DOE/RL-2014-18
Revision 0

Path Forward For Future 200-PW-1 Operable Unit Soil Vapor Extraction Operations

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

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Richland, Washington 99352

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Release Approval Date

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Concurrence Page

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Terms

CCU	Cold Creek unit
CPT	cone penetrometer technology
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
OU	operable unit
ppmv	part per million by volume
ROD	Record of Decision
SVE	soil vapor extraction

1 Introduction

In response to the historical discharges of liquid waste containing carbon tetrachloride and methylene chloride to four subsurface infiltration sites near the 200 West Area Plutonium Finishing Plant, soil vapor extraction (SVE) operations began in 1992 to recover these volatile organics. Between 1992 and 2012, 80,107 kg of carbon tetrachloride were recovered from the vadose zone. Since the 100 parts per million by volume (ppmv) and 50 ppmv final cleanup levels for carbon tetrachloride and methylene chloride, as specified in the *Record of Decision, Hanford 200 Area Superfund Site: 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-6 Operable Unit* (EPA et al., 2011) (hereafter referred to as the ROD), have been met in all of the SVE wells (and all but one soil vapor probe), the U.S. Environmental Protection Agency (EPA) approved a one-year rebound study beginning in March 2013.

The purpose of this document is to establish EPA and U.S. Department of Energy (DOE) concurrence with the path forward for gradually transitioning the 200-PW-1 Operable Unit (OU) SVE from the current cycle of active operations and monitoring to shutdown and closure. The path forward is based on the methods outlined in the recently published *Soil Vapor Extraction System Optimization, Transition, and Closure Guidance* (PNNL-21843), prepared by EPA, the U.S. Army Corps of Engineers, and Pacific Northwest National Laboratory. PNNL-21843 presents a stepwise approach for gathering information and performing evaluations to support decisions pertaining to optimization, transition, or closure of SVE operations. This path forward document presents the logic for determining when shutdown and closure is the appropriate decision for 200-PW-1 SVE operations.

In an effort to highlight the amount of information that is known about the nature and extent of contamination, this document provides summaries of the past carbon tetrachloride waste processing and discharge history, summaries of investigations and remediation activities within the 200-PW-1 OU, results from the past two decades of SVE operations, and conclusions from numerous supporting tests and studies. Data are also presented for the rebound trends derived from historical soil vapor monitoring data.

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2 Regulatory Compliance Overview

The discovery of a widespread carbon tetrachloride groundwater plume in the mid-1980s prompted the DOE and its contractors to evaluate technologies that could mitigate the spread of carbon tetrachloride contamination in the soil column and the underlying aquifer. After extensive evaluation and testing, SVE was determined to be the most effective technology for removing carbon tetrachloride from contaminated vadose zone soil. Subsequently, an engineering evaluation/cost analysis was prepared and recommended the SVE system with granular activated carbon recovery and offsite regeneration as the preferred remedial alternative.

In January 1992, EPA and the Washington State Department of Ecology (Ecology) issued the "Action Memorandum: Expedited Response Action Proposal for 200 West Area Carbon Tetrachloride Plume" (EPA and Ecology, 1992), directing the use of SVE at the source waste sites as the interim action to reduce the mass of carbon tetrachloride in the soil column beneath the 200 West Area. The purpose of this action was to mitigate the threat to site workers, public health, and the environment caused by the migration of carbon tetrachloride vapors through the soil column into the groundwater.

The ROD (EPA et al., 2011) was finalized in September 2011, and SVE was selected as the final remedial action to remove and treat carbon tetrachloride contamination in the vadose zone at contaminated sites. The ROD acknowledged the effectiveness of the SVE system and the success of the carbon tetrachloride removal process. The final cleanup levels for soil vapor concentrations were set at 100 ppmv for carbon tetrachloride and 50 ppmv for methylene chloride. The ROD further specified that soil vapor concentrations must be refined and assessed to ensure that the concentrations are protective of groundwater.

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3 Summary of 200-PW-1 Operable Unit Investigation and Remediation Activities

This chapter summarizes the history of previous carbon tetrachloride waste discharges, investigation and remediation activities, and conclusions from numerous tests and studies performed over the past two decades at the 200-PW-1 OU.

3.1 Carbon Tetrachloride Waste Disposal History

From 1955 to 1973, large volumes of liquid waste were generated from the production of plutonium at the Plutonium Finishing Plant. Waste liquids from process operations were primarily discharged to the following three subsurface infiltration sites: 216-Z-1A Tile Field, 216-Z-9 Trench, and 216-Z-18 Crib. A lesser amount was also discharged to the 216-Z-12 Crib. Figure 3-1 presents a map showing the locations of these four infiltration sites within the 200-PW-1 OU.

The liquid waste contained low levels of plutonium and volatile organic compounds. The organic liquid waste consisted of 50 to 80 percent by volume carbon tetrachloride mixed with tributyl phosphate, dibutyl butylphosphonate, or lard oil. The organic wastes comprised approximately 4 to 8 percent of the total volume of liquid wastes discharged to the waste sites. The liquid waste infiltrated into the ground, contaminating the underlying soil and groundwater.

3.2 Investigation and Remediation Activities

Numerous investigation and remediation activities were conducted at the 200-PW-1 OU source sites following the discovery of carbon tetrachloride in groundwater. Additional characterization activities were performed throughout the 200 West Area vadose zone to support the 200-PW-1 OU remedial investigation. Table 3-1 provides a summary of these activities, as well as a variety of supporting tests and studies.

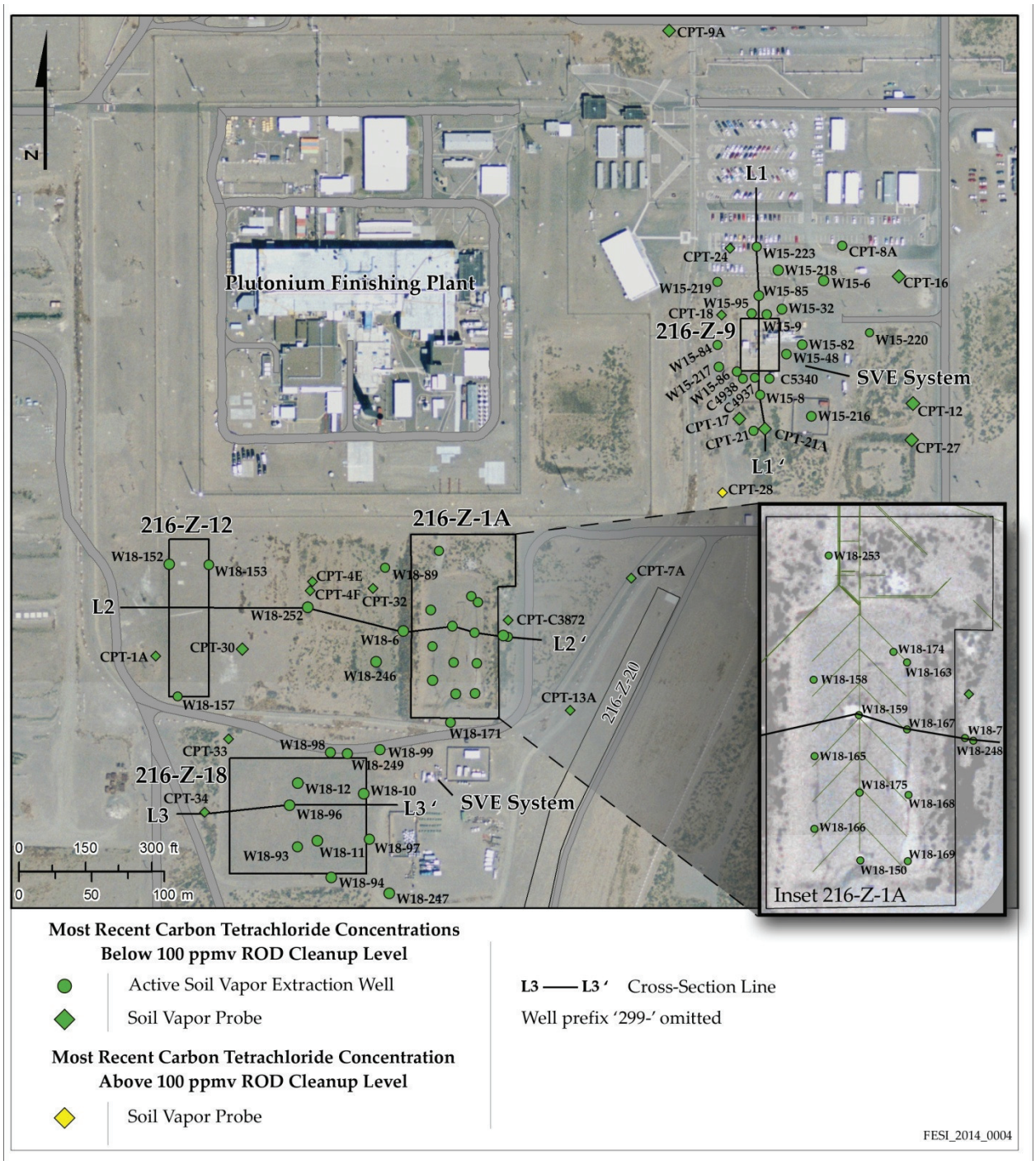

Figure 3-1. 200-PW-1 Carbon Tetrachloride Waste Sites and SVE Wells and Probes

Table 3-1. Summary of Investigation and Remediation Activities at the 200-PW-1 OU

Year	Project/Action	Description	Result/Recommendation	Key References
Mid-1980s	Initial groundwater sampling for volatile organic compounds	Discovery of a widespread carbon tetrachloride groundwater plume.	Initiated activities to evaluate removal of the carbon tetrachloride source in the vadose zone.	PNL-7396, 1990, *Hanford Site Ground-Water Surveillance for 1989*
1991–1992	Initial site evaluation of carbon tetrachloride disposal sites and conceptual site model	Conducted initial soil vapor sampling for carbon tetrachloride. Conducted pilot test of SVE system.	Proposed the use of SVE in the engineering evaluation/cost analysis as the preferred alternative.	DOE/RL-91-32, 1991, *Expedited Response Action Proposal (EE/CA & EA) for 200 West Area Carbon Tetrachloride Plume*
1992	Action Memorandum: Expedited Response Action Proposal for 200 West Area Carbon Tetrachloride Plume	EPA and Ecology approved DOE's proposal to conduct the 200 West Area Carbon Tetrachloride Plume Expedited Response Action. DOE initiated the carbon tetrachloride soil vapor removal action at the 200-PW-1 OU waste sites in the 200 West Area.	Selected vapor extraction as the preferred technology. Authorized the operation of the SVE system at the 200-PW-1 carbon tetrachloride waste sites.	"Action Memorandum: Expedited Response Action Proposal for 200 West Area Carbon Tetrachloride Plume" (EPA and Ecology, 1992)
1992–2001	Characterization of carbon tetrachloride source waste sites to support implementation of the interim action for the vadose zone	Drilled (or deepened) and characterized 15 SVE wells. Conducted active and passive soil vapor surveys. Installed soil vapor probes and wells using a cone penetrometer.	Updated conceptual site model for carbon tetrachloride in the vadose zone. Expanded number and location of wells available for use with SVE systems.	WHC-SD-EN-TI-063, 1992, *FY92 Site Characterization Status Report and Data Package for the Carbon Tetrachloride Site* WHC-SD-EN-TI-202, 1993, *FY93 Site Characterization Status Report and Data Package for the Carbon Tetrachloride Site* BHI-00105, 1995, *FY 1993 Wellfield Enhancement Status Report and Data Package for the 200 West Area Carbon Tetrachloride Expedited Response Action*

Table 3-1. Summary of Investigation and Remediation Activities at the 200-PW-1 OU

Year	Project/Action	Description	Result/Recommendation	Key References
1992–2014	Annual Performance Evaluation Report of SVE System SVE System Monitoring and Operation Plan	Removed carbon tetrachloride from the vadose zone using passive and active SVE at the source waste sites. Reported the SVE system operating data and the effectiveness based on the existing remedial design.	Significantly reduced the concentration of carbon tetrachloride at the source sites. Removed over 80,000 kg of carbon tetrachloride between 1991 (pilot test) and 2014. Recommended operational and sampling strategies for the following calendar year.	SGW-54566, 2013, *Performance Evaluation Report for Soil Vapor Extraction Operations at the 200-PW-1 Operable Unit Carbon Tetrachloride Site, Calendar Year 2012*. (Note: This is the most recent annual report.) DOE/RL-2013-28, 2013, *Carbon Tetrachloride Soil Vapor Extraction System Monitoring and Operating Plan for CY 2013*. (Note: This is the most recent monitoring and operating plan. Previous plans were attachments to Project Managers' meeting minutes.)

Table 3-1. Summary of Investigation and Remediation Activities at the 200-PW-1 OU

Year	Project/Action	Description	Result/Recommendation	Key References
1996–1997	Carbon tetrachloride soil vapor rebound study	Evaluated the increase in carbon tetrachloride concentrations following temporary shutdown of the SVE system.	Concluded the following: • Readily accessible mass has been removed. • The availability of additional carbon tetrachloride is limited due to the lower permeability zone. • Eight-month suspended operation caused no additional degradation of groundwater quality. Recommended the following: • Four to 8 weeks of operations followed by 8 to 16 weeks of non-operation. • Monitor carbon tetrachloride soil vapor and groundwater quality. • Evaluate change in rebound rate and refine remedial action goals and objectives.	BHI-01105, 1997, *Rebound Study Report for the Carbon Tetrachloride Soil Vapor Extraction Site, Fiscal Year 1997*

Table 3-1. Summary of Investigation and Remediation Activities at the 200-PW-1 OU

Year	Project/Action	Description	Result/Recommendation	Key References
1999–2007	Carbon tetrachloride remedial investigation activities	Investigated representative waste sites 216-Z-1A and 216-Z-9 to perform the following: • Characterize the nature and extent of chemical and radiological contamination • Characterize geology underlying the waste sites Investigated the dispersed carbon tetrachloride plume that had migrated beyond the 200-PW-1 waste sites to determine the following: • Lateral extent of vadose zone contamination overlying the carbon tetrachloride groundwater plume • Vertical extent of vadose zone contamination from the ground surface to the water table	Highest carbon tetrachloride concentrations in the vadose zone generally are located within about 75 to 150 m of the source sites. Highest carbon tetrachloride concentrations beneath the waste sites are located in fine-grained layers. Found carbon tetrachloride DNAPL in soil sample within a silt layer at 216-Z-9. No evidence of significant lateral migration along the top of the CCU. No evidence of downward migration from an undocumented source. At areas around the source sites, carbon tetrachloride concentrations up to about 10 to 12 ppmv were found at various locations in the vadose zone, but these concentrations are not considered to have significant impacts on groundwater. Sampling result at wells within the carbon tetrachloride groundwater hot spot areas indicated that the deep vadose zone soil vapor concentrations are not significant sources of groundwater contamination in these areas.	DOE/RL-2001-01, 2004, *Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units* DOE/RL-2006-51, 2007, *Remedial Investigation Report for the Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*

Table 3-1. Summary of Investigation and Remediation Activities at the 200-PW-1 OU

Year	Project/Action	Description	Result/Recommendation	Key References
2003–2007	Carbon tetrachloride DNAPL source term interim characterization	Investigated the presence, distribution, nature, extent, and mass of DNAPL in the vadose zone to support the remedial investigation. Developed conceptual model of the DNAPL in the vadose zone and unconfined aquifer.	Updated the conceptual model of the 216-Z-9 Trench. Found carbon tetrachloride DNAPL in soil samples within same silt layer at 216-Z-9. Concluded that all significant remaining DNAPL bounded in the fine-grained soils of the CCU and the overlying discontinuous silt lenses.	DOE/RL-2006-58, 2006,*Carbon Tetrachloride Dense Non-Aqueous Phase Liquid (DNAPL) Source Term Interim Characterization Report* DOE/RL-2007-22, 2007, *Carbon Tetrachloride Dense Non-Aqueous Phase Liquid (DNAPL) Source Term Interim Characterization Report Addendum*
2010–2012	Treatability test for characterization of vadose zone carbon tetrachloride source strength using tomographic methods at the 216-A-9 site	Conducted a test at the 216-Z-9 Trench to collect information to quantify the source mass and to estimate the size and location of the source. Used data to calculate the vapor-phase source strength (source mass discharge). The information was also used to support refinement of SVE performance goals based on impact to groundwater and provided input to operational strategies for continued operation, closure, or transition to other remedies.	Concluded that the CCU is the primary remaining source of carbon tetrachloride in the vadose zone. Areal extent of the source zone at the 216-Z-9 waste site is approximately 90 m by 90 m. Recommended three operational strategies: • Lengthen the SVE running time to minimize the built-up vapor • Lengthen the shutdown time to provide additional time for rebound in vapor concentration • Restart only at selected wells centralized around the diffusive mass discharge from the CCU contamination source	DOE/RL-2010-79, 2010, *Treatability Test Plan for Characterization of Vadose Zone Carbon Tetrachloride Source Strength Using Tomographic Methods at the 216-A-9 Site* PNNL-21326, 2012, *Treatability Test Report: Characterization of Vadose Zone Carbon Tetrachloride Source Strength Using Tomographic Methods at the 216-A-9 Site*

Table 3-1. Summary of Investigation and Remediation Activities at the 200-PW-1 OU

Year	Project/Action	Description	Result/Recommendation	Key References
2011	Proposed Plan for the Remediation of the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units	Proposed Plan for cleanup of 21 waste sites in the central portion of the Hanford Site.	Identified SVE for remediation of carbon tetrachloride in the vadose zone at the source sites as the common element to all alternatives. Stated that continued operation of the system is necessary for protection of groundwater until it is no longer necessary or is replaced by a component of a final action remedy.	DOE/RL-2009-117, 2011, *Proposed Plan for the Remediation of the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*
2011	Final Record of Decision for of the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units	Selected SVE as the final remedial action to remove and treat carbon tetrachloride contamination in the vadose zone at the contaminated sites.	Established the final cleanup levels for soil vapor concentrations of carbon tetrachloride as 100 ppmv and for methylene chloride as 50 ppmv. Specified that the soil vapor concentrations will be further refined and assessed to ensure the protectiveness of groundwater. Directed the continuing operation of the SVE until soil vapor levels no longer pose a threat to human health, the environment, and groundwater.	*Record of Decision, Hanford 200 Area Superfund Site: 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units* (EPA et al., 2011)
2012	SVE system operational strategy	Provided the strategy to sample, modify and operate the SVE system.	Recommended the following: • Increase the rebound period. • Operate SVE from June to September at highest concentration area. • Operate SVE from August to September at wells located along the periphery of high concentration area. • Evaluate biannual operational strategy if rebound continues to decline. • Collect data to evaluate rebound, individual well performance, and update source mass discharge.	SGW-53024, 2012, *200-PW-1 Operable Unit Soil Vapor Extraction System Operational Strategy*

Table 3-1. Summary of Investigation and Remediation Activities at the 200-PW-1 OU

Year	Project/Action	Description	Result/Recommendation	Key References
2013	SVE system optimization, transition, and closure guidance	Built upon existing guidance for SVE design, operation, optimization, and closure from the EPA, U.S. Army Corps of Engineers, and the Air Force Center for Engineering and the Environment. Presented an approach to evaluate the impact of remaining vadose zone contaminant source on groundwater to support optimization, transition, and closure decisions.	Presented a stepwise approach for gathering information and performing evaluations to support SVE remedy decisions. Steps include the following: • Revisiting the conceptual site model, considering relevant information • Quantifying the impact of remaining vadose zone contaminant sources on groundwater • Integrating the assessment outcomes into a decision logic approach to address optimization, transition, and closure decisions	PNNL-21843, 2013, *Soil Vapor Extraction System Optimization, Transition, and Closure Guidance*

CCU = Cold Creek unit
DNAPL = dense nonaqueous phase liquid
DOE = U.S. Department of Energy
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
OU = operable unit
ppmv = parts per million by volume
SVE = soil vapor extraction

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4 Soil Vapor Extraction System Performance Overview

The following sections highlight the effectiveness and the performance of the 200-PW-1 SVE system over the past 20 years. Three different SVE configurations (active, passive, and monitoring) are discussed below.

4.1 Carbon Tetrachloride Contamination Trends at Active Extraction Wells

SVE has been used as a remedial action in the 200-PW-1 OU vadose zone since 1992 and has significantly reduced vadose zone carbon tetrachloride contamination. Between 1992 and 2012, more than 80,000 kg of carbon tetrachloride were extracted from the vadose zone in the vicinity of the source waste sites using SVE systems with design capacities of 14, 28, and 42 m^3/min (500, 1,000, or 1,500 ft^3/min). Concentrations measured at all wells during active SVE operations have declined below final cleanup levels of 100 ppmv and 50 ppmv for carbon tetrachloride and methylene chloride, respectively. The SVE operational data and treatability test results indicate that SVE has been highly effective in the permeable sand and gravel portions of the vadose zone and that remaining contamination is present in the low-permeability silt zones of the Cold Creek unit (CCU) (PNNL-21326, *Treatability Test Report: Characterization of Vadose Zone Carbon Tetrachloride Source Strength Using Tomographic Methods at the 216-Z-9 Site*).

The decline in carbon tetrachloride and methylene chloride concentrations in extraction wells at each waste site is depicted in Figures 4-1 through 4-3. Concentration data were measured at each well online during SVE operations. Data presented are the maximum recorded concentration, regardless of year, and the maximum concentration measured during the final year that a well was online with the SVE system ("most recent concentration" values). Some wells were designed with two perforated intervals separated by a packer. These wells are listed with an "L" or "U" after the name to designate the "lower" or "upper" intervals, respectively.

Figure 4-1 depicts, on a logarithmic scale, the maximum recorded carbon tetrachloride concentrations in SVE wells screened or perforated above the CCU at all four waste sites. Figure 4-2 depicts, on a logarithmic scale, the maximum recorded carbon tetrachloride concentrations in SVE wells screened or perforated below the CCU at all four waste sites. Concentrations have decreased by two to three orders of magnitude since inception of SVE, as shown by the "most recent concentration" values in Figures 4-1 and 4-2. Carbon tetrachloride concentrations in all wells during active extraction have been below the 100 ppmv cleanup level since 2009.

Figure 4-3 depicts, on a linear scale, the maximum concentrations of methylene chloride concentrations in all wells completed above and below CCU at all waste sites. Methylene chloride concentrations in all wells have been below the 50 ppmv cleanup level since 2006.

Figures 4-4 through 4-6 show a different visual representation of the active SVE system performance using plate maps and cross sections. Figure 3-1 provides an overview map with the locations of all three cross sections. The concentrations displayed on the cross sections are the same carbon tetrachloride values used to create Figure 4-1 and 4-2. These figures show the vertical and lateral distribution of extraction wells with respect to the four waste sites.

Figure 4-7 shows the initial maximum and the final composite carbon tetrachloride concentrations for vapor extracted via the 216-Z-9 Trench SVE system during years of cyclic operation. The initial (or rebound) concentrations are measured at the beginning of annual SVE operations. The final (asymptotic) concentrations are measured at the end of the SVE operational cycle. In cycles prior to 2005, the maximum rebound concentrations were significantly higher than the final concentrations of the previous

cycle. Since 2005, both maximum and final concentrations during operational cycles have declined, and only small differences occur between maximum and final concentrations (PNNL-21326). These data demonstrate the decline in carbon tetrachloride source strength over time.

SVE wells at the 216-Z-1A, 216-Z-18, and 216-Z-12 sites were operated together on a single SVE system, separate from the SVE system for 216-Z-9. Figure 4-8 shows the initial maximum and the final composite carbon tetrachloride concentrations for vapor extracted during years of cyclic operation at these three waste sites. Composite concentrations at this SVE system did not have a significantly higher rebound in the initial phase of SVE, as was seen in the 216-Z-9 composite samples, but the data do still show a decline in carbon tetrachloride source strength over time.

4.2 Carbon Tetrachloride Contamination Trends at Passive Extraction Wells

Passive SVE was implemented in fiscal year 2000 at eight wells screened below the CCU in the 216-Z-1A and 216-Z-18 well field. Passive SVE is a naturally occurring process driven by barometric pressure fluctuations and is often referred to as “barometric pumping.” Based on monthly concentration data collected at the passive extraction wells, passive extraction has removed an estimated 110 kg of carbon tetrachloride from the vadose zone between October 1999 and March 2013. Passive SVE operations were discontinued in March 2013 based on the low carbon tetrachloride concentrations. Figure 4-9 shows the change in carbon tetrachloride concentrations that were observed. (Note that the passive SVE wells shown in Figure 4-9 are highlighted with an asterisk after the name.) The carbon tetrachloride concentrations at all passive wells have declined below the final cleanup level of 100 ppmv.

4.3 Carbon Tetrachloride Contamination Trends at Monitoring Wells and Probes

As discussed in Section 4.1, the remediation at source waste sites using active SVE systems has significantly reduced the carbon tetrachloride concentrations in the vadose zone surrounding the 200-PW-1 waste sites. Carbon tetrachloride concentrations were monitored not only at active and passive extraction wells, but also at monitoring wells and soil vapor probes. The downward trends observed in monitoring wells and probes indicate that the SVE operations not only reduced the soil vapor concentrations in the direct vicinity of SVE wells, but also at locations further afield both within and surrounding the vapor extraction treatment zone.

Figure 4-9 shows, on a logarithmic scale, the maximum carbon tetrachloride concentrations at monitoring wells and probes in the 200-PW-1 OU (the locations are shown in Figure 3-1). In order to collect samples from several vertical intervals, a cone penetrometer (CPT) was used to install soil vapor probes at multiple depths in one location. For these probes, CPT names are used in place of the well names. The highest concentration is selected, and the corresponding depth is listed next to the CPT name. The carbon tetrachloride concentrations at all monitoring wells and probes, with the exception of CPT-28, have declined below the final cleanup level of 100 ppmv. CPT-28 is located approximately 90 m (295 ft) south of the 216-Z-9 Trench, is screened above the CCU, and is likely not within the influence zone of the SVE system.

Figures 4-10 through 4-13 show the annual maximum carbon tetrachloride concentrations from one monitoring well or soil vapor probe at each of the four waste sites. Wells or soil vapor probes with screens either at or below the CCU were selected for inclusion in these figures because the highest historical concentrations and current residual concentrations are associated with the CCU. Concentration declines exhibit exponential decay curves, as illustrated. These data trends show that carbon tetrachloride concentrations are declining in the zone of highest contamination (the CCU).

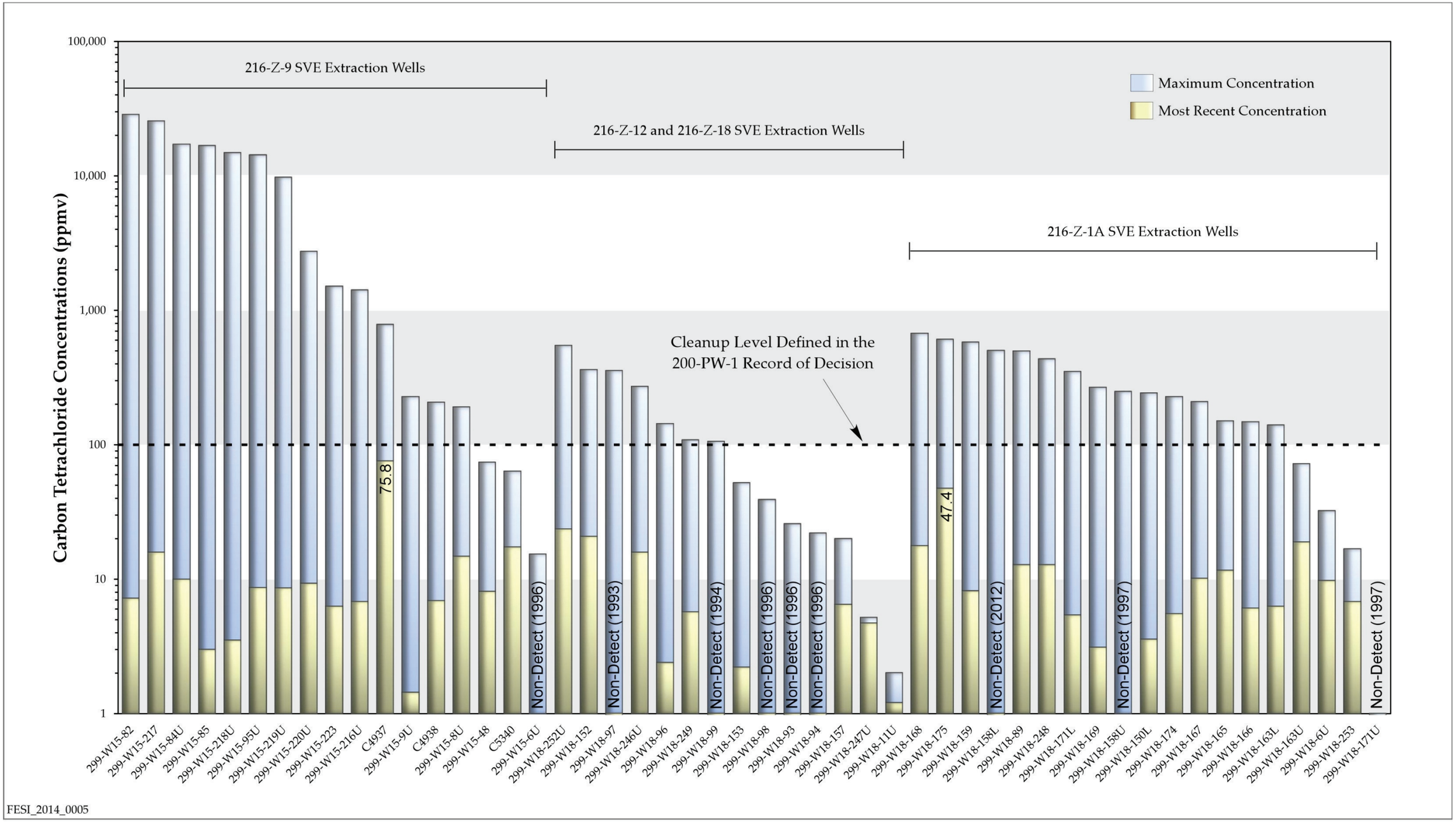

Figure 4-1. Historical Maximum Carbon Tetrachloride Concentration in SVE Wells with Perforated Intervals above the CCU (Data from 1993 through 2012)

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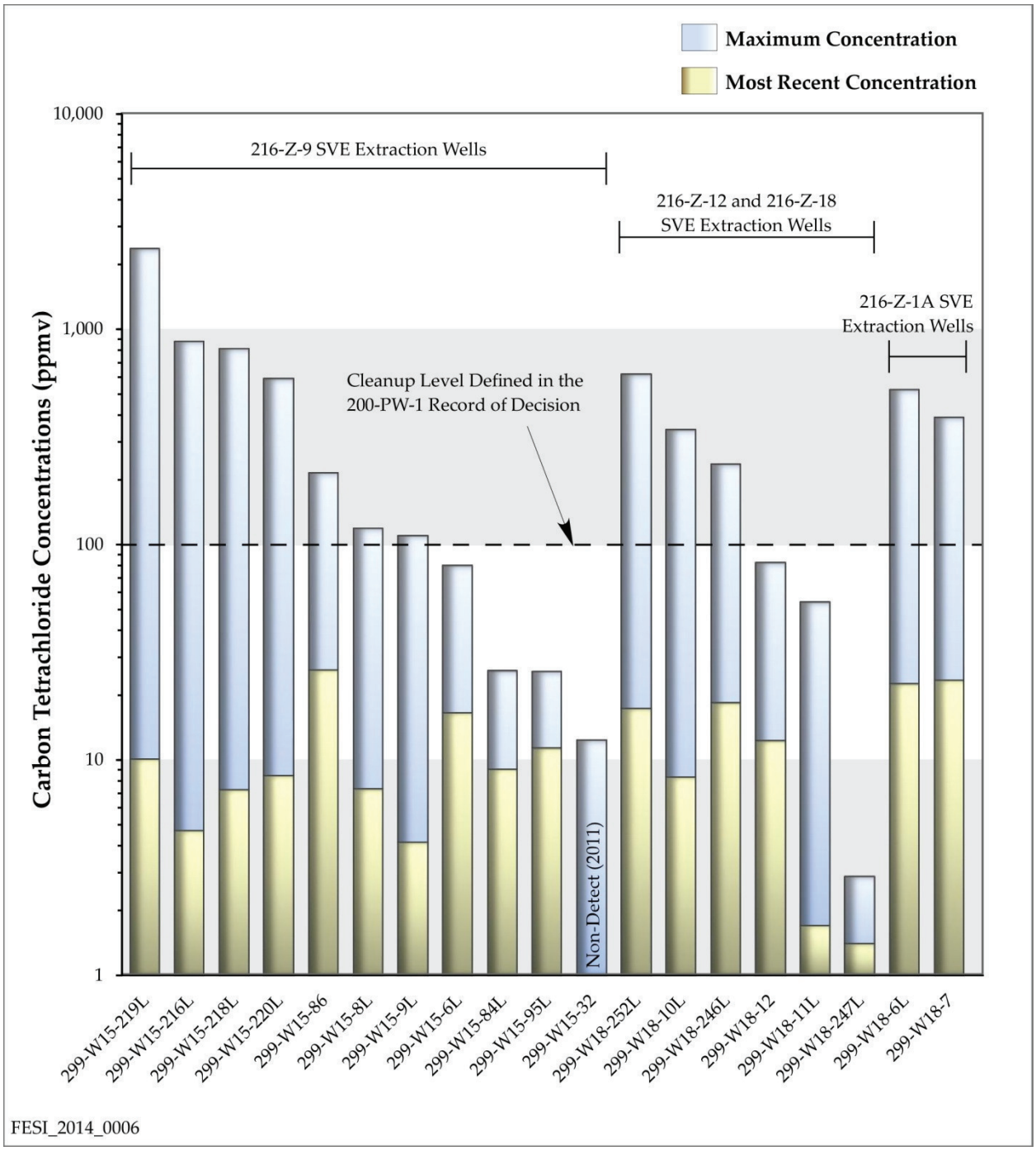

Figure 4-2. Historical Maximum Carbon Tetrachloride Concentrations in SVE Wells with Perforated Intervals below the CCU (Data from 1992 through 2012)

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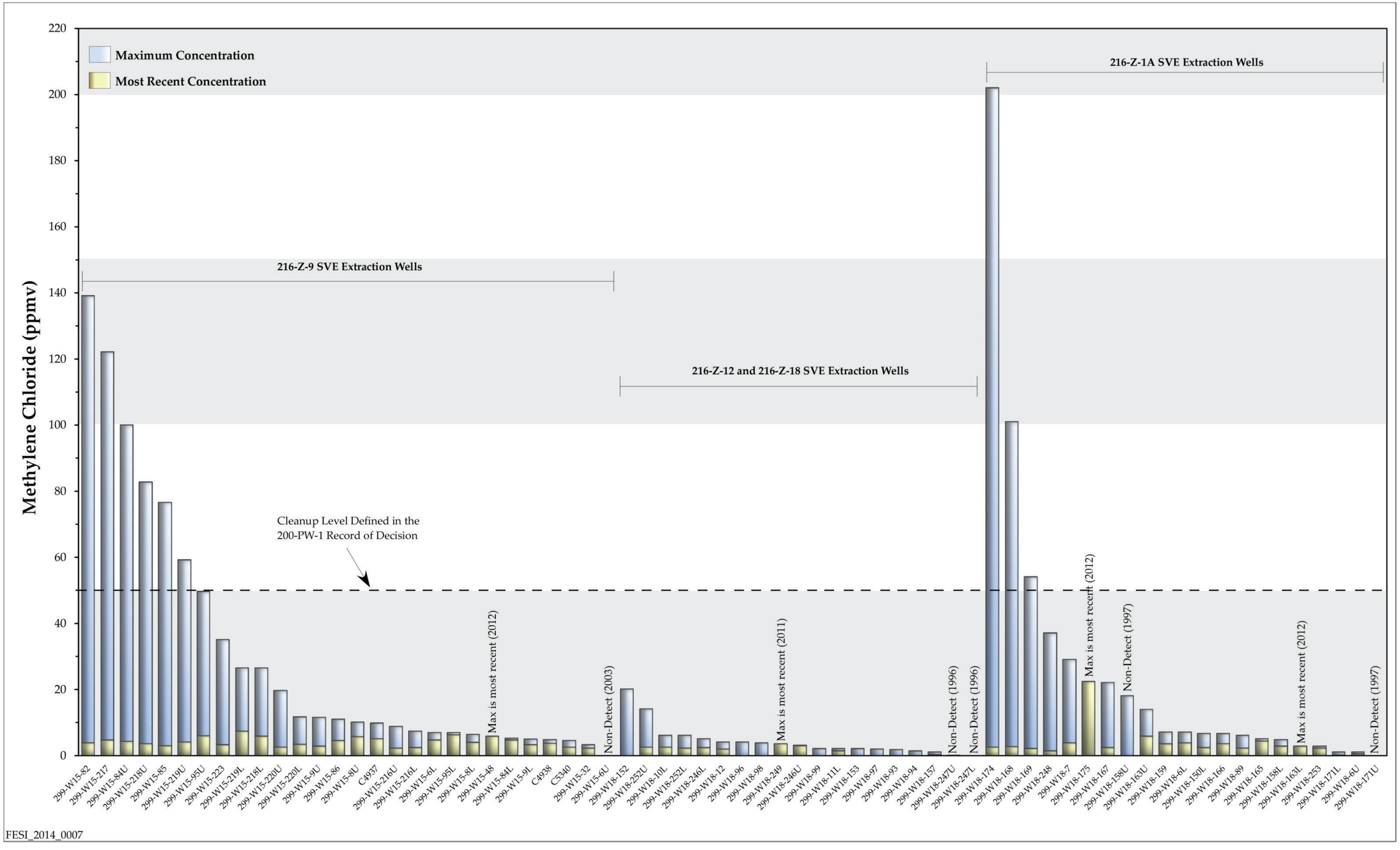


Figure 4-3. Historical Maximum Methylene Chloride Concentrations in SVE Wells (Data from 1992 through 2013)

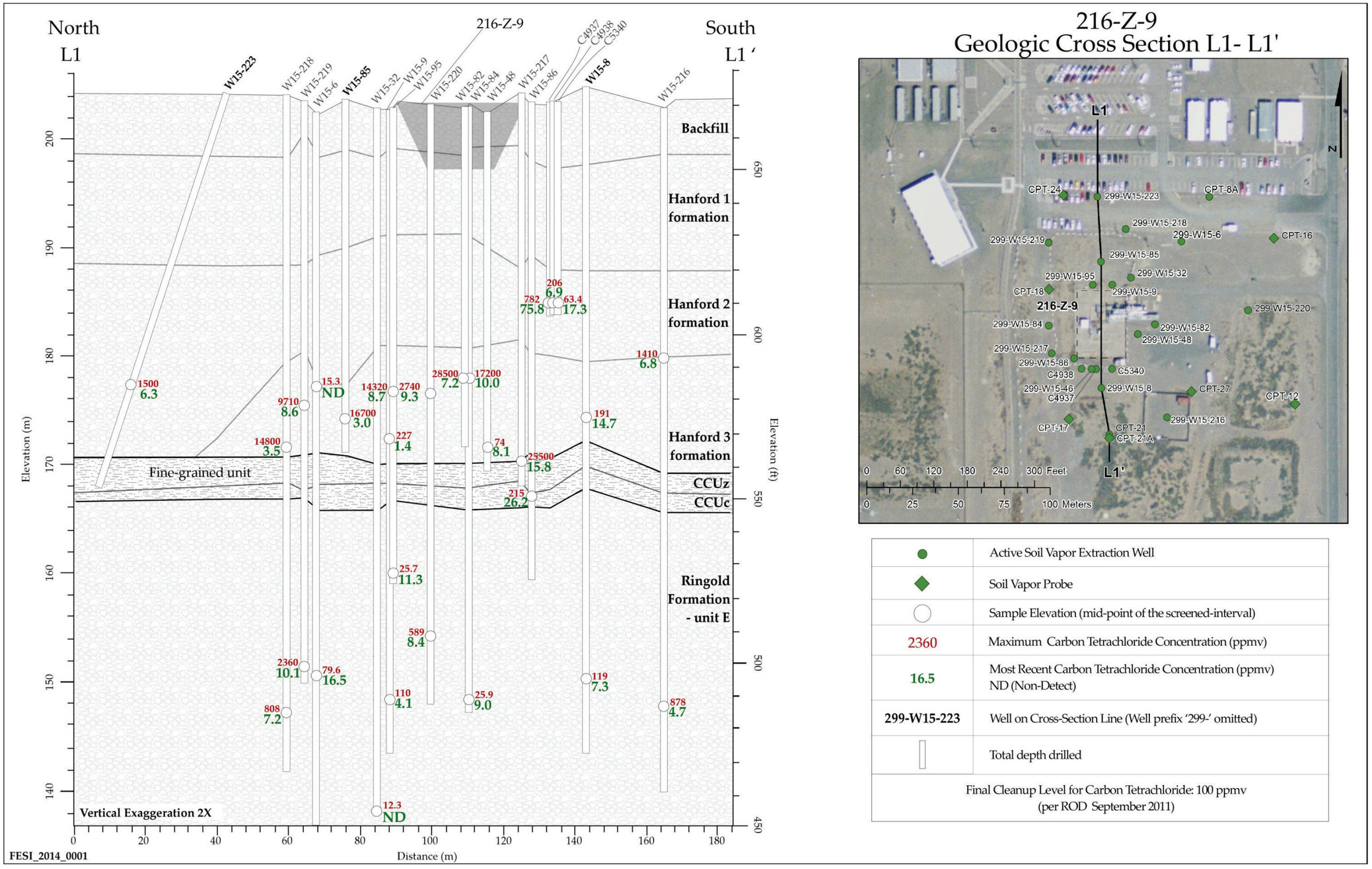


Figure 4-4. Cross Section of Historical Carbon Tetrachloride Concentrations in SVE Wells at 216-Z-9 Trench

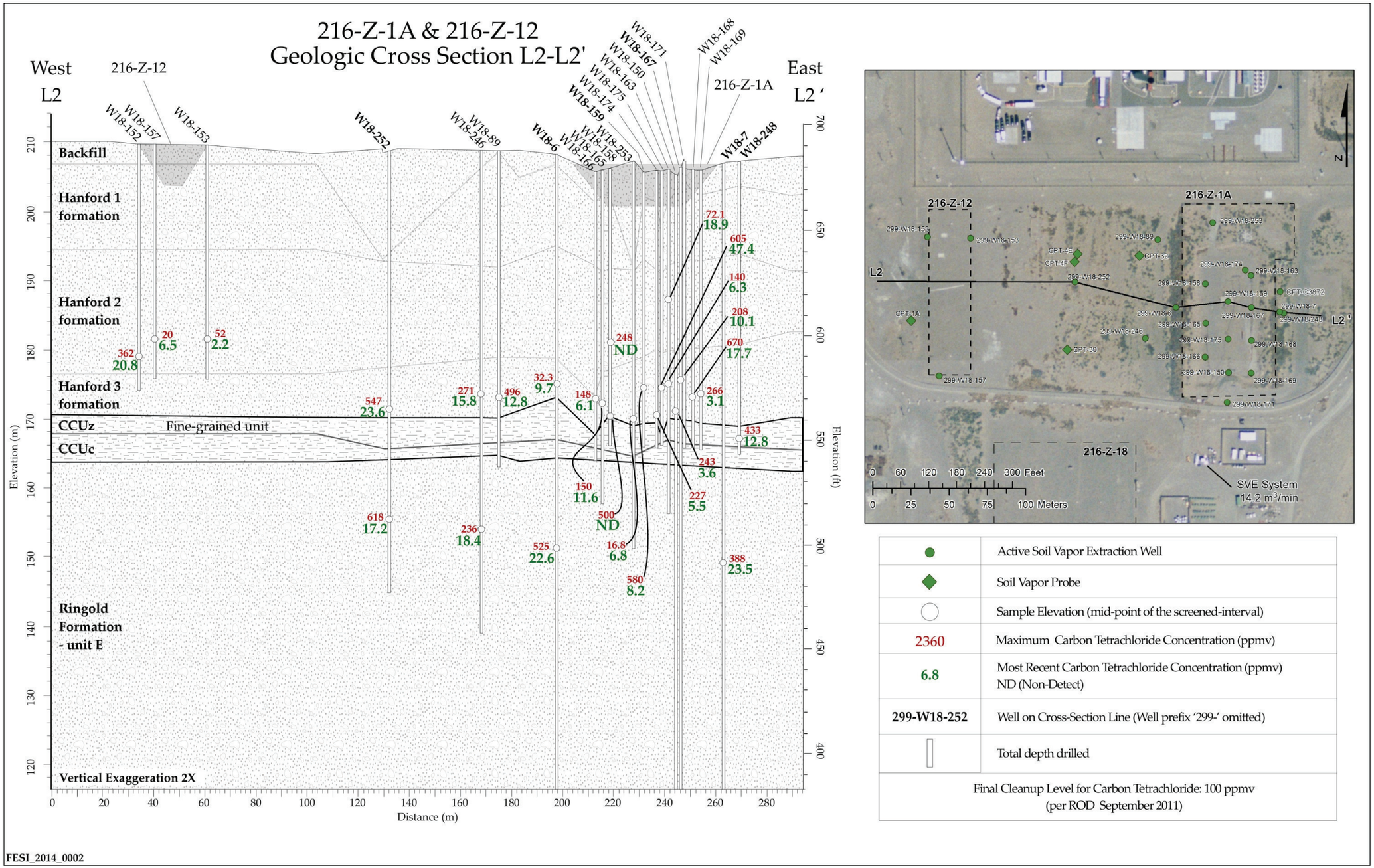


Figure 4-5. Cross Section of Historical Carbon Tetrachloride Concentrations in SVE Wells at 216-Z-1A Tile Field and 216-Z-12 Crib

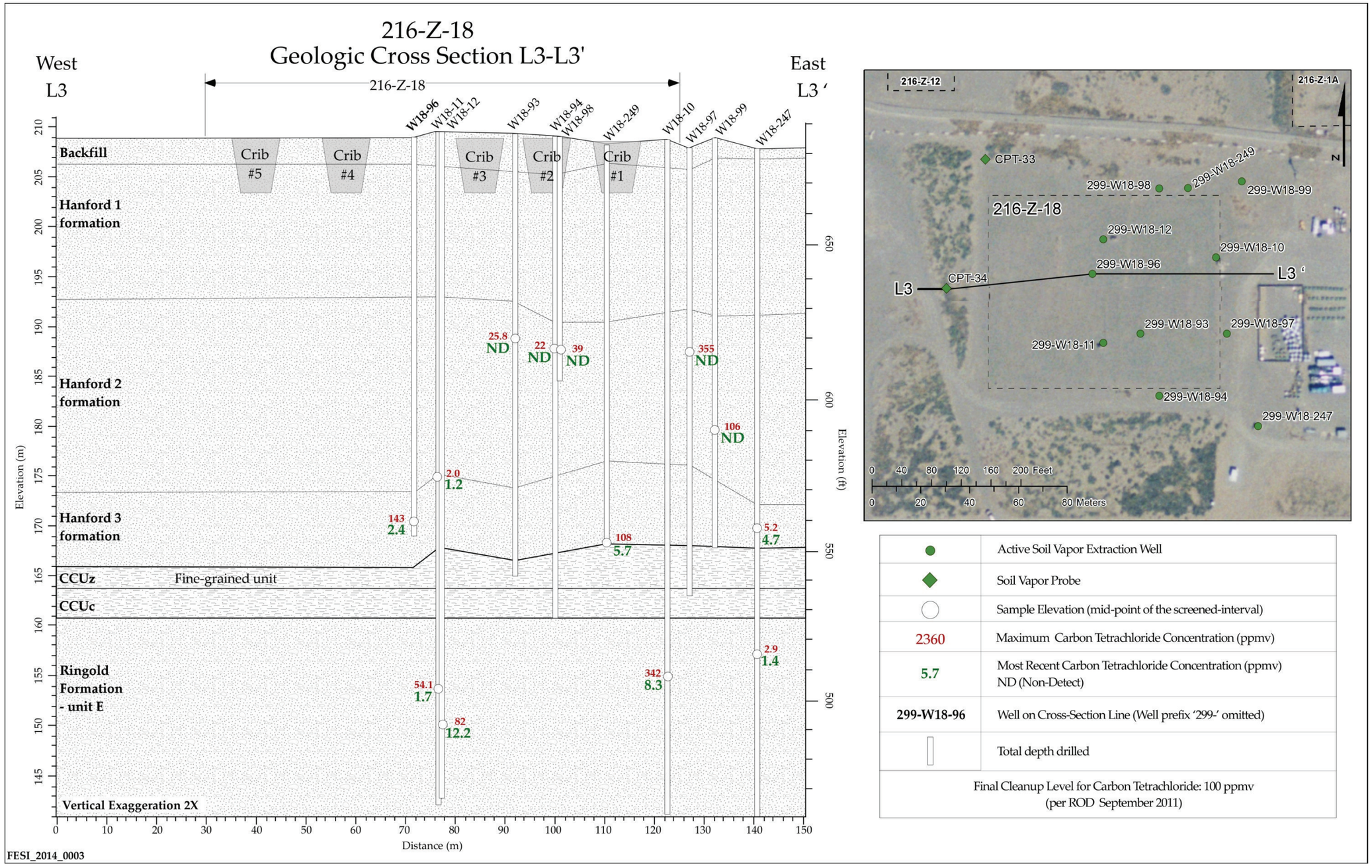
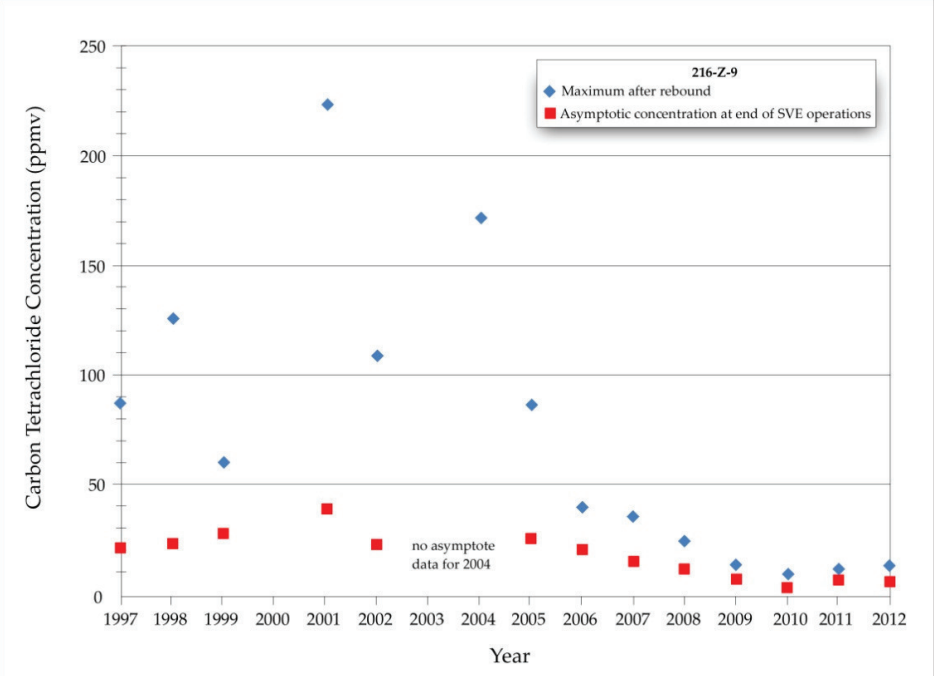
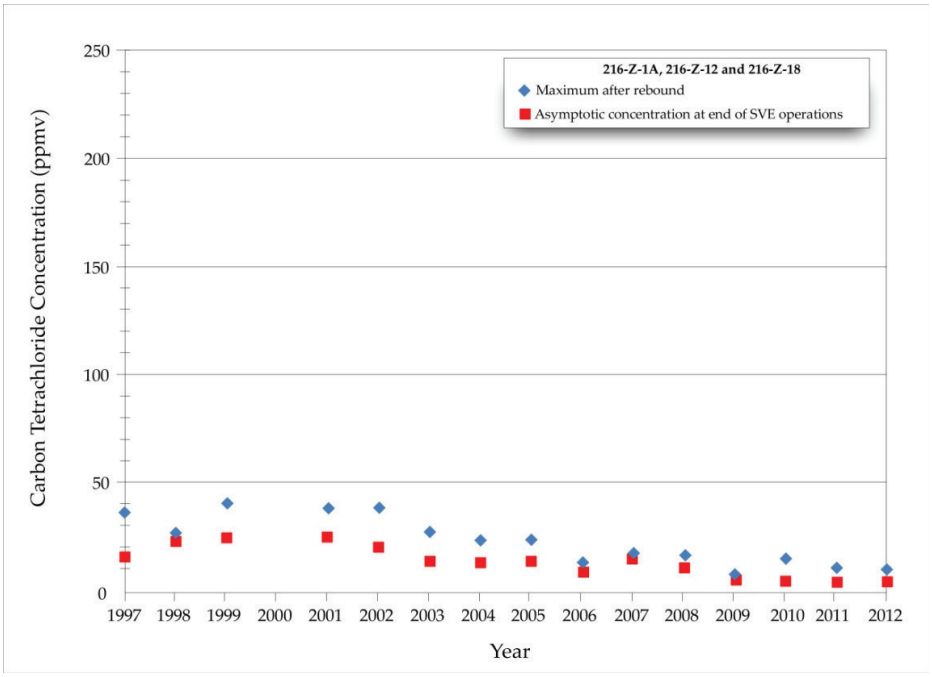


Figure 4-6. Cross Section of Historical Carbon Tetrachloride Concentrations in SVE Wells at 216-Z-18 Crib



Source: SGW-54566, *Performance Evaluation Report for Soil Vapor Extraction Operations at the 200-PW-1 Operable Unit Carbon Tetrachloride Site, Calendar Year 2012*; modified from PNNL-21326, *Treatability Test Report: Characterization of Vadose Zone Carbon Tetrachloride Source Strength Using Tomographic Methods at the 216-Z-9 Site*.

Figure 4-7. Annual Initial and Final Composite Carbon Tetrachloride Concentration Measured at the SVE System from Wells at 216-Z-9 (1997 through 2012)



Source: SGW-54566, *Performance Evaluation Report for Soil Vapor Extraction Operations at the 200-PW-1 Operable Unit Carbon Tetrachloride Site, Calendar Year 2012.*

Figure 4-8. Annual Initial and Final Composite Carbon Tetrachloride Concentration Measured at the SVE System from Wells at 216-Z-1A, 216-Z-12, and 216-Z-18 (1997 through 2012)

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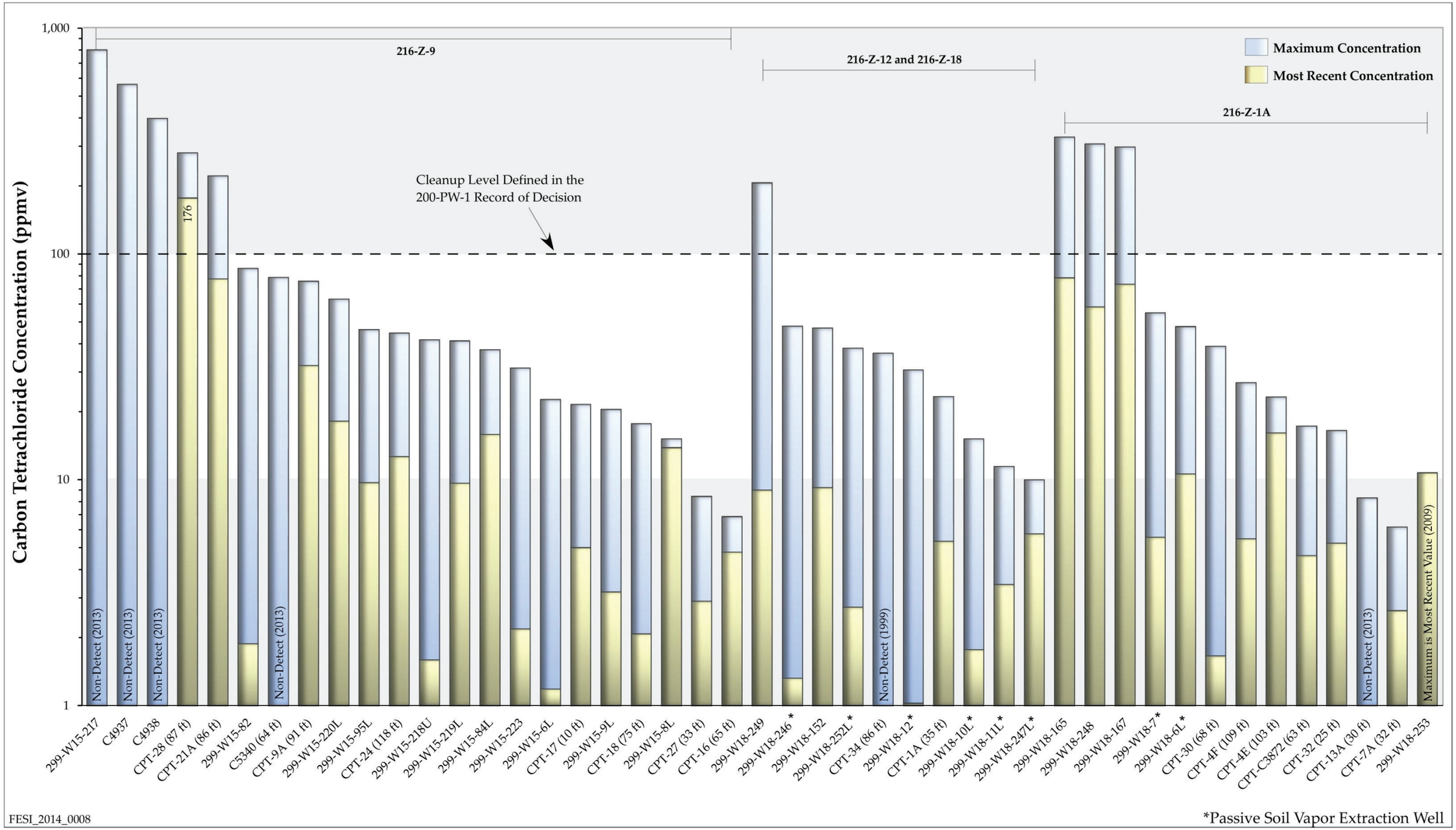

Figure 4-9. Historical Maximum Carbon Tetrachloride Concentrations in Monitoring Wells and Probes (Data from 1997 through 2013)

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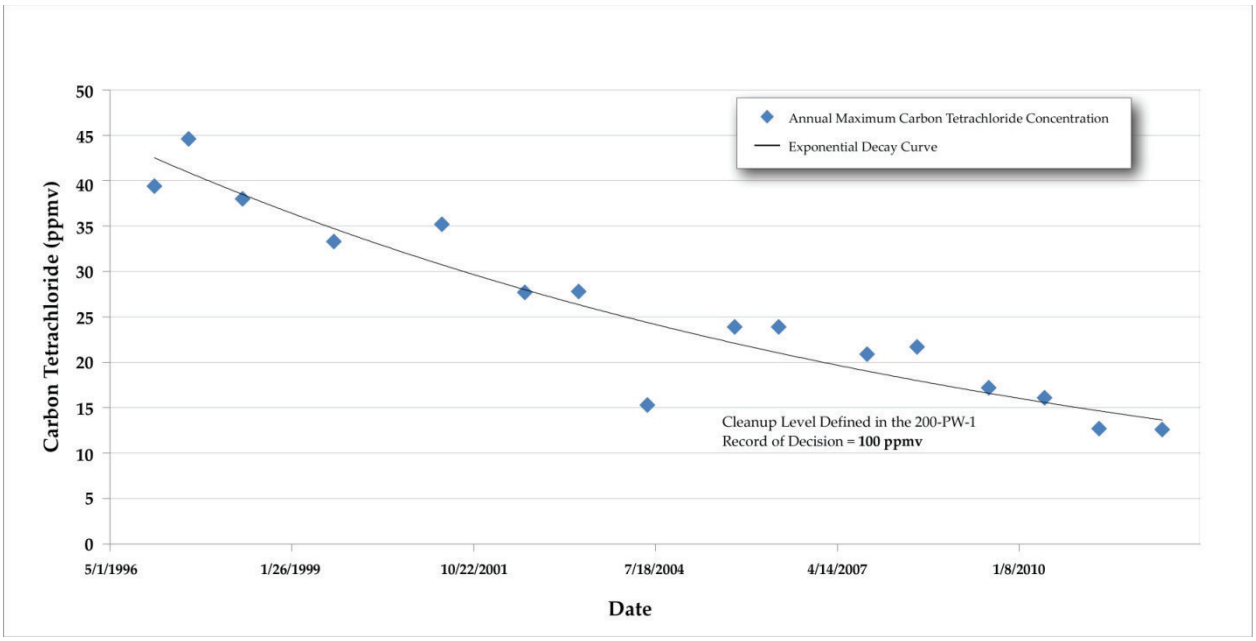

Figure 4-10. Carbon Tetrachloride Concentrations at CPT-24 (118 ft), near 216-Z-9 Trench (1996 through 2012)

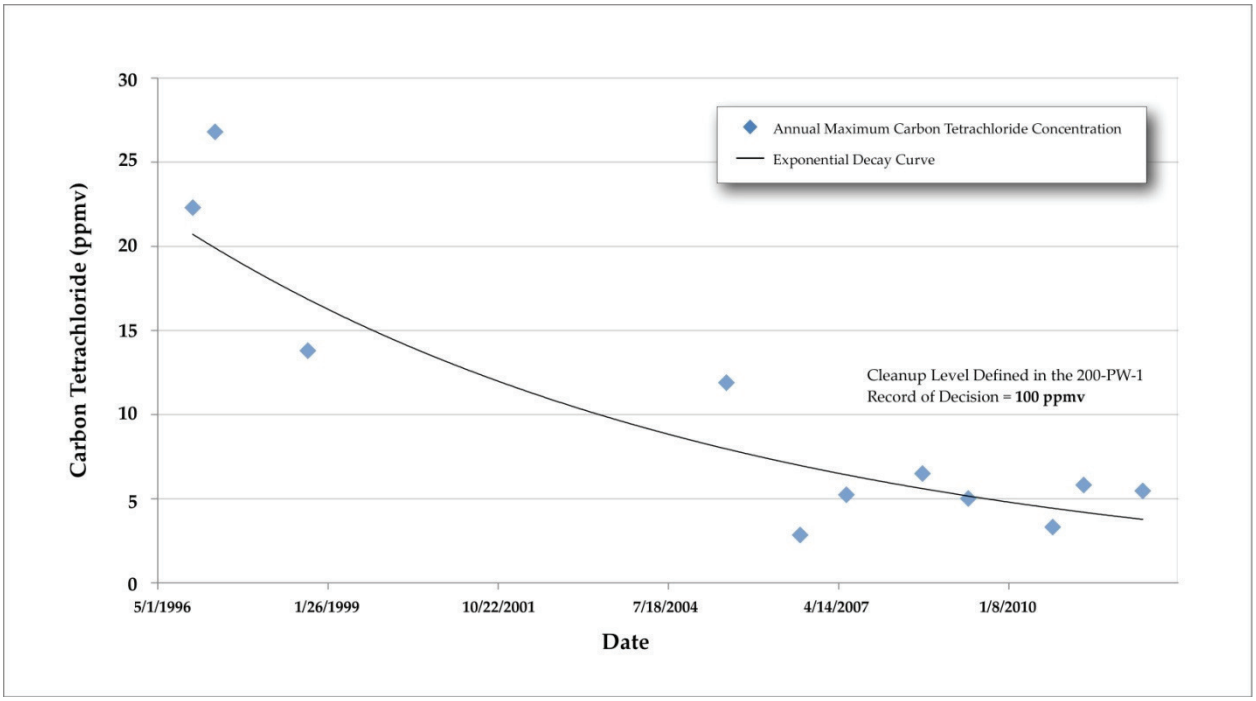

Figure 4-11. Carbon Tetrachloride Concentrations at CPT-4F (109 ft), near 216-Z-1A Tile Field (1996 through 2012)

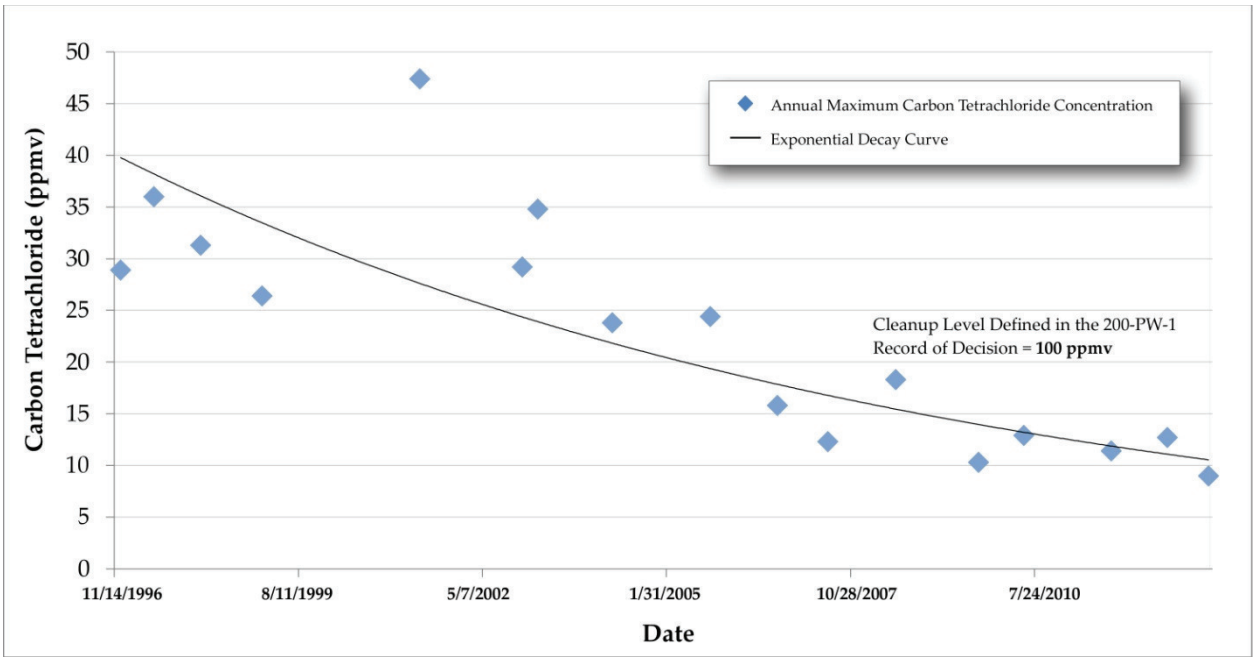

Figure 4-12. Carbon Tetrachloride Concentrations at Monitoring Well 299-W18-6L (172 ft), 216-Z-1A Tile Field (1996 through 2012)

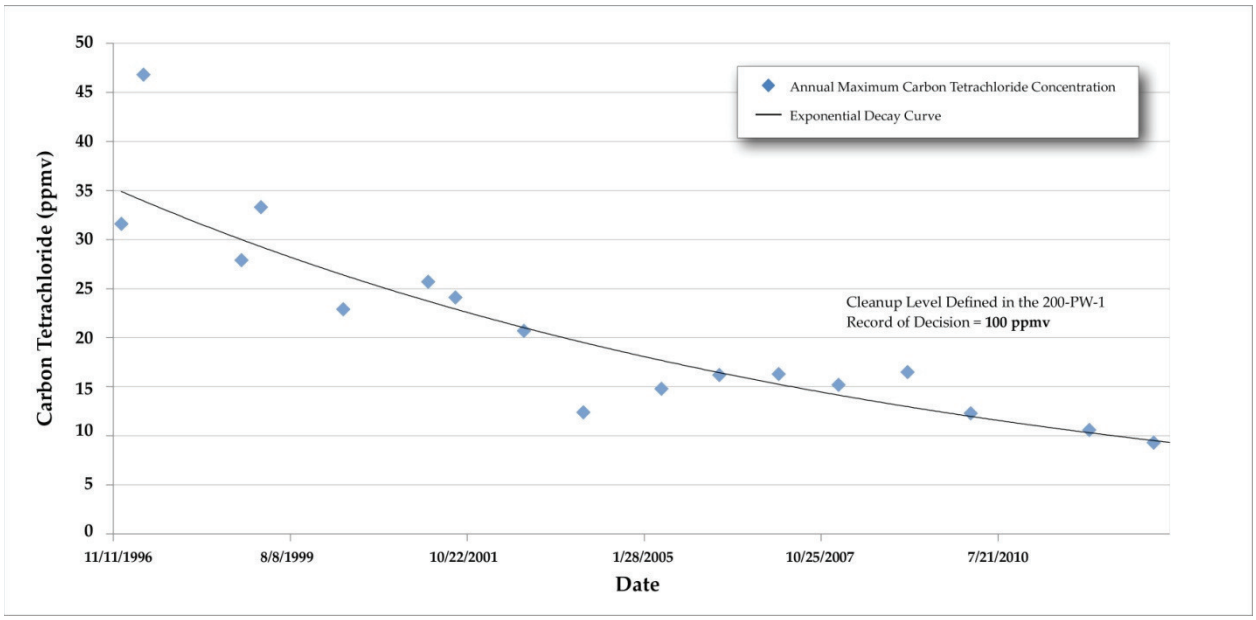

Figure 4-13. Carbon Tetrachloride Concentrations at Well 299-W18-152 (101 ft), 216-Z-12 Trench (1996 through 2012)

5 Guidance for Assessing Performance of Soil Vapor Extraction Operations

A guidance document pertaining to SVE system optimization, transition, and closure was recently published by Pacific Northwest National Laboratory, the U.S. Army Corps of Engineers, and EPA (PNNL-21843). The guidance presents a stepwise approach for gathering information and performing evaluations to support SVE remedy decisions. Steps include revisiting the conceptual site model; considering relevant information; quantifying the impact of remaining vadose zone contaminant sources on groundwater; and integrating the assessment outcomes into a decision logic approach to address optimization, transition, and closure decisions. Figure 5-1 summarizes the stepwise approach described in the PNNL-21843 guidance document.

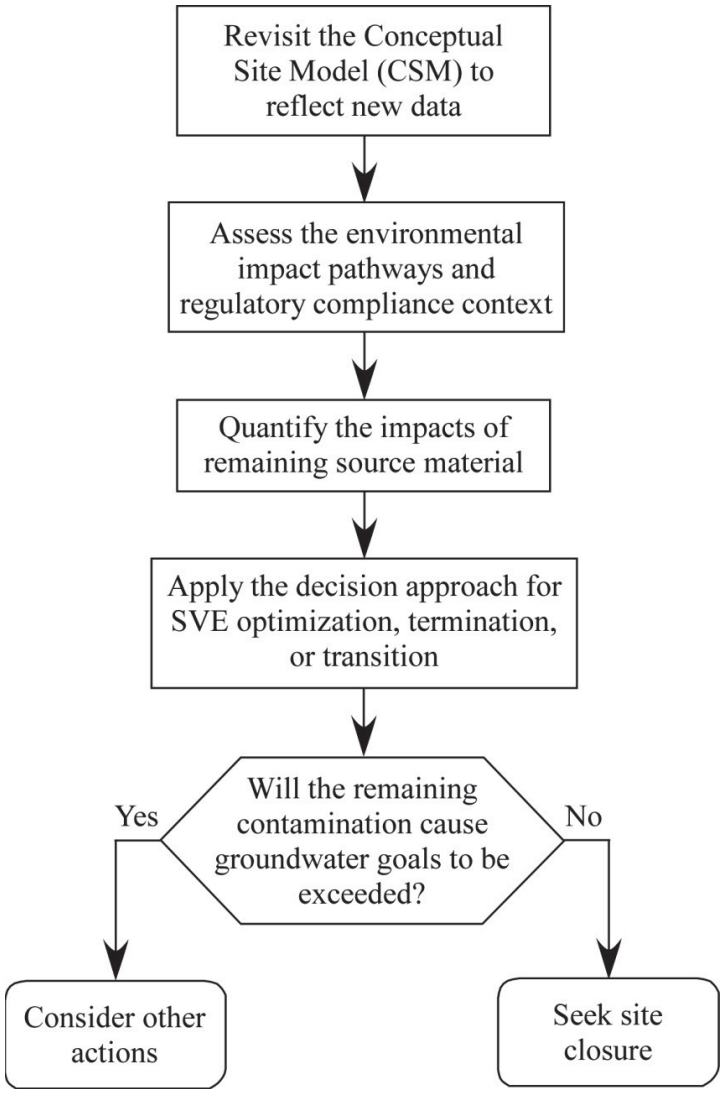

Figure 5-1. SVE System Closure Guidance Flow Sheet

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6 Conclusion

The DOE Richland Operations Office (DOE-RL) and EPA will use the SVE system optimization, transition, and closure guidance (PNNL-21843) approach to determine when 200-PW-1 SVE operations can be terminated. The general approach in the guidance will be specifically tailored to the 200-PW-1 OU SVE operations. Figure 6-1 provides a decision-making process flow sheet for the 200-PW-1 OU SVE systems.

Upon approval of this agreement, DOE-RL will evaluate the 200-PW-1 OU SVE operations according to the process outlined in Figure 6-1. The evaluation process and the results will be documented in a separate report.

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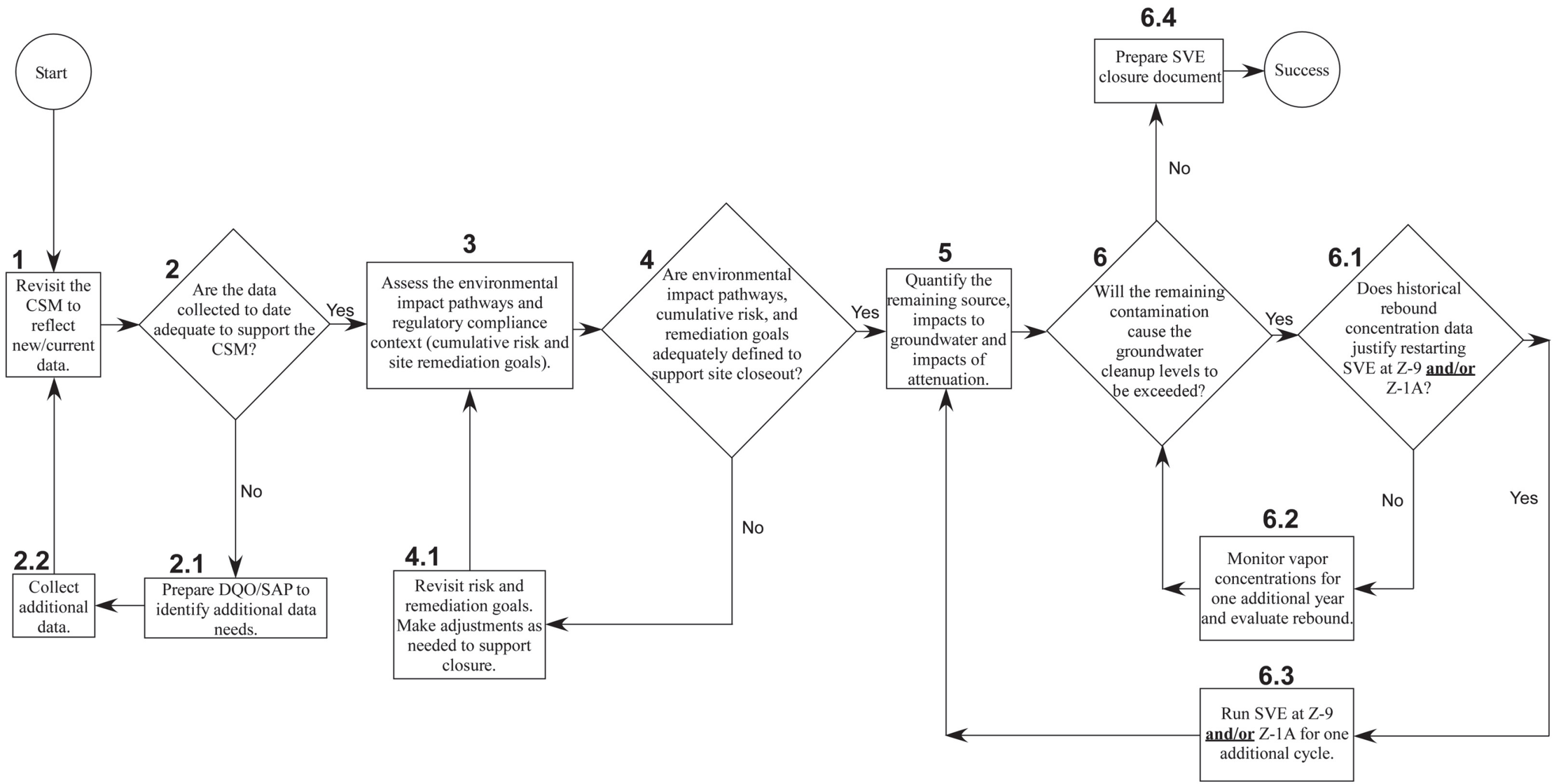

Figure 6-1. 200-PW-1 OU SVE System Path Forward Logic Flow Sheet

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7 References

BHI-00105, 1995, *Wellfield Enhancement Status Report and Data Package for the 200 West Area Carbon Tetrachloride Expedited Response Action*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI-01105, 1997, *Rebound Study Repot for the Carbon Tetrachloride Soil Vapor Extraction Site, Fiscal Year 1997*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D198067101.

DOE/RL-91-32, 1991, *Expedited Response Action Proposal (EE/CA) for 200 West Carbon Tetrachloride Plume*, Draft B, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196078303.

DOE/RL-2001-01, 2004, *Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, Rev. 0, Reissue, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D4573392.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D4361348.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D4361348.

DOE/RL-2006-51, 2007, *Remedial Investigation Report for the Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA05807591.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA05807868.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0805130070.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0805130071.

DOE/RL-2006-58, 2007, *Carbon Tetrachloride Dense Non-Aqueous Phase Liquid (DNAPL) Source Term Interim Characterization Report,* Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA04193109.

DOE/RL-2007-22, 2007, *Carbon-Tetrachloride Dense Non-Aqueous Phase Liquid (DNAPL) Source Term Characterization Report Addendum,* Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA04992076.

DOE/RL-2009-117, 2011, *Proposed Plan for the Remediation of the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093832.

DOE/RL-2010-79, 2010, *Treatability Test Plan for Characterization of Vadose Zone Carbon Tetrachloride Source Strength Using Tomographic Methods at the 216-Z-9 Site*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1010270169.

DOE/RL-2013-28, 2013, *Carbon Tetrachloride Soil Vapor Extraction System Monitoring and Operating Plan for CY 2013*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA and Ecology, 1992, "Action Memorandum: Expedited Response Action Proposal for 200 West Area Carbon Tetrachloride Plume," letter to R.D. Izatt (U.S. Department of Energy, Richland Operations Office), from R.F. Smith (U.S. Environmental Protection Agency, Region 10) and R. Stanley (Washington State Department of Ecology), January 21. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196088487.

EPA, Ecology, and DOE, 2011, *Record of Decision, Hanford 200 Area Superfund Site: 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093644.

PNL-7396, 1990, *Hanford Site Ground-Water Surveillance for 1989*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196055127.

PNNL-21326, 2012, *Treatability Test Report: Characterization of Vadose Zone Carbon Tetrachloride Source Strength Using Tomographic Methods at the 216-Z-9 Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1210310436.

PNNL-21843, 2013, *Soil Vapor Extraction System Optimization, Transition and Closure Guidance*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088374.

SGW-53024, 2012, *200-PW-1 Operable Unit Soil Vapor Extraction System Operational Strategy*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

SGW-54566, 2013, *Performance Evaluation Report for Soil Vapor Extraction Operations at the 200-PW-1 Operable Unit Carbon Tetrachloride Site, Calendar Year 2012*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

WHC-SD-EN-TI-063, 1992, *FY92 Site Characterization Status Report and Data Package for the Carbon Tetrachloride Site*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=D196113606.

WHC-SD-EN-TI-202, 1993, *200 West Carbon Tetrachloride Expedited Response Action: Volatile Organic Compounds – Arid Integrated Demonstration*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=D196108184.

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