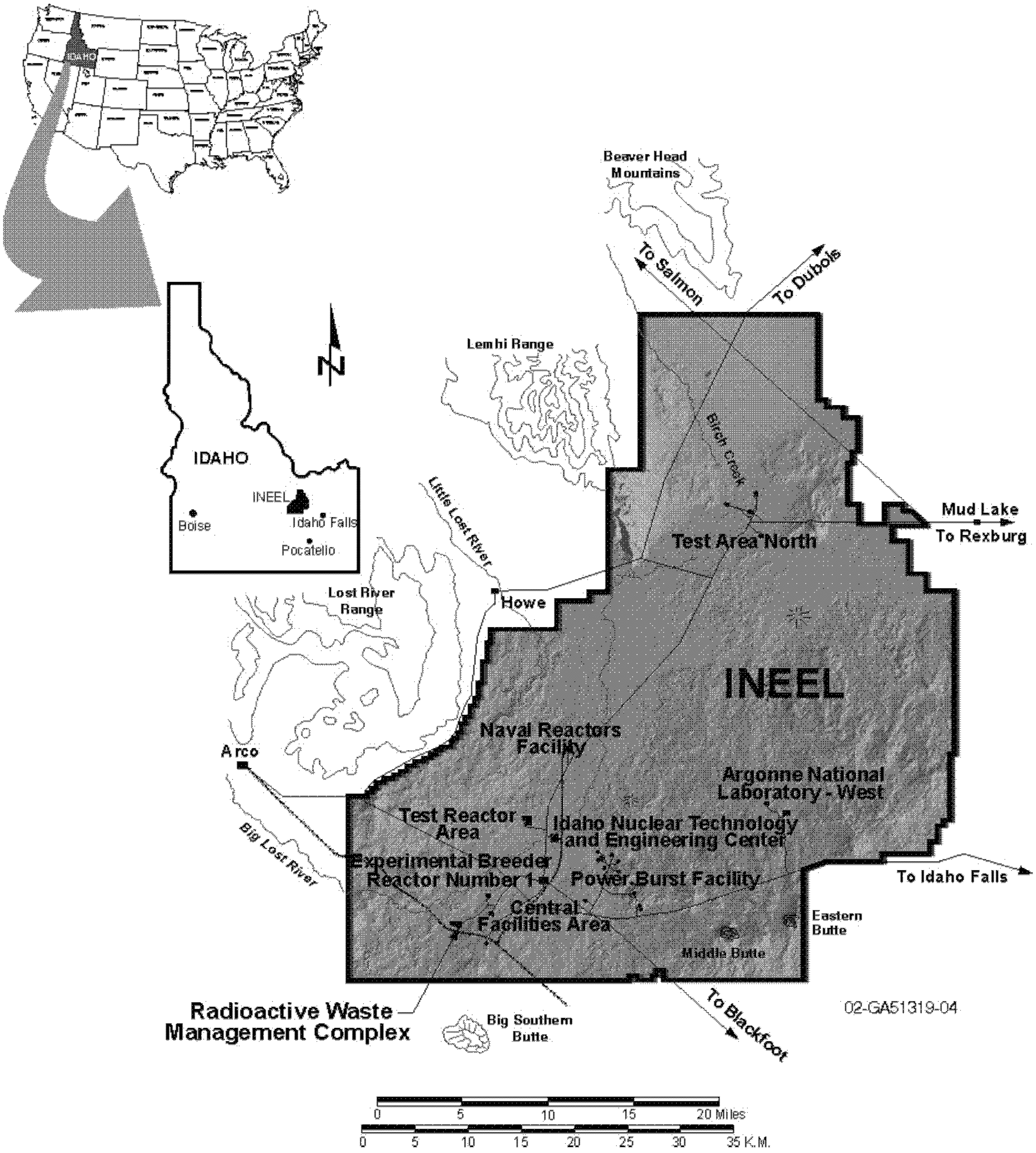


Figure 1-1. Map of the Idaho National Engineering and Environmental Laboratory showing the Radioactive Waste Management Complex and other major program sites.

Environmental monitoring data are used to support the following OU 7-13/14 objectives:

- Assess whether contaminants are being released from the waste zone
- Provide baseline data to choose monitoring locations to support the upcoming, comprehensive record of decision for OU 7-13/14
- Provide modelers with candidate calibration targets
- Verify conservatism in risk assessment modeling.

Monitoring priorities are established by collaboration between the Clean/Close RWMC Project and Landfills and Waste Disposal Project and other data users. The required data for the RWMC PA/CA Monitoring Program are identified in the *Performance Assessment and Composite Analysis Monitoring Program* description (McCarthy, Seitz, and Ritter 2001). Contaminants of concern (COCs) for the CERCLA risk assessment are identified in *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area* (Holdren et al. 2002) and include radionuclides plus some organics and nitrates. Table 1-1 summarizes contaminants of interest for the two programs.

Figure 1-2 shows the layout of disposal units at the SDA. More detailed maps of the SDA, additional information on the environmental setting and history of disposal operations at the SDA, and the disposal inventory are presented in the *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area* (Holdren et al. 2002).

Table 1-1. Contaminants of interest to the Performance Assessment and Composite Analysis Monitoring Program and Operable Unit 7-13/14.

Contaminants of Interest to the Performance Assessment and Composite Analysis Monitoring Program	Contaminants of Interest to Operable Unit 7-13/14
C-14	Am-241
Cl-36	C-14
I-129	H-3 (potential calibration target)
Np-237	I-129
U-234	Nb-94
U-238	Np-237
	Plutonium (special-case contaminant)
	Sr-90
	Tc-99
	U-233
	U-234
	U-235
	U-236
	U-238
	Carbon tetrachloride
	Methylene chloride
	Nitrates
	Tetrachloroethylene

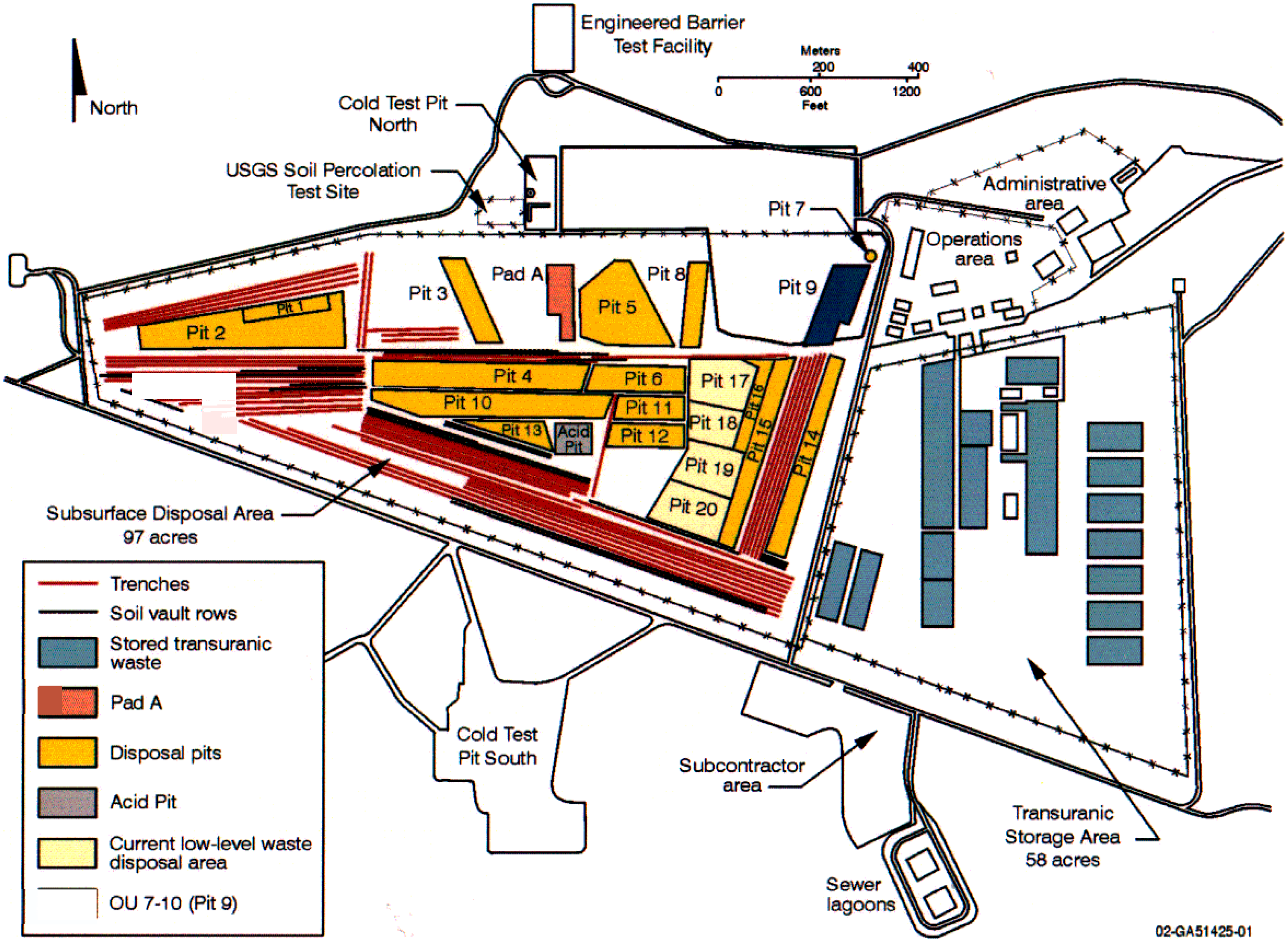


Figure 1-2. Waste disposal locations at the Radioactive Waste Management Complex.

2. MONITORING AT THE RADIOACTIVE WASTE MANAGEMENT COMPLEX

Environmental samples are collected routinely within and around the RWMC area and analyzed for a variety of radionuclide, nonradionuclide, and organic contaminants that are potential risk drivers. The routine monitoring program supporting Clean/Close RWMC Project and Landfills and Waste Disposal Project objectives focuses on sampling the waste zone, the vadose zone, and the aquifer, including soil moisture, soil vapor and gas, perched water, and aquifer sampling. The soil moisture, soil gas and vapor, and aquifer-monitoring networks are described in the following subsections. Following Section 2, analytical results are presented by discipline with Section 3 containing results from radionuclide analyses, Section 4 containing results from organic analyses, and Section 5 containing results from inorganic analyses. Results for each contaminant are presented by monitoring zone: waste zone, vadose zone, and aquifer. In contrast to vadose zone samples in the 0–35-ft depth interval, waste zone samples were collected near waste with the intention of characterizing the waste zone. Vadose zone depth intervals are detailed below:

- 0–35 ft, not including samples collected from the waste zone. Vadose zone samples from this depth interval were located some distance away from waste disposals, either between, beside, or away from pits or trenches in the SDA.
- 35–140 ft, which includes the A-B and B-C interbeds.
- Greater than 140 ft deep.

Summary tables and maps are presented for each contaminant, as appropriate. Time histories of monitoring results also are presented graphically to aid in understanding the evaluation discussions.

2.1 Soil-Moisture Sampling

Soil-moisture samples are collected quarterly with suction lysimeters throughout the waste and vadose zones of the SDA. Installation of lysimeters in the SDA began in 1985 with the Subsurface Investigation Program and continues today based on emerging interests and needs. A description of how the lysimeters are installed is provided in Section 2 of the *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area* (Holdren et al. 2002).

Lysimeter samples are limited in volume. Some lysimeters yield only a few milliliters per sampling event, while others occasionally yield up to approximately 900 mL. Of note for vadose zone monitoring in FY 2003, soil-moisture sample volumes have increased despite relatively dry weather. Increased volumes are attributable to improvements in sampling techniques. Several measures have been applied successfully, including upgrading surface hardware to minimize vacuum leaks, collecting samples at optimal sampling intervals, and applying continuous vacuum for a longer period. Lysimeter sample volumes have been sufficient to complete most analyses identified on the vadose zone analytical priority list for OU 7-13/14. Because not all analyses of interest can be performed with the limited sample volume, analytical priorities have been established for the lysimeter samples. The priorities were revised based on collaboration between the Clean/Close RWMC Project and the Landfills and Waste Disposal Project and are provided in Table 2-1.

Table 2-1. Analytical priorities for Fiscal Year 2003.

			Container			
Priority	Preservative	Titrate (mL)	250-mL HDPE (mL)	500-mL HDPE (mL)	100-mL HDPE (mL)	100-mL HDPE (mL)
January–March						
C-14	None	—	50	—	—	—
Tc-99/gamma	Acid	—	—	50	—	—
U/Pu/Am	Acid	—	—	50	—	—
H-3	None	—	50	—	—	—
Cl-36	Acid	—	—	50	—	—
I-129	None	—	50	—	—	—
Np-237	Acid	—	—	50	—	—
Anions	Chill, 24 hr	—	—	—	25	—
Metals	Acid	—	—	—	—	25
April–June						
Anions	Chill, 24 hr	—	—	—	25	—
pH/Alkalinity	Field titrate	25	—	—	—	—
Metals	Acid	—	—	—	—	25
Cl-36	Acid	—	—	50	—	—
Tc-99	None	—	50	—	—	—
U/Pu/Am	Acid	—	—	50	—	—
C-14	None	—	50	—	—	—
July–September						
C-14	None	—	50	—	—	—
Gamma/Tc-99	Acid	—	—	50	—	—
U/Pu/Am	Acid	—	—	50	—	—
H-3	None	—	50	—	—	—
Cl-36	Acid	—	—	50	—	—
I-129	None	—	50	—	—	—
Np-237	Acid	—	—	50	—	—
Anions	Chill, 24 hr	—	—	—	25	—
Metals	Acid	—	—	—	—	25
October–December						
C-14	None	—	50	—	—	—
Gamma/Tc-99	Acid	—	—	50	—	—
U/Pu/Am	Acid	—	—	50	—	—
Anions	Chill, 24 hr	—	—	—	25	—
Metals	Acid	—	—	—	—	25
H-3	None	—	50	—	—	—
Cl-36	Acid	—	—	50	—	—
I-129	None	—	50	—	—	—
Np-237	Acid	—	—	50	—	—

HDPE = high-density polyethylene

Locations for the 18 waste-zone lysimeters were chosen based on a need to investigate specific focus areas. The waste-zone lysimeters were placed from 1.5 to about 9 m (5 to about 30 ft) deep and are in or just below the target waste, at the point of waste and underburden contact, or at the point of contact with the underlying basalt. Locations of the focus areas are shown in Figure 2-1. The number of lysimeters per focus area is as follows:

- Two in the Uranium/Enriched Uranium Focus Area
- Two in the Americium/Neptunium Focus Area
- Six in the Organic Sludge Focus Area
- Six in the Depleted Uranium Focus Area
- Two in the Activated Metal Focus Area near Soil Vault Row (SVR) 12.

Only one waste-zone lysimeter yielded a soil-moisture sample during FY 2003. Approximately 10 mL of sample was extracted from Lysimeter 741-08-L1 in September 2003.

Twenty-nine sampled lysimeters are in the shallow vadose zone (0 to 11 m [0 to 35 ft] deep) (see Figure 2-2), and 15 lysimeters are in the intermediate vadose zone (11 to 43 m [35 to 140 ft] deep) (see Figure 2-3). Unlike the waste-zone lysimeters, the shallow vadose-zone lysimeters are located adjacent to the waste in undisturbed sediments, not within disposal units or next to waste. The intermediate vadose-zone lysimeters are located beneath the depth of the waste zone, generally in basalt or interbed sediments.

At a depth greater than 43 m (140 ft), both lysimeters and perched water wells provide samples (see Figure 2-4). Samples from Wells U.S. Geological Survey (USGS) -092 and -8802D are used to collect perched water from above the 67-m (220-ft) interbed.

2.2 Soil-Gas Sampling

Soil-gas samples are collected routinely from the SDA subsurface for analysis of volatile organic compounds (VOCs). Sample locations for VOCs and additional details are provided in the discussion of organic contaminant monitoring (see Section 4). Other soil-gas samples are collected from near buried beryllium reflector blocks to determine the extent of C-14 and H-3 releases. These sample locations and additional details are provided in the discussion of C-14 (Section 3.2) and H-3 (Section 3.4).

2.3 Aquifer Sampling

The INEEL collects aquifer samples on a quarterly basis. The USGS also collects data, but the data are not immediately available for use; therefore, the USGS data are not included here (except for organic contaminants). Aquifer well locations are shown in Figure 2-5. Well M10S has been out of commission since the end of 2000. A replacement well (S1835) was drilled in 2003, but the well has a very low yield, and drilling muds used in its construction remain in the hole. Because of the high turbidity, elevated total organic carbon and low yield, it was decided that samples would not be collected from this well for routine monitoring.

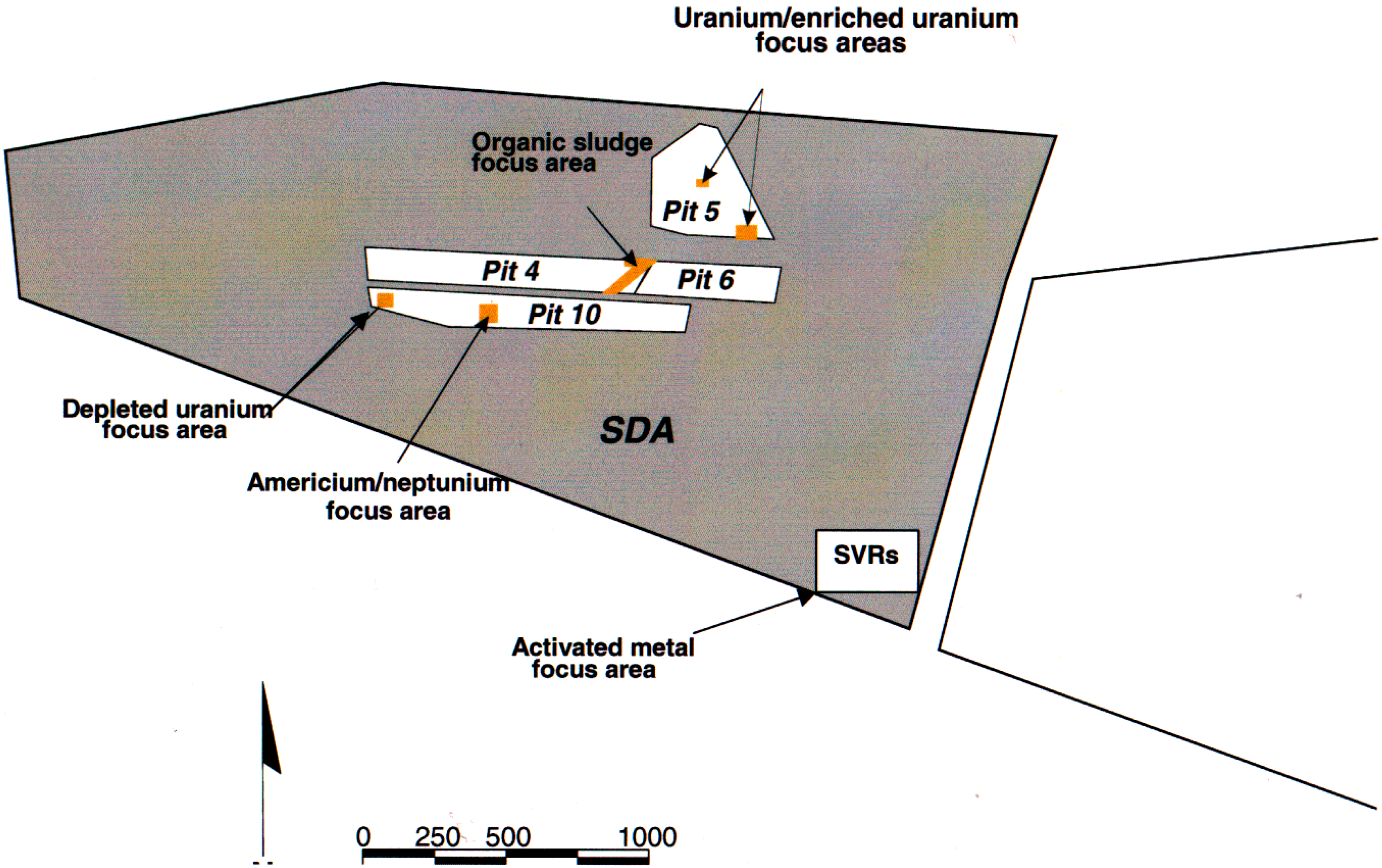


Figure 2-1. Location of focus areas at the Subsurface Disposal Area.

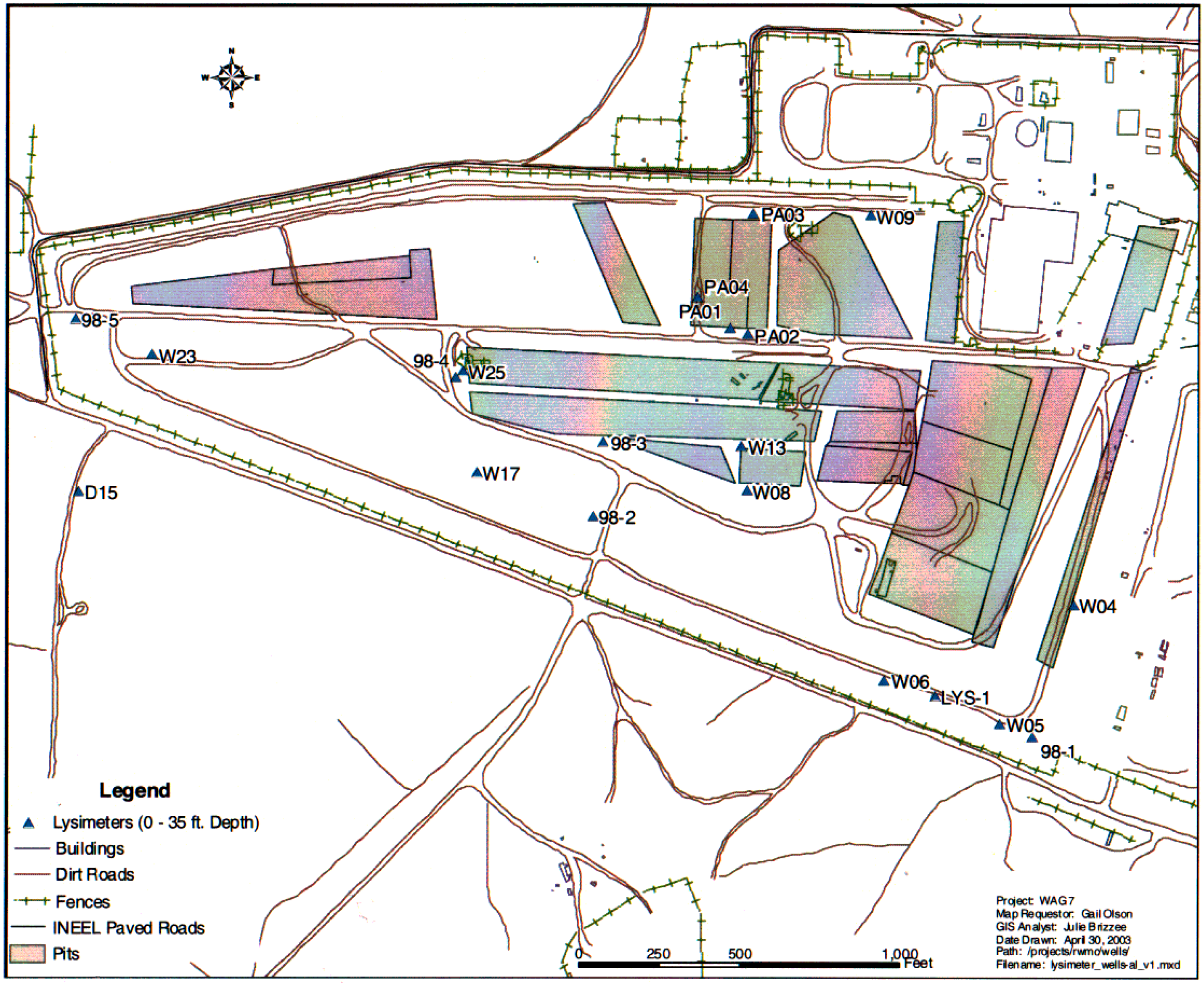
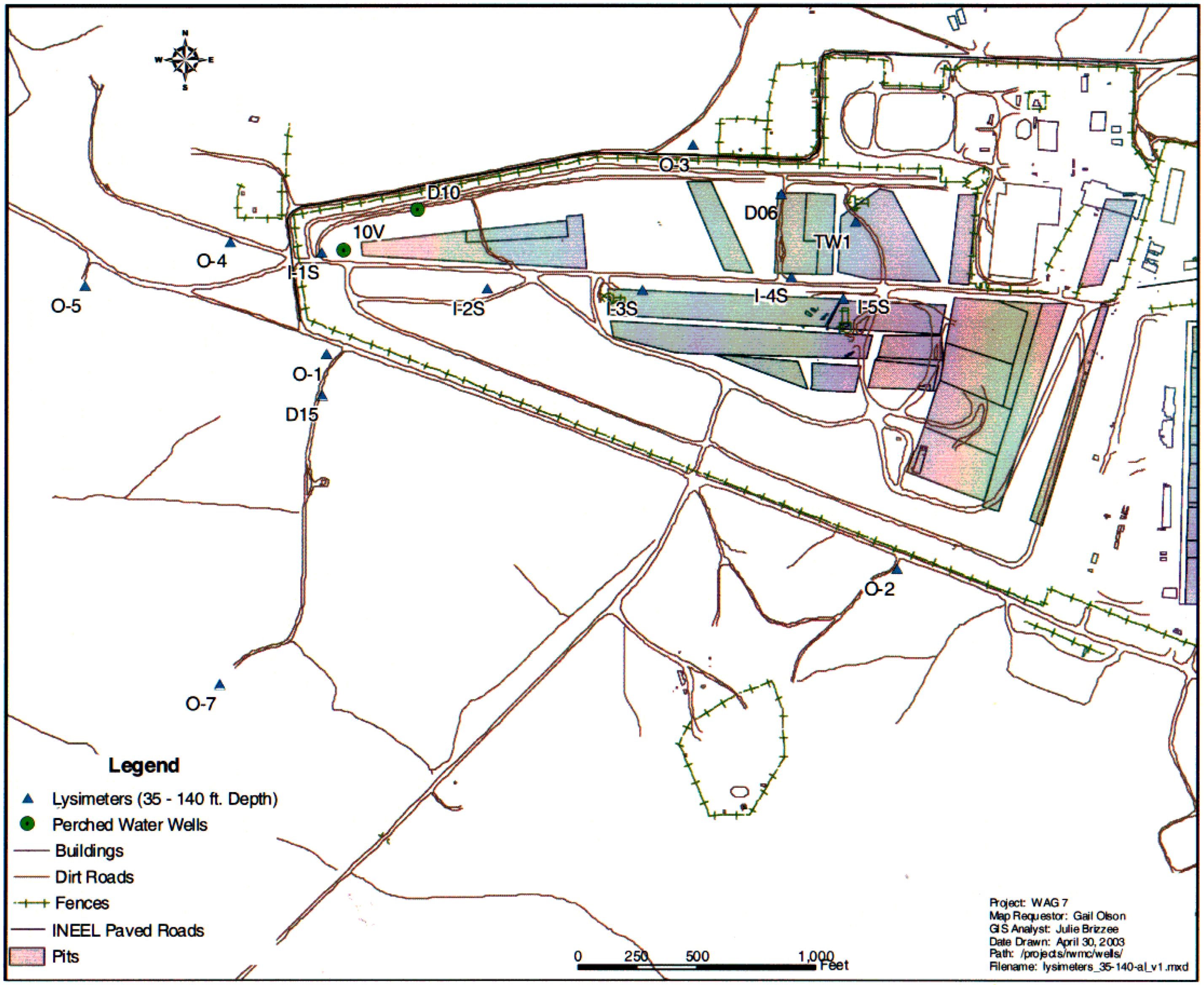


Figure 2-2. Locations of lysimeter monitoring wells in the 0- to 35-ft depth interval of the Subsurface Disposal Area.



Project: WAG 7
Map Requestor: Gail Olson
GIS Analyst: Julie Brizzee
Date Drawn: April 30, 2003
Path: /projects/rwmc/wells/
Filename: lysimeters_35-140-al_v1.mxd

Figure 2-3. Locations of lysimeter monitoring wells in the 35- to 140-ft depth interval of the Subsurface Disposal Area.

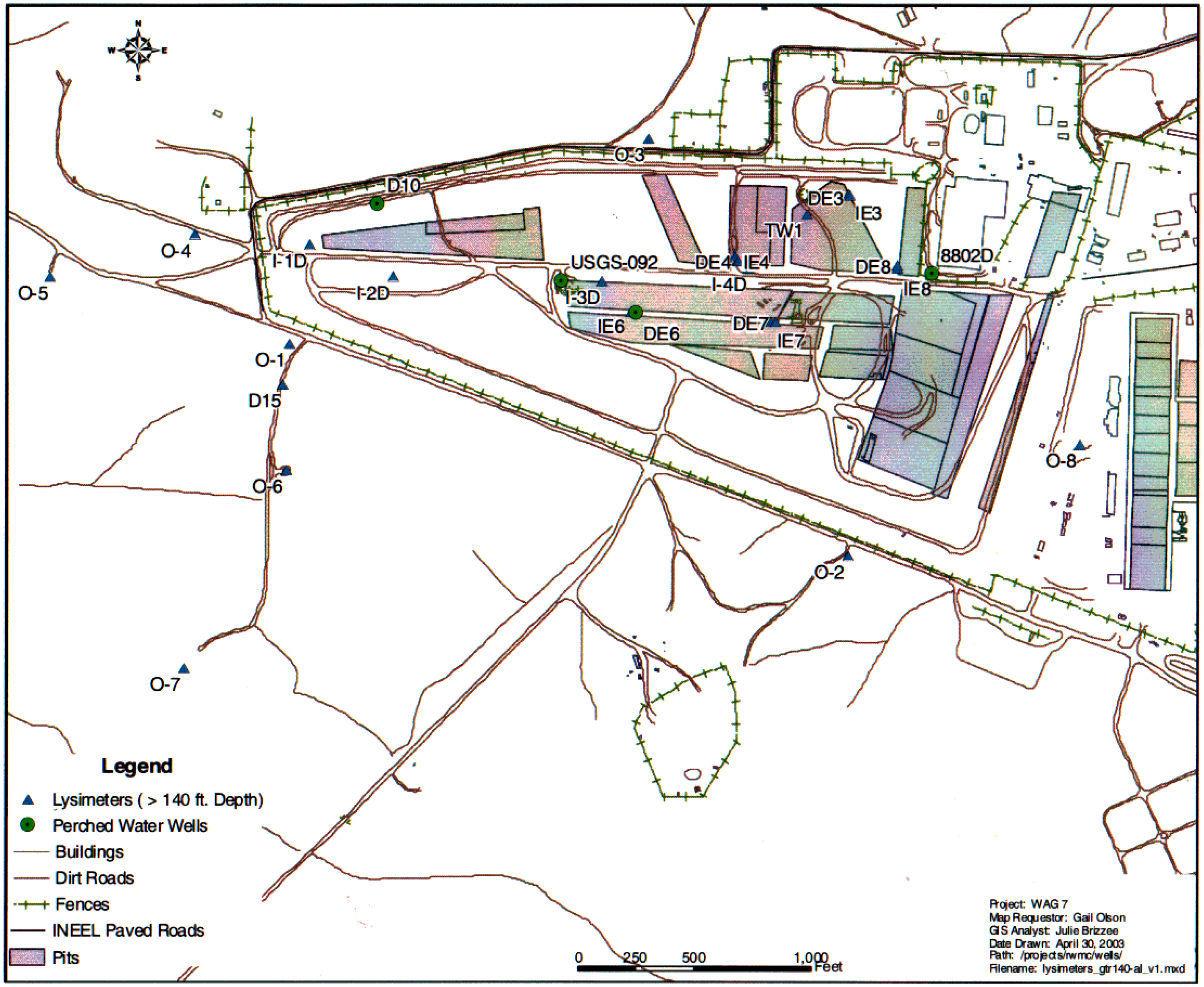


Figure 2-4. Locations of lysimeters and perched water monitoring wells in the >140-ft depth interval of the Subsurface Disposal Area.

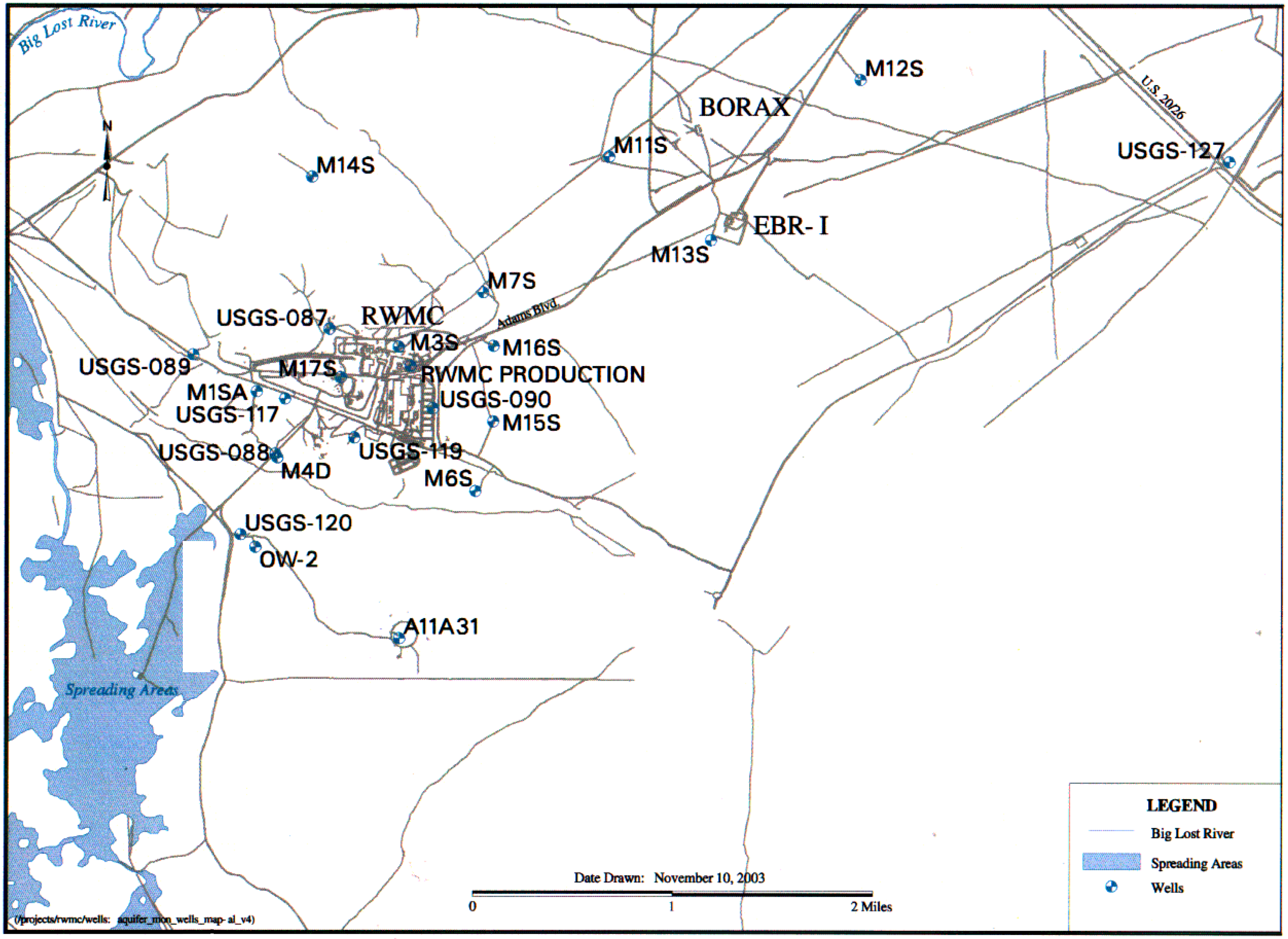


Figure 2-5. Locations of aquifer-monitoring wells at the Radioactive Waste Management Complex.

In an attempt to drill another M10S replacement well, S1898, near the southeast corner of the SDA, the drill bit broke off and lodged into the well. This rendered the well unusable for aquifer monitoring; however, alternatively, three vapor ports, one lysimeter, and one tensiometer were installed to monitor the vadose zone. The vapor ports are installed at three depth ranges: 93–95 ft, 213–216 ft, and 280–283 ft. The suction lysimeter is located at a depth of 223.5–225 ft, and the tensiometer is located at 226 ft.

2.4 Monitoring of Organic Contaminants

Routine monitoring for organic contaminants is conducted at the SDA in the atmosphere, shallow and deep soil gas, vadose zone, perched water, and aquifer. Sample locations and additional details are provided in the discussion of organic contaminant monitoring (see Section 4).

3. RADIONUCLIDE CONTAMINANTS IN THE ENVIRONMENT

Waste zone, vadose zone, and aquifer samples are collected routinely around the RWMC and are analyzed for a variety of radionuclides. Results from monitoring of radionuclides for FY 2003 are presented in this section. Historical data collected since FY 1997 also are summarized for perspective and to identify trends or lack thereof.

Radionuclide concentrations greater than 3σ and greater than the sample-specific minimum detectable activity (MDA) are referred to throughout this section as positive detections. Concentrations that are greater than 2σ and less than or equal to 3σ are referred to as statistically positive detections.

When the laboratory analysis results in a statistically positive detection of one or more actinides (i.e., Am-241, Np-237, Pu-238, and Pu-239/240) in aquifer samples, the laboratory pulls another aliquot from the sample container and conducts another analysis of the sample to confirm the detection. When the second analysis fails to confirm the presence of the actinide, the result is referred to throughout this section as an unconfirmed detection. In FY 2003, protocol for lysimeter samples was changed so that confirmation analyses are no longer conducted for actinide detections. The revised actinide protocol for lysimeters favors acquisition of data for various other priority analytes over confirmation of sporadic actinide detections.

3.1 Americium-241

Approximately 1.83E+05 Ci of Am-241 was disposed of in the SDA, and approximately 3.25E+04 Ci of Am-241 is expected to be generated over time through Pu-241 radioactive decay. The primary source of Am-241 and Np-237 in the SDA is the Rocky Flats Plant (RFP)[a] Series 741 sludge (i.e., first-stage wastewater sludge). An area in the central part of Pit 10 was identified as the Americium/Neptunium Focus Area for the OU 7-13/14 Probing Project.

3.1.1 Waste Zone

Approximately 10 mL of soil moisture was collected from Waste-Zone Lysimeter 741-08-L1 on September 8, 2003, but the volume was not sufficient to analyze for Am-241. However, the sample was analyzed for 13 targeted gamma-emitting radionuclides (Mn-54, Co-60, Zn-65, Ru-106, Ag-108m, Ag-110m, Sb-125, Cs-134, Cs-137, Ce-144, Eu-152, Eu-154, and Eu-155); plus any other positively detected anthropogenic, or unusually high, naturally occurring gamma emitters. No gamma-emitting radionuclides were detected.

3.1.2 Vadose Zone

3.1.2.1 Lysimeter Samples at Depths of 0 to 35 ft. Fourteen Am-241 analyses were performed on soil-moisture samples collected from 11 shallow lysimeters in and around the SDA in FY 2003, with no positive detections. Results for Am-241 in the shallow vadose zone samples, since routine monitoring began in 1997, are summarized in Figure 3-1. Sporadic detections occur, but no apparent trends for Am-241 are exhibited in the shallow lysimeters.

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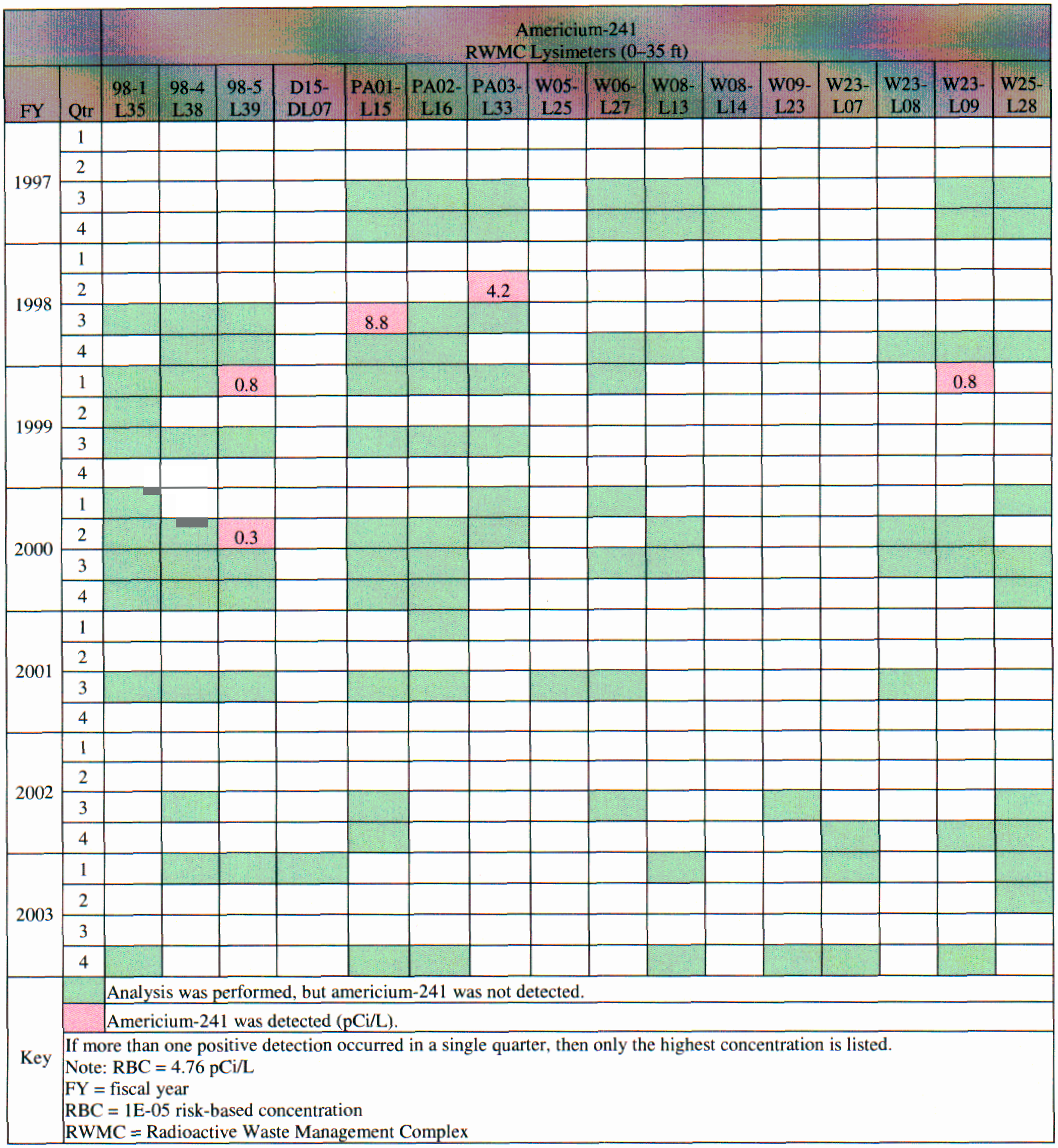
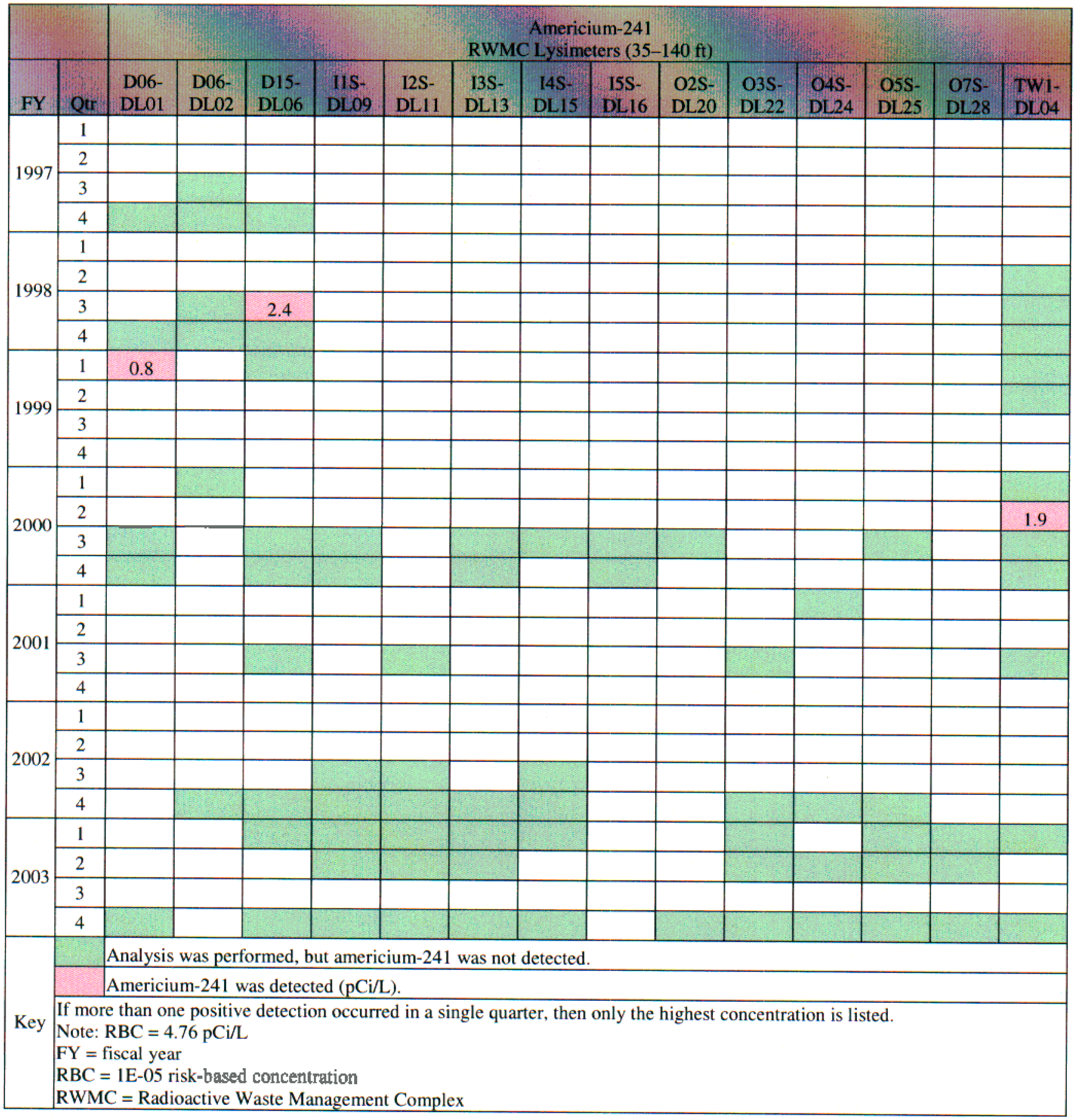
[a] The Rocky Flats Plant is located 26 km (16 mi) northwest of Denver, Colorado. In the mid-1990s, it was renamed the Rocky Flats Environmental Technology Site. In the late 1990s, it was again renamed, to its present name, the Rocky Flats Plant Closure Project.



FY	Qtr	Americium-241 RWMC Lysimeters (0–35 ft)															
FY	Qtr	98-1 L35	98-4 L38	98-5 L39	D15-DL07	PA01-L15	PA02-L16	PA03-L33	W05-L25	W06-L27	W08-L13	W08-L14	W09-L23	W23-L07	W23-L08	W23-L09	W25-L28
1997	1																
	2																
	3					🟩	🟩	🟩		🟩	🟩	🟩				🟩	🟩
	4					🟩	🟩	🟩		🟩	🟩	🟩				🟩	🟩
1998	1																
	2							4.2									
	3	🟩	🟩	🟩		8.8	🟩	🟩									
	4		🟩	🟩		🟩	🟩			🟩	🟩				🟩	🟩	🟩
1999	1	🟩	🟩	0.8		🟩	🟩	🟩		🟩						0.8	
	2	🟩															
	3	🟩	🟩	🟩		🟩	🟩	🟩									
	4																
2000	1	🟩						🟩		🟩							🟩
	2	🟩	🟩	0.3		🟩	🟩	🟩			🟩				🟩	🟩	
	3	🟩	🟩	🟩		🟩	🟩			🟩	🟩				🟩	🟩	🟩
	4	🟩	🟩	🟩		🟩	🟩										🟩
2001	1						🟩										
	2																
	3	🟩	🟩	🟩		🟩	🟩		🟩	🟩					🟩		
	4																
2002	1																
	2																
	3		🟩			🟩				🟩			🟩				🟩
	4					🟩								🟩		🟩	🟩
2003	1		🟩	🟩	🟩						🟩			🟩			🟩
	2																🟩
	3																
	4	🟩				🟩	🟩				🟩		🟩	🟩		🟩	
Key	🟩	Analysis was performed, but americium-241 was not detected.															
	🟥	Americium-241 was detected (pCi/L).															
	If more than one positive detection occurred in a single quarter, then only the highest concentration is listed. Note: RBC = 4.76 pCi/L FY = fiscal year RBC = 1E-05 risk-based concentration RWMC = Radioactive Waste Management Complex																

Figure 3-1. Occurrences of americium-241 detections in the shallow lysimeters since Fiscal Year 1997.

3.1.2.2 Lysimeter Samples at Depths of 35 to 140 ft. Twenty-eight Am-241 analyses were performed on soil-moisture samples collected from 12 intermediate-depth lysimeters in and around the SDA in FY 2003, with no positive detections. Results for the intermediate vadose zone samples, since routine monitoring began in 1997, are summarized in Figure 3-2. There are sporadic detections, but no apparent trends for Am-241 in the intermediate-depth lysimeters.



		Americium-241 RWMC Lysimeters (35–140 ft)													
FY	Qtr	D06-DL01	D06-DL02	D15-DL06	I1S-DL09	I2S-DL11	I3S-DL13	I4S-DL15	I5S-DL16	O2S-DL20	O3S-DL22	O4S-DL24	O5S-DL25	O7S-DL28	TW1-DL04
1997	1														
	2														
	3		🟩												
	4	🟩	🟩	🟩											
1998	1														
	2														🟩
	3		🟩	🟥 2.4											🟩
	4	🟩	🟩	🟩											🟩
1999	1	🟥 0.8		🟩											🟩
	2														🟩
	3														
	4														
2000	1		🟩												🟩
	2														🟥 1.9
	3	🟩		🟩	🟩		🟩	🟩	🟩	🟩			🟩		🟩
	4	🟩		🟩	🟩		🟩		🟩						🟩
2001	1											🟩			
	2														
	3			🟩		🟩					🟩				🟩
	4														
2002	1														
	2														
	3				🟩	🟩		🟩							
	4		🟩	🟩	🟩	🟩	🟩	🟩			🟩	🟩	🟩		
2003	1			🟩	🟩	🟩	🟩	🟩			🟩		🟩	🟩	🟩
	2				🟩	🟩	🟩				🟩	🟩	🟩	🟩	
	3														
	4	🟩		🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩	🟩

Key		
	🟩	Analysis was performed, but americium-241 was not detected.
	🟥	Americium-241 was detected (pCi/L).

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.
Note: RBC = 4.76 pCi/L
FY = fiscal year
RBC = 1E-05 risk-based concentration
RWMC = Radioactive Waste Management Complex

Figure 3-2. Occurrences of americium-241 detections in intermediate-depth (35- to 140-ft) lysimeters since Fiscal Year 1997.

3.1.2.3 *Lysimeter Samples at Depths Greater than 140 ft.* Seventeen Am-241 analyses were performed on perched water and deep-suction lysimeter samples collected from two perched wells and six lysimeters in and around the SDA in FY 2003, with no positive detections. Results for the samples, since routine monitoring began in 1997, are summarized in Figure 3-3. The "I" and "O" wells were installed between November 1999 and March 2000, and the first samples were collected in June 2000. No detections of Am-241 have occurred in any perched water or vadose zone samples at this depth interval in the 6-year reporting period addressed in this report.

		Americium-241 RWMC Perched Water and Lysimeters (>140 ft)									
FY	Qtr	8802D	USGS-092	I2D-DL10	I3D-DL12	I4D-DL14	O2-DL19	O4-DL23	O6-DL26	O7-DL27	O8-DL29
1997	1		🟩								
	2										
	3		🟩								
	4		🟩								
1998	1		🟩								
	2	🟩	🟩								
	3		🟩								
	4		🟩								
1999	1	🟩	🟩								
	2	🟩	🟩								
	3										
	4										
2000	1		🟩								
	2	🟩	🟩								
	3				🟩				🟩		
	4		🟩						🟩		
2001	1		🟩					🟩			
	2										
	3										
	4										
2002	1										
	2		🟩								
	3			🟩	🟩	🟩					🟩
	4				🟩				🟩	🟩	
2003	1	🟩	🟩		🟩	🟩	🟩	🟩		🟩	
	2		🟩		🟩	🟩	🟩	🟩			
	3										
	4		🟩	🟩				🟩		🟩	

🟩 Analysis was performed for americium-241, but none was detected.

🟥 Americium-241 was detected (pCi/L).

If more than one positive detection occurred in a well in a single quarter, then only the highest concentration is listed.
FY = fiscal year
RWMC = Radioactive Waste Management Complex

Figure 3-3. Occurrences of americium-241 detections in the deep-depth (>140 ft) lysimeters since Fiscal Year 1997.

3.1.3 Aquifer

Sixty-four Am-241 analyses were performed on aquifer samples collected from 15 monitoring wells in the vicinity of the RWMC in FY 2003, with no positive detections. Samples were collected in November 2002 and February, April, May, and August 2003. The results are summarized in Figure 3-4.

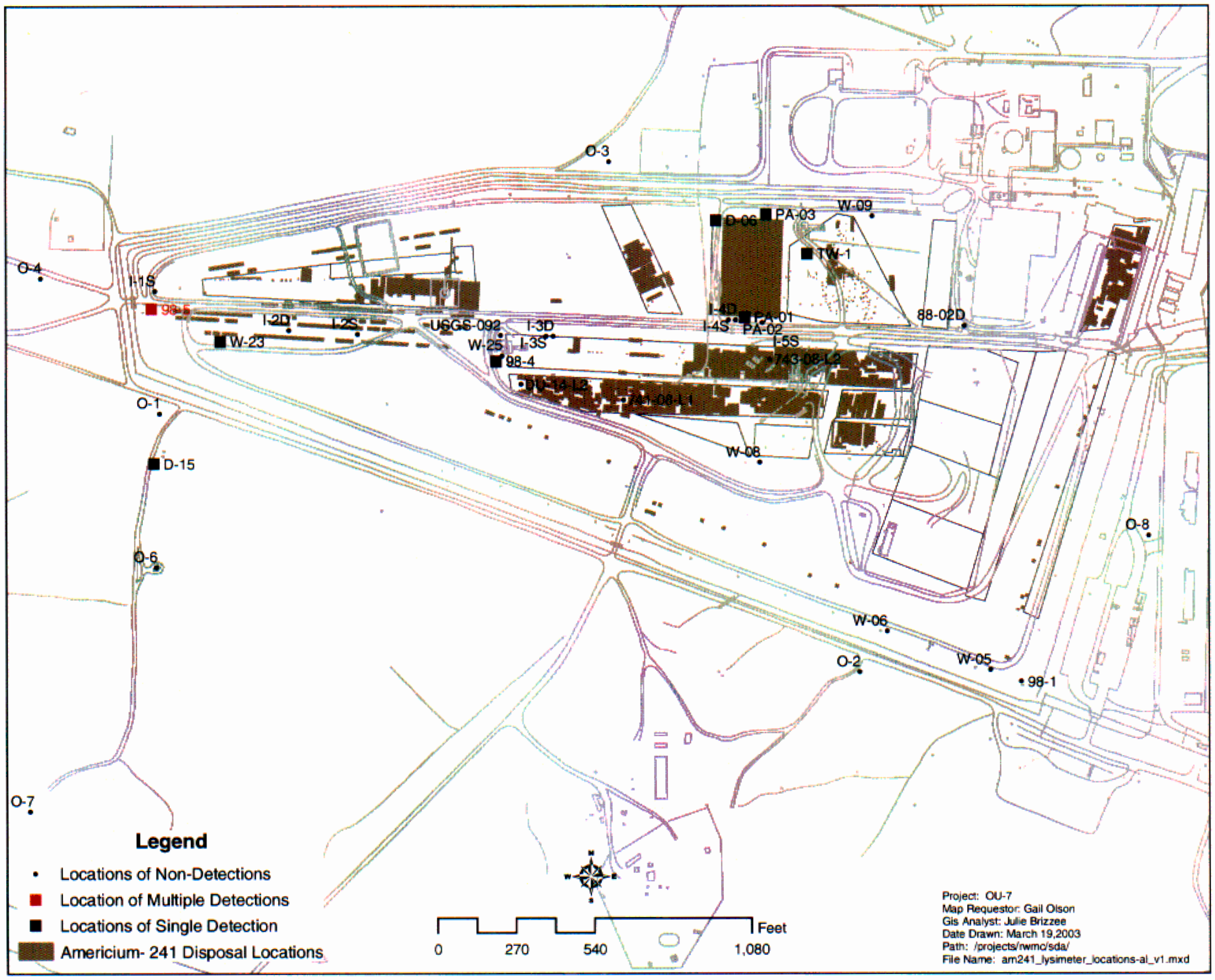
Results for the aquifer samples show sporadic detections but no evident trends. None of the positive detections exceeded the maximum contaminant level (MCL) of 15 pCi/L (total alpha) or the calculated aquifer 1E-05 RBC of 4.6 pCi/L.

		Americium-241 RWMC Aquifer-Monitoring Wells															
FY	Qtr	A11 A31	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	M1S	M3S	M4D	M6S	M7S	OW-2	USGS- 127
1993	All		🟩								🟩		🟩				
1994	All																
1995	All		🟩								🟩						
1996	All		🟩								🟩	🟩	🟩	🟩	🟩		
1997	1–4		🟩								🟩	🟩	🟩	🟩	🟩		
1998	1		🟩								1.13	🟩	🟩	🟩	🟩		
	2										🟩	🟩					
	3		🟩								1.97	🟩	🟩	🟩	🟩		
	4		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
1999	1		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	2		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	3		🟩	0.026	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	4		🟩	🟩		🟩	🟩				🟩	🟩	🟩	🟩	🟩		
2000	1		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	2		🟩	🟩	🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩		
	3									🟩							
	4		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	0.027	🟩	🟩	🟩		🟩
2001	1	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4			🟩	🟩	🟩	🟩	0.039	🟩	🟩	🟩	🟩	0.066	🟩	🟩	🟩	0.058
2002	1	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
2003	1	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩

Key
🟩 cium-241 was no
🟥 A
If n
No
FY = fiscal year
MCL = maximum contaminant level
RBC = 1E-05 risk-based concentration
RWMC = Radioactive Waste Management Complex
USGS = United States Geological Survey

3.1.4 Summary of Americium-241

Americium-241 was not detected in any of the soil-moisture or aquifer samples collected in FY 2003. Historical detections in the vadose zone are depicted with the locations of waste disposals known to contain Am-241 (see Figure 3-5). All but one of the mapped detections are one-time events that have not been substantiated with subsequent detections in more than 3 years. Two detections were made in Lysimeter 98-5L39, located on the west end of the SDA near some mapped disposals, but no positive detections have been found in the four sampled quarters since the second quarter of FY 2000. Aquifer detections of Am-241 also are sporadic. Sporadic detections of Am-241 in the vadose zone and the aquifer since 1993 do not point to any evident spatial or temporal trends.



Project: OU-7
Map Requestor: Gail Olson
Gis Analyst: Julie Brizzee
Date Drawn: March 19,2003
Path: /projects/rwmc/sda/
File Name: am241_lysimeter_locations-al_v1.mxd

Figure 3-5. Americium-241 disposal locations and vadose zone detection locations at the Subsurface Disposal Area.

3.2 Carbon-14

Carbon-14 is an activation product generated by nuclear operations. Most of the C-14 inventory in the SDA is contained in activated steel. Some of the disposal inventory is in the form of reactor core components, including beryllium reflector blocks and end pieces from reactor cores. Most of the remaining activity is in ion-exchange resins. Typical C-14-bearing waste was disposed of in the SVRs or trenches in the earlier years of operation.

Soil Vault Rows 12 and 20 in the southeast corner of the SDA are known to contain large amounts of C-14 because of disposals of activated steel and beryllium blocks. Soil Vault Row 20 contains beryllium blocks from the Advanced Test Reactor, which contained approximately 12 Ci of C-14. Soil Vault Row 12 contains numerous disposals of what are believed to be activated stainless steel. Information gathered through conversations with past and present INEEL staff (Salomon 2003) indicates that these disposals are probably highly irradiated stainless-steel end pieces removed from Experimental Breeder Reactor II spent fuel elements. Spent fuel elements from Experimental Breeder Reactor II were sent to the Idaho Nuclear Technology and Engineering Center (INTEC) for processing after use. The stainless-steel end pieces were physically separated from the fuel in underwater basins at the Chemical Processing Plant (CPP) (now INTEC) facility, CPP-603, before uncontained disposal (in baskets, not sealed) at the RWMC. Ten shipments were sent from CPP-603 and placed in SVR 12. The rate of C-14 release from activated steel, presumably by corrosion, is being studied at SVR 12. Type B probes with vapor ports were installed in 2001, and initial sampling was conducted in 2002.[b]

3.2.1 Waste Zone

Approximately 10 mL of soil moisture was collected from Waste-Zone Lysimeter 741-08-L1 on September 8, 2003, but the volume was not sufficient to analyze for C-14; however, the sample was analyzed for gamma-emitting radionuclides with no positive detections.

Carbon-14 samples are collected quarterly from the functioning Type B vapor probes at SVRs 12 and 20. Sampling sites near SVRs 12 and 20 are shown in Figure 3-6. The C-14 samples are analyzed for C-14-specific activity (i.e., C-14 activity per unit mass of total carbon). Carbon-14 results for the functioning probes at SVR 12 are contained in Table 3-1. The results for C-14 analyses indicate that the C-14-specific activity in SVR 12 samples is two to three orders of magnitude above the typical background concentration of C-14, which is 6.5 pCi/g C. The concentration of H-3 in soil gas near SVR 12 also was measured and determined to be less than 600 pCi/L and probably considerably less than 100 pCi/L (i.e., near background levels). The absence of H-3 in the soil gas provides confidence that the C-14 originates from the activated stainless steel in SVR 12 rather than activated beryllium.[c]

Specific activity of C-14 in CO_2 has been measured in grab samples of soil gas collected from the Gas Sampling Port (GSP) -1 ports. Results for soil-gas samples are summarized in Table 3-2. These results are for samples collected using caustic solutions in bubblers before FY 2000 and in Tedlar bags after FY 2000. The SVR 20-IPV-5-VP3 soil-gas sampling port is located approximately 5 m (16 ft) from the beryllium waste, and the GSP-1 gas sampling ports are located approximately 0.8 to 1 m (2.6 to 3 ft) from the waste. The specific activity of C-14 in CO_2 is approximately a factor of 3 less at the more distant location, based on the samples from both ports on November 15, 2001, and August 23, 2002.

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b. B. G. Schnitzler Letter to M. M. Garland, August 21, 1995, "Radionuclide Inventories of Advanced Test Reactor Outer Shim Control Cylinder and Reflector Block Components," BGS-12-95, Idaho National Engineering and Environmental Laboratory.

c. The SVR 12 Type B vapor ports are approximately 210 ft from the nearest activated beryllium disposal location (personal communication with D. Mahnami, February 2004).

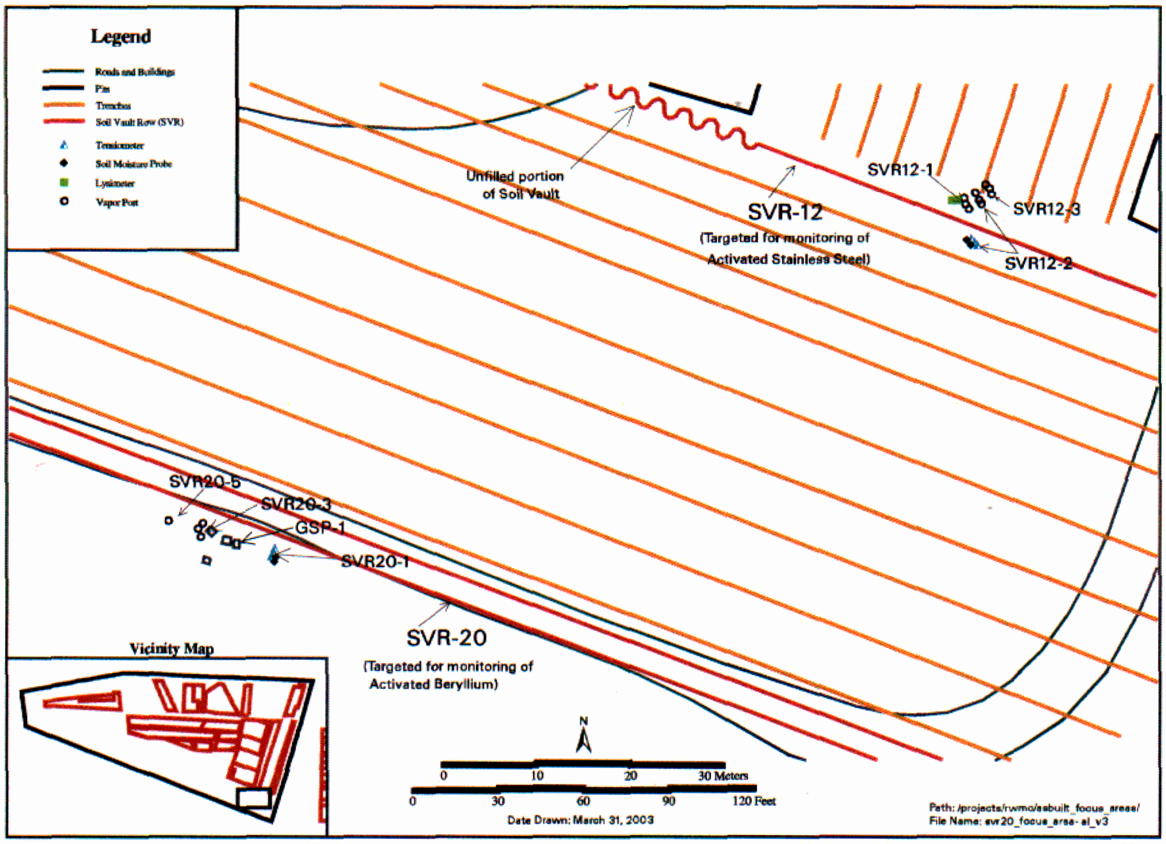


Figure 3-6. Vapor probes, tensiometers, lysimeters, and soil-moisture probes installed in the waste zone near or in Soil Vault Rows 12 and 20.

Table 3-1. Specific activity of carbon-14 (pCi [C-14]/g [C]) from vapor probes at Soil Vault Row 12.

Date	SVR-12-1-VP1	SVR-12-1-VP2	SVR-12-1-VP3	SVR-12-2-VP1	SVR-12-2-VP2	SVR-12-2-VP3	SVR-12-3-VP1	SVR-12-3-VP2	SVR-12-3-VP3
12/03/01	3,300	3,300	8,400	2,700	3,500	—[a]	2,900	3,000	8,200
2/20/02	2,100	450	—	1,400	—	—	2,000	1,500	16,000
5/23/02	990	990	2,800	1,400	840	630	1,200	1,600	370
8/13/02	1,200	1,200	1,600	1,300	1,000	380	2,200	1,200	480
8/23/02	—	—	—	—	—	—	—	—	—
11/13/02	710	560	<MDA[b]	1,500	590	<MDA	1,100	680	<MDA
2/3/03	880	680	<MDA	970	—	480	1,100	680	<MDA
5/15/03	710	480	230	820	550	280	480	680	110

a. Dash indicates that no sample was taken on that date.

b. Relative uncertainty >33%. The relative uncertainty of the other results is typically 5–10%. In addition, the CO_2 concentrations in these samples are relatively low.

c. In the analytical report, SVR-20-5-VP3 probe results apparently were switched with the SVR-12-1-VP3 results. The value reported here is considered the correct value for the sample.

MDA = minimum detectable activity

SVR ■ soil vault row

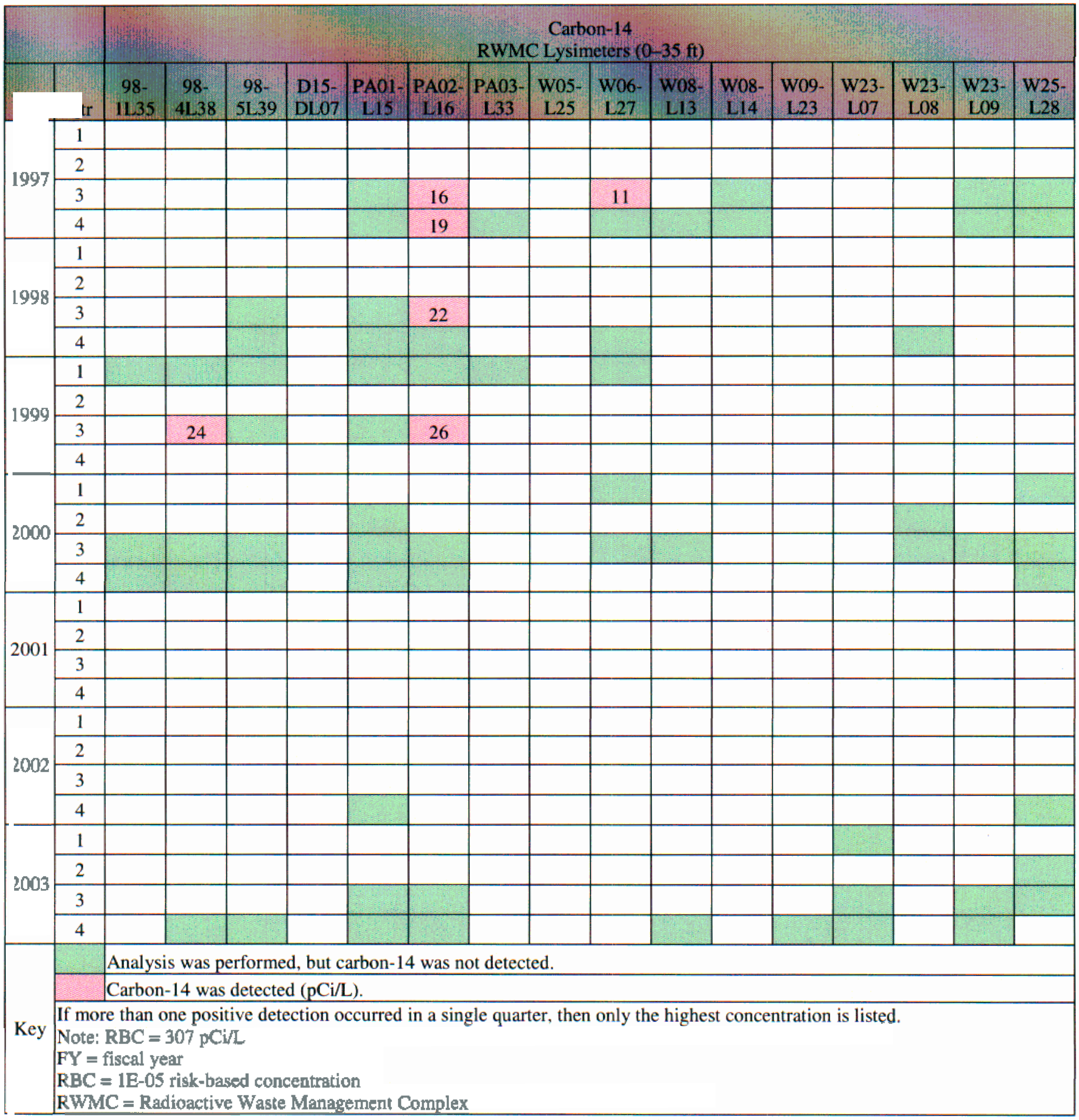
Table 3-2. Summary of carbon-14-specific activity (pCi [C-14]/g [C]) in CO_2 from soil-gas samples collected at Soil Vault Row 20.

	GSP-1	GSP-1	GSP-1	SVR 20-IPV-5-VP3
Depth (m)	2.7	4.5	6.2	5.4
Date				
6/5/96	1.7E+04	—	2.3E+04	—
7/2/96	—	3.4E+04	2.5E+04	—
12/12/96	1.3E+05	4.2E+04	3.3E+04	—
11/12/97	4.4E+04	2.0E+04	1.2E+04	—
11/15/01	3.6E+05	1.6E+05	2.4E+05	8.3E+04
2/20/02	—	—	—	2.8E+04
5/2/02	1.7E+05	1.4E+05	1.3E+05	—
5/23/02	—	—	—	3.1E+04
8/23/02	1.3E+05	1.3E+05	1.4E+05	3.7E+04
11/13/02	—	—	—	2.4E+04
11/5/03	—	—	—	4.1E+04[c]

GSP = gas sampling port
SVR = soil vault row

3.2.2 Vadose Zone

3.2.2.1 Lysimeter Samples at Depths of 0 to 35 ft. Fourteen C-14 analyses were performed on soil-moisture samples collected from nine shallow lysimeters in and around the SDA in FY 2003, with no positive detections. Results for C-14 in shallow vadose zone samples, since routine monitoring began in 1997, are summarized in Figure 3-7. Sporadic detections occur, but no apparent trends are exhibited in the shallow lysimeters.



		Carbon-14 RWMC Lysimeters (0–35 ft)															
	tr	98-1L35	98-4L38	98-5L39	D15-DL07	PA01-L15	PA02-L16	PA03-L33	W05-L25	W06-L27	W08-L13	W08-L14	W09-L23	W23-L07	W23-L08	W23-L09	W25-L28
1997	1																
	2																
	3					🟩	🟥 16			🟥 11		🟩				🟩	🟩
	4					🟩	🟥 19	🟩		🟩	🟩	🟩				🟩	🟩
1998	1																
	2																
	3			🟩		🟩	🟥 22										
	4			🟩		🟩	🟩			🟩					🟩		
1999	1	🟩	🟩	🟩		🟩	🟩	🟩		🟩							
	2																
	3		🟥 24	🟩		🟩	🟥 26										
	4																
2000	1									🟩							🟩
	2					🟩									🟩		
	3	🟩	🟩	🟩		🟩	🟩			🟩	🟩				🟩	🟩	🟩
	4	🟩	🟩	🟩		🟩	🟩										🟩
2001	1																
	2																
	3																
	4																
2002	1																
	2																
	3																
	4					🟩											🟩
2003	1													🟩			
	2																🟩
	3					🟩	🟩							🟩		🟩	🟩
	4		🟩	🟩		🟩	🟩				🟩		🟩	🟩		🟩	

Key
🟩 Analysis was performed, but carbon-14 was not detected.
🟥 Carbon-14 was detected (pCi/L).
If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.
Note: RBC = 307 pCi/L
FY = fiscal year
RBC = 1E-05 risk-based concentration
RWMC = Radioactive Waste Management Complex

Figure 3-7. Occurrences of carbon-14 detections in shallow lysimeters since Fiscal Year 1997.

3.2.2.2 Lysimeter Samples at Depths of 35 to 140 ft. Fifteen C-14 analyses were performed on soil-moisture samples collected from 12 lysimeters in and around the SDA in FY 2003, with one positive detection (see Table 3-3). Results for C-14 in intermediate-depth vadose zone samples, since routine monitoring began in 1997, are summarized in Figure 3-8. The positive result did not exceed the primary drinking water MCL of 2,000 pCi/L or the calculated aquifer 1E-05 RBC of 307 pCi/L. The MCL and aquifer RBC are not applicable to soil-moisture samples, but are used as a basis for comparison.

Table 3-3. Carbon-14 detection in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 35- to 140-ft depth interval.

Lysimeter	Depth (ft)	Sample Date	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pCi/L)	Aquifer RBC[b] (pCi/L)
I2S-DL11	92	07/21/03	46 ± 14[c]	46	Nondetect	307

a. The local soil-moisture background concentration for carbon-14 is defined as a nondetect (i.e., a result less than or equal to its MDA and less than or equal to three times its reported 1σ uncertainty).

b. RBC = 1E-05 for drinking water. The RBCs for the aquifer are provided here as a basis of comparison.

c. Black bold font indicates sample concentrations less than the RBC, but exceeding local soil-moisture background concentrations (see footnote a).

MDA = minimum detectable activity

RBC = risk-based concentration

SDA = Subsurface Disposal Area

		Carbon-14 Lysimeters (35–140 ft)													
FY	Qtr	D06 DL01	D06-DL02	D15-DL06	I1S-DL09	I2S-DL11	I3S-DL13	I4S-DL15	I5S-DL16	O2-DL20	O3-DL22	O4-DL24	O5-DL25	O7-DL28	TW1-DL04
1997	1														
	2														
	3														
	4		🟩												
1998	1														
	2														
	3		🟩	🟩											🟩
	4		🟩	🟩											🟩
1999	1														🟩
	2														
	3														
	4														
2000	1														
	2														
	3														
	4														
2001	1														
	2														
	3														
	4														
2002	1														
	2														
	3				🟩										
	4														
2003	1			🟩									🟩		
	2				🟩										
	3														
	4	🟩		🟩	🟩	46	🟩	🟩		🟩	🟩	🟩	🟩	🟩	🟩

Key		
	🟩	Analysis was performed for carbon-14, but none was detected.
	🟥	Carbon-14 was detected (pCi/L).
	If more than one positive detection occurred in a well in a single quarter, then only the highest concentration is listed. FY = fiscal year	

Figure 3-8. Occurrences of carbon-14 detections in intermediate-depth (35 to 140 ft) lysimeters since Fiscal Year 1997.

3.2.2.3 Lysimeter and Perched Water Samples at Depths Greater than 140 ft.

3.2.2.3 Lysimeter and Perched Water Samples at Depths Greater than 140 ft. Seven C-14 analyses were performed on perched water and deep-suction lysimeter samples collected from one perched well and five lysimeters in and around the SDA in FY 2003, with no positive detections. Results for C-14 in deep vadose zone samples, since routine monitoring began in 1997, are summarized in Figure 3-9.

		Carbon-14 RWMC Perched Water and Lysimeters (>140 ft)									
FY	Qtr	8802D	USGS-092	I2D-DL10	13D-DL12	I4D-DL14	O2-DL19	O4-DL23	O6-DL26	O7-DL27	O8-DL29
1997	1										
	2										
	3		🟥 12								
	4		🟥 13								
1998	1										
	2	🟥 20	🟥 20								
	3	🟩	🟩								
	4										
1999	1		🟩								
	2		🟩								
	3										
	4										
2000	1		🟩								
	2										
	3										
	4										
2001	1										
	2										
	3										
	4										
2002	1										
	2		🟥 134								
	3										
	4										
2003	1		🟩								
	2										
	3										
	4		🟩	🟩	🟩	🟩		🟩		🟩	

Key

🟩 Analysis was performed for carbon-14, but none was detected.

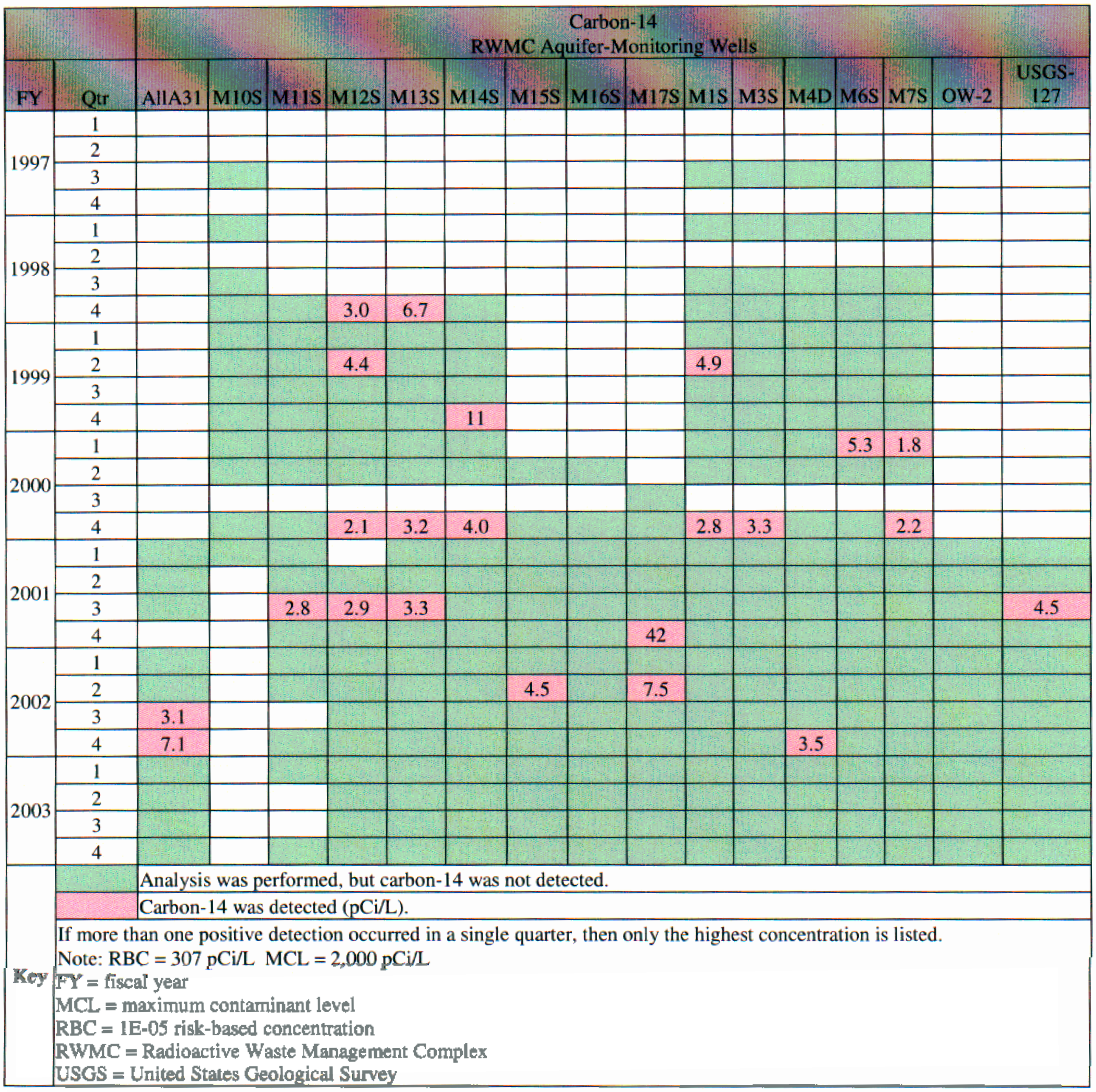
🟥 Carbon-14 was detected (pCi/L).

If more than one positive detection occurred in a well in a single quarter, then only the highest concentration is listed.
FY = fiscal year
RWMC = Radioactive Waste Management Complex

Figure 3-9. Occurrences of carbon-14 detections in deep-depth (>140 ft) lysimeters since Fiscal Year 1997.

3.2.3 Aquifer

Sixty-three C-14 analyses were performed on aquifer samples collected from 15 monitoring wells in the vicinity of the RWMC in FY 2003, with one detection. The detection, however, did not meet all the criteria of a positive detection, since its result (0.7±0.2 pCi/L) was less than the MDA (0.8 pCi/L). Therefore, the project assigned a "J" data qualifier flag to the result to indicate it was not a valid detection. Carbon-14 occurrences in aquifer samples, since 1997, are summarized in Figure 3-10. Results for the RWMC aquifer samples show sporadic detections but no evident trends. None of the positive detections exceeded the MCL of 2,000 pCi/L or the calculated aquifer 1E-05 RBC of 307 pCi/L.



		Carbon-14 RWMC Aquifer-Monitoring Wells															
FY	Qtr	AllA31	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	M1S	M3S	M4D	M6S	M7S	OW-2	USGS-127
1997	1																
	2																
	3		🟩								🟩	🟩	🟩	🟩	🟩		
	4																
1998	1		🟩								🟩	🟩	🟩	🟩	🟩		
	2																
	3		🟩								🟩	🟩	🟩	🟩	🟩		
	4		🟩	🟩	🟥 3.0	🟥 6.7	🟩				🟩	🟩	🟩	🟩	🟩		
1999	1		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	2		🟩	🟩	🟥 4.4	🟩	🟩				🟥 4.9	🟩	🟩	🟩	🟩		
	3		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	4		🟩	🟩	🟩	🟩	🟥 11				🟩	🟩	🟩	🟩	🟩		
2000	1		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟥 5.3	🟥 1.8		
	2		🟩	🟩	🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩		
	3									🟩							
	4		🟩	🟩	🟥 2.1	🟥 3.2	🟥 4.0	🟩	🟩	🟩	🟥 2.8	🟥 3.3	🟩	🟩	🟥 2.2		
2001	1	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩		🟥 2.8	🟥 2.9	🟥 3.3	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥 4.5
	4			🟩	🟩	🟩	🟩	🟩	🟩	🟥 42	🟩	🟩	🟩	🟩	🟩	🟩	🟩
2002	1	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩		🟩	🟩	🟩	🟩	🟥 4.5	🟩	🟥 7.5	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟥 3.1			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4	🟥 7.1		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥 3.5	🟩	🟩	🟩	🟩
2003	1	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩

Key

🟩 Analysis was performed, but carbon-14 was not detected.

🟥 Carbon-14 was detected (pCi/L).

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.

Note: RBC = 307 pCi/L MCL = 2,000 pCi/L

FY = fiscal year
MCL = maximum contaminant level
RBC = 1E-05 risk-based concentration
RWMC = Radioactive Waste Management Complex
USGS = United States Geological Survey

Figure 3-10. Occurrences of carbon-14 detections in the aquifer-monitoring wells since Fiscal Year 1997.

3.2.4 Summary of Carbon-14

Carbon-14 in soil-gas samples collected near the beryllium block disposals in SVR 20 are approximately four orders of magnitude higher than background levels. Results for C-14 analyses in the waste zone at SVR 12 indicate that the C-14-specific activity in soil gas is approximately two orders of magnitude higher than the background level of 6.5 pCi of C-14 per gram of carbon. The concentration of C-14 in soil-gas samples near activated steel (SVR 12) is much lower than the concentration observed near activated beryllium (SVR 20). This difference is as expected because of the relatively low concentration of C-14 in stainless steel and the much slower corrosion rate of stainless steel.

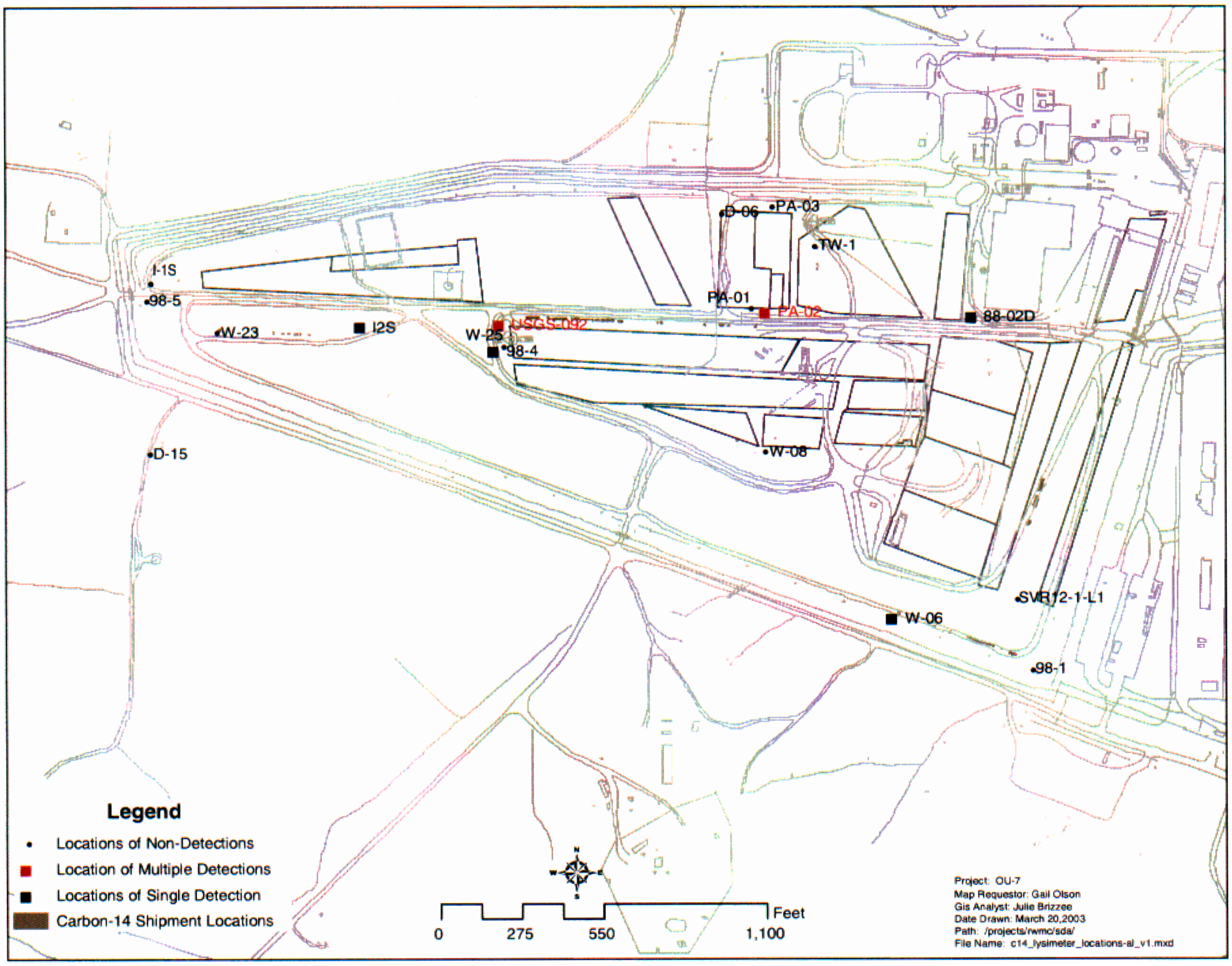


Figure 3-11. Carbon-14 disposal locations and vadose zone detection locations at the Subsurface Disposal Area.

Maximum concentrations of C-14 in vadose zone soil moisture and perched water since FY 1997 are shown in Table 3-4, and locations of detected C-14 in vadose zone samples are depicted in Figure 3-11 along with the known C-14 disposals. Carbon-14 was not detected in perched water or soil-moisture samples collected from the vadose zone in FY 2003, with the exception of I2S-DL11. The most frequent C-14 detections occurred in samples from the PA02-L16 shallow lysimeter (see Figure 3-7) and from the USGS-92 perched water well (see Figure 3-9). Most detections occurred between 1997 and 1999, with one in January 2002. Repeated positive detections in USGS-92 suggest that C-14 has migrated to the 67-m (220-ft) perched water region beneath the RWMC (see Holdren et al. 2002, Section 4). The concentration associated with the January 2002 sample from USGS-92 (i.e., 134 ± 38 pCi/L) is approximately 10 times higher than previous detections.

Table 3-4. Summary of maximum concentrations of carbon-14 in vadose zone soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.[a]

Sampling Range (feet below land surface)	Fiscal Year [b]	Maximum Concentration ± 1σ (pCi/L)[c]	Sample Location
Lysimeters 0 to 35 ft	1997	19 ± 4	PA02-L16
	1998	21.8 ± 1.9	PA02-L16
	1999	26 ± 5	PA02-L16
	2000	ND	Various[d]
	2001	NA	—
	2002	NA	—
	2003	ND	Various
Lysimeters 35 to 140 ft	1997	NA	—
	1998	ND	Various
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	NA	—
	2003	46 ± 14	I2S-DL11
Lysimeters >140 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	NA	—
	2003	ND	Various
Perched water wells >140 ft	1997	13 ± 2	USGS-92
	1998	20 ± 4	USGS-92 and 8802D
	1999	ND	USGS-92
	2000	NA	—
	2001	NA	—
	2002	134 ± 38	USGS-92
	2003	ND	USGS-92

a. MCL = 2,000 pCi/L
b. Fiscal year spans from October 1 to September (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).
c. NA = not analyzed ND = not detected
d. Various locations were sampled.
MCL = maximum contaminant level
USGS = United States Geological Survey

Trends are not apparent in any of the RWMC monitoring wells, and the detectable concentrations are well below the MCL of 2,000 pCi/L and the aquifer 1E-05 RBC of 307 pCi/L.

The lack of regularly occurring detections in the lysimeters or perched water wells in the vadose zone coupled with the possibility that an upgradient source of C-14 in the aquifer suggests that C-14 would not be a good calibration target for modeling concentrations in the aquifer. Maximum detections of C-14 in the aquifer since FY 1997 are presented in Table 3-5.

Table 3-5. Summary of maximum concentrations of carbon-14 in aquifer wells at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.[a]

Fiscal Year[b]	Maximum Concentration ± 1σ (pCi/L)	Well Location
1997	ND[c]	Various[d]
1998	6.7 ± 0.9	M13S
1999	10.9 ± 0.7	M14S
2000	5.3 ± 0.5	M6S
2001	42.1 ± 1.4	M17S
2002	7.5 ± 0.9	M17S
2003	ND	Various[d]

a. MCL = 2,000 pCi/L

b. Fiscal year spans from October 1 to September 30 (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).

c. ND = not detected

d. Various locations were sampled.

MCL = maximum contaminant level

3.3 Chlorine-36

Chlorine-36 is a radioisotope that is generated by nuclear reactor operations and weapons testing. In addition, it is produced in extremely low concentrations in the environment by cosmic-ray interactions with argon. It decays by the emission of beta particles, has a 30,100-year half-life, and was identified in the interim risk assessment as a contaminant of potential concern, primarily for the groundwater ingestion exposure pathways (Becker et al. 1998). Approximately 1.11 Ci of Cl-36 was disposed of in the SDA.

Results are presented for the vadose zone samples, but no analytical data for Cl-36 were collected from the waste zone or the aquifer samples in FY 2003. Lysimeters in the waste zone did not yield sufficient water for Cl-36 analyses in 2003, and the Cl-36 yearly sampling schedule for RWMC aquifer wells was not firmly established until the end of 2003.

3.3.1 Waste Zone

Approximately 10 mL of soil moisture was collected from Waste-Zone Lysimeter 741-08-L1 on September 8, 2003, but the volume was not sufficient to analyze for Cl-36; however, the sample was analyzed for gamma-emitting radionuclides with no positive detections.

3.3.2 Vadose Zone

3.3.2.1 Lysimeter Samples at Depths of 0 to 35 ft. Twenty-two Cl-36 analyses were performed on soil-moisture samples collected from 11 shallow lysimeters in and around the SDA in FY 2003, with three positive detections (see Table 3-6). The detections are associated with the

October 2002 sampling event, and the detected concentrations are considerably below the 1E-05 RBC of 144 pCi/L. Subsequent samples at these monitoring locations have not shown positive detections of Cl-36. The occurrence of Cl-36 detections in shallow lysimeters since 1997 is summarized in Figure 3-12; however, routine Cl-36 monitoring did not begin until October 2002. Sporadic detections occur, but no apparent trends are exhibited in the shallow lysimeters.

Table 3-6. Chlorine-36 detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 0- to 35-ft depth interval.

Lysimeter	Depth (ft)	Sample Date	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pCi/L)	Aquifer RBC[b] (pCi/L)
W08-L13	11.3	10/21/02	**5.8 ± 1.4**[c]	4.8	Nondetect	144
W23-L07	18.8	10/21/02	**32.3 ± 1.6_J**[cd]	3.3	Nondetect	144
98-5L39	10.5	10/21/02	**3.5 ± 0.9**[c]	3.0	Nondetect	144

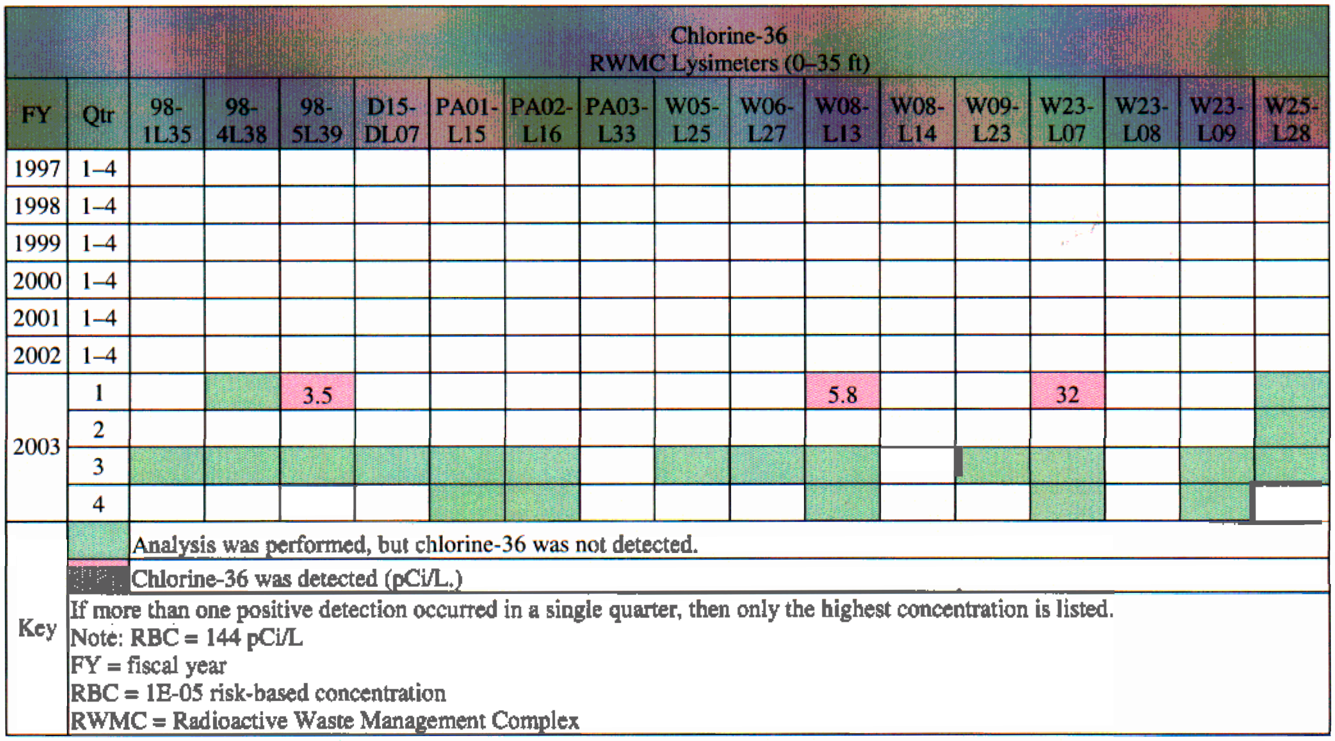
a. The local soil-moisture background concentration for chlorine-36 is defined as a nondetect (i.e., a result less than or equal to its MDA and less than or equal to three times its reported 1σ uncertainty).

b. RBC = 1E-05 for drinking water. The RBCs for the aquifer are provided here as a basis of comparison.

c. **Black bold font** indicates sample concentrations less than the RBC, but exceeding local soil-moisture background concentrations (see footnote a).

d. The sample result for W23-L07 was assigned a "J" data qualifier flag, because the result of the laboratory duplicate (23.8 ± 1.5 pCi/L) did not meet precision criterion. Therefore, the reported concentration might not accurately represent the actual sample concentration and should therefore only be used as an estimated quantity. In other words, Cl-36 was definitely detected, but the reported concentration might not be accurate. Internal quality control test results, such as the laboratory duplicate (split) analysis, are not normally reported in these summary tables, but are included as a footnote to provide additional evidence of the presence of Cl-36 in this sample.

MDA = minimum detectable activity
RBC = risk-based concentration
SDA = Subsurface Disposal Area



		Chlorine-36 RWMC Lysimeters (0–35 ft)															
FY	Qtr	98-1L35	98-4L38	98-5L39	D15-DL07	PA01-L15	PA02-L16	PA03-L33	W05-L25	W06-L27	W08-L13	W08-L14	W09-L23	W23-L07	W23-L08	W23-L09	W25-L28
1997	1–4																
1998	1–4																
1999	1–4																
2000	1–4																
2001	1–4																
2002	1–4																
2003	1		🟩	🟥 3.5							🟥 5.8			🟥 32			🟩
	2																🟩
	3	🟩	🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩		🟩	🟩		🟩	🟩
	4					🟩	🟩				🟩			🟩		🟩	

Key
🟩 Analysis was performed, but chlorine-36 was not detected.
🟥 Chlorine-36 was detected (pCi/L.)
If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.
Note: RBC = 144 pCi/L
FY = fiscal year
RBC = 1E-05 risk-based concentration
RWMC = Radioactive Waste Management Complex

Figure 3-12. Occurrence of chlorine-36 detections in shallow lysimeters.

3.3.2.2 Lysimeter Samples at Depths of 35 to 140 ft. Thirty-six Cl-36 analyses were performed on soil-moisture samples collected from 13 intermediate-depth lysimeters in and around the SDA in FY 2003, with three detections. One of the detections, however, did not meet the validation criteria for a positive detection, since its result (98 pCi/L) was less than the MDA (101 pCi/L). Therefore, the project assigned a "J" data qualifier flag to the I2S-DL11 result to indicate that it was not a valid detection. The other two detections are associated with the October 2002 sampling event, and the detected concentrations are considerably below the 1E-05 RBC of 144 pCi/L (see Table 3-7). Subsequent samples at these monitoring locations have not shown positive detections of Cl-36. The occurrence of Cl-36 detections in intermediate-depth lysimeters since 1997 is summarized in Figure 3-13; however, routine Cl-36 monitoring did not begin until October 2002. Sporadic detections occur, but no apparent trends are exhibited in the intermediate depth.

Table 3-7. Chlorine-36 detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 35- to 140-ft depth interval.

Lysimeter	Depth (ft)	Sample Date	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pCi/L)	Aquifer RBC[b] (pCi/L)
I1S-DL09	101	10/21/02	**5.6 ± 0.9**[c]	3.0	Nondetect	144
TW1-DL04	101.7	10/21/02	**3.7 ± 1.2**$_J$[cd]	4.3	Nondetect	144

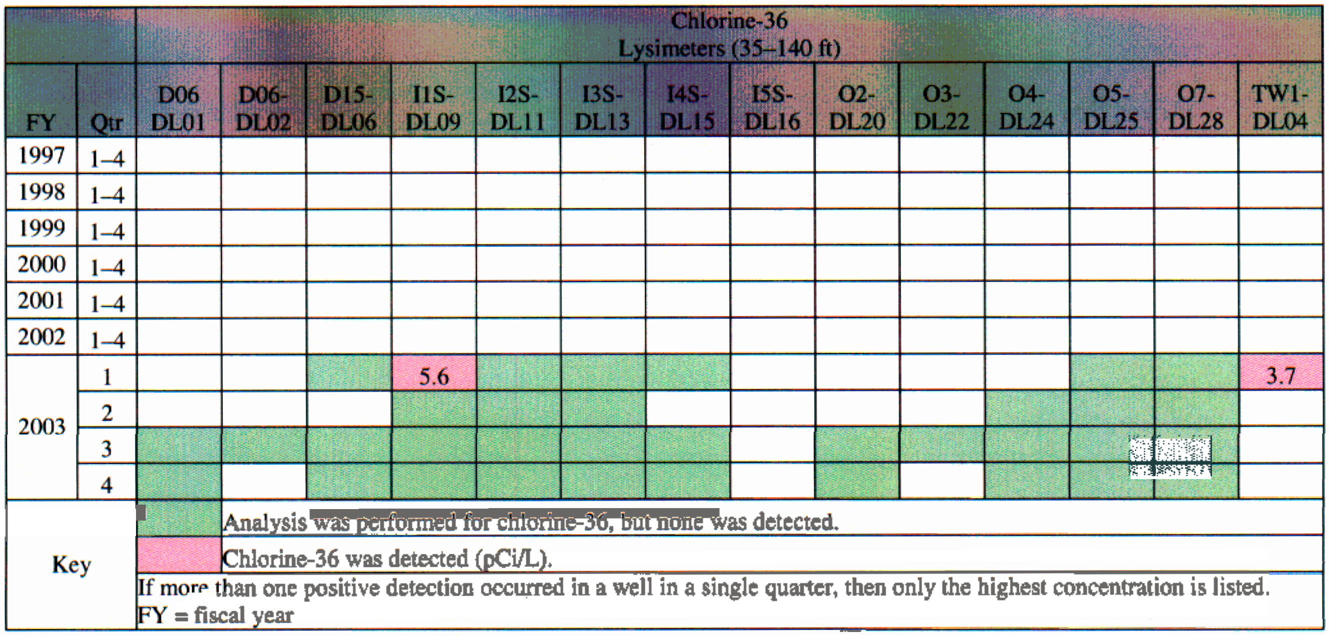
a. The local soil-moisture background concentration for chlorine-36 is defined as a nondetect (i.e., a result less than or equal to its MDA and less than or equal to three times its reported 1σ uncertainty).

b. RBC = 1E-05 for drinking water. The RBCs for the aquifer are provided here as a basis of comparison.

c. **Black bold font** indicates sample concentrations less than the RBC, but exceeding local soil-moisture background concentrations (see footnote a).

d. The sample result for TW1-DL04 was assigned a "J" data qualifier flag, because the concentration is below the MDA, but greater than three times its reported 1σ standard deviation. Even though the concentration is below the MDA, it is reported herein, because the result of the laboratory duplicate (10.6 ± 1.5 pCi/L) provides good evidence for the presence of Cl-36 in this sample. The reported concentration might not accurately represent the actual sample concentration and therefore should only be used as an estimated quantity. In other words, Cl-36 was definitely detected, but the reported concentration might not be precise. Laboratory internal quality control test results, such as duplicates (splits), are not normally reported in these summary tables, but are included as a footnote to provide additional evidence of the presence of Cl-36 in this sample.

MDA = minimum detectable activity
RBC = risk-based concentration
SDA = Subsurface Disposal Area



		Chlorine-36 Lysimeters (35–140 ft)													
FY	Qtr	D06 DL01	D06-DL02	D15-DL06	I1S-DL09	I2S-DL11	I3S-DL13	I4S-DL15	I5S-DL16	O2-DL20	O3-DL22	O4-DL24	O5-DL25	O7-DL28	TW1-DL04
1997	1–4														
1998	1–4														
1999	1–4														
2000	1–4														
2001	1–4														
2002	1–4														
2003	1			🟩	🟥 5.6	🟩	🟩	🟩					🟩	🟩	🟥 3.7
	2				🟩	🟩	🟩					🟩	🟩	🟩	
	3	🟩	🟩	🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩	
	4	🟩		🟩	🟩	🟩	🟩	🟩		🟩		🟩	🟩	🟩	

Key		
	🟩	Analysis was performed for chlorine-36, but none was detected.
	🟥	Chlorine-36 was detected (pCi/L).
	If more than one positive detection occurred in a well in a single quarter, then only the highest concentration is listed. FY = fiscal year	

Figure 3-13. Occurrences of chlorine-36 detections in intermediate-depth (35 to 140 ft) lysimeters.

3.3.2.3 Lysimeter and Perched Water Samples at Depths Greater than 140 ft.

Sixteen Cl-36 analyses were performed on samples collected from four lysimeters and two perched water wells in and around the SDA in FY 2003, with one positive detection (see Table 3-8). The detection is associated with a sample collected from the USGS-92 perched water well in October 2002, with a concentration considerably below the 1E-05 RBC of 144 pCi/L. Subsequent perched water samples at this monitoring location have not shown positive detections of Cl-36. The occurrence of Cl-36 detections since 1997 are summarized in Figure 3-14; however, routine Cl-36 monitoring did not begin until October 2002. Sporadic detections occur, but no apparent trends are exhibited in the deeper depths.

Table 3-8. Chlorine-36 detection in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture and perched water samples from depths greater than 140 ft.

Lysimeter	Depth (ft)	Sample Date	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pC[redacted]	Aquifer RBC[b] [redacted]L)
USGS-92	214	10/22/02	**8.7 ± 1.0**[c]	2.9	Nondetect	144

a. The local soil-moisture background concentration for chlorine-36 is defined as a nondetect (i.e., a result less than or equal to its MDA and less than or equal to three times its reported 1σ uncertainty).

b. RBC = 1E-05 for drinking water. The RBCs for the aquifer are provided here as a basis of comparison.

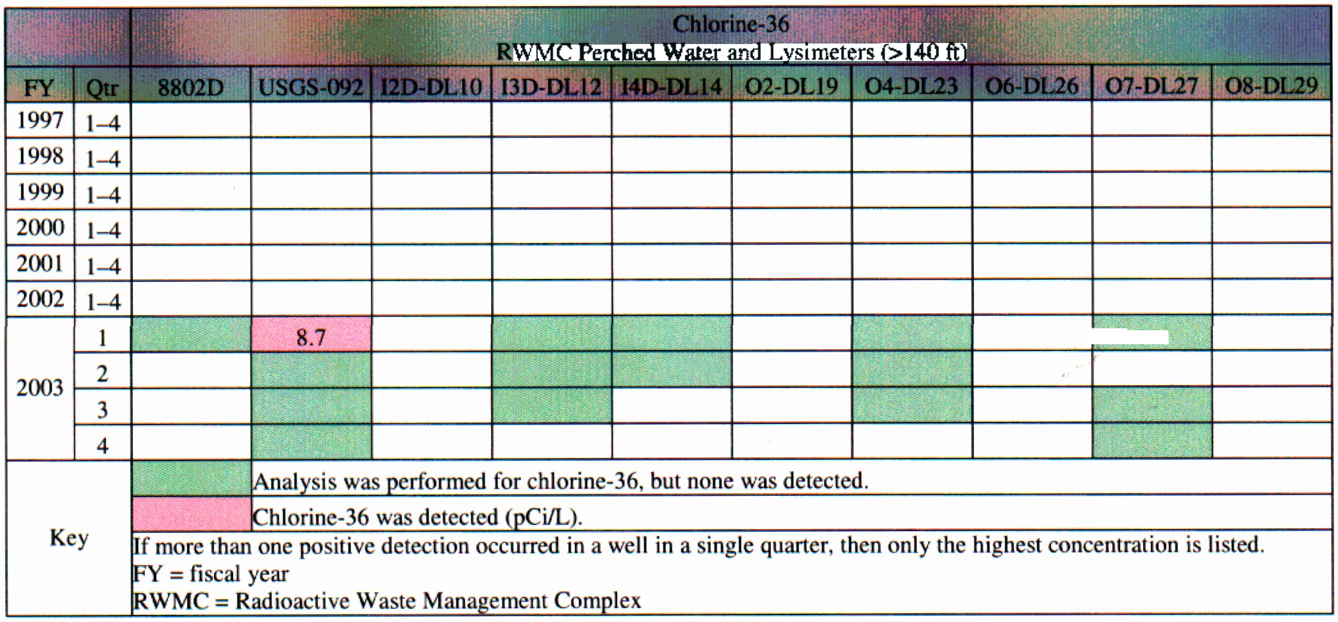
c. **Black bold font** indicates sample concentrations less than the RBC, but exceeding local soil-moisture background concentrations (see footnote a).

MDA = minimum detectable activity

RBC = risk-based concentration

SDA = Subsurface Disposal Area

USGS = United States Geological Survey



		Chlorine-36 RWMC Perched Water and Lysimeters (>140 ft)									
FY	Qtr	8802D	USGS-092	I2D-DL10	I3D-DL12	I4D-DL14	O2-DL19	O4-DL23	O6-DL26	O7-DL27	O8-DL29
1997	1–4										
1998	1–4										
1999	1–4										
2000	1–4										
2001	1–4										
2002	1–4										
2003	1	🟩	🟥 8.7		🟩	🟩		🟩		🟩	
	2		🟩		🟩	🟩		🟩			
	3		🟩		🟩			🟩		🟩	
	4		🟩							🟩	
Key		🟩	Analysis was performed for chlorine-36, but none was detected.								
		🟥	Chlorine-36 was detected (pCi/L).								
		If more than one positive detection occurred in a well in a single quarter, then only the highest concentration is listed. FY = fiscal year RWMC = Radioactive Waste Management Complex									

Figure 3-14. Occurrences of chlorine-36 detections in deep-depth (>140 ft) lysimeters.

3.3.3 Aquifer

No RWMC aquifer samples were analyzed for Cl-36 in FY 2003. Chlorine-36 was not regarded as a WAG 7 contaminant of potential concern until late 2001; thus, no sample data exist before that time. The analytical priority and sampling and analysis schedule for Cl-36 was officially established in 2003.

The established frequency was set at once per year. Figure 3-15 summarizes the occurrence of Cl-36 detections in the aquifer since 1997.

		Chlorine-36 RWMC Aquifer-Monitoring Wells															
FY	Qtr	AIIA31	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	M1S	M3S	M4D	M6S	M7S	OW-2	USGS-127
1997	1–4																
1998	1–4																
1999	1–4																
2000	1–4																
2001	1																
	2																
	3																
	4			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
2002	1	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2																
	3																
	4																
2003	1																
	2																
	3																
	4																
Key	🟩	Analysis was performed, but chlorine-36 was not detected.															
	🟥	Chlorine-36 was detected (pCi/L).															
	If more than one positive detection occurred in a single quarter, then only the highest concentration is listed. Note: MCL = 700 pCi/L FY = fiscal year MCL = maximum contaminant level RBC = 1E-05 risk-based concentration RWMC = Radioactive Waste Management Complex USGS = United States Geological Survey																

Figure 3-15. Occurrences of chlorine-36 detections in the aquifer-monitoring wells since Fiscal Year 1994.

3.3.4 Summary of Chlorine-36

Analytical data to evaluate the nature and extent of Cl-36 contamination at the RWMC are limited, because Cl-36 did not become a target analyte for environmental monitoring until 2001. Chlorine-36 data also are limited, because past lysimeter and perched water sample volumes have been insufficient to analyze for Cl-36. Currently, there are not enough data for Cl-36 to draw any conclusions. In FY 2002, Cl-36 was added to the analytical priority list for lysimeter, perched water, and aquifer samples; in 2003, lysimeter sample volumes have increased because of improved sampling techniques. Chlorine-36 is fifth on the lysimeter analysis priority list with an established analysis frequency of four times per year. Once a year, analysis is performed for Cl-36 in the aquifer samples. If Cl-36 is detected in the aquifer samples, then the need to intensify the aquifer sampling frequency will be reviewed.

In FY 2003, seventy-four vadose zone sample analyses were performed, and seven positive detections were observed. Locations where Cl-36 was detected in the vadose zone are the same lysimeter and perched water wells where other contaminants have been detected in the past. Other detected contaminants are primarily uranium isotopes and Tc-99, although some wells also have a history of H-3 and C-14 detections. Detections are rare and appear to be confined to the vadose zone between 0 and 214 ft. All positive results were below the MCL of 700 pCi/L and the 1E-05 aquifer RBC of 144 pCi/L.

Maximum concentrations of Cl-36 in vadose zone soil moisture and perched water since October 2002 are shown in Table 3-9; Table 3-10 shows the aquifer maximums. Positive detections in USGS-92 suggest that Cl-36 has migrated to the 65-m (214-ft) perched water region beneath the RWMC (see Holdren et al. 2002, Section 4).

Table 3-9. Summary of maximum concentrations of chlorine-36 in vadose zone soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Years 1997 through 2003.[a]

Sampling Range (feet below land surface)	Fiscal Year[b]	Maximum Concentration ± 1σ (pCi/L)[c]	Sample Location
Lysimeters 0 to 35 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	NA	—
	2003	32.3 ± 1.6	W23-L07
Lysimeters 35 to 140 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	NA	—
	2003	5.6 ± 0.9	I1S-DL09
Lysimeters >140 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	NA	—
	2003	ND	Various
Perched water wells >140 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	NA	—
	2003	8.7 ± 1.0	USGS-92

Table 3-9. (continued).

Sampling Range (feet below land surface)	Fiscal Year[b]	Maximum Concentration ± 1σ (pCi/L)[c]	Sample Location

a. MCL = 700 pCi/L
b. Fiscal year spans from October 1 to September (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).
c. NA = not analyzed ND = not detected
d. Various locations were sampled.
MCL = maximum contaminant level
USGS = United States Geological Survey

Table 3-10. Summary of maximum concentrations of chlorine-36 in aquifer wells at the Radioactive Waste Management Complex from Fiscal Years 1997 through 2003.[a]

Fiscal Year[b]	Maximum Concentration ± 1σ (pCi/L)[c]	Well Location
1997	NA	—
1998	NA	—
1999	NA	—
2000	NA	—
2001	ND	Various[d]
2002	ND	Various
2003	NA	—

a. MCL = 700 pCi/L
b. Fiscal year spans from October 1 to September 30 (e.g., Fiscal Year 1997 is October 1, 1996, through September 30, 1997).
c. NA = not analyzed ND = not detected
d. Various locations were sampled.
MCL = maximum contaminant level

3.4 Tritium

Even though tritium is not a contaminant of potential concern, it is monitored because its distribution and migration are important to the overall understanding of contaminant movement in the vadose zone and aquifer, given there are uncertainties regarding whether the source of tritium is from the SDA or upgradient facilities. Tritium is produced naturally by interactions of cosmic rays and atmospheric gases, and tritium is produced by nuclear reactor operations. Beryllium in reactors undergoes (n,2n) and (n,α) reactions, generating substantial amounts of He-4, He-3, and H-3. The accumulation of helium and hydrogen atoms causes the beryllium to swell, requiring it to be replaced periodically. Between 1970 and 1993, irradiated reactor beryllium reflector waste from the Advanced Test Reactor, Engineering Test Reactor, and the Materials Test Reactor was buried in the SDA. These activated beryllium disposals contain a substantial fraction of the RWMC's total C-14 inventory and practically the entire RWMC H-3 inventory. The most recent disposal of beryllium consisted of six Advanced Test Reactor reflector blocks that were buried in SVR 20, approximately 96 m (315 ft) from the east row marker. These six blocks contain approximately 114,800 Ci of H-3 (predominantly as $^{3}H_2$, corrected for decay to September 2001) and about 12 Ci of C-14 (Mullen et al. 2003). Tritium and C-14 are released from the beryllium by corrosion.

3.4.1 Waste Zone

3.4.1.1 Ambient Air Sampling. Because a substantial amount of H-3 released from waste migrates to the atmosphere, ambient air sampling is included as part of the characterization of the waste zone and source environment. The INEEL Environmental Monitoring Program conducted continuous sampling for airborne H-3 at SVR 20 from 1995 to 2002 (see Figure 3-16), using a sampling inlet set approximately 1 m (3 ft) above grade, approximately 1 m outside the edge of the backfilled auger hole. This sampling inlet was located downwind with respect to the nighttime primary wind direction at the RWMC. Moisture from the air samples was collected by pumping air at a constant rate through desiccant, which was collected when the desiccant was approximately 80% saturated. Atmospheric humidity conditions varied through the year, so there was no definite collection period.[d]

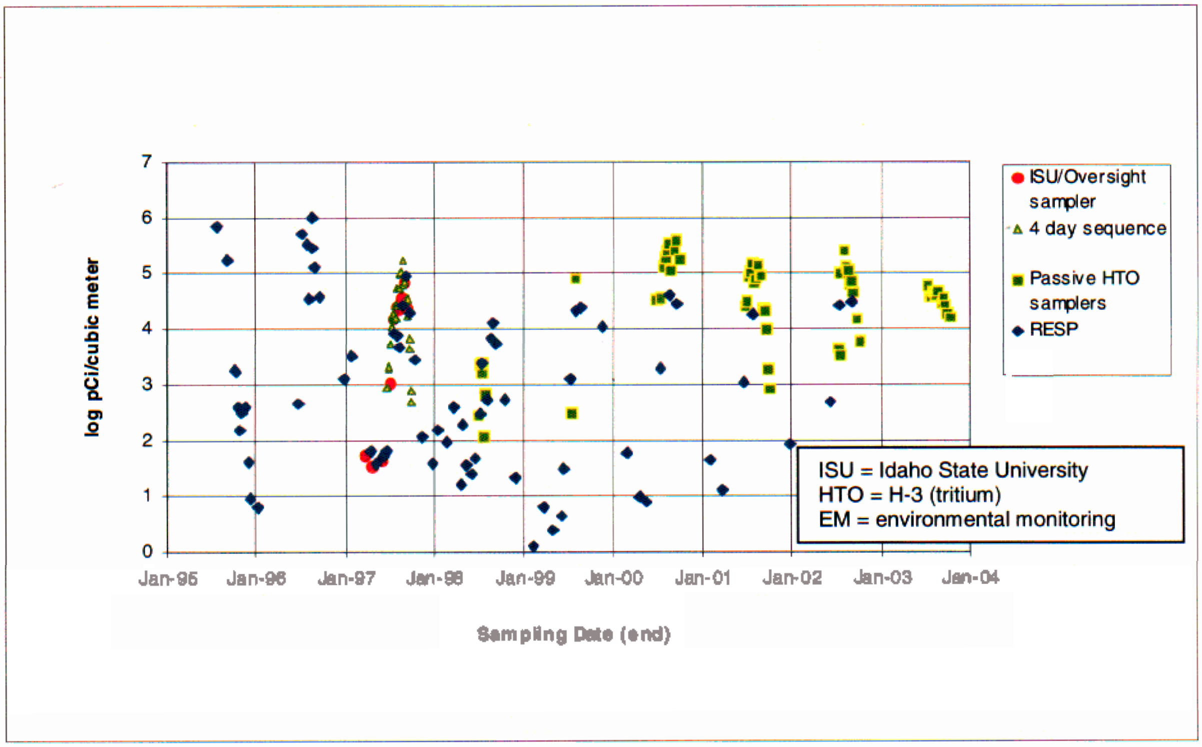


Figure 3-16. Airborne tritium concentration above the beryllium blocks at Subsurface Disposal Area Soil Vault Row 20.

Measurements by the Environmental Monitoring Program during 1994 and 1995 showed that H-3 concentration in air above SVR 20 ranges over several orders of magnitude during the year, with peak concentrations occurring in late summer. To develop more detailed release information, additional sampling is conducted during summer and fall. Passive airborne H-3 samplers (Wood and Workman 1992; Wood 1996) are used to sample over 1-week periods during the peak emission period. The passive samples are collected at three heights at a location that is approximately on the edge of the backfilled auger hole, downwind with respect to the primary daytime primary wind direction. Results from the INEEL Environmental Monitoring Program's samplers and the passive samplers show similar temporal fluctuations, but are not directly comparable. Based on results for FY 2000 through 2002, the passive samplers are exposed to air concentrations that are typically an order of magnitude greater than the environmental monitoring sampler. Estimated annual emissions of H-3 from buried activated beryllium at SVR 20 for Calendar Year (CY) 1995 through 2003 are shown in Table 3-11. Results for CY 1995 through 1999 are based on environmental monitoring sampling and results for CY 2000 through 2003 are

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[d] The collection periods for the environmental monitoring of airborne H-3 samples have ranged from a few weeks to 3 months, depending on humidity.

based on the passive sampling results. These data are used to develop emission estimates by calendar year for all disposed beryllium as required by 40 *Code of Federal Regulations* (CFR) 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities."

Table 3-11. Estimated annual emission of tritium to air from buried activated beryllium at Soil Vault Row 20.

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003
Emission (Ci)	30	30	3	0.5	3	20	10	10	5

3.4.1.2 Soil Gas. Since CY 1996,[e] soil-gas samples have been collected from the GSP-1 vapor ports, located approximately 60 to 100 cm (24 to 39 in.) from the beryllium at depths of 2.7, 4.5, and 6.2 m (8.9, 14.8, and 20.3 ft). The samples directly represent the concentrations during relatively brief sample collection periods in small (i.e., approximately 10 L) volumes of soil near the ports.

During FY 2003, the concentration of H-3 in soil moisture reached 8.0, 0.98, and 0.71 μCi/mL in soil 8.9, 14.8, and 20.3 ft deep, respectively (see Figures 3-17, 3-18, and 3-19). The concentration of H-3 in soil moisture appears to fluctuate with a period of 1 year. Fluctuations at each depth are correlated (Holdren et al. 2002), suggesting that concentrations at various depths are influenced similarly by soil and source conditions. From FY 1996 through FY 2003, H-3 concentrations in soil increased at a progressively greater rate. The average FY 2003 concentrations in soil 8.9, 14.8, and 20.3 ft deep are factors of 10, 40, and 20 times the pre-1997 concentrations.

3.4.2 Vadose Zone

Tritium has been detected in some of the routine vadose zone soil-moisture and perched water samples, with the highest concentrations found in samples from W06-L27 at about 3.7 m (12 ft) deep. Since tritium was not a WAG 7 contaminant of potential concern, the analysis priority for tritium in soil moisture was at the end of the priority list; thus, many data gaps exist. In 2003, tritium analysis was reprioritized (see Table 2-1), and a sampling and analysis frequency of three times per year was chosen.

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[e] The first samples were taken in FY 1995. No data were recovered for the 2.7-m (8.9-ft) deep sampling port because of sampling problems.

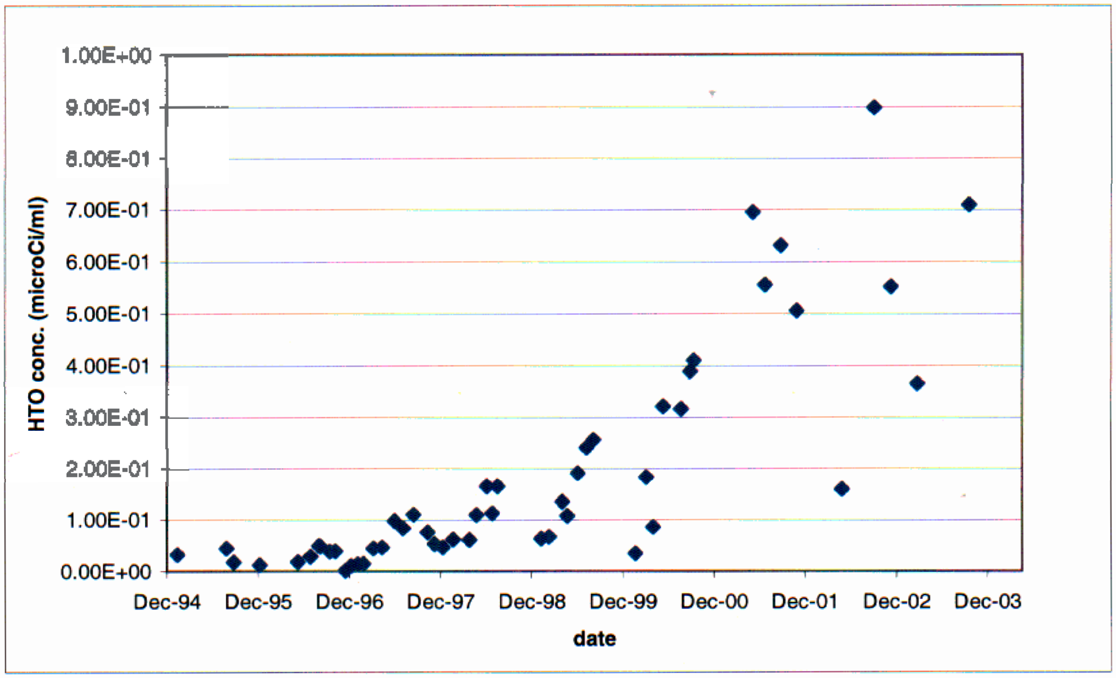


Figure 3-17. Tritium concentration in water vapor from the 8.9-ft-deep GSP-1 soil-gas sampling port.

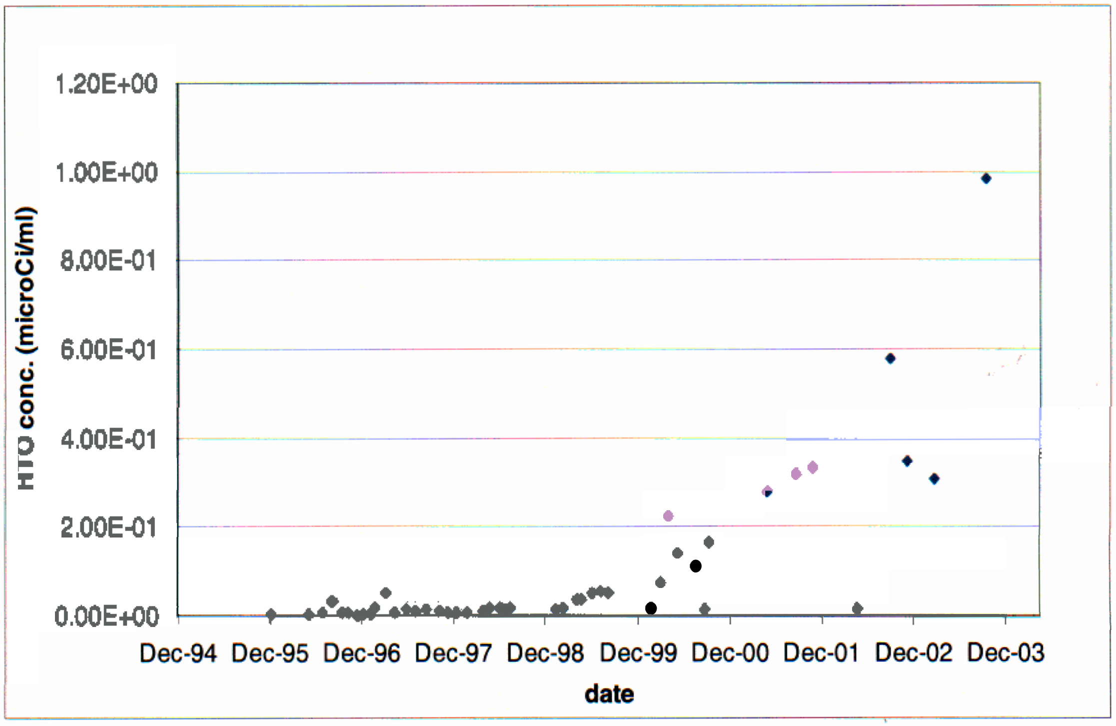


Figure 3-18. Tritium concentration in water vapor from the 15-ft-deep GSP-1 soil-gas sampling port.

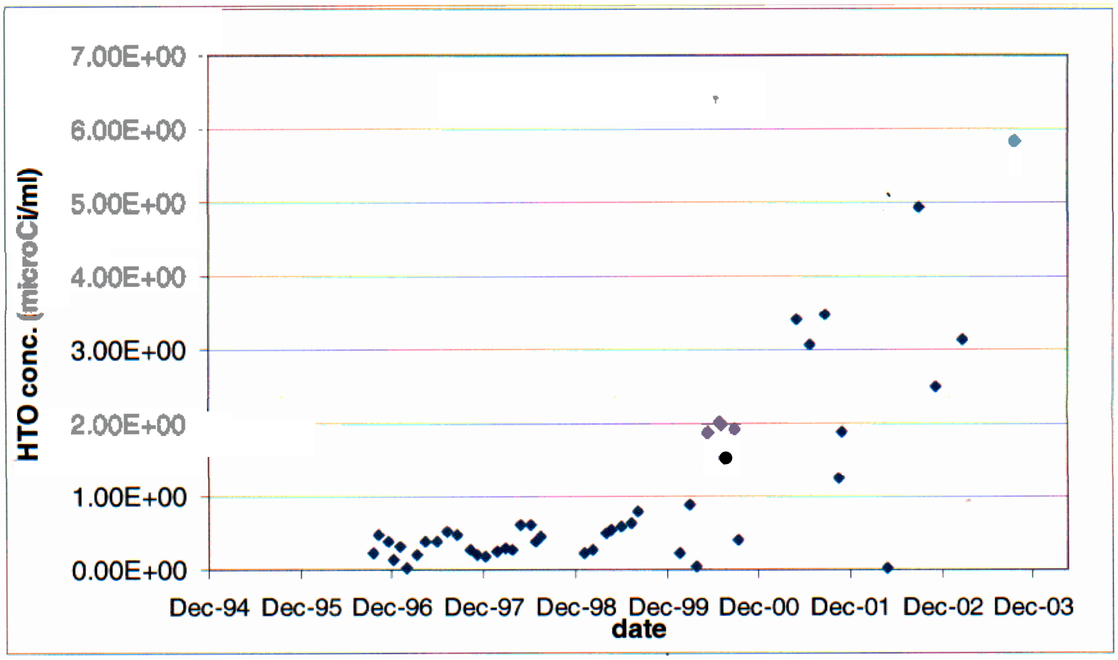


Figure 3-19. Tritium concentration in water vapor from the 20.3-ft-deep GSP-1 soil-gas sampling port.

3.4.2.1 Lysimeter Samples at Depths of 0 to 35 ft. Seven tritium analyses were performed on soil-moisture samples collected from six shallow lysimeters in and around the SDA in FY 2003, with one positive detection (see Table 3-12). Results for tritium in the shallow vadose-zone samples, since routine monitoring began in 1997, are summarized in Figure 3-20. Sporadic detections occur, but no apparent trends for tritium are exhibited in the shallow lysimeters, except for W06:DL27 (see Figure 3-21). Concentrations in this lysimeter had increased from FY 1997 through 1999, but no samples have been collected since then (see Table 3-15). The closest known source of H-3, relative to the location of W06-L27, is the activated beryllium at SVR 20, which is approximately 48 m (150 ft) to the east. Tritium also was detected in Lysimeter PA02-L16 at 2.7 m (8.7 ft) deep from 1997 through 1998. The "I" and "O" series wells were installed between November 1999 and March 2000, and the first samples were collected in June 2000. Unfortunately, conditions at W06 are apparently very dry due to several years of below-average precipitation, and very limited sample volume has been extracted. No samples have been analyzed for H-3 from that well since 2000, so it is not possible to assess current trends in that well.

Table 3-12. Tritium detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 0- to 35-ft depth interval.

Lysimeter	Depth (ft)	Sample Dat[redacted]	Sample Result ± 1σ ([illegible]L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pCi/L)	Aquifer RBC[b] ([illegible]L)
PA02-L16	8.7	07/21/03	**368 ± 77**[c]		Nondetect	**9392**

a. The local soil-moisture background concentration for tritium is defined as a nondetect (i.e., a result less than or equal to its MDA and less than or equal to three times its reported 1σ uncertainty).

b. RBC = 1E-05 for drinking water. The RBCs for the aquifer are provided here as a basis of comparison.

c. **Black bold font** indicates sample concentrations less than the RBC, but exceeding local soil-moisture background concentrations (see footnote a).

MDA = minimum detectable activity
RBC = risk-based concentration
SDA = Subsurface Disposal Area

		Tritium RWMC Lysimeters (0–35 ft)															
FY	Qtr	98-1 L35	98-4 L38	98-5 L39	D15-DL07	PA01-L15	PA02-L16	PA03-L33	W05-L25	W06-L27	W08-L13	W08-L14	W09-L23	W23-L07	W23-L08	W23-L09	W25-L28
1997	1																
	2																
	3					🟩	243			2510		129				154	366
	4					🟩	167	🟩		3270	1140	🟩				🟩	235
1998	1																
	2																
	3			🟩		🟩	328										
	4			🟩		991	🟩			7290					383	🟩	
1999	1			🟩		🟩	1380			8650							
	2																
	3		🟩	🟩		🟩	🟩										
	4																
2000	1									9100							🟩
	2					🟩									🟩	🟩	🟩
	3	🟩		🟩		🟩	🟩			9070	815				🟩	🟩	🟩
	4	🟩		🟩		🟩											
2001	1																
	2																
	3																
	4																
2002	1																
	2																
	3																
	4																
2003	1													187			
	2																🟩
	3																
	4					🟩	368						🟩	🟩		🟩	

Key

🟩 Analysis was performed, but tritium was not detected.

🟥 Tritium was detected (pCi/L).

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.
Note: RBC = 9,392 pCi/L
FY = fiscal year
RBC = 1E-05 risk-based concentration
RWMC = Radioactive Waste Management Complex

Figure 3-20. Occurrences of tritium detections in the shallow lysimeters since Fiscal Year 1997.

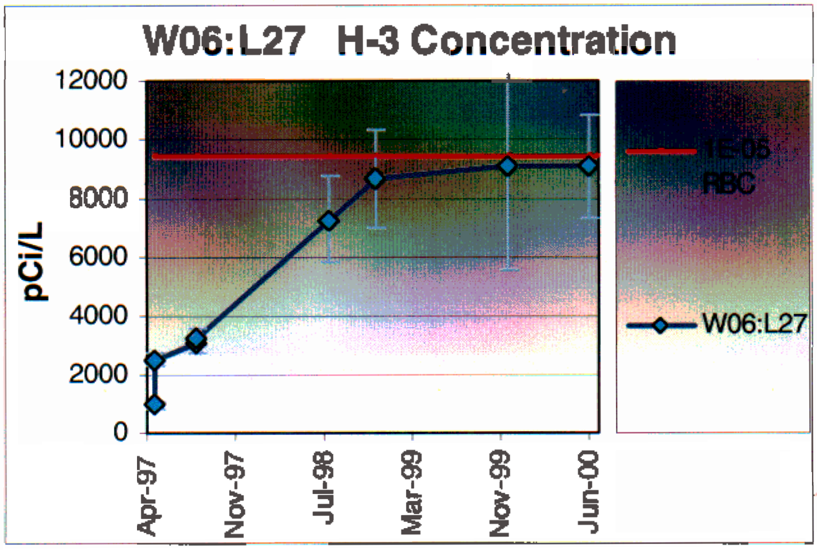


Figure 3-21. Tritium concentration history for Lysimeter W06:L27 from April 1997 to June 2000.

3.4.2.2 Lysimeter Samples at Depths of 35 to 140 ft. Eleven tritium analyses were performed on soil-moisture samples collected from 11 intermediate-depth lysimeters in and around the SDA in FY 2003, with four positive detections (see Table 3-13). Results for the intermediate vadose zone samples, since routine monitoring began in 1997, are summarized in Figure 3-22. There are sporadic detections, but no apparent increasing trends for tritium in the intermediate-depth lysimeters. Tritium is consistently detected in an intermediate-depth lysimeter (TW1-DL04) at about 31 m (102 ft) deep, but there is no apparent trend (see Figure 3-23).

Table 3-13. Tritium detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 35- to 140-ft depth interval.

Lysimeter	Depth (ft)	Sample Date	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pCi/L)	Aquifer RBC[b] (pCi/L)
O4S:DL24	108.5	07/10/03	**228 ± 70**	223	Nondetect	9392
I2S:DL11	92	07/21/03	**580 ± 85**	242	Nondetect	9392
TW1:DL04	101.7	07/21/03	**1,690 ± 178**	476	Nondetect	9392
I1S:DL09	101	07/22/03	**277 ± 69**	217	Nondetect	9392

a. The local soil-moisture background concentration for tritium is defined as a nondetect (i.e., a result less than or equal to its MDA and less than or equal to three times its reported 1σ uncertainty).
b. RBC = 1E-05 for drinking water. The RBCs for the aquifer are provided here as a basis of comparison.
c. **Black bold font** indicates sample concentrations less than the RBC, but exceeding local soil-moisture background concentrations (see footnote a).
MDA = minimum detectable activity
RBC = risk-based concentration
SDA = Subsurface Disposal Area

FY	Qtr	Tritium RWMC Lysimeters (35–140 ft)													
FY	Qtr	D06-DL01	D06-DL02	D15-DL06	I1S-DL09	I2S-DL11	I3S-DL13	I4S-DL15	I5S-DL16	O2S-DL20	O3S-DL22	O4S-DL24	O5S-DL25	O7S-DL28	TW1-DL04
1997	1														
	2														
	3														
	4		🟩												
1998	1														
	2														
	3		🟩	🟩											2520
	4		🟩	🟩											1680
1999	1														2950
	2														
	3														
	4														
2000	1														
	2														
	3														
	4														
2001	1														
	2														
	3														
	4														
2002	1														
	2														
	3														
	4														
2003	1												🟩		
	2														
	3														
	4	🟩		🟩	277	580		🟩		🟩		228	🟩	🟩	1690

Key

🟩 Analysis was performed, but tritium was not detected.

🟥 Tritium was detected (pCi/L).

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.
Note: RBC = 9,392 pCi/L
FY = fiscal year
RBC = 1E-05 risk-based concentration
RWMC = Radioactive Waste Management Complex

Figure 3-22. Occurrences of tritium detections in intermediate-depth (35- to 140-ft) lysimeters since Fiscal Year 1997.

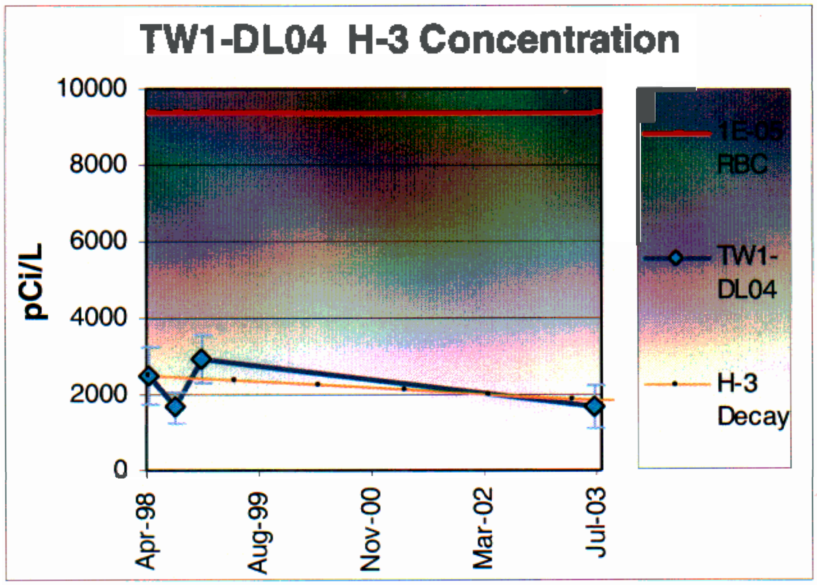


Figure 3-23. Tritium concentration history for Lysimeter TW1:DL04.

3.4.2.3 Lysimeter Samples at Depths Greater than 140 ft. One tritium analysis was performed on a deep-suction lysimeter sample collected outside the SDA in FY 2003, with no positive detection. Results for the samples, since routine monitoring began in 1997, are summarized in Figure 3-24. The "I" and "O" series wells were installed between November 1999 and March 2000, and the first samples were collected in June 2000. Tritium is frequently detected in the USGS-92 perched water well at concentrations slightly above the method detection limits, with no observable trend.

		Tritium RWMC Perched Water and Lysimeters (>140 ft)									
FY	Qtr	8802D	USGS-092	I2D-DL10	I3D-DL12	I4D-DL14	O2-DL19	O4-DL23	O6-DL26	O7-DL27	O8-DL29
1997	1										
	2										
	3		310								
	4		196								
1998	1										
	2		314								
	3										
	4										
1999	1		1570								
	2		🟩								
	3										
	4										
2000	1		🟩								
	2										
	3										
	4										
2001	1										
	2										
	3										
	4										
2002	1										
	2		🟩								
	3										
	4										
2003	1		🟩								
	2										
	3										
	4									🟩	

Key	🟩	Analysis was performed for tritium, but none was detected.
	🟥	[illegible]
	[illegible] listed. FY = fiscal year RWMC = Radioactive Waste Management Complex USGS = United States Geological Survey	

3.4.3 Aquifer

Sixty-four H-3 analyses were performed on aquifer samples collected from 15 monitoring wells in the vicinity of the RWMC in FY 2003, with 26 positive detections above aquifer background levels but significantly below the drinking water MCL (see Table 3-14). Detections of H-3 in aquifer samples occur regularly in Wells M3S, M7S, M12S, M14S, M16S, and M17S (see Figure 3-25) and have never occurred in Wells M1S, M4D, M6S, M10S, M112, M13S, M15S, or USGS-127. The occurrence of H-3 detections since 1997 are summarized in Figure 3-25. Tritium detections above background have been isolated to the northeastern part of the SDA; however, in FY 2003, H-3 was detected at low concentrations in two wells south of the SDA. The two wells, OW-2 and A11A31, are located approximately 1.0 and 1.5 mi south of the SDA, respectively. Subsequent samples collected from these two monitoring wells have not shown positive detections for H-3.

able 3-14. Tritium detected above aquifer background concentrations.

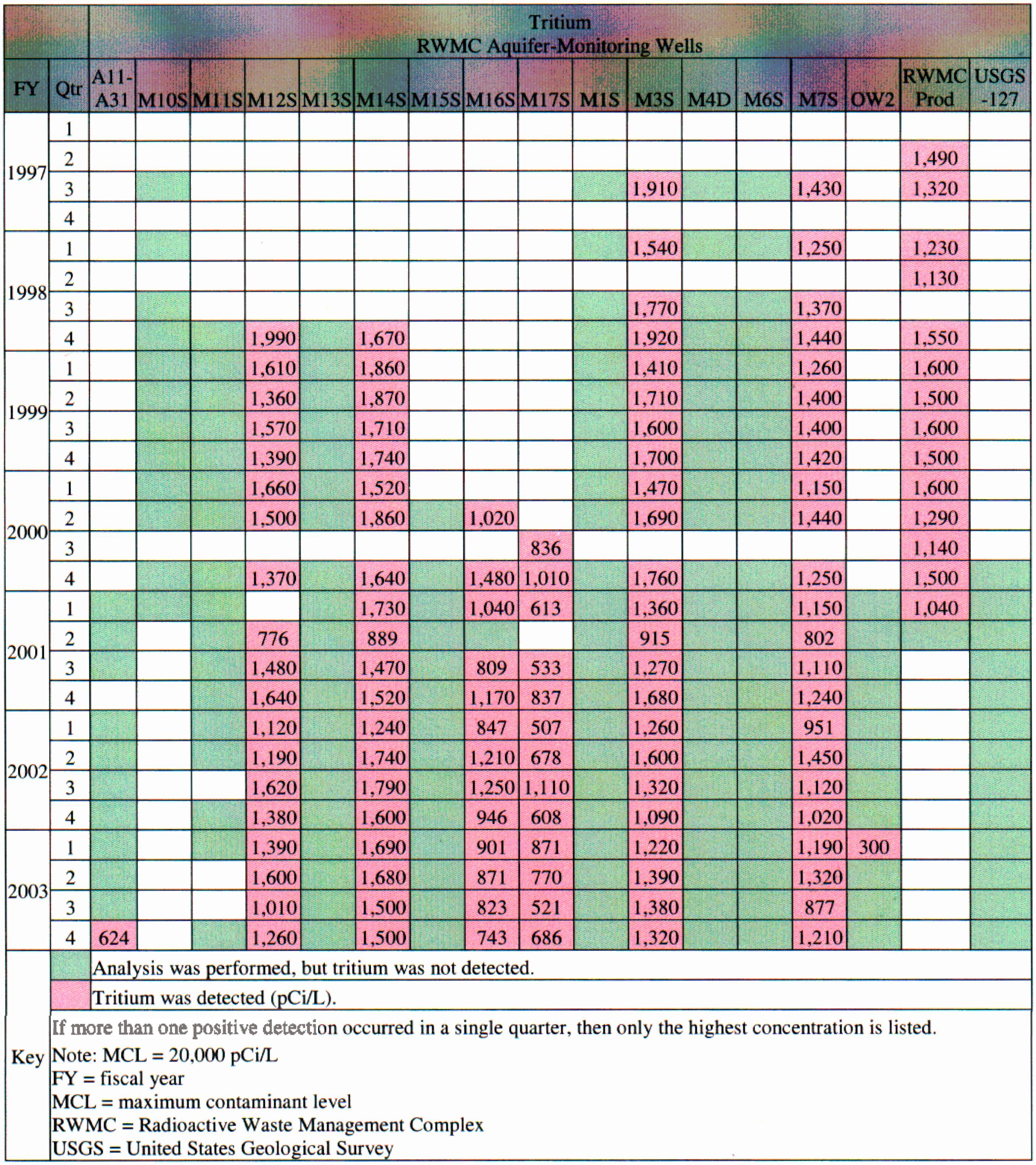
Well	Sample Date	Radionuclide	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Aquifer Background[a] (pCi/L)	MCL[b] (pCi/L)
M3S	11/05/02	H-3	**1,220 ± 104**[c]	278	0–40	20,000
	02/05/03	H-3	**1,390 ± 122**[c]	321	0–40	20,000
	05/06/03	H-3	**1,380 ± 107**[c]	280	0–40	20,000
	08/06/03	H-3	**1320 ± 152**[c]	363	0–40	20,000
M7S	11/12/02	H-3	**1,190 ± 102**[c]	283	0–40	20,000
	02/03/03	H-3	**1,320 ± 123c**	331	0–40	20,000
	04/29/03	H-3	**877 ± 101**[c]	288	0–40	20,000
	08/05/03	H-3	**1210 ± 144**[c]	347	0–40	20,000
M12S	11/05/02	H-3	**1,390 ± 107**[c]	278	0–40	20,000
	02/03/03	H-3	**1,600 ± 129**[c]	325	0–40	20,000
	04/29/03	H-3	**1,010 ± 102**[c]	285	0–40	20,000
	08/04/03	H-3	**1260 ± 157**[c]	388	0–40	20,000
M14S	11/05/02	H-3	**1,690 ± 121**[c]	307	0–40	20,000
	02/03/03	H-3	**1,680 ± 97**[c]	222	0–40	20,000
	04/28/03	H-3	**1,500 ± 110**[c]	283	0–40	20,000
	08/05/03	H-3	**1500 ± 158**[c]	366	0–40	20,000
M16S	11/11/02	H-3	**901 ± 99**[c]	287	0–40	20,000
	02/04/03	H-3	**871 ± 106**[c]	311	0–40	20,000
	04/30/03	H-3	**823 ± 100**[c]	289	0–40	20,000
	08/04/03	H-3	**743 ± 134**[c]	369	0–40	20,000
M17S	11/06/02	H-3	**871 ± 106**[c]	305	0–40	20,000
	11/06/02	H-3	**752 ± 105**[c]	307	0–40	20,000
	02/03/03	H-3	**770 ± 106**[c]	324	0–40	20,000
	05/07/03	H-3	**521 ± 94**[c]	285	0–40	20,000
	08/06/03	H-3	**686 ± 132**[c]	369	0–40	20,000
A11A31	08/04/03	H-3	**624 ± 129**[c]	366	0–40	20,000
OW-2	11/11/02	H-3	**300 ± 90**[c]	288	0–40	20,000

. The USGS established the SRPA background ranges in 1992 from samples collected upgradient (i.e., Mud Lake area) and downgradient i.e., Magic Valley area) of the INEEL (Knobel, Orr, and Cecil 1992).

. The MCLs are from the "National Primary Drinking Water Regulations" (40 CFR 141) established by the U.S. Environmental Protection gency.

. **Black bold font** indicates sample concentrations less than the MCL, but exceeding aquifer background concentrations (see footnote a).

FR = *Code of Federal Regulations*
NEEL = Idaho National Engineering and Environmental Laboratory
CL = maximum contaminant level
DA = minimum detectable activity
RPA = Snake River Plain Aquifer
SGS = United States Geological Survey



		Tritium RWMC Aquifer-Monitoring Wells																
FY	Qtr	A11-A31	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	M1S	M3S	M4D	M6S	M7S	OW2	RWMC Prod	USGS -127
1997	1																	
	2																1,490	
	3		🟩								🟩	1,910	🟩	🟩	1,430		1,320	
	4																	
1998	1		🟩								🟩	1,540	🟩	🟩	1,250		1,230	
	2																1,130	
	3		🟩								🟩	1,770	🟩	🟩	1,370			
	4		🟩	🟩	1,990	🟩	1,670				🟩	1,920	🟩	🟩	1,440		1,550	
1999	1		🟩	🟩	1,610	🟩	1,860				🟩	1,410	🟩	🟩	1,260		1,600	
	2		🟩	🟩	1,360	🟩	1,870				🟩	1,710	🟩	🟩	1,400		1,500	
	3		🟩	🟩	1,570	🟩	1,710				🟩	1,600	🟩	🟩	1,400		1,600	
	4		🟩	🟩	1,390	🟩	1,740				🟩	1,700	🟩	🟩	1,420		1,500	
2000	1		🟩	🟩	1,660	🟩	1,520				🟩	1,470	🟩	🟩	1,150		1,600	
	2		🟩	🟩	1,500	🟩	1,860	🟩	1,020		🟩	1,690	🟩	🟩	1,440		1,290	
	3									836							1,140	
	4		🟩	🟩	1,370	🟩	1,640	🟩	1,480	1,010	🟩	1,760	🟩	🟩	1,250		1,500	🟩
2001	1	🟩	🟩	🟩		🟩	1,730	🟩	1,040	613	🟩	1,360	🟩	🟩	1,150	🟩	1,040	🟩
	2	🟩		🟩	776	🟩	889	🟩	🟩		🟩	915	🟩	🟩	802	🟩	🟩	🟩
	3	🟩		🟩	1,480	🟩	1,470	🟩	809	533	🟩	1,270	🟩	🟩	1,110	🟩		🟩
	4			🟩	1,640	🟩	1,520	🟩	1,170	837	🟩	1,680	🟩	🟩	1,240	🟩		🟩
2002	1	🟩		🟩	1,120	🟩	1,240	🟩	847	507	🟩	1,260	🟩	🟩	951	🟩		🟩
	2	🟩		🟩	1,190	🟩	1,740	🟩	1,210	678	🟩	1,600	🟩	🟩	1,450	🟩		🟩
	3	🟩			1,620	🟩	1,790	🟩	1,250	1,110	🟩	1,320	🟩	🟩	1,120	🟩		🟩
	4	🟩		🟩	1,380	🟩	1,600	🟩	946	608	🟩	1,090	🟩	🟩	1,020	🟩		🟩
2003	1	🟩		🟩	1,390	🟩	1,690	🟩	901	871	🟩	1,220	🟩	🟩	1,190	300		🟩
	2	🟩			1,600	🟩	1,680	🟩	871	770	🟩	1,390	🟩	🟩	1,320	🟩		🟩
	3	🟩			1,010	🟩	1,500	🟩	823	521	🟩	1,380	🟩	🟩	877	🟩		🟩
	4	624		🟩	1,260	🟩	1,500	🟩	743	686	🟩	1,320	🟩	🟩	1,210	🟩		🟩

Key

🟩 Analysis was performed, but tritium was not detected.

🟥 Tritium was detected (pCi/L).

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.

Note: MCL = 20,000 pCi/L

FY = fiscal year

MCL = maximum contaminant level

RWMC = Radioactive Waste Management Complex

USGS = United States Geological Survey

Figure 3-25. Occurrences of tritium detections in the aquifer since Fiscal Year 1997.

3.4.4 Summary of Tritium

Tritium is not a contaminant of potential concern; however, it is present in the SDA vadose zone and aquifer. In addition, a substantial fraction of H-3 released from waste migrates to the atmosphere. Tritium concentration in air above SVR 20 ranges over several orders of magnitude during the year, with peak concentrations occurring in late summer. There is an obvious trend of increasing tritium concentrations over time in soil vapor samples collected near the buried beryllium blocks near SVR 20. Elevated H-3 concentrations were detected in the air samples collected above the beryllium block disposals; however, trends are not evident. Estimated emissions of H-3 from buried activated beryllium at SVR 20 for CY 2003 were about 5 Ci. These data are used to develop emission estimates by calendar year for all disposed beryllium as required by 40 CFR 61, Subpart H.

Tritium was detected in several lysimeters located in and around Pad A and Pit 5 areas, and it was detected in some of these lysimeters in 1998 and 2000. Adequate volume for H-3 analyses was obtained for the first time from samples on the western end of the SDA ("I" and "O" wells), and low levels of H-3 were detected. Some of the measured concentrations are near the detection sensitivities of about 300–400 pCi/L; thus, it will require a few more sampling events to establish a sense of potential H-3 trends in these monitoring wells. The samples from Wells PA01 and W25 have relatively high H-3 concentrations of 10,200 pCi/L and 3,680 pCi/L, respectively. These relatively high concentrations are unexpected, since these wells have no previous history of recurrent H-3 detections. Further sampling of PA01 and W25, as well as the other wells, is necessary to substantiate the actual concentration of H-3 in these monitoring wells.

In the aquifer beneath the RWMC, H-3 is consistently measured in six monitoring wells and is consistently absent in the other wells. Tritium concentrations in these six wells are gradually decreasing, and the decrease appears to correlate with the calculated rate of radioactive decay (see Figure 3-26, M7S example); however, it does not correlate with expected influences from dilution and dispersion. Under normal conditions, an initial pulse of H-3 decayed, dispersed, and diffused over time would decrease much more rapidly (see Figure 3-26, USGS-65 example). It could be that H-3 is being added to the aquifer at a rate that exceeds decay effects. Tritium is not detected downgradient of the RWMC, and the general pattern of H-3 occurrence around RWMC area wells is not yet understood.

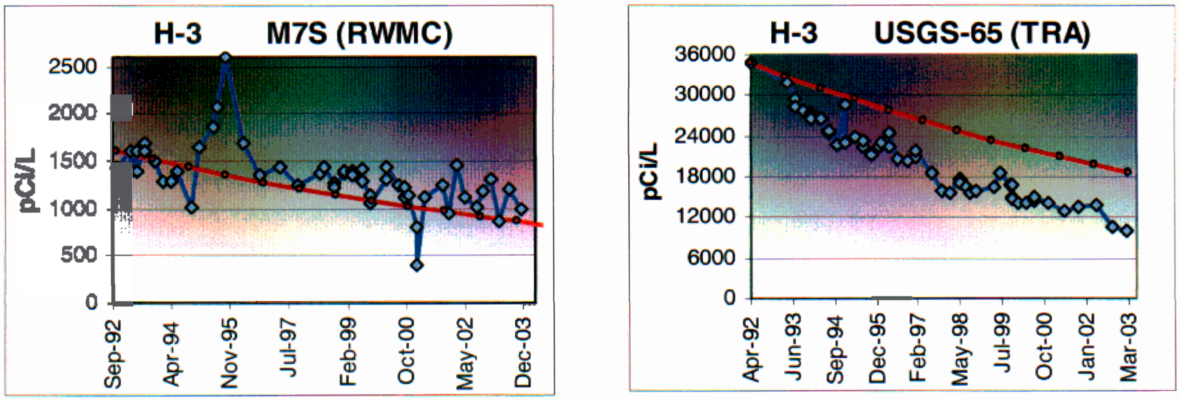


Figure 3-26. Comparison of tritium concentration time histories showing the observed effects of radioactive decay (•) and dilution and dispersion (Test Reactor Area well); and the observed effects of radioactive decay (•) with no apparent dilution and dispersion (Radioactive Waste Management Complex well).

The clear pattern of H-3 detections and nondetections in RWMC area wells suggests that H-3 might be a good modeling calibration target; however, the source term is difficult to define. Tritium has been injected into the aquifer at the Test Reactor Area (TRA) and INTEC, and tritium has migrated through both the vapor phase and infiltrating waters in the vadose zone at the SDA. Quantifying and tracking these varied inputs, while also accounting for complex source-release rates and adjusting for decay, could result in large uncertainties that diminish the effort. A study to determine the impact of upgradient facilities on the aquifer at the RWMC was conducted in the spring and summer of 2003. It was determined that the source of tritium detected in wells on the north side of the RWMC could be the TRA, and tritium detected on the east side of the RWMC could be from INTEC and/or TRA. However, there still exists a possibility that some tritium is from the SDA. Additional information is needed to reach a conclusion about the source(s) of tritium in the RWMC aquifer. Maximum concentrations of H-3 in vadose zone soil moisture and perched water since October 2002 are shown in Table 3-15. Maximum concentrations of H-3 in the RWMC aquifer since October 2002 are shown in Table 3-16.

Table 3-15. Summary of maximum concentrations of tritium in vadose zone soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.[a]

Sampling Range (feet below land surface)	Fiscal Year [b]	Maximum Concentration ● 1σ (pCi/L)[c]	Sample Location
Lysimeters 0 to 35 ft	1997	3270 ± 100	W06-L27
	1998	7290 ± 474	W06-L27
	1999	8650 ± 554	W06-L27
	2000	9100 ± 1180	W06-L27
	2001	NA	—
	2002	NA	—
	2003	368 ± 77	PA02-L16
Lysimeters 35 to 140 ft	1997	NA	—
	1998	2520 ± 249	TW1-DL04
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	NA	—
	2003	1690 ± 178	TW1-DL04
Lysimeters >140 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	NA	—
	2003	ND	O7D-DL27, DE-06

Table 3-15. (continued).

Sampling Range (feet below land surface)	Fiscal Year [b]	Maximum Concentration ● 1σ (pCi/L)[c]	Sample Location
Perched water wells >140 ft	1997	ND	USGS-92
	1998	310 ± 35	USGS-92
	1999	1570 ± 188	USGS-92
	2000	ND	USGS-92
	2001	NA	—
	2002	NA	—
	2003	ND	USGS-92

a. MCL = 20,000 pCi/L

b. Fiscal year spans from October 1 to September (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).

c. NA = not analyzed ND = not detected

MCL = maximum contaminant level

USGS = United States Geological Survey

Table 3-16. Summary of maximum concentrations of tritium in aquifer wells at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.[a]

Fiscal Year [b]	Maximum Concentration ± 1σ (pCi/L)	Well Location
1997	1910 ± 182	M3S
1998	1990 ± 270	M12S
1999	1860 ± 247	M14S
2000	1860 ± 177	M14S
2001	1730 ± 192	M14S
2002	1740 ± 148	M14S
2003	1690 ± 121	M14S

a. MCL = 20,000 pCi/L

b. Fiscal year spans from October 1 to September 30 (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).

MCL = maximum contaminant level

3.5 Iodine-129

Iodine-129 is produced from nuclear reactor operations and weapons testing, and it occurs naturally in the environment through interactions of cosmic rays with atmospheric gases and from the spontaneous fission of U-238. Approximately 0.15 Ci of I-129 was disposed of in the SDA, primarily from INEEL reactor operations waste.

3.5.1 Waste Zone

Approximately 10 mL of soil moisture was collected from Waste-Zone Lysimeter 741-08-L1 on September 8, 2003, but the volume was not sufficient to analyze for I-129; however, the sample was analyzed for gamma-emitting radionuclides with no positive detections.

3.5.2 Vadose Zone

3.5.2.1 Lysimeter Samples at Depths from 0 to 35 ft. Three I-129 analyses were performed on soil-moisture samples collected from three shallow lysimeters in and around the SDA in FY 2003, with no positive detections. Occurrences of I-129 detections in the shallow vadose-zone samples, since routine monitoring began in 1997, are summarized in Figure 3-27.

		Iodine-129 RWMC Lysimeters (0–35 ft)															
FY	Qtr	98-1 L35	98-4 L38	98-5 L39	D15-DL07	PA01-L15	PA02-L16	PA03-L33	W05-L25	W06-L27	W08-L13	W08-L14	W09-L23	W23-L07	W23-L08	W23-L09	W25-L28
1997	1																
	2																
	3					🟩	🟩			🟩		🟩				🟩	🟩
	4					🟩	🟩	🟩		🟩	🟩	🟩				🟩	🟩
1998	1																
	2																
	3			🟩		🟩	🟩										
	4			🟩		🟩	🟩			🟩					🟩	🟩	
1999	1	53		29		🟩	🟩			🟩							
	2																
	3		🟩	🟩		🟩	🟩										
	4																
2000	1									🟩							🟩
	2					🟩									🟩	🟩	
	3	🟩	🟩	🟩		🟩	🟩			🟩	🟩				🟩	🟩	22
	4	🟩	🟩	🟩		🟩	🟩										🟩
2001	1																
	2																
	3																
	4																
2002	1																
	2																
	3																
	4					🟩											🟩
2003	1													🟩			
	2																🟩
	3																
	4												🟩				

Key		
	🟩	Analysis was performed, but iodine-129 was not detected.
	🟥	Iodine-129 was detected (pCi/L).
	If more than one positive detection occurred in a single quarter, then only the highest concentration is listed. Note: RBC = 3.22 pCi/L FY = fiscal year RBC = 1E-05 risk-based concentration RWMC = Radioactive Waste Management Complex	

Figure 3-27. Occurrences of iodine-129 detections in shallow lysimeter wells.

Since monitoring began, only three positive results have been observed in soil-moisture samples collected from the vadose zone. There is a concern about why there are so few I-129 detections in soil-moisture samples. The process to sample soil moisture (i.e., vacuum) could cause a significant portion of I-129 to volatilize from the water sample, thereby reducing the concentrations to a level that cannot be measured by routine analytical methods.

3.5.2.2 Lysimeter Samples from 35 to 140 ft Deep. Four I-129 analyses were performed on soil-moisture samples collected from four intermediate-depth lysimeters in and around the SDA in FY 2003, with no positive detections. Two samples were collected in October 2002 from Lysimeters D15-DL06 and O5-DL25. One sample was collected in January 2003 from Lysimeter I1S-DL09. One sample was collected in July 2003 from Lysimeter O4-DL24. No Np-237 has been detected in shallow lysimeter samples since monitoring began in FY 2000; therefore, a figure showing occurrences is not presented.

3.5.2.3 Lysimeter and Perched Water Samples at Depths Greater than 140 ft. One perched water sample and no soil-moisture samples were obtained at a range deeper than 140 ft and analyzed for I-129 in FY 2003, resulting in no positive detections. The perched water sample was collected from USGS-92 in October 2002. No I-129 has been detected in any wells or lysimeters from this depth range since sample collection began in 1997; therefore, a figure showing occurrences is not presented.

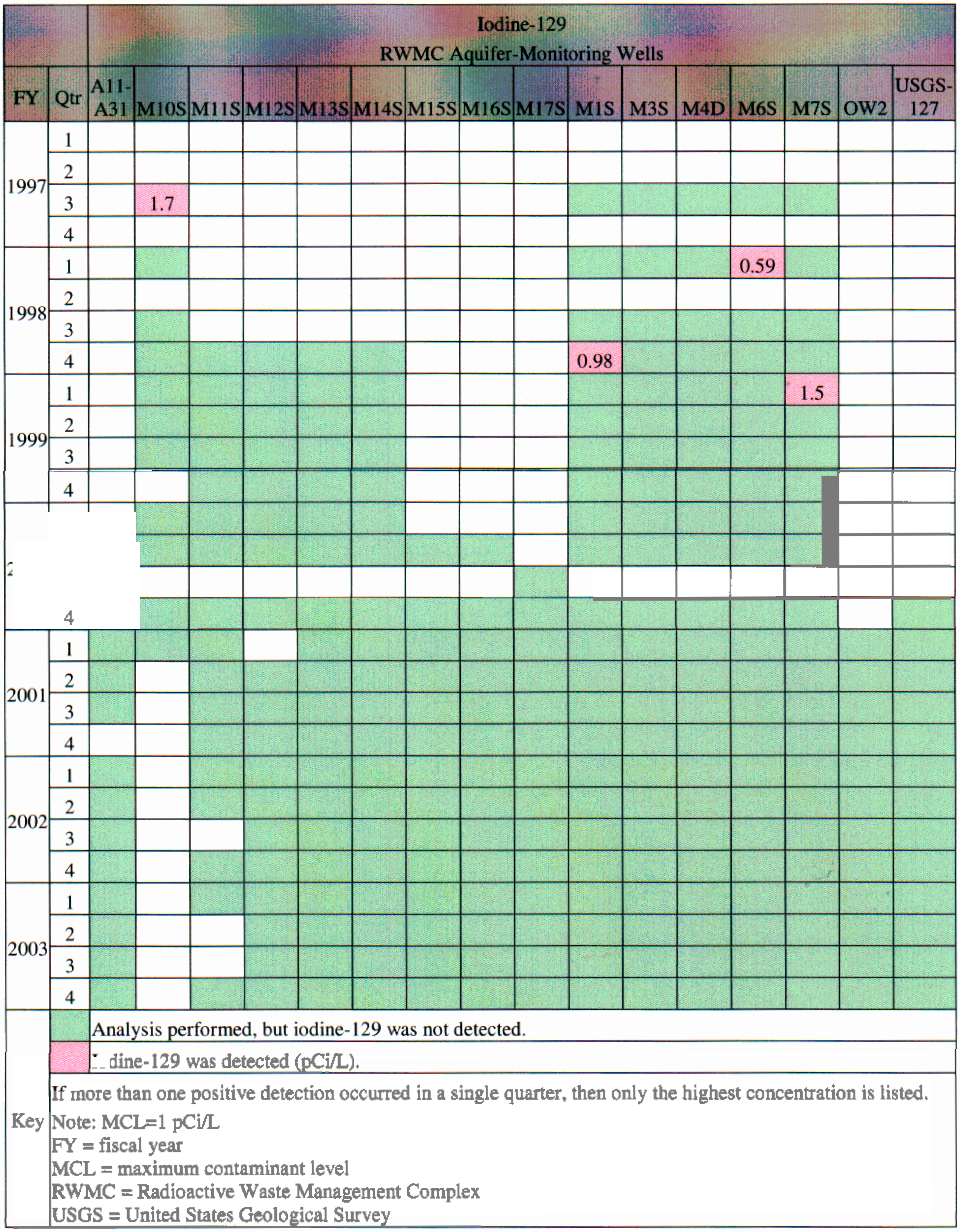
3.5.3 Aquifer

Seventy-eight I-129 analyses were performed on aquifer samples collected from 15 monitoring wells in the vicinity of the RWMC in FY 2003, with one detection (Well M13S). The detection did not meet the criteria of a positive detection, since its result (0.7±0.2 pCi/L) was less than the MDA (0.8 pCi/L). Therefore, the project assigned a "J" data qualifier flag to the result to indicate it was not a valid detection. In addition, an I-129 result from a separate sample collected from M13S in conjunction with this sample, but for another purpose, was a nondetect. Iodine-129 has not been detected in any aquifer wells since 1999 (Figure 3-28).

A special sampling and analysis event, outside the scope of routine WAG 7 aquifer monitoring, was conducted in April and May 2003. The special study assessed possible impacts to the aquifer at the RWMC from upgradient facilities and included analysis of I-129 at detection sensitivities less than or equal to 0.1 pCi/L, which is 10 times lower than the standard method detection limit of 1 pCi/L. Fourteen RWMC aquifer wells were sampled and none of the aquifer samples tested positive for I-129 at these low concentrations. The samples were collected from Wells AllA31, M1S, M3S, M4D, M6S, M7S, M12S, M13S, M14S, M15S, M16S, M17S, OW2, and USGS-127.

3.5.4 Summary of Iodine-129

No I-129 was detected in soil-moisture samples collected in FY 2003 from the SDA vadose zone or from water samples collected from RWMC aquifer-monitoring wells. Historical detections in the vadose zone and perched water are sporadic and not indicative of trends. Figure 3-29 depicts historical I-129 detections with the known I-129 disposal locations. The detection of I-129 in soil moisture from Lysimeter 98-1L35, at a depth of 5 m (16.5 ft), is the only detection that occurred near a mapped disposal location. The three lone detections depicted in Figure 3-27 were not substantiated in later sampling events. Tables 3-17 and 3-18 summarize the maximum I-129 concentrations detected in vadose zone and aquifer samples since FY 1997, respectively. Detections are sporadic and not indicative of trends or widespread contamination. The absence of I-129 in the aquifer around the RWMC, as determined by the special study conducted in May 2003, provides evidence that I-129 is not present in the SRPA in or around the RWMC.



		Iodine-129 RWMC Aquifer-Monitoring Wells															
FY	**Qtr**	**A11-A31**	**M10S**	**M11S**	**M12S**	**M13S**	**M14S**	**M15S**	**M16S**	**M17S**	**M1S**	**M3S**	**M4D**	**M6S**	**M7S**	**OW2**	**USGS-127**
1997	1																
	2																
	3		1.7								🟩	🟩	🟩	🟩	🟩		
	4																
1998	1		🟩								🟩	🟩	🟩	0.59	🟩		
	2																
	3		🟩								🟩	🟩	🟩	🟩	🟩		
	4		🟩	🟩	🟩	🟩	🟩				0.98	🟩	🟩	🟩	🟩		
1999	1		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	1.5		
	2		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	3		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	4			🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
2			🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
			🟩	🟩	🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩		
										🟩							
	4		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩		🟩
2001	1	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
2002	1	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
2003	1	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩

Key

🟩 Analysis performed, but iodine-129 was not detected.

🟥 Iodine-129 was detected (pCi/L).

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.

Note: MCL=1 pCi/L
FY = fiscal year
MCL = maximum contaminant level
RWMC = Radioactive Waste Management Complex
USGS = United States Geological Survey

Figure 3-28. Occurrences of iodine-129 detections in Radioactive Waste Management Complex aquifer wells.

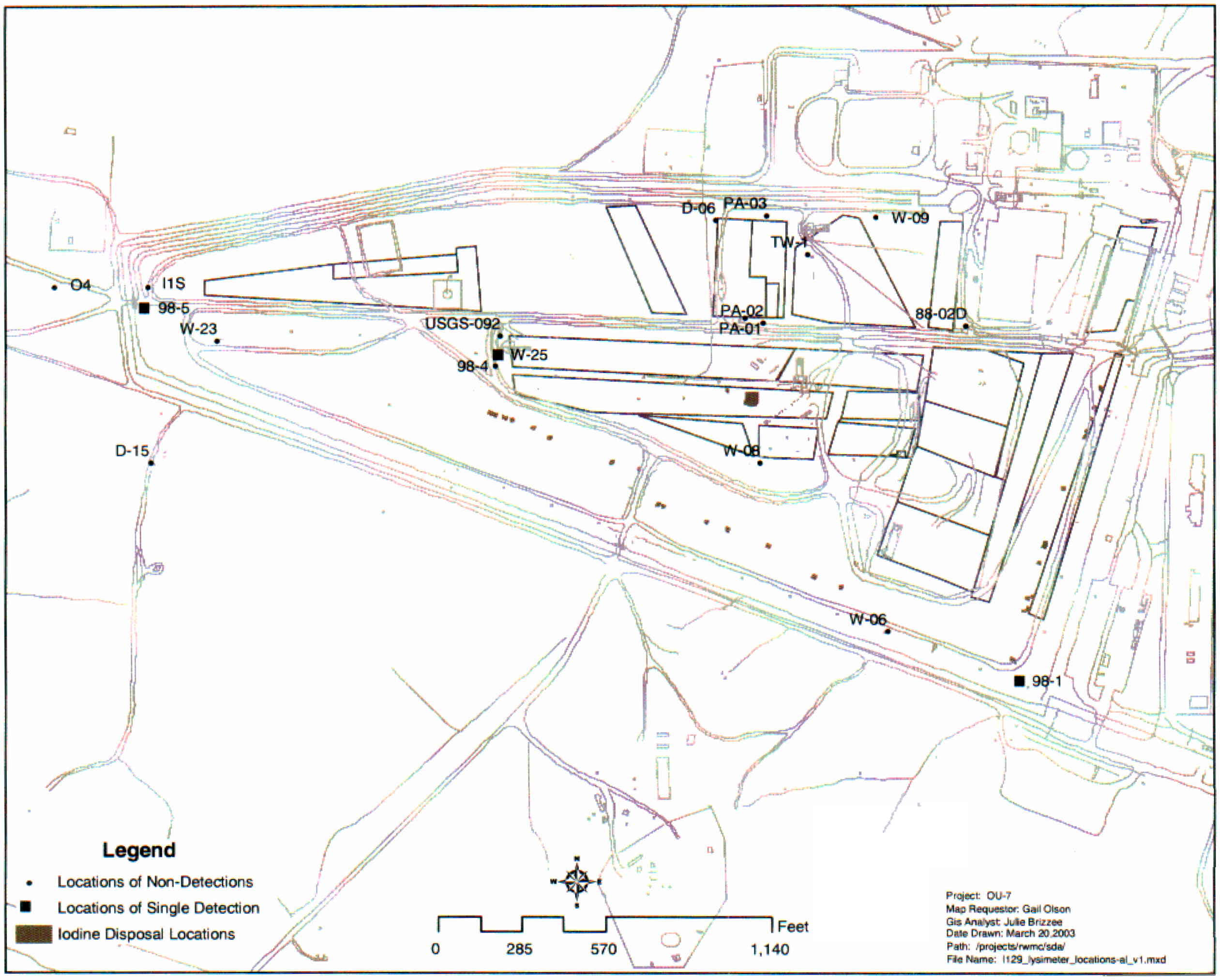


Figure 3-29. Iodine-129 disposal locations and vadose zone detection locations at the Subsurface Disposal Area.

Table 3-17. Summary of maximum concentrations of iodine-129 in vadose zone soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.[a]

Sampling Range (feet below land surface)	Fiscal Year[b]	Maximum Concentration ± 1σ (pCi/L)[c]	Sample Location
Lysimeters 0 to 35 ft	1997	ND	Various[d]
	1998	ND	Various
	1999	53 ± 18	**98-1L35**
	2000	22 ± 7	**W25-L28**
	2001	NA	—
	2002	NA	—
	2003	ND	Various
Lysimeters 35 to 140 ft	1997	ND	D06-DL02
	1998	ND	Various
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	NA	—
	2003	ND	Various
Lysimeters >140 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	NA	—
	2003	ND	DE-06
Perched water wells >140 ft	1997	ND	USGS-92
	1998	ND	8802D
	1999	ND	USGS-92
	2000	NA	—
	2001	NA	—
	2002	ND	USGS-92
	2003	ND	USGS-92

a. MCL = 1 pCi/L

b. Fiscal year spans from October 1 to September 30 (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).

c. NA = not analyzed ND = not detected

d. Various locations were sampled.

MCL = maximum contaminant level

USGS = United States Geological Survey

Table 3-18. Summary of maximum concentrations of iodine-129 in aquifer wells at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.[a]

Fiscal Year[b]	Maximum Concentration ± 1σ (pCi/L)	Well Location
1997	1.7 ± 0.4	M10S
1998	1.0 ± 0.2	M1S
1999	1.5 ± 0.4	M7S
2000	ND[c]	Various[d]
2001	ND[c]	Various[d]
2002	ND[c]	Various[d]
2003	ND	Various[d]

a. MCL = 1 pCi/L

b. Fiscal year spans from October 1 to September 30 (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).

c. ND = not detected

d. Various locations were sampled.

MCL = maximum contaminant level

3.6 Neptunium-237

Neptunium-237 is a transuranic (TRU) isotope that is a product of nuclear reactor operations and is a decay product of Am-241. Approximately 2.6 Ci of Np-237 was disposed of in the SDA, and approximately 37 Ci of Np-237 is expected to be produced over time from the radioactive decay of Pu-241.

3.6.1 Waste Zone

Approximately 10 mL of soil moisture was collected from Waste-Zone Lysimeter 741-08-L1 on September 8, 2003, but the volume was not sufficient to analyze for Np-237; however, the sample was analyzed for gamma-emitting radionuclides with no positive detections. Historically, Np-237 has been detected in soil moisture from Waste-Zone Lysimeter 741-08-L1 in April 2002.

3.6.2 Vadose Zone

3.6.2.1 Lysimeter Samples from 0 to 35 ft Deep. Ten Np-237 analyses were performed on soil-moisture samples collected from eight shallow lysimeters in and around the SDA in FY 2003, with no positive detections. Five samples were collected in October 2002 from Lysimeters W08-L13, W23-L07, W25-L28, 98-4L38, and 98-5L39. One sample was collected in January 2003 from Lysimeter W25-L28. Four samples were collected in July 2003 from Lysimeters PA01-L15, PA02-L16, W23-L07, and W23-L09. No Np-237 has been detected in shallow lysimeter samples since monitoring began in FY 2000; therefore, a figure showing occurrences is not presented.

3.6.2.2 Lysimeter Samples from 35 to 140 ft Deep. Twenty-three Np-237 analyses were performed on soil-moisture samples collected from 12 intermediate-depth lysimeters in and around the SDA in FY 2003, with no positive detections. Eight samples were collected in October 2002 from Lysimeters D15-DL06, I1S-DL09, I2S-DL11, I3S-DL13, I4S-DL15, O5-DL25, O7-DL28, and TW1-DL04. Seven samples were collected in January 2003 from Lysimeters I1S-DL09, I2S-DL11, I3S-DL13, O3-DL22, O4-DL24, O5-DL25, and O7-DL28. Eight samples were collected in July 2003 from Lysimeters D06-DL01, D15-DL06, I1S-DL09, I2S-DL11, I4S-DL15, O2-DL20, O4-DL24, and

O7-DL28. No Np-237 has been detected in intermediate-depth lysimeter samples since monitoring began in FY 2000; therefore, a figure showing occurrences is not presented.

3.6.2.3 Lysimeter and Perched Water Samples Deeper than 140 ft. Twelve Np-237 analyses were performed on samples collected from five lysimeters and two perched water wells in and around the SDA in FY 2003, with no positive detections. The perched water samples were collected from 8802D and USGS-92 in October 2002 and January 2003. Five samples were collected in October 2002 from Lysimeters I3D-DL12, I4D-DL14, O2-DL19, O4-DL23, and O7-DL27. Three samples were collected in January 2003 from Lysimeters I3D-DL12, I4D-DL14, O2-DL19, and O4-DL23. No Np-237 has been detected in any samples collected at this depth since monitoring began; therefore, a figure showing occurrences is not presented.

3.6.3 Aquifer

Sixty-three Np-237 analyses were performed on aquifer samples collected from 15 monitoring wells in the vicinity of the RWMC in FY 2003, with no positive detections. Samples were collected in November 2002 and February, April, May, and August 2003 from Monitoring Wells A11A31, M1S, M3S, M4D, M6S, M7S, M11S, M12S, M13S, M14S, M15S, M16S, M17S, OW2, and USGS-127. Other than three low-level, unconfirmed detections last fiscal year, no Np-237 has been detected in RWMC monitoring wells since monitoring for Np-237 began in FY 1999; therefore, a figure showing occurrences is not presented.

3.6.4 Summary of Neptunium-237

Neptunium-237 has never been detected in the vadose zone or perched water since monitoring began; however, there was one detection in the waste zone soil-moisture sample in April 2002. Other than three low-level, unconfirmed Np-237 detections in the aquifer in FY 2002, no detections have occurred since monitoring began in FY 1999. Tables 3-19 and 3-20 summarize the maximum Np-237 concentrations detected in vadose zone and aquifer samples since FY 1997, respectively.

Table 3-19. Summary of maximum concentrations of neptunium-237 in soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.[a]

Sampling Range (feet below land surface)	Fiscal Year [b]	Maximum Concentration ± 1σ (pCi/L)[c]	Sample Location
Lysimeters 0 to 35 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	ND	Various[d]
	2001	ND	Various
	2002	6.1±1.7	741-08-L1 (Waste Zone)
	2003	ND	Various
Lysimeters 35 to 140 ft	1997	NA	—
	1998	NA	—
	1999	NA	
	2000	ND	Various
	2001	ND	Various
	2002	ND	Various
	2003	ND	Various

Table 3-19. (continued).

Sampling Range (feet below land surface)	Fiscal Year [b]	Maximum Concentration ± 1σ (pCi/L)[c]	Sample Location
Lysimeters >140 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	NA	—
	2003	ND	Various
Perched water wells >140 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	ND	USGS-92
	2001	ND	USGS-92
	2002	ND	USGS-92
	2003	ND	USGS-92, 8802D

a. MCL = 15 pCi/L total alpha activity concentration
b. Fiscal year spans from October 1 to September (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).
c. NA = not analyzed ND = not detected
d. Various locations were sampled.
MCL = maximum contaminant level
USGS = United States Geological Survey

Table 3-20. Summary of maximum concentrations of neptunium-237 in aquifer wells at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.[a]

Fiscal Year[b]	Maximum Concentration ± 1σ (pCi/L)[c]	Well Location
1997	NA	—
1998	NA	—
1999	ND	Various[d]
2000	ND	Various
2001	ND	Various
2002	0.38 ± 0.04	A11A31
2003	ND	Various

a. MCL = 15 pCi/L total alpha activity concentration
b. Fiscal year spans from October 1 to September (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).
c. NA = not analyzed ND = not detected
d. Various locations were sampled.
MCL = maximum contaminant level

3.7 Plutonium

All plutonium isotopes are anthropogenic and TRU products of nuclear reactor operations or nuclear weapons production, deployment, and testing. Approximately 1.71E+04 Ci of Pu-238 was disposed of in the SDA, primarily from INEEL reactor operations waste. Approximately 6.48E+04 Ci of Pu-239, primarily from RFP, was disposed of in the SDA. Approximately 1.71E+04 Ci of Pu-240 was disposed of in the SDA, primarily from RFP with a significant portion from INEEL reactor operations.

3.7.1 Waste Zone

Approximately 10 mL of soil moisture was collected from Waste-Zone Lysimeter 741-08-L1 on September 8, 2003, but the volume was not sufficient to analyze for plutonium; however, the sample was analyzed for gamma-emitting radionuclides with no positive detections. Historically, Pu-239/240 has been detected in soil moisture from Waste-Zone Lysimeter 741-08-L1 in November 2001 and again in April 2002.

3.7.2 Vadose Zone

3.7.2.1 Lysimeter Samples at Depths of 0 to 35 ft. Fourteen Pu-238 and Pu-239/240 analyses were performed on soil-moisture samples collected from 11 shallow lysimeters in and around the SDA in FY 2003, with no positive detections. Historical detections in shallow lysimeter samples are depicted in Figure 3-30 for Pu-238 and Figure 3-31 for Pu-239/240.

		Plutonium-238 RWMC Lysimeters (0–35 ft)															
FY	Qtr	98-1 L35	98-4 L38	98-5 L39	D15-DL07	PA01-L15	PA02-L16	PA03-L33	W05-L25	W06-L27	W08-L13	W08-L14	W09-L23	W23-L07	W23-L08	W23-L09	W25-L28
1997	1																
	2																
	3					🟩	🟩			🟩	🟩	🟩				🟩	
	4					🟩	🟩	24		🟩	🟩	🟩				🟩	🟩
1998	1																
	2							2.2									
	3	🟩	🟩	5.6		8.5	🟩	🟩									
	4		🟩	🟩		🟩	🟩			🟩	🟩				🟩	🟩	🟩
1999	1	🟩	🟩	🟩		🟩	🟩	🟩		🟩						🟩	
	2	🟩															
	3	🟩	🟩	🟩		🟩	🟩	🟩									
	4																
2000	1	🟩						🟩		🟩							🟩
	2	🟩	🟩	🟩		🟩	🟩	🟩			🟩				🟩	🟩	
	3	🟩	🟩	🟩		🟩	🟩			🟩	🟩				🟩	🟩	🟩
	4	🟩	0.88	🟩		2.3	🟩										🟩
2001	1						3.7										
	2																
	3	🟩	🟩	🟩		🟩	🟩		🟩	🟩					🟩		
	4																
2002	1																
	2																
	3		🟩			🟩				🟩			🟩				🟩
	4					🟩								🟩		🟩	🟩
2003	1		🟩	🟩	🟩						🟩			🟩			🟩
	2		🟩	🟩	🟩												🟩
	3																
	4	🟩				🟩	🟩				🟩		🟩	🟩		🟩	

Key

🟩 plutoni

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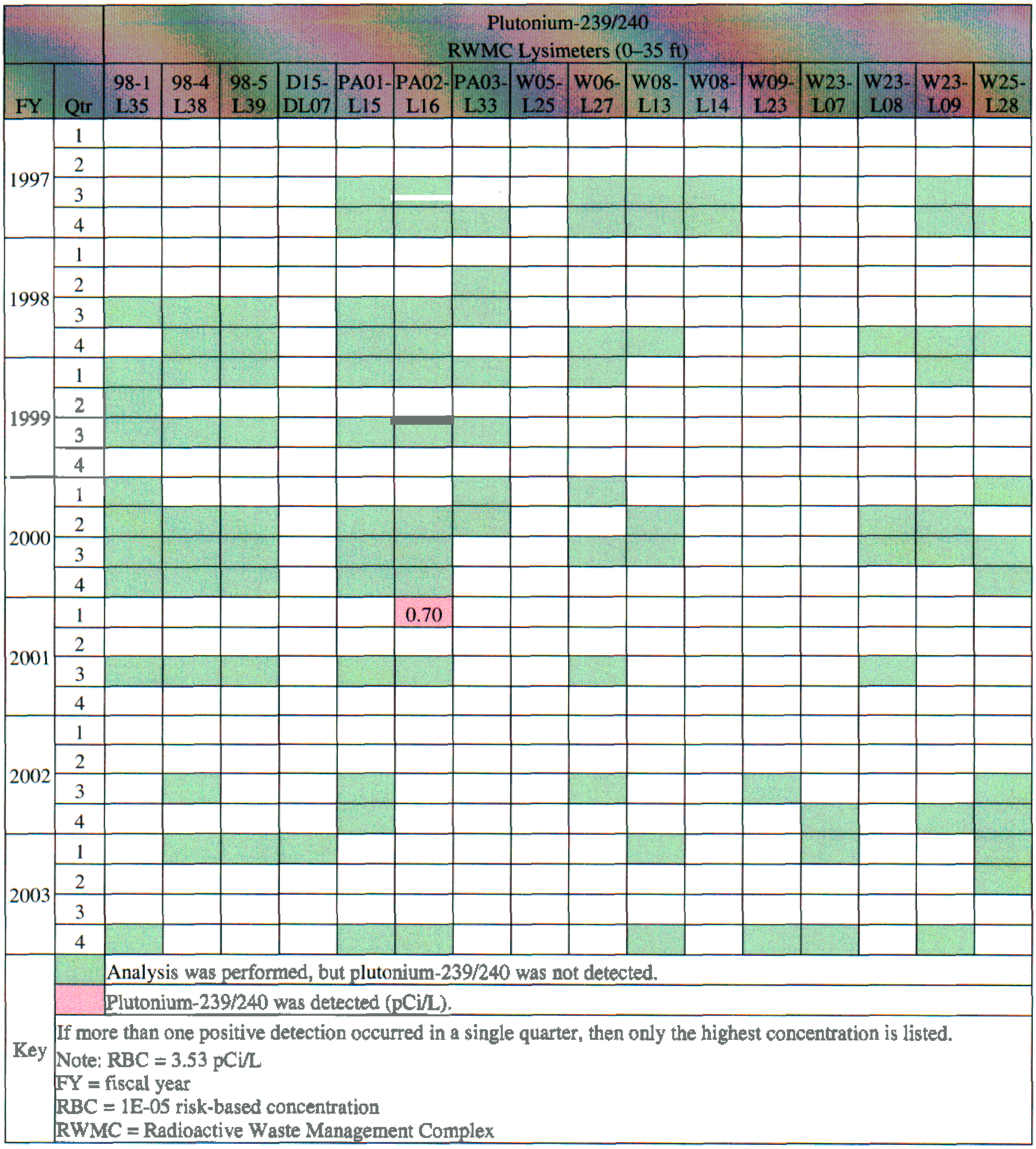
If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.

Note: RBC = 3.64 pCi/L

FY = fiscal year

RBC = 1E-05 risk-based concentration

RWMC = Radioactive Waste Management Complex



		Plutonium-239/240 RWMC Lysimeters (0–35 ft)															
FY	Qtr	98-1 L35	98-4 L38	98-5 L39	D15- DL07	PA01- L15	PA02- L16	PA03- L33	W05- L25	W06- L27	W08- L13	W08- L14	W09- L23	W23- L07	W23- L08	W23- L09	W25- L28
1997	1																
	2																
	3					🟩	🟩			🟩	🟩	🟩				🟩	
	4					🟩	🟩	🟩		🟩	🟩	🟩				🟩	🟩
1998	1																
	2							🟩									
	3	🟩	🟩	🟩		🟩	🟩	🟩									
	4		🟩	🟩		🟩	🟩			🟩	🟩				🟩	🟩	🟩
1999	1	🟩	🟩	🟩		🟩	🟩	🟩		🟩						🟩	
	2	🟩															
	3	🟩	🟩	🟩		🟩	🟩	🟩									
	4																
2000	1	🟩						🟩		🟩							🟩
	2	🟩	🟩	🟩		🟩	🟩	🟩			🟩				🟩	🟩	
	3	🟩	🟩	🟩		🟩	🟩			🟩	🟩				🟩	🟩	🟩
	4	🟩	🟩	🟩		🟩	🟩										🟩
2001	1						0.70										
	2																
	3	🟩	🟩	🟩		🟩	🟩			🟩					🟩		
	4																
2002	1																
	2																
	3		🟩			🟩				🟩			🟩				🟩
	4					🟩								🟩		🟩	🟩
2003	1		🟩	🟩	🟩						🟩			🟩			🟩
	2																🟩
	3																
	4	🟩				🟩	🟩				🟩		🟩	🟩		🟩	

Key

🟩 Analysis was performed, but plutonium-239/240 was not detected.

🟥 Plutonium-239/240 was detected (pCi/L).

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.
Note: RBC = 3.53 pCi/L
FY = fiscal year
RBC = 1E-05 risk-based concentration
RWMC = Radioactive Waste Management Complex

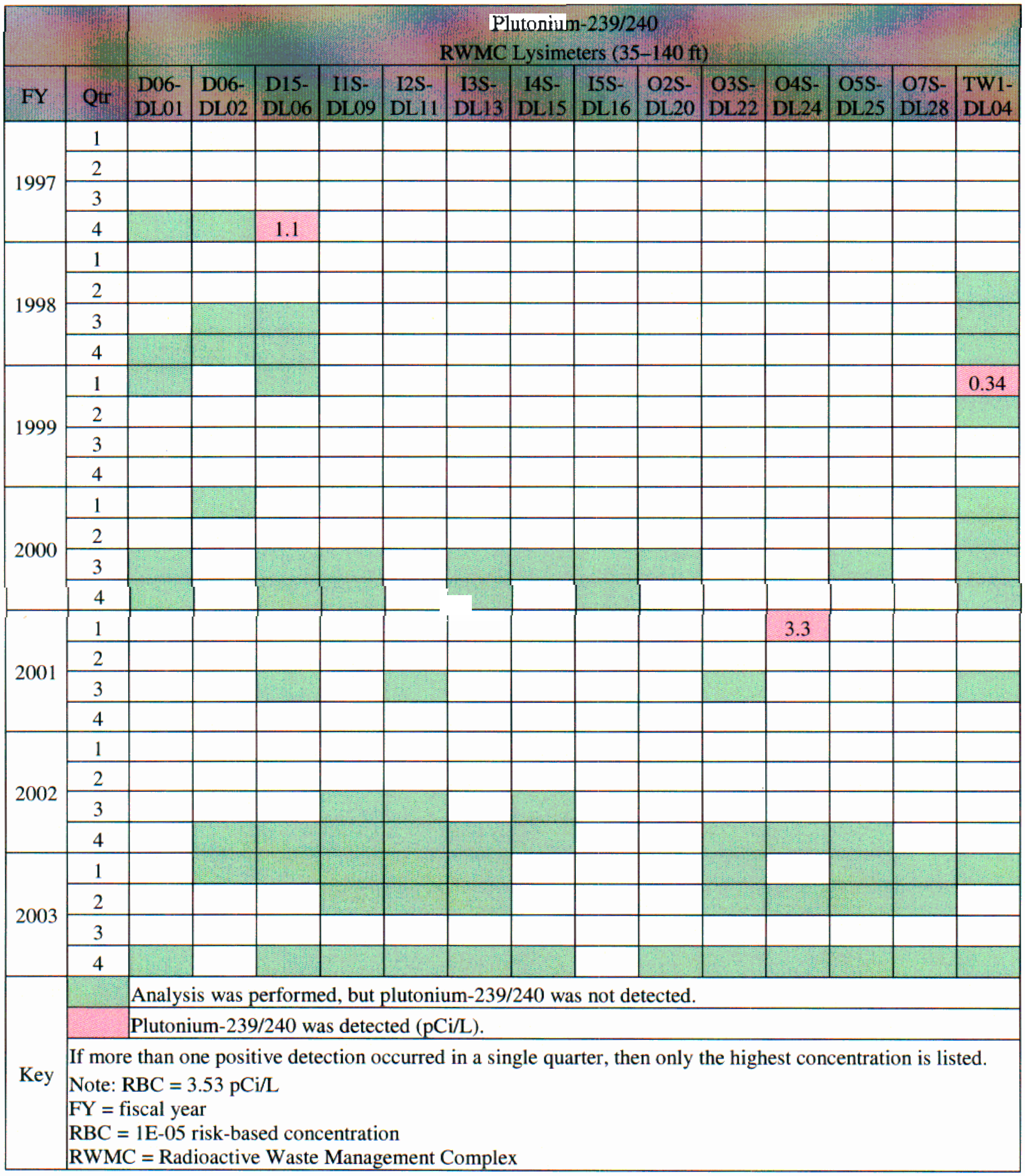
Figure 3-31. Occurrences of plutonium-239/240 detections in shallow lysimeters since Fiscal Year 1997.

3.7.2.2 Lysimeter Samples at Depths of 35 to 140 ft. Twenty-eight Pu-238 and Pu-239/240 analyses were performed on soil-moisture samples collected from 12 intermediate-depth lysimeters in and around the SDA in FY 2003, with no positive detections. Historical detections are shown in Figure 3-32 for Pu-238 and Figure 3-33 for Pu-239/240.

		Plutonium-238 RWMC Lysimeters (35–140 ft)													
FY	Qtr	D06-DL01	D06-DL02	D15-DL06	I1S-DL09	I2S-DL11	I3S-DL13	I4S-DL15	I5S-DL16	O2S-DL20	O3S-DL22	O4S-DL24	O5S-DL25	O7S-DL28	TW1-DL04
1997	1														
	2														
	3														
	4	🟥 11.6	🟥 3.3	🟥 3.1											
1998	1														
	2														🟩
	3		🟩	🟩											🟩
	4	🟩	🟩	🟩											🟩
1999	1	🟩		🟩											🟩
	2														🟩
	3														
	4														
2000	1		🟩												🟩
	2														🟩
	3	🟩		🟩	🟩		🟩	🟩	🟩	🟩			🟩		🟩
	4	🟩		🟩	🟩		🟩		🟩						🟩
2001	1											🟩			
	2														
	3			🟩		🟩					🟩				🟩
	4														
2002	1														
	2														
	3				🟩	🟩		🟩							
	4		🟩	🟩	🟩	🟩	🟩	🟩			🟩	🟩	🟩		
2003	1			🟩	🟩	🟩	🟩	🟩			🟩		🟩	🟩	🟩
	2				🟩	🟩	🟩				🟩	🟩	🟩	🟩	
	3														
	4	🟩		🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩	🟩

Key
🟩 Analysis was performed, but plutonium-238 was not detected.
🟥 Plutonium-238 was detected (pCi/L).
If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.
Note: RBC = 3.64 pCi/L
FY = fiscal year
RBC = 1E-05 risk-based concentration
RWMC = Radioactive Waste Management Complex

Figure 3-32. Occurrences of plutonium-238 detections in intermediate-depth lysimeters since Fiscal Year 1997.



		Plutonium-239/240 RWMC Lysimeters (35–140 ft)													
FY	Qtr	D06-DL01	D06-DL02	D15-DL06	I1S-DL09	I2S-DL11	I3S-DL13	I4S-DL15	I5S-DL16	O2S-DL20	O3S-DL22	O4S-DL24	O5S-DL25	O7S-DL28	TW1-DL04
1997	1														
	2														
	3														
	4	🟩	🟩	🟥 1.1											
1998	1														
	2														🟩
	3		🟩	🟩											🟩
	4	🟩	🟩	🟩											🟩
1999	1	🟩		🟩											🟥 0.34
	2														🟩
	3														
	4														
2000	1		🟩												🟩
	2														🟩
	3	🟩		🟩	🟩		🟩	🟩	🟩	🟩			🟩		🟩
	4	🟩		🟩	🟩		🟩		🟩						🟩
2001	1											🟥 3.3			
	2														
	3			🟩		🟩					🟩				🟩
	4														
2002	1														
	2														
	3				🟩	🟩		🟩							
	4		🟩	🟩	🟩	🟩	🟩	🟩			🟩	🟩	🟩		
2003	1		🟩	🟩	🟩	🟩	🟩				🟩		🟩	🟩	🟩
	2				🟩	🟩	🟩				🟩	🟩	🟩	🟩	
	3														
	4	🟩		🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩	🟩

Key

🟩 Analysis was performed, but plutonium-239/240 was not detected.

🟥 Plutonium-239/240 was detected (pCi/L).

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.
Note: RBC = 3.53 pCi/L
FY = fiscal year
RBC = 1E-05 risk-based concentration
RWMC = Radioactive Waste Management Complex

Figure 3-33. Occurrences of plutonium-239/240 detections in intermediate-depth lysimeters since Fiscal Year 1997.

3.7.2.3 Lysimeter and Perched Water Samples at Depths Greater than 140 ft. Eighteen Pu-238 and Pu-239/240 analyses were performed on samples collected from six lysimeter and two perched water wells in and around the SDA in FY 2003, with no positive detections. Historical detections are shown in Figure 3-34 for Pu-238 and Figure 3-35 for Pu-239/240.

		Plutonium-238 RWMC Perched Water and Lysimeters (>140 ft)									
FY	Qtr	8802D	USGS-092	I2D-DL10	I3D-DL12	I4D-DL14	O2-DL19	O4-DL23	O6-DL26	O7-DL27	O8-DL29
1997	1		🟩								
	2										
	3		🟩								
	4		🟩								
1998	1		🟩								
	2	🟩	🟩								
	3		🟩								
	4		🟩								
1999	1	🟩	🟩								
	2	🟩	🟩								
	3										
	4										
2000	1		🟩								
	2	🟩	🟩								
	3				🟩				🟩		
	4		🟩						🟩		
2001	1		🟥 4.8					🟩			
	2										
	3										
	4										
2	1										
	2		🟩								
				🟩	🟩	🟩					🟩
					🟩				🟩	🟩	
2		🟩	🟩		🟩	🟩	🟩	🟩		🟩	
			🟩		🟩	🟩	🟩	🟩		🟩	
								[redacted]			
			🟩	🟩				🟩		🟩	

🟩 Analysis was performed for plutonium-238, but none was detected.

🟥]

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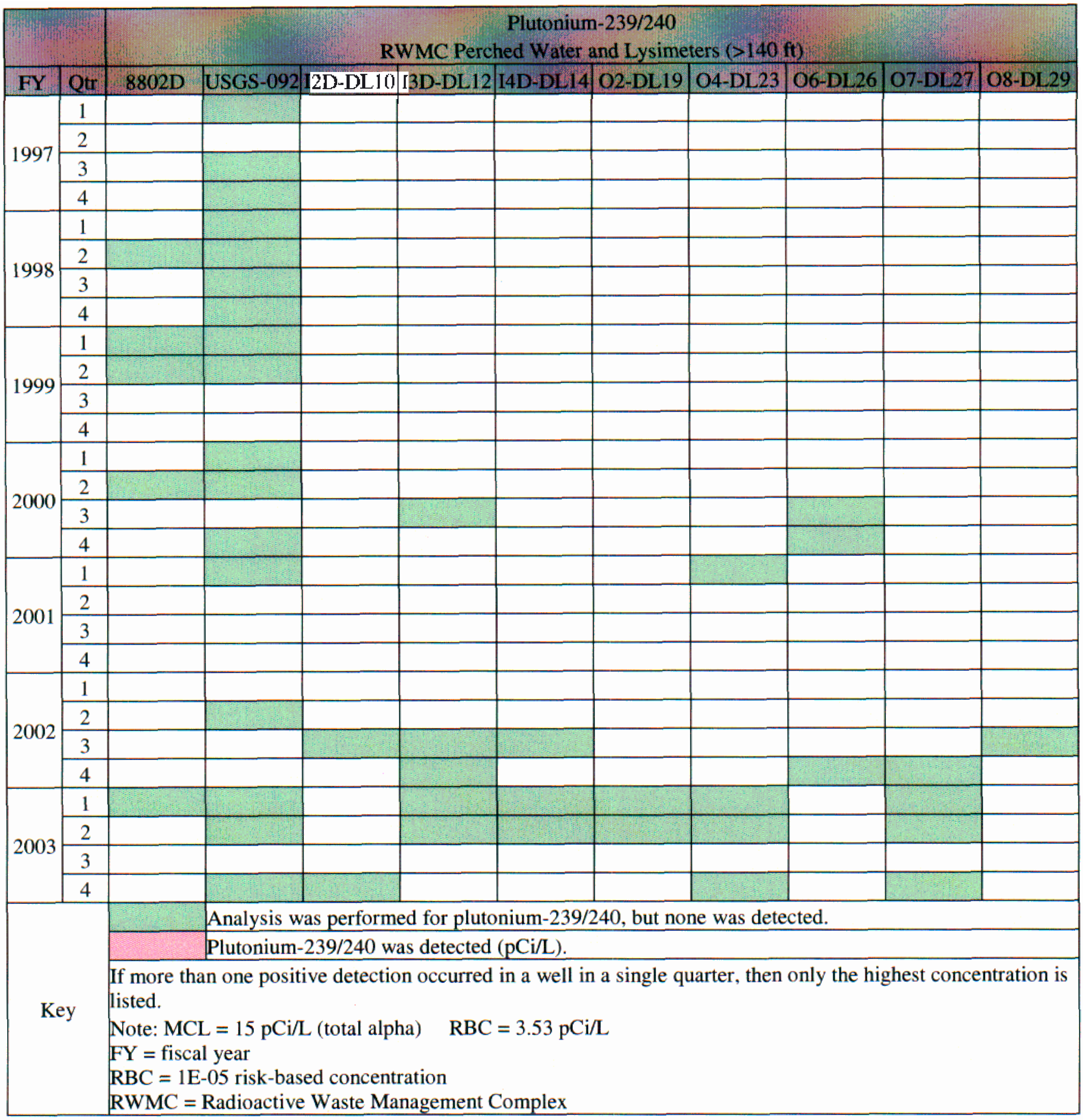
Note: MCL = 15 pCi/L (total alpha) RBC = 3.64 pCi/L
FY = fiscal year
RBC = 1E-05 risk-based concentration
RWMC = Radioactive Waste Management Complex

Figure 3-34. Occurrences of plutonium-238 detections in deep lysimeters since Fiscal Year 1997.



FY	Qtr	Plutonium-239/240 RWMC Perched Water and Lysimeters (>140 ft)									
		8802D	USGS-092	I2D-DL10	I3D-DL12	I4D-DL14	O2-DL19	O4-DL23	O6-DL26	O7-DL27	O8-DL29
1997	1		🟩								
	2										
	3		🟩								
	4		🟩								
1998	1		🟩								
	2	🟩	🟩								
	3		🟩								
	4		🟩								
1999	1	🟩	🟩								
	2	🟩	🟩								
	3										
	4										
2000	1		🟩								
	2	🟩	🟩								
	3				🟩				🟩		
	4		🟩						🟩		
2001	1		🟩					🟩			
	2										
	3										
	4										
2002	1										
	2		🟩								
	3			🟩	🟩	🟩					🟩
	4				🟩				🟩	🟩	
2003	1	🟩	🟩		🟩	🟩	🟩	🟩		🟩	
	2		🟩		🟩	🟩	🟩	🟩		🟩	
	3										
	4		🟩	🟩				🟩		🟩	

Key

🟩 Analysis was performed for plutonium-239/240, but none was detected.

🟥 Plutonium-239/240 was detected (pCi/L).

If more than one positive detection occurred in a well in a single quarter, then only the highest concentration is listed.

Note: MCL = 15 pCi/L (total alpha)   RBC = 3.53 pCi/L

FY = fiscal year

RBC = 1E-05 risk-based concentration

RWMC = Radioactive Waste Management Complex

Figure 3-35. Occurrences of plutonium-239/240 detections in deep lysimeters since Fiscal Year 1997.

3.7.3 Aquifer

Sixty-three Pu-238 and Pu-239 analyses were performed on aquifer samples collected from 15 monitoring wells in the vicinity of the RWMC in FY 2003, with no positive detections. Occurrences of Pu-238 and Pu-239/240 in aquifer samples since FY 1997 are depicted in Figures 3-36 and 3-37, respectively.

FY	Qtr	Plutonium-238 RWMC Aquifer-Monitoring Wells															
		A11-A31	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	M1S	M3S	M4D	M6S	M7S	OW-2	USGS-127
1997	1																
	2																
	3		🟩								🟩	🟩	🟩	🟩	🟩		
	4																
1998	1		🟩								🟩	🟩	🟩	🟩	🟩		
	2										🟩	🟩					
	3		🟩								🟩	🟩	🟩	🟩	🟩		
	4		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
1999	1		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	2		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	3		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	0.044	🟩		
	4		🟩	🟩		🟩	🟩				🟩	🟩	🟩	🟩	🟩		
2000	1		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	2		🟩	🟩	🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩		
	3									🟩							
	4		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	0.37	🟩	🟩	🟩		🟩
2001	1	🟩	0.018	0.030		🟩	🟩	🟩	🟩	🟩	0.019	🟩	0.028	🟩	0.071	🟩	🟩
	2	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	0.17	🟩	🟩	🟩
	3	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4			🟩	🟩	🟩	🟩	🟩	0.034	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
2002	1	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
2003	1	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩

Key

🟩 Analysis was performed, but plutonium-238 was not detected.

🟥 Plutonium-238 was detected (pCi/L).

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.

Note: MCL = 15 pCi/L total alpha

FY = fiscal year

MCL = maximum contaminant level

RWMC = Radioactive Waste Management Complex

USGS = United States Geological Survey

Figure 3-36. Occurrences of plutonium-238 detections in aquifer samples collected around the Radioactive Waste Management Complex since Fiscal Year 1997.

		Plutonium-239/240 RWMC Aquifer-Monitoring Wells															
FY	Qtr	A11 A31	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	M1S	M3S	M4D	M6S	M7S	OW-2	USGS-127
1997	1																
	2																
	3		🟩								🟩	🟩	🟩	🟩	🟩		
	4																
1998	1		🟩								🟩	🟩	🟩	🟩	🟩		
	2										🟩	🟩					
	3		🟩								🟩	🟩	🟩	🟩	🟩		
	4		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
1999	1		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	2		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	3		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	4		🟩	🟩		🟩	🟩				🟩	🟩	🟩	🟩	🟩		
2000	1		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	2		🟩	🟩	🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩		
	3									🟩							
	4		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥 0.09	🟩	🟩	🟩		🟩
2001	1	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4			🟩	🟩	🟩	🟩	🟩	🟥 0.03	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
2002	1	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	
2003	1	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩

Key

🟩 Analysis was performed, but plutonium-239/240 was not detected.

🟥 Plutonium-239/240 was detected (pCi/L).

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.
Note: MCL = 15 pCi/L total alpha
FY = fiscal year
MCL = maximum contaminant level
RWMC = Radioactive Waste Management Complex
USGS = United States Geological Survey

Figure 3-37. Occurrences of plutonium-239/240 detections in aquifer samples collected around the Radioactive Waste Management Complex since Fiscal Year 1997.

3.7.4 Summary of Plutonium

Plutonium-238 and Pu-239/240 were not detected in the vadose zone soil-moisture samples, perched water samples, or RWMC aquifer samples in FY 2003. The locations of historical plutonium detections in the vadose zone are depicted in Figure 3-38, with locations of plutonium-containing disposals. Plutonium detections are sporadic and do not point to any discernable trends.

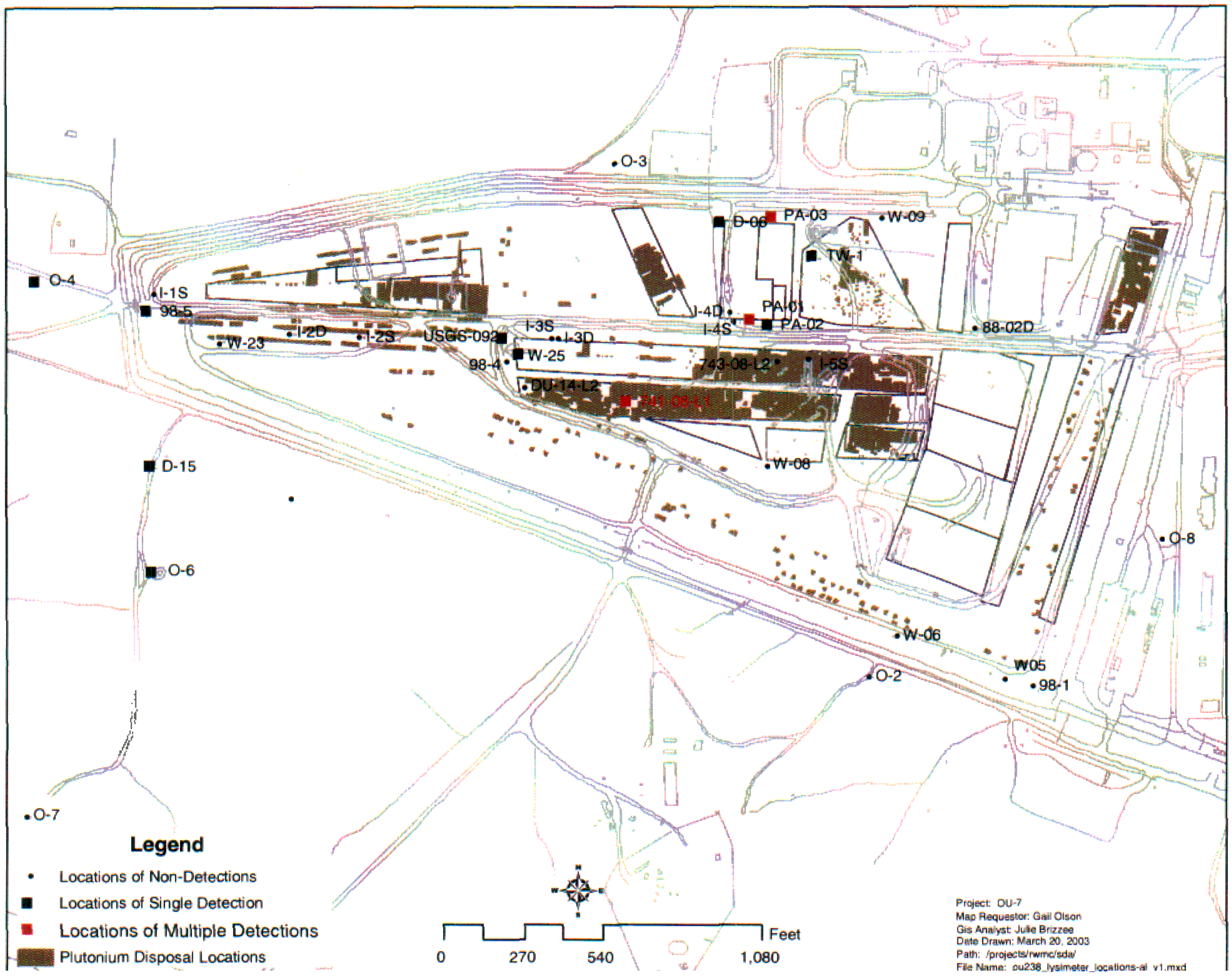


Figure 3-38. Plutonium disposal locations and vadose zone detection locations at the Subsurface Disposal Area.

Plutonium-239/240 was not detected more than once in any SDA vadose zone soil-moisture samples, perched water samples, or RWMC aquifer samples since FY 1997. Figure 3-39 presents a time history of vadose zone and aquifer plutonium concentrations since 1997. Plutonium-238 was detected more than once in Lysimeters PA01 and PA03 (see Figure 3-30) and in Aquifer Well M6S (see Figure 3-36). Both lysimeter wells are located near Pad A. Lysimeter PA01 is 4.3 m (14 ft) deep and is located north of known disposals in Pits 4 and 6. Lysimeter PA03 is 3 m (10 ft) deep and is located just north of Pad A, with no known plutonium disposals nearby. Plutonium has not been detected in Lysimeter PA03 since FY 1998 until the lysimeter was damaged in FY 2000. The lysimeter was repaired in late 2003 and samples will be collected the next time soil moisture is available. Aquifer Well M6S is located approximately 0.25 mi southeast of the RWMC. Plutonium has not been detected in this aquifer well since 2001.

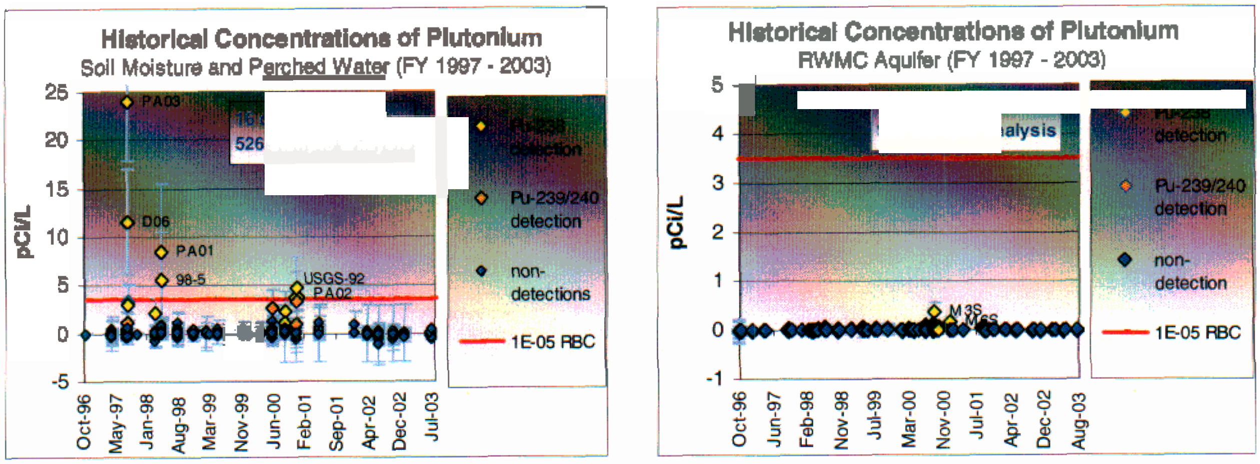


Figure 3-39. Plutonium concentration time history associated with Subsurface Disposal Area vadose zone and Radioactive Waste Management Complex aquifer monitoring for Fiscal Year 2003.

In soil-moisture and perched water samples from 1997, most of the positive plutonium detections occurred in Pit 5, around Pad A, and in the western part of the SDA. Nine of the 16 detections were from the Pit 5 and Pad A areas (PA01, PA02, PA03, D06, and TW1), three of the 16 occurred in monitoring wells located in the western part of the SDA (98-4, 98-5, and USGS-92), and four of the 16 also occurred in the western part of the RWMC but outside the SDA (D15, O4S, and O6D).

Contrary to expectations based on an order-of-magnitude larger disposal of Pu-239/240 compared to Pu-238, most subsurface plutonium detections are Pu-238 rather than Pu-239/240. Of the 16 plutonium detections in the vadose zone since FY 1997, 11 (69%) were Pu-238. In the aquifer, 82% (9 out of 11) of the plutonium detections were Pu-238. Plutonium-238 is associated with nuclear fuel rather than RFP weapons-related waste. In contrast, most of the plutonium-containing disposals are documented as originating from RFP, which would contain proportionately more Pu-239/240.

Positive detections of just Pu-238 (characteristic of reactor operations waste) were primarily associated with monitoring wells around Pad A (PA01, PA02, PA03, and D06). Low-level detections of just Pu-239/240 (characteristic of weapons manufacturing waste) were associated with soil-moisture samples from monitoring wells in Pit 5 (TW1) and outside the SDA (O4S and O6D). Sample results from Wells D15 and PA02 had detections of both Pu-238 and Pu-239/240. The isotopic ratio of D15 results was inconclusive, whereas that of PA02 suggests plutonium from reactor operations waste.

3.8 Strontium-90

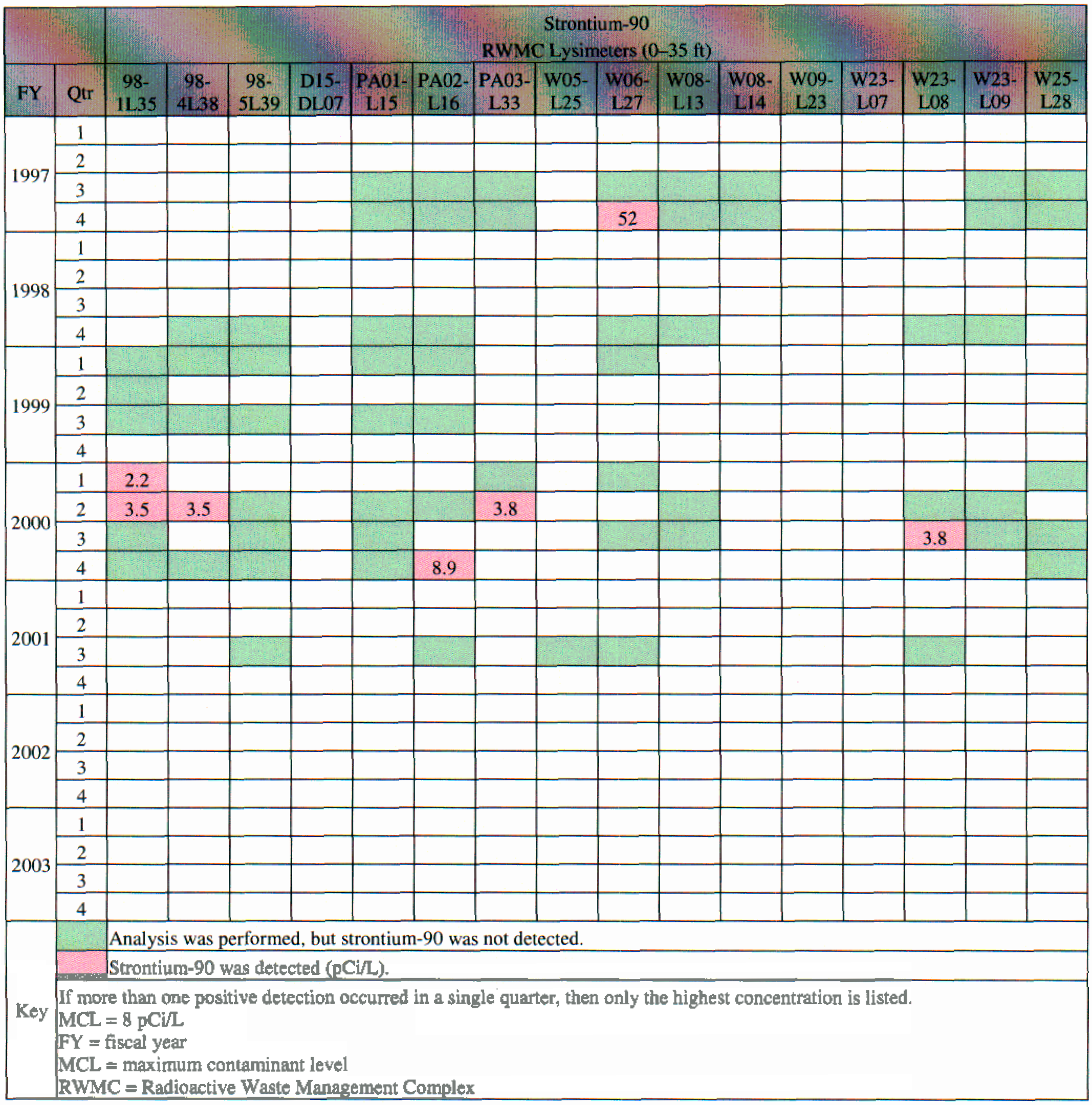
Strontium-90 is generated by nuclear reactor operations. Approximately 6.44E+05 Ci of Sr-90 was disposed of in the SDA, mostly from INEEL reactor operations and subassembly hardware. Carcinogenic risk of Sr-90 is primarily through a surface exposure pathway (e.g., crop ingestion).

3.8.1 Waste Zone

Waste zone soil-moisture samples are not analyzed for Sr-90.

3.8.2 Vadose Zone

No soil-moisture or perched water samples from the vadose zone were analyzed for Sr-90 in FY 2003. Historical detections of Sr-90 in shallow lysimeters are shown in Figure 3-40. One detection of Sr-90 occurred in the intermediate-depth lysimeters and no detections have occurred in the deep vadose zone since monitoring for it began in 1997; therefore, a figure showing occurrences is not presented. The Sr-90 detection of 4.1 ± 1.2 pCi/L occurred in the TW1-DL04 intermediate-depth lysimeter in November 1998.



		Strontium-90 RWMC Lysimeters (0–35 ft)															
FY	Qtr	98-1L35	98-4L38	98-5L39	D15-DL07	PA01-L15	PA02-L16	PA03-L33	W05-L25	W06-L27	W08-L13	W08-L14	W09-L23	W23-L07	W23-L08	W23-L09	W25-L28
1997	1																
	2																
	3					🟩	🟩	🟩		🟩	🟩	🟩				🟩	🟩
	4					🟩	🟩	🟩		52	🟩	🟩				🟩	🟩
1998	1																
	2																
	3																
	4		🟩	🟩		🟩	🟩			🟩	🟩				🟩	🟩	
1999	1	🟩	🟩	🟩		🟩	🟩			🟩							
	2	🟩															
	3	🟩	🟩	🟩		🟩	🟩										
	4																
2000	1	2.2						🟩		🟩							🟩
	2	3.5	3.5	🟩		🟩	🟩	3.8			🟩				🟩	🟩	
	3	🟩		🟩		🟩				🟩	🟩				3.8	🟩	🟩
	4	🟩	🟩	🟩		🟩	8.9										🟩
2001	1																
	2																
	3			🟩			🟩		🟩	🟩					🟩		
	4																
2002	1																
	2																
	3																
	4																
2003	1																
	2																
	3																
	4																

Key

🟩 Analysis was performed, but strontium-90 was not detected.

🟥 Strontium-90 was detected (pCi/L).

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.
MCL = 8 pCi/L
FY = fiscal year
MCL = maximum contaminant level
RWMC = Radioactive Waste Management Complex

Figure 3-40. Occurrences of strontium-90 in shallow lysimeter samples since Fiscal Year 1997.

3.8.3 Aquifer

Sixty-three aquifer samples were collected from 15 RWMC monitoring wells and screened for Sr-90 activity in FY 2003 using gross beta analysis. Six sample results exceeded the gross beta trigger level of 5 pCi/L and were analyzed for Sr-90, with no positive detections. The trigger level of 5 pCi/L is set below the MCL of 8 pCi/L. Samples were collected in November 2002 and February, April, May, and August 2003 from Monitoring Wells AllA31, M1S, M3S, M4D, M6S, M7S, M11S, M12S, M13S, M14S, M15S, M16S, M17S, OW2, and USGS-127. No Sr-90 has been detected in RWMC aquifer samples since monitoring began in FY 1997; therefore, a figure showing occurrences is not presented.

The gross beta activities measured in all aquifer-monitoring wells around the RWMC were typical of concentrations normally found in the SRPA, with the exception of Well M4D. Well M4D gross beta activity has been consistently higher than gross beta levels observed in all other monitoring wells at the RWMC and has remained relatively constant throughout the past 10-year monitoring period. The gross beta activity for Well M4D is consistently around 23 pCi/L, whereas all other RWMC monitoring wells are about 4 pCi/L. Because Well M4D is much deeper than other RWMC aquifer-monitoring wells (i.e., 244 versus approximately 198 m [838 versus approximately 650 ft]), the higher gross beta activity likely is due to elevated levels of K-40, since elemental potassium is appreciably above SRPA background levels in this well. The concentration difference of other geochemical and radiochemical constituents (i.e., Ca, Na, Mg, and natural uranium), between Well M4D and the other RWMC wells, suggests that M4D is located in a section of the aquifer that is isolated from the shallower wells.

3.8.4 Summary of Strontium-90

No Sr-90 was detected in SDA vadose zone soil-moisture samples or in RWMC aquifer samples in FY 2003. Historical detections of Sr-90 in the vadose zone are shown in Figure 3-41 along with the known disposal locations. Lysimeter 98-1L35, the only lysimeter where Sr-90 has been detected more than once, is located at the southeast corner of the SDA. The Sr-90 detections are sporadic and not indicative of emerging trends. Because Sr-90 detections are sporadic, the data probably are not useful to support modeling assumptions and calibration.

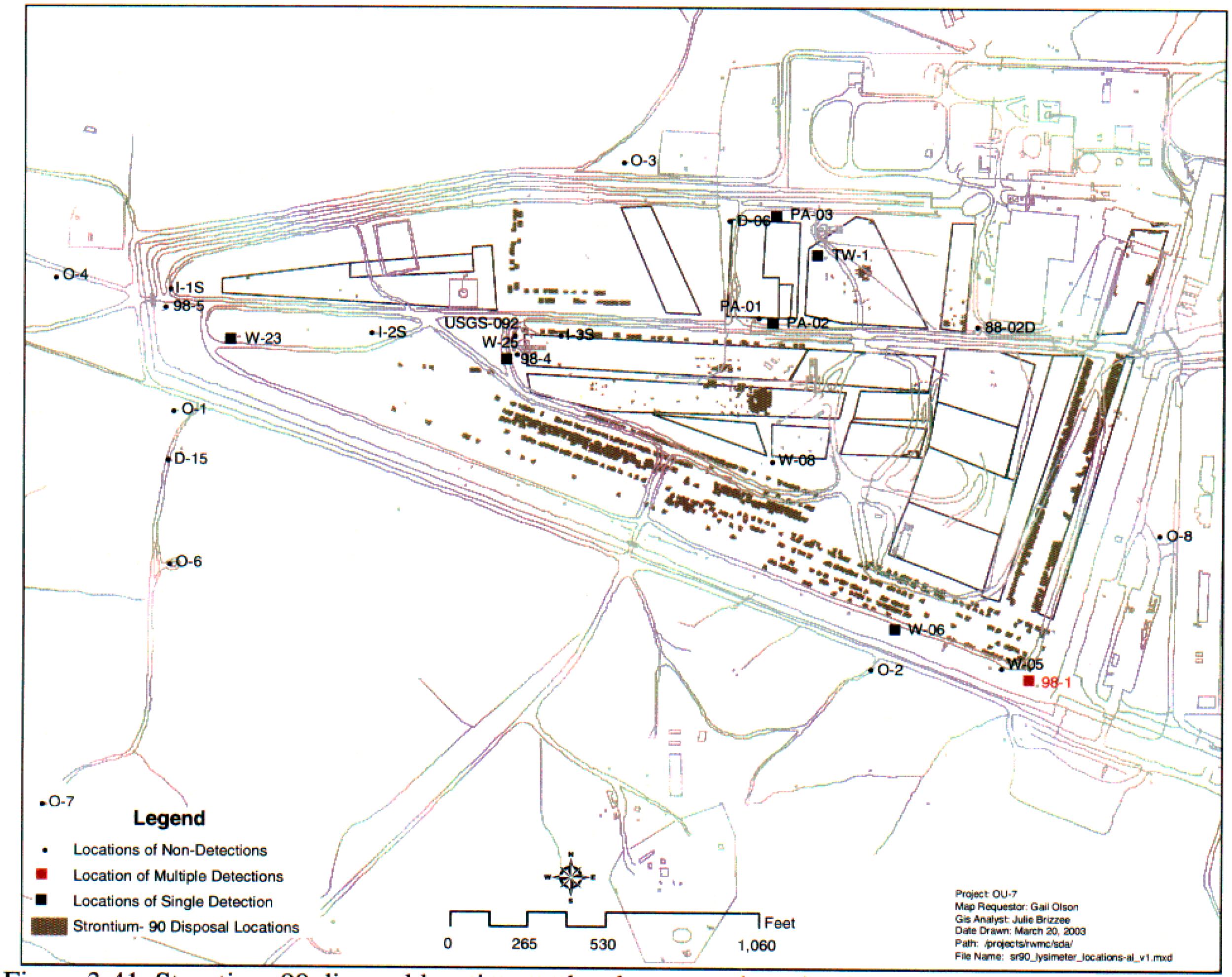


Figure 3-41. Strontium-90 disposal locations and vadose zone detection locations at the Subsurface Disposal Area.

3.9 Technetium-99

Technetium-99 is generated primarily by nuclear reactor operations. Approximately 61 Ci of Tc-99 was disposed of in the SDA. Most originated from INEEL reactor operations waste.

3.9.1 Waste Zone

Approximately 10 mL of soil moisture was collected from Waste-Zone Lysimeter 741-08-L1 on September 8, 2003, but the volume was not sufficient to analyze for Tc-99; however, the sample was analyzed for gamma-emitting radionuclides with no positive detections.

3.9.2 Vadose Zone

3.9.2.1 Lysimeter Samples at Depths of 0 to 35 ft. Twenty-nine Tc-99 analyses were performed on soil-moisture samples collected from 13 shallow lysimeters in and around the SDA in FY 2003, with six positive detections (see Table 3-21). All detected concentrations were below the 1E-05 RBC for the aquifer. Most historical detections in the 0–35-ft region of vadose zone are from lysimeter wells located around Pad A (PA01, PA02, and PA03) and the western part of the SDA (W23). Historical detections of Tc-99 in the shallow vadose zone are shown in Figure 3-42.

Table 3-21. Technetium-99 detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 0- to 35-ft depth interval.

Lysimeter	Depth (ft)	Sample Date	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pCi/L)	Aquifer RBC[b] (pCi/L)
98-4L38	17	10/21/02	**$28 \pm 5_{J}^{cd}$**	16	Nondetect	173
98-5L39	10.5	10/21/02	**$34 \pm 6_{J}^{cd}$**	19	Nondetect	173
D15-DL07	32.2	10/21/02	**$22 \pm 5_{J}^{cd}$**	16	Nondetect	173
W23-L07	18.8	10/21/02	**$68 \pm 6_{J}^{cde}$**	17	Nondetect	173
W23-L09	7.7	07/21/03	**42 ± 10^{c}**	30	Nondetect	173
W25-L28	15.5	10/21/02	**$25 \pm 6_{J}^{cd}$**	20	Nondetect	173

a. The local soil-moisture background concentration for Tc-99 is defined as a nondetect (i.e., a result less than or equal to its MDA and less than or equal to three times its reported 1σ uncertainty), because levels in the environment are far below the detection sensitivity of routine radioanalytical methods with small sample volumes.

b. RBC = 1E-05 for drinking water. The RBCs for the aquifer are provided here as a basis of comparison.

c. **Black bold font** indicates sample concentrations less than the RBC, but exceeding local soil-moisture background concentrations (see footnote a).

d. Concentrations with a "J" subscript were positively identified in the sample and assigned a "J" data qualifier flag, because the laboratory control sample exceeded the upper recovery limit. Therefore, the reported concentrations may have a high bias and should only be used as estimated quantities. In other words, Tc-99 was definitely detected, but the reported concentrations may be slightly inflated.

e. The laboratory performed a duplicate (split) analysis on this particular sample as part of their routine internal quality control protocol. Internal quality control test results, not normally reported in these tables, are mentioned to provide confirmation of the initial detection. The laboratory-generated duplicate analysis result is 69 ± 6 pCi/L, which substantiates the presence and concentration of Tc-99 at this lysimeter location.

MDA = minimum detectable activity
RBC = risk-based concentration
SDA = Subsurface Disposal Area

		Technetium-99 RWMC Lysimeters (0–35 ft)																	
FY	Qtr	98-1 L35	98-4 L38	98-5 L39	D15-DL07	LYS1-L41	PA01-L15	PA02-L16	PA03-L33	W05-L24	W05-L25	W06-L27	W08-L13	W08-L14	W09-L23	W23-L07	W23-L08	W23-L09	W25-L28
1997	1																		
	2																		
	3						🟩	🟩				🟩	🟩	🟩				17	🟩
	4						🟩	🟩	🟩			🟩	🟩	🟩				30	🟩
1998	1																		
	2																		
	3																		
	4		🟩	🟩			🟩	🟩				🟩	🟩				15*	20	🟩
1999	1	🟩	🟩	🟩			🟩	13	36			🟩							
	2	🟩																	
	3	🟩	🟩	🟩			🟩	🟩											
	4																		
2000	1	🟩							21			🟩							🟩
	2	🟩	🟩	🟩			🟩	🟩	17				🟩				🟩	20	
	3	16	🟩	21			17	🟩				🟩	15				39	33	🟩
	4	🟩	🟩	🟩			27	🟩											🟩
2001	1							🟩											
	2																		
	3	🟩	🟩	🟩			🟩	🟩			🟩	🟩					46		
	4																		
2002	1																		
	2																		
	3																		
	4						🟩						🟩			🟩		15*	🟩
2003	1		28*	34*	22*	🟩							🟩			68*			25*
	2																		🟩
	3	🟩	🟩	🟩			🟩	🟩		🟩			🟩		🟩	🟩		🟩	🟩
	4	🟩	🟩	🟩	🟩		🟩	🟩					🟩		🟩	🟩		42	

Key

🟩 naly forn

🟥

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.

* Indicates a positive detection that received a "J" qualifier flag because of a minor quality control anomaly.

Note: RBC = 173 pCi/L

FY = fiscal year

RBC = 1E-05 risk-based concentration

RWMC = Radioactive Waste Management Complex

Figure 3-42. Occurrences of technetium-99 detections in shallow lysimeters since Fiscal Year 1997.

3.9.2.2 Lysimeter Samples at Depths of 35 to 140 ft. Forty-two Tc-99 analyses were performed on soil-moisture samples collected from 13 intermediate-depth lysimeters in and around the SDA in FY 2003, with eight positive detections (see Table 3-22). All detected concentrations were below the 1E-05 RBC for the aquifer. Most historical detections in the 35–140-ft region of the vadose zone are from lysimeter wells located around Pad A (D06) and the western part of the SDA (I1S, I2S, I3S, and D15). Historical detections in lysimeter samples from this depth range are depicted in Figure 3-43. A Tc-99 concentration trend appears to be developing at Lysimeter D06-DL01 (see Figure 3-44).

Table 3-22. Technetium-99 detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 35- to 140-ft depth interval.

Lysimeter	Depth (ft)	Sample Date	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pCi/L)	Aquifer RBC[b] (pCi/L)
D06-DL01	88	10/22/02	**13 ± 4**[c]	13	Nondetect	173
		04/29/03	**34 ± 8**[c]	25	Nondetect	173
		07/10/03	**61 ± 9**[c]	28	Nondetect	173
D15-DL06	97.9	10/21/02	**28 ± 5_J**[cd]	16	Nondetect	173
I1S-DL09	101	10/21/02	**29 ± 6_J**[cd]	20	Nondetect	173
I2S-DL11	92	10/21/02	**25 ± 5_J**[cd]	16	Nondetect	173
I3S-DL13	93	10/21/02	**18 ± 6_J**[cd]	18	Nondetect	173
O7S-DL28	119	10/21/02	**20 ± 6_J**[cd]	19	Nondetect	173

a. The local soil-moisture background concentration for Tc-99 is defined as a nondetect (i.e., a result less than or equal to its MDA and less than or equal to three times its reported 1σ uncertainty), because levels in the environment are far below the detection sensitivity of routine radioanalytical methods with small sample volumes.

b. RBC = 1E-05 for drinking water. The RBCs for the aquifer are provided here as a basis of comparison.

c. **Black bold font** indicates sample concentrations less than the RBC, but exceeding local soil-moisture background concentrations (see footnote a).

d. Concentrations with a "J" subscript were positively identified in the sample and assigned a "J" data qualifier flag, because the laboratory control sample exceeded the upper recovery limit. Therefore, the reported concentrations may have a high bias and should only be used as estimated quantities. In other words, Tc-99 was definitely detected, but the reported concentrations may be slightly inflated.

MDA = minimum detectable activity
RBC = risk-based concentration
SDA = Subsurface Disposal Area

		Technetium-99 RWMC Lysimeters (35–140 ft)													
FY	Qtr	D06-DL01	D06-DL02	D15-DL06	I1S-DL09	I2S-DL11	I3S-DL13	I4S-DL15	I5S-DL16	O2S-DL20	O3S-DL22	O4S-DL24	O5S-DL25	O7S-DL28	TW1-DL04
1997	1														
	2														
	3														
	4			🟩											
1998	1														
	2														🟩
	3														
	4	11	33	🟩											🟩
1999	1			43*											20*
	2														🟩
	3														
	4														
2000	1		🟩												
	2														
	3			21				🟩					🟩		
	4			🟩	🟩		🟩								
2001	1											🟩			
	2														
	3			🟩		🟩					🟩				🟩
	4														
2002	1														
	2														
	3				🟩										
	4	🟩	🟩	🟩	🟩	🟩	🟩	🟩			🟩	🟩	🟩		
2003	1	13		28*	29*	25*	18*	🟩			🟩		🟩	20*	🟩
	2			🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	
	3	34	🟩	🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩	
	4	61		🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩	🟩

Key

🟩 Analysis was performed, but technetium-99 was not detected.

🟥 Technetium-99 was detected (pCi/L).

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.

* Indicates a positive detection that received a “J” qualifier flag because of a minor quality control anomaly.

Note: RBC = 173 pCi/L
FY = fiscal year
RBC = 1E-05 risk-based concentration
RWMC = Radioactive Waste Management Complex

Figure 3-43. Occurrences of technetium-99 detections in intermediate-depth lysimeters since Fiscal Year 1997.

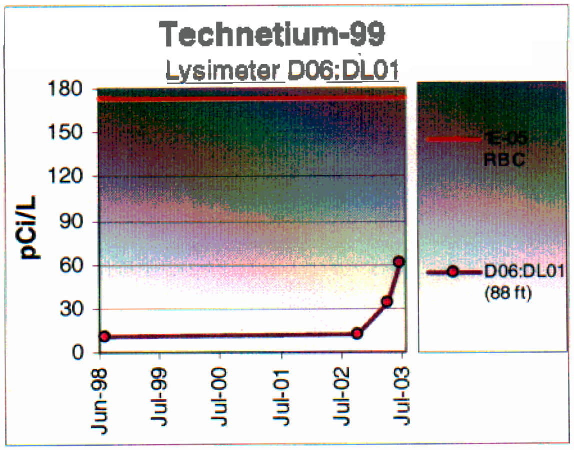


Figure 3-44. Lysimeter D06-DL01 Tc-99 concentration history since monitoring began in 1998.

3.9.2.3 Lysimeter and Perched Water Samples at Depths Greater than 140 ft.

Twenty-eight Tc-99 analyses were performed on samples collected from eight lysimeter and two perched water wells in and around the SDA in FY 2003, with five positive detections (see Table 3-23). All detected concentrations were below the 1E-05 RBC for the aquifer. Historical detections in the 140–250-ft region of the vadose zone are from perched water in the western part of the SDA (USGS-92) and from lysimeter wells located outside the SDA (O2, O4, O6, and O7). Three unconfirmed detections of Tc-99 have occurred in vadose zone well samples deeper than 140 ft since monitoring began in 1997, all from Well USGS-92. Technetium-99 was detected in the filtered sediment portion of two samples since FY 1997 (December 1998 and September 2000). Both detections were less than 4 pCi/L. Technetium also was detected in the liquid portion of the sample at 280 pCi/L (September 2000). Historical detections are shown in Figure 3-45.

Table 3-23. Technetium-99 detections in Fiscal Year 2003 Subsurface Disposal Area vadose zone soil-moisture samples from the 140- to 250-ft depth interval.

Lysimeter	Depth (ft)	Sample Date	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pCi/L)	Aquifer RBC[b] (pCi/L)
O2-DL19	240	10/21/02	**31 ± 9_J^{cd}**	28	Nondetect	173
O4-DL23	225	10/21/02	**37 ± 8_J^{cd}**	24	Nondetect	173
O6-DL26	225	10/21/02	**18 ± 5_J^{cd}**	17	Nondetect	173
O7-DL27	240	10/21/02	**29 ± 6_J^{cd}**	18	Nondetect	173
USGS-92	214	07/22/03	**28 ± 6^{c}**	20	Nondetect	173

a. The local soil-moisture background concentration for Tc-99 is defined as a nondetect (i.e., a result less than or equal to its MDA and less than or equal to three times its reported 1σ uncertainty), because levels in the environment are far below the detection sensitivity of routine radioanalytical methods with small sample volumes.

b. RBC = 1E-05 for drinking water. The RBCs for the aquifer are provided here as a basis of comparison.

c. **Black bold font** indicates sample concentrations less than the RBC, but exceeding local soil-moisture background concentrations (see footnote a).

d. Concentrations with a "J" subscript were positively identified in the sample and assigned a "J" data qualifier flag, because the laboratory control sample exceeded the upper recovery limit. Therefore, the reported concentrations may have a high bias and should only be used as estimated quantities. In other words, Tc-99 was definitely detected, but the reported concentrations may be slightly inflated.

MDA = minimum detectable activity
RBC = risk-based concentration
SDA = Subsurface Disposal Area

		Technetium-99 RWMC Perched Water and Lysimeters (>140 ft)									
FY	Qtr	8802D	USGS-092	I2D-DL10	I3D-DL12	I4D-DL14	O2-DL19	O4-DL23	O6-DL26	O7-DL27	O8-DL29
1997	1										
	2										
	3		🟩								
	4		🟩								
1998	1										
	2	🟩	🟩								
	3										
	4										
1999	1	🟩	28*								
	2	🟩	🟩								
	3										
	4										
2000	1		🟩								
	2										
	3				🟩						
	4		280								
2001	1		🟩					🟩			
	2										
	3										
	4										
2002	1										
	2		🟩								
	3										
	4				🟩				🟩	🟩	
2003	1	🟩	🟩	🟩	🟩	🟩	31*	37*	18*	29*	🟩
	2		🟩	🟩	🟩	🟩	🟩	🟩		🟩	🟩
	3		🟩		🟩			🟩		🟩	
	4		28		🟩	🟩		🟩		🟩	

Key

🟩 Analysis was performed for technetium-99, but none was detected.

🟥 Technetium-99 was detected (pCi/L).

If more than one positive detection occurred in a well in a single quarter, then only the highest concentration is listed.

* Indicates a positive detection that received a "J" qualifier flag because of a minor quality control anomaly.

Note: RBC = 173 pCi/L
FY = fiscal year
RBC = 1E-05 risk-based concentration
RWMC = Radioactive Waste Management Complex

Figure 3-45. Occurrences of technetium detections in lysimeters at depths >140 ft since Fiscal Year 1997.

3.9.3 Aquifer

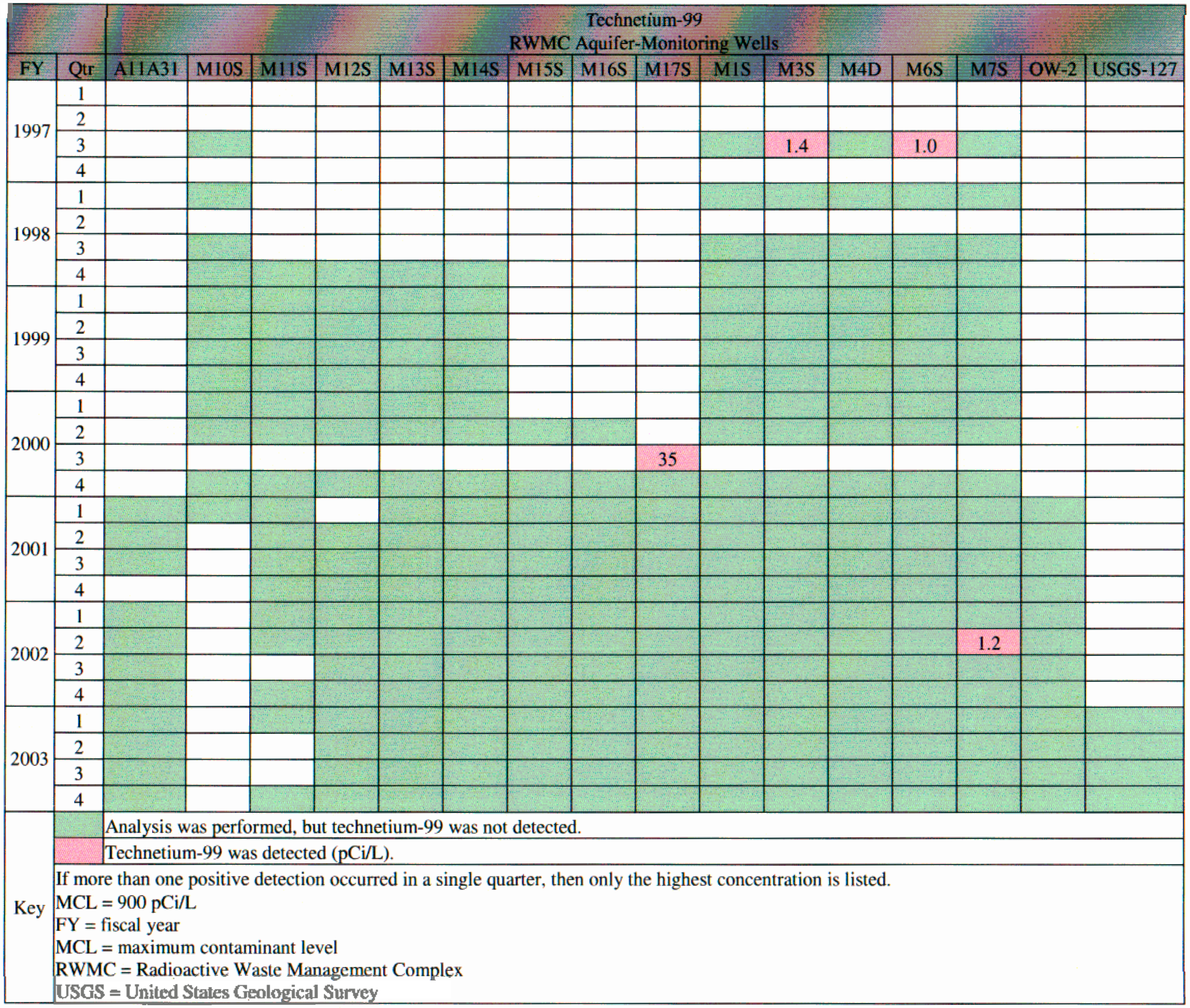
Sixty-three Tc-99 analyses were performed on aquifer samples collected from 15 monitoring wells in the vicinity of the RWMC in FY 2003, with no positive detections. Occurrences of Tc-99 in aquifer samples since FY 1997 are depicted in Figure 3-46.

3.9.4 Summary of Technetium-99

Of the 19 positive detections in the vadose zone and perched water in FY 2003, 14 were assigned "J" data qualifier flags, because the laboratory control sample exceeded the upper recovery limit. Thus, the reported concentrations might have a high bias and should only be used as estimated quantities. In other words, Tc-99 was definitely detected, but the reported concentrations might be slightly inflated. Though many detections were qualified as questionable in October 2002, Lysimeter Wells D06, D15, and W23 have exhibited the most frequent Tc-99 detections (see Figures 3-42 and 3-43). Most other vadose zone lysimeters have had either one or no detections since monitoring began. Locations of historical Tc-99 detections in the vadose zone are shown on Figure 3-47 along with the locations of disposals containing Tc-99. As shown, Wells D06 and W23 are located in areas of the SDA where there are no noted disposals, but where uranium is increasing over time in the soil-moisture samples (see Section 3.10).

None of the 63 aquifer samples collected in FY 2003 contained detectable Tc-99. Detections of Tc-99 occur sporadically in the aquifer (see Figure 3-46) and are not indicative of trends or widespread contamination.

The consistent detections of Tc-99 in D06:DL01 and W23:L09—at depths of 26.8 m (88 ft) and 2.3 m (7.7 ft), respectively—suggest that Tc-99 might be a useful modeling target; however, the inventory records do not indicate that Tc-99 is present in these areas of the SDA. Because the current source release model is based on inventory records, this currently precludes use of this location for calibration.



FY	Qtr	Technetium-99 RWMC Aquifer-Monitoring Wells															
FY	Qtr	A11A31	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	M1S	M3S	M4D	M6S	M7S	OW-2	USGS-127
1997	1																
	2																
	3		🟩								🟩	🟥 1.4	🟩	🟥 1.0	🟩		
	4																
1998	1		🟩								🟩	🟩	🟩	🟩	🟩		
	2																
	3		🟩								🟩	🟩	🟩	🟩	🟩		
	4		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
1999	1		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	2		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	3		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	4		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
2000	1		🟩	🟩	🟩	🟩	🟩				🟩	🟩	🟩	🟩	🟩		
	2		🟩	🟩	🟩	🟩	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩		
	3									🟥 35							
	4		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩		
2001	1	🟩	🟩	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	
	2	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	
	3	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	
	4			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	
2002	1	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	
	2	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥 1.2	🟩	
	3	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	
	4	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	
2003	1	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	2	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	3	🟩			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
	4	🟩		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩

Key

🟩 Analysis was performed, but technetium-99 was not detected.

🟥 Technetium-99 was detected (pCi/L).

If more than one positive detection occurred in a single quarter, then only the highest concentration is listed.
MCL = 900 pCi/L
FY = fiscal year
MCL = maximum contaminant level
RWMC = Radioactive Waste Management Complex
USGS = United States Geological Survey

Figure 3-46. Occurrences of technetium-99 in aquifer samples collected in the vicinity of the Radioactive Waste Management Complex since Fiscal Year 1997.

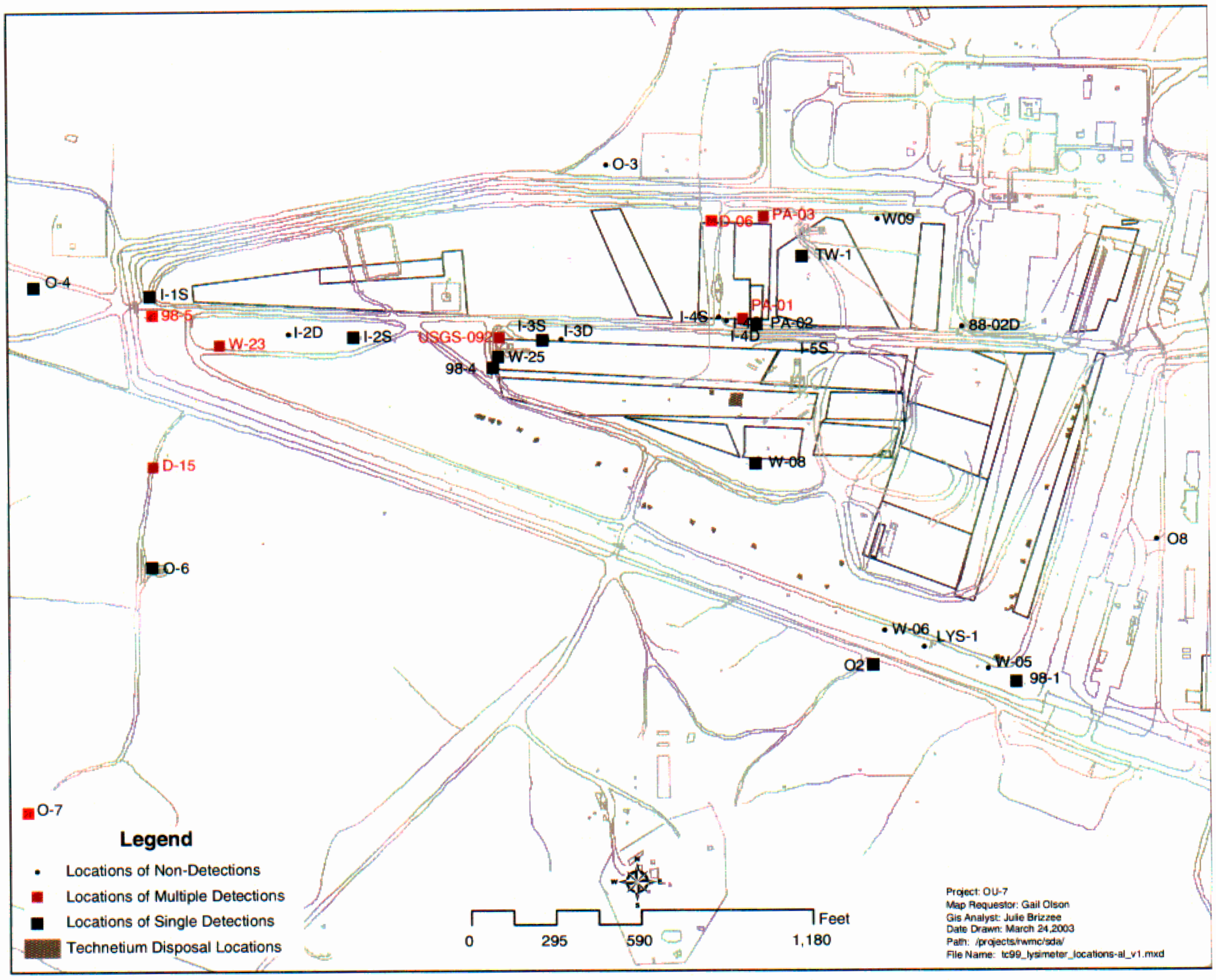


Figure 3-47. Disposals and vadose zone detections of technetium-99.

3.10 Uranium

Uranium occurs naturally in the environment and is processed and handled for use in nuclear weapons and reactors. Because several isotopes are naturally occurring, it is necessary to differentiate background concentrations from anthropogenic uranium. Background concentration guidelines for U-234 and U-238 in the aquifer beneath the RWMC are 1.9 and 0.9 pCi/L, respectively (Leecaster, Olson, and Koeppen 2003), and the background concentration for U-235/236 is 0.12 pCi/L based on the maximum range of 267 U-235/236 results from aquifer samples collected from wells in the vicinity of the RWMC. Background concentrations in the soil moisture are highly variable and estimated to be 3.7, 0.7, and 1.8 pCi/L based on the mean values plus the standard deviation of the mean of 60 lysimeter samples collected at background locations. The background locations are outside of the SDA fences and are not expected to be impacted by disposed of waste.

Ratios of uranium isotopes also are expected to remain within a certain range when the uranium is naturally occurring. The U-238:U-235 activity ratio for natural uranium is 21.7. The U-238:U-235 activity ratio for slightly enriched (2%) uranium is approximately 8 and approximately 0.01 for highly enriched (greater than 93%) uranium.

3.10.1 Waste Zone

Approximately 10 mL of soil moisture was collected from Waste-Zone Lysimeter 741-08-L1 on September 8, 2003, but the volume was not sufficient to analyze for uranium isotopes; however, the sample was analyzed for gamma-emitting radionuclides with no positive detections.

3.10.2 Vadose Zone

3.10.2.1 Lysimeter Samples at Depths of 0 to 35 ft. Seventy-two isotopic uranium analyses were performed on soil-moisture samples collected from 11 shallow lysimeters in and around the SDA in FY 2003, with 52 detections above local soil-moisture background (see Table 3-24). Of the 52 results above background, 20 exceeded the 1E-05 RBC for the aquifer.

Table 3-24. Isotopic uranium results above local soil-moisture background in the 0- to 35-ft depth interval.

Location	Depth (ft)	Sample Date	Radionuclide	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pCi/L)	Aquifer RBC[b] (pCi/L)
D15-DL07	32.2	10/21/02	U-233/234	**4.1 ± 1.1**	2.7	3.7	6.7
W08-L13	11.3	10/22/02	U-233/234	**6.5 ± 0.9**	1.2	3.7	6.7
			U-238	**2.8 ± 0.5**	0.9	1.8	5.5
W23-L07	18.8	10/21/02	U-233/234	**84 ± 7**	1.2	3.7	6.7
			U-235/236	**2.9 ± 0.6**	0.8	0.7	6.6
			U-238	**54 ± 5**	0.6	1.8	5.5
W25-L28	15.5	10/21/02	U-233/234	**4.2 ± 0.7**	1.3	3.7	6.7
			U-238	**2.4 ± 0.5**	1.1	1.8	5.5
98-4L38	17.0	10/21/02	U-233/234	**4.1 ± 0.8**	1.1	3.7	6.7
			U-238	**2.0 ± 0.5**	1.0	1.8	5.5
98-5L39	10.5	10/21/02	U-233/234	**11.4 ± 1.3**	1.1	3.7	6.7
			U-238	**8.7 ± 1.1**	1.3	1.8	5.5
W25-L28	15.5	01/06/03	U-238	**3.3 ± 0.6[d]**	0.6	1.8	5.5
PA01-L15	14.3	04/30/03	U-233/234	**34 ± 3[e]**	0.8	3.7	6.7
			U-235/236	**2.5 ± 0.5[c]**	0.6	0.7	6.6
			U-238	**22 ± 2[d]**	0.6	1.8	5.5
PA02-L16	8.7	04/30/03	U-233/234	**33 ± 3[d]**	0.5	3.7	6.7
			U-235/236	**1.7 ± 0.4[c]**	0.9	0.7	6.6
			U-238	**16.7 ± 1.7[d]**	0.6	1.8	5.5
W08-L13	11.3	04/30/03	U-233/234	**18.8 ± 1.6[d]**	0.5	3.7	6.7
			U-235/236	**1.8 ± 0.4[c]**	0.5	0.7	6.6
			U-238	**9.3 ± 1.0[d]**	0.6	1.8	5.5
W23-L07	18.8	04/28/03	U-233/234	**73 ± 6[d]**	0.9	3.7	6.7
			U-235/236	**3.1 ± 0.5[c]**	0.8	0.7	6.6
			U-238	**39 ± 3[d]**	0.5	1.8	5.5

Table 3-24. (continued).

Location	Depth (ft)	Sample Date	Radionuclide	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pCi/L)	Aquifer RBC[b] (pCi/L)
W23-L09	7.7	04/28/03	U-233/234	**63 ± 5[d]**	0.7	3.7	6.7
			U-235/236	**7.8 ± 0.9[d]**	0.4	0.7	6.6
			U-238	**38 ± 3[d]**	0.5	1.8	5.5
W25-L28	15.5	04/30/03	U-233/234	**4.8 ± 0.7[c]**	0.6	3.7	6.7
			U-238	**2.4 ± 0.4[c]**	0.4	1.8	5.5
98-1L35	16.5	04/30/03	U-233/234	**8.4 ± 1.0[d]**	0.6	3.7	6.7
			U-238	**7.3 ± 0.9[d]**	0.4	1.8	5.5
98-5L39	10.5	04/30/03	U-233/234	**12.4 ± 1.4[d]**	1.3	3.7	6.7
			U-238	**7.0 ± 0.9[d]**	1.0	1.8	5.5
PA01-L15	14.3	07/21/03	U-233/234	**38 ± 4[d]**	0.8	3.7	6.7
			U-235/236	**3.1 ± 0.8[c]**	1.2	0.7	6.6
			U-238	**24 ± 3[d]**	0.5	1.8	5.5
PA02-L16	8.7	07/21/03	U-233/234	**29 ± 3[d]**	1.1	3.7	6.7
			U-235/236	**2.1 ± 0.6[c]**	0.9	0.7	6.6
			U-238	**16 ± 2[d]**	0.4	1.8	5.5
W08-L13	11.3	07/21/03	U-233/234	**20.4 ± 2.5[d]**	1.1	3.7	6.7
			U-235/236	**1.8 ± 0.4[c]**	0.5	0.7	6.6
			U-238	**9.3 ± 1.0[d]**	0.6	1.8	5.5
W23-L07	18.8	07/21/03	U-233/234	**71 ± 7[d]**	1.5	3.7	6.7
			U-235/236	**5.3 ± 1.1[c]**	1.1	0.7	6.6
			U-238	**38 ± 4[d]**	0.9	1.8	5.5
W23-L09	7.7	07/21/03	U-233/234	**63 ± 6[d]**	1.8	3.7	6.7
			U-235/236	**2.7 ± 0.8[c]**	1.0	0.7	6.6
			U-238	**30 ± 4[d]**	0.5	1.8	5.5
98-1-L35	16.5	07/10/03	U-233/234	**13.4 ± 1.8[d]**	1.6	3.7	6.7
			U-238	**8.1 ± 1.3[d]**	1.2	1.8	5.5

a. Local soil-moisture background concentrations for uranium isotopes are defined as the mean plus the standard deviation of the mean of 60 soil-moisture samples collected between 1998 and 2003 from the "O" and D15 lysimeter wells located outside of the SDA.

b. RBC = 1E-05 for drinking water. The RBCs for the aquifer are provided here as a basis of comparison.

c. **Black bold font** indicates sample concentrations less than the RBC, but exceeding local soil-moisture background concentrations (see footnote a).

d. **Red bold font** indicates sample concentrations that exceed the 1E-05 RBC (see footnote b).

MDA = minimum detectable activity

RBC = risk-based concentration

SDA = Subsurface Disposal Area

Concentrations of U-233/234, U-235/236, and U-238 in the 0–35-ft depth interval during FY 2003 remained relatively constant with a few exceptions. Concentrations of isotopic uranium increased in Lysimeter Wells PA01, PA02, W08, and W23 (see Figures 3-48a, 3-48b, and 3-48c) in FY 2003. However, their concentrations over the long term—even though elevated—essentially stayed constant, except for U-235/236 in Wells PA01 and W23 (see Figure 3-48b). The concentration of U-235/236 in PA01 during its 5-year monitoring history is gradually increasing, while U-233/234 and U-238 remain relatively constant. This condition produces a trend in the U-238:U-235 ratio, and the trend is suggestive of slightly enriched uranium at this monitoring location (see Figure 3-49a). Even though long-term isotopic uranium concentrations in PA02, located near PA01, appear relatively constant, the U-238:U-235 ratio also is trending toward slightly enriched uranium (see Figure 3-49b), again suggesting the presence of slightly enriched uranium at this location. Monitoring Well W23 contains two lysimeters—located at approximately an 8-ft and 19-ft depth, respectively—that show isotopic uranium results that are different than other lysimeters. The lysimeter at 19 ft (W23:L07) shows U-235/236 concentrations increasing and U-233/234 and U-238 decreasing; whereas, the lysimeter at 8 ft (W23-L09) shows a very significant long-term increase in U-235/236 with a sudden decrease in July 2003, while the concentrations of U-233/234 and U-238 remain relatively constant over the 5-year monitoring period. The only commonality between both lysimeters in Well W23 is that U-238:U-235 ratios are trending in the direction that suggests the uranium may be anthropogenic with a slight U-235 enrichment (see Figure 3-49c).

Even though U-238:U-235 activity ratios are suggesting enriched uranium, the U-234:U-238 ratios are more indicative of natural uranium. The U-234:U-238 activity ratios for these shallow lysimeters are approximately 2:1, which is drastically different than the 10:1 ratio associated with Lysimeter TW1-DL04 where enriched uranium is known to be present. The U-234:U-238 ratio of approximately 2:1 is typical of natural activity in RWMC groundwater and vadose zone soil moisture. Since records show significant quantities of depleted uranium were disposed of in the SDA, it is conjectured that its U-238 might be interfering with an accurate interpretation of isotopic uranium ratios. Confirming the presence of anthropogenic uranium and its U-235 enrichment will require high precision measurements with extremely low-level capabilities to accurately quantify U-235 and identify U-236. Such analyses can only be obtained with several mass-spectrometric methods.

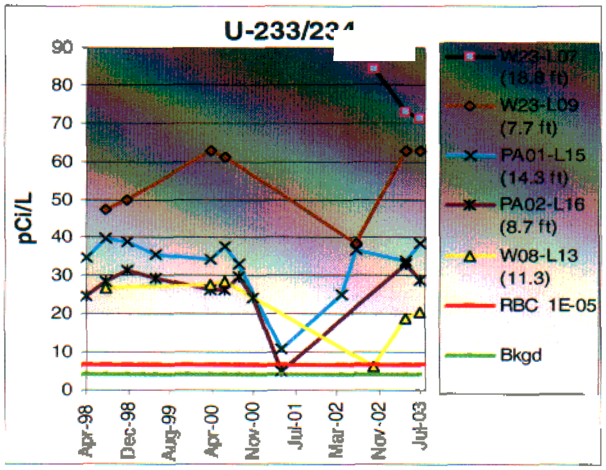


Figure 3-48a. Uranium-233/234 in select lysimeters from the shallow vadose zone, April 1998 through July 2003.

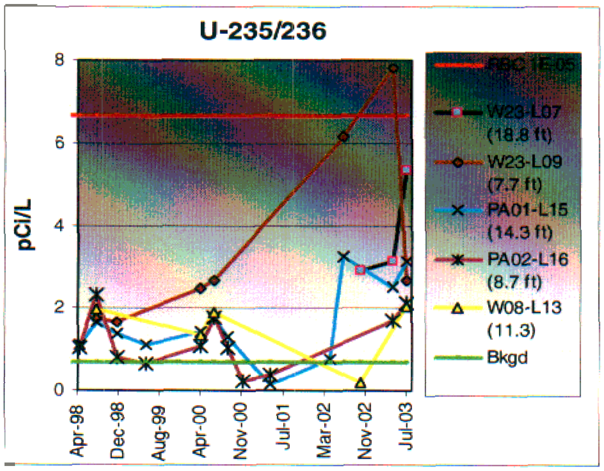


Figure 3-48b. Uranium-235/236 in select lysimeters from the shallow vadose zone, April 1998 through July 2003.

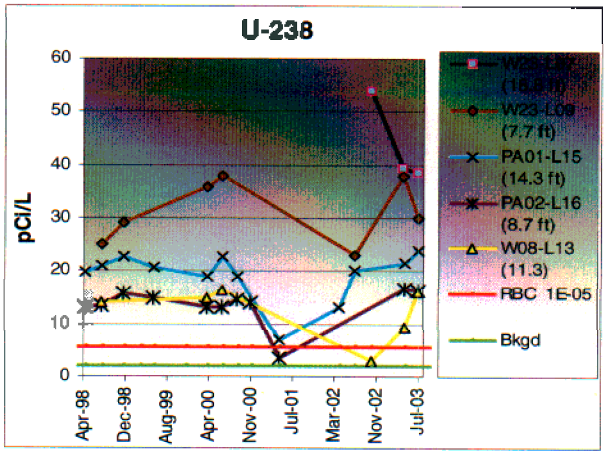


Figure 3-48c. Uranium-238 in select lysimeters from the shallow vadose zone, April 1998 through July 2003.

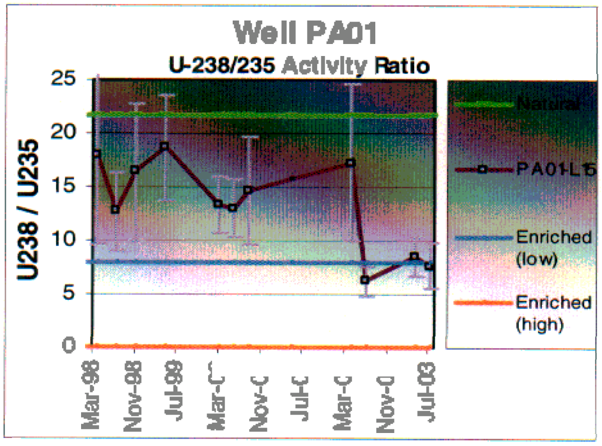


Figure 3-49a. Uranium-238/235 activity ratios for the PA01-L15 shallow lysimeter from April 1998 through July 2003.

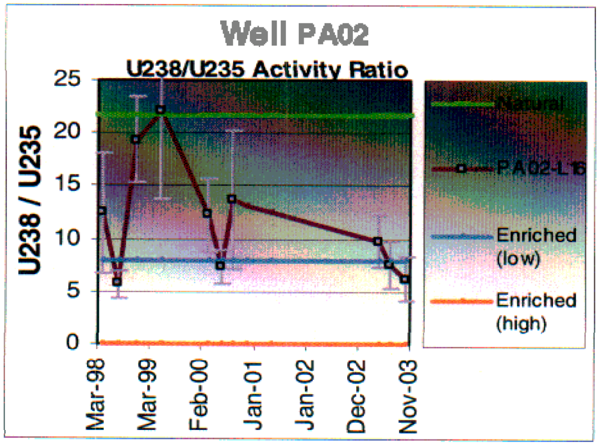


Figure 3-49b. Uranium-238/235 activity ratios for the PA02-L16 shallow lysimeter from April 1998 through July 2003.

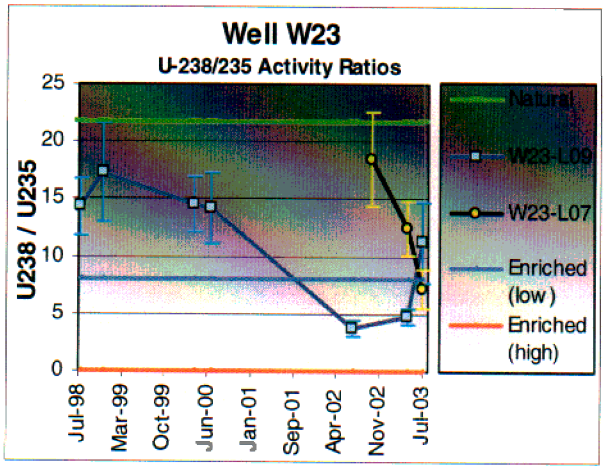


Figure 3-49c. Uranium-238/235 activity ratios for the W23-L07 and W23-L09 shallow lysimeters from August 1998 through July 2003.

3.10.2.1.1 Lysimeter Samples at Depths of 35 to 140 ft—One hundred and twenty isotopic uranium analyses were performed on soil-moisture samples collected from 13 lysimeters in and around the SDA in FY 2003, with 35 detections above local soil-moisture background (see Table 3-25). Of the 35 results above background, 21 exceeded the 1E-05 RBC for the aquifer.

Table 3-25. Isotopic uranium results above local soil-moisture background in the 35- to 140-ft depth interval.

Location	Depth (ft)	Sample Date	Radionuclide	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pCi/L)	Aquifer RBC[b] (pCi/L)
I1S-DL09	101	10/21/02	U-233/234	**20.8 ± 2.1**	1.3	3.7	6.7
			U-238	**9.9 ± 1.3**	1.2	1.8	5.5
I4S-DL15	97	10/22/02	U-233/234	**4.4 ± 0.7**	0.7	3.7	6.7
			U-235/236	**1.7 ± 0.4**	0.5	0.7	6.6
			U-238	**2.4 ± 0.5**	0.2	1.8	5.5
TW1-DL04	101.7	10/22/02	U-233/234	**57 ± 5**	0.9	3.7	6.7
			U-235/236	**1.8 ± 0.5**	0.9	0.7	6.6
			U-238	**5.1 ± 0.8**	0.9	1.8	5.5
I1S-DL09	101	01/08/03	U-233/234	**16.9 ± 2.1[c]**	1.0	3.7	6.7
			U-238	**8.4 ± 1.3[c]**	0.7	1.8	5.5
W25-L28	15.5	01/06/03	U-238	**3.3 ± 0.6[d]**	0.6	1.8	5.5
D06-DL01	88	04/29/03	U-233/234	**86 ± 6[d]**	0.6	3.7	6.7
			U-235/236	**10.3 ± 1.0[d]**	0.2	0.7	6.6
			U-238	**44 ± 3[d]**	0.5	1.8	5.5
D06-DL02	44	04/29/03	U-233/234	**97 ± 7[d]**	0.8	3.7	6.7
			U-235/236	**17.0 ± 1.5[d]**	0.9	0.7	6.6
			U-238	**39 ± 3[d]**	0.8	1.8	5.5
I1S-DL09	101	04/29/03	U-233/234	**15.8 ± 1.5[d]**	1.3	3.7	6.7
			U-238	**9.9 ± 1.0[d]**	0.4	2.1	5.5
I4S-DL15	97	04/29/03	U-233/234	**8.4 ± 0.9[d]**	0.6	3.7	6.7
			U-238	**4.7 ± 0.6[c]**	0.4	1.8	5.5
O2-DL20	106	05/01/03	U-233/234	**5.0 ± 0.7[c]**	0.8	3.7	6.7
			U-238	**2.7 ± 0.5[c]**	0.5	1.8	5.5
D06-DL01	88	7/10/03	U-233/234	**100 ± 10[d]**	0.5	3.7	6.7
			U-235/236	**6.0 ± 1.0[c]**	0.9	0.7	6.6
			U-238	**45 ± 5[d]**	0.5	1.8	5.5
I1S-DL09	101	7/22/03	U-233/234	**14.4 ± 1.9[d]**	0.4	3.7	6.7
			U-238	**8.3 ± 1.3[d]**	0.8	1.8	5.5
I4S-DL15	97	7/21/03	U-233/234	**7.0 ± 1.2[d]**	1.3	3.7	6.7
			U-238	**4.2 ± 0.9[c]**	1.1	1.8	5.5
TW1-DL04	101.7	7/21/03	U-233/234	**101± 9**	0.9	3.7	6.7
			U-235/236	**4.8 ± 0.9[c]**	0.8	0.7	6.6
			U-238	**9.3 ± 1.4[c]**	0.8	1.8	5.5

Table 3-25. (continued).

Location	Depth (ft)	Sample Date	Radionuclide	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pCi/L)	Aquifer RBC[b] (pCi/L)

soil-moisture samples collected between 1998 and 2003 from the "O" and D15 lysimeter wells located outside of the SDA.
b. RBC = 1E-05 for drinking water. The RBCs for the aquifer are provided here as a basis of comparison.
c. **Black bold font** indicates sample concentrations less than the RBC, but exceeding local soil-moisture background concentrations (see footnote a).
d. **Red bold font** indicates sample concentrations that exceed the 1E-05 RBC (see footnote b).
MDA = minimum detectable activity
RBC = risk-based concentration
SDA = Subsurface Disposal Area

Isotopic uranium concentrations in the SDA at intermediate depths appear fairly constant, except for Monitoring Well D06 and TW1. Uranium concentrations in these wells are very elevated, while concentrations over the past 5 years remain fairly constant, except for U-235 in Wells PA01 and W23 (see Figures 3-48). The concentration of U-235 in PA01 during its 5-year monitoring history is gradually increasing, while U-234 and U-238 are remaining relatively constant. This scenario is generating a U-238/U-235 activity ratio trend suggestive of slightly enriched uranium (see Figure 3-49a). Even though long-term isotopic uranium concentrations in PA02, located near PA01, appear relatively constant, the U-238/U-235 activity ratio also is trending toward slightly enriched uranium (see Figure 3-49b). Well W23 contains two lysimeters—located at approximately 8 ft and 19 ft, respectively—that are showing isotopic uranium results that are different than other lysimeters. The lysimeter at 19 ft (W23:L07) shows U-235 concentrations increasing and U-234 and U-238 decreasing, whereas the lysimeter at 8 ft (W23-L09) shows a sudden decrease in U-235, while the concentrations of U-234 and U-238 are relatively constant. The similarity with both lysimeters is that U-238/U-235 activity ratios, which are constant in nature, are trending and suggesting uranium might be anthropogenic with a slight U-235 enrichment (see Figure 3-49).

Concentrations of U-233/234, U-235/236, and U-238 in the 35–140-ft depth interval in FY 2003 remained relatively constant with a few exceptions. Concentrations of uranium isotopes increased in Lysimeter TW1-DL04 during FY 2003 but essentially stayed constant over the entire 6-year monitoring period (see Figures 3-50a, 3-50b, and 3-50c). The U-238:U-235 ratio also stayed constant (see Figure 3-51b), further demonstrating that anthropogenic uranium with a slight U-235 enrichment exists at the TW1 monitoring location. Uranium results obtained from Lysimeters D06-DL01 and D06-DL02 in FY 2003 show an increase in U-235/236, while U-233/234 and U-238—even though elevated—remained relatively constant or decreased to some extent (see Figures 3-50a, 3-50b, and 3-50c). As shown in Figure 3-51a, the U-238:U-235 ratio for Lysimeters D06-DL01 and D06-DL02 are trending downward because of increasing U-235 activity over time, and the trends are suggestive of slightly enriched uranium. Although the U-234:U-238 ratios in Well D06-DL02 are still within the expected range for natural uranium, increasing U-234 coupled with increasing U-235 suggests that enriched uranium is impacting the soil moisture at this location (near Pad A).

Even though U-238:U-235 activity ratios are suggesting enriched uranium, the U-234:U-238 ratios are more indicative of natural uranium. The U-234:U-238 activity ratios for these shallow lysimeters are approximately 2:1, which is drastically different than the 10:1 ratio associated with Lysimeter TW1-DL04 where enriched uranium is known to be present. The U-234:U-238 ratio of approximately 2:1 is typical of natural activity in RWMC groundwater and vadose zone soil moisture. Since records show significant quantities of depleted uranium were disposed of in the SDA, it is conjectured that its U-238 might be interfering with an accurate interpretation of isotopic uranium ratios. To absolutely confirm the presence of anthropogenic uranium and its U-235 enrichment will require high precision measurements with

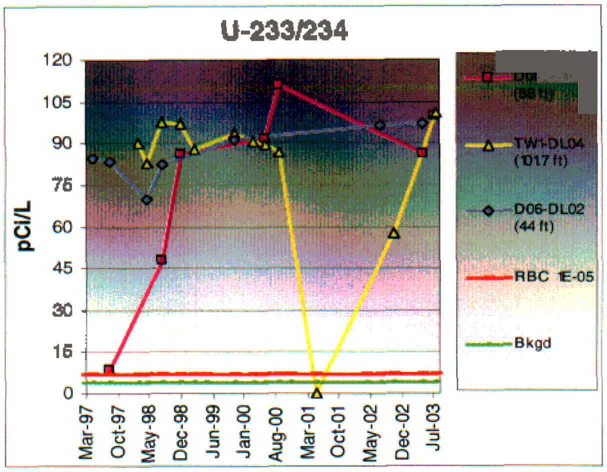


Figure 3-50a. Uranium-233/234 in mid-depth lysimeters, March 1997 through July 2003.

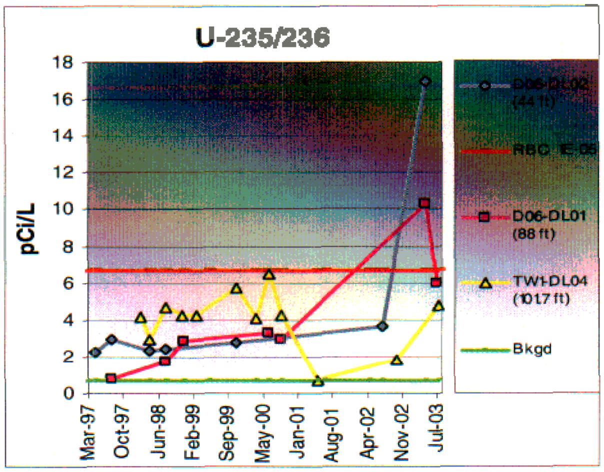


Figure 3-50b. Uranium-235/236 in mid-depth lysimeters, March 1997 through July 2003.

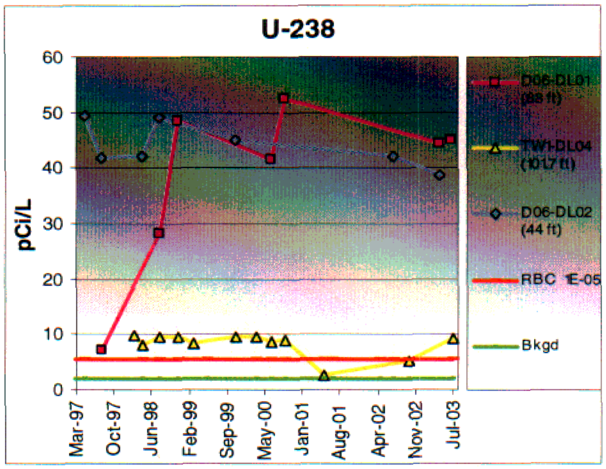


Figure 3-50c. Uranium-238 in mid-depth lysimeters, March 1997 through July 2003.

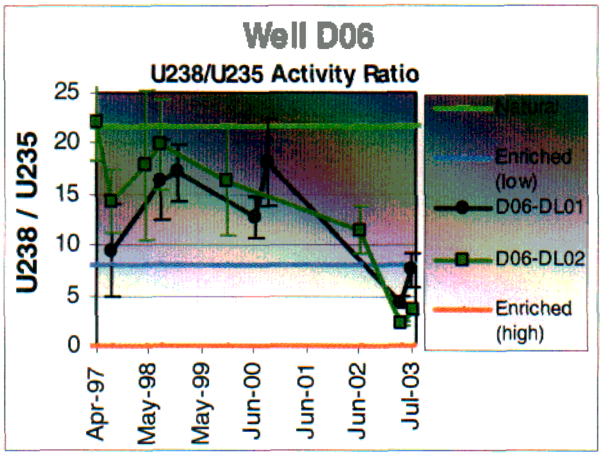


Figure 3-51a. Uranium-238:235 activity ratio in D06-DL01 and D06-DL02 over time.

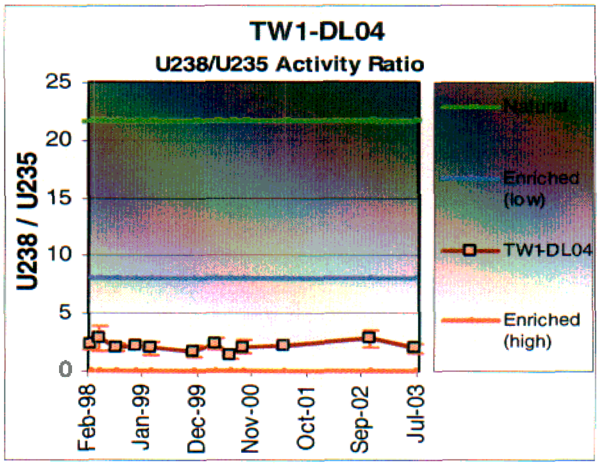


Figure 3-51b. Uranium-238:235 activity ratio in TW1-DL04 over time.

extremely low-level capabilities to accurately quantify U-235 and identify U-236. Trends are not apparent in lysimeters elsewhere in the SDA, although all uranium isotopes measured in Well I1S on the west end of the SDA are relatively high. Well I1S is located near Well W23, which yielded samples high in uranium from the shallow vadose zone.

3.10.2.2 Lysimeter and Perched Water Samples at Depths Greater than 140 ft. Sixty-nine isotopic uranium analyses were performed on soil-moisture and perched water samples collected from six lysimeters and two perched wells in and around the SDA in FY 2003, with six detections slightly above local soil-moisture background (see Table 3-26). None of the six results above local soil-moisture background exceeded the 1E-05 RBC for the aquifer. It does not appear as though there has been an anthropogenic impact to soil moisture at this depth and location within the SDA. Historical U-233/234 and U-238 data from Well USGS-92 (65 m [214 ft] deep) are depicted in Figures 3-52a and 3-52b. Perched water samples from Well USGS-92 often exceed background concentrations for U-233/234 and U-238; however, the data show no constant trends.

Table 3-26. Isotopic uranium results above local soil-moisture background in the 140- to 250-ft depth interval.

Location	Depth (ft)	Sample Date	Radionuclide	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Local Soil-Moisture Background[a] (pCi/L)	Aquifer RBC[b] (pCi/L)
O2D:DL19	240	10/21/02	U-233/234	**4.7 ± 0.8**[c]	0.8	3.7	6.7
			U-238	**3.0 ± 0.6**[c]	0.8	1.8	5.5
USGS-92	214	10/22/02	U-233/234	**4.4 ± 0.8**[c]	0.9	3.7	6.7
			U-238	**3.7 ± 0.7**[c]	1.2	1.8	5.5
USGS-92	214	01/08/03	U-238	**2.1 ± 0.4**[c]	0.4	1.8	5.5
USGS-92	214	07/22/03	U-238	**2.6 ± 7**[c]	0.4	1.8	5.5

a. Local soil-moisture background concentrations for uranium isotopes are defined as the mean plus the standard deviation of the mean of 60 soil-moisture samples collected between 1998 and 2003 from the "O" and D15 lysimeter wells located outside of the SDA.

b. RBC = 1E-05 for drinking water. The RBCs for the aquifer are provided here as a basis of comparison.

c. **Black bold font** indicates sample concentrations less than the RBC, but exceeding local soil-moisture background concentrations (see footnote a).

MDA = minimum detectable activity

RBC = risk-based concentration

SDA = Subsurface Disposal Area

USGS = United States Geological Survey

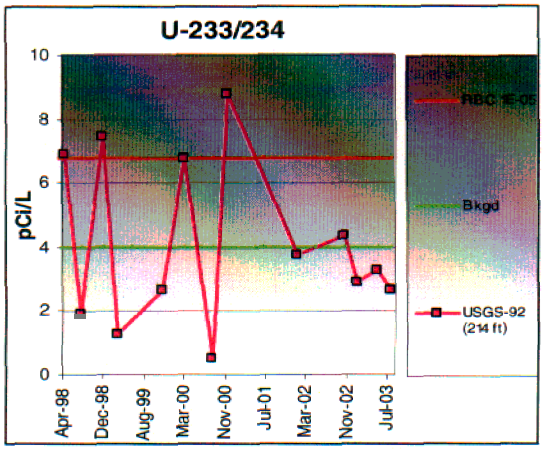


Figure 3-52a. Uranium-233/234 data from Well USGS-92, April 1998 through July 2003.

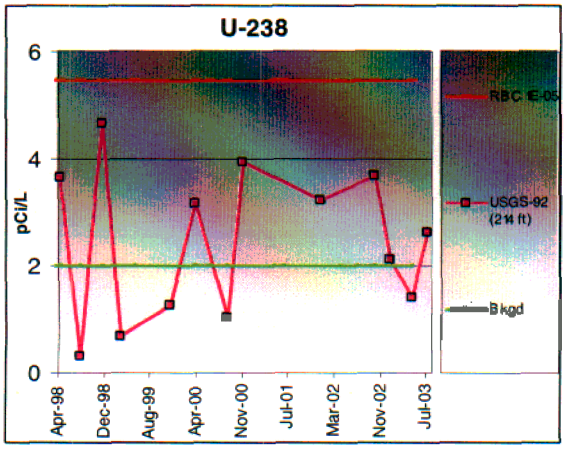


Figure 3-52b. Uranium-238 data from Well USGS-92, April 1998 through July 2003.

3.10.3 Aquifer

One hundred and eighty-nine isotopic uranium analyses were performed on aquifer samples collected from 15 monitoring wells in the vicinity of the RWMC in FY 2003, with four positive detections. All isotopic uranium concentrations were within concentration ranges typically observed in the SRPA, with the exception of three U-235/236 results and one U-233/234 result (see Table 3-27). None of the results exceeded the 1E-05 aquifer RBCs for each uranium isotope. The elevated U-235/236 concentrations were measured in samples collected from Monitoring Wells M15S, M16S, and OW2.

Table 3-27. Isotopic uranium results above aquifer background levels.

Well	Sample Date	Radionuclide	Sample Result ± 1σ (pCi/L)	MDA (pCi/L)	Aquifer Background[a] (pCi/L)	RBC[b] (pCi/L)
OW2	02/04/03	U-235/236	**0.14 ± 0.02**[c]	0.04	0.12	6.63
M16S	04/30/03	U-235/236	**0.15 ± 0.02**[c]	0.04	0.12	6.63
OW2	08/05/03	U-233/234	**2.01 ± 0.18**[c]	0.06	1.92	6.74
M15S	08/05/03	U-235/236	**0.26 ± 0.04**[c]	0.04	0.12	6.63

a. Aquifer background for U-235 in the vicinity of the RWMC is defined as the upper concentration range of 267 aquifer samples collected from 14 monitoring wells within about a 5-mi radius of the RWMC between 1998 and 2003. The background for U-233/234 is based on the upper 95% coverage 95% confidence tolerance limit of 272 aquifer samples collected within 10 mi of the RWMC.

b. RBC = 1E-05 for drinking water. The RBCs are provided here instead of the MCL, because the MCL for uranium (27 pCi/L) is applicable to total uranium not each individual uranium isotope.

c. **Black bold font** indicates sample concentrations less than the RBC, but exceeding local soil-moisture background concentrations (see footnote a).

MCL = maximum contaminant level
MDA = minimum detectable activity
RBC = risk-based concentration
RWMC = Radioactive Waste Management Complex
SDA = Subsurface Disposal Area

Uranium detected in the aquifer in the vicinity of the RWMC is typical of naturally occurring uranium in the SRPA. In FY 2003, slightly elevated concentrations of U-233/234 in Aquifer Well OW2 and U-235/236 in Wells M15S, M16S, and OW2 appear to be anomalous, because all other quarterly sampling results for FY 2003 show U-233/234 and U-235/236 to be representative of aquifer background concentrations. A summary of the maximum detected concentrations of U-233/234 and U-238 in aquifer samples since FY 1997 are presented in Tables 3-28 and 3-29, respectively.

Table 3-28. Summary of maximum detected concentrations of uranium-233/234 from aquifer wells in the vicinity of the Radioactive Waste Management Complex since Fiscal Year 1997.[a]

Fiscal Year[b]	Maximum Concentration ± 1σ (pCi/L)	Well Location
1997	NA[c]	—
1998	1.65 ± 0.16	M3S
1999	1.54 ± 0.13	M12S
2000	1.6 ± 0.2	M14S
2001	4.3 ± 0.4	M14S
2002	1.68 ± 0.14	M4D
2003	2.01 ± 0.18	OW-2

a. MCL = 27 pCi/L (total uranium)

b. Fiscal year spans from October 1 to September (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).

c. No samples were analyzed for U-233/234.

MCL = maximum contaminant level

Table 3-29. Summary of maximum detected concentrations of uranium-238 from aquifer wells in the vicinity of the Radioactive Waste Management Complex since Fiscal Year 1997.[a]

Fiscal Year[b]	Maximum Concentration ● 1σ (pCi/L)	Well Location
1997	NA	—
1998	0.74 ± 0.08	M7S
1999	0.75 ± 0.07	M12S
2000	0.72 ± 0.11	M3S
2001	2.1 ± 0.2	M14S
2002	0.78 ± 0.08	M4D
2003	0.90 ± 0.10	A11A31

a. MCL = 27 pCi/L (total uranium)

b. Fiscal year spans from October 1 to September (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).

c. Not analyzed

MCL = maximum contaminant level

3.10.4 Summary of Uranium

Uranium levels measured in FY 2003 in numerous vadose zone soil-moisture samples significantly exceed local soil-moisture background levels and RBCs for water ingestion. The soil-moisture detections of uranium above RBCs are depicted in Figure 3-53 with the locations of uranium disposals based on disposal records. Maximum concentrations detected in soil-moisture and perched water samples are presented in Tables 3-30 and 3-31. Some locations are where multiple detections of uranium correlate with disposal locations, suggesting that uranium might be a potential candidate for model validation or comparison. In the Pad A area, uranium is detected above background levels in all lysimeters above 30 m (100 ft), but has not been measured above background levels at Well I-4D (at 59 m [226.5 ft]). Most interesting is that uranium has been repeatedly detected above background in Well I-4S at the 29.6-m (97-ft) depth (Well I-4S), suggesting that uranium might have migrated to the first B-C interbed, but might not have reached the C-D interbed yet at 67 m (220 ft). Wells D06 and PA01 from the Pad A area routinely contain elevated uranium concentrations and are indicative of enriched uranium.

Table 3-30. Summary of maximum detections of uranium-238 in vadose zone soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.[a]

Sampling Range (feet below land surface)	Fiscal Year[b]	Maximum Concentration ± 1σ (pCi/L)[c,d]	Sample Location
Lysimeters 0 to 35 ft	1997	34 ± 3	PA03-L33
	1998	40 ± 3	PA03-L33
	1999	41 ± 3	PA03-L33
	2000	46 ± 3	W23-L08
	2001	53 ± 5	W23-L08
	2002	53 ± 4	W06-L27
	2003	54 ± 5	W23-L07
Lysimeters 35 to 140 ft	1997	49 ± 4	D06-DL02
	1998	49 ± 4	D06-DL02
	1999	49 ± 3	D06-DL01
	2000	53 ± 5	D06-DL01
	2001	4.7 ± 1.0	O3-DL22
	2002	9.4 ± 1.1	I1S-DL09
	2003	45 ± 5	D06-DL01
Lysimeters >140 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	NA	—
	2003	3.0 ± 0.6	O2-DL19
Perched water wells >140 ft	1997	NA	—
	1998	3.6 ± 1.1	USGS-92
	1999	4.7 ± 0.4	USGS-92
	2000	3.2 ± 0.4	USGS-92
	2001	NA	—
	2002	NA	—
	2003	3.7 ± 0.7	USGS-92

a. MCL = 27 pCi/L (total uranium)

b. Fiscal year spans from October 1 to September (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).

c. NA = not analyzed ND = not detected

d. Local soil-moisture background for U-233/234 is 1.5 pCi/L based on soil-moisture samples collected outside the SDA (Holdren et al. 2002).

MCL = maximum contaminant level
SDA = Subsurface Disposal Area
USGS = United States Geological Survey

Table 3-31. Summary of maximum detections of uranium-233/234 in vadose zone soil-moisture and perched water samples at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.[a]

Sampling Range (feet below land surface)	Fiscal Year[b]	Maximum Concentration ± 1σ (pCi/L)[c,d]	Sample Location
Lysimeters 0 to 35 ft	1997	43 ± 3	PA03-L33
	1998	60 ± 4	W23-L08
	1999	57 ± 4	PA03-L33
	2000	76 ± 5	W23-L08
	2001	87 ± 8	W23-L08
	2002	125 ± 10	W06-L27
	2003	84 ± 7	W23-L07
Lysimeters 35 to 140 ft	1997	84 ± 6	D06-DL02
	1998	97 ± 7	TW1-DL04
	1999	90 ± 14	TW1-DL04
	2000	111 ± 10	D06-DL01
	2001	7.3 ± 1.3	O3-DL22
	2002	17.3 ± 1.7	I1S-DL09
	2003	101 ± 9	TW1-DL04
Lysimeters >140 ft	1997	NA	—
	1998	NA	—
	1999	NA	—
	2000	NA	—
	2001	NA	—
	2002	9 ± 0.4	I4D-DL14
	2003	4.7 ± 0.8	O2D-DL19
Perched water wells >140 ft	1997	NA	—
	1998	NA	—
	1999	7.5 ± 0.6	USGS-92
	2000	6.7 ± 0.7	USGS-92
	2001	NA	—
	2002	NA	—
	2003	4.4 ± 0.8	USGS-92

a. MCL = 27 pCi/L (total uranium)

b. Fiscal year spans from October 1 to September (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).

c. NA = not analyzed ND = not detected

d. Local soil-moisture background for U-233/234 is 3 pCi/L based on soil-moisture samples collected outside the SDA (Holdren et al. 2002).

MCL = maximum contaminant level
SDA = Subsurface Disposal Area
USGS = United States Geological Survey

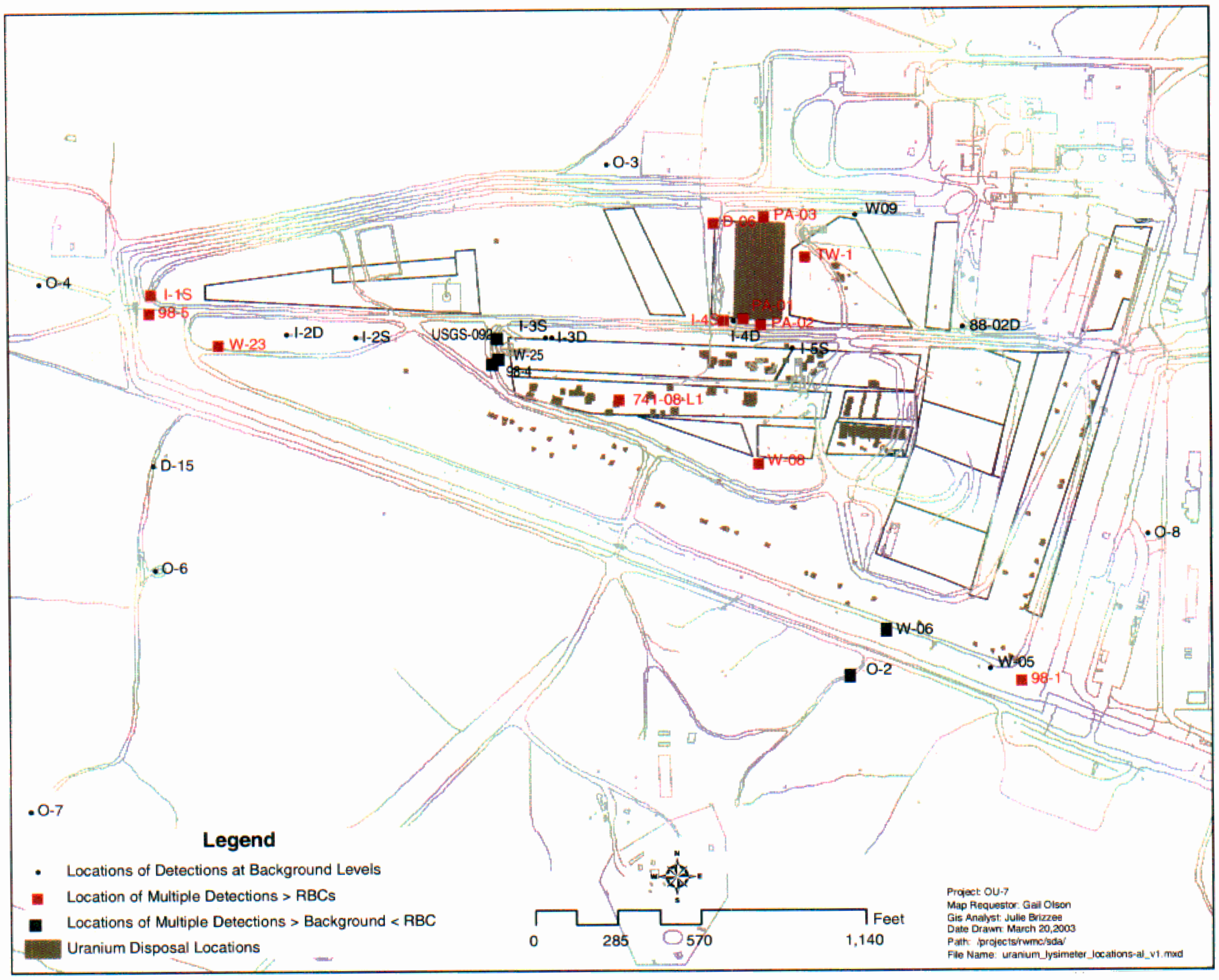


Figure 3-53. Uranium disposal locations and vadose zone detection locations at the Subsurface Disposal Area.

Uranium concentrations at the west end of the SDA also are significantly above background in Lysimeter Wells 98-5, I-1S, and W23 with concentration and isotopic ratio trends in Well W23; however, no uranium disposals have been recorded in that area. Therefore, the uranium monitoring data cannot be used for model calibration, which starts in the source term with the inventory records; however, the uranium trends in the western end of the SDA highlight some limitations and uncertainties of the inventory records.

3.11 Other Radionuclide Contaminants

All waste zone, vadose zone, and aquifer samples were analyzed for 20 or more gamma-emitting radionuclides, and there was only one detection. A positive detection of Cs-137 was reported in the third quarter aquifer sample pulled from Well M7S. No Cs-137 was detected in the subsequent quarter from the same well.

4. ORGANIC CONTAMINANTS

Carbon tetrachloride, tetrachloroethene (PCE), and methylene chloride have been identified as contaminants of potential concern, primarily for the groundwater ingestion exposure pathway for OU 7-13/14. This section presents sampling results for those contaminants of potential concern followed by sampling results for other organics compounds detected during monitoring.

4.1 Carbon Tetrachloride

The primary source of CCl_4 at the SDA is Series 743 waste drums shipped from RFP between 1966 and 1970 (Miller and Varvel 2001). Initially, 9,691 Series 743 waste drums were buried in multiple pits in the SDA, including Pits 4, 5, 6, 9, 10, 11, and 12. In the 1970s, all 1,015 drums from Pits 11 and 12 were retrieved, leaving 8,676 drums of Series 743 waste drums in the SDA. The estimated mass of CCl_4 contained in these 8,676 drums is 8.2E+05 kg (Miller and Varvel 2001).

Carbon tetrachloride has been detected at the SDA in surficial sediments, vadose zone soil gas, vadose zone soil water (perched water and lysimeters), and the aquifer beneath and surrounding the SDA. Carbon tetrachloride vapor also has been detected emanating from the soil surface by surface isolation flux chambers.

4.1.1 Waste Zone

Carbon tetrachloride was detected in high concentrations in soil-gas samples collected from vapor probes placed in the waste in Pits 4 and 10. The samples were collected in Tedlar bags or Summa canisters using a glovebox and analyzed with an INNOVA Model 1314 photoacoustic multigas analyzer. Some of the field duplicate samples also were analyzed using standard laboratory gas chromatography/mass spectrometry (GC/MS) as an accuracy check on the INNOVA results.

In FY 2003, carbon tetrachloride was detected in all of the probes that would yield a sample. The probes were sampled quarterly and seven or eight probes consistently produced a sample. During the last quarter of FY 2003, samples were obtained from five probes that had not previously yielded a sample. The success in obtaining samples from these previously unyielding probes is attributed to modifications to the glovebox and replacement of the line at the pump. However, the validity of the results from these five probes has been questioned and further sampling is necessary.

Table 4-1 contains results for CCl_4 and other VOCs for which analysis was performed. The maximum CCl_4 concentration measured was 55,080 ppmv at the 743-08-VP2 probe (4.1 m [13.4 ft] below land surface [bls]) in August 2003. Although this is down slightly from the FY 2002 maximum concentration, all results at this location are approaching the predicted equilibrium vapor concentration of CCl_4 in Series 743 sludge (46,000 at 10C) and close to the pure component equilibrium gas-concentration value (71,000 at 10C). This indicates the Series 743 sludge continues to be a source of CCl_4 and other VOCs. There was one higher concentration measured in a duplicate sample sent to the Southwest Laboratories of Oklahoma, but these results were J-flagged because of dilution and holding time issues.

During the last two quarters of FY 2003, there was a divergence in waste zone soil-gas sampling results between the INNOVA and the duplicate analyses performed using GC/MS. Up until this time, there was good agreement (<10%) between the INNOVA and the GC/MS. This issue currently is being

Table 4-1. Volatile organic compound vapor concentration results from Subsurface Disposal Area vapor probes in Fiscal Year 2003. All analyses were performed with the INNOVA gas analyzer except where noted. The Southwest Laboratory of Oklahoma and the Idaho National Engineering and Environmental Laboratory Environmental Chemistry Laboratory analyses were performed with gas chromatography/mass spectrometry.

Probe	Port Depth (ft)	Date Sampled	Sample No.	Carbon Tetrachloride (ppmv)	Chloroform (ppmv)	1,1,1-TCA[b] (ppmv)	TCE[b] (ppmv)]	PCE[b] (ppmv)
743-03-VP1	19	8/4/03	IPV29101VA	169	35	9	47	14
743-03-VP2	14	8/4/03	IPV29201VA	82	20	5	17	8
743-03-VP3	5	8/4/03	IPV29301VA	1,011	246	50	26	–2
743-08-VP1	21	11/20/02	IPV17101VA	44,640	22,160[a]	1,550	7,080	–192[b]
		2/18/03	IPV20401VA	37,860	19,700	1,359	5,494	50
		5/21/03	IPV27001VA	45,360	20,670	1,585	8,494	–490[b]
		5/21/03	IPV27001VT[d]	29,000	12,000	1,100 J	9,700	2,100 U
		8/6/03	IPV28601VA	50,370	21,670	1,701	9,116	–599[b]
		8/6/03	IPV28601VT[d]	26,000	9,600	960	7,600	120 U
743-08-VP2	14	11/20/02	IPV17201VA	54,750	15,810	1,475	3,070	33
		11/20/02	IPV17201VT[c]	42,000 J	19,000 J	<1 R	4,900 J	1.4 J
		11/20/02	IPV17202VT[c]	61,000 J	22,000 J	1,900 J	5,300 J	<1 J
		11/20/02	IPV17202VA	54,460	15,300	1,459	2,944	33
		2/18/03	IPV20502VA	42,590	13,860	1,236	2,451	38
		2/18/03	IPV20501VT[d]	45,000	11,000	1,200	2,900	290 U
		2/18/03	IPV20502VT[d]	47,000	11,000	1,300	3,000	200 U
		5/20/03	IPV27101VA	45,700	14,340	1,308	3,100	48
		5/20/03	IPV27102VA	46,460	13,950	1,306	3,194	41
		8/6/03	IPV28701VA	55,080[a]	15,600	1,488	3,607	54
		8/6/03	IPV28702VA	54,680	15,090	1,462	3,585	39
743-18-VP1	21	8/4/03	IPV29501VA	117	45	14	47	25
743-18-VP4	15	11/18/02	IPV17301VA	10,800	1,670	374	2,070	66
		5/20/03	IPV27201VA	7,567	1,218	249	1,467	58
		8/4/03	IPV28801VA	8,261	1,116	270	1,459	33
DU-08-VP2	16	11/18/02	IPV16601VA	12,670	8,185	3,793[a]	8,863	1,963
		2/17/03	IPV19901VA	11,120	7,516	3,484	7,618	2,219
		5/21/03	IPV26501VA	10,170	6,826	3,167	6,096	1,664
		8/4/03	IPV28101VA	10,140	6,722	3,203	5,851	1,364
DU-10-VP2	11	11/18/02	IPV16701VA	6,220	1,890	2,220	4,160	2,070
		2/17/03	IPV20001VA	3,976	1,360	1,570	3,000	1,694
		5/21/03	IPV26601VA	3,657	1,499	1,471	2,656	1,374
		5/21/03	IPV26601VT[d]	2,400	540	1,100	2,100	750
		8/6/03	IPV28101VA	5,110	2,100	1,950	3,258	1,593
		8/6/03	IPV28201VT[d]	2,800	650	1,400	2,400	900

Table 4-1. (continued).

Probe	Port Depth (ft)	Date Sampled	Sample No.	Carbon Tetrachloride (ppmv)	Chloroform (ppmv)	1,1,1-TCA[b] (ppmv)	TCE[b] (ppmv)]	PCE[b] (ppmv)
DU-10-VP3	7	11/18/02	IPV16801VA	10,200	1,570	1,880	2,870	2,160
		2/17/03	IPV20101VA	7,077	1,150	1,448	2,220	1,700
		5/21/03	IPV26701VA	7,069	1,194	1,568	2,252	1,593
		8/6/03	IPV28301VA	9,793	1,682	2,211	3,129	2,274[a]
DU-14-VP1	17	8/4/03	IPV29001VA	221	133	71	174	93
DU-14-VP2	12	11/18/02	IPV16901VA	7,300	5,110	1,650	10,240[a]	–52[b]
		2/18/03	IPV20201VA	5,902	4,322	1,433	8,400	364
		5/21/03	IPV26801VA	5,833	4,270	1,325	7,935	209
		8/4/03	IPV28401VA	5,301	3,934	1,186	7,428	184
DU-14-VP3	5	11/18/02	IPV17001VA	840	571	449	1,020	546
		2/18/03	IPV20301VA	891	564	449	953	493
		5/21/03	IPV26901VA	1,108	793	562	1,257	552
		8/4/03	IPV28501VA	930	731	461	1,146	457

a. Maximum measured concentration excludes the J flag or estimated data.

b. Negative results are considered undetected.

c. The Southwest Laboratory of Oklahoma analyzed the 6-L Summa canister sample.

d. The Idaho National Engineering and Environmental Laboratory Environmental Chemistry Laboratory analyzed the 250-mL Summa canister sample.

PCE = tetrachloroethene

TCA = 1,1,1-trichloroethane

PCE = trichloroethene

investigated to determine the cause for the discrepancy. A plan will be prepared to correct the problem. The full set of results from all the probes is contained in the "Fiscal Year 2003 Summary Report for the OU 7-13/14 Probing Project (Draft).[f]

Waste zone soil-moisture samples were not collected and analyzed for VOCs in FY 2003 because of arid conditions, limited sample volumes, and analytical priorities.

4.1.2 Vadose Zone

4.1.2.1 Perched Water and Lysimeter. Vadose zone soil-moisture samples were not collected and analyzed for VOCs in FY 2003 because of arid conditions, limited sample volumes, and analytical priorities. Lysimeter samples have not been collected and analyzed for VOCs since September 2000.

The USGS personnel collected a single perched water sample from Well USGS-92 on April 10, 2003. The CCl_4 concentration in that sample was 279 µg/L. Figure 4-1 shows the history of the CCl_4 concentrations in perched water in Well USGS-92. The decline in CCl_4 concentrations in Well USGS-92 is attributed to operation of the organic contamination in the vadose zone (OCVZ) vapor vacuum extraction with treatment (VVET) system. Well USGS-92 is located near the 7V vapor vacuum extraction well.

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[f] Meyers, Dennis R., Joel M. Hubbell, Nicholas Josten, L. Don Koeppen, Paul D. Ritter, Hopi Salomon, A. Jeffrey Sondrup, Deborah L. McElroy, and Carolyn W. Bishop, 2004, "Fiscal Year 2003 Summary Report for the OU 7-13/14 Probing Project (Draft)," ICP/EXT-04-00189, Rev. A, Idaho Completion Project, February 2004.

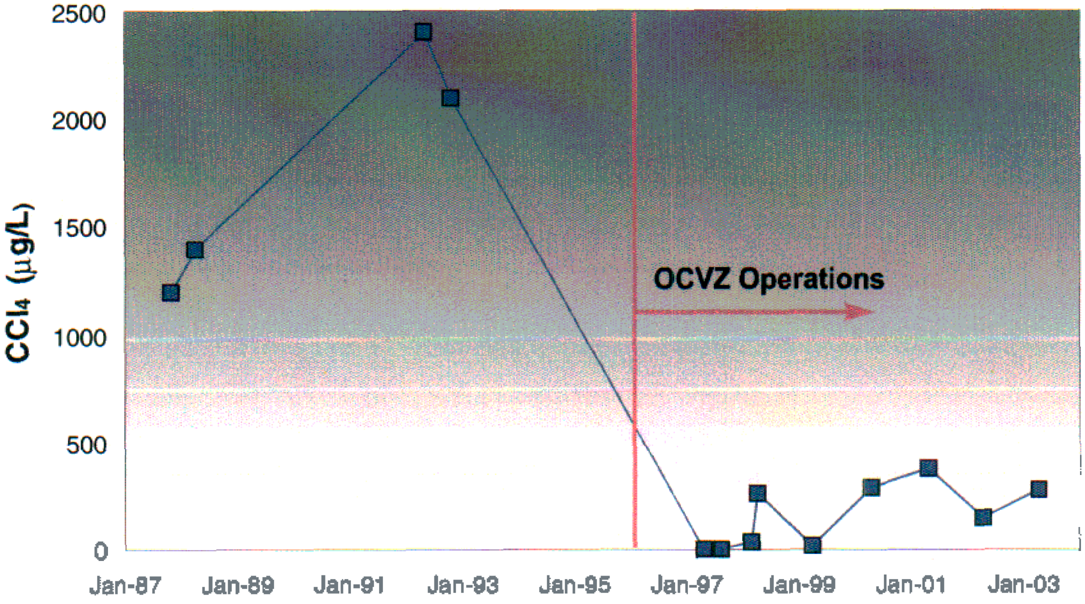


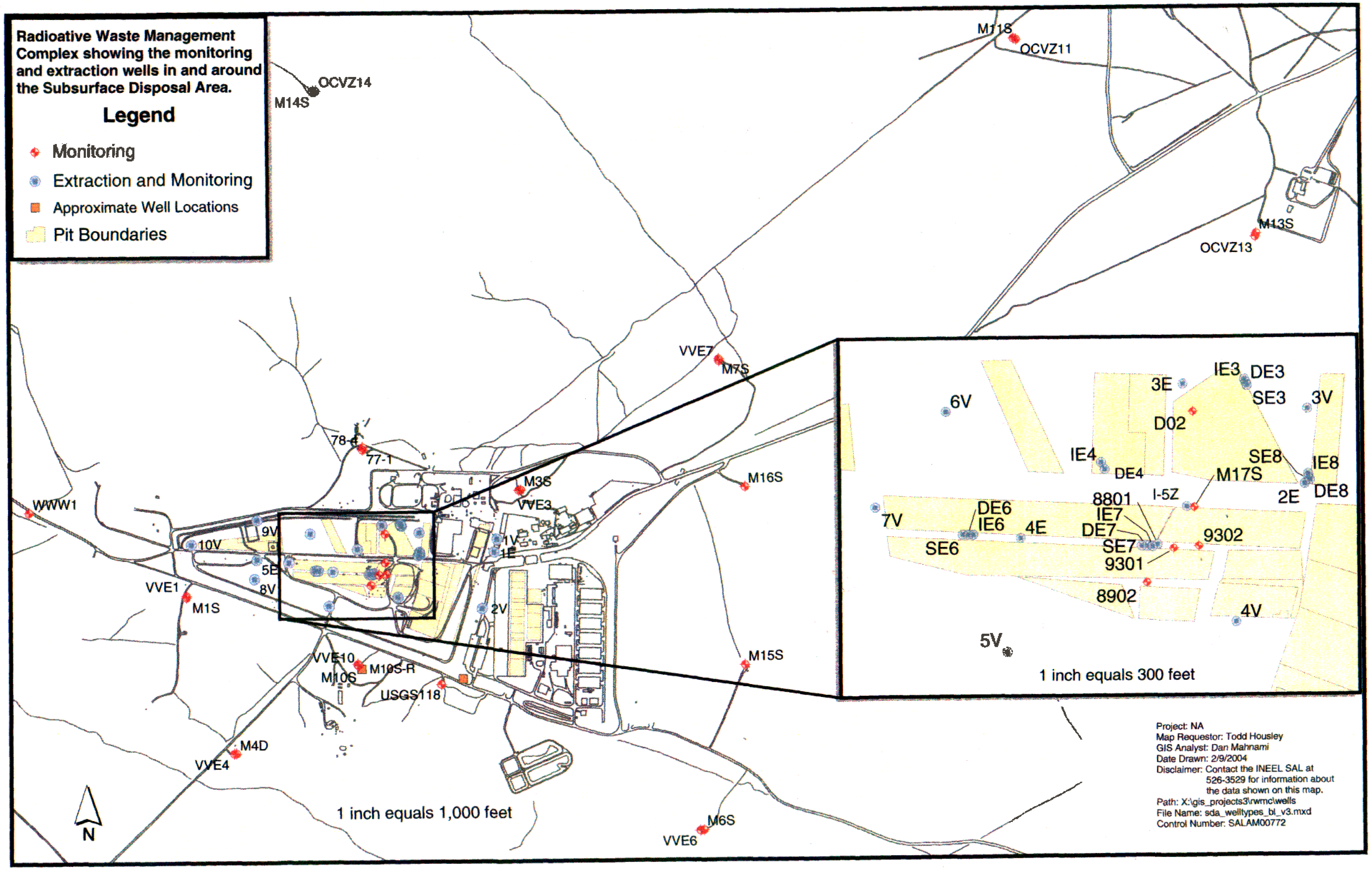
Figure 4-1. History of carbon tetrachloride concentration in Well USGS-92.

4.1.2.2 Soil Gas. Soil-gas monitoring in the vadose zone is accomplished using an extensive system of permanent soil-gas sampling ports inside and outside the SDA boundary. The ports are made of stainless-steel tubing attached to the outside of well casings. The bottom of the tubes are perforated and surrounded by sand. Figures 4-2a and 4-2b show the location of wells with soil-gas sampling ports in the vicinity of the SDA and the depths of the ports. The port depths range from a minimum depth of 4.6 m (15 ft) in Well WWW-1 to a maximum depth of 180.1 m (591 ft), just above the water table in Well M13S.

Hundreds of vadose zone soil-gas samples were collected in FY 2003. The complete set of soil-gas data can be found in the *Environmental and Operational Mid-Year Data Report for the OU 7-08 Organic Contamination in the Vadose Zone Project—2003* (Housley 2003) and the *Environmental and Operational End-Year Data Report for the OU 7-08 Organic Contamination in the Vadose Zone Project—2003* (Housley 2004). The highest levels of CCl_4 were located in the central portion of the SDA between Pits 4, 5, 6, and 10 and decrease with distance away from this area. Concentrations in the wells farthest from the SDA, OCVZ-11, and OCVZ-13 are less than 1 ppmv.

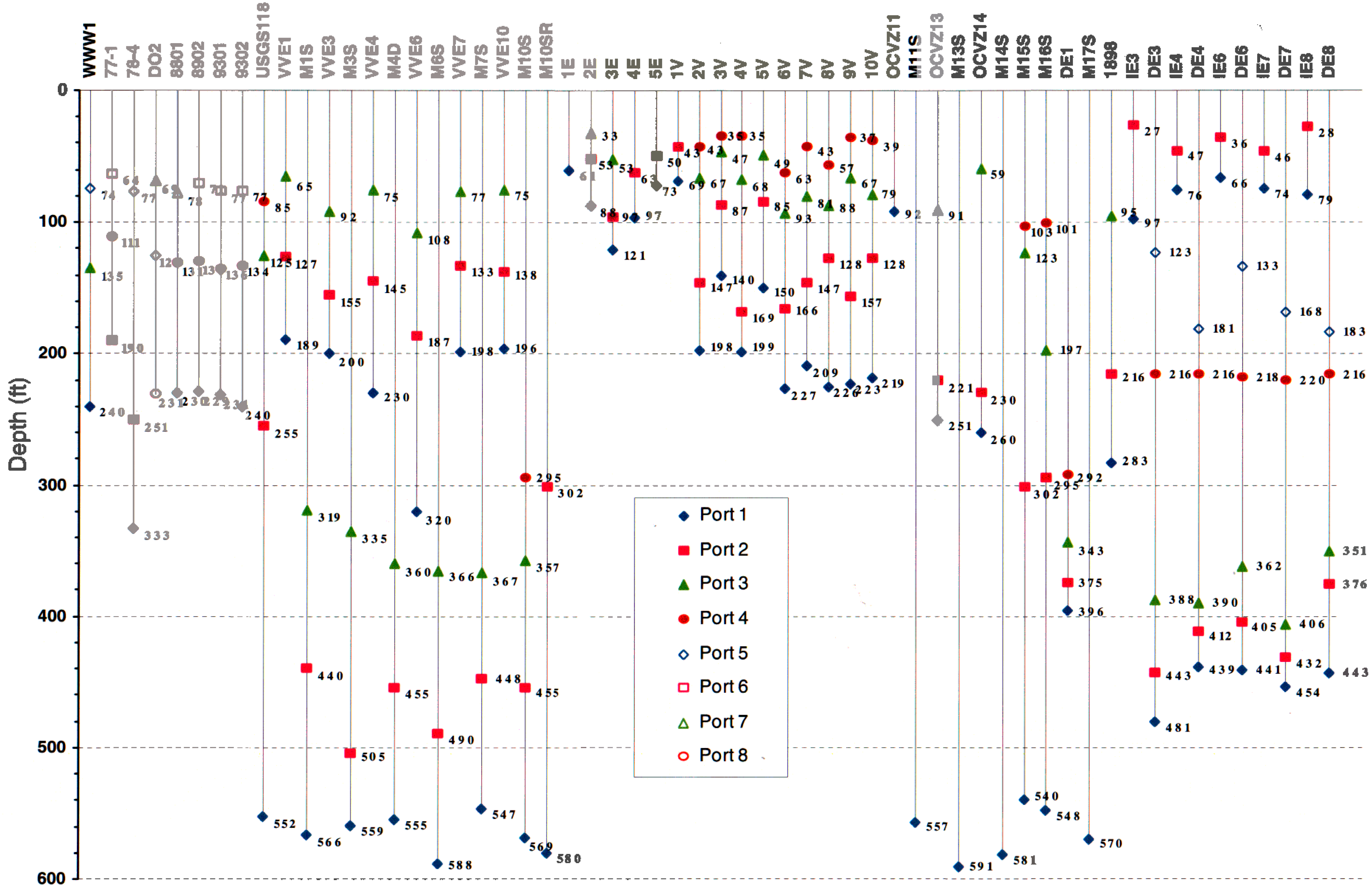
The maximum concentration measured in FY 2003 was 2,900 ppmv in Well 8801, Port 4 at a depth of 23.7 m (78 ft) on July 8, 2003. This is much less than the highest CCl_4 concentration ever measured, which was 4,864 ppmv in Well 9302, Port 6 at a depth of 23.5 m (77 ft) in January 1995. The maximum concentration in FY 2002 was 1,600 ppmv at the same location. The reason for the increase in FY 2003 likely results from the VVET units being shut down from June 12 to July 4, 2003, because of a power outage at the RWMC to install new cable and a transformer. Well 8801 is located approximately 80 ft from Vapor Extraction Well 8901D.

Vertically, the CCl_4 soil-gas contamination extends from land surface down to the water table. Currently, in the center of the SDA, the CCl_4 concentrations are 1,000 ppmv or higher above the B-C interbed. Concentrations then decrease sharply across the B-C interbed down to a few hundred ppmv. Below the C-D interbed, concentrations are generally less than 50 ppmv.



Project: NA
Map Requestor: Todd Housley
GIS Analyst: Dan Mahnami
Date Drawn: 2/9/2004
Disclaimer: Contact the INEEL SAL at 526-3529 for information about the data shown on this map.
Path: X:\gis_projects3\rwmc\wells
File Name: sda_welltypes_bl_v3.mxd
Control Number: SALAM00772

Figure 4-2a. Location of soil-gas sampling wells in the vicinity of the Radioactive Waste Management Complex.



*Wells Ports 3V-1, 3V-2, M10S-1 and M10S-2 were removed and are no longer operational

Figure 4-2b. Depth of the sampling ports in wells in the vicinity of the Radioactive Waste Management Complex.

Concentrations at most locations are much less now than before full-time operation of the OCVZ VVET system began in January 1996. Figures 4-3 and 4-4 show the soil-gas concentrations at two wells (8801 and 9301) near Vapor Extraction Well 8901D. In 1993, a treatability study was performed and soil-gas extraction from Well 8901D was performed for approximately 3 months. This event had little lasting impact on the concentration levels. Before 1996, the CCl_4 concentration at about the 23.5-m (77-ft) depth (above the B-C interbed) was approximately 3,000 ppmv in these two wells. However, after full-time extraction began in January 1996, the concentration dropped to about 1,000 ppmv. Near the 40-m (130-ft) depth below the B-C interbed, the concentration dropped from about 600 ppmv before vapor vacuum extraction operations to 100 ppmv after operations. Concentrations in the deeper ports, around 70 m (230 ft), appear to be unchanged by operations. In Well 9V (see Figure 4-5), the initial drop in concentration was not so dramatic, probably because it is located farther from an extraction well; however, the decrease has been steady. Even the deep gas port at 68 m (223 ft) shows a clear decline in concentrations.

In FY 2003, vadose zone soil-gas concentrations at several locations show an overall increase over FY 2002 levels. As shown in Figure 4-3, there was a large spike in the carbon tetrachloride soil-gas concentration in 8801-7 around July 2003. Although a serious outlier, the quality control data suggest that the number is valid. The standards for that day indicate that the instrument used for analyzing the 8801-7 sample was within 5% of the 1,000-ppm standard. The laboratory blank, analyzed just prior to the 8801-7 sample, contained 45 ppm carbon tetrachloride, which might have had a small but relatively insignificant contribution to the 919-ppmv reading in the sample from 8801-7. Part of the concentration rebound might be because VVET Unit A went down on June 12 and was not restarted until July 4. Samples were collected on July 7 and 8 and showed elevated carbon tetrachloride concentrations around Unit A, including 8801-7. Therefore, the conclusion for now is that it is an outlier and the validity will be determined by subsequent sampling.

During FY 2003, fourteen new vapor extraction wells were drilled and 10 of those wells have permanent vapor sampling ports. The locations of the new wells are shown in Figure 4-2a. The new well names begin with SE, IE, or DE signifying a Shallow (above the BC interbed), Intermediate (between the BC and CD interbeds), or Deep (below the CD interbed) extraction well, respectively. Only the IE and DE wells have vapor sampling ports. The most interesting thing to note in the data from the new wells is that VOC concentrations below the CD interbed are higher than previously thought. Until FY 2003, the DE1 well was the only well inside the SDA with vapor ports below the CD interbed. The CCl_4 concentrations in DE1 were less than 10 ppmv. Concentrations in the newer DE wells have been as high as 60 ppmv. Plans are being made to analyze samples from these wells with something other than the B&K gas analyzer to confirm the high concentrations. Consequently, previous model results (Magnuson and Sondrup 1998) predicted concentrations directly below the CD interbed could be as high as 100 ppmv.

4.1.3 Aquifer

Eighty-eight aquifer samples were collected in FY 2003 from 22 monitoring wells in the vicinity of the RWMC and analyzed for VOCs. Sixty-two of the samples were collected by WAG 7 personnel from 15 monitoring wells and analyzed for CCl_4. Thirty-three of those 62 samples had detections above the quantitation limit of 1 μg/L. Of those 33 detections, seven exceeded the primary drinking water MCL of 5 μg/L. Samples collected by WAG 7 were collected in November 2002 and February, April/May, and September 2003 from Monitoring Wells A11A31, M1S, M3S, M4D, M6S, M7S, M11S, M12S, M13S, M14S, M15S, M16S, M17S, OW2, and USGS-127. The WAG 7 results above the quantitation limit are summarized in Table 4-2.

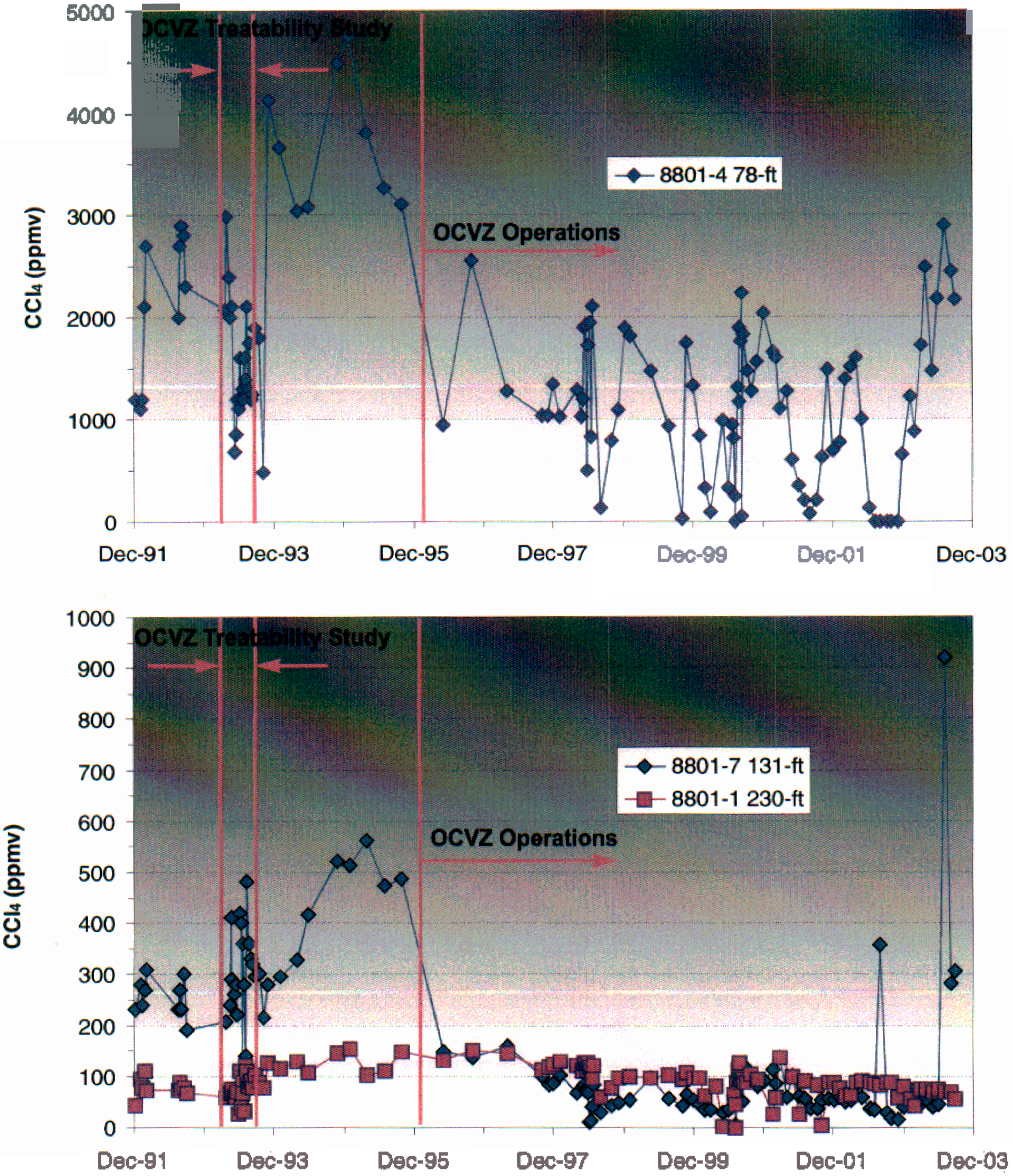


Figure 4-3. Carbon tetrachloride soil-gas concentration time history for selected ports in Well 8801.

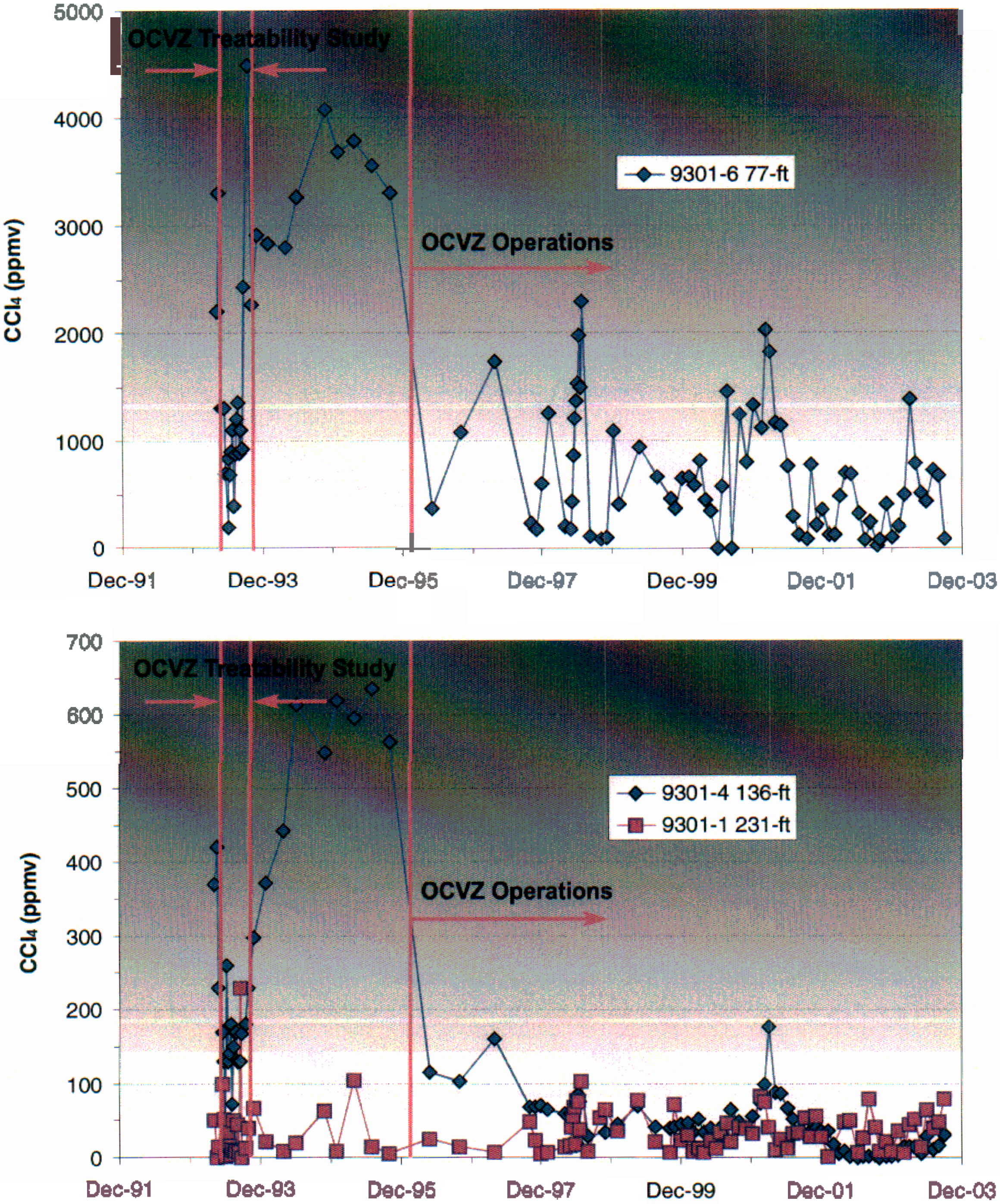


Figure 4-4. Carbon tetrachloride soil-gas concentration time history for selected ports in Well 9301

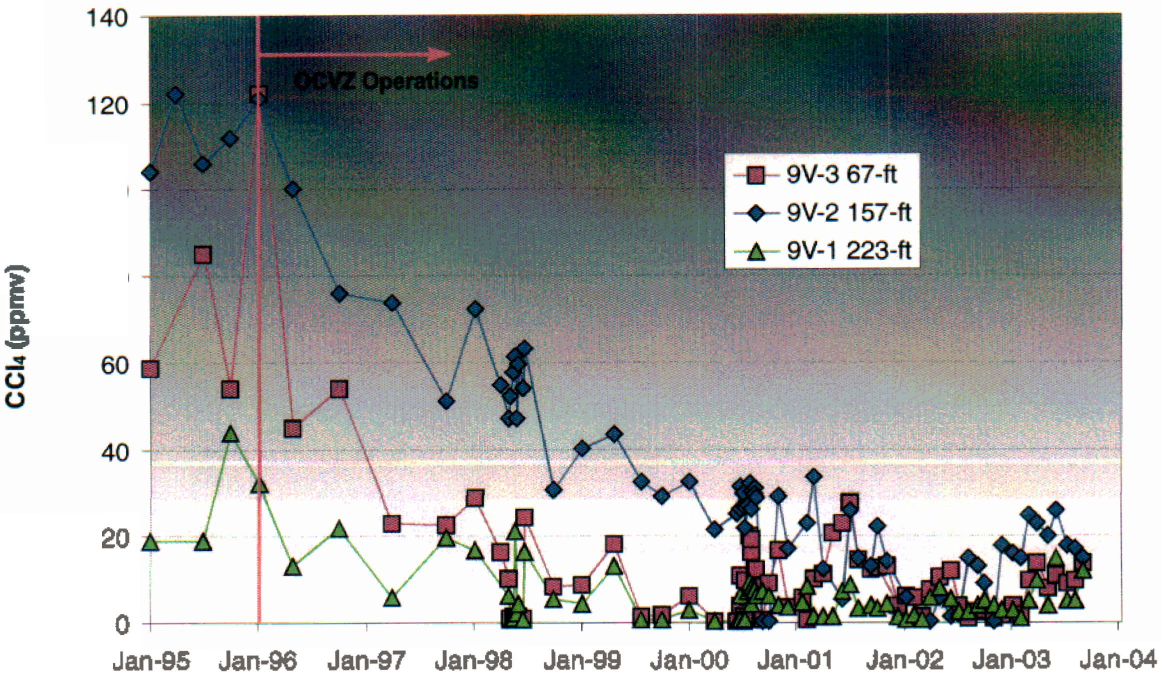


Figure 4-5. Carbon tetrachloride soil-gas concentration time history for selected ports in Well 9V.

Table 4-2. Carbon tetrachloride results above quantitation limit (Waste Area Group 7) or minimum reporting level in the aquifer in the vicinity of the Radioactive Waste Management Complex.

Well	Sample Date	Sample Concentration (µg/L)	Quantitation Limit or Minimum Reporting Level (µg/L)
Waste Area Group 7 Monitoring Results			
A11A31	11/05/02	5.5	1.0
M14S	11/05/02	1.2	1.0
M3S	11/05/02	2.1	1.0
M15S	11/06/02	1.3	1.0
M17S	11/06/02	2.2	1.0
M17S	11/06/02	2	1.0
M16S	11/11/02	4.6	1.0
M6S	11/11/02	2.2	1.0
OW2	11/11/02	0.55$_{J}$[b]	1.0
M7S	11/12/02	5.5	1.0
A11A31	02/03/03	6	1.0
M6S	02/03/03	2	1.0
M7S	02/03/03	5	1.0
M15S	02/04/03	1	1.0
M16S	02/04/03	5	1.0
M17S	02/04/03	2	1.0
M14S	04/28/03	1$_{J}$[b]	1.0

Table 4-2. (continued).

Well	Sample Date	Sample Concentration (µg/L)	Quantitation Limit or Minimum Reporting Level (µg/L)
M6S	04/28/03	2_{J}[b]	1.0
M7S	04/29/03	**6**$_{J}$[b]	1.0
A11A31	04/30/03	5_{J}[b]	1.0
M16S	04/30/03	5_{J}[b]	1.0
OW2	05/05/03	0.8_{J}[b]	1.0
M15S	05/06/03	2	1.0
M3S	05/06/03	3	1.0
M17S	05/07/03	2	1.0
M17S	05/07/03	3	1.0
A11A31	08/04/03	**7**$_{J}$[b]	1.0
M16S	08/04/03	**7**$_{J}$[b]	1.0
M6S	08/04/03	4_{J}[b]	1.0
M15S	08/05/03	2	1.0
M7S	08/05/03	**8**	1.0
M17S	08/06/03	2	1.0
M3S	08/06/03	3_{J}[b]	1.0
United States Geological Survey Monitoring Results			
RWMC Production	10/10/02	4.8	0.2
RWMC Production	11/14/02	4.9	0.2
RWMC Production	12/12/02	**5.5**	0.2
RWMC Production	1/9/03	**5.8**	0.2
RWMC Production	2/13/03	4.4	0.2
RWMC Production	3/13/03	**5.1**	0.2
RWMC Production	4/10/03	**5.6**	0.2
RWMC Production	5/15/03	**5.5**	0.2
RWMC Production	6/12/03	**5.6**	0.2
RWMC Production	7/10/03	**6.6**	0.2
RWMC Production	8/14/03	**6.3**	0.2
RWMC Production	9/10/03	4	0.2
USGS-087	10/10/02	2.9	0.2
USGS-087	4/10/03	3.2	0.2
USGS-088	10/1/02	1.3	0.2
USGS-088	4/2/03	1.6	0.2
USGS-089	10/21/02	0.2	0.2
USGS-089	5/20/03	0.2	0.2
USGS-117	10/1/02	0.2	0.2
USGS-117	4/9/03	0.2	0.2
USGS-117	9/30/03	0.2	0.2

Table 4-2. (continued).

Well	Sample Date	Sample Concentration (μg/L)	Quantitation Limit or Minimum Reporting Level (μg/L)
USGS-119	10/3/02	0.2	0.2
USGS-119	4/7/03	0.2	0.2
USGS-119	9/30/03	0.2	0.2
USGS-120	10/10/02	3.4	0.2
USGS-120	4/10/03	3	0.2

a. **Red bold font** indicates sample concentrations that exceed the MCL.
b. Concentrations with a "J" subscript were positively identified in the sample and assigned a "J" data qualifier flag. The qualifier flag was assigned, because the recovery of one of the surrogates was slightly above the upper control limit. The reported concentrations might not be an accurate representation of the amount actually present in the sample and should only be used as estimated quantities.
MCL = maximum contaminant level
NA = not available
RWMC = Radioactive Waste Management Complex
USGS = United States Geological Survey

The USGS personnel collected 26 of the 88 aquifer samples from eight aquifer wells in the vicinity of the RWMC. Eighteen of the 26 samples had detections greater than or equal to the minimum reporting level of 0.2 μg/L. Of the 18 detections, eight met or exceeded the primary drinking water MCL of 5 μg/L, and, in comparison, six samples met or exceeded the primary drinking water MCL in FY 2002. Monthly, samples were collected by the USGS from the RWMC production well and in April and October 2003 from Wells USGS-87, USGS-88, USGS-89, USGS-117, USGS-119, and USGS-120. The USGS sample results greater than or equal to the minimum reporting level also are summarized in Table 4-2.

When FY 2003 WAG 7 and USGS results are combined, CCl_4 was consistently detected in 13 of 22 aquifer-monitoring wells. Concentrations in these wells varied from 0.2 to 8 μg/L, with four wells (A11A31, M7S, M16S, and RWMC production) exceeding the MCL. The nine wells where CCl_4 was not detected are M1S, M4D, M11S, M12S, M13S, USGS-89, USGS-117, USGS-119, and USGS-119. Wells M11S, M12S, M13S, and USGS-127 are more than 2.4 km (1.5 mi) from the SDA.

Figure 4-6 shows the concentration time history of CCl_4 in RWMC vicinity wells. Although concentrations have increased over the past several years, data from the last few years indicate a flat trend in most wells. Wells that exhibited an increasing trend during FY 2003 are M6S, M7S, M15S, M16S, and USGS-87. Wells that exhibited a decreasing trend during FY 2003 are M14S and USGS-120.

4.1.4 Summary of Carbon Tetrachloride

Carbon tetrachloride was detected in FY 2003 in waste zone soil gas, vadose zone soil gas, perched water, and in the aquifer in and around the RWMC. The highest soil-gas concentration was 55,080 ppmv, measured in the waste zone soil gas. The maximum soil-gas concentration outside the waste zone was 3,630 ppmv measured in Well 8801 Port 4 at 24 m (78 ft) bls. A single perched water sample contained 279 μg/L CCl_4. Carbon tetrachloride concentrations in vadose zone soil gas and perched water are appreciably lower since the OCVZ Project began operation of a VVET system.

In FY 2003, low levels of CCl_4 were consistently detected in aquifer-monitoring wells in and around the RWMC. The maximum concentration was 8 μg/L measured in Well M7S. The concentration exceeded the MCL of 5 μg/L in four wells (Wells AllA31, M7S, M16S, and the RWMC production well). Although concentrations have increased over the past several years, the data indicate a relatively flat trend in most wells during the past few years. The only well to exhibit an increasing trend over the past few years is Well A11A31, and the only well with a clearly decreasing trend over the past few years is Well USGS-120.

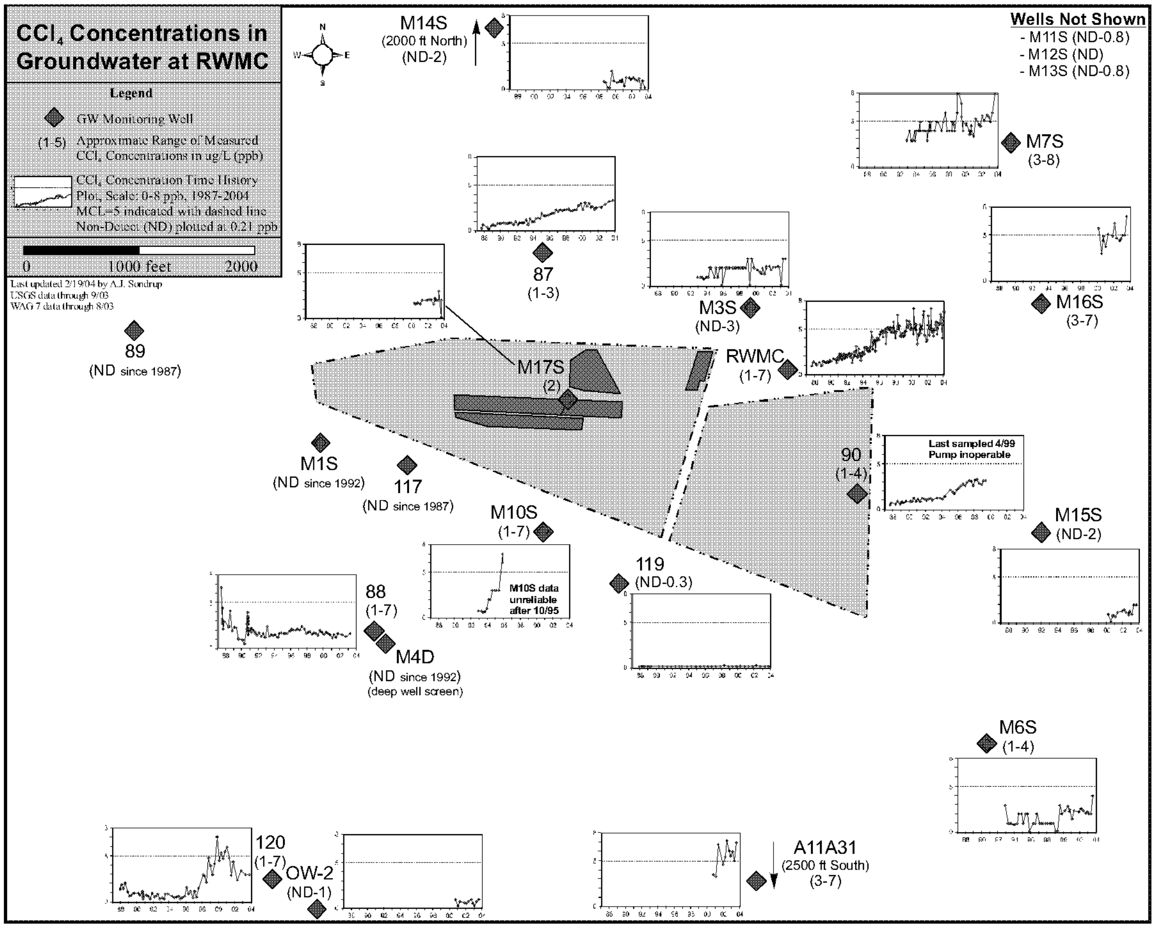


Figure 4-6. Carbon tetrachloride aquifer concentrations in monitoring wells in the vicinity of the Radioactive Waste Management Complex.

4.2 Tetrachloroethene

The primary source of PCE at the SDA is Series 743 waste. The estimated mass of PCE contained in Series 743 sludge is 9.8E+04 kg (Varvel 2001).

Tetrachloroethene has been detected at the SDA in surficial sediments, vadose zone soil gas, vadose zone soil water (perched water and lysimeters), and groundwater. Tetrachloroethene vapor also has been detected emanating from the soil surface by surface isolation flux chambers.

4.2.1 Waste Zone

Tetrachloroethene was detected in high concentration in gas samples collected from vapor probes placed in the waste in Pits 4 and 10. The samples were collected in Tedlar bags or Summa canisters using a glovebox and analyzed with an INNOVA Model 1314 photoacoustic multigas analyzer. Some of the field duplicate samples also were analyzed using standard laboratory GC/MS as an accuracy check on the INNOVA results.

Tetrachloroethene was detected in all but one of the probes that would yield a vapor sample. Table 4-1 contains the PCE results as well as results for the other gases for which analyses were performed. The highest concentrations of PCE are in the DU Focus Area in the west end of Pit 10. The PCE concentrations in the 743 Focus Area are typically less than 50 ppmv, while concentrations in the DU Focus Area range from a few hundred ppmv to over 2,000 ppmv. The maximum PCE concentration measured was 2,274 ppmv at the DU-10-VP3 location (1.9 m [6.2 ft] bls) in August 2003. This is slightly less than the maximum concentration measured last year, but is still greater than the estimated equilibrium vapor concentration of CCl_4 in Series 743 sludge (750 ppmv at 10C). However, the equilibrium vapor concentration for PCE is small, because PCE is estimated to be a small fraction of the VOC components in Series 743 sludge. Nevertheless, results indicate that Series 743 sludge continues to be a source of PCE and other VOCs. The full set of results from all the probes is contained in the "Fiscal Year 2003 Summary Report for the OU 7-13/14 Probing Project (Draft)" (see footnote f).

Waste zone soil-moisture samples were not collected and analyzed for VOCs in FY 2003 because of arid conditions, limited sample volumes, and analytical priorities.

4.2.2 Vadose Zone

4.2.2.1 Perched Water and Lysimeter. Vadose zone soil-moisture samples were not collected and analyzed for VOCs in FY 2003 because of arid conditions, limited sample volumes, and analytical priorities. Lysimeter samples have not been collected and analyzed for VOCs since September 2000.

The USGS personnel collected a single perched water sample from Well USGS-92 on April 10, 2003. The PCE concentration in that sample was 39.5 µg/L. Tetrachloroethene has consistently been detected in Well USGS-92 since 1987. The maximum concentration measured was 180 µg/L on February 29, 1996, and the minimum was 23 µg/L on March 30, 1999. Since the OCVZ Project began operating the VVET system, PCE concentrations have declined in USGS-92.

4.2.2.2 Soil Gas. Tetrachloroethene has consistently been detected in soil gas at the RWMC for several years, but at much lower concentrations than CCl_4. Before FY 2002, the historic maximum PCE concentration was 135 ppmv in Well 8902, Port 4 at a depth of 39 m (130 ft) on January 4, 1996. Since April 1998, the PCE concentrations in Well 8902, Port 4 have been less than 10 ppmv. Concentrations at other wells inside the SDA have generally been less than 20 ppmv. Inside the SDA, below the C-D interbed, concentrations have been less than 2 ppmv. Outside the SDA, the historic maximum PCE concentration measured was 75 ppmv in Well 77-1, Port 2 at a depth of 58 m (190 ft). Concentrations in this port now are generally less than 30 ppmv. Outside the SDA, below the C-D interbed, concentrations are generally less than 1 ppmv.

Since June 2002, there have been several anomalously high PCE measurements. They have almost exclusively occurred at Wells 77-1 and 78-4. Sulfur hexafluoride (SF_6) gas was used for a gas tracer test in these two wells and it appears that the SF6 interferes with the PCE filter on the B&K gas analyzer. The number of anomalous readings has decreased but still persists in FY 2003. The maximum PCE concentration in soil gas in FY 2003 was 179 ppmv in Well 77-1, Port 4 at a depth of 32 m (104 ft) on November 4, 2002. Typical concentrations in this port are less than 20, so it likely that the SF_6 interference still persists.

4.2.3 Aquifer

Eighty-eight aquifer samples were collected in FY 2003 from 22 monitoring wells in the vicinity of the RWMC and analyzed for VOCs. Sixty-two of the samples were collected by WAG 7 personnel in November 2002 and February, April/May, and September 2003 from Monitoring Wells AllA31, M1S, M3S, M4D, M6S, M7S, M11S, M12S, M13S, M14S, M15S, M16S, M17S, OW2, and USGS-127. None of the 62 samples had detections above the quantitation limit of 1 µg/L.

Twenty-six of the 88 aquifer samples were collected by USGS personnel from eight aquifer wells in the vicinity of the RWMC. Samples were collected by the USGS monthly from the RWMC production well and in April and October 2003 from Wells USGS-87, USGS-88, USGS-89, USGS-117, USGS-119, USGS-120, and USGS-127. Only one of the 26 samples had detection greater than or equal to the minimum reporting level of 0.2 μg/L, and it was 0.3 μg/L in the RWMC production well in August 2003.

Positive detections of PCE in SDA-vicinity aquifer wells are infrequent. The historical maximum PCE concentration measured was 0.4 μg/L in Well M7S on five different occasions from 1993 to 1996. This is well below the MCL of 5 μg/L.

4.2.4 Summary of Tetrachloroethene

Tetrachloroethene was detected in FY 2003 in waste zone soil gas, vadose zone soil gas, perched water, and in the aquifer in the vicinity of the RWMC. The maximum soil-gas concentration was 2,274 ppmv measured in the waste zone soil gas. Vadose zone soil-gas concentrations measured in FY 2003 are typical except for a few anomalously high measurements likely due to interference from a tracer gas (SF_6) used in 2002. A single perched water sample contained 39.5 μg/L of PCE. Tetrachloroethene was detected in only one of 88 aquifer samples. It was detected in the RWMC production well at 0.3 μg/L, which is just about above the minimum reporting level of 0.2 μg/L.

4.3 Methylene Chloride

Approximately 1.4E+04 kg of methylene chloride was disposed of in the SDA (Holdren et al. 2002). Information about methylene chloride disposal is scant compared to that for other, more prevalent VOCs like CCl_4. It should be noted that CCl_4 could degrade to methylene chloride; thus, considering the large mass of CCl_4 buried in the SDA, detections of methylene chloride in samples might not necessarily be related to the original inventory disposed of in the SDA.

4.3.1 Waste Zone

Only the duplicate gas samples from the soil vapor probes in the waste zone that are sent to a laboratory are analyzed for methylene chloride. In FY 2003, methylene chloride was identified above the method detection limit in five of eight samples from three different probes. However, only two of those results were above the practical quantitation limit (no J-flag). The maximum concentration was 710 ppmv on August 6, 2003, at Probe 743-08-VP1 at a depth of 6.4 m (21 ft). The results are shown in Table 4-3.

Waste zone soil-moisture samples were not collected and analyzed for VOCs in FY 2003 because of arid conditions, limited sample volumes, and analytical priorities.

4.3.2 Vadose Zone

4.3.2.1 Perched Water and Lysimeter. Vadose zone soil-moisture samples were not collected and analyzed for VOCs in FY 2003 because of arid conditions, limited sample volumes, and analytical priorities. Lysimeter samples have not been collected and analyzed for VOCs since September 2000.

The USGS personnel collected a single perched water sample from Well USGS-92 on April 10, 2003. The methylene chloride concentration in that sample was less than the reporting limit of 0.2 μg/L. The perched water sample from Well USGS-92 in April 2002 was 4.7 μg/L for comparison. Methylene chloride has been consistently detected in Well USGS-92 since April 1997. Before that, it was analyzed for but not detected above the minimum reporting level of 0.2 μg/L. The maximum methylene chloride concentration in perched water from Well USGS-92 was 22.4 μg/L on April 17, 2001.

Table 4-3. Fiscal Year 2003 methylene chloride vapor concentration results from Subsurface Disposal Area soil vapor probes.

Probe	Port Depth (ft)	Date Sampled	Sample No.	Laboratory	Methylene Chloride (ppmv)
743-08-VP1	21	5/21/03	IPV27001VT	Southwest Laboratory of Oklahoma	730 J
		8/6/03	IPV28601VT	Southwest Laboratory of Oklahoma	710
743-08-VP2	14	11/20/02	IPV17201VT	Environmental Chemistry Laboratory	550 J
		11/20/02	IPV17202VT	Environmental Chemistry Laboratory	<1 U
		2/18/03	IPV20501VT	Environmental Chemistry Laboratory	420 U
		2/18/03	IPV20502VT	Environmental Chemistry Laboratory	500
DU-10-VP2	11	5/21/03	IPV26601VT	Environmental Chemistry Laboratory	27 J
		8/6/03	IPV28201VT	Environmental Chemistry Laboratory	65 U

4.3.2.2 Soil Gas. No soil gas samples collected in FY 2002 or 2003 from the vadose zone vapor sampling ports were analyzed for methylene chloride. However, of the hundreds of samples collected prior to FY 2002 and analyzed for methylene chloride, only five returned positive detections and the concentrations were relatively low compared to other VOCs (e.g., CCl_4, trichloroethene [TCE], and PCE).

4.3.3 Aquifer

Eighty-eight aquifer samples were collected in FY 2003 from 22 monitoring wells in the vicinity of the RWMC and analyzed for VOCs. Sixty-two of the samples were collected by WAG 7 personnel in November 2002 and February, April/May, and September 2003 from Monitoring Wells A11A31, M1S, M3S, M4D, M6S, M7S, M11S, M12S, M13S, M14S, M15S, M16S, M17S, OW2, and USGS-127. Only one of the 62 samples had detection above the quantitation limit of 1 µg/L. Methylene chloride was reported at 2.8 µg/L in Well M1S in November 2002, but it was also detected in the associated blank.

The USGS personnel collected 26 of the 88 aquifer samples from eight aquifer wells in the vicinity of the RWMC. Samples were collected by the USGS monthly from the RWMC production well and in April and October 2003 from Wells USGS-87, USGS-88, USGS-89, USGS-117, USGS-119, USGS-120, and USGS-127. None of the 26 samples had detection greater than or equal to the minimum reporting level of 0.2 µg/L.

Positive detections of methylene chloride in SDA-vicinity aquifer wells are infrequent. The historical maximum methylene chloride concentration measured was 8 µg/L in Well M10S, collected on July 22, 1996, which is greater than the MCL of 5 µg/L. However, five of the total seven detections historically were during the same sampling round (July 1996), which raises the question whether the samples were cross-contaminated before or during analysis. Except for the sample in M1S in November 2002, which was also detected in the associated blank, methylene chloride has not been detected in any aquifer wells since October 1997.

4.3.4 Summary of Methylene Chloride

Methylene chloride was detected in soil vapor samples taken from vapor probes in the waste zone. The maximum concentration was 710 ppmv. Methylene chloride was not detected in a single perched water sample collected from Well USGS-92 in FY 2003. Soil gas was not analyzed for methylene chloride, and of 88 aquifer samples, methylene chloride was detected only once, but it was also detected in the associated blank.

4.4 Other Organic Contaminants

4.4.1 Waste Zone

Besides CCl_4 and PCE, gas samples collected from vapor probes placed in the waste in Pits 4 and 10 were analyzed for TCE, 1,1,1-trichloroethane (1,1,1-TCA), and chloroform using an INNOVA Model 1314 photoacoustic multigas analyzer. Some of the field duplicate samples also were analyzed using standard laboratory GC/MS (EPA 1999) as an accuracy check on the INNOVA results. The GC/MS analyzed for several other VOCs.

Trichloroethene, 1,1,1-TCA, and chloroform were detected in all of the vapor probes that would yield a vapor sample. Other VOCs detected in the samples analyzed by GC/MS include chloroethane (J-flag), chloromethane, 1,1-dichloroethane, and 1,1,2-trichloro-1,2,2-trifluoroethane (Freon-113). Table 4-4 shows the maximum results for each of the other organics identified in the vapor probes samples.

Table 4-4. Maximum concentrations of trichloroethene, 1,1,1-trichloroethane, chloroform, and Freon-113 detected in soil gas from waste zone vapor probes.

Organic Compound	Sample Date	Well Port	Depth (ft)	Concentration (ppmv)
Trichloroethene	11/18/02	DU-14-VP2	12	10,240
1,1,1-Trichloroethane	11/18/02	DU-08-VP2	16	3793
Chloroform	11/20/02	743-08-VP1	21	22,160
Chloromethane	8/6/03	743-08-VP1	21	950
Freon-113	8/6/03	743-08-VP1	21	180
1,1-Dichloroethane	8/6/03	DU-10-VP2	11	35

No waste zone soil-moisture samples were collected and analyzed for VOCs in FY 2003 because of arid conditions, limited sample volumes, and analytical priorities.

4.4.2 Vadose Zone

4.4.2.1 Perched Water and Lysimeter. Vadose zone soil-moisture samples were not collected and analyzed for VOCs in FY 2003, because of arid conditions, limited sample volumes, and analytical priorities. Lysimeter samples have not been collected and analyzed for VOCs since September 2000.

The USGS personnel collected a single perched water sample from Well USGS-92 on April 11, 2003. The concentrations of other organics besides CCl_4, PCE, and methylene chloride in that sample are shown in Table 4-5.

4.4.2.2 Soil Gas. Trichloroethene, 1,1,1-TCA, and chloroform are the only other VOCs for which analysis is performed on vadose zone soil-gas samples collected at the SDA. All three compounds are ubiquitous in the vicinity of the RWMC, but at much lower concentrations than CCl_4. The complete set of soil-gas data is presented in the *Environmental and Operational Mid-Year Data Report for the OU 7-08 Organic Contamination in the Vadose Zone Project—2003* (Housley 2003) and *Environmental and Operational End-Year Data Report for the OU 7-08 Organic Contamination in the Vadose Zone Project—2003* (Housley 2004).

Table 4-5. Concentrations of other organic compounds detected in a perched water sample from Well USGS-92 in Fiscal Year 2003.

Organic Compound	Fiscal Year 2003 Concentration (μg/L)	Fiscal Year 2002 Concentration for Comparison (μg/L)	Maximum Contaminant Level (μg/L)
Chloroform	256	236	100
1,1,1-Trichloroethane	30	22	200
Trichloroethene	232	198	5

The maximum concentrations detected in FY 2003 both inside and outside the SDA are shown in Table 4-6. The maximum concentrations detected historically both inside and outside the SDA are shown in Table 4-7.

Table 4-6. Maximum concentrations of trichloroethene, 1,1,1-trichloroethane, and chloroform detected in vadose zone soil gas inside and outside the Subsurface Disposal Area in Fiscal Year 2003.

Organic Compound	Inside or Outside the Subsurface Disposal Area	Sample Date	Well Port	Depth (ft)	Concentration (ppmv)
Trichloroethene	Inside	4/1/03	8801-4	78	591
1,1,1-Trichloroethane	Inside	7/8/03	IE7-1	74	187
Chloroform	Inside	7/8/03	8801-4	78	898
Trichloroethene	Outside	4/1/03	1V-1	69	18
1,1,1-Trichloroethane	Outside	9/2/03	77-1-4	111	14
Chloroform	Outside	9/2/03	77-1-4	111	12

Table 4-7. Historic maximum concentrations of trichloroethene, 1,1,1-trichloroethane, and chloroform detected in vadose zone soil gas inside and outside the Subsurface Disposal Area.

Organic Compound	Inside or Outside the Subsurface Disposal Area	Sample Date	Well Port	Depth (ft)	Concentration (ppmv)
Trichloroethene	Inside	5/00	9301-6	77	5,539
1,1,1-Trichloroethane	Inside	1/96	8801-4	78	199
Chloroform	Inside	1/96	8801-4	78	1,160
Trichloroethene	Outside	3/01	VVE10-3	75	28
1,1,1-Trichloroethane	Outside	1/99	M7S-2	448	501
Chloroform	Outside	4/94	VVE10-3	75	25

4.4.3 Aquifer

In addition to CCl_4, PCE, and methylene chloride, RWMC aquifer samples in FY 2003 were analyzed for other VOCs and most were nondetections. Chloroform, TCE, toluene, and 1,1,1-TCA were the only compounds detected at concentrations above the quantitation limit (WAG 7) or minimum reporting level (USGS). All compounds were below the respective MCLs (see Table 4-8).

Table 4-8. Concentration of volatile organic compounds detected in the aquifer in the vicinity of the Radioactive Waste Management Complex in Fiscal Year 2003.

Organic Compound	Sample Date	Well	Sample Concentration (µg/L)	Quantitation Limit or Minimum Reporting Level (µg/L)	MCL (µg/L)
Waste Area Group 7 Monitoring Results					
Chloroform	A11A31	11/05/02	1.1	1.0	100
Chloroform	A11A31	02/03/03	1	1.0	100
Chloroform	A11A31	04/30/03	1	1.0	100
Chloroform	A11A31	08/04/03	1	1.0	100
Trichloroethene	A11A31	11/05/02	2.3	1.0	5
Trichloroethene	M16S	11/11/02	1.9	1.0	5
Trichloroethene	M7S	11/12/02	2	1.0	5
Trichloroethene	A11A31	02/03/03	2	1.0	5
Trichloroethene	M7S	02/03/03	2	1.0	5
Trichloroethene	M16S	02/04/03	2	1.0	5
Trichloroethene	M7S	04/29/03	2	1.0	5
Trichloroethene	A11A31	04/30/03	3	1.0	5
Trichloroethene	M16S	04/30/03	2	1.0	5
Trichloroethene	A11A31	08/04/03	2	1.0	5
Trichloroethene	M16S	08/04/03	2	1.0	5
Trichloroethene	M7S	08/05/03	3	1.0	5
Trichloroethene	A11A31	11/05/02	2.3	1.0	5
Trichloroethene	M16S	11/11/02	1.9	1.0	5
Trichloroethene	M7S	11/12/02	2	1.0	5
Trichloroethene	A11A31	02/03/03	2	1.0	5
Trichloroethene	M7S	02/03/03	2	1.0	5
Trichloroethene	M16S	02/04/03	2	1.0	5
Toluene	A11A31	02/03/03	29	1.0	1,000
Toluene	M7S	02/03/03	2	1.0	1,000
Toluene	M7S	04/29/03	7	1.0	1,000
Toluene	A11A31	04/30/03	47	1.0	1,000
Toluene	A11A31	08/04/03	2	1.0	1,000
Toluene	M7S	08/05/03	5	1.0	1,000
Toluene	A11A31	02/03/03	29	1.0	1,000
Toluene	M7S	02/03/03	2	1.0	1,000
United States Geological Survey Monitoring Results					
Chloroform	RWMC	10/10/02	0.9	0.2	100
Chloroform	RWMC	11/14/02	1.7	0.2	100
Chloroform	RWMC	12/12/02	1	0.2	100
Chloroform	RWMC	1/9/03	1.3	0.2	100
Chloroform	RWMC	2/13/03	0.9	0.2	100
Chloroform	RWMC	3/13/03	0.9	0.2	100
Chloroform	RWMC	4/10/03	1.1	0.2	100
Chloroform	RWMC	5/15/03	1.1	0.2	100
Chloroform	RWMC	6/12/03	1.1	0.2	100
Chloroform	RWMC	7/10/03	1.2	0.2	100
Chloroform	RWMC	8/14/03	1.3	0.2	100

Table 4-8. (continued).

Organic Compound	Sample Date	Well	Sample Concentration (µg/L)	Quantitation Limit or Minimum Reporting Level (µg/L)	MCL (µg/L)
Chloroform	RWMC	9/10/03	0.8	0.2	100
Chloroform	USGS-87	10/10/02	0.1	0.2	100
Chloroform	USGS-87	4/10/03	0.2	0.2	100
Chloroform	USGS-88	10/1/02	0.4	0.2	100
Chloroform	USGS-88	4/2/03	0.4	0.2	100
Chloroform	USGS-120	10/10/02	0.6	0.2	100
Chloroform	USGS-120	4/10/03	0.5	0.2	100
1,1,1-TCA	RWMC	10/10/02	0.4	0.2	200
1,1,1-TCA	RWMC	11/14/02	0.5	0.2	200
1,1,1-TCA	RWMC	12/12/02	0.5	0.2	200
1,1,1-TCA	RWMC	1/9/03	0.5	0.2	200
1,1,1-TCA	RWMC	2/13/03	0.4	0.2	200
1,1,1-TCA	RWMC	3/13/03	0.4	0.2	200
1,1,1-TCA	RWMC	4/10/03	0.5	0.2	200
1,1,1-TCA	RWMC	5/15/03	0.5	0.2	200
1,1,1-TCA	RWMC	6/12/03	0.5	0.2	200
1,1,1-TCA	RWMC	7/10/03	0.6	0.2	200
1,1,1-TCA	RWMC	8/14/03	0.5	0.2	200
1,1,1-TCA	RWMC	9/10/03	0.4	0.2	200
1,1,1-TCA	USGS-87	10/10/02	0.2	0.2	200
1,1,1-TCA	USGS-87	4/10/03	0.2	0.2	200
1,1,1-TCA	USGS-120	10/10/02	0.3	0.2	200
1,1,1-TCA	USGS-120	4/10/03	0.2	0.2	200
Trichloroethene	RWMC	10/10/02	2.1	0.2	5
Trichloroethene	RWMC	11/14/02	2.2	0.2	5
Trichloroethene	RWMC	12/12/02	2.4	0.2	5
Trichloroethene	RWMC	1/9/03	2.4	0.2	5
Trichloroethene	RWMC	2/13/03	2.1	0.2	5
Trichloroethene	RWMC	3/13/03	2.3	0.2	5
Trichloroethene	RWMC	4/10/03	2.6	0.2	5
Trichloroethene	RWMC	5/15/03	2.7	0.2	5
Trichloroethene	RWMC	6/12/03	2.4	0.2	5
Trichloroethene	RWMC	7/10/03	2.7	0.2	5
Trichloroethene	RWMC	8/14/03	2.8	0.2	5
Trichloroethene	RWMC	9/10/03	1.8	0.2	5
Trichloroethene	USGS-87	10/10/02	0.7	0.2	5
Trichloroethene	USGS-87	4/10/03	0.7	0.2	5
Trichloroethene	USGS-88	10/1/02	0.6	0.2	5
Trichloroethene	USGS-88	4/2/03	0.6	0.2	5
Trichloroethene	USGS-120	10/10/02	1.1	0.2	5
Trichloroethene	USGS-120	4/10/03	0.9	0.2	5

MCL = maximum contaminant level
RWMC = Radioactive Waste Management Complex
1,1,1-TCA = 1,1,1-trichloroethane
USGS = United Stated Geological Survey

Chloroform was detected in Wells A11A31, RWMC, USGS-87, USGS-88, USGS-120, and the maximum concentration was 1.7 μg/L. Trichloroethene was detected in Wells M7S, M16S, AllA31, RWMC, USGS-87, USGS-88, and USGS-120, and the maximum concentration was 3. 1,1,1-Trichloroethane was detected in the RWMC production well and Wells USGS-87 and USGS-120. The maximum 1,1,1-trichloroethane concentration was 0.6 μg/L. Toluene was detected consistently in Wells M7S and A11A31, and the maximum concentration was 47 μg/L. Samples were analyzed for 54 other organic compounds, but none were detected above the quantitation limit (WAG 7) or minimum reporting level (USGS).

4.4.4 Summary

Other organics detected during sampling at the RWMC include TCE, 1,1,1-TCA, chloroform, Freon-113, 1,1-dichloroethane, chloromethane, and toluene. All organics, except for toluene, were detected in waste zone soil gas. The concentrations of chloroform and TCE were down slightly from FY 2002 values.

A single perched water sample contained TCE, 1,1,1-TCA, and chloroform. These concentrations are appreciably less than before operation of the OCVZ VVET system began in 1996. During aquifer monitoring in FY 2003, only four other organic compounds (i.e., TCE, 1,1,1-TCA, chloroform, and toluene) were detected in 88 samples. All sample results were below MCLs. Toluene had the highest concentration (47 μg/L) in Well A11A31, followed by TCE (3 μg/L) in Wells A11A31 and M7S. The maximum chloroform concentration was 1.7 μg/L, and the maximum 1,1,1-TCA concentration was 0.6 μg/L, both in the RWMC production well.

Detections of TCE and 1,1,1-TCA are not surprising, because those were components of Series 743 sludge. Chloroform detections also are not surprising, because it is likely being produced by degradation of the CCl_4. Detections of the other organics like Freon-113, 1,1-dichloroethane (soil gas), and toluene (groundwater) are low-level detections and will continue to be monitored.

5. INORGANIC CONTAMINANTS

Numerous anion and metal analyses results were significantly above soil-moisture (lysimeter) background concentrations in FY 2003, and a few results exceeded MCLs. None of the perched water sample results exceeded the MCL of 10 mg/L; however, a few analytes in the aquifer exceeded MCLs. Nitrates, which are discussed in Section 5.1, are one of the COCs for OU 7-13/14. Other inorganic contaminants are described in Section 5.2.

5.1 Nitrates

5.1.1 Waste Zone

No waste zone soil-moisture samples were collected and analyzed for nitrates in FY 2003.

5.1.2 Vadose Zone

5.1.2.1 ***Lysimeter Samples at Depths of 0 to 35 ft.*** Eighteen nitrate (as nitrogen) analyses were performed on samples collected from 14 lysimeter wells in and around the SDA in FY 2003, with 15 detections above local soil-moisture background (see Table 5-1). Of the 15 detections, eight exceeded the drinking water MCL of 10 mg/L. The primary drinking water MCL is not applicable to soil-moisture samples, but it is used as a basis for comparison.

Nitrate concentrations in the shallow region of the vadose zone show wide variations, ranging from 0.4 mg/L in Well W23 to 91 mg/L in Well PA02. Background levels of nitrate in the vadose zone outside the SDA typically range from 0.1 to 6 mg/L. Water from Well W-08 exceeded the MCL of 10 mg/L, but the level has been stable since monitoring began in the mid-1990s. The highest nitrate concentrations were measured in Well PA02, which is adjacent to Pad A where nitrate-laden waste is disposed of. Nitrate concentrations have been fairly stable in this well at about 45–55 mg/L; however, data from the last two samples indicate increases above this baseline level (see Figure 5-1). Nitrates in this location appear to have migrated to a depth of about 100 ft, as nitrate concentrations at this 100-ft depth also are above background (see results of Lysimeter I4S-DL11 in Table 5-2). Another area where elevated nitrate levels are measured is west of Pit 4 in two adjacent wells (i.e., 98-4 and W-25). Data have indicated a gradual upward trend in nitrate in Well W-25 since 1997 (see Figure 5-1).

5.1.2.2 ***Lysimeter Samples at Depths of 35 to 140 ft.*** Twenty-two nitrate (as nitrogen) analyses were performed on samples collected from 13 lysimeter wells in and around the SDA in FY 2003, with nine detections above local soil-moisture background (see Table 5-2). Of the nine detections, six exceeded the drinking water MCL. The primary drinking water MCL is not applicable to soil-moisture samples, but is used as a basis for comparison. Nitrate concentrations in the intermediate vadose zone also show wide variations, ranging from 0.3 mg/L in Well O2S to 110 mg/L in Well I2S. Wells completed in this depth interval around Pad A (i.e., D06, TW1, and I4S) generally have nitrate concentrations in the range of 12–15 mg/L. Nitrate concentrations in Well I4S show nitrate contamination has migrated to about the 100-ft depth around Pad A. This lysimeter well is located in the same vicinity as the high and trending nitrate concentrations observed in PA02. Well I2S has the highest nitrate concentration observed in the 35–140-ft depth interval, and the concentration is increasing a fairly significant rate (see Figure 5-1).

Table 5-1. Positive detections of nitrate concentrations above local soil-moisture background in the 0- to 35-ft depth interval of the Subsurface Disposal Area vadose zone soil moisture (lysimeter).

Lysimeter	Depth (ft)	Sample Date	Analyte	Sample Result (mg/L)	Local Soil-Moisture Background[a] (mg/L)	MCL[b] (mg/L)
98-1L35	16.5	04/30/03	Nitrate-N	**10**[c]	6.0	10
98-4L38	17.0	04/30/03	Nitrate-N	**43**[d]	6.0	10
98-5L39	10.5	04/30/03	Nitrate-N	**7.8**[c]	6.0	10
D15-DL07	32	05/01/03	Nitrate-N	**27**[d]	6.0	10
PA01-L15	14.3	04/30/03	Nitrate-N	**9.2**[c]	6.0	10
PA02-L16	8.7	04/30/03	Nitrate-N	**89**[d]	6.0	10
W05-L24	16	04/29/03	Nitrate-N	**7**[c]	6.0	10
W08-L13	11.3	04/30/03	Nitrate-N	**36**[d]	6.0	10
W08-L14	6.2	04/29/03	Nitrate-N	**13**[d]	6.0	10
W09-L23	14.8	04/30/03	Nitrate-N	**8.4**[c]	6.0	10
W23-L09	7.7	04/28/03	Nitrate-N	**6.8**[c]	6.0	10
W25-L28	15.5	04/30/03	Nitrate-N	**32**[d]	6.0	10
PA01-L15	14.3	7/21/03	Nitrate-N	**9.3_{J}**[c,c]	6.0	10
PA02-L16	8.7	7/21/03	Nitrate-N	**91_{J}**[d,c]	6.0	10
W23-L09	7.7	7/21/03	Nitrate-N	**8.4_{J}**[d,c]	6.0	10

a. Local soil-moisture background values are the upper concentration ranges obtained from up to 30 soil-moisture samples collected between 1997 and 2003 from the D15 and O-series lysimeter wells located outside of the SDA.

b. The MCLs are from the "National Primary Drinking Water Regulations" (40 CFR 141) established by the U.S. Environmental Protection Agency. The MCLs for vadose zone water samples are applicable to perched water, but not to soil-moisture (lysimeter) samples. The MCLs for lysimeter sample results are provided here only as a basis of comparison.

c. **Black bold font** indicates sample concentrations less than the MCL, but exceeding local soil-moisture background concentrations (see footnote a).

d. **Red bold font** indicates sample concentrations that exceed the MCL (see footnote b).

e. Concentration values with a "J" subscript denote that "J" data validation qualifier flags were assigned. The "J" flags were assigned to the results because of high matrix spike recoveries. The results are usable, but should only be used as estimated quantities.

CFR = *Code of Federal Regulations*
MCL = maximum contaminant level
SDA = Subsurface Disposal Area

Table 5-2. Positive detections of nitrate concentrations above local soil-moisture background in the 35-to 140-ft depth interval of the Subsurface Disposal Area vadose zone soil moisture (lysimeter).

Lysimeter	Depth (ft)	Sample Date	Analyte	Sample Result (mg/L)	Local Soil-Moisture Background[a] (mg/L)	MCL[b] (mg/L)
D06-DL01	88	04/29/03	Nitrate-N	**8.9**[c]	5.3	10
D06-DL02	44	04/29/03	Nitrate-N	14[e]	5.3	10
I1S-DL09	101	04/29/03	Nitrate-N	**6.5**[c]	5.3	10
I2S-DL11	92	04/29/03	Nitrate-N	**97**[e]	5.3	10
I4S-DL15	97	04/29/03	Nitrate-N	**14**[e]	5.3	10
TW1-DL04	102	04/28/03	Nitrate-N	12[e]	5.3	10
I1S:DL09	101	7/22/03	Nitrate-N	10[c]	5.3	10
I2S:DL11	92	7/21/03	Nitrate-N	**110_J**[d,e]	5.3	10
I4S:DL15	97	7/21/03	Nitrate-N	**15_J**[d,e]	5.3	10

a. Local soil-moisture background values are the upper concentration ranges obtained from up to 30 soil-moisture samples collected between 1997 and 2003 from the D15 and O-series lysimeter wells located outside of the SDA.

b. The MCLs are from the "National Primary Drinking Water Regulations" (40 CFR 141) established by the U.S. Environmental Protection Agency. The MCLs for vadose zone water samples are applicable to perched water, but not to soil-moisture (lysimeter) samples. The MCLs for lysimeter sample results are provided here only as a basis of comparison.

c. **Black bold font** indicates sample concentrations less than the MCL, but exceeding local soil-moisture background concentrations (see footnote a).

d. **Red bold font** indicates sample concentrations that exceed the MCL (see footnote b).

e. Concentration values with a "J" subscript denote that "J" data validation qualifier flags were assigned. The "J" flags were assigned to the results because of high matrix spike recoveries. The results are usable, but should only be used as estimated quantities.

CFR = *Code of Federal Regulations*

MCL = maximum contaminant level

SDA = Subsurface Disposal Area

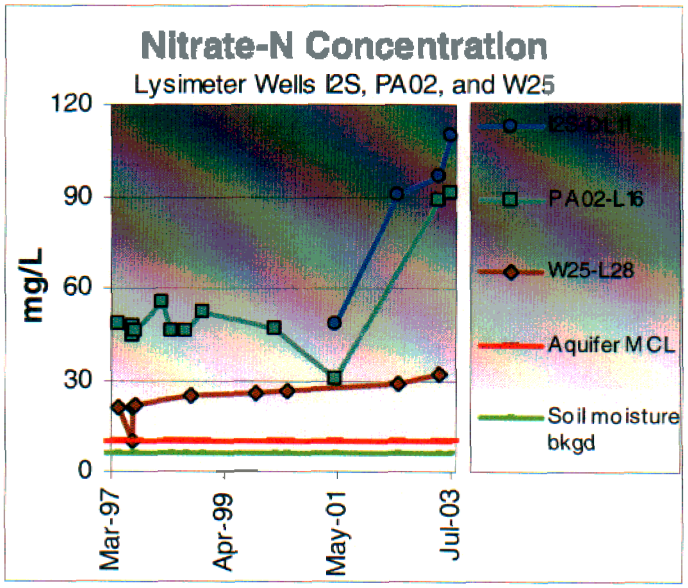


Figure 5-1. Lysimeters in the Subsurface Disposal Area vadose zone exhibiting concentration trends.

5.1.2.3 *Lysimeter Samples at Depths of 140 to 250 ft.* Ten nitrate (as nitrogen) analyses were performed on samples collected from six lysimeter and two perched water wells in and around the SDA in FY 2003, with one detection above local soil-moisture background (see Table 5-3). The concentration did not exceed the drinking water MCL. The primary drinking water MCL is not applicable to soil-moisture samples, but is used as a basis for comparison. Nitrate concentrations detected in the deep vadose zone are near background levels and indicate much less variation than do nitrate concentrations in the shallow and intermediate vadose zone. Nitrate concentrations in this depth interval range from 0.13 to 7.7 mg/L. It should be noted that the concentration of 7.7 mg/L is associated with Well I2D and is located in the same vicinity as Well I2S, which shows a nitrate trend.

Table 5-3. Positive detections of nitrate concentrations above local soil-moisture background in the 140- to 250-ft depth interval of the Subsurface Disposal Area vadose zone soil moisture (lysimeter).

Lysimeter	Depth (ft)	Sample Date	Analyte	Sample Result (mg/L)	Local Soil-Moisture Background[a] (mg/L)	MCL[b] (mg/L)
I2D-DL10	196	04/29/03	Nitrate-N	**7.7**[c]	5.3	10

a. Local soil-moisture background values are the upper concentration ranges obtained from up to 30 soil-moisture samples collected between 1997 and 2003 from the D15 and O-series lysimeter wells located outside of the SDA.
b. The MCLs are from the "National Primary Drinking Water Regulations" (40 CFR 141) established by the U.S. Environmental Protection Agency. The MCLs for vadose zone water samples are applicable to perched water, but not to soil-moisture (lysimeter) samples. The MCLs for lysimeter sample results are provided here only as a basis of comparison.
c. **Black bold font** indicates sample concentrations less than the MCL, but exceeding local soil-moisture background concentrations (see footnote a).
CFR = *Code of Federal Regulations*
MCL = maximum contaminant level
SDA = Subsurface Disposal Area

5.1.3 Aquifer

Sixty-two nitrate (as nitrogen) analyses were performed on samples collected from 15 RWMC monitoring wells around the RWMC in FY 2003, with three detections slightly above the SRPA background concentration of 1 to 2 mg/L established by Knobel, Orr, and Cecil (1992). Samples were collected in November 2002 and February, April, May, and August 2003 from Monitoring Wells AllA31, M1S, M3S, M4D, M6S, M7S, M11S, M12S, M13S, M14S, M15S, M16S, M17S, OW2, and USGS-127. Low levels of nitrates were detected in all RWMC aquifer samples at concentrations characteristic of SRPA background levels, except for Well M6S. Nitrate concentrations in FY 2003 ranged from 0.4 mg/L in Well M13S to 3.4 mg/L in M6S. All results were below the primary drinking water MCL of 10 mg/L. The nitrate concentrations above aquifer background were collected from Monitoring Well M6S. Nitrate levels from Aquifer Well M6S continue to exhibit an increasing trend that appears to be stabilizing at concentrations near the SRPA background (see Figure 5-2). The results above background are summarized in Table 5-4.

5.1.4 Summary of Nitrates

Low levels of nitrates were detected in all aquifer-monitoring wells in the vicinity of the RWMC in FY 2003 at concentrations characteristic of background levels typically found in the SRPA, with the exception of Well M6S. Nitrate concentrations in Well M6S are slightly above SRPA background and have a long-term trend that appears to be stabilizing at concentrations near the SRPA background level (see Figure 5-2).

Table 5-4. Nitrate (as nitrogen) aquifer concentrations detected above background at the Radioactive Waste Management Complex in Fiscal Year 2003.

Well	Sample Date	Sample Result (mg/L)	Aquifer Background[a] (mg/L)	Maximum Contaminant Level[b] (mg/L)
M6S	11/11/02	**3.4**[c]	1–2	10
M6S	04/28/03	**2.1**[c]	1–2	10
M6S	8/4/2003	**2.1**[c]	1–2	10

a. The USGS established SRPA background levels in 1992 from samples collected upgradient (i.e., Mud Lake area) and downgradient (i.e., Magic Valley area) of the INEEL (Knobel, Orr, and Cecil 1992).
b. The MCL is from the "National Primary Drinking Water Regulations" (40 CFR 141) established by the U.S. Environmental Protection Agency.
c. **Black bold font** indicates sample concentrations less than the MCL, but exceeding SRPA background concentrations (see footnote a).
CFR = *Code of Federal Regulations*
INEEL = Idaho National Engineering and Environmental Laboratory
MCL = maximum contaminant level
SRPA = Snake River Plain Aquifer
USGS = United Stated Geological Survey

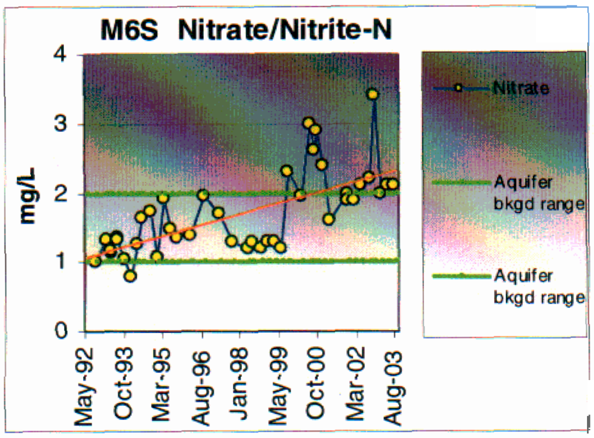


Figure 5-2. Concentration of nitrates (as nitrogen) in Radioactive Waste Management Complex Aquifer Monitoring Well M6S from 1992 to August 2003.

Of the 50 vadose zone soil-moisture and perched water samples collected and analyzed for nitrates in FY 2003, 25 results were above background levels and 14 of those 25 exceeded the primary drinking water MCL. Significant concentration trends were associated with Lysimeters PA02-L16 and I2S-DL11, providing evidence that nitrates have migrated to about 100 ft in the vadose zone. Nitrate concentrations are highest in the 0- to 35-ft and 35- to 140-ft regions of the vadose zone and most prevalent in lysimeter wells located around the Pit 5 and Pad A area (i.e., Wells D06, I4S, PA01, PA02, and TW1), the west end of the SDA (i.e., Wells I2S, W23, and 98-5), the east end of Pit 4 (i.e., Wells 98-4 and W25), and the acid pit (Well W08).

5.2 Other Inorganic Contaminants

Numerous anions and metals analysis results were above background in samples collected from RWMC aquifer-monitoring wells and vadose zone soil moisture in FY 2003. Many of these anions and metals have high concentrations that exceed aquifer MCLs. Anion and metal contaminants detected in the vadose zone have relatively high concentrations, and many are attributed to dust-suppression activities at the SDA up to 20 years ago. In 1984, 1985, 1992, and 1993, magnesium chloride brine was applied to roads in the SDA to suppress dust. The chemical constituents of the brine are now widely distributed in the vadose zone at the SDA, and most of the elevated concentrations of cations and anions can be related to the brine application. The primary anion in brine is chloride, but bromide and sulfate also are present at high concentrations. Magnesium from the brine exchanges for cations on clay minerals; therefore, elevated calcium, sodium, potassium, and magnesium are related to the brine application. Lysimeter and aquifer results for other inorganic contaminants are addressed in the following sections.

5.2.1 Vadose Zone

In FY 2003, lysimeter wells with evidence of brine contamination were consistent with wells where brine was previously identified (Hull and Bishop 2003), namely 8802D, 98-1, 98-4, 98-5, D06, LYS-1, I1S, I4S, I4D, O-4S, PA01, PA02, TW1, W05, and W23. Wells 98-1, LYS-1, and PA02 have the highest measured chloride concentrations in the shallow vadose zone with up to 11,000 mg/L. Wells 98-1 and LYS-1 are located in the southeast corner of the SDA, and PA02 is located adjacent to Pad A. In the intermediate vadose zone, chloride levels have reached 5,300 mg/L in Well I1S. Two wells in the deep region of the vadose zone, 8802D and I4D, show chloride levels about 800 mg/L, which are slightly above soil-moisture background. Evidence indicates that brine has migrated to a depth of 240 ft at the SDA. Elevated concentrations of anions and cations associated with brine contamination are not reported in Table 5-5, because they are not contaminants of concern and detract from emphasizing important waste constituents that are migrating.

Metals that are not associated with brine appear in a few samples at concentrations above local soil-moisture backgrounds (see Table 5-5). These elevated concentrations may be sampling artifacts, natural elevated concentrations, or related to contaminant migration. Based on the association of metals and the similarities and differences in the geochemistry of the metals, an evaluation can be made as to which possibility is most likely.

Selenium is frequently detected in numerous lysimeter samples at concentrations near the MCL, although one well (D15_DL07) exceeded the MCL. The source of the low-level selenium has yet to be identified, but an evaluation is ongoing.

Aluminum and iron are elevated in the sample from Well USGS-92, which is sampled by bailing. When the bailer is lowered to the bottom of the well, the sediment in the well is disturbed and becomes suspended in the water sample. These suspended solids then become part of the water sample brought to the surface in the bailer. Both aluminum and iron are common elements in sedimentary interbed minerals and are likely from suspended solids as artifacts of the sampling process.

Elevated concentrations of chromium, iron, and nickel were found in the lysimeter sample from Well O7-DL28. Nickel and chromium are not abundant rock-forming elements, and other rock-forming species (e.g., aluminum) are low in this sample; therefore, the metals in Lysimeter O7-DL28 do not appear to be suspended solids from natural rock materials. The geochemical behavior of iron, chromium, and nickel are very different. Iron is higher in solubility at low redox potential, chromium is higher in solubility at high redox potential, and nickel is not affected by redox potential. Therefore, the metals do not appear to be related to geochemical conditions in the vadose zone. The ratio of iron to chromium to nickel in this water sample is typical of the ratio of the same metals in stainless steel. Conjecture is that elevated metals in the sample from Lysimeter O7-DL28 are likely the result of stainless steel from lysimeter materials suspended in the sample that were dissolved during sample digestion.

Table 5-5. Positive detections of anions and metals above local soil-moisture background in Subsurface Disposal Area vadose zone soil-moisture (lysimeter) samples, excluding brine contaminants.

Lysimeter	Depth (ft)	Sample Date	Analyte	Sample Result (mg/L)	Local Soil-Moisture Background[a] (mg/L)	MCL[b] (mg/L)
D06-DL01	88	04/29/03	Selenium	**0.04**[c]	0.014	0.05
			Zinc	**0.61**[c]	0.47	NA
		07/15/03	Selenium	**0.034**[c]	0.014	0.05
D06-DL02	44	04/29/03	Selenium	**0.05**[c]	0.014	0.05
			Zinc	**2.4**[c]	0.47	NA
D15-DL07	32	05/01/03	Selenium	**0.09**[d]	0.014	0.05
I2D-DL10	196	04/29/03	Iron	**0.97**[c]	0.20	NA
			Selenium	**0.05**[c]	0.014	0.05
O7-DL27	240	05/01/03	Chromium	**1.3**[d]	0.013	0.10
			Iron	**22**[d]	0.20	NA
			Nickel	**12**[d]	0.71	0.10
O7-DL28	119	07/23/03	Selenium	**0.018**[c]	0.014	0.05
PA01-L15	14.3	04/30/03	Fluoride	**5.7**[d]	1.2	4.0
			Selenium	**0.05**[c]	0.014	0.05
		07/21/03	Fluoride	**5.6**$_J$[d,e]	1.2	4.0
			Selenium	**0.042**[c]	0.014	0.05
USGS-92	214	05/01/03	Aluminum	**11**[c]	0.14	NA
			Iron	**11**[c]	0.20	NA
W23-L09	7.7	04/28/03	Selenium	**0.02**[c]	0.014	0.05
		07/21/03	Fluoride	**1.7**$_J$[c,e]	1.2	4.0

a. Local soil-moisture background values are the upper concentration ranges obtained from up to 49 soil-moisture samples collected between 1987 and 2003 from the C01, C02, D15, and O-series lysimeter wells located outside of the SDA.
b. The MCLs are from the "National Primary Drinking Water Regulations" (40 CFR 141) established by the U.S. Environmental Protection Agency. The MCLs for vadose zone water samples are applicable to perched water, but not to soil-moisture (lysimeter) samples. The MCLs for lysimeter sample results are provided here only as a basis of comparison.
c. **Black bold font** indicates sample concentrations less than the MCL, but exceeding local soil-moisture background concentrations (see footnote a).
d. **Red bold font** indicates sample concentrations that exceed the MCL (see footnote b).
e. Concentration values with a "J" subscript denote that "J" data validation qualifier flags were assigned. The "J" flags were assigned to the results because of high matrix spike recoveries. The results are usable, but should only be used as estimated quantities.
CFR = *Code of Federal Regulations*
MCL = maximum contaminant level
SDA = Subsurface Disposal Area

5.2.2 Aquifer

Several anions and metals have been detected in concentrations greater than aquifer background values in FY 2003, and a few exceeded drinking water MCLs (see Table 5-5). Antimony and lead analysis results of samples from Well A11A31 exceeded MCLs. Historically lead has been detected sporadically in this well; however, the frequency of lead detections increased in FY 2003. Lead is likely associated with corrosion of the well casing, which is constructed of galvanized steel. Corrosion of the galvanized steel casing also explains why concentrations of aluminum, iron, and zinc also are elevated in this well, as they are all components of galvanized steel. Antimony was detected above the MCL in February 2003, and all previous and subsequent analysis results have been nondetections. Table 5-6 lists anions and metals detected in concentrations that exceed background values or MCLs.

Table 5-6. Anions and metals concentrations in excess of aquifer background levels or maximum contaminant levels.

Well	Sample Date	Analyte	Sample Result[a] (µg/L)	Aquifer Background Range (µg/L)	MCL[b] (µg/L)
M1S	11/05/02	Aluminum	**1,[redacted]**[c,d]	<10–10[e]	—
		Chromium	**70**	1–22[e]	100
		Copper	**15_J**[c,d]	<10[e]	1,300
		Iron	**970**[c]	4–85[e]	—
		Nickel	**27**[c]	<10[e]	100
	02/05/03	Chromium	**34**[c]	1–22[e]	100
	05/06/03	Chromium	**33_U**[c,d]	1–22[e]	100
	08/06/03	Chromium	**32**[c]	1–22[e]	100
			31[c] **filtered**	1–22[e]	100
		Vanadium	**15**[c]	<6–14[e]	—
			15[c] **filtered**	<6–14[e]	—
M3S	08/06/03	Calcium	**48,000**[c]	35,000–46,000[e]	—
			48,000[c] **filtered**	35,000–46,000[e]	—
M4D	11/12/02	Arsenic	**6.8**[c]	1–5[f]	10
		Potassium	**22,000**[c]	1,000–6,000[e]	—
	02/03/03	Arsenic	**6.2**[c]	1–5[f]	10
		Potassium	**23,000**[c]	1,000–6,000[e]	—
		Sodium	**43,000**[c]	5,400–28,000[e]	—
	05/05/03	Aluminum	**20**[c]	<10–10[e]	—
		Potassium	**22,000**[c]	1,000–6,000[e]	—
		Sodium	**42,000**[c]	5,400–28,000[e]	—
	08/05/03	Arsenic	**6.6**[c]	1–5[f]	50
			7.2[c] **filtered**	1–5[f]	50
		Fluoride	**810**[c]	100–500[f]	4,000
		Potassium	**22,000**[c]	1,000–6,000[e]	—
		Sodium	**41,000**[c]	5,400–28,000[e]	—
			41,000[c] **filtered**	5,400–28,000[e]	—
M6S	11/11/02	Chromium	**37**[c]	1–22[e]	100
		Iron	**$4{,}500_J$**[c,d]	4–85[e]	—
		Nickel	**15**[c]	<10[e]	100
	02/03/03	Chromium	**32**[c]	1–22[e]	100
		Iron	**1,500**[c]	4–85[e]	—
		Nickel	**12**[c]	<10[e]	100
	04/28/03	Aluminum	**91**[c]	<10–10[e]	—
		Chloride	**25,200**[c]	8,000–20,000[e]	
		Chromium	**36_U**[c,d]	1–22[e]	100
		Iron	**3,200**[c]	4–85[e]	—

Table 5-6. (continued).

Well	Sample Date	Analyte	Sample Result[a] (µg/L)	Aquifer Background Range (µg/L)	MCL[b] (µg/L)
		Nickel	**12[c]**	<10[e]	100
		Sulfate	**65,400[c]**	23,000–30,000[e]	—
	08/04/03	Chloride	**29,000[c]**	8,000–20,000[e]	—
		Chromium	**36[c]**	1–22[e]	100
			30[c] filtered	1–22[e]	100
		Iron	**3,800[c]**	4–85[e]	—
		Nickel	**11[c]**	<10[e]	100
		Selenium	**3.7[c]**	<1[f]	50
			4.5[c] filtered	<1[f]	50
		Sulfate	**71,000[c]**	23,000–30,000[e]	—
M11S	11/12/02	Chromium	**30[c]**	1–22[e]	100
		Nickel	**51[c]**	<10[e]	100
	08/04/03	Chloride	**32,000[c]**	8,000–20,000[e]	—
		Chromium	**27[c]**	1–22[e]	100
			6.7_J[b] filtered	1–22[e]	100
		Iron	**180[c]**	4–85[e]	—
		Nickel	**73[c]**	<10[e]	100
			75[c] filtered	<10[e]	100
M12S	02/03/03	Aluminum	**25**	<10–10[e]	—
		Chromium	**26[c]**	1–22[e]	100
		Iron	**700[c]**	4–85[e]	—
		Lead	**8.6**	<5[f]	15
	04/29/03	Aluminum	**57[c]**	<10–10[e]	—
		Iron	**260[c]**	4–85[e]	—
	08/04/03	Iron	**110[c]**	4–85[e]	—
M13S	11/12/02	Vanadium	**15[c]**	<6–14[e]	—
	02/03/03	Vanadium	**15[c]**	<6–14[e]	—
	08/04/03	Vanadium	**15[c]**	<6–14[e]	—
M14S	11/05/02	Aluminum	**$2{,}800_J$[c]**	<10–40[e]	—
		Chromium	**34[c]**	1–22[e]	100
		Iron	**3,200[c]**	4–85[e]	—
		Manganese	**52[c]**	<1–15[e]	—
		Nickel	**18**	<10[e]	100
	02/03/03	Aluminum	**180[c]**	<10–10[d]	—
			99[c] duplicate	<10–10[d]	—
	04/28/03	Aluminum	**300[c]**	≤10–10[e]	—
		Iron	**600[c]**	4–85[e]	—
	08/05/03	Calcium	**47,000[c]**	35,000–46,000[e]	—
			47,000[c] filtered	35,000–46,000[e]	—

Table 5-6. (continued).

Well	Sample Date	Analyte	Sample Result^{a} (μg/L)	Aquifer Background Range (μg/L)	MCL^{b} (μg/L)
		Iron	**280^{c}**	4–85^{d}	—
M15S	11/06/02	Chromium	**35^{c}**	1–22^{e}	100
	02/03/03	Chromium	**29^{c}**	1–22^{e}	100
	05/06/03	Chloride	**35.1^{c}**	8,000–20,000^{e}	—
			35.2^{c} duplicate	8,000–20,000^{e}	—
		Chromium	**32$_{U}^{c,g}$**	1–22^{e}	100
			duplicate	1–22^{e}	
		Sulfate	**36.9^{c,d}**	23,000–30,000^{e}	—
			37.6^{c,d}	23,000–30,000^{e}	—
	08/05/03	Chloride	**41,000^{c}**	8,000–20,000^{e}	—
			40,000^{c} duplicate	8,000–20,000^{e}	—
		Chromium	**33^{c}**	1–22^{e}	100
			27^{c} filtered	1–22^{e}	100
		Chromium duplicate	**34^{c}**	1–22^{e}	100
			27^{c} filtered	1–22^{e}	100
		Iron	**120^{c}**	4–85^{e}	—
			120^{c} duplicate	4–85^{e}	—
		Sulfate	**36,000^{c}**	23,000–30,000^{e}	—
			36,000^{c} duplicate	23,000–30,000^{e}	—
M17S	11/06/02	Aluminum	**560$_{J}^{c,d}$**	<10–40^{e}	—
		Iron	**540^{c}**	4–85^{e}	—
	02/04/03	Aluminum	**65^{c}**	<10–10^{e}	—
	05/07/03	Iron	**210^{c}**	4–85^{e}	—
	08/06/03	Iron	**280^{c}**	4–85^{e}	—
OW-2	05/05/03	Sulfate	**38,600^{c}**	23,000–30,000^{e}	—
	08/05/03	Iron	**200^{c}**	4–85^{e}	—
		Sulfate	**36,000^{c}**	23,000–30,000^{e}	—
USGS-127	11/11/02	Iron	**830$_{J}^{c,d}$**	4–85^{e}	—
	02/04/03	Aluminum	**31^{c}**	<10–10^{e}	—
		Iron	**240^{c}**	4–85^{e}	—
	05/05/03	Aluminum	**60^{c}**	<10–10^{e}	—
		Iron	**260^{c}**	4–85^{e}	—
	08/04/03	Iron	**360^{c}**	4–85^{e}	—
A11A31	11/05/02	Potassium	**6,100^{c}**	1,000–6,000^{e}	—
		Sodium	**39,000^{c}**	5,400–28,000^{e}	—
		Zinc	**290$_{J}^{d,i}$**	3–210^{e}	—

Table 5-6. (continued).

Well	Sample Date	Analyte	Sample Result[a] (µg/L)	Aquifer Background Range (µg/L)	MCL[b] (µg/L)
	02/03/03	Aluminum	**700**[c,i]	<10–10[e]	—
		Antimony	**6.7**[h]	—	6
		Chromium	**25**[c]	1–22[e]	100
		Iron	**1,300**[c,i]	4–85[e]	—
		Lead	**66**[h,i]	<5[f]	15
		Manganese	**26**[c]	<1–15[e]	—
		Sodium	**39,000**[c]	5,400–28,000	—
		Zinc	**4,700**[c,i]	3–210[e]	—
	04/30/03	Aluminum	**310**[c,i]	<10–10[e]	—
		Chloride	**35,400**[c]	8,000–20,000[e]	—
		Iron	**490**[c,i]	4–85[e]	—
		Lead	**29**[h,i]	<5[f]	15
		Sodium	**38,000**[c]	5,400–28,000[e]	—
		Sulfate	**64,500**[c]	23,000–30,000[e]	—
		Zinc	**2,300**[c,i]	3–210[e]	—
	08/04/03	Aluminum	**690**[c,i]	<10–10[e]	—
		Chloride	**40,000**[c]	8,000–20,000[e]	—
		Chromium	**27**[c]	1–22[e]	100
		Iron	**1,100**[c,i]	4–85[e]	—
		Lead	**38**[h,i]	<5[f]	15
		Manganese	**20**[c]	<1–15[e]	—
		Sodium	**38,000**[c]	5,400–28,000[e]	—
			37,000[c] **filtered**	5,400–28,000[e]	—
		Sulfate	**66,000**[c]	23,000–30,000[e]	—
		Zinc	**3,000**[c,i]	<3–210[e]	—
South-1835	8/7/03	Aluminum	**5,400**[c]	<10–10[e]	—
			300[c] **filtered**	<10–10[e]	—
		Barium	**140**[c]	<2–110[e]	—
		Bicarbonate	**400,000**[c]	228,000[e]	—
		Cadmium	**2.3**[c]	<1–2[e]	5
		Calcium	**66,000**[c]	35,000–46,000[e]	—
			66,000[c] **filtered**	35,000–46,000[e]	—
		Chloride	**73,000**[c]	8,000–20,000[e]	—
		Chromium	**60**[c]	1–22[e]	100
		Cobalt	**8.5**[c]	<3–3[e]	—
			4.9[c] **filtered**	<3–3[e]	—
		Copper	**33**[c]	<10–10[e]	1,300
		Iron	**7,800**[c]	4–85[e]	—
		Lead	**10**[c]	<5[f]	15
		Manganese	**1,500**[c]	<1–15[e]	—

Table 5-6. (continued).

Well	Sample Date	Analyte	Sample Result[a] (μg/L)	Aquifer Background Range (μg/L)	MCL[b] (μg/L)
			1,600[c] filtered	<1–15[e]	—
		Nickel	**67[c]**	<10[e]	100
			32[c] filtered	<10[e]	100
		Potassium	**7,100[c]**	1,000–6,000[e]	—
		Sodium	**180,000[c]**	5,400–28,000[e]	—
			190,000[c] filtered	5,400–28,000[e]	—
		Sulfate	**75,000[c]**	23,000–30,000[e]	—
		Vanadium	**29[c]**	<6–14[e]	—
		Zinc	**610[c]**	<3–210[e]	—

a. Reported results are unfiltered, unless otherwise indicated.

b. The MCLs are from the "National Primary Drinking Water Regulations" (40 CFR 141) established by the U.S. Environmental Protection Agency.

c. **Black bold font** indicates sample concentrations less than the MCL, but exceeding aquifer background concentrations (see footnote f).

d. November 2002 sample results with a "J" subscript were positively identified in the sample and assigned a "J" data qualifier flag, because one of the laboratory's internal quality control test results (i.e., serial dilution sample percent difference) was above the acceptance criteria of ±10%. The difference may be because of chemical or physical interferences, which could influence the accuracy of the measurement. Therefore, the reported concentrations should be used only as estimated quantities.

e. The USGS established concentration ranges of various analytes in the SRPA at or near the INEEL in 1999 from samples collected from 39 locations at or near the vicinity of the INEEL and Eastern Snake River Plain (Knobel et al. 1999). The aquifer concentration range shown for chromium, iron, sulfate, and zinc does not include atypical concentrations measured near the Test Reactor Area (i.e., 210, 210, 150, and 420 μg/L, respectively). In addition, chloride and sodium concentration ranges do not include atypical concentrations measured near the Idaho Nuclear Technology and Engineering Center. Furthermore, most analyte concentrations associated with Lidy Hot Springs were excluded, because they are not representative of the aquifer at or near the INEEL.

f. The USGS established the SRPA background ranges in 1992 from samples collected upgradient (i.e., Mud Lake area) and downgradient (i.e., Magic Valley area) of the INEEL (Knobel, Orr, and Cecil 1992). If a background concentration has not been established for a particular analyte, then sample results are compared to concentration ranges typically observed in the aquifer at or near the INEEL (see footnote e).

g. April and May 2003 concentration values with a "U" subscript denote that "U" data validation qualifier flags were assigned. The "U" flags were assigned to the chromium results because chromium contamination was detected in the laboratory batch blank (i.e., continuing calibration blank). The field sample chromium results are not considered reliable or defensible, but are reported herein because the measured concentrations are typical of historical concentrations, are above INEEL aquifer background levels, and chromium was not detected in any other associated blank samples (i.e., preparation blank and field blank). These data are usable, even though their defensibility is limited.

h. **Red bold font** indicates sample concentrations that exceed the MCL.

i. Well A11A31 casing is constructed of galvanized steel, which is the likely cause of the elevated concentration of zinc and other metals.
CFR = *Code of Federal Regulations*
INEEL = Idaho National Engineering and Environmental Laboratory
MCL = maximum contaminant level
SRPA = Snake River Plain Aquifer
USGS = United States Geological Survey
— = not established or not applicable

Some analytes reported in Table 5-6 have historical concentrations above aquifer background levels, but concentrations of these analytes consistently remain below drinking water MCLs and show no observable concentration trends. Only the RWMC monitoring wells exhibiting concentration trends or sudden increases in FY 2003 are discussed below.

Many chromium concentrations in the aquifer beneath the RWMC are significantly above INEEL aquifer background levels. Total chromium concentrations in FY 2003 ranged from 5 pCi/L in Well M4D to 70 pCi/L in Well M1S. Total chromium includes contributions from dissolved and solid chromium as well as chromium in various oxidation states (e.g., Cr^{3+} and Cr^{6+}). Total chromium concentrations in four RWMC monitoring wells (i.e., M1SA, M6S, M11S, and M15S) exceed levels typically detected in the

SRPA around the INEEL (1 to 22 µg/L), as determined from data published by Knobel et al. (1999), which excludes high total chromium concentrations measured around the TRA. Chromium concentrations measured in these four RWMC wells are considerably above aquifer background levels and show increasing trends (see Figure 5-3). Potential sources of chromium include the basalt, well-construction materials, well pumps, buried waste, and upgradient facilities. The following USGS aquifer monitoring wells also have chromium concentrations above 22 µg/L: USGS-088, USGS-089, and USGS-119. Figure 5-4 shows locations of wells with relatively high chromium concentrations.

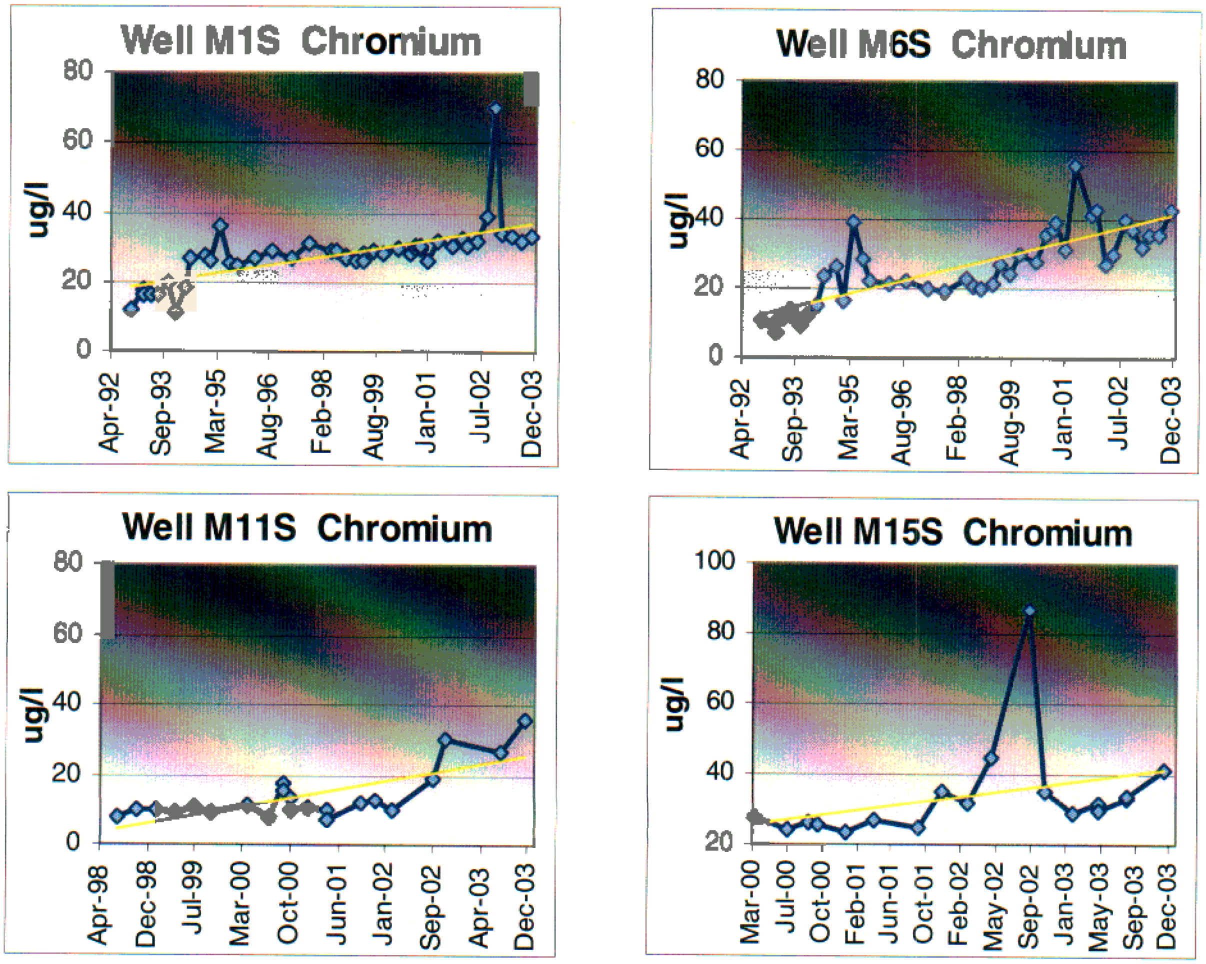


Figure 5-3. Radioactive Waste Management Complex aquifer-monitoring wells exhibiting increasing concentrations of chromium.

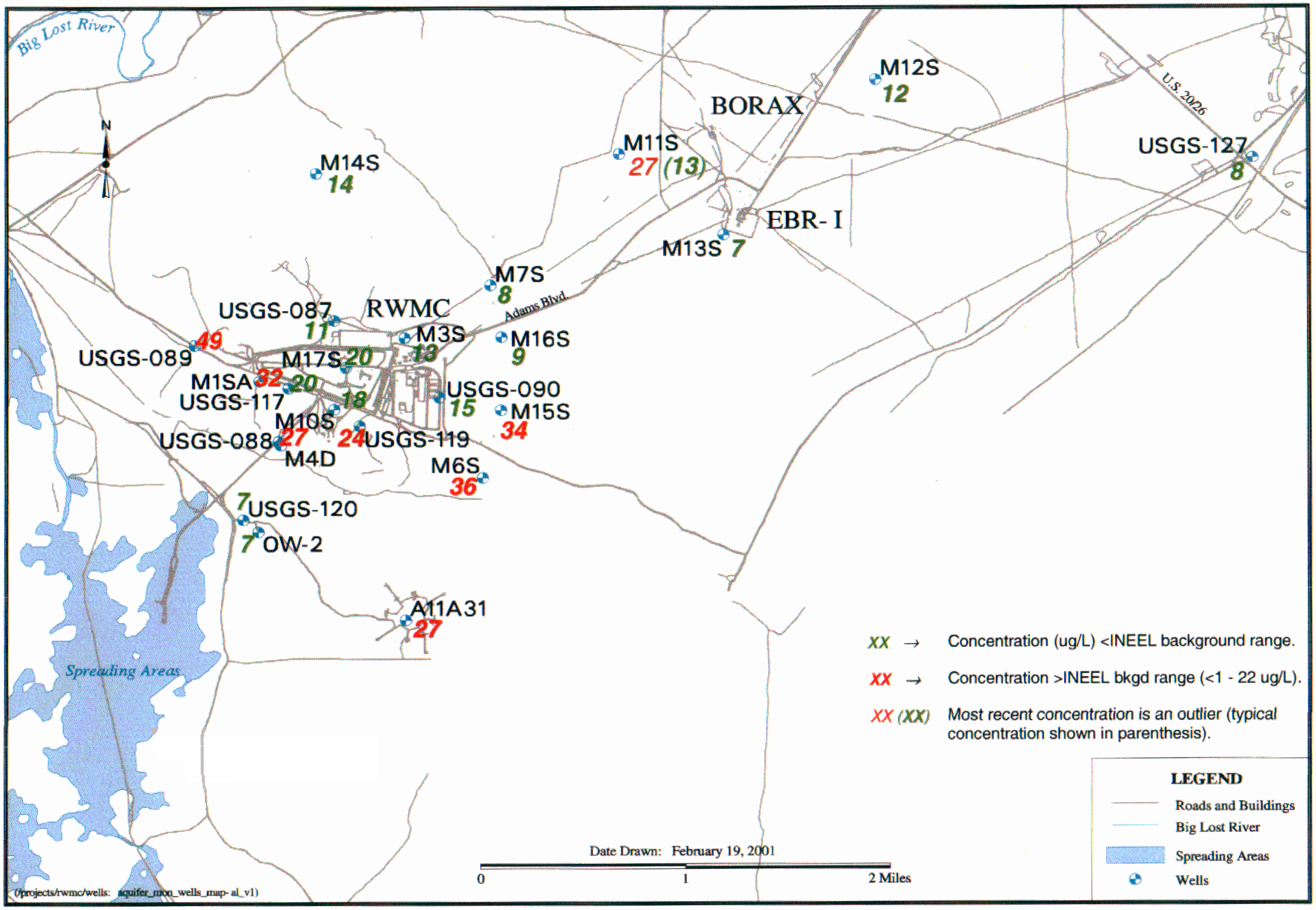


Figure 5-4. Total chromium concentrations in aquifer wells near the Radioactive Waste Management Complex.

Both filtered and unfiltered samples were collected in August 2003 to determine whether chromium is in the dissolved phase, from suspended solids in clays and precipitates in the aquifer, or from well-construction material. It was determined from filtered and unfiltered sample results that chromium in the aquifer around the RWMC exists mainly in the dissolved phase, except for the M11S upgradient well, where it is present mostly as a suspended solid. Wells M6S and M15S, on the east side of the SDA, also have a significant fraction of suspended chromium.

Dissolved chromium is commonly found in groundwater systems where water interacts with basaltic rock. Concentrations of dissolved chromium in the SRPA upgradient and downgradient of the INEEL range from 1 to 50 µg/L (Knobel, Orr, and Cecil 1992), whereas concentrations on or near the INEEL range from 1 to 190 µg/L, with the highest concentrations near TRA (Knobel et al. 1999). It has yet to be determined whether elevated levels of chromium in wells located at the south-southeast side of the RWMC are from the SDA, TRA, or natural occurrences.

Anion and metal concentrations in Well M4D are unlike all other RWMC aquifer-monitoring wells. Potassium and sodium concentrations are about six times higher than other wells and arsenic is about two times higher, whereas calcium and magnesium are about five times lower, and naturally occurring uranium concentrations are about two times lower than other RWMC wells. The difference in chemistry between Well M4D and the other RWMC wells suggests that this well is isolated from the shallower wells. Well M4D is much deeper than other RWMC aquifer-monitoring wells (i.e., 838 ft versus about 650 ft); the atypical concentrations might be related to low flow at this greater depth.

Magnesium chloride brine was historically used on SDA roads for dust suppression, and elevated concentrations of some of the anionic components have been detected in some of the RWMC area wells: M6S, M15S, and A11A31. Elevated chloride is detected in Well M11S and sulfate in OW2. It has been shown that brine contaminants have migrated to the 240-ft level, but it has yet to be established that brine has moved through the vadose zone to the aquifer. It will require continued sampling of the vadose zone and aquifer to identify the source(s) of chloride and sulfate in the RWMC aquifer. Meanwhile, the pattern of the chloride and sulfate detections suggests that there might be input from an upgradient source such as INTEC or TRA.

Most of the anions and metals measured in Well South-1835 were above background. Well South-1835 was a replacement well for M10S. Following well construction, Well South-1835 was determined to have a very low yield with highly turbid water containing suspended solids. X-ray diffraction patterns of the filtered solids were compared to x-ray diffraction patterns of well-construction materials and natural interbed material. The x-ray patterns suggest that the suspended solids are natural silts and clays similar to sedimentary interbed or fracture fill material. During well development, several chemicals were used to break down the drilling mud assumed to remain in the well. Because the well has a low yield, it was not possible to purge and remove all of the added chemicals,[g] as is evident from the analytical results shown in Table 3. Joel Hubbell and Larry Hull[h] conclude that the problems with Well South-1835 occurred mainly from attempts to develop the well after drilling rather than from the drilling itself. Because of its high turbidity and organic carbon, Hubbell and Hull also recommend that water samples from Well S-1835 not be used for groundwater contamination monitoring.

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[g] Joel Hubbell Informal Report to T. J. Meyer, et al., 2003, "Well South 1835," Idaho National Engineering and Environmental Laboratory, July 22, 2003.

[h] Joel Hubbell and Larry Hull Interoffice Correspondence to T. J. Meyer, 2003, "Evidence for Unsuitability of Using Well S1835 for Groundwater Contaminant Monitoring (Draft)," Idaho National Engineering and Environmental Laboratory, August 26, 2003.

5.2.3 Summary of Other Inorganic Contaminants

Chromium concentrations in most RWMC monitoring wells are consistent with levels typically observed around the INEEL (i.e., 1-22 μg/L). Nonetheless, the RWMC-INEEL chromium concentrations are above SRPA background at the INEEL. The chromium trend for Wells M1S, M6S, M11S, and M15S as well as elevated chloride and sulfate in Wells M6S, M11S, M15S, and A11A31 continue to be of concern.

6. SUMMARY

Soil moisture, soil gas, perched water, and the aquifer are measured around the RWMC to meet a variety of INEEL needs. Monitoring data were summarized for radionuclide and nonradionuclide contaminants for the shallow (0 to 35 ft), intermediate (35 to 140 ft), and deep (greater than 140 ft) vadose zone and for the perched water and the aquifer. Aquifer samples are collected on a quarterly basis.

The Environmental Monitoring Program at the RWMC serves multiple needs. This report is focused on the needs of two specific activities: (1) continued operation of the low-level waste disposal facility and (2) efforts associated with the CERCLA evaluation. Although many objectives are similar for the two projects, there are a number of differences in COCs and other specific needs. Thus, separate summaries of the data presented in the report are provided in the following two sections in the context of the different needs.

6.1 Summary in the Context of Low-Level Waste Disposal

Chapter IV of DOE Order 435.1, "Radionuclide Waste Management," requires that the results of PA/CA modeling be used to design an environmental monitoring program for the disposal facility. The monitoring results are to be used to verify modeling assumptions, confirm that the model adequately represents actual conditions, and demonstrate compliance with the RWMC performance objectives. The required data streams for the RWMC PA/CA monitoring program are identified in the PA/CA monitoring program description (McCarthy, Seitz, and Ritter 2001). Most of the required information can be gathered from results of the ongoing INEEL monitoring programs, but several new monitoring efforts have been initiated to characterize the migration of radionuclides in surface sediment near specific types of waste. Results of the monitoring are discussed in the following sections.

The FY 2003 monitoring results will be compared with FY 2003 action levels developed based on the modeling conducted for the performance assessment. This comparison is made in the annual PA/CA review (Parsons and Seitz 2004). The action levels are concentrations predicted at different locations in the vadose zone and aquifer based on modeling conducted for the existing PA/CA. Thus, if measured concentrations are below the action levels, then the model conclusions about compliance remain valid. The summary information in this report (see Tables 3-5, 3-6, 3-9, 3-10, 3-11, 3-14, 3-15, 3-23, and 3-24) is presented in a manner that facilitates identifying the maximum measured concentration at different depths to make the comparison with the action levels.

6.1.1 Performance Assessment and Composite Analysis Source Monitoring Summary

The Beryllium Source Monitoring Project has produced a useful record of H-3 concentrations in the subsurface and atmosphere. Some of the results and methods developed for beryllium source monitoring may be used to find other beryllium disposal locations for the early risk-reduction project. It is evident that long-term monitoring is required to adequately represent the conditions around the buried beryllium. Air-concentration data show consistent annual fluctuations, yet there is no obvious long-term trend in air concentrations. The H-3 concentration in soil gas has increased at an accelerating rate, and although the concentration must reach a peak and eventually decline, there is no evidence of a peak yet.

Other source-monitoring projects were established to characterize C-14 releases from activated stainless steel and the subsurface conditions in typical disposal pits. The first sampling for the Activated Steel-Monitoring Project was conducted in FY 2002, and it is evident that the C-14 concentrations are substantially lower than the concentrations found around the beryllium blocks, as expected. Sampling equipment and instrumentation are being installed in the active pit, but no data will be available until the equipment and waste have been covered.

6.1.2 Performance Assessment and Composite Analysis Vadose Zone Monitoring Summary

The vadose zone in the vicinity of the RWMC contains a network of suction lysimeters that allow repeated soil-moisture sampling from soil surrounding the waste and from interbeds in the vadose zone. Data were summarized for the PA/CA radionuclides of concern (i.e., C-14, Cl-36, H-3, I-129, Np-237, U-233/234, and U-238). Tritium also was included, because it is a good early indicator for contaminant movement. Maximum concentrations detected were presented for each FY since 1997 and for each depth interval within the vadose zone: shallow (0 to 35 ft), intermediate (35 to 140 ft), and deep (greater than 140 ft). As shown in Table 6-1, data for C-14, H-3, I-129, and uranium are available starting in FY 1997, whereas data for Cl-36 and Np-237 were not collected until years later. Vadose zone analyses for Np-237 began in FY 2000, and Cl-36 was just added to the lysimeter analyte list in FY 2002. The first Cl-36 samples from the vadose zone were analyzed in FY 2003.

In FY 2003, lysimeter sampling results were obtained for all of the PA/CA radionuclides of concern. Iodine-129 and Np-237 were not detected in any of the samples. The maximum concentration of C-14 was found in the intermediate vadose zone (46 pCi/L), two orders of magnitude less than the aquifer MCL (2,000 pCi/L). Chlorine-36 was detected at low levels throughout the vadose zone with maximum concentrations (up to 32.3 pCi/L) much less than the 700-pCi/L aquifer MCL. Tritium was expected in samples from the shallow and intermediate vadose zone. Maximum concentrations of H-3 were one to two orders of magnitude smaller than the MCL of 20,000. Uranium concentrations have been, and continue to be, detected above background for U-233/234 (3 pCi/L) and U-238 (1.5 pCi/L) in several lysimeters in the shallow and intermediate vadose zone. In the deep vadose zone, the maximum concentrations of uranium are at background levels.

Table 6-1. Summary of radionuclide detections in vadose zone soil-moisture and perched water samples from the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.

Sampling Range (feet below land surface)	Fiscal Year [a]	C-14	Cl-36	H-3	I-129	Np-237	U-233/ 234	U-238
		Number of Detection Results/Total Environmental Samples						
Lysimeters 0 to 35 ft	1997	4/17	NA[b]	13/29	0/20	NA	2/2	2/2
	1998	1/9	NA	3/8	0/7	NA	23/24	24/24
	1999	2/11	NA	3/7	2/9	NA	25/25	25/25
	2000	0/21	NA	3/12	1/18	0/20	62/62	63/63
	2001	NA	NA	NA	NA	0/8	8/8	7/7
	2002	NA	NA	NA	NA	0/5	5/5	5/5
	2003	0/15	3/22	2/7	0/3	0/10	24/24	22/24
Lysimeters 35 to 140 ft	1997	0/1	NA	0/1	0/1	NA	3/3	3/3
	1998	0/5	NA	2/6	0/4	NA	11/11	8/8
	1999	NA	NA	1/1	NA	NA	2/2	5/5
	2000	NA	NA	NA	NA	0/11	18/21	19/20
	2001	NA	NA	NA	NA	0/5	5/5	3
	2002	0/1	NA	NA	NA	0/3	2/3	2/3
	2003	1/15	2/36	4/11	0/4	0/23	33/40	30/40

Table 6-1. (continued).

Sampling Range (feet below land surface)	Fiscal Year [a]	C-14	Cl-36	H-3	I-129	Np-237	U-233/ 234	U-238
Lysimeters >140 ft	1997	NA	NA	NA	NA	NA	NA	NA
	1998	NA	NA	NA	NA	NA	NA	NA
	1999	NA	NA	NA	NA	NA	NA	NA
	2000	NA	NA	NA	NA	0/2	0/1	0/1
	2001	NA	NA	NA	NA	0/1	0/1	0/1
	2002	NA	NA	NA	NA	0/4	3/3	0/3
	2003	0/6	0/12	0/2	0/1	0/10	6/17	3/17
Perched water wells >140 ft	1997	2/2	NA	3/5	0/2	NA	NA	NA
	1998	3/4	NA	3/3	0/3	NA	1/2	1/2
	1999	0/2	NA	0/2	0/3	NA	4/6	2/7
	2000	NA	NA	0/1	0/1	0/1	4/6	4/6
	2001	1/1	NA	NA	NA	0/1	0/1	0/1
	2002	NA	NA	0/1	0/1	0/1	1/1	1/2
	2003	0/2	1/5	0/1	0/1	0/3	5/5	4/5

a. Fiscal year spans from October 1 to September (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).
b. NA = not analyzed

6.1.3 Performance Assessment and Composite Analysis Aquifer Monitoring Summary

Groundwater monitoring has been ongoing from the network of monitoring wells located around the RWMC for many years. Groundwater samples are collected on a quarterly basis as required for the OU 7-13/14 routine monitoring program. Data for H-3, C-14, and I-129 were summarized beginning in FY 1997 (see Table 6-2). Aquifer sampling for uranium was conducted from FY 1998 through the present, while Np-237 data were not collected until FY 1999. Aquifer sampling for Cl-36 began in FY 2001 in the vicinity of the RWMC.

Aquifer sampling results in FY 2003 were obtained for all of the PA/CA COCs (i.e., C-14, I-129, Np-237, U-233/234, and U-238) as well as H-3. No samples were analyzed for Cl-36. Furthermore, C-14, I-129, and Np-237 were not detected in the aquifer (see Table 6-1). Tritium was found in about one-half of the samples collected in FY 2003. The maximum H-3 concentration was 1,690 pCi/L, which is below the aquifer MCL of 20,000 pCi/L. Uranium-233/234 and U-238 were detected in all aquifer samples at levels at or below the normal background concentrations at the RWMC. Typical aquifer background concentrations for U-233/234 and U-238 are 1.1 pCi/L (Holdren et al. 2002).

6.2 Summary in the Context of the Comprehensive Environmental Response, Compensation, and Liability Act

Results from the waste zone, vadose zone, and aquifer monitoring indicate that some contaminants are migrating out of the waste zone and into the vadose zone; however, the data about the aquifer are inconclusive. Tritium is detected in the aquifer beneath the RWMC, but significant detections also are occurring upgradient of the RWMC. It is speculated that H-3 is from upgradient facilities, primarily TRA; however, it is also likely that the some H-3 beneath the RWMC is from sources in the SDA. Uranium is regularly detectable above background concentrations in the shallow- and intermediate-depth lysimeters around Pad A, Pit 5, and the western end of SDA; uranium is sporadically detected in the vadose zone

Table 6-2. Summary of aquifer sampling results for radionuclides at the Radioactive Waste Management Complex from Fiscal Year 1997 through 2003.

Fiscal Year[a]	C-14	Cl-36	H-3	I-129	Np-237	U-233/234	U-238
	Number of Detection Results/Total Environmental Samples						
1997	0/7	NA[b]	10/24	1/8	NA	NA	NA
1998	2/23	NA	18/52	2/24	NA	18/18	18/18
1999	3/31	NA	29/73	1/39	0/47	22/44	33/44
2000	9/46	NA	34/79	0/53	0/55	52/53	53/53
2001	5/49	0/15	23/65	0/54	0/62	62/63	63/63
2002	3/45	0/9	20/43	0/53	3/48	46/46	46/46
2003	0/63	NA	28/64	0/78	0/63	63/63	63/63

a. Fiscal year spans from October 1 to September (e.g., Fiscal Year 1997 is October 1, 1996, to September 30, 1997).
b. NA = not analyzed

over 140 ft deep. Detections in the aquifer are representative of natural uranium. Thus, the uranium trend data appear to warrant further investigation for use as a modeling calibration target or model validation. Other results are provided below:

- Low concentrations of CCl_4 and nitrates are affecting the aquifer beneath the RWMC.
- Carbon tetrachloride and nitrates are exhibiting concentration trends.
- Chromium concentrations in Wells M1S, M6S, M11S, and M15S are significantly above aquifer background levels and have evident concentration trends. Chromium levels in all RWMC aquifer wells, including the trending wells, remain below the MCL.
- Nitrates, H-3, Tc-99, and uranium were detected in soil-moisture samples from the vadose zone. There are significant concentration trends associated with nitrates around Pad A and the west end of the SDA.
- Uranium concentrations in a few isolated areas of the SDA, between the 0- and 140-ft depth interval, are significantly elevated and continue to show both concentration trends and isotopic ratio trends. Some lysimeters have isotopic ratios and ratio trends indicative of anthropogenic uranium that is slightly enriched in U-235.
- Technetium-99 was consistently detected in soil moisture from Lysimeter Well D06 and W23 in FY 2003. These lysimeter wells have exhibited many Tc-99 detections, suggesting the presence and migration of Tc-99 in areas of the SDA.
- Plutonium isotopes were not detected in any samples in FY 2003.
- Air concentration data from beryllium-block monitoring show consistent annual fluctuations of H-3 and a total release for FY 2003 of 5 Ci, but with no obvious long-term trend in air concentrations.
- Carbon-14 concentrations around the beryllium blocks are substantially higher than C-14 concentrations near the activated steel or low-level waste disposals, as expected.

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