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Rebound Study Report for the Carbon Tetrachloride Soil Vapor Extraction Site, Fiscal Year 1997

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Richland, Washington

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Rebound Study Report for the Carbon Tetrachloride Soil Vapor Extraction Site, Fiscal Year 1997

Author
V. J. Rohay

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EXECUTIVE SUMMARY

A rebound study was conducted at the 200-ZP-2 carbon tetrachloride soil vapor extraction (SVE) site from October 1996 through September 1997. The purpose of the study was to evaluate the increase in carbon tetrachloride concentrations following shutdown of the SVE systems. The scope of the study included monitoring carbon tetrachloride vapor concentrations, evaluating the carbon tetrachloride concentration rebound, and addressing the issues identified in the Data Quality Objectives meeting. During the time when the SVE systems were off-line (November 1996 through July 1997), carbon tetrachloride concentrations were monitored at 90 subsurface monitoring locations ranging in depth from 1.5 m to 64 m. Carbon tetrachloride concentrations were also measured at on-line wells during the week prior to shutdown of the SVE systems and following restart of the SVE systems. Carbon tetrachloride and subsurface pressure data collected during five short-term tests were evaluated from June through September 1997 to supplement the rebound study data evaluation. Three of the tests were also conducted during this time; two were conducted during previous site activities.

The primary conclusions of the 200-ZP-2 rebound study, and their implications regarding project issues, are as follows.

1. Amount of additional carbon tetrachloride available for removal using SVE

- Carbon tetrachloride concentrations rebounded significantly (i.e., by an order of magnitude) at only five locations, indicating that in many areas the readily accessible mass has been removed and the availability of additional carbon tetrachloride is limited by diffusion from contaminant sources (e.g., lower permeability zones).

- During the first 3 weeks of SVE operations following 8 months of rebound, the SVE systems were extracting an average of 178 kg of carbon tetrachloride per week; but after 7 weeks, SVE extraction was approaching the pre-shutdown rate of 100 kg of carbon tetrachloride per week.

2. Distribution of Remaining Carbon Tetrachloride Sources

- The maximum carbon tetrachloride rebound concentrations were detected at sampling locations from 25 to 40 m depth, suggesting that the remaining carbon tetrachloride available for SVE is primarily associated with the lower permeability zone at approximately 40-m depth.

- Carbon tetrachloride concentrations near the water table increased relatively slowly, suggesting that volatilization of dissolved carbon tetrachloride from the groundwater into the unsaturated zone, or downward migration of carbon tetrachloride from the lower permeability zone toward the groundwater, is occurring slowly relative to the 8-month-long rebound study period.

3. Evaluation of the Carbon Tetrachloride Transport Between the Unsaturated and Saturated Zones

- Carbon tetrachloride concentrations in the soil vapor and underlying groundwater do not appear to be in equilibrium, and the expected direction of carbon tetrachloride migration is from the groundwater to the unsaturated zone.

- Because carbon tetrachloride concentrations increased relatively slowly near the water table, temporarily suspending operation of the SVE systems for 8 months appears to have caused no additional degradation of groundwater quality.

4. Effectiveness of Using SVE for Plume Control in the Unsaturated Zone

- Because carbon tetrachloride concentrations did not increase significantly at the 1.5-m-deep shallow probes, temporarily suspending operation of the SVE systems for 8 months appears to have caused minimal detectable vertical transport of carbon tetrachloride through the soil surface to atmosphere.

- Because carbon tetrachloride concentrations did not increase significantly at a limited number of laterally distant probes, temporarily suspending operation of the SVE systems for 8 months appears to have caused minimal detectable lateral transport of carbon tetrachloride beyond the area remediated using SVE.

- Carbon tetrachloride soil vapor moves through the subsurface by advection driven by barometric pressure fluctuations and by diffusion, indicating that the subsurface is a dynamic system and that soil vapor concentrations will migrate over time.

- As carbon tetrachloride migrates, it will tend to be redistributed in the subsurface and can be adsorbed in previously uncontaminated or remediated areas.

5. Optimization of Current SVE System Operations

- To optimize the mass removal of carbon tetrachloride per unit time using SVE, the minimum operating cycle should be 4 to 8 weeks of SVE operation followed by 8 to 16 weeks of rebound.

- The optimum operating cycle is likely to change as SVE continues and should be re-evaluated for each succeeding period of operations.

- Extending the period of nonoperation up to 8 months does not necessarily degrade groundwater quality, but does reduce the total mass that could have been removed during that time.

6. Identification and Achievement of Cleanup Goals

- The spatial and temporal variability of the magnitude and rate of carbon tetrachloride rebound indicates some of the complexities associated with selecting a single numerical target level.

7. Selection of Final Remedy for Carbon Tetrachloride in the Unsaturated Zone

- The increasingly slower release rate of carbon tetrachloride vapor in the subsurface is consistent with a previous study at the 200-ZP-2 site that suggested that SVE will only remove 10% to 15% of the initial mass in the subsurface under ideal conditions where flow is passing directly through the area of contamination, and that the release of the remaining mass is limited by slow diffusion kinetics.

- Passive SVE, which operates at the same rate that contaminant is released in mass-transfer limited cases, may become a more attractive alternative for continued 200-ZP-2 operations.

- Evaluation of supplemental testing indicates that the incorporation of a one-way valve in passive soil extraction systems can increase the carbon tetrachloride removal rate.

The primary recommendations regarding the 200-ZP-2 vapor extraction project indicated by the rebound study data are as follows.

1. Implement cyclic operation of the SVE systems using a minimum of 4 to 8 weeks of operation followed by 8 to 16 months of rebound to optimize the carbon tetrachloride mass removal rate.

2. Implement carbon tetrachloride vapor monitoring during future periods of nonoperation of the SVE systems to confirm that groundwater quality is not being degraded and to evaluate the changes to carbon tetrachloride rebound rates that are expected as mass and distance to residual sources change.

3. Refine the remedial action goals and objectives of the 200-ZP-2 vapor extraction project.

ACKNOWLEDGMENTS

Design and fabrication of the field sampling equipment and successful collection of the rebound study data from November 1996 through September 1997 was performed by Randy Coffman, Glenn Johnson, Jeff Gale, Rhett Tranbarger, Rick Kerkow, Carlos Parker, and Bob Edrington. Bill McMahon analyzed the Fiscal Year 1992-1993 in situ soil vapor and groundwater data and wrote Appendix J of this report; Craig Swanson analyzed the Fiscal Year 1995 surface cover data and wrote Appendix K of this report.

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1.0 INTRODUCTION

This report presents the field measurements and evaluation of the rebound of carbon tetrachloride vapor concentrations during an 8-month shutdown of the 200-ZP-2 soil vapor extraction (SVE) systems in the 200 West Area of the Hanford Site. The magnitude, extent, and rate of rebound in carbon tetrachloride vapor concentrations during this shutdown period have been evaluated to determine the availability of additional carbon tetrachloride for removal using SVE.

1.1 PURPOSE AND SCOPE OF REBOUND STUDY

The three SVE systems were shut down in November 1996 to both minimize the generation of water condensate during the winter months and to enable the rebound study to be conducted. In March 1997, the shutdown was extended through the summer as a cost saving measure implemented because the rebound concentration increases were relatively low. The rebound study was conducted during the 8 months that the SVE systems were not operating. The purpose of the rebound study was to evaluate the increase in carbon tetrachloride concentrations and to recommend changes to optimize future SVE system operations.

The scope of the rebound study was to:

- Measure the carbon tetrachloride vapor concentrations periodically at multiple subsurface monitoring points within the radial influence of the SVE systems
- Evaluate the magnitude, extent, and rate of increase in carbon tetrachloride vapor concentrations in support of future remediation recommendations
- Use the rebound study data to address the 200-ZP-2 project issues identified during the Data Quality Objectives (DQO) meeting.

Results of five short-term tests were evaluated from June through August 1997 to supplement the rebound study data evaluation. Three of these tests were also conducted during this time; two were conducted during previous site activities. The scope of these tests was to:

- Measure carbon tetrachloride vapor concentrations and subsurface pressures periodically manually or using automated systems at specific monitoring points
- Evaluate the impact of engineered enhancements on the carbon tetrachloride removal rate
- Evaluate the relationship between concentration measurements and sources of variability.

1.2 BACKGROUND

Carbon tetrachloride, discharged to the soil column from 1955 to 1973, was observed throughout the 66-m-thick unsaturated zone during site characterization from 1991 to 1993. Soil vapor extraction was initiated in February 1992 as the preferred remedial alternative for the Carbon Tetrachloride Expedited Response Action (ERA) for removal of carbon tetrachloride from the unsaturated zone beneath the primary carbon tetrachloride disposal sites. By September 1997, three SVE systems had been used to remove 75,000 kg of carbon tetrachloride from the subsurface and inlet vapor concentrations had decreased from a maximum of approximately 30,000 parts per million by volume (ppmv) to 25 ppmv.

1.2.1 Carbon Tetrachloride Waste Disposal

A total of 570,000 to 920,000 kg of carbon tetrachloride is estimated to have been discharged to the soil column between 1955 and 1973 in the 200 West Area (Table 1-1) (DOE-RL 1991). The three primary carbon tetrachloride disposal sites during this period were the 216-Z-9 Trench (Z-9), the 216-Z-1A Tile Field (Z-1A), and the 216-Z-18 Crib (Z-18) (Figure 1-1). In addition, carbon tetrachloride was discharged in lesser amounts to the 216-Z-12 Crib (Z-12).

1.2.2 Characteristics of the Unsaturated Zone

The unsaturated zone underlying the three principal carbon tetrachloride disposal sites currently averages 66 m thick and consists of gravel-, sand-, and silt-dominated sedimentary intervals. For discussion purposes, the unsaturated zone has been divided into seven informal hydrogeologic units. Although the thickness and configuration of these units vary laterally across the carbon tetrachloride vapor extraction site, average values are used to summarize the characteristics of the unsaturated zone (Table 1-2).

The presence of the less permeable Hanford lower fine and Plio-Pleistocene ("caliche") intervals within the sequence of more permeable sand and gravel layers affects both the distribution and remediation of carbon tetrachloride in the unsaturated zone. The lower permeability of these units probably slowed the vertical migration of organic and aqueous liquid and vapor phases and most likely temporarily diverted them laterally away from the waste disposal sites. Because this relatively low permeability zone also has greater soil particle surface area, it potentially adsorbed more carbon tetrachloride. Finally, the less permeable Hanford lower fine and Plio-Pleistocene intervals effectively divide the SVE wellfield into two zones: an upper zone from the ground surface to the top of the Hanford lower fine layer and a lower zone from the bottom of the Plio-Pleistocene layer to the water table.

1.2.3 Carbon Tetrachloride Distribution

Carbon tetrachloride was found throughout the unsaturated zone underlying the three primary disposal sites during site characterization from 1991 through 1993. Laterally, the highest carbon tetrachloride concentrations in sediment samples were consistently observed at the 216-Z-9 site. Vertically, the highest concentrations at all three sites were associated with the fine-grained, less permeable Hanford lower fine and Plio-Pleistocene units (Rohay et al. 1994).

1.2.4 Vapor Extraction Wells and Monitoring Probes

There are currently 46 drilled wells available for on-line extraction and/or monitoring (Figure 1-1). Thirteen of these wells were drilled during 1992 and 1993 and were completed as vapor extraction wells with stainless steel casing and screens; one well was drilled at a 45° incline. Thirty-three wells, drilled between 1954 and 1978 and completed with carbon steel casing, were adapted for vapor extraction by perforating the well casing using mechanical or jet perforators. Seventeen of the 46 available wells have two screened or perforated open intervals (designated U for upper and L for lower) isolated by downhole packers. Twenty-one open intervals are available at each of the three wellfields, 216-Z-18/12, 216-Z-1A, and 216-Z-9 (Figure 1-2). Well diameters range from 6.4 to 20 cm. Each of the three SVE systems extracts simultaneously from multiple wells open either above and/or below the Plio-Pleistocene layer.

There are 125 subsurface monitoring points at depths greater than 2 m: 11 cone penetrometer (CPT) wells, 104 CPT soil vapor probes, and 10 stainless steel tubes. A CPT was used to install 11 extraction and/or monitoring wells and 104 subsurface monitoring probes emplaced at 33 locations at the carbon tetrachloride site in 1993 and 1994 (Figure 1-1). The 11 CPT wells are constructed of 2.5-cm-diameter carbon steel rods. The open interval, located at the bottom of each well, consists of 4 m of rod machined with thirty-three 0.6-cm-diameter holes per each 1-m interval. Each of the 104 CPT subsurface monitoring probes consists of a sintered metal monitoring screen (12.7 cm long with an outside diameter of 1.3 cm) attached to a tube that runs to the surface. Each monitoring screen is surrounded by a column of up to 1.2 m of clean sand; bentonite was added to the column between sampling probes to isolate them (Figure 1-3). Up to five monitoring screens were installed per location at various depths (Figure 1-2). Ten stainless steel tubes were strapped to the outside of the casing of four drilled wells during installation in 1993 to allow monitoring above and below the screened intervals (Figure 1-4).

A network of 73 shallow soil vapor probes was installed between 1991 and 1995 at depths ranging from 1.2 to 1.8 m below ground surface (Figure 1-5). Some of the probes are no longer available because the tubes have broken at or below the surface, the probe has been removed, or the probe has been covered over with gravel or asphalt.

1.2.5 Carbon Tetrachloride Remediation Using Soil Vapor Extraction

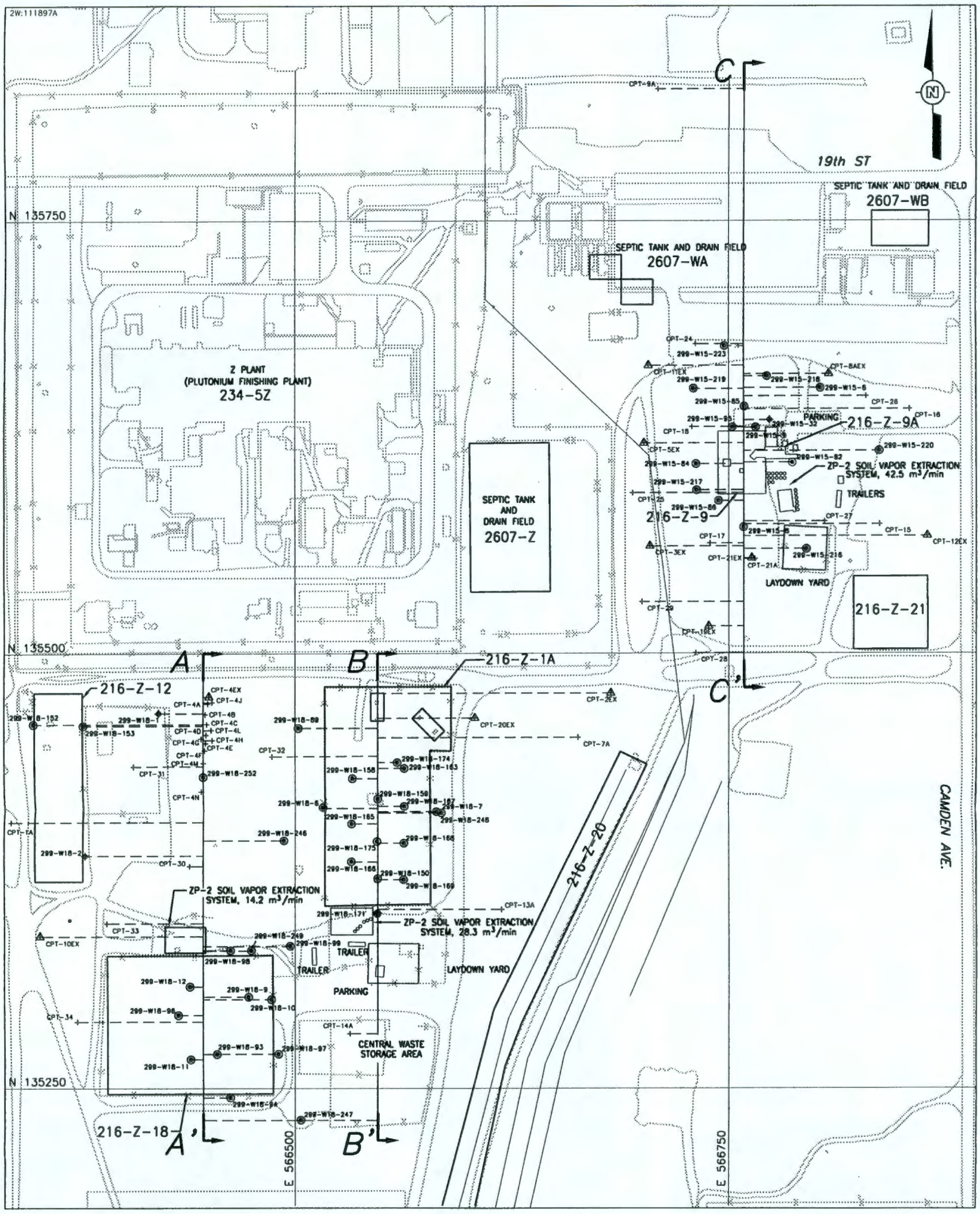
Soil vapor extraction was initiated in February 1992 to remove carbon tetrachloride from the unsaturated zone underlying the primary disposal sites. As of September 1997, 75,000 kg of carbon tetrachloride had been removed from the subsurface (Table 1-1). The mass of carbon tetrachloride removed from the 216-Z-1A, 216-Z-18, and 216-Z-12 sites is reported as a combined value because wells from the 216-Z-1A and 216-Z-18 sites were undergoing extraction simultaneously using one SVE system in 1992 and 1993, and wells from the 216-Z-18 and 216-Z-12 sites have been undergoing extraction simultaneously using another SVE system since 1995. The wellfields at these sites overlap.

The zone of influence of SVE operations above the Plio-Pleistocene layer in the Z-9 area was estimated as 59,000 m^2 and in the Z-1A/Z-18/Z-12 area as 150,000 m^2, based on airflow modeling using measurements of SVE vacuum and flow made in 1995 and 1996. Below the

Plio-Pleistocene layer, the zone of influence of SVE operations was estimated to be 20,000 m^2 in the Z-9 area and 150,000 m^2 in the Z-1A/Z-18/Z-12 area (Rohay and McMahon 1996).

Carbon tetrachloride concentrations in extracted soil vapor have decreased significantly at all three wellfields during operation of the SVE systems. The most dramatic decrease has been at the 216-Z-9 wellfield, where carbon tetrachloride concentrations in extracted soil vapor have declined from approximately 30,000 ppmv in 1993 to 25 ppmv in 1996. In comparison, carbon tetrachloride concentrations in soil vapor extracted from the 216-Z-1A wellfield have declined from approximately 1,500 ppmv in 1992 to 15 ppmv in 1996.

The three SVE systems have been operated 24 hours/day, 7 days/week at a typical operating efficiency of 90% at the carbon tetrachloride site since 1994 (Rohay 1996b). The 42.5-m^3/min SVE system is used to extract from wells at the 216-Z-9 site; the 28.3-m^3/min SVE system is used to extract from wells at the 216-Z-1A site; and the 14.2-m^3/min SVE system is used to extract from wells at the 216-Z-18/12 site.



SCALE 1:2500

25 0 25 50 100

1 cm = 25 meters

LEGEND

+ CPT-33	CONE PENETROMETER SOIL VAPOR PROBE LOCATION AND NUMBER DESIGNATION
CPT-4EX	CONE PENETROMETER SOIL VAPOR EXTRACTION WELL LOCATION AND NUMBER DESIGNATION
299-W15-82	200-ZP-2 SOIL VAPOR EXTRACTION/MONITORING WELL LOCATION AND NUMBER DESIGNATION
299-W18-1	ADDITIONAL NEARBY MONITORING WELL LOCATION AND NUMBER DESIGNATION
216-Z-18	LIQUID WASTE DISPOSAL SITE
A—A'	CROSS SECTION LOCATION

Figure 1-1. Carbon Tetrachloride Vapor Extraction Site.

Figure 1-2a. Cross Section Through the 216-Z-18/Z-12 Wellfield. (Location shown in Figure 1-1.)

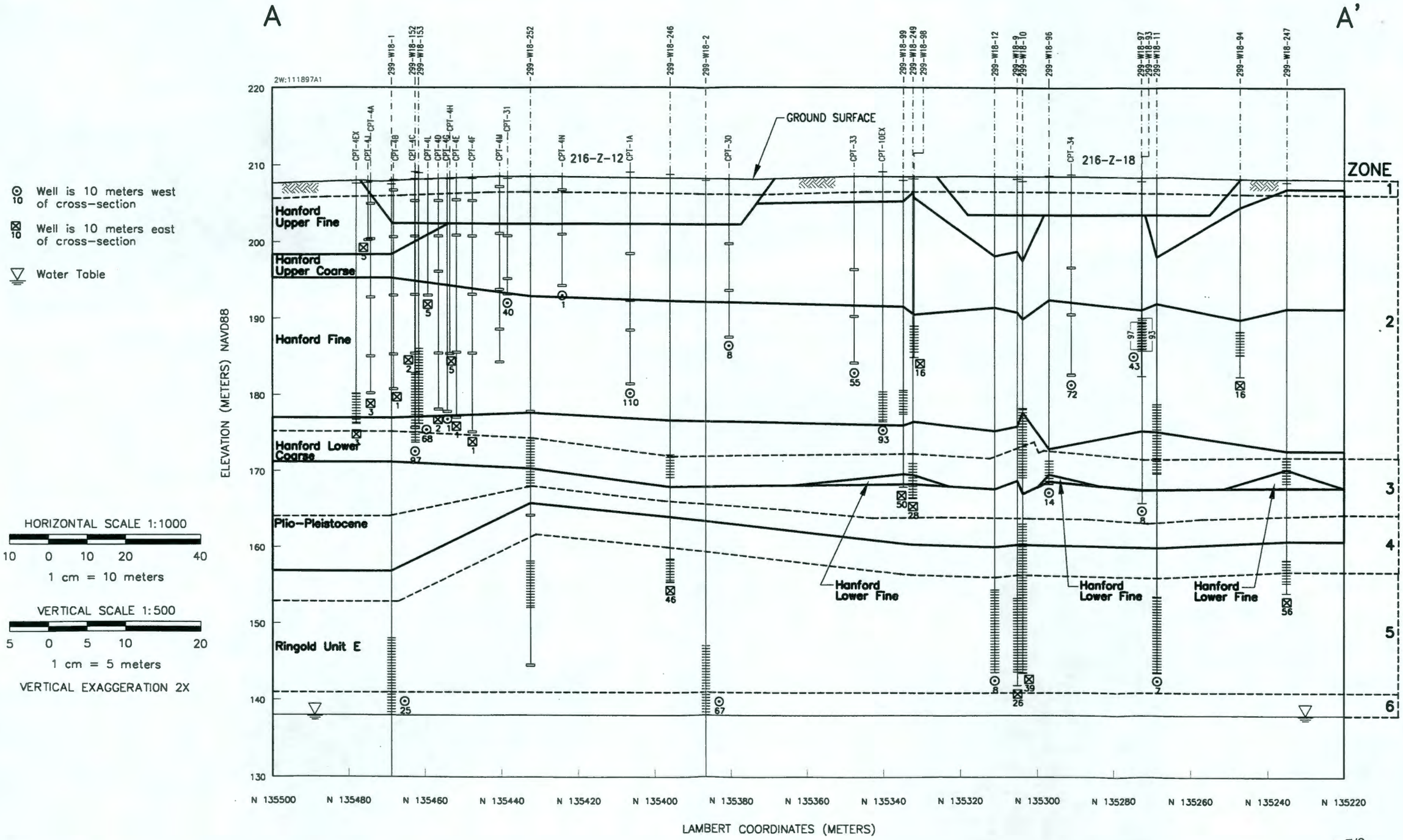


Figure 1-2b. Cross Section Through the 216-Z-1A Wellfield. (Location shown in Figure 1-1.)

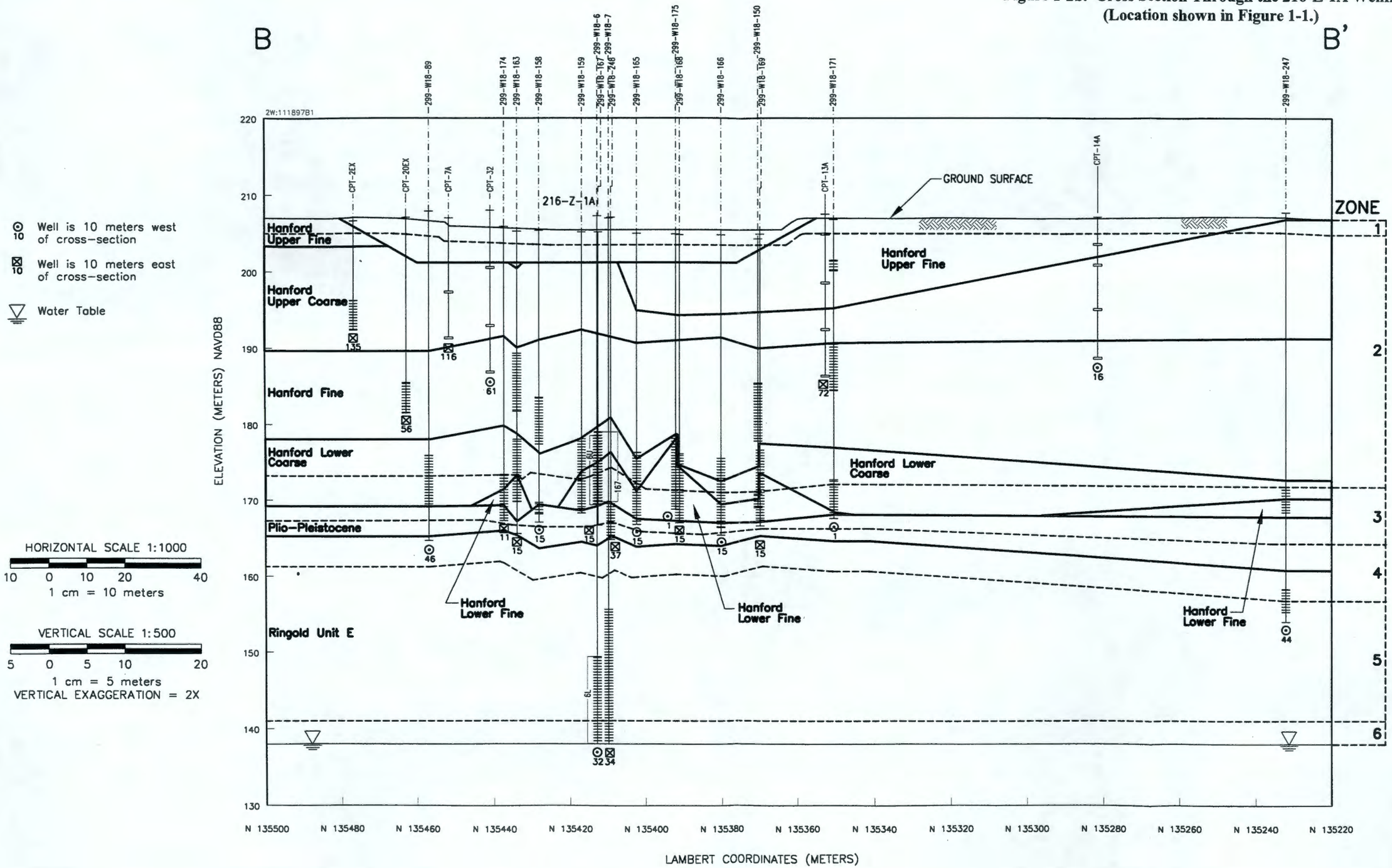


Figure 1-2c. Cross Section Through the 216-Z-9 Wellfield. (Location shown in Figure 1-1.)

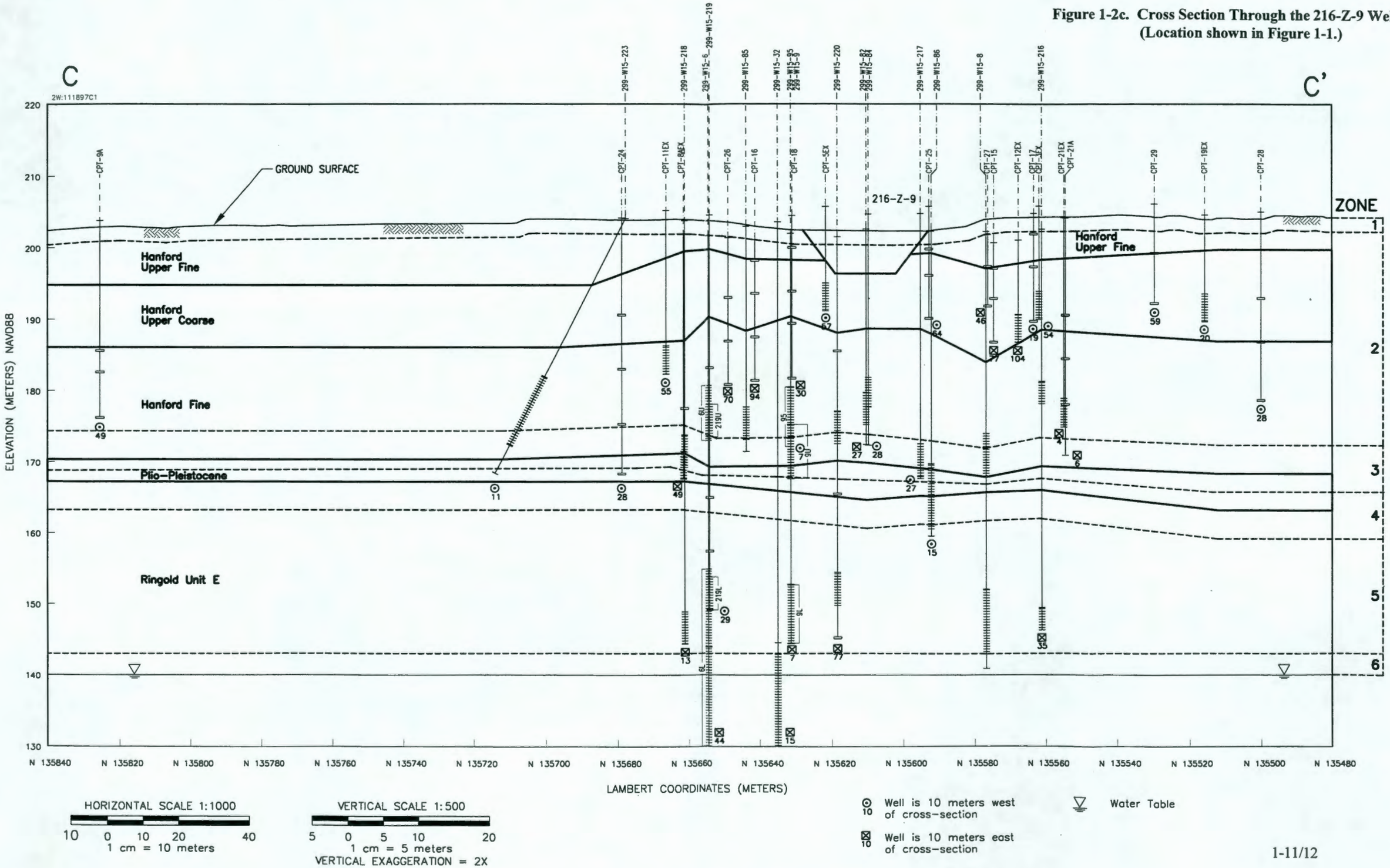


Figure 1-3. Construction of Deep Soil Vapor Monitoring Probes Installed Using Cone Penetrometer.

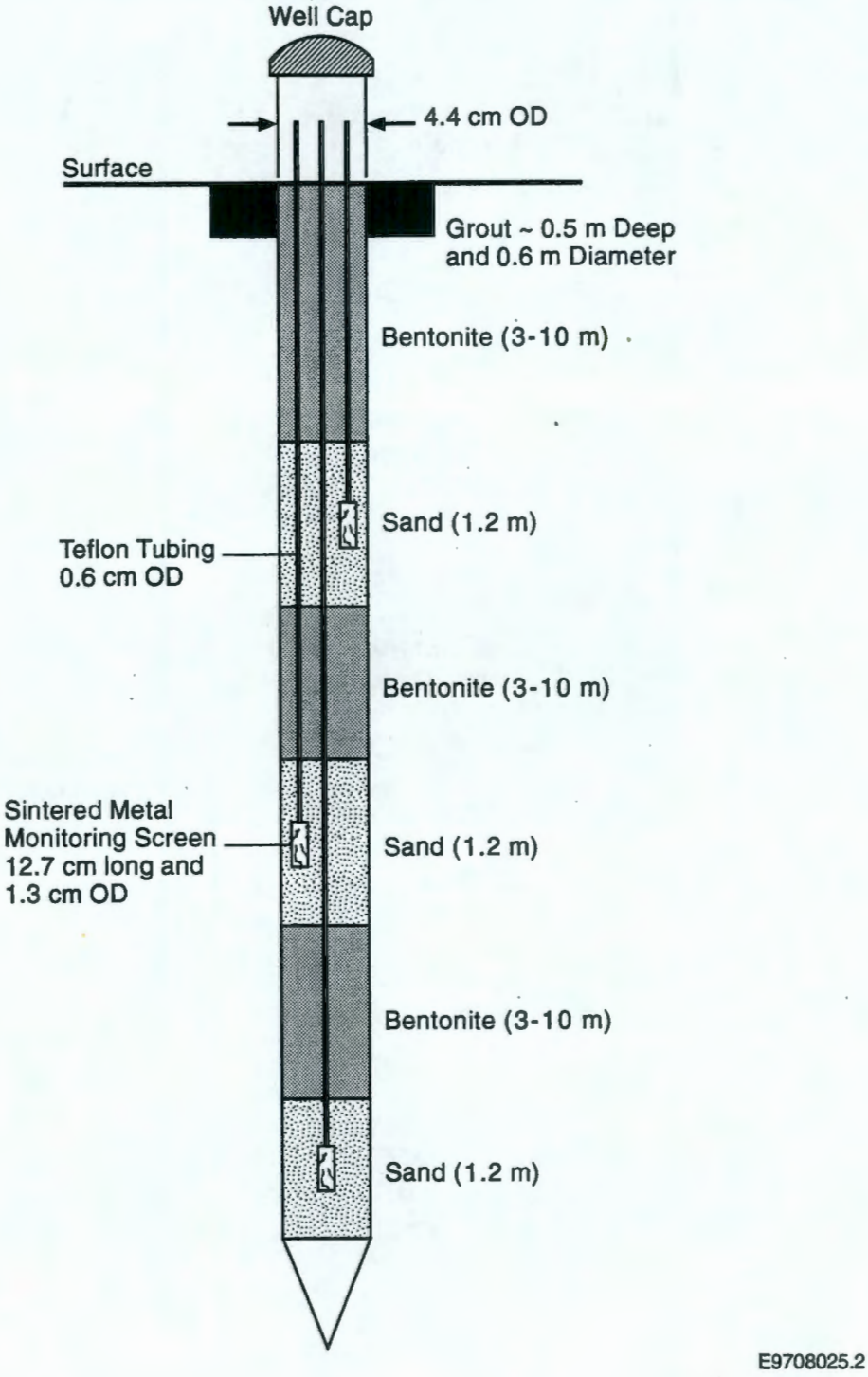


Figure 1-4. Construction of Vapor Extraction Wells Installed with Two Screened Intervals and Stainless Steel Monitoring Tubes.

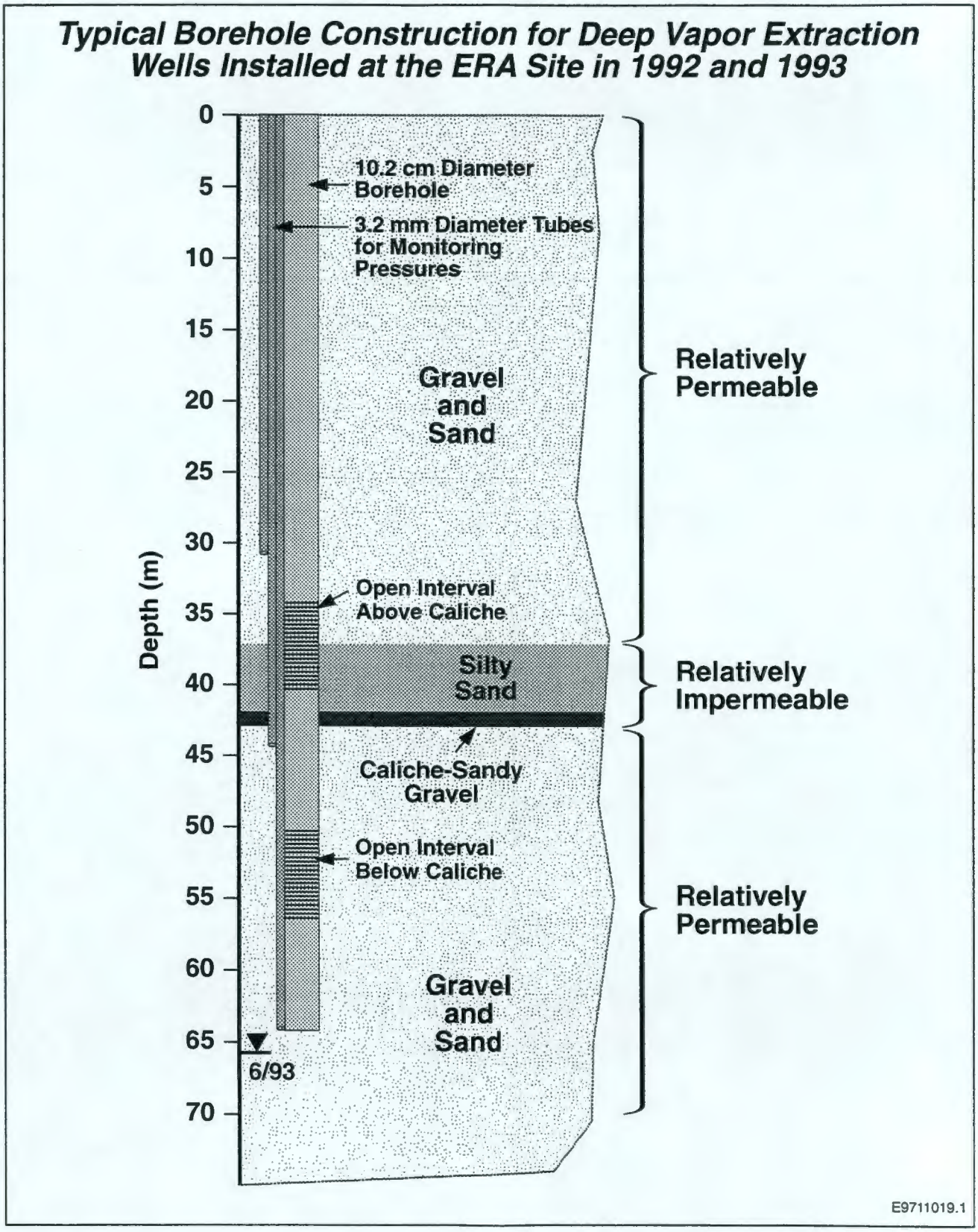


Figure 1-5. Location of Shallow Soil Vapor Probes at the Carbon Tetrachloride Site.

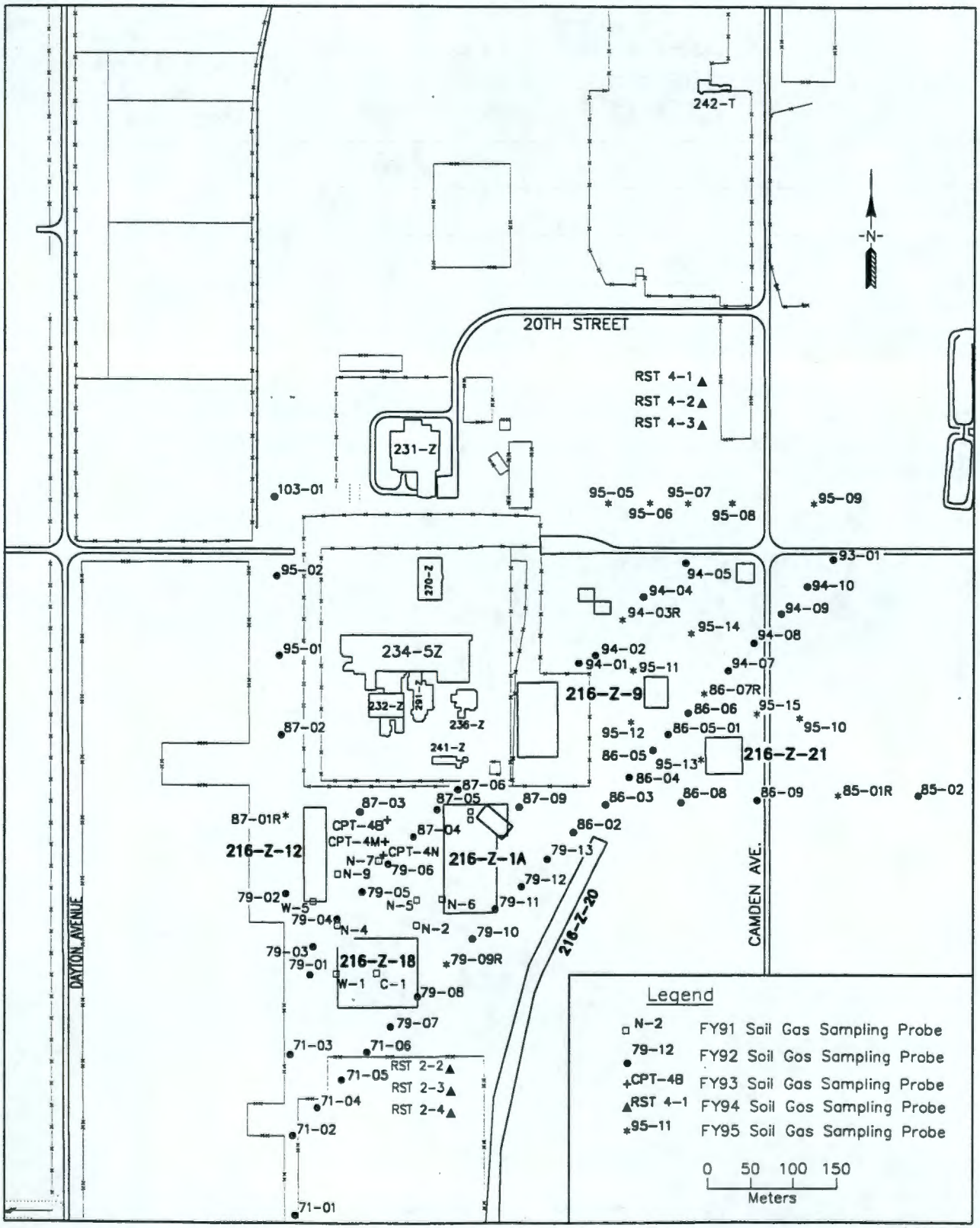


Table 1-1. Carbon Tetrachloride Inventory in Primary Disposal Sites.

Site	Carbon Tetrachloride (kg)		
	Estimated Mass Discharged 1955 - 1973[a]	**Estimated Mass Lost to Atmosphere 1955 - 1990[b]**	**Mass Removed Using Soil Vapor Extraction 1992 - 1997[c]**
216-Z-1A	270,000	56,700	22,729[d]
216-Z-18	170,000	35,700	
216-Z-9	130,000 - 480,000	27,300 - 100,800	51,984
Total	570,000 - 920,000	119,700 - 193,200	74,713

[a] Based on DOE-RL (1991).
[b] Based on WHC (1993).
[c] Based on 200-ZP-2 Project Weekly.
[d] Includes mass removed from 216-Z-12 site; reported as a combined value because the wellfields overlap.

Table 1-2. General Characteristics of the Unsaturated Zone Underlying the Carbon Tetrachloride Disposal Sites.

Geologic Unit	Geologic Material	Depth (m below ground surface)	Thickness (m)	Permeability (m^2)[a]	Field Moisture Content[b] (vol%)
Hanford upper fine (H_{uf})	Gravelly sand and sand	0 - 6	6	1.6 E-11	5.5
Hanford upper coarse (H_{uc})	Gravel	6 - 16	10	4.1 E-10	4.6 - 5.7
Hanford fine (H_f)	Sand	16 - 31	15	1.6 E-11	1.5 - 19.7
Hanford lower coarse (H_{lc})[c]	Sandy gravel	31 - 34	3	3.3 E-10	5.1 - 5.3
Hanford lower fine (H_{lf})[c]	Interbedded silt and fine sand	34 - 38	4	1.6 E-12	6.1 - 11.8
Plio-Pleistocene (PP)	Fine sandy silt/carbonate-cemented sandy gravel ("caliche")	38 - 45	7	8.2 E-13	8.1 - 38.5
Ringold Unit E (R_{ge})	Gravel	45 - 66	21	1.3 E-10	3.4 - 17.6

[a] Calibrated values based on numerical airflow model (Rohay and McMahon 1996).
[b] Source: Wright et al. (1994).
[c] Not present underlying 216-Z-9 Trench.

2.0 DESCRIPTION OF SOIL VAPOR CONCENTRATION REBOUND PROCESS

Rebound refers to the increase in soil vapor contaminant concentrations following cessation of vapor extraction operations. Vapor concentrations will rebound if diffusion and/or desorption is limiting the contaminant removal rate. The source of the additional carbon tetrachloride includes desorption and diffusion from the sediment particle micropores, desorption and diffusion from soil moisture and/or the exterior of sediment particles, and/or diffusion through a low-permeability zone. The magnitude of the concentration rebound becomes smaller as contaminant removal progresses, and the rate of the rebound becomes slower as diffusion distances lengthen.

Increases in contaminant vapor concentrations may also be caused by diffusion of the contaminant from soils beyond the radial influence of the SVE systems, from soils within the radial influence but bypassed due to nonuniform induced airflow, and from groundwater.

The magnitude of the contaminant concentration rebound can be used to indicate the amount of potentially accessible contamination in the vapor phase. An order-of-magnitude increase in concentration was chosen for this study to indicate significant rebound (Rohay and Tranbarger 1996). The lateral and vertical extent of the rebound concentration can be used to indicate the distribution of contaminant sources. The rate of concentration rebound at several monitoring points may help identify the location of the contaminant source.

The length of time required to achieve equilibrium may be very long (months to years) because of the slow process of diffusion out of the intraparticle micropores into the interparticle pore spaces and the length of the diffusion pathways. However, if the vapor concentrations increase rapidly and then approach equilibrium asymptotically, extrapolation to the equilibrium concentration may be possible.

3.0 ISSUES IDENTIFIED DURING THE DATA QUALITY OBJECTIVES PROCESS

A data quality objectives (DQO) process was completed to establish the rebound study data needs. The resulting agreements on policy and technical issues are documented in the rebound study DQO workshop meeting minutes (ERC 1996). The DQO process determined that data collected during the rebound study would be used to support decisions related to the following issues.

1. **Amount of additional carbon tetrachloride available for removal using SVE.** This issue was addressed by monitoring both the magnitude and rate of changes in carbon tetrachloride concentration throughout the SVE area.

2. **Distribution of remaining carbon tetrachloride sources.** This issue was addressed by monitoring carbon tetrachloride concentrations at selected depths within the unsaturated zone and at various distances from the source cribs.

3. **Evaluation of carbon tetrachloride transport between the unsaturated and saturated zones.** This issue was addressed by evaluating carbon tetrachloride vapor concentrations collected near the water table as part of the 200-ZP-2 rebound study and by evaluating carbon tetrachloride groundwater concentrations collected by other projects (e.g., 200-ZP-1 pump-and-treat remediation). Data trends from the two independent sampling programs were compared to detect possible correlations. In the DQO meeting, it was recognized that the rebound study was not designed to address this specific issue (e.g., collection of groundwater data was not within the rebound study scope). However, it was agreed that comparison of the rebound vapor and existing groundwater data trends would provide the basis for evaluating the need for follow-on studies.

4. **Effectiveness of using SVE for plume control in the unsaturated zone.** This issue was addressed by collecting carbon tetrachloride concentration data at the periphery and the core of the vapor extraction area to evaluate lateral transport of carbon tetrachloride vapor and at shallow soil vapor probes to evaluate vertical transport of carbon tetrachloride through the soil surface to the atmosphere.

5. **Optimization of current SVE system operations.** This issue was addressed by monitoring the magnitude and rate of changes in carbon tetrachloride concentration within the SVE area during the rebound study and by comparing inlet SVE concentration data before and after the rebound study. The data were used to compare carbon tetrachloride removal rates expected for continuous (constant) and intermittent (periodically on and off) SVE operations. The rate of rebound was used to suggest a reasonable frequency (e.g., weekly or monthly) for cyclic operations.

6. **Identification and achievement of cleanup goals.** In the DQO meeting, it was recognized that identifying target carbon tetrachloride cleanup levels was not within the scope of the rebound study. However, it was agreed that the carbon tetrachloride rebound

study data would be useful to support discussions elsewhere related to identifying target cleanup levels.

7. **Selection of final remedy for carbon tetrachloride in the unsaturated zone.** This issue was addressed by evaluating the carbon tetrachloride rebound characteristics at the 200-ZP-2 site and the implications for the effectiveness of future remediation using the SVE technology. Data gaps in the information needed to support selection and operation of the final cleanup technology were identified. It was recognized in the DQO meeting that identifying a final cleanup technology was not within the scope of the rebound study.

4.0 DATA COLLECTION

Data collection objectives, locations, methods, and tasks were described in the rebound study test plan (Rohay and Tranbarger 1996).

4.1 DATA COLLECTION OBJECTIVES

The data collection objectives of the rebound study were to obtain the following data:

- Baseline carbon tetrachloride concentrations in extraction wells when the SVE systems are taken off-line

- Magnitude of change in carbon tetrachloride concentrations while the SVE systems are off-line

  - Within the radial influence of the SVE systems
  - At the perimeter or beyond the radial influence of the SVE systems
  - Within geologic units of higher permeability
  - Within geologic units of lower permeability
  - Within soil near the ground surface
  - Within soil near the water table

- Rate of change in carbon tetrachloride concentrations while the SVE systems are off-line

  - Within the radial influence of the SVE systems
  - At the perimeter or beyond the radial influence of the SVE systems
  - Within geologic units of higher permeability
  - Within geologic units of lower permeability
  - Within soil near the ground surface
  - Within soil near the water table

- Rate of decrease in carbon tetrachloride concentrations in extraction wells when operation of the SVE systems resumes

- Sources of variability in carbon tetrachloride concentrations resulting from natural phenomena (e.g., barometric pressure fluctuations), sampling method, and/or analytical method.

4.2 SAMPLING LOCATIONS AND DEPTHS

Soil vapor sampling locations and depths were selected to address the issues identified in the DQO process. Soil vapor samples were collected both close to the source cribs and, where available, at the perimeter of the radial influence of the SVE systems. To support a systematic

approach to data collection, the unsaturated zone was divided into six sampling zones (Figure 1-2). The target depths were selected to test different zones as potential sources of carbon tetrachloride (Table 4-1). Concentrations in samples collected near the water table (zone 6) were compared to the equilibrium soil vapor concentrations expected if the source were the groundwater. Samples from fine- and coarse-grained layers (zones 3 and 4 and zones 2 and 5, respectively) were compared to determine if carbon tetrachloride were preferentially diffusing from fine-grained layers. Concentrations in samples collected near ground surface (zone 1) were used to indicate the potential migration of carbon tetrachloride to atmosphere.

A total of 27 wells; 38 deep CPT soil vapor probes, CPT wells, and stainless steel tubes; and 25 shallow soil vapor probes were selected for rebound monitoring (Table 4-2). Selected sampling locations are listed in Table 4-3.

Vapor extraction wells and stainless steel tubes have open intervals in five geologic units: Hanford fine, Hanford lower coarse, Hanford lower fine, Plio-Pleistocene, and Ringold Unit E. The deep CPT soil vapor probes and wells do not extend below the Plio-Pleistocene layer. To increase the number of wells available for sampling in the unsaturated zone near the water table, one additional well at the Z-9 site (W15-32) and two additional wells at the Z-1A site (W18-1, W18-2) were included, although they had not been used for vapor extraction.

4.3 SAMPLING METHODS

Soil vapor samples were collected using either a sample pump or barometric pump (barometric pressure fluctuations). When the SVE systems were on-line, vapor samples were collected using a vapor extraction system.

4.3.1 Sample Pump

A low-flow (0.8-L/min) sampling pump was used to draw soil vapor samples from wells and probes into a 1-L Tedlar (a registered trademark of E.I. du Pont de Nemours & Company, Wilmington, Delaware) bag for analysis (Figure 4-1). Two purge volumes were drawn before the sample was collected from the well or deep CPT probe.

For the 12 wells sampled using the sample pump, a sampling tube was lowered to the target depth at the open interval to minimize the volume of air to be purged. The tubes were 0.3-cm-inside diameter Teflon-lined Tygon (a registered trademark of Norton Performance Plastics Corporation, Akron, Ohio). A metal filter attached to the end of the tube also served as a weight. Each sampling tube remained in the well for reuse for the duration of the rebound test and was removed at the conclusion of the study. With the exception of sampling tube adjustments at a few wells, each well remained sealed throughout the rebound study.

The subsurface sampling tubes attached to the deep CPT probes monitored during the rebound study are made of Teflon (Figure 1-3). The sampling tubes are typically 0.3-cm inside diameter (0.6-cm outside diameter).

Previous monitoring at wells and soil vapor probes had indicated that barometric pressure fluctuations could affect the soil vapor concentration available for sampling at a given depth. To evaluate this variability, the subsurface-surface differential pressure was measured at each sampling depth at the time of each soil vapor sample collection.

Duplicate samples were collected at a maximum of every twentieth sample to evaluate the repeatability of the sampling method.

Carbon tetrachloride concentrations in samples collected from extraction wells using the sample pump were compared to those collected using the SVE systems prior to and after the rebound study to evaluate how these two sampling methods compare.

4.3.2 Barometric Pump

Subsurface air vents from wells when barometric pressure is low. On days when wells would be venting, the wells selected for sampling using a barometric pump were opened to purge the well volume. The length of time required to vent one well volume was estimated assuming that the average air flow rate was 0.06 m^3/min (Rohay 1996a). The wells were then resealed, and the sample pump was used to collect samples in 1-L Tedlar bags for analysis. Because each well was sealed between sampling events, subsurface air was drawn progressively toward the well each time it was sampled, providing information on the distribution of carbon tetrachloride relative to the well. The samples were used to provide additional observations of soil vapor concentrations from intervals open above and below the Plio-Pleistocene unit. The data were compared to data collected using the sample pump only to evaluate how the sampling methods compare.

4.3.3 Soil Vapor Extraction Systems

Each SVE system is used to extract simultaneously from multiple wells. The combined inlet concentration to the SVE system is automatically monitored, and daily average concentrations, flows, and hours of operation are recorded. During operation of the SVE systems before and after the rebound study, soil vapor samples were collected at selected individual wellheads in 1-L Tedlar bags for analysis.

4.3.4 Sampling Frequency

During the first ten working days of the rebound study, soil vapor samples were collected from 12 wells and 38 deep probes using the sample pump at least on alternate days (Table 4-3). This sampling frequency was selected to observe potentially rapid concentration changes. Four of these 50 locations were sampled twice per day to evaluate whether diurnal barometric pressure fluctuations affected the observed carbon tetrachloride concentrations. Evaluation of the data collected during the first 10 days of the study indicated that sampling frequency could be reduced because carbon tetrachloride concentrations did not appear to be changing rapidly. For the next 6 weeks, until January 1997, samples were collected from each well and deep probe once per week; the same four wells continued to be sampled twice per day on sampling days. For the next 6 months of the study, January through June 1997, samples were collected from each well and

deep probe once per month. In addition, 15 wells and probes that had exhibited the greatest concentration fluctuations were sampled twice per month. All of the wells and probes were sampled once in July prior to restart of the SVE systems.

The 15 wells identified for barometric pump sampling were sampled during periods of low barometric pressure approximately once per month. Plastic bags were taped to two wells (W18-99, open above the Plio-Pleistocene layer; and W18-9, open below the Plio-Pleistocene layer) to indicate the direction of natural airflow; these indicator wells were used to determine favorable times for barometric sampling.

The shallow soil vapor probes were sampled once per month to evaluate long-term changes.

The SVE systems were used to collect one set of baseline characterization data at every on-line well on October 29, 1996 prior to initiation of the rebound study. When SVE operations resumed on July 18, 1997 following the rebound study, carbon tetrachloride concentrations were monitored at selected wellheads every third day for the first 2 weeks (July 18, 21, 24, 28, and 31).

4.3.5 Soil Vapor Sample Analysis

Soil vapor samples were analyzed using a Bruel & Kjaer Type 1302 photo-acoustic infrared spectrometer (B&K, a trademark of Bruel & Kjaer, DK-2850). Samples collected in Tedlar bags were transported to a B&K located in a support trailer at the 200-ZP-1 pump-and-treat site approximately 350 m north of the Z-12 Crib. The B&Ks are the analytical instrument used to monitor concentrations at the extraction wells and SVE inlet during SVE operations.

Soil vapor samples were analyzed primarily for carbon tetrachloride. The samples were also analyzed for chloroform and methylene chloride, which are degradation products of carbon tetrachloride, and for methyl ethyl ketone (MEK), because the B&Ks are configured to analyze for all four contaminants. These four contaminants are routinely monitored during SVE operations. The B&Ks are also configured to analyze water in the vapor sample; water concentrations were also recorded starting in January.

The B&K detectors are factory-calibrated a minimum of once per year. The B&Ks were challenged in the field with a gas of known carbon tetrachloride concentration every time samples were analyzed.

The B&K has two filters for carbon tetrachloride, one calibrated for carbon tetrachloride concentrations between 1.5 and 108 ppmv (Low B filter) and one calibrated for carbon tetrachloride concentrations exceeding 108 ppmv (High A filter). All soil vapor samples were analyzed using the Low B filter until January 13, 1997. After January 13, samples with concentrations exceeding 108 ppmv using the Low B filter were also analyzed using the High A filter. A plot of the Low B-High A analysis pairs indicated a linear relationship from approximately 100 to 800 ppmv (Figure 4-2); the slope of the best fit line (1.2) was used to correct concentrations exceeding 108 ppmv measured using the Low B filter prior to January 13 to the concentration that would have been measured using the High A filter.

The lower detection limit for the B&K is approximately 1 ppmv; measurements between 0 and 1 ppmv were recorded but are considered equivalent to 0 ppmv.

4.3.6 Pressure Monitoring

The subsurface-surface differential pressure was measured at each sampling depth using a pressure transducer at the time of collection of each soil vapor sample. For this study, a positive differential pressure indicates that the subsurface pressure was higher than the barometric, and a negative differential pressure indicates that barometric pressure was higher than subsurface.

The test plan specified that at a minimum of one location, barometric pressure would be monitored hourly using a pressure transducer and recorded on a datalogger; and that data from the Hanford Meteorological Station, located approximately 2.5 km northeast of the carbon tetrachloride site, would be used as an alternate (Rohay and Tranbarger 1996, Table 5). The alternative to acquire site meteorological data, including barometric pressure, from the Hanford Meteorological Station was used during the rebound study. The test plan also specified that at selected locations (at least one above the Plio-Pleistocene layer and one below), subsurface differential pressure would be monitored hourly using a pressure transducer and recorded on a datalogger. The intent of this task was to establish the expected differential pressure response to barometric pressure fluctuations. This data was not collected during the rebound study because the differential pressures measured during each day of sampling formed a consistent set that could be understood in terms of previous differential and barometric pressure monitoring (Rohay 1996a).

4.4 DATA COLLECTION TASKS

4.4.1 Rebound Study

Task 1: Baseline the Rebound Study. The purpose of baseline characterization was to use the SVE systems to provide a known starting point for the rebound study.

All of the extraction wells at the Z-1A and Z-9 sites were placed on-line during the baseline characterization task to sweep the unsaturated zone of carbon tetrachloride. The wells at the Z-18 site were not included because there was not enough extraction hose onsite to connect every well to a SVE system, and evaluation of rebound at Z-1A, where soil vapor concentrations are higher, was a higher priority. However, soil vapor samples were collected from locations at the Z-18 site during the rebound study for comparison to concentrations at Z-1A.

After 2 weeks of continuous SVE operations, October 14 through October 28, the carbon tetrachloride concentration, flow, and vacuum was measured individually at every on-line well on October 29. The carbon tetrachloride concentration provided the baseline for comparison to rebound concentrations; the flow and vacuum indicate the radial influence of the SVE systems. The induced vacuum was measured at selected deep soil vapor probes to indicate the influence of SVE operations at those locations on October 30 and 31. The soil vapor survey conducted in

May 1996 was used to provide baseline concentration data for the shallow soil vapor probes (Fancher 1996).

Task 2: Prepare for Rebound Study Data Collection. All three SVE systems were taken off-line on November 4, 1996. Tubing for rebound sample collection was installed on November 4, 1996 in the 12 wells identified for sampling with the sample pump (Table 4-3).

Task 3: Collect and Analyze Soil Vapor Samples and Differential Pressure Data. Soil vapor sample collection began November 4, 1996 at deep soil vapor probes. Soil vapor sample collection at wells was delayed until November 6, 1996 to allow the vacuum induced by SVE operations to decay. Soil vapor samples were collected using the soil vapor and differential pressure sampling apparatus (Figure 4-3) and were analyzed on the same day that they were collected. The subsurface-surface differential pressure was measured at each sample location immediately prior to sample collection.

In March, an agreement was reached to extend the restart date for the SVE systems from April 30, 1997 to July 31, 1997. It was also agreed that, as a result, soil vapor monitoring would be continued at selected rebound study wells and probes. The reasons for continued monitoring were (1) to evaluate carbon tetrachloride rebound, (2) to confirm that carbon tetrachloride was not impacting ambient air or groundwater, and (3) to evaluate concentrations for SVE restart. Additional deep wells were selected to be monitored to establish a carbon tetrachloride baseline prior to 200-ZP-1 Phase III pump-and-treat operations at the Z-9 site. Soil vapor sample collection concluded on July 10, 1997.

Task 4: Conclude the Rebound Study. Two 3-hour SVE tests were conducted at two individual wells at the Z-9 site to observe initial carbon tetrachloride concentration changes during restart. In addition, soil vapor samples were collected using the SVE systems for comparison to those collected using the sample pump. Well W15-82 was tested on July 14, and well W15-217 was tested on July 15. During each test, only the one test well was placed on-line to the SVE system, and vacuums were monitored at nearby wells. A minimum volume of air was extracted initially to obtain a representative sample of the concentration adjacent to the well ("puffer test") (Figure 4-4). Soil vapor extraction then continued to determine the carbon tetrachloride concentration at progressive distances from the well. (Note: The term "puffer test" was coined by ERA project staff during the 1991 SVE pilot testing to describe collection of an initial, representative soil vapor sample using a minimal amount of vapor extraction to minimize potential redistribution of the soil vapor concentrations that might be produced by prolonged pumping [DOE-RL 1991, Appendix F].)

All of the wells that were on-line in October 1996 were placed on-line on July 18, 1997 under the same conditions as when the baseline task concluded to facilitate comparison of inlet concentrations before and after the rebound study. The carbon tetrachloride concentrations were monitored at selected wells on July 18, July 21, July 24, July 28, and July 31 to observe concentration changes at individual wells.

A low-flow test was conducted at the Z-1A wellfield from August 14 to August 21 to evaluate the impact on the carbon tetrachloride removal rate of extracting under low flow conditions and to determine the generally lowest flow rates that the 28.3-m^3/min SVE system could maintain.

Soil vapor extraction was continued at these same wells until September 30, 1997, as part of SVE operations.

4.4.2 CPT Location Surveying

The CPT wells and probes were surveyed in February 1997 using a Global Positioning System (GPS) to provide more accurate locations relative to vapor extraction wells and carbon tetrachloride sources.

4.4.3 Supplemental Tests

In March 1997, five short-term tests (lasting 2 to 3 weeks each) were identified that could be implemented and evaluated to address data gaps in the rebound study or supplement the rebound study data.

Test 1: Carbon Tetrachloride-Packer Test

The carbon tetrachloride-packer test was conducted at well W15-217 at the Z-9 site and well W18-89 at the Z-1A site to investigate why significant fluctuations in carbon tetrachloride concentrations were observed in measurements from wells but not from deep soil vapor probes. Packers were installed in the wells to isolate the screened intervals from the overlying column of air, and concentrations were monitored once per day for 10 working days (during at least one barometric pressure inversion) using the sample tube (threaded through the packer) and sample pump. Soil vapor monitoring for the carbon tetrachloride-packer test was conducted from June 19 through July 7.

Test 2: Carbon Tetrachloride-Barometric Pressure Test

The carbon tetrachloride-barometric pressure test was conducted at well W18-252U at the Z-1A site to establish the relationship between barometric pressure fluctuations and carbon tetrachloride fluctuations. The well was instrumented to automatically measure and record the barometric pressure, subsurface-surface differential pressure, and carbon tetrachloride concentration hourly for 14 days (during at least one barometric pressure inversion). Soil vapor monitoring for the carbon tetrachloride-barometric pressure test was conducted from June 25 through July 14.

Test 3: Passive Extraction Valve Test

The passive extraction valve test was conducted at wells W18-246L, W18-247L, and W18-252L at the Z-1A site to determine the relationship between the type of one-way valve used on passive SVE systems and the carbon tetrachloride removal rate. Passive SVE systems on wells use natural barometric pressure fluctuations to extract the contaminated air (barometric pumping).

Three wells were instrumented to simultaneously and automatically measure and record flow, barometric pressure, subsurface-surface differential pressure, and carbon tetrachloride concentration hourly for at least 14 working days (during at least one barometric pressure inversion). One well had no valve; one well had a flow-activated valve; and one well had a pressure-activated valve. Soil vapor monitoring for the passive extraction valve test was conducted from August 18 through September 16.

Test 4: Evaluation of FY 1992 and FY 1993 In Situ Soil Vapor and Groundwater Concentration Data

Vapor and groundwater data were collected from different depths at the same location during installation of extraction wells at the carbon tetrachloride site in FY 1992 and FY 1993. The data were evaluated to help address the issue of transport of carbon tetrachloride between the unsaturated and saturated zones. In situ soil vapor and groundwater samples were collected from wells W15-216, W15-218, and W15-220 at the Z-9 site, and from wells W18-246, W18-247, and W18-252 at the Z-1A site in 1992 and 1993. In situ soil vapor samples were also collected from wells W15-217 and W15-223 at the Z-9 site and from wells W18-248 and W18-249 at the Z-1A site; however, groundwater samples were not collected at these wells because the wells did not extend below the Plio-Pleistocene layer.

Test 5: Evaluation of FY 1995 Surface Cover Test Data

Test data to evaluate the impact of an impermeable surface cover on the radial influence of an extraction well were collected in FY 1995. The 28.3-m^3/min SVE system was used to apply vacuum to an extraction well, and induced pressures were monitored at various distances from the screened intervals with (1) a surface cover emplaced around the well and (2) without a surface cover. The impact of the surface cover was tested at well W18-252U at the Z-1A site.

Figure 4-1. Schematic Drawing of Soil Vapor Sampling at a Vapor Extraction Well.

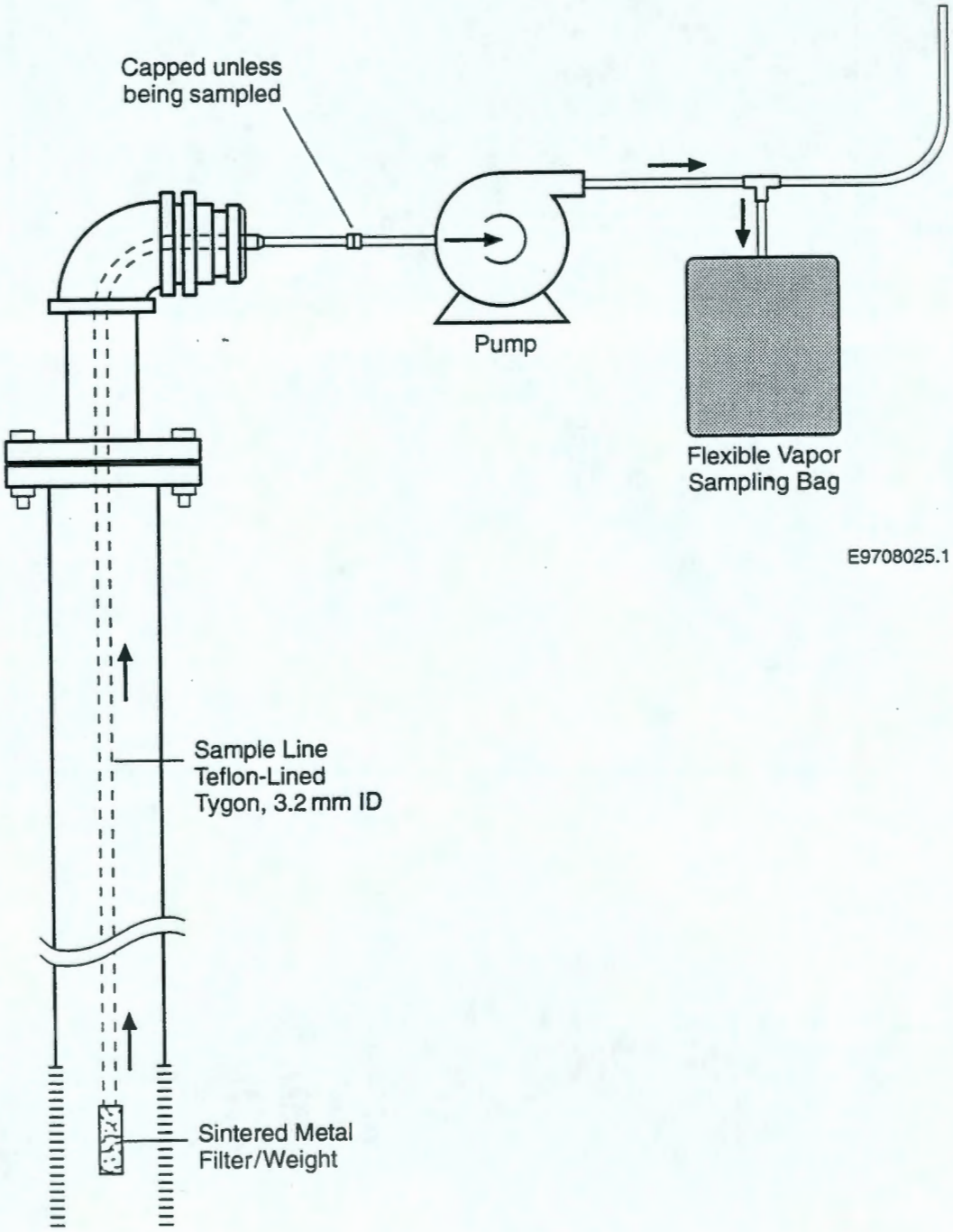
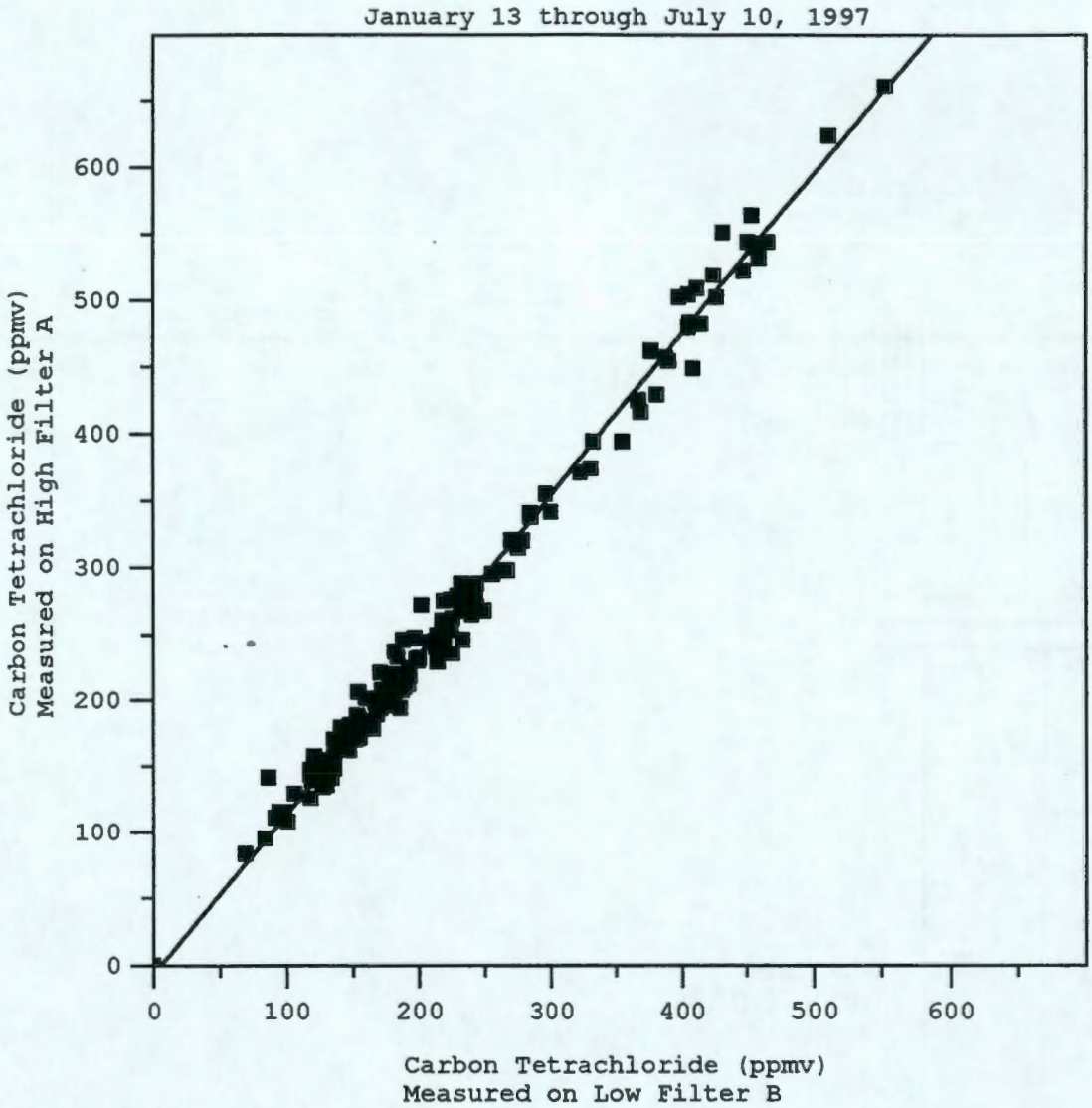


Figure 4-2. Plot of Carbon Tetrachloride Concentrations Measured on B&K High Filter A and Low Filter B.



Filter A = 1.20463 * Filter B + -6.85663
correlation = 0.990735

Figure 4-3. Schematic Drawing of Soil Vapor and Differential Pressure Sampling Apparatus.

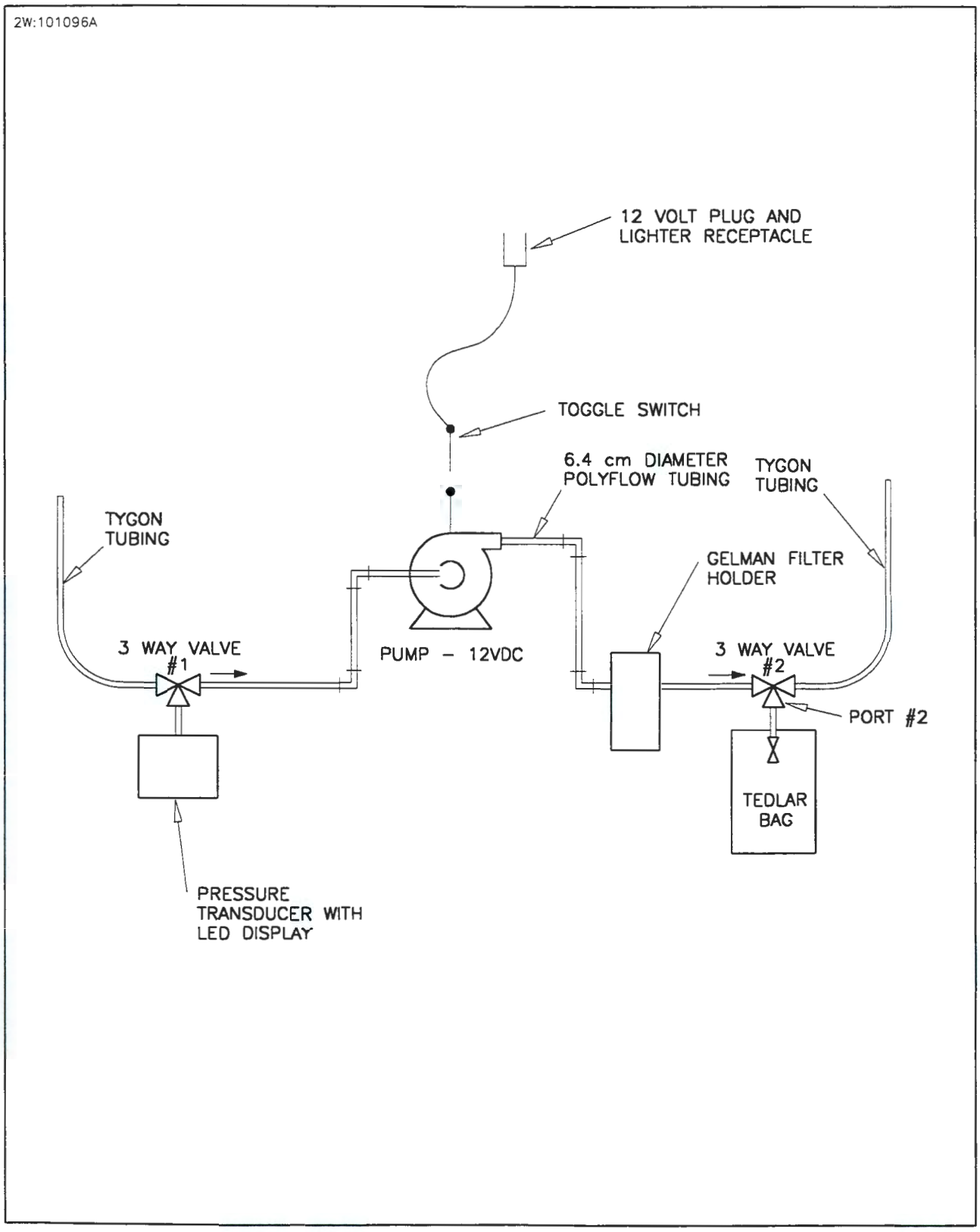


Figure 4-4. Schematic for Puffer Test Soil Vapor Sampling Using the Soil Vapor Extraction Systems.

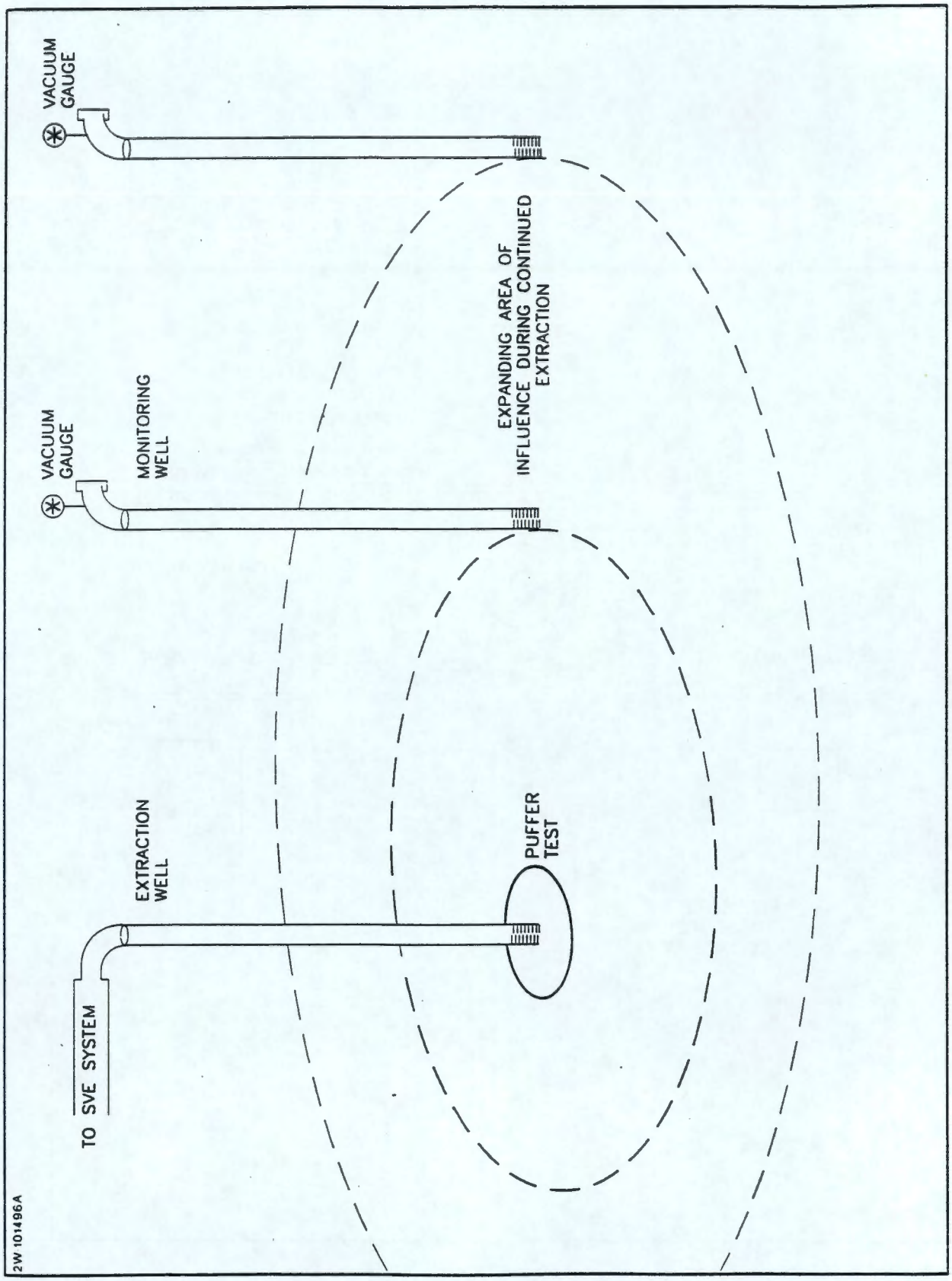


Table 4-1. Rationale for Selection of Soil Vapor Sampling Depths.

Sampling Zone	Interval	Rationale
1	0 to 2 m below ground surface	Evaluate carbon tetrachloride rebound in near-surface soils available to vent to atmosphere through soil surface
2	Between zones 1 and 3	Evaluate rebound in relatively permeable soils through which significant airflow has been induced by soil vapor extraction systems
3	4 m above Plio-Pleistocene to midline of Plio-Pleistocene	Evaluate distribution of carbon tetrachloride remaining in low-permeability Plio-Pleistocene layer and potential long-term effect on zone 2 rebound
4	Midline of Plio-Pleistocene to 4 m below Plio-Pleistocene	Evaluate distribution of carbon tetrachloride remaining in low-permeability Plio-Pleistocene layer and potential long-term effect on zone 5 rebound
5	Between zones 4 and 6	Evaluate rebound in relatively permeable soils through which significant airflow has been induced by soil vapor extraction systems
6	3 m above water table to water table	Evaluate potential exchange of carbon tetrachloride between unsaturated and saturated zones

Table 4-2. Summary of Sampling Points Monitored for Rebound.

Sampling Location	Zone	Well Intervals	Cone Penetrometer Probes/Wells > 2 m Deep	Stainless Steel Tubes	Soil Vapor Probes < 2 m Deep
Z-1A/18/12	1				12
	2	1	18	1	
	3	9			
	4	1		1	
	5	1		1	
	6	4			
	Total	16	18	3	12
Z-9	1				13
	2	2	10	2	
	3	4	1		
	4	1		2	
	5	2		2	
	6	2			
	Total	11	11	6	13

Table 4-3. Selected Sampling Locations. (Page 1 of 3)

Sampling Type	Total	Wellfield	Total by Wellfield	Sampling Location	Depth (m bgs)	Geologic Unit	Zone	Comment
Sample Pump	12 Wells	Z-9	6 Wells	W15-9L	58	Rge near gw	5	2 m above zone 6
	38 Probes		17 Probes	W15-217	35	top of PP	3	
				W15-6L	58	Rge to gw	5-6	
				W15-82	25	Hf	2	historic high concentrations
				W15-86	37	across PP	3-4	
				W15-218U	33	top of PP	3	
				W15-219SST/21	21	Hf	2	
				W15-219SST/40	40	bottom of PP	4	
				W15-219SST/47	47	Rge	5	
				W15-220SST/16	16	Hf	2	
				W15-220SST/36	36	bottom of PP	4	
				W15-220SST/56	56	Rge near gw	5	
				CPT-9A/18	18	Hf	2	perimeter
				CPT-9A/28	28	Hf near PP	2	perimeter
				CPT-16/20	20	Hf	2	substitute for CPT-8AEX (tight)
				CPT-17/8	8	Huc	2	substitute for CPT-24/29 (tight)
				CPT-18/11	11	Huc	2	substitute for W15-218/26 (tight)
				CPT-21A/14	14	Huc	2	
				CPT-21A/26	26	Hf	2	high in 1996 soil gas survey
				CPT-24/36	36	top of PP	3	
				CPT-27/10	10	Huc	2	near bottom of trench
				CPT-28/12	12	Huc	2	perimeter
				CPT-28/27	27	Hf	2	perimeter
		Z-1A	6 Wells	W18-7	62	Rge to gw	5-6	
			21 Probes	W18-174	37	top of PP	3	
				W18-248	40	PP	3	
				W18-167	38	Hlc,Hlf/top of PP	2-3	
				W18-89	35	Hlc/top of PP	2-3	
				W18-252U	36	Hlc/PP	3	
				W18-252SST/31	31	Hf	2	
				W18-252SST/44	44	Rge near PP	4	
				W18-252SST/64	64	Rge near gw	5	1 m above zone 6
				CPT-4C/23	23	Hf	2	
				CPT-4C/33	33	Hlc	2	
				CPT-4E/23	23	Hf	2	
				CPT-4E/31	31	Hf	2	
				CPT-4F/23	23	Hf	2	
				CPT-4F/33	33	Hlc	2	
				CPT-1A/11	11	Huf	2	perimeter

Table 4-3. Selected Sampling Locations. (Page 2 of 3)

Sampling Type	Total	Wellfield	Total by Wellfield	Sampling Location	Depth (m bgs)	Geologic Unit	Zone	Comment
Sample Pump	12 Wells	Z-9	6 Wells	W15-9L	58	Rge near gw	5	2 m above zone 6
				CPT-1A/28	28	Hf	2	perimeter
				CPT-2EX	12	Huc	2	perimeter
				CPT-7A/16	16	Huc	2	perimeter
				CPT-13A/9	9	Huf	2	perimeter
				CPT-13A/21	21	Huc	2	perimeter
				CPT-30/21	21	Hf	2	
				CPT-31/23	23	Hf	2	high in 1996 soil gas survey
				CPT-32/21	21	Hf	2	
				CPT-33/24	24	Hf	2	
				CPT-34/12	12	Huc	2	perimeter
				CPT-34/26	26	Hf	2	perimeter
Barometric Pump	15 Wells	Z-9	5 Wells	W15-9U	31	Hf, PP	2-3	above PP
				W15-32	61	Rge to gw	6	below PP
				W15-216U	23	Hf	2	above PP
				W15-216L	55	Rge	5	below PP
				W15-223	33	Hf, PP	3	above PP; prior rebound record
		Z-1A	10 Wells	W18-96	39	Hlc, Hlf, PP	3	above PP
				W18-168	33	Hlf, PP	2-3	above PP
				W18-169	33	Hlc, Hlf	2-3	above PP
				W18-249	40	Hlc, Hlf, PP	3	above PP
				W18-152	31	Hf	2	above PP; perimeter; prior rebound record
				W18-6L	61	Rge to gw	5-6	below PP
				W18-1	63	Rge to gw	5-6	below PP
				W18-2	63	Rge to gw	5-6	below PP
				W18-252L	53	Rge	5	below PP
				W18-247L	51	Rge near PP	4-5	below PP; long baro pumping data record
Shallow Probe	25 Probes	Z-9	13	85-01R	1.5		1	perimeter
				86-03	1.5		1	between Z-9 and Z-1A
				86-04	1.5		1	perimeter
				86-06	1.5		1	close to Z-9
				94-02	1.5		1	historic high
				94-03R	1.5		1	historic high
				94-05	1.5		1	historic high
				94-09	1.5		1	perimeter
				95-07	1.5		1	perimeter
				95-09	1.5		1	perimeter
				95-11	1.5		1	close to Z-9

Table 4-3. Selected Sampling Locations. (Page 3 of 3)

Sampling Type	Total	Wellfield	Total by Wellfield	Sampling Location	Depth (m bgs)	Geologic Unit	Zone	Comment
Sample Pump	12 Wells	Z-9	6 Wells	W15-9L	58	Rge near gw	5	2 m above zone 6
				95-12	1.5		1	close to Z-9
				95-08	1.5		1	perimeter
		Z-1A	12	71-04	1.5		1	perimeter
				79-02	1.5		1	perimeter
				79-03	1.5		1	perimeter
				79-11	1.5		1	close to Z-1A
				79-13	1.5		1	perimeter
				87-01R	1.5		1	perimeter
				87-03	1.5		1	between Z-1A and Z-12
				87-04	1.5		1	close to Z-1A
				95-01	1.5		1	perimeter
				C-1	1.5		1	center of Z-18
				N-5	1.5		1	close to Z-1A
				N-9	1.5		1	historic high

5.0 REBOUND STUDY DOCUMENTATION

5.1 TEST CHRONOLOGY

The rebound study at the carbon tetrachloride site was conducted from October 14, 1996 through September 16, 1997; the SVE systems were off-line from November 4, 1996 until July 18, 1997.

The primary field activities of the rebound testing were:

October 14, 1996	Wellfields for all three SVE systems reconfigured to place all possible extraction wells on-line.
October 29, 1996	Baseline characterization conducted at all on-line wells.
November 4, 1996	All three SVE systems taken off-line.
November 4, 1996 - July 10, 1997	Carbon tetrachloride rebound concentration data collected.
June 19 - July 7, 1997	Carbon tetrachloride-packer supplemental test data collected at wells W15-217 and W18-89.
June 25 - July 14, 1997	Carbon tetrachloride-barometric pressure supplemental test data collected at well W18-252U.
July 14, 1997	Three-hour SVE test conducted at well W15-82.
July 15, 1997	Three-hour SVE test conducted at well W15-217.
July 18, 1997	All three SVE systems resumed operation on the same wells that had been on-line from October 15 - November 4, 1996.
July 18 - 31, 1997	Characterization conducted at selected on-line wells.
August 13, 1997	Wells W18-6L, W18-7, W18-246U&L, and W18-252U&L taken off-line to support passive extraction valve supplemental test.
August 14 - 21, 1997	Low-flow test conducted at Z-1A wellfield.
August 18 - September 16, 1997	Passive extraction valve supplemental test data collected at wells W18-246l, W18-247L, W18-252L.

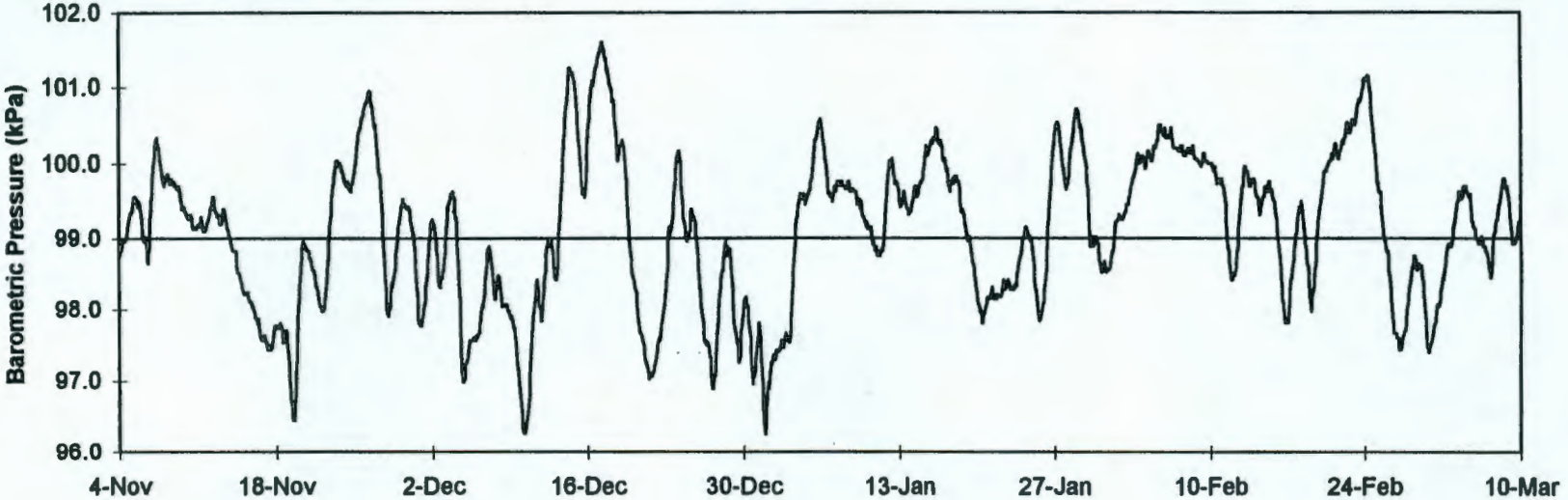
5.2 TEST CONDITIONS

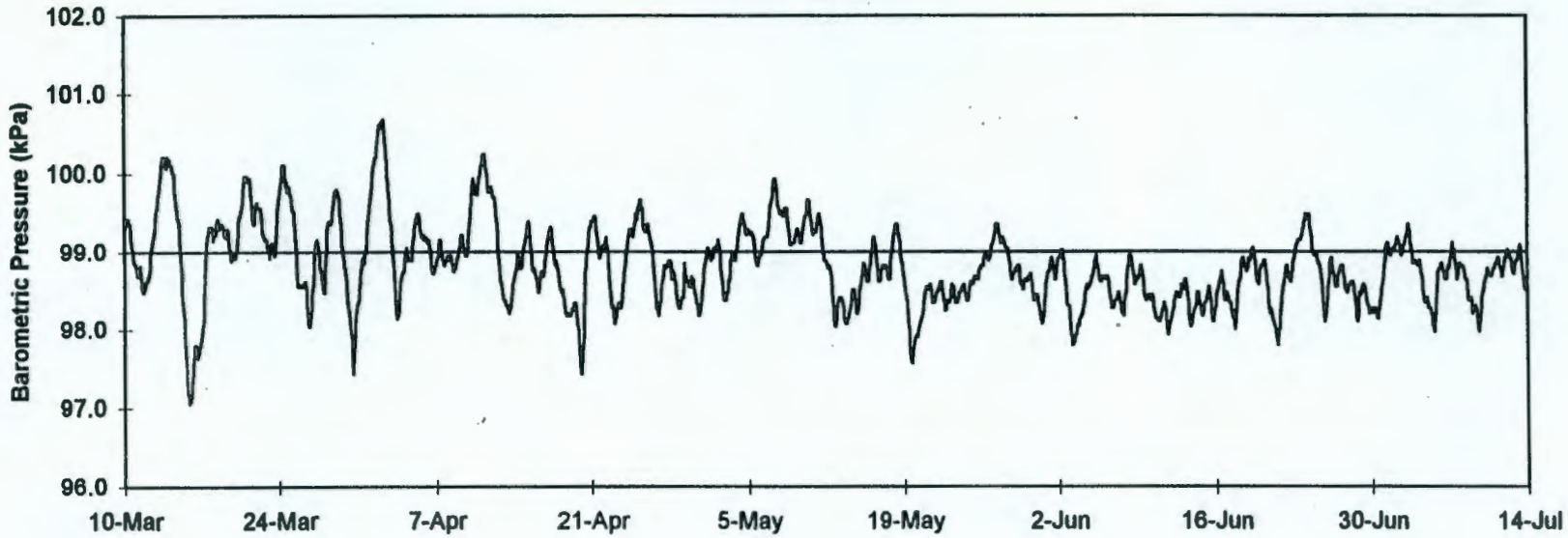
Soil vapor in the subsurface is always moving. When SVE systems are off-line, soil vapor will flow in response to gradients caused by barometric pressure fluctuations. When the SVE systems are operating, the vacuum induced in the subsurface within the radial influence of the extraction well can overcome these natural pressure gradients and cause soil vapor to flow toward the extraction well. The barometric pressure during the rebound study for the period while the SVE systems were off-line, November 4, 1996 through July 13, 1997, is shown in Figure 5-1. The mean barometric pressure for the Hanford Site is 98.9 kPa, which is shown in the figure for reference. In general, the barometric pressure is higher in the winter than in the summer, and the pressure fluctuations are greater in the winter than in the summer (DOE 1988).

Barometric pressure during the rebound study followed these typical patterns. The mean barometric pressure for the data shown in Figure 5-1 is 98.9 kPa. The maximum barometric pressure, 101.6 kPa, occurred on December 17, 1996 from 0900 to 1100 hours; the minimum barometric pressure, 96.3 kPa, occurred on December 10, 1996 at 0500 and 0700 hours and on December 31, 1996 at 2300 hours.

The surface air temperature during the rebound study for this same time interval is shown in Figure 5-2. The mean surface air temperature for the Hanford Site is approximately 12 °C, which is shown in the figure for reference. The mean temperature for the data shown in Figure 5-2 is 9°C. The maximum temperature, 37°C, occurred on July 5, 1997 at 1500 hours; the minimum temperature, -21°C, occurred on December 28, 1996 from 0700 to 0800 hours.

Figure 5-1. Barometric Pressure During Rebound Study While Soil Vapor Extraction Systems were Off-Line, November 4, 1996 through July 13, 1997.





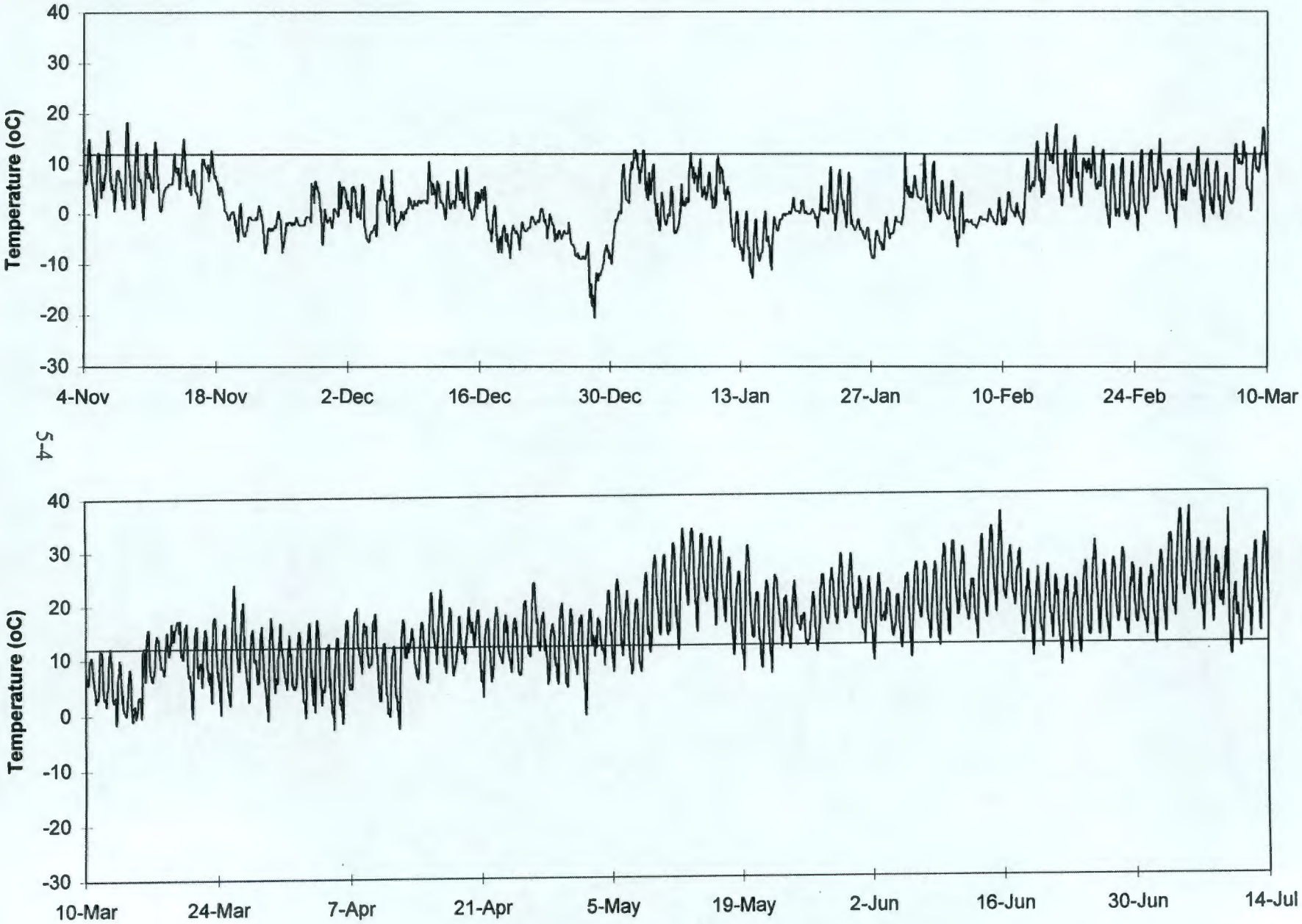


Figure 5-2. Temperature During Rebound Study While Soil Vapor Extraction Systems were Off-Line, November 4, 1996 through July 13, 1997.

6.0 REBOUND STUDY DATA

All of the data collected during the rebound study are presented and summarized in this section, with reference to appendices for complete data records.

6.1 BASELINE DATA

The baseline carbon tetrachloride concentrations for Z-1A and Z-9 vapor extraction wells were collected on October 29, 1996 (Table 6-1). Prior to shutdown of the SVE systems, carbon tetrachloride concentrations at individual wells ranged from 0 ppmv to 78 ppmv.

Carbon tetrachloride concentrations measured during a soil vapor survey in May 1996 were selected as baseline data for the soil vapor probes (Table 6-2). These samples were analyzed using a Photovac 10S PLUS (trademark of Photovac International Inc.) portable gas chromatograph (Fancher 1996). The highest carbon tetrachloride concentration detected in the shallow soil vapor probes (zone 1) in May 1996 was 0.2 ppmv at the Z-9 site (Table 6-2).

Carbon tetrachloride concentrations detected in deep soil vapor probes (zones 2 through 3) in May 1996 ranged from 0 ppmv to 350 ppmv (Table 6-2). Relatively high concentrations (greater than 5 ppmv) measured at CPT-9A, CPT-21A, and CPT-28 suggest that these probes were outside of the radial influence of the 42.5-m^3/min SVE system. Vacuums measured in SVE monitoring wells in May 1996, and the resulting airflow modeling, also suggest that these locations were beyond the radial influence of the SVE system in May 1996 (Rohay and McMahon 1996).

The baseline concentration data for the soil vapor probes were collected 6 months prior to the rebound study. Therefore, these data were not used to calculate rebound magnitude or rates. They are included as reference because they provide the most recent prior measurements at these locations.

Differential pressures were measured at deep soil vapor probes from October 30 through 31, 1996 to indicate which probes were within the radial influence of the SVE systems at the time the rebound study started (Table 6-3). Vacuums exceeding 0.025 kPa at 8-m depth to 0.075 kPa at 23-m depth in zone 2; 0.125 kPa in zone 3; and 0.375 kPa in zones 4-6 are attributed to the influence of SVE operations. These values were chosen based on measured subsurface vacuums induced naturally by barometric pressure fluctuations (Rohay and McMahon 1996). On this basis, probes CPT-1A and CPT-9A, and possibly CPT-7A, were beyond the radial influence of the SVE systems in October 1996.

6.2 REBOUND SAMPLE DATA

All of the rebound study data for the Z-9 and Z-1A sites were organized by zone and are tabulated in Appendix A. For each sample point, the primary data are the sample location and

depth, the sample date and time, the subsurface-surface differential pressure, and the carbon tetrachloride concentration. Additional data recorded for the soil vapor samples are the concentrations of chloroform, methylene chloride, MEK, and water; and comments related to observations during sample collection. The barometric pressure data for November 4, 1996 through July 13, 1997 are shown in Figure 5-1.

For the data presented in Appendix A, carbon tetrachloride concentrations measured prior to January 13, 1997 that exceeded 108 ppmv on the low B filter were corrected to the equivalent High A filter value (noted by comment "High A calculated") (Section 4.3.5); and duplicate measurements were averaged. Six carbon tetrachloride concentrations were flagged as anomalous and excluded from further analysis (CPT-30/21, 1/29/97; CPT-4F/23, 11/22/96; CPT-31/23, 12/19/96; CPT21A/26, 11/25/96; W15-6L, 5/5/97; and W15-86, 5/5/97). Initial samples collected from November 6, 1996 through November 12, 1996 at wells W15-6L and W18-174 were not representative of subsurface soil vapor because the sample tube intakes were in water, and on March 3, 1997 at well W18-174 because the sample tube assembly was leaking. These results were also excluded from analysis.

Samples could not be drawn from three of the sample locations originally selected (W15-218SST/26, CPT-24/29, CPT-8AEX); these probes were deleted from rebound monitoring and replaced by probes CPT-18/11, CPT-17/8, and CPT-16/20. Shallow soil vapor probe RST4-1 was no longer available and was replaced by probe 95-08. Eight deep soil vapor sampling locations were reassigned from their original subsurface zone (indicated in the test plan) to the overlying zone based on reevaluation of their actual elevations relative to the definitions of the zone boundaries following the GPS location survey. At the Z-9 site, CPT-9A/28 moved from zone 3 to zone 2; CPT-24/36 moved from zone 4 to zone 3; and W15-220SST/56 moved from zone 6 to zone 5. At the Z-1A site, CPT-4C/33, CPT-4E/31, CPT-4F/33, W18-152, and W18-252SST/31 all moved from zone 3 to zone 2.

Plots of the rebound data for each sample point are provided in Appendix B.

The minimum and maximum carbon tetrachloride concentrations measured at each sample point are summarized in Table 6-4.

The highest carbon tetrachloride concentration measured during the rebound study at a shallow probe in zone 1 near the ground surface was 1 ppmv at Z-9 and 4 ppmv at Z-1A. Concentrations at the shallow probes were zero most of the time.

The maximum carbon tetrachloride concentrations measured at probes and wells in zone 3, which includes the upper portion of the lower permeability silt and Plio-Pleistocene layers, were higher than concentrations measured in any other zone; concentrations measured at Z-9 were similar to those measured at Z-1A. At the Z-9 site, concentrations ranged from 0 to 797 ppmv; at the Z-1A site, concentrations ranged from 0 to 573 ppmv.

Maximum carbon tetrachloride concentrations measured at probes and wells in zone 2, which is between zones 1 and 3 and generally represents the high flow zone above the Plio-Pleistocene layer for airflow induced by the SVE systems, were higher at the Z-9 site than at the Z-1A site.

At Z-9, concentrations ranged from 0 to 280 ppmv; at Z-1A, concentrations ranged from 0 to 47 ppmv. The maximum concentrations differ by an order of magnitude between Z-9 and Z-1A in zone 2.

Maximum carbon tetrachloride concentrations measured at probes and wells in zone 4, which includes the lower portion of the lower permeability silt and Plio-Pleistocene layers, were lower than those measured in zone 3. At the Z-9 site, concentrations ranged from 1 to 298 ppmv (based on three sample locations); at the Z-1A site, concentrations ranged from 0 to 94 ppmv (based on two sample locations).

Maximum carbon tetrachloride concentrations measured at wells in zone 6 near the water table were similar at the Z-9 and Z-1A sites. At Z-9, concentrations ranged from 0 to 23 ppmv; at Z-1A, concentrations ranged from 0 to 47 ppmv.

Carbon tetrachloride concentrations measured at probes and wells in zone 5, which is between zones 4 and 6 and generally represents the high flow zone below the Plio-Pleistocene layer for airflow induced by the SVE systems, were higher at the Z-1A site than at the Z-9 site. For zone 5 locations at Z-9, concentrations ranged from 0 to 60 ppmv (based on two sample locations); at Z-1A, concentrations ranged from 0 to 48 ppmv (based on one sample location).

Samples collected from well W15-82 were observed to have methylene chloride concentrations that fluctuated between zero ppmv and hundreds of ppmv (maximum 563 ppmv). Additional samples were collected from seven wells on January 6 to confirm these high concentrations. The additional samples were analyzed using a Photovac 10S Plus gas chromatograph with an 11.7-eV lamp (Table 6-5). The gas chromatograph detected no methylene chloride or MEK at any of the wells; the carbon tetrachloride and chloroform concentrations detected using the gas chromatograph were very similar to those detected using the B&K. Gas chromatograph analysis of samples from three wells on January 9 detected no methylene chloride or MEK at the two Z-9 wells, and a trace of methylene chloride at a Z-1A well (W18-174). Samples collected at five locations on March 11 and analyzed using the B&K 1301 instrument had methane concentrations ranging from 53 ppmv to 110 ppmv at four of the locations and 606 ppmv at W15-82. It is believed that the methane produces at least part of the apparent methylene chloride peak at W15-82 (methane with a concentration two-and-a-half to three times an apparent methylene chloride concentration would be needed to produce that methylene chloride concentration). (It is interesting to note that the SVE system was extracting from W15-82 on June 3, 1993 when the granular activated carbon [GAC] canister overheated. Subsequent testing in 1993 showed that, at an inlet carbon tetrachloride concentration of 30,000 ppmv, oxidation of trace solvents can be initiated and can contribute additional heat [Driggers 1994]).

Some relatively high concentrations of chloroform, MEK, and methylene chloride were observed in samples from some shallow soil vapor probes on January 24, but analysis of the same Tedlar bag samples on the Photovac gas chromatograph did not detect any chloroform or MEK (Table 6-5).

6.3 QUALITY ASSURANCE DATA

Duplicate samples were collected at a maximum of every twentieth sample to evaluate the repeatability of the sampling method. All of the analyses of carbon tetrachloride concentrations in the pairs of duplicate samples are provided in Appendix C.

The duplicate samples were used to calculate the precision of the carbon tetrachloride analyses, defined as a measure of the degree to which individual measurements of the same property under similar conditions approach the same value (BHI-QA-03, Plan No. 5.2). Using the duplicate samples, the relative percent difference (RPD) was calculated according to the formula: $RPD = (C_1 - C_2) \times 100 / (C_1 + C_2)/2$, where C_1 is the larger of the two observed values and C_2 is the smaller (BHI-QA-03, Plan No. 5.2, Section 11.1). Concentration measurements less than 1.5 ppmv were not used for these calculations because the B&K is not calibrated below 1.5 ppmv.

The RPD calculated using the duplicate samples is shown in Figure 6-1. All but two of the duplicates were within 25% of each other. The maximum RPD was 43%, the minimum was 0%, and the average was 5%. These calculations indicate that sample method produced repeatable measurements.

The B&Ks were challenged with calibration gases of known carbon tetrachloride concentration every time samples were analyzed. The calibration gases had carbon tetrachloride concentrations ranging from 10.4 ppmv to 550 ppmv. All of the measured and standard carbon tetrachloride concentrations are provided in Appendix D.

The pairs of standard and measured carbon tetrachloride concentrations were used to evaluate the accuracy of the carbon tetrachloride analyses. The percent recovery (%R) was calculated according to the formula: $\%R = 100 \times (C_m/C_s)$, where C_m is the measured concentration of carbon tetrachloride and C_s is the standard (BHI-QA-03, Plan No. 5.2, Section 11.1). Measurements of standard gases with concentrations exceeding 108 ppmv using the Low B filter (calibrated from 1.5 to 108 ppmv) were not included in the calculations.

The %R calculated using measurements of the standard gases is shown in Figure 6-2. The maximum %R was 106%, the minimum was 91%, and the average was 97%. These calculations indicate that the B&K analyses of the carbon tetrachloride concentrations were accurate within 10% in general and within 3% on average.

Four of the wells were sampled twice per sampling day, once in the morning and once in the afternoon, from November 1996 through January 1997 to evaluate whether the diurnal barometric pressure cycles would affect concentration measurements. Two wells, W15-217 at Z-9 and W18-89 at Z-1A, were sampled at 35-m depth above the Plio-Pleistocene layer; and two of the wells, W15-9L at Z-9 and W18-7 at Z-1A, were sampled at 60-m depth above the groundwater table. All of the morning-afternoon results for carbon tetrachloride are provided in Appendix E.

All of the carbon tetrachloride concentrations measured at wells W15-217 and W18-89 from November 1996 through January 1997 (including once per day samples) are plotted in

Figure 6-3. All of the carbon tetrachloride concentrations measured at wells W15-9L and W18-7 from November 1996 through January 1997 (including once-per-day samples) are plotted in Figure 6-4. Carbon tetrachloride fluctuations measured at wells W15-217 and W18-89 show the same pattern even though the wells are 270 m apart. Carbon tetrachloride fluctuations measured at wells W15-9L and W18-7 are also separated by approximately 270 m and also follow similar patterns. The similar patterns in wells at two different locations suggest that the fluctuations are caused by something other than leaks in the wellhead assembly or well construction. (The carbon tetrachloride-packer test was designed to investigate these fluctuations.)

The maximum difference in carbon tetrachloride concentrations between a morning and afternoon sample was 72 ppmv at W15-217 (Table 6-6). This well has significantly higher carbon tetrachloride concentrations than the other three and therefore would be expected to exhibit the highest absolute concentration fluctuations. The largest increase from morning to afternoon was 72 ppmv; the largest decrease from morning to afternoon was 67 ppmv. For both zone 3 wells, the maximum absolute daily concentration difference at each well was 17% of the maximum concentration detected in any sample. For both zone 6 wells, the maximum absolute daily concentration difference at each well was 12% to 14% of the maximum concentration detected in any sample.

6.4 SOIL VAPOR EXTRACTION TEST DATA

6.4.1 Puffer Tests

Three-hour SVE puffer tests were conducted at wells W15-82 on July 14 and W15-217 on July 15 to observe initial carbon tetrachloride concentration changes during restart of SVE operations. The puffer test data are provided in Table 6-7.

During extraction at W15-82, carbon tetrachloride concentrations increased with time from 34 ppmv to 97 ppmv (Figure 6-5). The last rebound concentration measured at this well was 28 ppmv on July 7, 1997. The steady increase of concentrations during extraction at this well suggests that the carbon tetrachloride source is not at the location of the well screen. These data are consistent with the initial rebound measurements at this well after shutdown of SVE operations. Carbon tetrachloride concentrations decreased steadily from 29 ppmv on November 6 to 10 ppmv on November 25, which also suggested that contaminated vapor is drawn to the well by the SVE vacuum.

Tracer gas testing at the Z-9 wellfield in 1995 indicated that the soil vapor velocity was 16.5 to 20.4 m/hr at a flow rate of 5.1 m^3/min measured at the SVE system (Barna 1995). During the 3-hour test, the SVE flowrate was lower, averaging 2.7 m^3/min, so the subsurface velocity would also have been slower, approximately 9 m/hr, assuming a linear relationship between SVE flowrate and soil vapor velocity in the zone corresponding to the open interval of the well. At that velocity, the source of the higher carbon tetrachloride concentration observed after 3 hours of extraction would have been approximately 27 m from the well. Although the specific location (direction and depth) of the source of the contaminated vapor cannot be determined, it may be the

Plio-Pleistocene layer underlying the Z-9 disposal site. Well W15-82 is 25 m east of the center of the Z-9 trench, and the well is screen approximately 5 m above the Plio-Pleistocene layer.

During extraction at W15-217, carbon tetrachloride concentrations remained nearly constant at approximately 150 ppmv throughout the test (Figure 6-6). The last rebound concentration measured at this well was approximately 300 ppmv on July 7, 1997. Carbon tetrachloride concentrations at this well fluctuated throughout the rebound study, but were generally higher than 150 ppmv. Monitoring at W15-217 during the 3-hour test at W15-82 indicates that the vacuum at W15-217 increased from 0.025 kPa to 0.150 kPa, possibly indicating the extraction at W15-82 drew more contaminated vapor away from W15-217.

6.4.2 Restart of Soil Vapor Extraction Operations

All of the Z-9 and Z-1A wells were placed on-line on July 18, 1997. The carbon tetrachloride concentrations were monitored at seven wells at the Z-9 site on July 18; and then at these wells plus an additional six wells at the Z-1A site on July 21, July 24, July 28, and July 31 (Table 6-8).

The carbon tetrachloride concentrations before, during, and after the rebound study are compared for these 13 wells in Figures 6-7, 6-8, and 6-9. Of the four wells open at or above the Plio-Pleistocene layer at Z-9 (Figure 6-7), concentration trends after SVE restart are consistent with the rebound study trends. For example, after SVE shutdown in November 1996, carbon tetrachloride concentrations initially decreased at well W15-82 (zone 2); and after SVE restart, they increased. After SVE shutdown in November, carbon tetrachloride concentrations at W15-218U (zone 3) initially were relatively constant; although concentrations later increased slightly, after SVE restart they decreased to approximately the same concentrations as in October-November and remained relatively constant. After SVE shutdown in November 1996, carbon tetrachloride concentrations increased at wells W15-217 (zone 3) and W15-86 (zone 4), and after SVE restart, they decreased back to approximately the concentrations they had in October 1996.

All four wells in zone 3 at Z-1A (Figure 6-8) decreased after SVE restart to concentrations comparable to those measured in October. The decline in carbon tetrachloride concentrations following SVE restart suggests that the contaminant is being removed more rapidly than it can be supplied to the high flow zone. The flowrates measured at wells W18-174 and W18-248 were very low both in October 1996 and in July 1997 (Tables 6-1 and 6-8). The flow rate through well W18-248 typically has been low throughout SVE operations, suggesting that airflow pathways at this well, which is open within the low-permeability Plio-Pleistocene layer, are limited. The flowrate through well W18-174 typically has been moderate throughout SVE operations in summer months, but zero in winter months. The reason for the low to zero flow measurements is uncertain, but may be related to the presence of water noted during the rebound study measurements (Appendix A).

Concentrations at the three wells screened near the water table at Z-9 (Figure 6-9) did not change significantly during the first 2 weeks after SVE restart, although the data suggest the concentrations were beginning to decrease at W15-9L and W15-218L, approaching October 1996 levels. Flowrates at these wells in July 1997 were comparable to flowrates for other SVE wells

(Table 6-8). The data are somewhat similar for two zone 6 wells at Z-1A (Figure 6-9), although the flowrate at W18-6 in July 1997 is significantly lower than expected (Table 6-8). The cause of the decreased flowrate is unknown.

Daily average carbon tetrachloride concentrations measured at the SVE inlets following SVE restart are shown in Figure 6-10. For each SVE system, inlet concentrations before and after the rebound study are summarized in Table 6-9.

At the 42.5-m^3/min SVE system at the Z-9 site, the inlet carbon tetrachloride concentration was 25 ppmv on November 4 when the SVE systems were taken off-line. After 8 months of rebound, the maximum carbon tetrachloride concentration at, or shortly after, restart on July 18 was 87 ppmv. Concentrations then decreased to 28 ppmv by August 22, after 842 hours of SVE operation, and continued to decrease more slowly to 24 ppmv after 1154 hours of SVE operation. The breakpoint of August 22 was chosen based on visual inspection of Figure 6-10. The carbon tetrachloride concentration decreased an average of 0.08 ppmv/hr during the first 3 weeks of SVE operation; the average decrease between July 18 and September 4 was 0.05 ppmv/hr. For the 28.3-m^3/min system, the average carbon tetrachloride decrease during the first 7 weeks of SVE operation was 0.01 ppmv/hr; and for the 14.2-m^3/min system, the average decrease was 0.03 ppmv/hr.

6.4.3 Low Flow Test at Z-1A

A low-flow test was conducted using the 28.3-m^3/min SVE system at the Z-1A wellfield to evaluate the impact of lower flow on the carbon tetrachloride removal rate. In practice, the flow rate is reduced by reducing the vacuum. On August 14, 1997, at 1000 hours, the system vacuum was reduced from 12.5 kPa to 3.0 kPa, reducing the flow from 28.8 m^3/min to 13.5 m^3/min (Figure 6-11). This was the lowest flow achievable for this system without overheating the blower motor. Carbon tetrachloride concentrations at the system inlet decreased from 25-27 ppmv to 21-22 ppmv (Figure 6-12).

The time needed to purge the entire SVE system of stored air at the lower flow rate was estimated as less than 15 minutes, based on the calculation that 2.3 minutes was needed to replace the air in a 10.2-cm-diameter hose 244 m long, assuming that only one well was on-line to that hose and that the flow from the one well was one-sixteenth of the total flow (16 wells were on-line to the system). Because the first carbon tetrachloride concentration reading was 25 minutes after the vacuum change, it is assumed to be representative of concentrations extracted under the lower flow conditions.

On August 15 at 1130 hours, the vacuum was increased to 6.7 kPa, chosen to be intermediate between the high and low values the previous day. The system operated until August 18 at 0630 hours in this configuration; the vacuum varied from 6.7 to 7.5 kPa and the flow varied from 22.1 to 22.6 m^3/min (Figures 6-11 and 6-12). The carbon tetrachloride concentration during this time was 23 ppmv. Between August 18 and August 21, the flow varied from 27 m^3/min to 22 m^3/min; the carbon tetrachloride concentration was 24 ppmv during the higher flow and 22 ppmv during the lower flow (Figure 6-12). The carbon tetrachloride concentration remained

at approximately 22 ppmv until at least September 4 (Figure 6-10), although the flow was increased to 26 m^3/min on August 29.

The time needed to purge the subsurface of the contaminated vapor drawn within the radial influence of the well using the higher vacuum and flow rate was approximately 3.5 days, assuming a radial influence of 30 m for an individual well, an average perforated interval length of 7 m, a subsurface porosity of 30%, and a flow rate one-sixteenth of the total flow, which changed after 24 hours from 13.5 m^3/min to 22.4 m^3/min. Based on this estimate, the zone of radial influence is assumed to have been swept out during the low-flow test, indicating that the inlet concentrations observed after 3.5 days were representative of concentrations extracted under lower flow conditions.

These tests suggest that reducing the flow by half produced only a minor change in the carbon tetrachloride concentrations in the extracted soil vapor.

6.5 SAMPLE LOCATION DATA

The locations and elevations of the CPT wells and probes were surveyed using a GPS February 1997. The elevations are of the ground surface at each location. The data are provided in Appendix F.

When the stainless steel tubes were installed at wells W15-219, W15-220, and W18-252 in 1993, the depths were recorded on the field activity sheets and the tubes were identified by their relative positions on the casing. However, after the protective casing was emplaced, the relative positions of the tubes were not visible, and it was unknown which tube corresponded to which depth. The tubes were color-coded for convenience during rebound data collection, and at the conclusion of the study each tube was assigned to one of the recorded depths based on the differential pressure and carbon tetrachloride concentration measurements. Depth assignments were not readily apparent for two pairs of tubes: W15-220SST/36 and W15-220SST/56, and W18-252SST/44 and W18-252SST/64. In each of these two cases, the potential exists that the rebound data assigned to the shallower depth (36 or 44 m) were actually collected at the deeper depth (56 and 64 m), and that the data assigned to the deeper depth belongs to the shallower depth. Because of the uncertainty in the correct depths, these data were not used in the evaluation. However, they are reported in Appendices A and B for completeness.

At least some of the Teflon-lined Tygon sampling tubes that were lowered into the wells appear to have stretched during the rebound study, changing the sampling depths. When the tubes were removed from wells W15-217 and W18-89 to install packers and then replaced for the carbon tetrachloride-packer test, the change in tube length was discovered. As a result, additional tube lengths were measured when the sampling tubes were removed in preparation for SVE operations. The five tubes measured stretched by 7% to 21% (Table 6-10).

When the sampling tube was removed from well W15-82 on July 14, 1997, the sampling screen and lower part of the tube were observed to be caked with silt, and very moist, which suggests that it had been lying at the bottom of the well. The observation suggests that this sample tube

also stretched during the study and that vapor flow into the tube may have been reduced. However, no sampling difficulties were noted at this location (Appendix A).

When the sampling tube was being removed from well W15-6L, a joint broke on the tube and 30 m of tubing plus the sampling screen fell to the bottom of the well.

6.6 SUPPLEMENTAL TEST DATA

The carbon tetrachloride-packer test was conducted at wells W15-217 and W18-89, which exhibited fluctuations in carbon tetrachloride concentrations during the rebound study. Carbon tetrachloride concentrations measured in these two wells did not stabilize after the downhole packers were installed, suggesting that (1) airflow pathways exist outside of the well casing, and (2) vapor moving through these pathways in response to barometric pressure fluctuations could be affecting the concentrations measured at the well screen. As a result, natural soil vapor movement can introduce variability into concentrations measured at a well sampling location even if the well is sealed. The data and evaluation are included in Appendix G.

The carbon tetrachloride-barometric pressure test was conducted at well W18-252U. The carbon tetrachloride concentration varied inversely with barometric pressure during the test. However, the numerical relationship between concentration and pressure appears to be complex, and a mechanism has not yet been developed for accurately filtering the effects of barometric pressure from the effects of rebound. The data and evaluation are included in Appendix H.

The passive extraction valve test was conducted at wells W18-246L, W18-247L, and W18-252L. Passive SVE was found to remove carbon tetrachloride at similar rates with and without a flow-activated valve, although inclusion of the valve can increase the removal rate. The radial GAC canisters were observed to be leaking despite efforts to seal them, and they are not recommended for use during additional testing. They are still marginally acceptable for use during application of passive SVE because carbon tetrachloride removal was effective with and without the one-way valve (i.e., introducing a small leak into a passive system supposedly sealed by the valve would not significantly compromise the remediation at this site). The data and evaluation are included in Appendix I.

In situ soil vapor and groundwater data collected at vapor extraction wells during drilling in 1992 and 1993 were evaluated for the potential for carbon tetrachloride exchange between the unsaturated and saturated zone. Comparisons of measured to theoretical equilibrium concentrations were made using Henry's Law as a guideline. No single pattern emerged at either the Z-9 site or the Z-1A site. The potential for migration of carbon tetrachloride from the soil vapor to the groundwater in 1993 was identified at well W15-218 at the Z-9 site. The data and evaluation are included in Appendix J.

Subsurface pressure data were collected in 1995 to test the impact of an impermeable surface cover on the radial influence of an extraction well at the carbon tetrachloride site. Using a sealed ground surface to block the vertical flow of atmospheric air into the subsurface is common industrial practice for SVE systems. The sealed surface enhances horizontal subsurface airflow

toward the extraction well by preventing short circuiting through the ground surface adjacent to the extraction well. It may also retard dilution of contaminant concentrations by preventing the introduction of clean air adjacent to the extraction well. Analysis of the 1995 test data indicated that the particular surface cover used during the test did not provide an effective seal because it was easily torn and billowed by the wind. Therefore, the impact of a surface seal has yet to be demonstrated at this site. The data and evaluation are included in Appendix K.

Figure 6-1. Relative Percent Difference for Duplicate Sample Analyses of Carbon Tetrachloride.

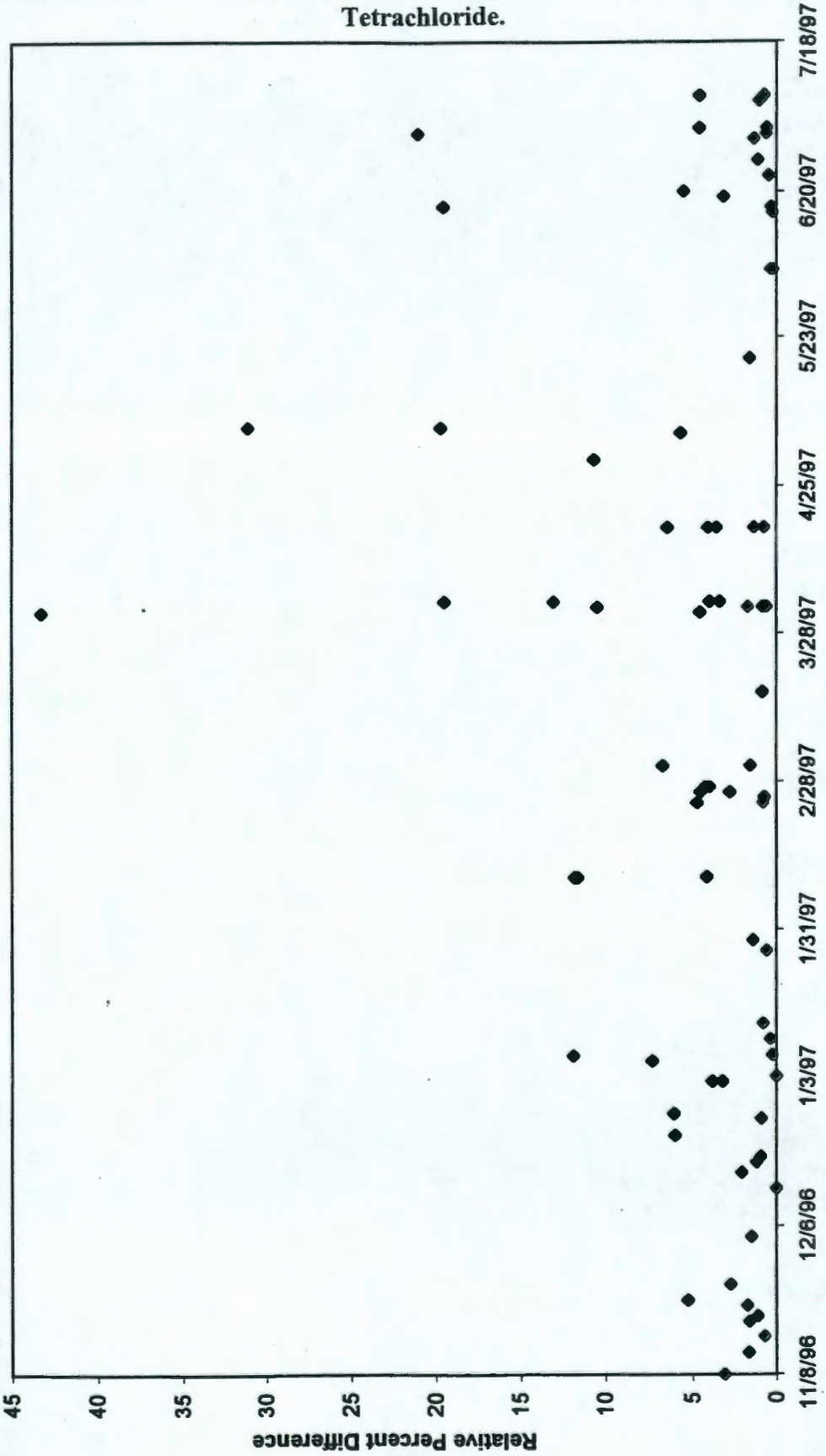


Figure 6-2. Percent Recovery for Carbon Tetrachloride Concentrations in Standard Gases Analyzed Using the B&K.

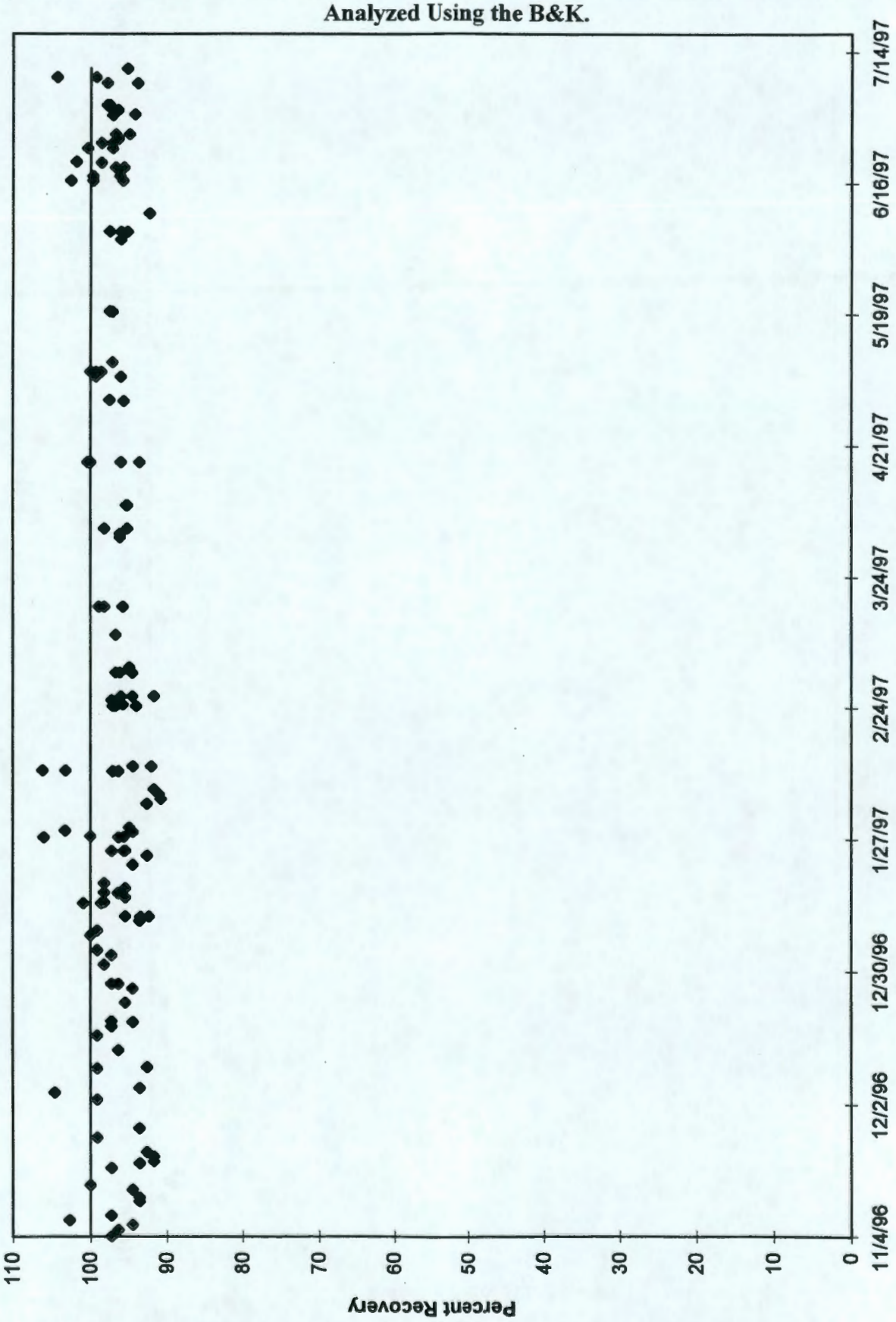


Figure 6-3. Comparison of Morning and Afternoon Concentration Measurements at W15-217 and W18-89.

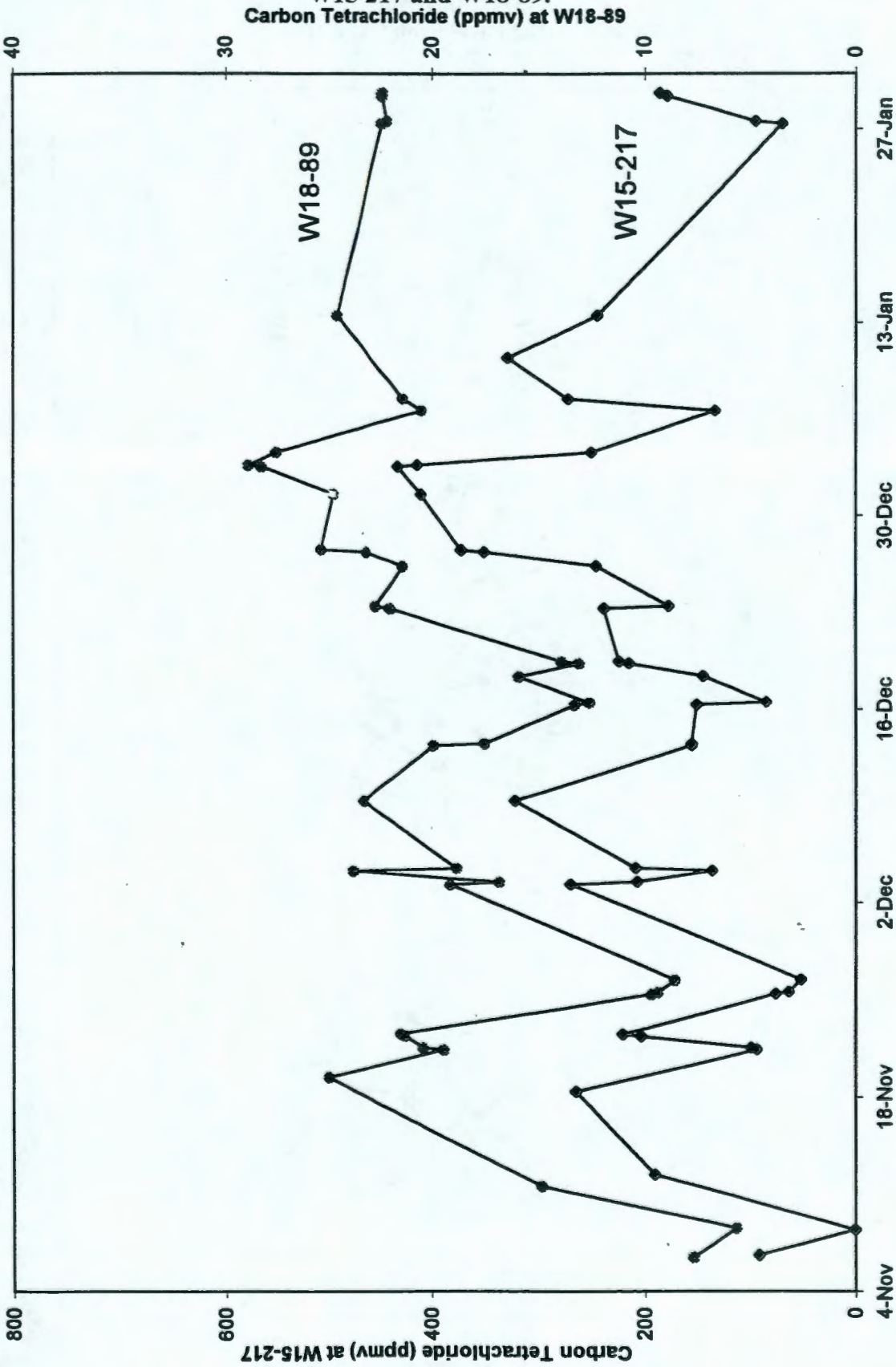


Figure 6-4. Comparison of Morning and Afternoon Concentration Measurements at W15-9L and W18-7.

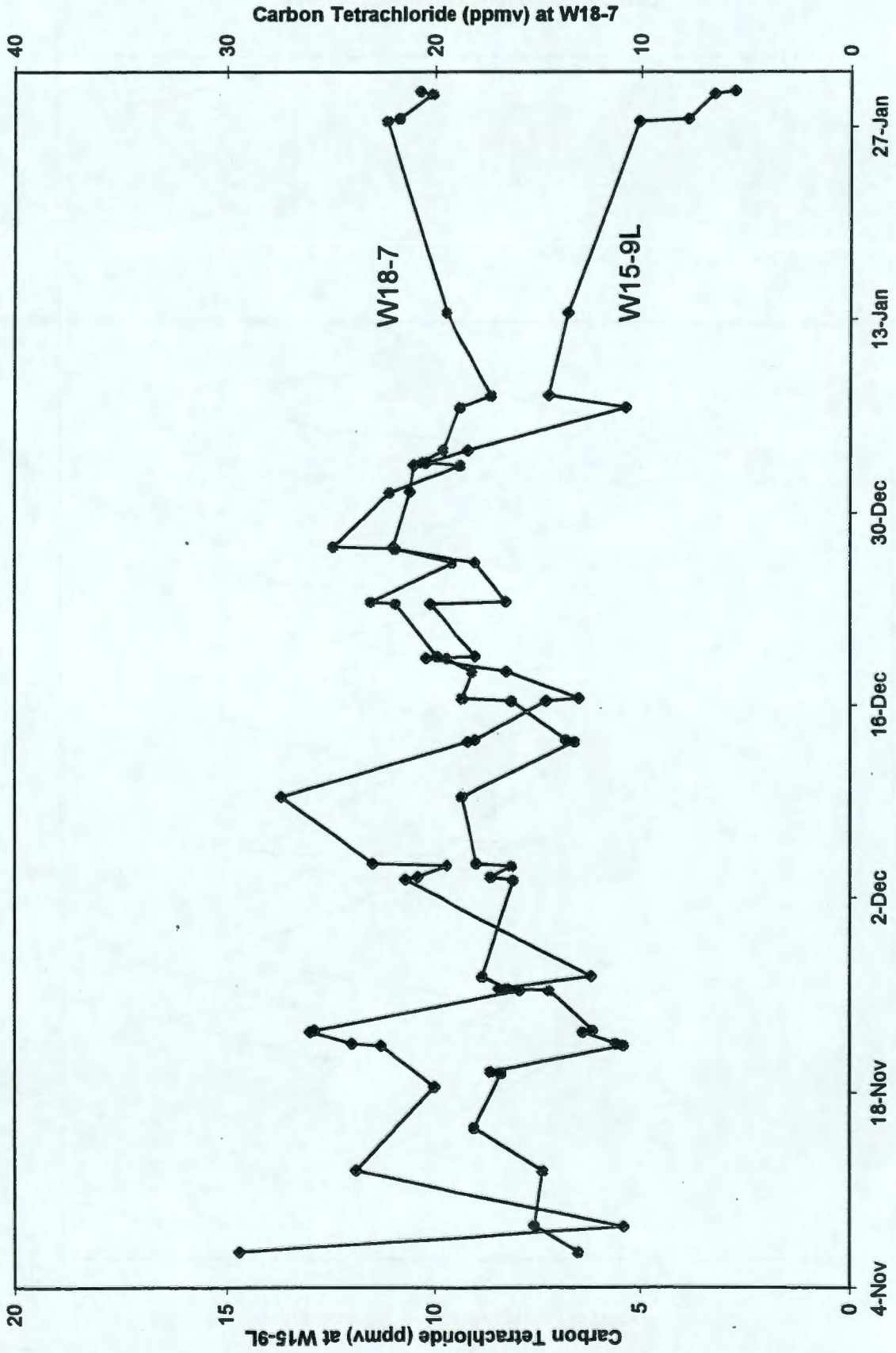


Figure 6-5. Carbon Tetrachloride Concentrations Measured at Well W15-82 During Three-Hour Puffer Test, July 14, 1997.

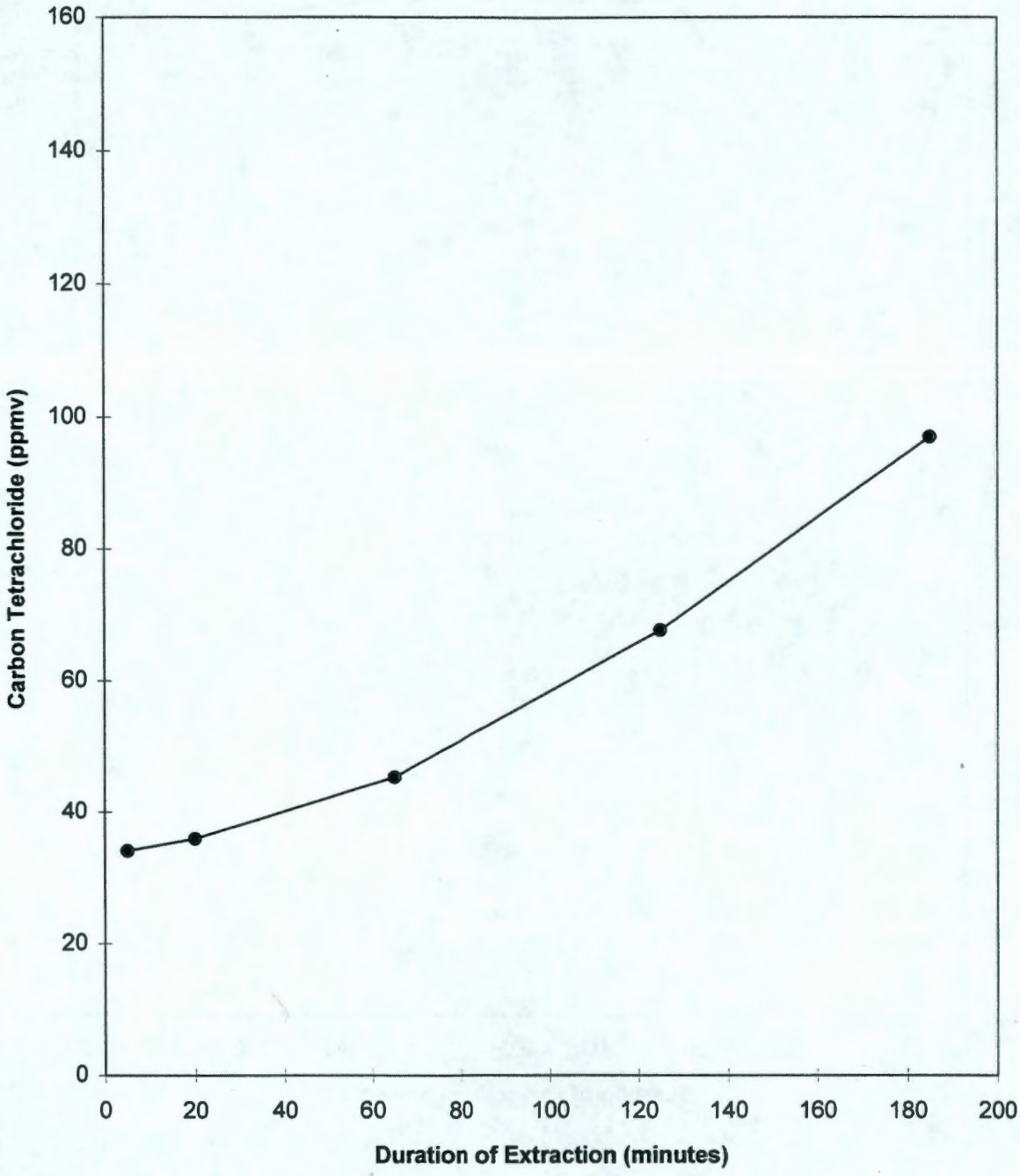


Figure 6-6. Carbon Tetrachloride Concentrations Measured at Well W15-217 During Three-Hour Puffer Test, July 15, 1997.

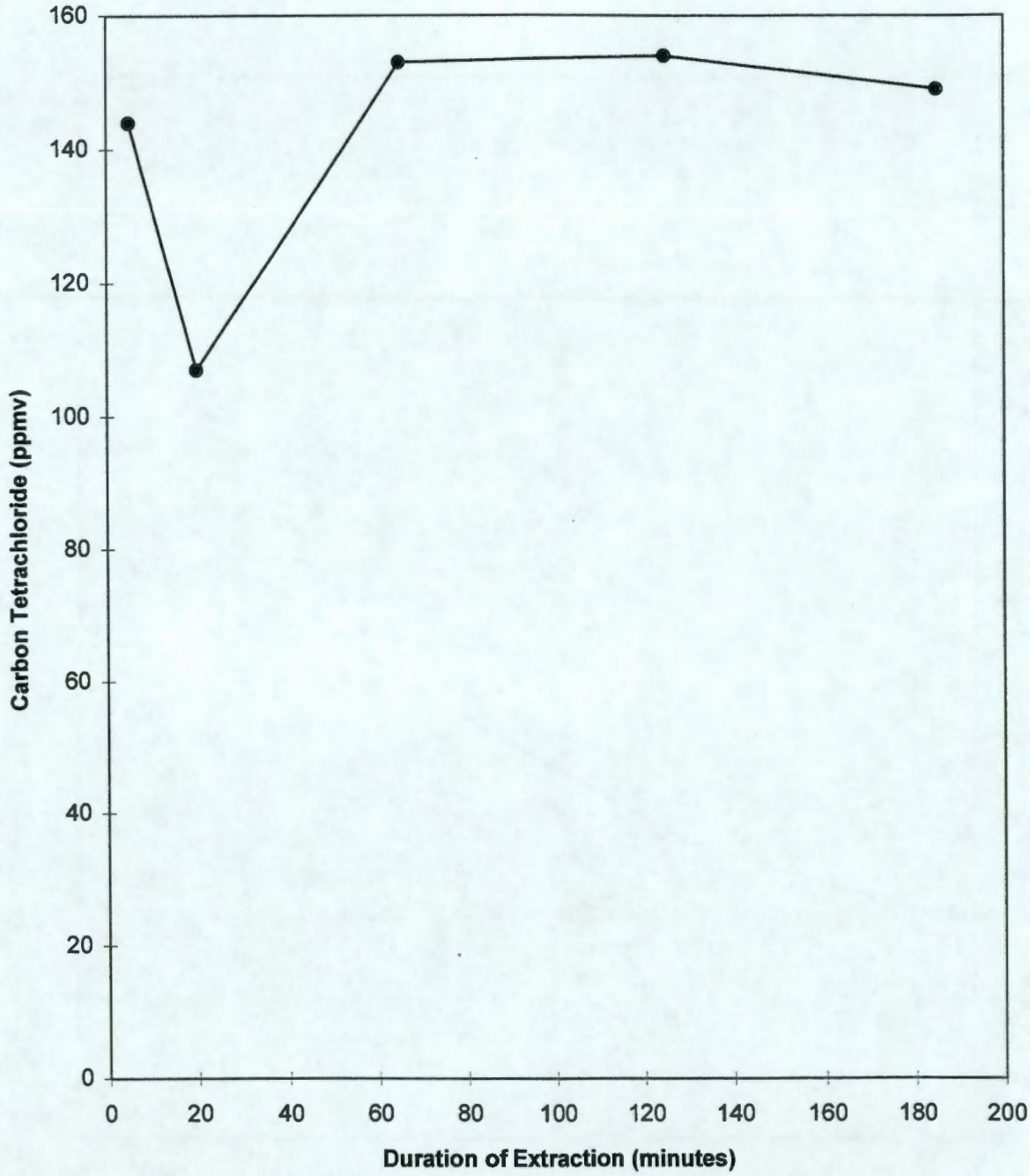


Figure 6-7. Comparison of Carbon Tetrachloride Concentrations Before, During, and After the Rebound Study at Z-9 Wells Open Above the Plio-Pleistocene Layer.

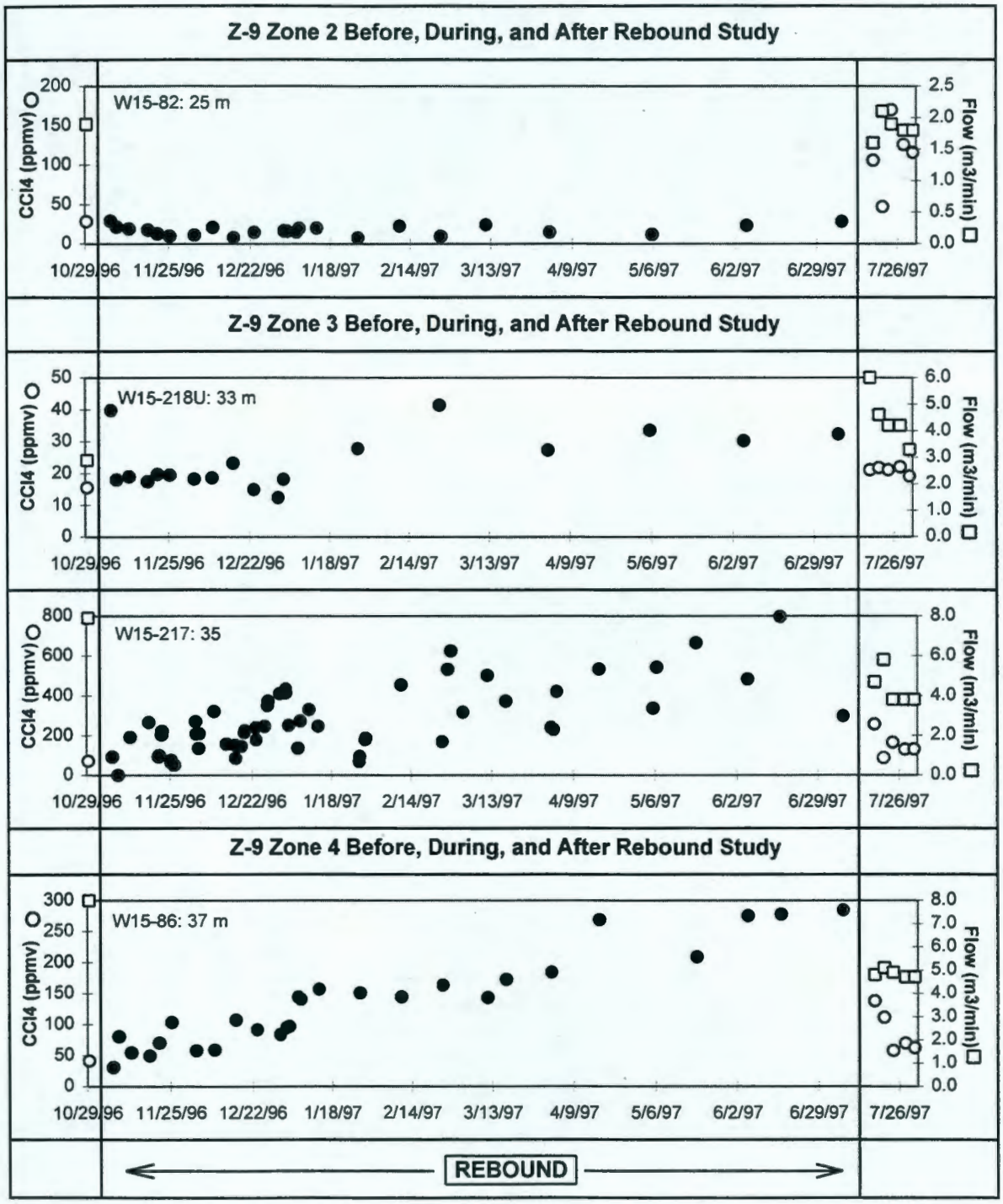


Figure 6-8. Comparison of Carbon Tetrachloride Concentrations Before, During, and After the Rebound Study at Z-1A Wells Open Above the Plio-Pleistocene Layer.

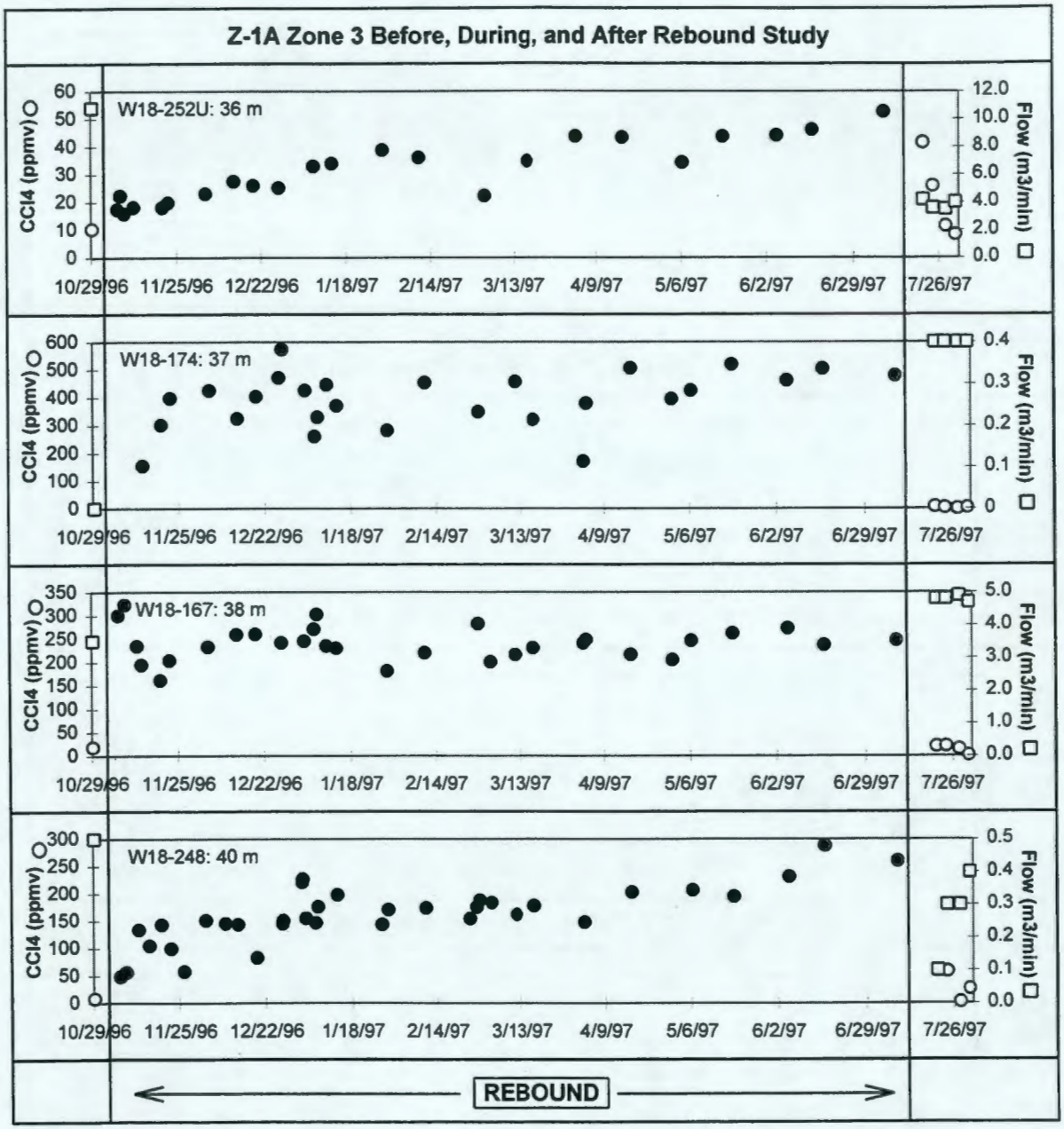
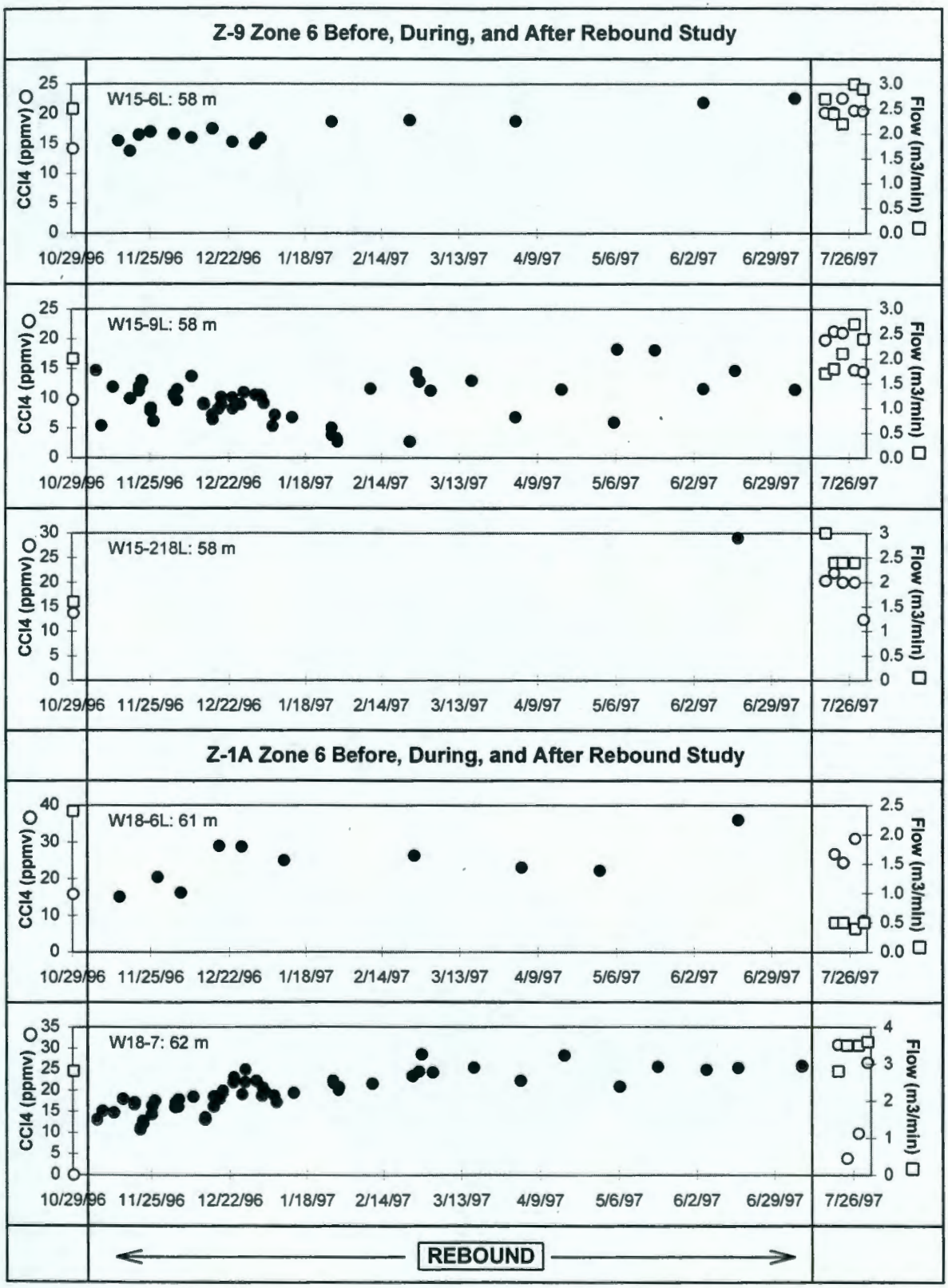


Figure 6-9. Comparison of Carbon Tetrachloride Concentrations Before, During, and After the Rebound Study at Z-9 and Z-1A Wells Open Above the Water Table.



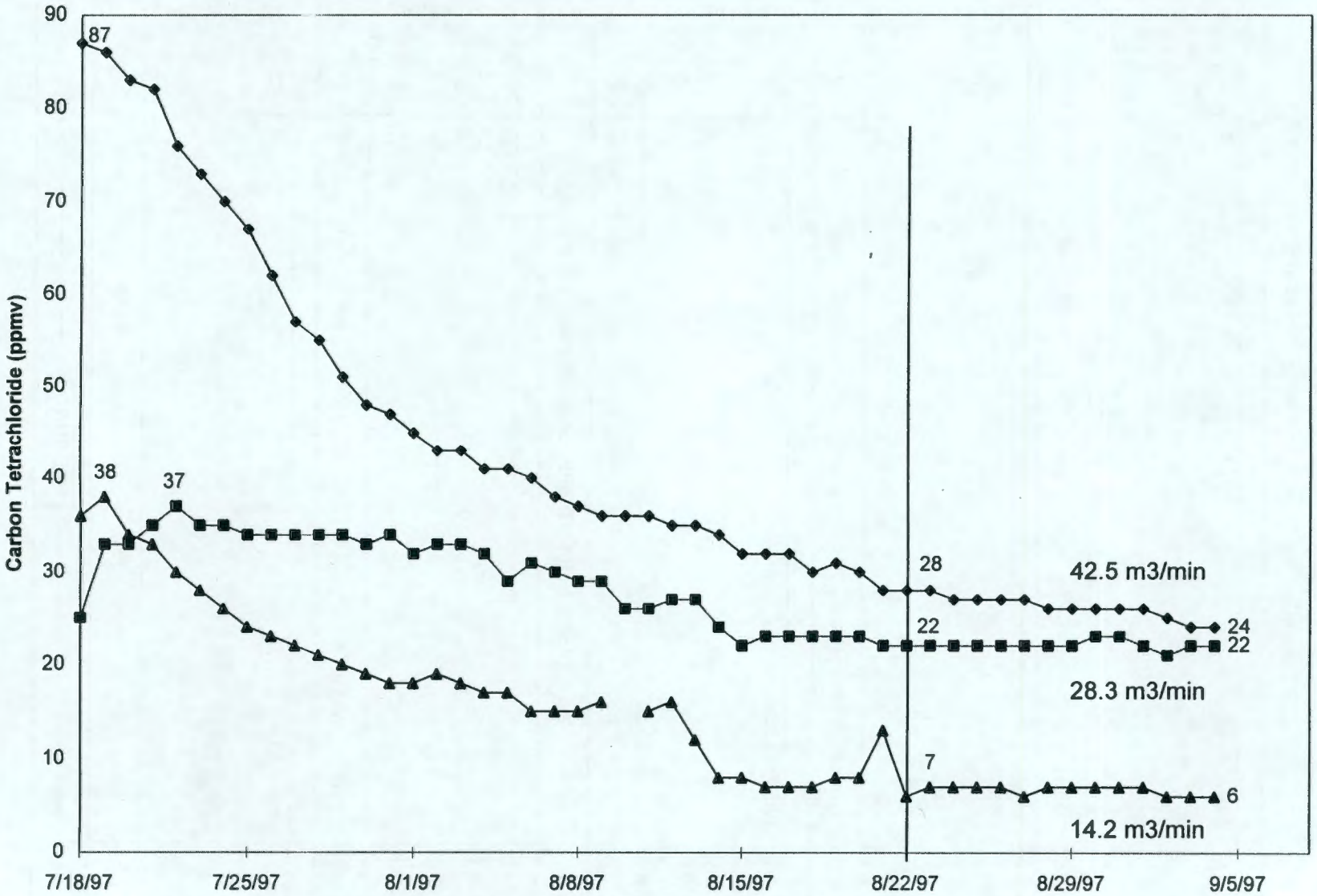


Figure 6-10. Inlet Carbon Tetrachloride Concentrations at the Three Soil Vapor Extraction Systems, July 18 through September 4, 1997.

Figure 6-11. Relationship Between Vacuum and Flow Rate at the 28.3-m^3/min Soil Vapor Extraction System, August 1997.

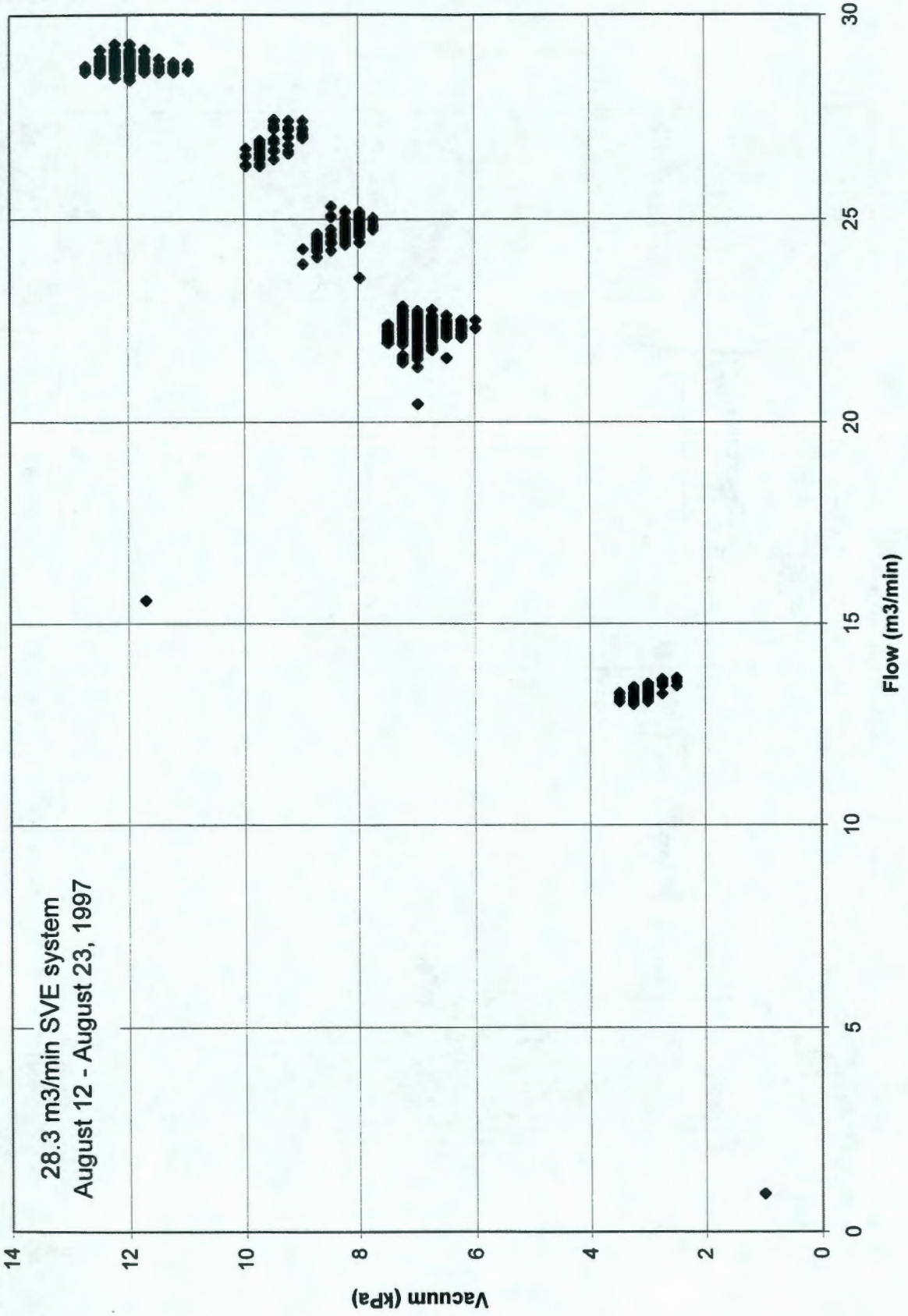


Figure 6-12. Flow Rate and Carbon Tetrachloride Concentrations at the 28.3-m³/min Soil Vapor Extraction System During the Low Flow Test, August 14 through August 21, 1997.

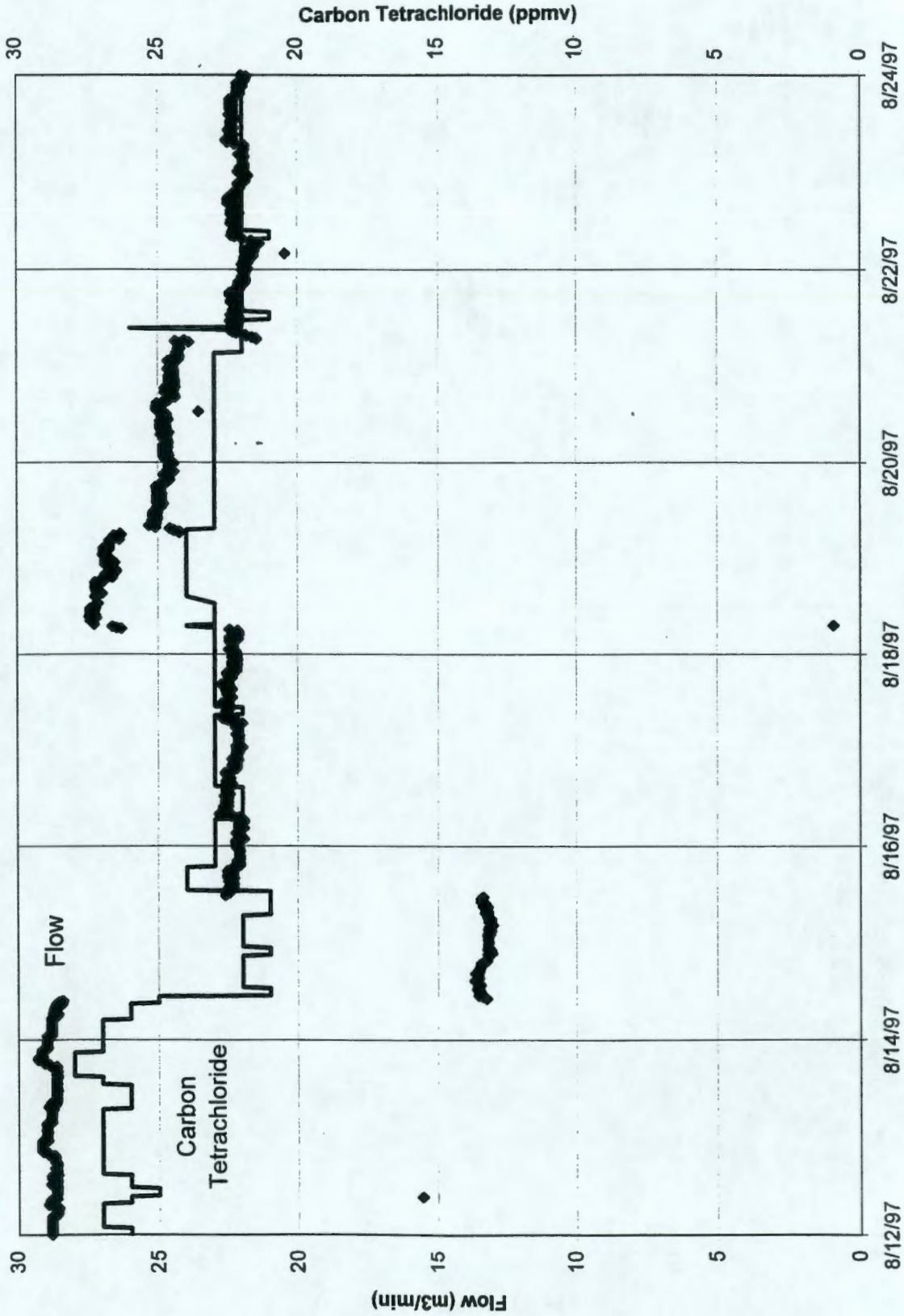


Table 6-1. Baseline Characterization of Soil Vapor Extraction Wells, October 1996.

Date	Well/Interval	Well Vacuum (kPa)	SVE Vacuum (kPa)	Flow (m3/min)	CCl4 (ppmv)	CCl4 Flux (kg/day)	CHCl3 (ppmv)	CH2Cl2 (ppmv)	MEK (ppmv)
14.2 m3/min system									
10/29/96	W18-152	2.2	10.0	1.0	11.4	0.003	1.7	0.0	0.0
10/29/96	W18-153	2.5	10.0	3.8	0.0	0.000	0.0	0.0	0.0
10/29/96	W18-246L	7.5	10.0	1.4	6.9	0.003	2.0	0.0	0.0
10/29/96	W18-246U	5.5	10.0	11.6	9.0	0.029	0.0	0.0	0.0
10/29/96	W18-252L	9.0	10.0	14.2	14.6	0.058	0.0	0.0	0.0
10/29/96	W18-252U	4.5	10.0	10.8	10.4	0.031	0.0	0.0	0.0
28.3 m3/min system									
10/29/96	W18-6L	3.5	14.4	2.4	15.8	0.010	0.0	0.0	0.0
10/29/96	W18-6U	3.2	14.4	2.5	1.2	0.001	1.1	0.0	0.0
10/29/96	W18-7	3.0	14.4	2.8	0.0	0.000	0.0	0.0	0.0
10/29/96	W18-89	3.2	14.4	3.4	20.8	0.020	0.0	0.0	1.1
10/29/96	W18-158L	3.5	14.4	0.0	77.6	0.000	0.0	0.0	6.5
10/29/96	W18-158U	2.5	14.4	1.4	0.0	0.000	1.3	0.0	0.0
10/29/96	W18-159	3.5	14.4	3.1	11.7	0.010	0.0	0.0	2.1
10/29/96	W18-163L	2.0	14.4	0.5	1.7	0.000	0.0	0.0	0.0
10/29/96	W18-163U	1.7	14.4	2.4	5.6	0.004	0.0	1.3	8.7
10/29/96	W18-165	3.0	14.4	2.7	29.9	0.022	0.0	0.0	1.9
10/29/96	W18-166	2.7	14.4	2.1	8.4	0.005	0.0	0.0	0.0
10/29/96	W18-167	3.0	14.4	3.5	18.9	0.018	0.0	0.0	1.8
10/29/96	W18-168	2.5	14.4	0.8	2.8	0.001	1.3	0.0	0.0
10/29/96	W18-169	3.5	14.4	3.7	0.0	0.000	0.0	0.0	0.0
10/29/96	W18-171L	7.0	14.4	4.6	4.6	0.006	1.3	0.0	0.0
10/29/96	W18-171U	6.0	14.4	7.8	0.0	0.000	0.0	0.0	1.6
10/29/96	W18-174	1.0	14.4	0.0	0.0	0.000	0.0	0.0	0.0
10/29/96	W18-248	6.0	14.4	0.5	8.4	0.001	0.0	0.0	0.0
42.5 m3/min system									
10/29/96	W15-6L	8.7	21.4	2.5	14.2	0.010	0.0	2.0	0.0
10/29/96	W15-6U	7.5	21.4	2.4	0.0	0.000	0.0	0.0	0.0
10/29/96	W15-9L	10.0	21.4	2.0	9.7	0.005	0.0	0.0	0.0
10/29/96	W15-9U	10.7	21.4	1.3	8.1	0.003	0.0	1.1	1.1
10/29/96	W15-82	13.4	21.4	1.9	28.5	0.015	1.2	0.0	0.0
10/29/96	W15-84	10.5	21.4	10.0	1.6	0.004	0.0	0.0	0.0
10/29/96	W15-85	10.5	21.4	2.4	6.2	0.004	0.0	0.0	0.0
10/29/96	W15-86	16.2	21.4	8.0	41.8	0.094	1.2	1.7	0.0
10/29/96	W15-95	9.5	21.4	3.3	0.0	0.000	1.6	0.0	0.0
10/29/96	W15-216L	14.4	21.4	1.4	11.3	0.004	0.0	0.0	0.0
10/29/96	W15-216U	8.7	21.4	5.7	12.0	0.019	0.0	0.0	0.0
10/29/96	W15-217	16.9	21.4	7.9	71.7	0.158	0.0	2.6	0.0
10/29/96	W15-218L	8.0	21.4	1.6	13.7	0.006	0.0	1.8	0.0
10/29/96	W15-218U	7.0	21.4	2.9	15.6	0.013	0.0	2.5	0.0
10/29/96	W15-219L	13.9	21.4	2.6	12.8	0.009	0.0	2.9	0.0
10/29/96	W15-219U	13.7	21.4	4.0	0.0	0.000	0.0	0.0	0.0
10/29/96	W15-220L	11.2	21.4	3.2	12.1	0.011	1.2	0.0	0.0
10/29/96	W15-220U	10.0	21.4	3.8	8.1	0.009	1.2	0.0	0.0
10/29/96	W15-223	9.0	21.4	3.9	10.0	0.011	2.7	0.0	0.0

Table 6-2. Baseline Characterization of Soil Vapor Probes, May 1996.

Sample Location	Sample Depth (m)	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	Comment
Zone 1						
216-Z-9 SITE						
85-01R	1.5	5/16/96 13:41	0.000	<0.045	<0.095	
86-03	1.5	5/16/96 13:20	0.000	<0.045	<0.095	
86-04	1.5	5/16/96 13:27	0.000	<0.045	<0.095	
86-06	1.5	5/16/96 13:57	0.000	<0.045	<0.095	
94-02	1.5	5/16/96 14:29	0.000	<0.045	<0.095	
94-03R	1.5	5/16/96 14:38	0.000	0.2	<0.095	duplicates averaged
94-05	1.5	5/16/96 15:02	0.000	<0.045	<0.095	
94-09	1.5	5/16/96 15:12	0.000	<0.045	<0.095	
95-07	1.5	5/16/96 12:13	0.000	0.1	<0.095	
95-09	1.5	5/16/96 15:18	0.000	<0.045	<0.095	
95-11	1.5	5/16/96 14:16	0.000	<0.045	<0.095	
95-12	1.5	5/16/96 13:36	0.000	<0.045	<0.095	
216-Z-1A SITE						
71-04	1.5	5/13/96 10:27	0.000	<0.045	<0.095	
79-02	1.5	5/13/96 11:19	0.000	<0.045	<0.095	
79-03	1.5	5/13/96 10:48	0.000	<0.045	<0.095	
79-11	1.5	5/13/96 13:57	0.000	<0.045	<0.095	
87-01R	1.5	5/13/96 11:27	0.000	<0.045	<0.095	
87-03	1.5	5/13/96 13:26	0.000	<0.045	<0.095	
87-04	1.5	5/13/96 13:35	0.000	<0.045	<0.095	
95-01	1.5	5/13/96 11:36	0.000	0.023j	<0.095	
C-1	1.5	5/13/96 10:55	0.000	<0.045	<0.095	water vapor in tubing at point
N-5	1.5	5/13/96 11:44	0.000	<0.045	<0.095	water vapor inside tube
N-9	1.5	5/13/96 13:13	0.000	<0.045	<0.095	hard to pull purge vacuum
Zone 2						
216-Z-9 SITE						
CPT-18/11	11	5/15/96 13:09	0.000	0.2	<0.095	
CPT-28/12	12	5/15/96 14:14	0.000	99.0	0.5	
CPT-21A/14	14	5/15/96 14:40	0.000	21.0	0.3	
CPT-9A/18	18	5/15/96 11:40	0.000	18.0	<0.095	
CPT-16/20	20	5/16/96 11:08	0.000	0.2	<0.095	
CPT-21A/26	26	5/15/96 15:15	0.000	100.0	0.9	
CPT-28/27	27	5/15/96 14:33	0.000	290.0	0.9	
		5/16/96 11:24	0.000	350.0	1.3	replicate
CPT-9A/28	28	5/15/96 11:25	-0.025	70.0	0.092j	
216-Z-1A SITE						
CPT-1A/11	11	5/13/96 14:51	0.000	0.5	<0.095	
CPT-34/12	12	5/14/96 10:26	0.000	0.9	<0.095	
CPT-30/21	21	5/14/96 11:41	0.000	0.1	<0.095	
CPT-32/21	21	5/14/96 12:07	-0.050	0.2	<0.095	
CPT-4F/23	23	5/14/96 14:13	0.000	<0.045	<0.095	
CPT-31/23	23	5/14/96 11:19	-0.050	4.5	0.082j	
CPT-33/24	24	5/13/96 14:35	0.025	0.9	0.082j	duplicates averaged
		5/14/96 10:19	-0.125	0.9	0.092j	replicate
		5/15/96 10:57	-0.249	0.9	0.089j	replicate
		5/16/96 10:05	-0.125	0.8	0.076j	replicate
CPT-34/26	26	5/14/96 10:45	-0.125	0.6	<0.095	
CPT-1A/28	28	5/13/96 15:17	0.050	0.024j	<0.095	
		5/13/96 15:17	0.050	<0.045	<0.095	duplicate
CPT-4F/33	33	5/14/96 14:27	0.000	<0.045	<0.095	
		5/14/96 14:27	0.000	0.1	<0.095	duplicate
Zone 3						
216-Z-9 SITE						
CPT-24/36	36	5/15/96 12:17	-0.050	1.9	<0.095	duplicates averaged

j = concentration estimated

Table 6-3. Differential Pressure Measurements in Soil Vapor Probes, October 1996.

Sample Location	Sample Depth (m)	Sample Date/Time	Differential Pressure (kPa)	Differential	Comment
Zone 2					
216-Z-9 SITE					
CPT-27/10	10	10/31/96 11:16	-0.052	-0.21	
CPT-28/12	12	10/31/96 11:04	-0.065	-0.26	no cap
CPT-21A/14	14	10/31/96 11:11	-0.127	-0.51	
W15-220SST/16	16	10/31/96 11:30	-0.540	-2.17	
CPT-9A/18	18	10/31/96 11:48	-0.015	-0.06	no cap
W15-219SST/21	21	10/31/96 13:23	-1.392	-5.59	
CPT-21A/26	26	10/31/96 11:09	-0.214	-0.86	
CPT-28/27	27	10/31/96 11:04	-0.179	-0.72	no cap
CPT-9A/28	28	10/31/96 11:49	-0.062	-0.25	no cap
216-Z-1A SITE					
CPT-13A/9	9	10/31/96 9:30	-0.035	-0.14	no cap
CPT-1A/11	11	10/30/96 13:50	-0.022	-0.09	no cap
CPT-2EX	12	10/31/96 10:48	-0.291	-1.17	climbing
CPT-7A/16	16	10/31/96 9:35	-0.050	-0.2	no cap
CPT-13A/21	21	10/31/96 9:30	-0.087	-0.35	
CPT-32/21	21	10/30/96 14:00	-0.289	-1.16	
CPT-4C/23	23	10/31/96 10:15	-0.493	-1.98	no cap
CPT-4E/23	23	10/31/96 10:37	-0.139	-0.56	no cap
CPT-4F/23	23	10/31/96 12:55	-0.324	-1.3	climbing
CPT-31/23	23	10/31/96 9:12	-0.705	-2.83	
CPT-33/24	24	10/30/96 13:40	-0.765	-3.07	
CPT-34/26	26	10/30/96 13:30	-0.680	-2.73	
CPT-1A/28	28	10/30/96 13:52	-0.007	-0.03	no cap
W18-252SST/31	31	10/31/96 9:20	-0.461	-1.85	
CPT-4E/31	31	10/31/96 10:41	-1.051	-4.22	no cap
CPT-4C/33	33	10/31/96 12:59	-0.777	-3.12	no cap; climbing
Zone 3					
216-Z-9 SITE					
CPT-24/36	36	10/31/96 13:12	-0.697	-2.80	climbing
		10/31/96 13:13	-0.847	-3.40	
Zone 4					
216-Z-9 SITE					
W15-220SST/36	36	10/31/96 11:31	-0.755	-3.03	
W15-219SST/40	40	10/31/96 13:21	-0.705	-2.83	
216-Z-1A SITE					
W18-252SST/44	44	10/31/96 9:20	-0.249	-1.00	
Zone 5					
216-Z-9 SITE					
W15-219SST/47	47	10/31/96 13:24	-0.722	-2.9	
W15-220SST/56	56	10/31/96 11:32	-0.872	-3.50	
Zone 6					
216-Z-1A SITE					
W18-252SST/64	64	10/31/96 9:20	-0.199	-0.8	

Table 6-4. Summary of Carbon Tetrachloride Rebound Measurements. (Page 1 of 2)

					Carbon Tetrachloride Rebound			
Sampling Location	Depth (m bgs)	Geologic Unit	Zone	Sampling Method	Minimum (ppmv)	Date of Minimum	Maximum (ppmv)	Date of Maximum
Z-9								
85-01R	1.5		1	Sample Pump	0	NA	0	NA
86-03	1.5		1	Sample Pump	0	NA	0	NA
86-04	1.5		1	Sample Pump	0	NA	0	NA
86-06	1.5		1	Sample Pump	0	NA	1.3	5/8
94-02	1.5		1	Sample Pump	0	NA	0	NA
94-03R	1.5		1	Sample Pump	0	NA	0	NA
94-05	1.5		1	Sample Pump	0	NA	1.1	7/10
94-09	1.5		1	Sample Pump	0	NA	1.4	4/8
95-07	1.5		1	Sample Pump	0	NA	0	NA
95-09	1.5		1	Sample Pump	0	NA	0	NA
95-11	1.5		1	Sample Pump	0	NA	0	NA
95-12	1.5		1	Sample Pump	0	NA	1.1	6/9, 7/10
95-08	1.5		1	Sample Pump	0	NA	0	NA
CPT-17/8	8	Huc	2	Sample Pump	0.2	11/18	7.01	4/1
CPT-27/10	10	Huc	2	Sample Pump	0.11	11/17	1.2	7/7
CPT-18/11	11	Huc	2	Sample Pump	0	11/25	4.8	6/5
CPT-28/12	12	Huc	2	Sample Pump	19	11/5	40.1	7/7
CPT-21A/14	14	Huc	2	Sample Pump	4.8	11/5	65.6	7/7
W15-220SST/16	16	Hf	2	Sample Pump	0.35	11/25	2	11/18
CPT-9A/18	18	Hf	2	Sample Pump	35.1	1/27	45.5	1/2
CPT-16/20	20	Hf	2	Sample Pump	0	11/21	4.6	5/5
W15-219SST/21	21	Hf	2	Sample Pump	0.65	7/7	14.6	5/19
W15-216U	23	Hf	2	Baro Pump	7.89	12/18	18.9	4/3
W15-82	25	Hf	2	Sample Pump	7.49	1/27	28.9	11/6
CPT-21A/26	26	Hf	2	Sample Pump	0.52	11/25	221	7/7
CPT-28/27	27	Hf	2	Sample Pump	105	11/5	280	7/7
CPT-9A/28	28	Hf	2	Sample Pump	34.6	7/7	103	1/2
W15-9U	31	Hf, PP	2-3	Baro Pump	0.7	12/18	95.2	7/17
W15-218U	33	top of PP	3	Sample Pump	12.4	12/31	41.4	2/24
W15-223	33	Hf, PP	3	Baro Pump	0	1/7	31.2	2/13
W15-217	35	top of PP	3	Sample Pump	0.6	11/8	797	6/16
W15-220SST/36	36	bottom of PP	4	Sample Pump	0.79	1/2	21.9	12/31
CPT-24/36	36	top of PP	3	Sample Pump	24.2	11/25	44.6	7/7
W15-86	37	across PP	4	Sample Pump	5.08	5/5	284.5	7/7
W15-219SST/40	40	bottom of PP	4	Sample Pump	14.5	11/5	298	4/17
W15-219SST/47	47	Rge	5	Sample Pump	0.16	4/2	59.6	5/19
W15-216L	55	Rge	5	Baro Pump	7.9	12/26	16.7	11/15
W15-220SST/56	56	Rge near gw	5	Sample Pump	4.1	11/25	14.5	12/31
W15-9L	58	Rge near gw	6	Sample Pump	2.74	1/29	18.3	5/6
W15-6L	58	Rge to gw	6	Sample Pump	0	11/12	22.6	7/7
W15-32	56	Rge to gw	6	Baro Pump	0.38	12/18	5.39	11/15
Z-1A								
71-04	1.5		1	Sample Pump	0	NA	0	NA
79-02	1.5		1	Sample Pump	0	NA	0	NA
79-03	1.5		1	Sample Pump	0	NA	0	NA
79-11	1.5		1	Sample Pump	0	NA	0	NA
79-13	1.5		1	Sample Pump	0	NA	0	NA
87-01R	1.5		1	Sample Pump	0	NA	3.5	6/9
87-03	1.5		1	Sample Pump	0	NA	0	NA
87-04	1.5		1	Sample Pump	0	NA	0	NA
95-01	1.5		1	Sample Pump	0	NA	4.4	5/8
C-1	1.5		1	Sample Pump	0	NA	0	NA
N-5	1.5		1	Sample Pump	0	NA	0	NA

Table 6-4. Summary of Carbon Tetrachloride Rebound Measurements. (Page 2 of 2)

					Carbon Tetrachloride Rebound			
Sampling Location	Depth (m bgs)	Geologic Unit	Zone	Sampling Method	Minimum (ppmv)	Date of Minimum	Maximum (ppmv)	Date of Maximum
N-9	1.5		1	Sample Pump	0	NA	0	NA
CPT-13A/9	9	Huf	2	Sample Pump	0.1	11/22	2.21	4/2
CPT-1A/11	11	Huf	2	Sample Pump	0.3	11/4	2.04	5/6
CPT-2EX	12	Huc	2	Sample Pump	0	11/15	5.09	4/30
CPT-34/12	12	Huc	2	Sample Pump	0.22	11/4	2.3	12/27
CPT-7A/16	16	Huc	2	Sample Pump	0	11/15	2.61	4/2
CPT-13A/21	21	Huc	2	Sample Pump	3.19	1/7	5.23	7/8
CPT-30/21	21	Hf	2	Sample Pump	0.5	11/13	1.7	11/22
CPT-32/21	21	Hf	2	Sample Pump	0.12	11/4	7.4	5/6
CPT-4C/23	23	Hf	2	Sample Pump	0.62	11/7	4.47	5/6
CPT-4E/23	23	Hf	2	Sample Pump	0.19	11/7	4.53	4/2
CPT-4F/23	23	Hf	2	Sample Pump	0.25	11/4	3.95	5/6
CPT-31/23	23	Hf	2	Sample Pump	0.72	11/4	4.01	5/6
CPT-33/24	24	Hf	2	Sample Pump	0.34	11/4	5.81	7/8
CPT-34/26	26	Hf	2	Sample Pump	0.33	11/4	36.3	7/8
CPT-1A/28	28	Hf	2	Sample Pump	0.63	1/7	3.91	4/2
W18-252SST/31	31	Hf	2	Sample Pump	0.37	11/7	38.2	7/8
CPT-4E/31	31	Hf	2	Sample Pump	0.39	11/4	23.2	4/2
W18-152	31	Hf	2	Baro Pump	0.06	1/24	46.8	4/30
CPT-4C/33	33	Hlc	2	Sample Pump	0.32	11/4	31.6	6/5
CPT-4F/33	33	Hlc	2	Sample Pump	0.28	11/4	26.8	4/2
W18-168	33	Hlf, PP	2-3	Baro Pump	8.5	11/13	84.2	4/3
W18-169	33	Hlc, Hlf	2-3	Baro Pump	6.6	11/13	21.2	6/17
W18-89	35	Hlc/top of PP	3	Sample Pump	5.66	11/8	48.3	6/16
W18-252U	36	Hlc, PP	3	Sample Pump	15.85	11/8	52.6	7/8
W18-174	37	top of PP	3	Sample Pump	2.04	11/6	573	12/27
W18-167	38	Hlc, Hlf, top of PP	3	Sample Pump	160.8	11/19	322.8	11/8
W18-96	39	Hlc, Hlf, PP	3	Baro Pump	24.55	12/18	68	6/17
W18-248	40	PP	3	Sample Pump	48.2	11/6	288	6/16
W18-249	40	Hlc, Hlf, PP	3	Baro Pump	0	11/11	206	4/3
W18-252SST/44	44	Rge near PP	4	Sample Pump	17.4	5/6	93.8	11/11
W18-247L	51	Rge near PP	4	Baro Pump	0.2	11/11	2.7	2/25
W18-252L	53	Rge	5	Baro Pump	0.3	11/11	47.7	6/17
W18-6L	61	Rge to gw	5-6	Baro Pump	15.1	11/14	36	6/17
W18-7	62	Rge to gw	5-6	Sample Pump	10.8	11/21	28.5	2/27
W18-1	63	Rge to gw	5-6	Baro Pump	0.3	12/18	13.4	12/5
W18-2	63	Rge to gw	5-6	Baro Pump	2.4	6/17	10.6	4/30
W18-252SST/64	64	Rge near gw	6	Sample Pump	0.5	11/22	47.2	7/8

Table 6-5. Comparison of Selected Samples Analyzed Using the B&K and a Gas Chromatograph.

Sample Location	Sample Depth (m)	Zone	Sample (Date/Time)	Differential Pressure (in w.c.)	B&K CCl4 (ppmv)	B&K CHCl3 (ppmv)	B&K MEK (ppmv)	B&K CH2Cl2 (ppmv)	Comment
Z-9									
W15-82	25	2	1/6/97 14:45	N/A	15.05	0.00	8.08	184.50	
			1/6/97 14:45	N/A	15.40	0.15	0.00	0.00	PCE=1.0; Photovac 10S Plus GC #TB920109 with 11.7 eV Lamp
			1/7/97 11:30	-0.17	19.78	0.02	6.00	181.50	
			1/9/97 0:00		22.62	0.20		0.00	PCE=0.9 ppm; TCE=0; 1,1,2 TCA=0; Photovac
			1/9/97 0:00		21.00	0.17		0.00	PCE=0.2 ppm; TCE=0; 1,1,2 TCA=0; Photovac
			3/11/97 11:45		24.00	0.00	11.40	249.00	CH4 = 606 ppm
W15-217	35	3	1/6/97 14:30	0.98	112.00	0.99	0.76	3.11	
			1/7/97 11:15	-0.31	227.00	1.57	0.67	3.89	
			1/9/97 0:00		338.40	2.38		0.00	PCE=0 ppm; TCE=0; 1,1,2 TCA=0; Photovac
			3/11/97 11:35		502.00	5.93	0.00	2.98	CH4 = 60 ppm
W15-86	37	4	1/6/97 14:28	0.65	120.00	1.70	0.57	7.17	
			1/6/97 14:28	0.65	110.00	1.00	0.00	0.00	Photovac 105 Plus GC #TB920109 with 11.7 eV Lamp
			3/11/97 11:55		143.00	0.92	1.06	40.30	CH4 = 110 ppm
W15-9L	58	6	1/6/97 14:40	0.68	5.36	0.00	0.83	4.82	
			1/6/97 14:40	0.68	4.70	<0.1	0.00	0.00	Photovac 105 Plus GC #TB920109 with 11.7 eV Lamp
CPT-21A/26	26	2	3/11/97 11:25		139.00	1.55	0.37	2.61	CH4 = 53 ppm
Z-1A									
W18-89	35	3	1/6/97 14:07	0.94	20.50	0.11	0.84	3.65	
			1/6/97 14:07	0.94	19.60	<0.1	0.00	0.00	Photovac 105 Plus GC #TB920109 with 11.7 eV Lamp
W18-174	37	3	1/6/97 14:15	0.97	217.00	2.67	0.20	3.19	
			1/6/97 14:15	0.97	200.00	2.50	0.00	0.00	TCE=1.0; PCE?; Photovac 105 Plus GC #TB920109 with 11.7 eV Lamp
			1/7/97 13:05	-0.54	274.00	2.51	0.21	3.02	
			1/9/97 0:00		393.50	2.19		0.05	PCE=0 ppm; TCE=0.4 ; 1,1,2 TCA=0; Photovac
			3/11/97 11:05		457.00	4.32	0.29	3.78	CH4 = 60 ppm
W18-248	40	3	1/6/97 14:22	1.29	122.00	1.50	0.37	2.29	
			1/6/97 14:22	1.29	110.00	1.60	0.00	0.00	TCE=0.06; Photovac 105 Plus GC #TB920109 with 11.7 eV Lamp
W18-7	62	6	1/6/97 14:20	0.48	18.70	0.79	0.54	3.55	
			1/6/97 14:20	0.48	17.90	0.50	0.00	0.00	Photovac 105 Plus GC #TB920109 with 11.7 eV Lamp
Z-9									
95-11	1.5	1	1/24/97 12:28	-0.03	0.00	7.62	13.60	0.53	no CHCl3, MEK on gc
95-08	1.5	1	1/24/97 12:15	-0.03	0.00	8.72	13.30	0.00	no CHCl3, MEK on gc
Z-1A									
79-11	1.5	1	1/24/97 11:10	-0.04	0.07	1.05	0.66	0.00	no CHCl3 on gc
87-01R	1.5	1	1/24/97 10:40	-0.04	0.00	6.07	5.64	0.00	no CHCl3, MEK on gc
87-03	1.5	1	1/24/97 10:52	-0.04	0.31	0.00	2.25	1.78	no CHCl3, CH2CL2 on gc

Table 6-6. Comparison of Morning and Afternoon Carbon Tetrachloride Concentrations.

Carbon Tetrachloride Concentration	Well W15-217	Well W18-89	Well W15-9L	Well W18-7
Maximum daily difference (ppmv)	72	5	2	3
Minimum daily difference (ppmv)	0	0	0	0
Average daily difference (ppmv)	32	2	1	1
Maximum concentration (ppmv)	433	29	13	25
Maximum daily difference divided by maximum concentration (%)	17%	17%	14%	12%

Table 6-7. Three-Hour Soil Vapor Extraction Test Data for Wells W15-82 and W15-217.

Date	Time	Soil Vapor Extraction System		Extraction Well			Monitoring Wells		
		Vacuum (kPa)	Flow (m^3/min)	Carbon Tetrachloride (ppmv)	Chloroform (ppmv)	Methylene Chloride (ppmv)	Vacuum (kPa)		
7/14/97	10:10	31.1	3.0	W15-82			W15-95	W15-85	W15-217
	10:15			34.1	5.15	3.5			
	10:20						0.05	0	0.02
	10:30			35.9	3.22	3.21			
	11:15	30.6	2.6	45.3	3.22	3.06			
	12:05						0.42	0.02	0.15
	12:15	30.6	2.7	67.7	3.25	3.47			
	13:15			97.0	4.53	5.98			
7/15/97	8:10	18.4	4.0	W15-217			W15-95	W15-84	W15-82
	8:15			144	4.97	0			
	8:20						0.10	0.05	0.10
	8:30			107	2.7	0			
	9:15	19.9	3.7	153	5.03	2.53			
	9:20						0.95	0.35	0.35
	10:15			154	5.7	1.81			
	11:15	21.9	3.7	149	5.48	2.01			

Table 6-8. Wellhead Characterization Data at Soil Vapor Extraction Wells, July 18 Through July 31, 1997. (Page 1 of 2)

Date	Well/Interval	Well Vacuum (kPa)	SVE Vacuum (kPa)	Flow (m3/min)	CCl4 (ppmv)	CCl4 Flux (kg/day)	CHCl3 (ppmv)	CH2Cl2 (ppmv)	MEK (ppmv)
42.5 m3/min system									
7/18/97	W15-6L	10.0	21.4	2.7	20.2	0.015	3.9	0.0	0.0
7/18/97	W15-9L	16.2	21.4	1.7	19.8	0.009	2.2	0.0	0.0
7/18/97	W15-82	15.9	21.4	1.6	106.0	0.046	2.8	6.7	0.0
7/18/97	W15-86	15.2	21.4	4.8	138.0	0.186	4.2	0.0	0.0
7/18/97	W15-217	15.7	21.4	4.7	256.0	0.336	3.5	0.5	0.0
7/18/97	W15-218L	19.9	21.4	3.0	20.3	0.017	3.0	0.3	0.0
7/18/97	W15-218U	17.4	21.4	6.0	21.1	0.036	1.9	0.9	0.0
14.2 m3/min system									
7/21/97	W18-252U	3.7	10.0	4.2	41.5	0.049	4.4	0.0	0.0
28.3 m3/min system									
7/21/97	W18-6L	1.5	11.2	0.5	26.8	0.004	3.7	0.0	0.0
7/21/97	W18-7	2.5	11.2	2.8	30.8	0.024	6.1	0.0	0.0
7/21/97	W18-167	1.7	11.2	4.8	20.6	0.028	3.6	5.5	1.1
7/21/97	W18-174	2.5	11.2	0.4	7.0	0.001	3.1	0.0	0.0
7/21/97	W18-248	3.2	11.2	0.1	59.3	0.001	3.7	0.0	0.0
42.5 m3/min system									
7/21/97	W15-6L	8.0	23.2	2.4	20.3	0.014	2.9	1.3	0.0
7/21/97	W15-9L	19.4	23.2	1.8	21.3	0.011	3.6	0.0	0.0
7/21/97	W15-82	13.7	23.2	2.1	46.8	0.027	4.1	0.0	0.0
7/21/97	W15-86	12.5	23.2	5.1	111.0	0.158	3.4	0.0	0.0
7/21/97	W15-217	12.5	23.2	5.8	86.3	0.140	4.1	0.0	0.0
7/21/97	W15-218L	12.7	23.2	2.4	21.9	0.015	2.7	1.6	0.2
7/21/97	W15-218U	11.5	23.2	4.6	21.8	0.028	2.0	1.5	0.0
14.2 m3/min system									
7/24/97	W18-252U	4.7	10.0	3.6	25.8	0.026	3.1	0.0	0.0
28.3 m3/min system									
7/24/97	W18-6L	2.0	12.2	0.5	24.4	0.004	2.9	0.0	0.0
7/24/97	W18-7	2.0	12.2	3.5	3.9	0.004	3.3	0.0	0.0
7/24/97	W18-167	2.2	12.2	4.8	21.2	0.029	3.4	2.2	0.0
7/24/97	W18-174	2.5	12.2	0.4	2.9	0.000	1.4	0.0	0.0
7/24/97	W18-248	3.7	12.2	0.3	57.9	0.004	2.2	0.0	0.0
42.5 m3/min system									
7/24/97	W15-6L	11.0	22.4	2.2	22.6	0.014	2.9	0.0	0.0
7/24/97	W15-9L	21.2	22.4	2.1	21.0	0.012	1.4	0.0	0.0
7/24/97	W15-82	16.9	22.4	1.9	170.0	0.090	4.2	0.0	0.0
7/24/97	W15-86	16.4	22.4	4.9	57.8	0.079	3.5	0.0	0.0
7/24/97	W15-217	17.4	22.4	3.8	164.0	0.174	3.6	2.7	0.0
7/24/97	W15-218L	15.9	22.4	2.4	20.0	0.013	2.5	0.0	0.0
7/24/97	W15-218U	13.7	22.4	4.2	21.1	0.025	4.8	0.0	0.0
14.2 m3/min system									
7/28/97	W18-252U	4.2	10.0	3.5	11.4	0.011	4.1	0.0	0.0
28.3 m3/min system									
7/28/97	W18-6L	1.9	11.7	0.4	30.9	0.004	3.8	0.0	0.0

Table 6-8. Wellhead Characterization Data at Soil Vapor Extraction Wells, July 18 Through July 31, 1997. (Page 2 of 2)

Date	Well/Interval	Well Vacuum (kPa)	SVE Vacuum (kPa)	Flow (m3/min)	CCl4 (ppmv)	CCl4 Flux (kg/day)	CHCl3 (ppmv)	CH2Cl2 (ppmv)	MEK (ppmv)
7/28/97	W18-7	2.0	11.7	3.5	9.8	0.009	2.7	0.0	0.0
7/28/97	W18-167	2.0	11.7	4.9	15.3	0.021	3.5	1.8	0.0
7/28/97	W18-174	2.5	11.7	0.4	0.0	0.000	1.8	0.0	0.0
7/28/97	W18-248	3.5	11.7	0.3	2.7	0.000	2.9	0.0	0.0
42.5 m3/min system									
7/28/97	W15-6L	12.5	23.2	3.0	20.6	0.017	3.8	0.0	0.0
7/28/97	W15-9L	20.9	23.2	2.7	14.8	0.011	3.3	0.0	0.0
7/28/97	W15-82	16.7	23.2	1.8	126.0	0.063	3.8	0.0	0.0
7/28/97	W15-86	13.9	23.2	4.7	69.6	0.091	5.1	0.0	0.0
7/28/97	W15-217	14.7	23.2	3.8	129.0	0.137	5.3	0.0	0.0
7/28/97	W15-218L	14.9	23.2	2.4	20.0	0.013	2.4	0.0	0.0
7/28/97	W15-218U	12.7	23.2	4.2	22.0	0.026	2.7	0.0	0.0
14.2 m3/min system									
7/31/97	W18-252U	5.0	10.0	4.0	8.4	0.009	2.6	0.0	0.0
28.3 m3/min system									
7/31/97	W18-6L	2.1	12.5	0.5	8.6	0.001	2.0	0.0	0.0
7/31/97	W18-7	2.5	12.5	3.6	26.6	0.027	3.2	0.0	0.0
7/31/97	W18-167	2.4	12.5	4.7	1.8	0.002	2.7	0.0	0.0
7/31/97	W18-174	3.2	12.5	0.4	4.0	0.000	1.9	0.0	0.0
7/31/97	W18-248	3.7	12.5	0.4	26.4	0.003	2.0	0.0	0.0
42.5 m3/min system									
7/31/97	W15-6L	10.0	24.4	2.9	20.5	0.017	1.9	0.0	0.0
7/31/97	W15-9L	19.4	24.4	2.4	14.5	0.010	3.7	0.0	0.0
7/31/97	W15-82	18.4	24.4	1.8	116.0	0.058	4.0	0.0	0.0
7/31/97	W15-86	16.7	24.4	4.7	62.5	0.082	2.8	0.0	0.0
7/31/97	W15-217	17.4	24.4	3.8	131.0	0.139	3.5	0.0	0.0
7/31/97	W15-218L	16.2	24.4		12.4		1.9	0.0	0.0
7/31/97	W15-218U	16.2	24.4	3.3	19.1	0.018	3.4	0.0	0.0

Table 6-9. Soil Vapor Extraction Inlet Concentrations Before and After Shutdown.

Soil Vapor Extraction System	Z-9 Site	Z-1A Site	
	42.5 m^3/min	28.3 m^3/min	14.2 m^3/min
Carbon tetrachloride concentration (ppmv) on 11/4/96	25	16	10
Maximum carbon tetrachloride concentration at restart on 7/18/97	87	37	38
Carbon tetrachloride concentration (ppmv) on 8/22/97	28	22	7
Carbon tetrachloride concentration (ppmv) on 9/4/97	24	22	6
Hours operated from 7/18 through 8/22	842	853	801
Hours operated from 7/18 through 9/4	1154	1163	1096

Table 6-10. Sampling Tube Length Changes During Rebound Study.

Well Sampling Location	Depth Below Ground Surface (m)	Height Above Ground Surface (m)	90-Degree Elbow Length (m)	Original Length Nov-96 (m)	Final Length Jul-97 (m)	Final Minus Original (m)	Percent Change (%)
W15-9L	57.6	1.1	0.5	59.1	NM		
W15-217	35.1	1.3	0.5	36.8	39.4	2.6	7
W15-6L	57.6	1.3	0.5	59.3	NM		
W15-82	25.3	1.1	0.5	26.9	NM		
W15-86	36.9	1.2	0.5	38.6	NM		
W15-218U	32.9	1.3	0.5	34.7	NM		
W18-7	61.9	1.1	0.5	63.4	72.3	8.9	14
W18-174	36.9	0.6	0.5	37.9	NM		
W18-248	40.2	1.2	0.5	41.8	45.9	4.0	10
W18-167	38.4	1.1	0.5	39.9	NM		
W18-89	35.1	1.2	0.5	36.7	40.6	3.9	11
W18-252U	36.0	0.9	0.5	37.3	45.3	8.0	21

NM = Not Measured

7.0 REBOUND STUDY EVALUATION

The rebound study data were evaluated to address 200-ZP-2 project issues identified during the DQO process. Each of the following subsections corresponds to a DQO issue.

7.1 AMOUNT OF ADDITIONAL CARBON TETRACHLORIDE AVAILABLE FOR REMOVAL USING SOIL VAPOR EXTRACTION

A previous study conducted using carbon tetrachloride and 200-ZP-2 soils concluded that calculation of carbon tetrachloride soil concentrations using measured vapor phase concentrations and either empirical relationships or adsorption isotherms to estimate the soil partitioning coefficient can lead to significant error (Yonge et al. 1996). In particular, these relationships do not account for the nonequilibrium partitioning of carbon tetrachloride within soil particles (the apparent "irreversible" adsorption). Therefore, the mass of carbon tetrachloride remaining in the soil cannot be reliably determined using the rebound study data. However, the rebound study data can be used to indicate the magnitude and rate of change in vapor concentrations, and SVE extraction following rebound can be used to quantify the additional amount for that recovery interval.

The magnitude of the carbon tetrachloride rebound was calculated for SVE wells by comparing the maximum rebound concentration to the baseline concentration (Table 7-1). The largest increase in concentration at any well was 725 ppmv at well W15-217. As originally defined in the test plan (Rohay and Tranbarger 1996), rebound would be considered significant if concentrations changed by an order of magnitude. Rebound was significant at five wells, three (W18-167, W18-168, W18-248) within or adjacent to the Z-1A tilefield and two (W15-9U, W15-217) adjacent to the Z-9 crib; all five are zone 3 wells open within and/or above the Plio-Pleistocene layer.

The rate of change in carbon tetrachloride concentration was calculated by dividing the magnitude of the concentration change by the length of time between the baseline and maximum measurements. However, because the maximum concentration was observed in June or July at 10 of 19 of the wells, this calculation seems nonsignificant. That so many maximum readings occurred in June and July suggests that rebound is still increasing. Seasonal surface temperature variations may potentially impact measured concentrations at locations where atmospheric air moves into the subsurface. This effect has not been identified and/or removed from the rebound study data set.

The magnitude and rate of decrease in concentrations at individual wells was calculated using the characterization measurements on July 18, 21, 24, 28, and 31 (Table 7-1). During the first 2 weeks of extraction, concentrations at most of the wells decreased by a factor of 1 to 2. Concentrations measured during restart (July 18 or July 21) were greater than baseline concentrations for all of the wells characterized.

The rapid decrease in carbon tetrachloride concentrations at some wells following SVE restart (Figure 6-8) indicates that the rate of supply of contaminant is slower than the rate of removal. For wells that maintained a relatively constant concentration following SVE restart (W15-218, Figures 6-7 and 6-9), the contaminant source is probably diffuse and relatively homogeneous, rather than consisting of a point source. The increase in carbon tetrachloride concentrations at a well following SVE restart (W15-82, Figure 6-7) suggests that the contaminant source is located at a distance from the well and is drawn to the well by the induced vacuum.

The daily carbon tetrachloride concentrations measured at the inlet to each SVE system during restart of operations from July 18 through September 4 are shown in the context of the history of daily carbon tetrachloride concentrations for each system in Figures 7-1 through 7-3. For each system, the initial concentration in July 1997 is projected back in time until it intersects the concentration trend established during previous operations. Another line is projected from that intersection to the time axis to indicate when daily concentrations had been at that level in the past. After restart, daily concentrations at the three SVE systems were equivalent to concentrations measured previously at times ranging from September 1995 to February 1996. However, the figures also show the July 1997 concentrations are decreasing faster than the equivalent concentrations did in the past.

During the last 3 weeks of SVE operations in 1996, the three SVE systems combined were extracting an average of 102 kg/week (Table 7-2). During the first 3 weeks of SVE operations in 1997, the three SVE systems combined were extracting an average of 178 kg/week. The mass removal rates at the three systems are continuing to decline, approaching the October-November 1996 levels.

These comparisons all indicate that carbon tetrachloride is still available for extraction using SVE. Even at the time of shutdown in November 1996, SVE was removing 100 kg/week. Since its initiation in 1992, SVE is estimated to have removed 6% of the residual mass at the Z-1A site and 21% of the residual mass at the Z-9 site (Rohay 1996b). (This estimate assumes that all of the mass that has not been lost to atmosphere or dissolved in groundwater remains as residual mass in the vadose zone.) The continuing rebound at many locations indicates that the supply of additional carbon tetrachloride to the high flow zone affected by SVE is limited by diffusion of the contaminant from the micropores and/or from the lower permeability zones. Under these conditions, the removal rate of the additional carbon tetrachloride using SVE is controlled by the desorption and diffusion rates of the contaminant.

Note: These estimates of the percent of residual mass removed at each site cannot be correlated to the estimate made by Yonge et al. (1996) that SVE can remove only 10% to 15% of the initial mass in contaminated zones through which flow is passing directly. Yonge et al. established known initial conditions for their experiments in order to compare the amount removed to the amount they loaded into the soil. At the carbon tetrachloride site, the corresponding initial conditions are unknown, and the data are not available to determine what percent of the "initial" (residual) mass has been removed by SVE. In addition, no dense nonaqueous phase liquid (DNAPL) carbon tetrachloride was included in this particular experiment by Yonge et al., but concentrations observed at the Z-9 site in 1993 and 1994 suggest that carbon tetrachloride was present in the vadose zone as a DNAPL (Rohay 1996b).

7.2 DISTRIBUTION OF REMAINING CARBON TETRACHLORIDE SOURCES

The maximum carbon tetrachloride concentration measured at each sampling location is plotted with depth in Figure 7-4. This vertical profile indicates that the remaining carbon tetrachloride available for SVE is primarily associated with the silt and Plio-Pleistocene "caliche" layers (zones 3 and 4). For comparison, the baseline concentrations measured in SVE wells on October 29, 1996 are plotted in Figure 7-5. The location of remaining carbon tetrachloride sources in zones 3 and 4 is a result of the initial accumulation of carbon tetrachloride in the finer-grained, lower permeability layers, observed during characterization in 1991-1993 (Rohay et al. 1994); and the relative inability of SVE to induce airflow through this lower permeability zone to remove it.

Carbon tetrachloride rebound data collected from three pairs of deep probes located west of Z-1A in zone 2 (CPT-4C, CPT-4E, and CPT-4F) were compared to evaluate whether the higher concentrations measured in the probes nearer zone 3 can be observed later as increases in the concentrations measured at the overlying probes (Figure 7-6). (Note: The curves shown on Figures 7-6 through 7-10 were hand-fit.) If the underlying lower permeability soils (zone 3) were the primary source of carbon tetrachloride at these locations, then the concentration rebound observed at all the probes would be a result of upward migration along the concentration gradient, and increases at the shallower probes would lag behind increases at the deeper probes. Concentrations of the magnitude measured in the deeper probes (15 to 30 ppmv) were not observed in the shallower probes (0 to 5 ppmv). However, concentrations at all six probes appear to be increasing simultaneously, relative to the measurement interval. Additional carbon tetrachloride may be slowly migrating from the soil moisture and micropores of soil particles within zone 2. Even though concentrations in zone 2 appear to be low, the large volume of soil represents a potentially significant mass of carbon tetrachloride distributed throughout zone 2.

Carbon tetrachloride concentrations measured in zone 6 near the water table increased relatively slowly during the rebound study and remained relatively constant during SVE restart in July 1997 (Figures 6-9 and 7-7). Air flow was measured at these wells during SVE operations in July, so the maintenance of concentrations is not a result of lack of extraction. These relatively slow changes during the rebound study suggest that the volatilization of dissolved carbon tetrachloride from groundwater into the unsaturated zone, and/or the downward migration of carbon tetrachloride from the lower permeability zone toward the groundwater, is occurring slowly relative to the 8-month-long rebound study.

The four primary wells that were monitored to represent zone 6, W15-6L, W15-9L, W18-6L, and W18-7, have perforated intervals that are also open in zone 5. The concentrations monitored in these zone 6 wells are similar to the concentrations monitored in the zone 5 wells (Figure 7-7). During the rebound study, zone 5 and zone 6 wells all had (1) similar baseline carbon tetrachloride concentrations (10 to 15 ppmv), (2) similar relatively slow rebound rates, and (3) similar relatively low maximum rebound magnitudes (10 to 50 ppmv). The similar concentration behavior observed among the zone 5 and zone 6 wells, which occur at two different sites and together represent open intervals covering a 16-m vertical span between the Plio-Pleistocene layer and the groundwater, suggest that the sources of the carbon tetrachloride

rebound are relatively broad and diffuse. In addition, because the water table elevation is declining approximately 0.8 m/yr, the position of these monitoring points relative to the groundwater is continually changing.

During SVE, soil vapor is drawn through the zone 5 soils above the groundwater. The relatively constant concentrations observed during SVE restart also indicate that the vapor reservoir within zone 5 would need to be sufficiently uniform and diffuse and/or the transfer from the aqueous phase to the vapor phase would need to be sufficiently rapid to maintain the observed concentrations.

The carbon tetrachloride vapor concentrations observed in zone 5 and zone 6 wells are similar despite overlying groundwater plumes of different concentrations (3,000 μg/L at Z-1A and 6,000 μg/L at Z-9). The vapor concentrations are an order of magnitude lower than the equilibrium vapor concentrations predicted for these groundwater concentrations using Henry's Law (450 ppmv at Z-1A and 900 ppmv at Z-9; see Section 7.3). The rebound vapor concentrations might be less uniform and higher, i.e., more representative of underlying groundwater concentrations, if they had been measured at the capillary fringe/unsaturated zone interface, but no vapor samples were collected from that discrete interval.

The carbon tetrachloride vapor concentrations observed in zone 5 and zone 6 wells during the rebound study are also much lower than saturated vapor concentrations in equilibrium with a carbon tetrachloride DNAPL phase (120,000 ppmv). Although carbon tetrachloride vapor volatilizing from a residual DNAPL source may have been diluted by the time it reached the sampling locations, the rebound study data suggest that SVE may have removed much of the vadose zone source and that the continuous carbon tetrachloride contamination source indicated for the groundwater at Z-9 may now be within the aquifer rather than slowly draining from the vadose zone.

7.3 EVALUATION OF CARBON TETRACHLORIDE TRANSPORT BETWEEN THE UNSATURATED AND SATURATED ZONES

The potential for transport of carbon tetrachloride between the soil vapor and the groundwater was evaluated using Henry's Law as a guideline. Henry's Law describes the equilibrium partitioning of a compound between the aqueous and vapor phases. In the absence of forced advection (e.g., SVE), the assumption of equilibrium partitioning between the vapor and aqueous phases appears to be valid for chlorinated solvent compounds in the unsaturated zone (Pankow and Cherry 1996). The Henry's Law constant expresses the relationship of the concentration of a compound in the vapor phase to the concentration in the aqueous phase; the constant will be different for each compound and will also vary with temperature. The Henry's Law constant for carbon tetrachloride was used to calculate a conversion factor to relate a vapor phase concentration in ppmv to an aqueous phase concentration in μg/L (Rohay 1997). The resulting relationship between the carbon tetrachloride concentration in groundwater and in soil vapor is:

$$C_v = 0.151 * C_{aq}$$

where

C_v = concentration of carbon tetrachloride in the soil vapor (ppmv)
C_{aq} = concentration of carbon tetrachloride in the aquifer (μg/L)
0.151 = the aqueous-vapor phase conversion factor for carbon tetrachloride at 20 °C.

Groundwater temperature obtained for groundwater monitoring wells in the vicinity of the carbon tetrachloride site averaged 19.8 °C in 1996-1997 (Table 7-3). The groundwater temperature data are provided in Table J-1. Comparing calculated equilibrium concentrations to measured concentrations provides a reference for evaluating the potential for carbon tetrachloride transport between aqueous and vapor phases.

Carbon tetrachloride vapor concentrations measured at zone 6 wells during the rebound study were compared to groundwater concentration data collected from nearby groundwater wells for the 200-ZP-1 project (BHI 1997). At both the Z-9 and Z-1A sites, the measured vapor concentrations were less than the equilibrium vapor concentrations predicted using Henry's Law and site groundwater concentrations. Based on this comparison, the current carbon tetrachloride concentration gradient would drive contaminants from the groundwater to the vadose zone at the carbon tetrachloride site.

Maximum carbon tetrachloride vapor concentrations measured at zone 6 wells at the Z-9 site during the rebound study and SVE restart in July 1997 were approximately 20 to 25 ppmv (Tables 6-4 and 6-8). The carbon tetrachloride concentration measured in groundwater at well W15-5 in July 1997 was 6,000 μg/L; the concentration measured in well W15-32 adjacent to the Z-9 crib was 6,900 μg/L in September 1997. For a groundwater concentration of 6,000 to 7,000 μg/L, the equilibrium soil vapor concentration would be 900 to 1,000 ppmv. This predicted equilibrium concentration is an order of magnitude greater than the maximum vapor concentration observed during the rebound study at the Z-9 site.

The in situ carbon tetrachloride soil vapor concentration measured near the water table during installation of well W15-218 at the Z-9 site in 1993 was 10,400 ppmv (Appendix J). The carbon tetrachloride groundwater concentration measured at the same time at well W15-218 was 6,500 μg/L. At this time, prior to full-scale SVE operations at the Z-9 site, the measured carbon tetrachloride soil vapor concentration was an order of magnitude greater than the equilibrium soil vapor concentration predicted based on the groundwater concentration. Removal of carbon tetrachloride from the vadose zone using SVE thus appears to have reversed the local carbon tetrachloride concentration gradient at this location.

Maximum carbon tetrachloride vapor concentrations measured at zone 6 wells at the Z-1A site during the rebound study and SVE restart in July 1997 were approximately 30 to 40 ppmv (Tables 6-4 and 6-8). The carbon tetrachloride concentration measured in groundwater at well W15-18 ranged from 3,000 μg/L in January 1996 to 1,000 μg/L in May 1997; the concentration measured in well W18-24 ranged from 1,000 μg/L in January 1996 to 1,400 μg/L in May 1997. For a groundwater concentration of 1,000 to 3,000 μg/L, the equilibrium soil vapor concentration would be 150 to 450 ppmv. This predicted equilibrium concentration is an order of magnitude

greater than the maximum vapor concentration observed during the rebound study at the Z-1A site.

7.4 EFFECTIVENESS OF USING SOIL VAPOR EXTRACTION FOR PLUME CONTROL IN THE UNSATURATED ZONE

Carbon tetrachloride concentrations measured at the periphery of the vapor extraction area are sparse; the scope of the rebound study was limited to monitoring points within the radial influence of the SVE systems. Differential pressure measurements at soil vapor probes in October suggest that probes CPT-1A and CPT-9A, and possibly CPT-7A, were beyond the radial influence of the SVE systems at that time. At CPT-1A (west of the Z-12) and at CPT-7A (west of Z-1A), the carbon tetrachloride concentrations at depths from 11 to 28 m did not exceed 4 ppmv. At CPT-9A, concentrations at 18 m depth were relatively constant at 40 to 44 ppmv and at 28-m depth appeared to decrease from approximately 90 ppmv to 40 ppmv. Based on limited data, carbon tetrachloride concentrations did not increase significantly at laterally distant probes.

Carbon tetrachloride was detected in the near surface zone at concentrations exceeding 1.5 ppmv (the minimum of the calibrated range for filter B in the B&K) only twice during the rebound study, once at 87-01R and once at 95-01 (Table 6-4). Both of these probes are located along the western margin of the soil vapor network; 87-01R is approximately 20 m west of the Z-12 crib and 95-01 is approximately 75 m west of the Plutonium Finishing Plant 234-5Z Building (Figure 1-5). This shallow zone is probably swept out by barometric pressure fluctuations. However, the lack of widespread detections in shallow probes on the sampling days when the two detections were observed suggests that vertical transport of carbon tetrachloride through the soil surface to atmosphere has been minimal during the rebound study.

7.5 OPTIMIZATION OF CURRENT SOIL VAPOR EXTRACTION SYSTEM OPERATIONS

The rebound data for wells in zone 3 (near the potential source in the silt and Plio-Pleistocene layers) and zone 6 (near the potential source in groundwater) show increasing carbon tetrachloride concentrations with increasing time during the rebound period. Zone 3 wells (Figure 7-8) tend to exhibit a rapid increase in concentration followed by a slow increase. The initial rapid increase appears to take place during the first 6 to 8 weeks of rebound. Zone 6 wells (Figure 7-9) exhibit the same kinds of concentration trends. In one well (W18-7), the change to the slower rate of increase appears to occur after 4 months.

Daily carbon tetrachloride concentrations incoming to the SVE systems have shown a continuous decrease following restart of SVE operations in July. The trend is initially rapid, followed by a slower decrease (Figure 6-10). The rapid decrease took place during the first 5 weeks (Table 6-8).

The mass of carbon tetrachloride removed during the first 7 weeks of SVE operation following rebound is shown for each SVE system in Figures 7-10 through 7-12. The projected mass

removed had the SVE systems continued to operate since November 1996 is also shown. The estimates of projected mass removed are based on the daily concentration at the time of shutdown and continuous operation of each SVE system at its full capacity; during actual operations, the daily concentrations probably would have continued to slowly decrease, and the availability of the systems might have been less than 100% during the winter months (Rohay 1996b). The length of time of actual operations from July 18 through September 4 (49 days) is 16% of the length of time of projected operations from November 4 through September 4 (305 days).

One advantage to maintaining continuous SVE operations is that, compared to a complete operating/nonoperating cycle, more mass would be removed if operations continued uninterrupted. An additional advantage to continuous operations is that a maximum concentration gradient would be maintained between the saturated zone and the vadose zone to drive contaminants from groundwater to the vapor phase.

The 42.5-m^3/min SVE system actually removed 891 kg, compared to a projected 2,965 kg (Figure 7-11), or 30% of the mass in 16% of the time. The 28.3-m^3/min SVE system actually removed 326 kg, compared to a projected 1,253 kg (Figure 7-12), or 26% of the mass in 16% of the time. The 14.2-m^3/min SVE system actually removed 87 kg, compared to a projected 391 kg (Figure 7-13), or 22% of the mass in 16% of the time (a decrease in the actual mass removal rate in August reflects the removal of four out of six well intervals from extraction to support the passive extraction valve test). These comparisons indicate that, once the readily accessible mass of contaminant has been removed during early stages of SVE, mass removal is more efficient (in terms of mass removed per hour of operation) if SVE operations are intermittent or cyclic rather than continuous. An additional advantage to cyclic operations is that the higher carbon tetrachloride concentrations require less GAC per unit mass of carbon tetrachloride extracted because the GAC adsorption of the carbon tetrachloride is more efficient at higher concentrations.

These rebound data suggest that the minimum length of time for rebound between operating cycles is 8 to 16 weeks, and that a reasonable length of time for an operating cycle is 4 to 8 weeks.

Wilson et al. (1994) point out that in situations where contaminant supply is controlled by diffusion/desorption kinetics, the rebound data can be used to adjust the flowrate of the extracted soil vapor to match the rate of contaminant supply. They suggest (based on modeling a single well) that the flowrate is too high if the contaminant concentrations in the extracted soil vapor are significantly lower than the rebound soil vapor concentrations. The rapid decline in carbon tetrachloride concentrations observed at some extraction wells after restart in July 1997 would thus indicate that lower flowrates using either active SVE systems or passive SVE systems would be more efficient to remove the same contaminant mass. The limited low-flow testing at Z-1A indicated that reducing the flow had minimal impact on contaminant concentrations in the extracted soil vapor.

Under these diffusion/desorption-limited conditions, Wilson et al. (1994) suggest as an alternative approach that cyclic SVE operations be implemented in which the period of operation is initiated at a rebound concentration less than the maximum and the period of nonoperation is initiated when the extracted concentrations reach a selected fraction of the concentration when operations started. As remediation continues, the maximum rebound concentration and rate of concentration decrease will change, indicating that the operating/nonoperating cycle must be re-evaluated for each successive period of operations.

7.6 IDENTIFICATION AND ACHIEVEMENT OF CLEANUP GOALS

The rebound data indicate some of the complexities associated with selecting a single numerical target level. Selection of the monitoring location(s) with respect to the SVE radial influence and contaminant residual sources, monitoring frequency, monitoring time with respect to meteorological conditions (e.g., barometric pressure), and monitoring time with respect to shutdown of the SVE systems can all affect the magnitude of the carbon tetrachloride concentrations detected.

7.7 SELECTION OF FINAL REMEDY FOR CARBON TETRACHLORIDE IN THE UNSATURATED ZONE

With continued operation of the SVE systems at the 200-ZP-2 site, inlet carbon tetrachloride concentrations have decreased from a maximum of 30,000 ppmv to less than 50 ppmv, which is indicative of the effectiveness of using SVE to remove the readily available carbon tetrachloride. The increasingly slower release rate of carbon tetrachloride vapor in the subsurface is consistent with a previous study at the 200-ZP-2 site that suggested that SVE will only remove 10% to 15% of the initial mass in the subsurface under ideal conditions where flow is passing directly through the area of contamination, and that the release of the remaining mass is limited by slow diffusion kinetics (Yonge et al. 1996). The rebound study data indicate that additional carbon tetrachloride remains in the lower permeability zone at 35- to 40-m depth, through which air flow is limited and thus remediation using SVE is less effective.

A preliminary evaluation of soil-heating technologies that could enhance the volatilization and thus the removal of carbon tetrachloride (Jackson et al. 1996) concluded that hot air and steam injection are potentially the most practical and cost effective for application to permeable soil layers. The principal uncertainties of these techniques relate to (1) the ability to obtain uniform flow of heating media in the subsurface; and (2) the potential for condensation of organic-contaminated liquids that could potentially migrate to groundwater. For application to the lower permeability soil layers, the study concluded that electrical and RF heating may be more effective because these techniques are not dependent on the permeability of the soil for distribution of the heating media. However, implementability of either technology is highly uncertain and the costs are very speculative because of the greater depth and volumes of contamination that need to be addressed at 200-ZP-2.

Passive SVE, which operates at the same rate that contaminant is released in mass-transfer limited cases, may become a more attractive alternative for continued 200-ZP-2 operations. A preliminary review of supplemental testing indicates that the incorporation of a one-way valve in passive extraction systems can increase the carbon tetrachloride removal rate.

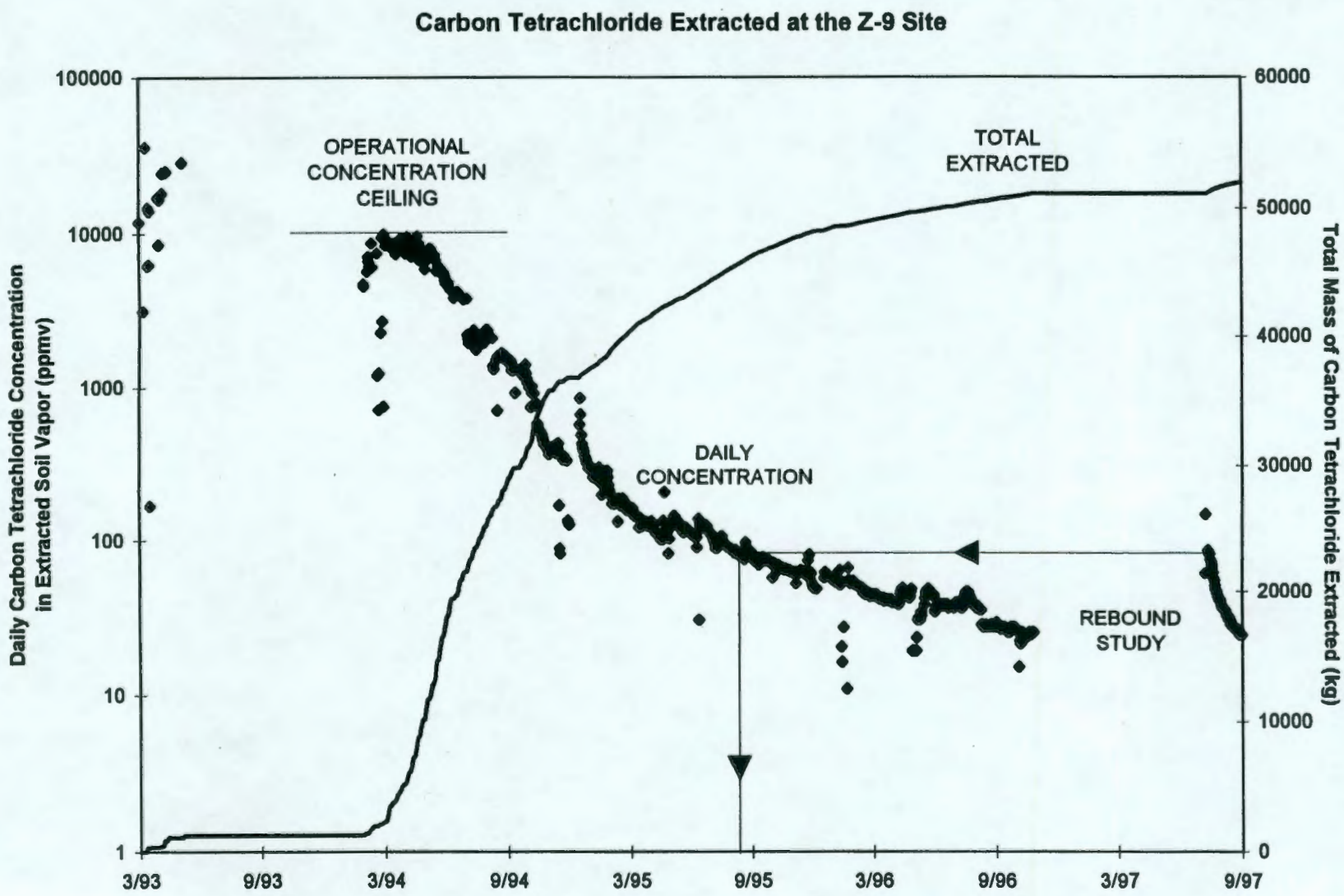


Figure 7-1. Daily Carbon Tetrachloride Concentrations in Soil Vapor Extracted Using the 42.5-m^3/min SVE System.

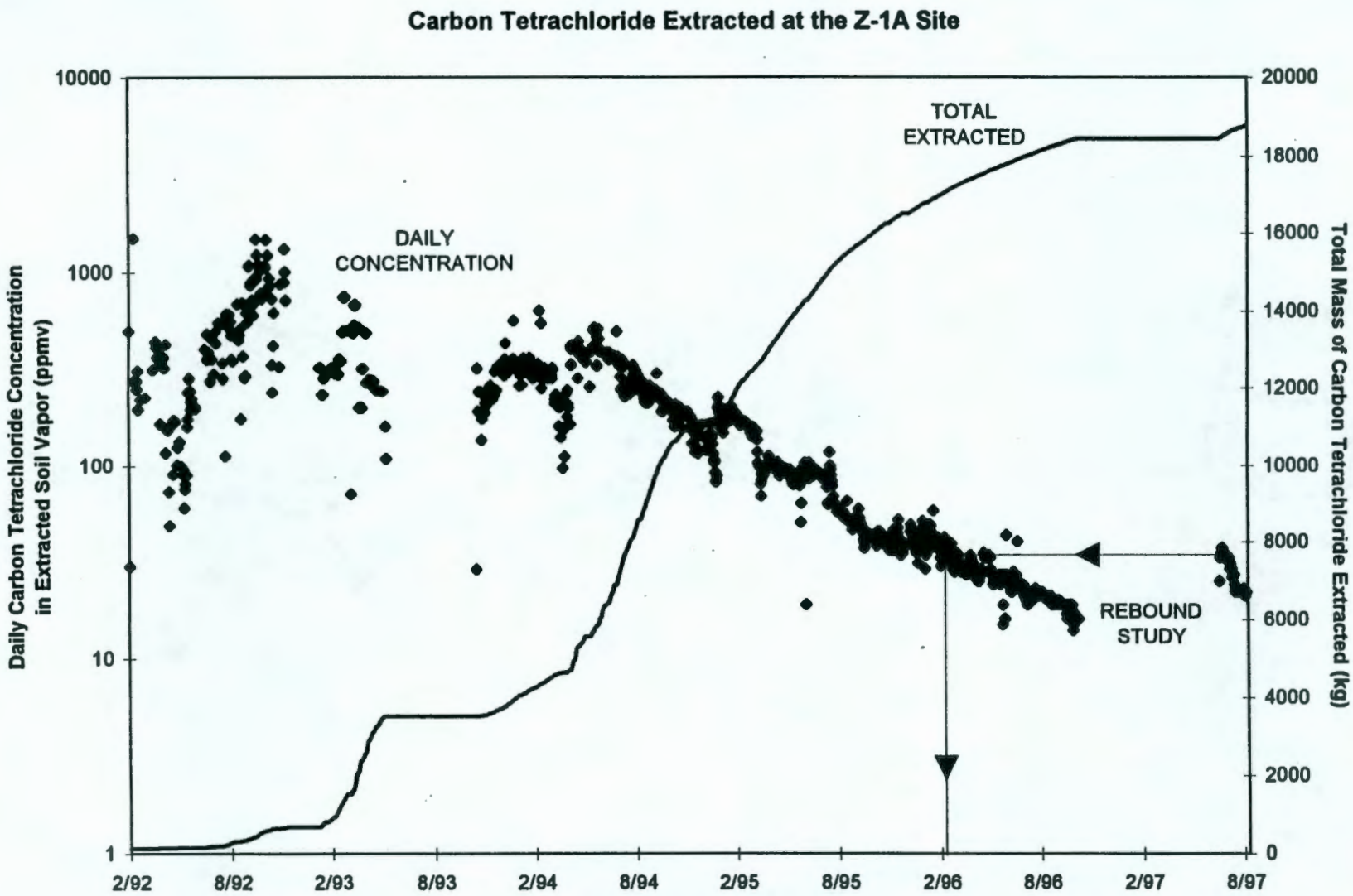


Figure 7-2. Daily Carbon Tetrachloride Concentrations in Soil Vapor Extracted Using the 28.3-m^3/min SVE System.

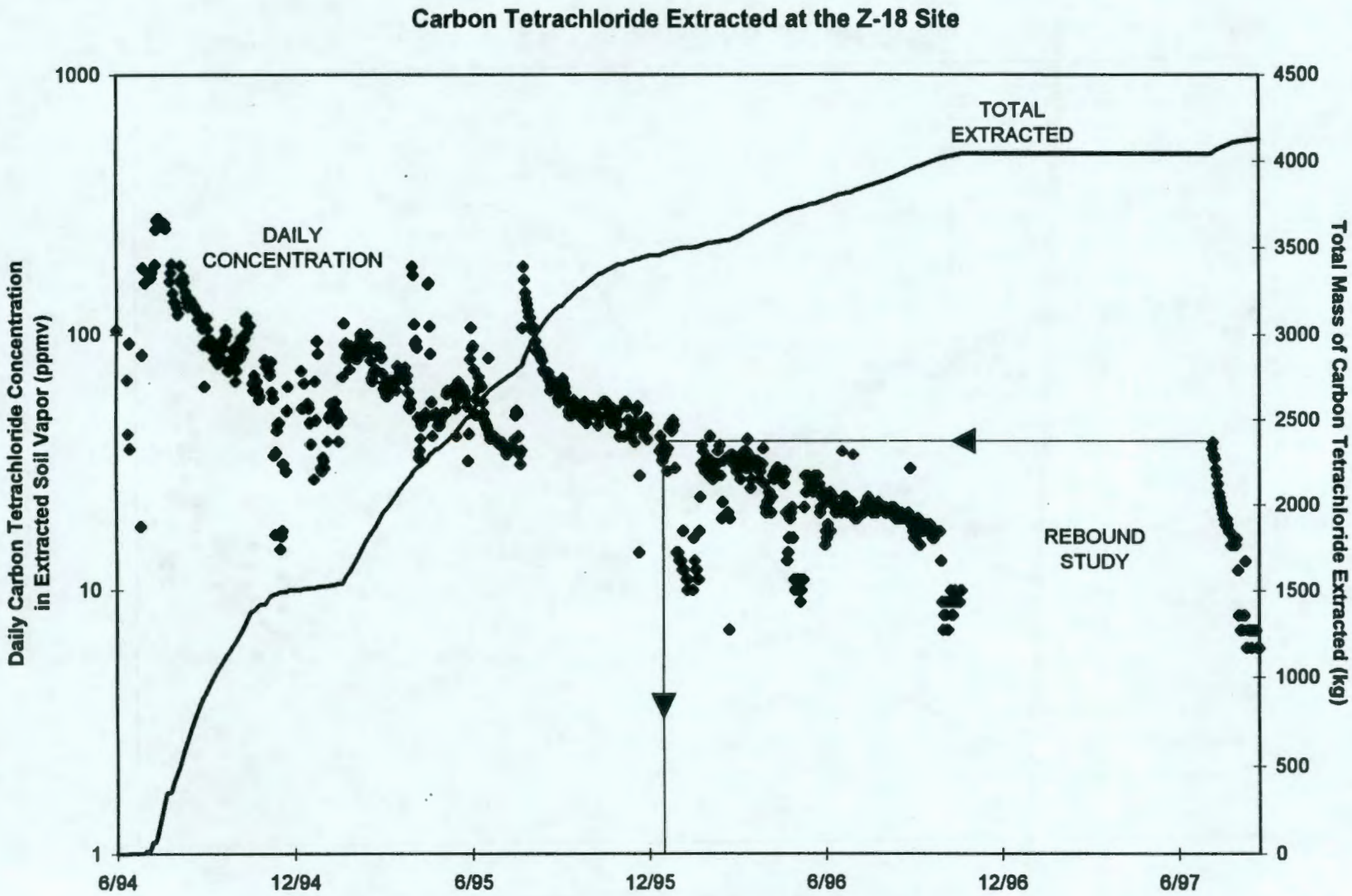
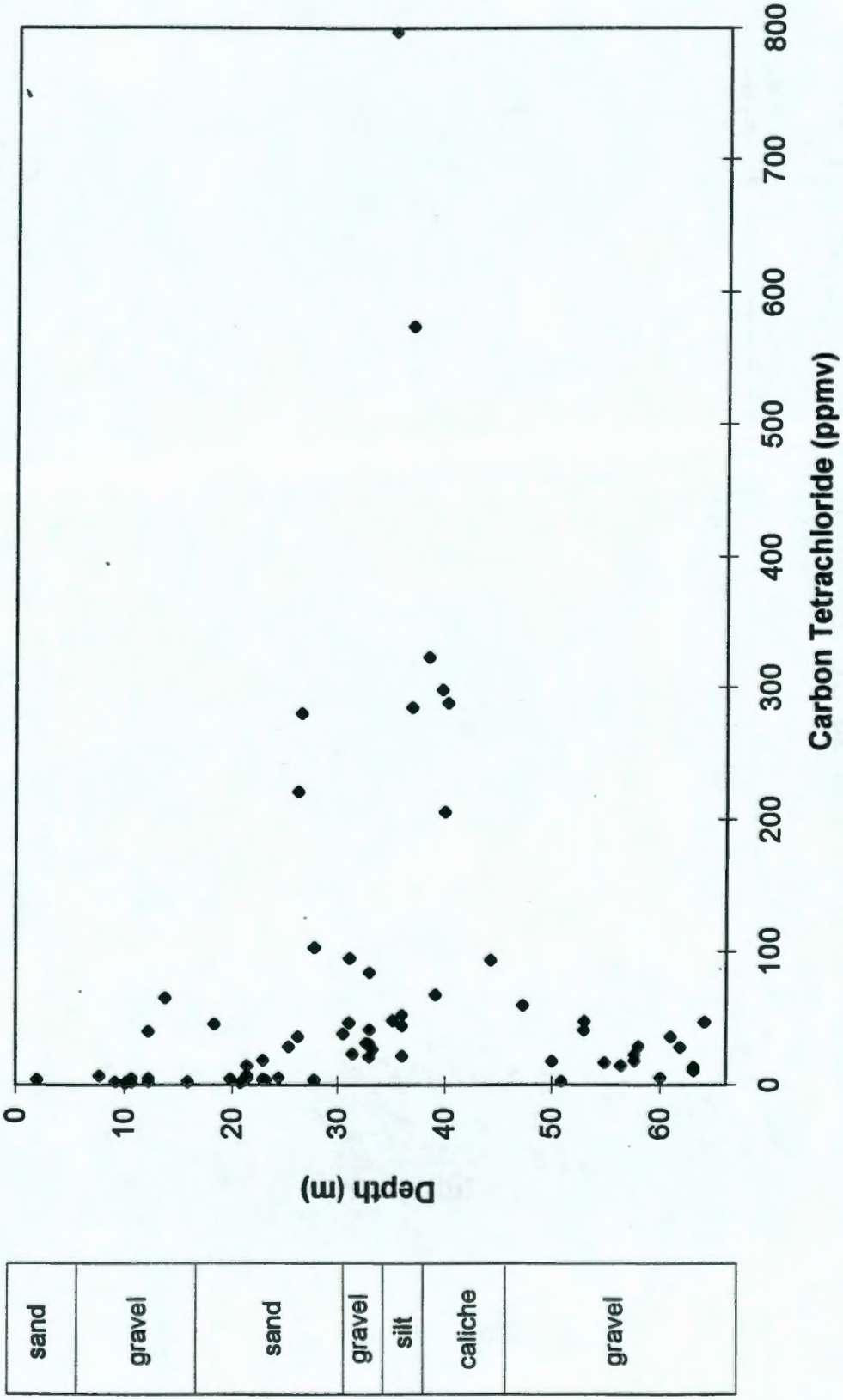


Figure 7-3. Daily Carbon Tetrachloride Concentrations in Soil Vapor Extracted Using the 14.2-m^3/min SVE System.

Figure 7-4. Vertical Profile of Maximum Carbon Tetrachloride Rebound Concentrations, November 4, 1996 through July 10, 1997.



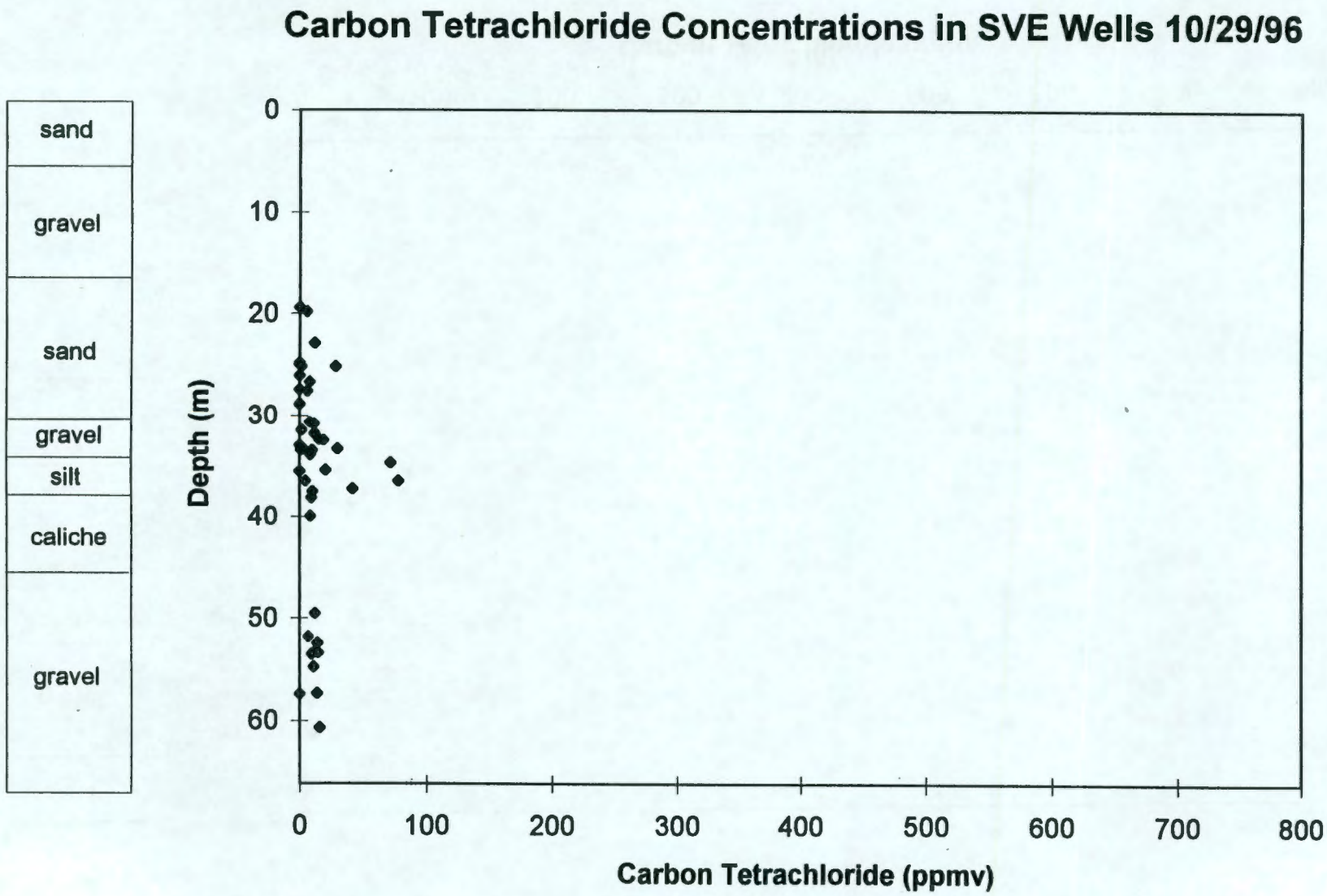


Figure 7-5. Vertical Profile of Baseline Carbon Tetrachloride Concentrations, October 29, 1996.

Figure 7-6. Carbon Tetrachloride Rebound Concentrations Measured at Pairs of Zone 2 Probes West of the Z-1A Site.

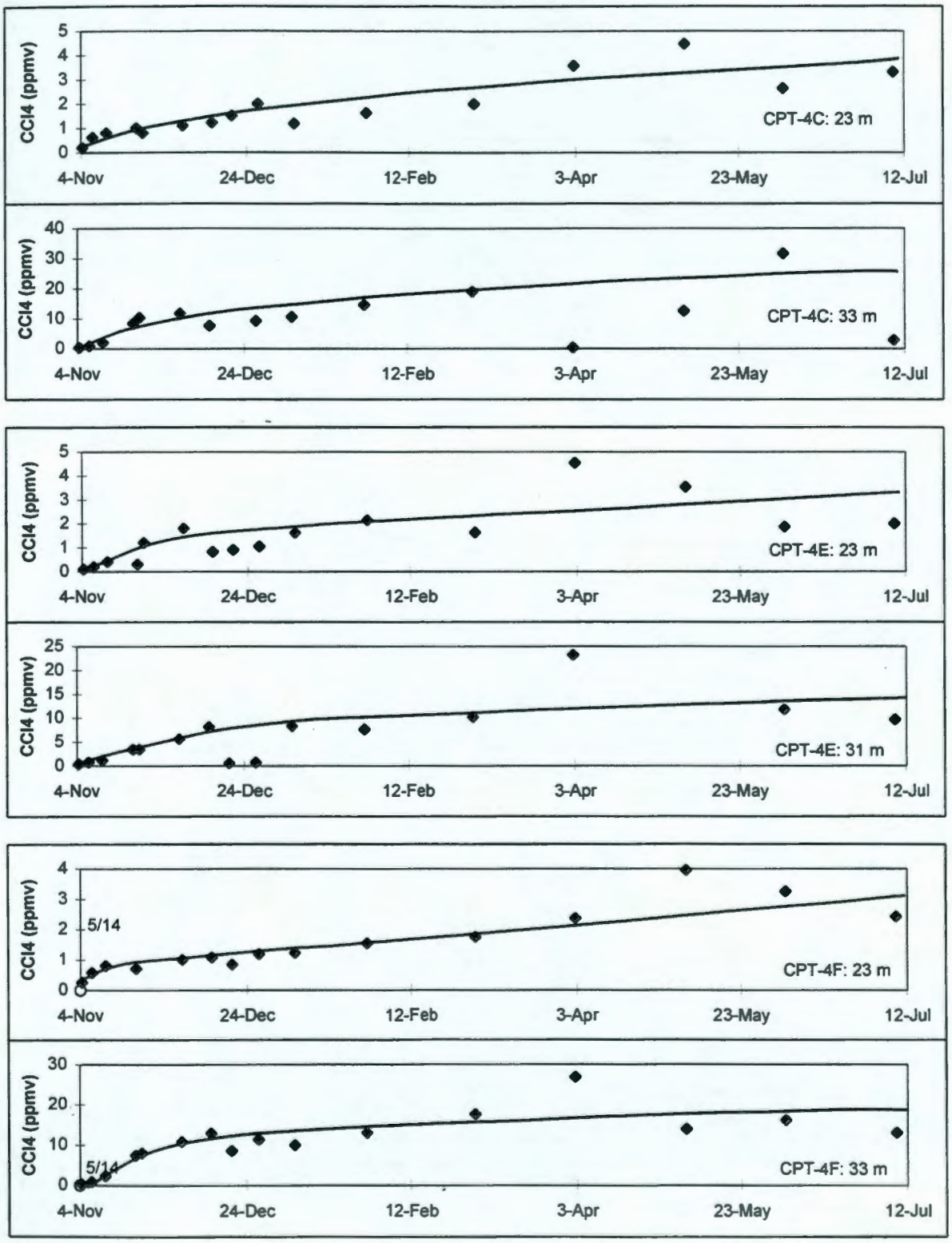


Figure 7-7. Carbon Tetrachloride Rebound Concentrations Measured Near the Water Table at the Z-9 and Z-1A Sites.

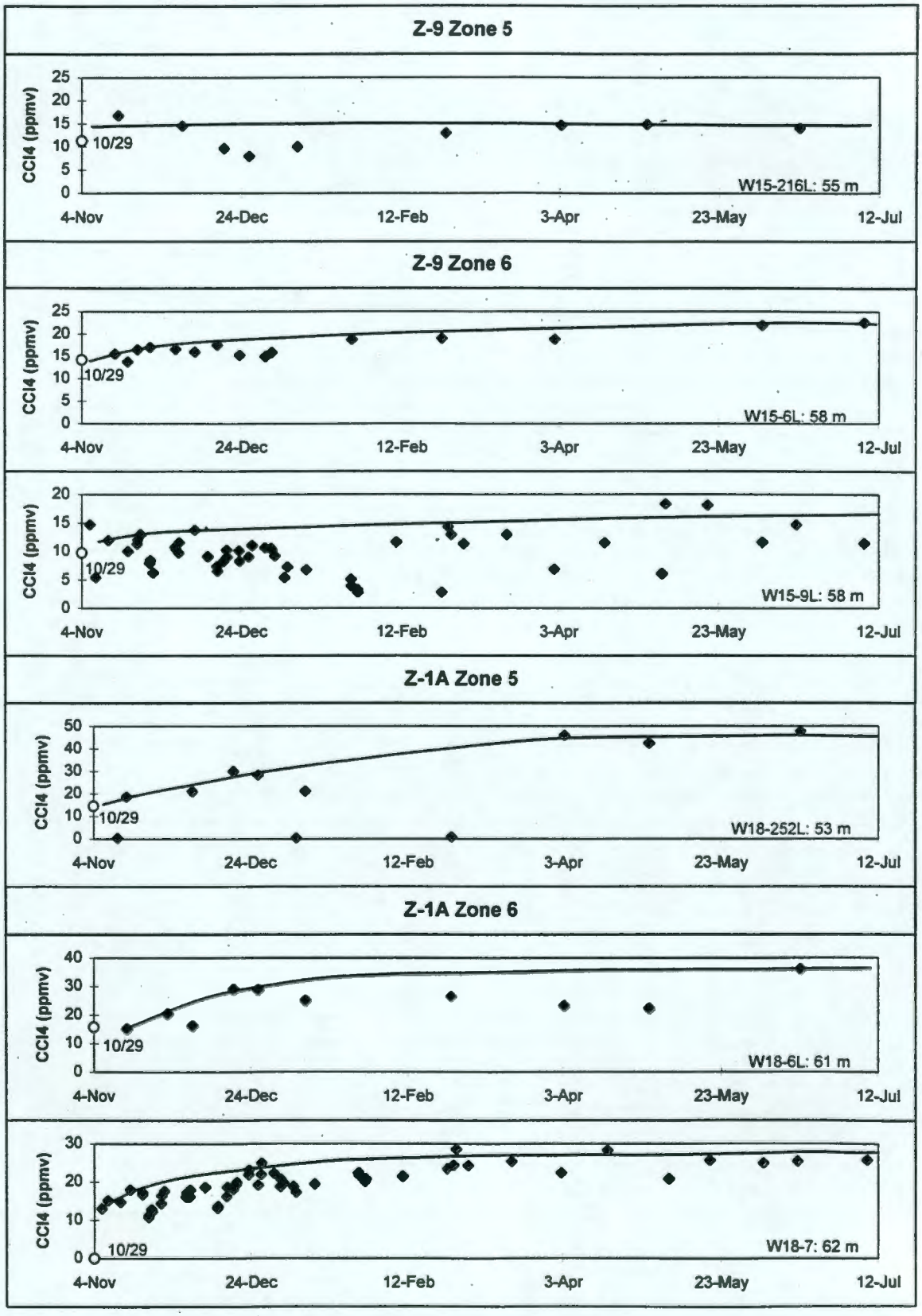


Figure 7-8. Carbon Tetrachloride Rebound Trends for Zone 3 and Zone 4 Wells at the Z-9 Site.

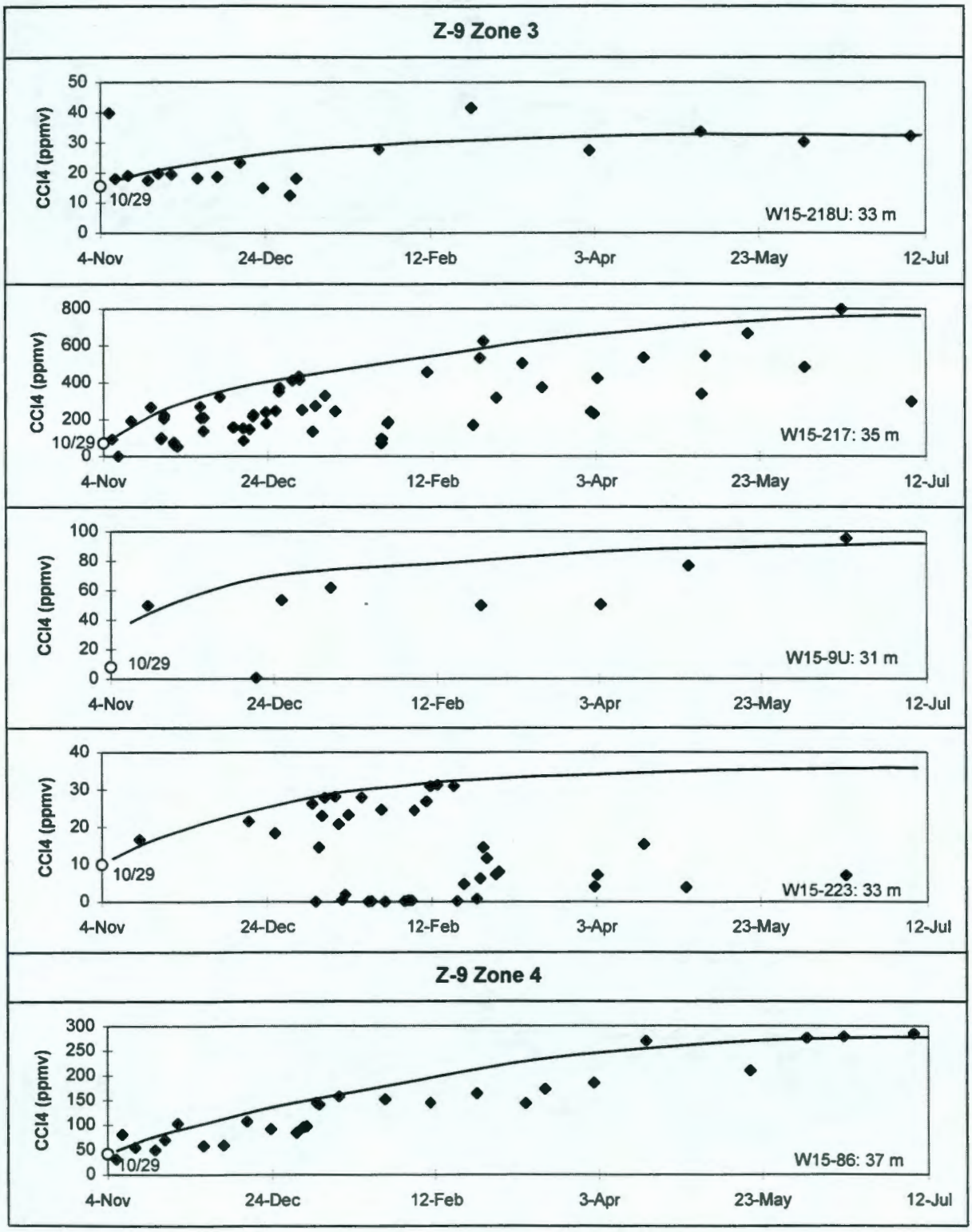


Figure 7-9. Carbon Tetrachloride Rebound Trends for Zone 3 Wells Within the Z-1A Tile Field.

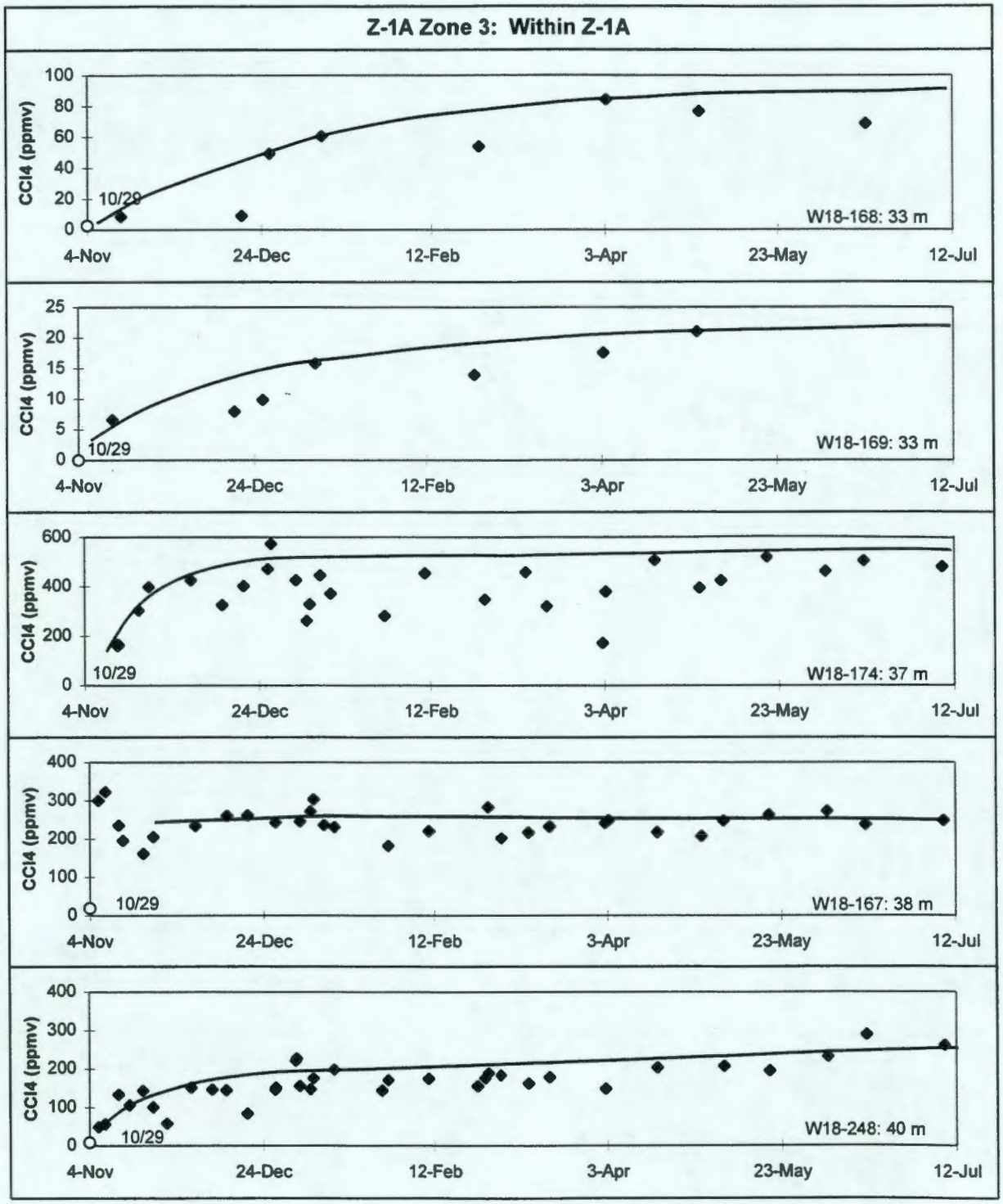
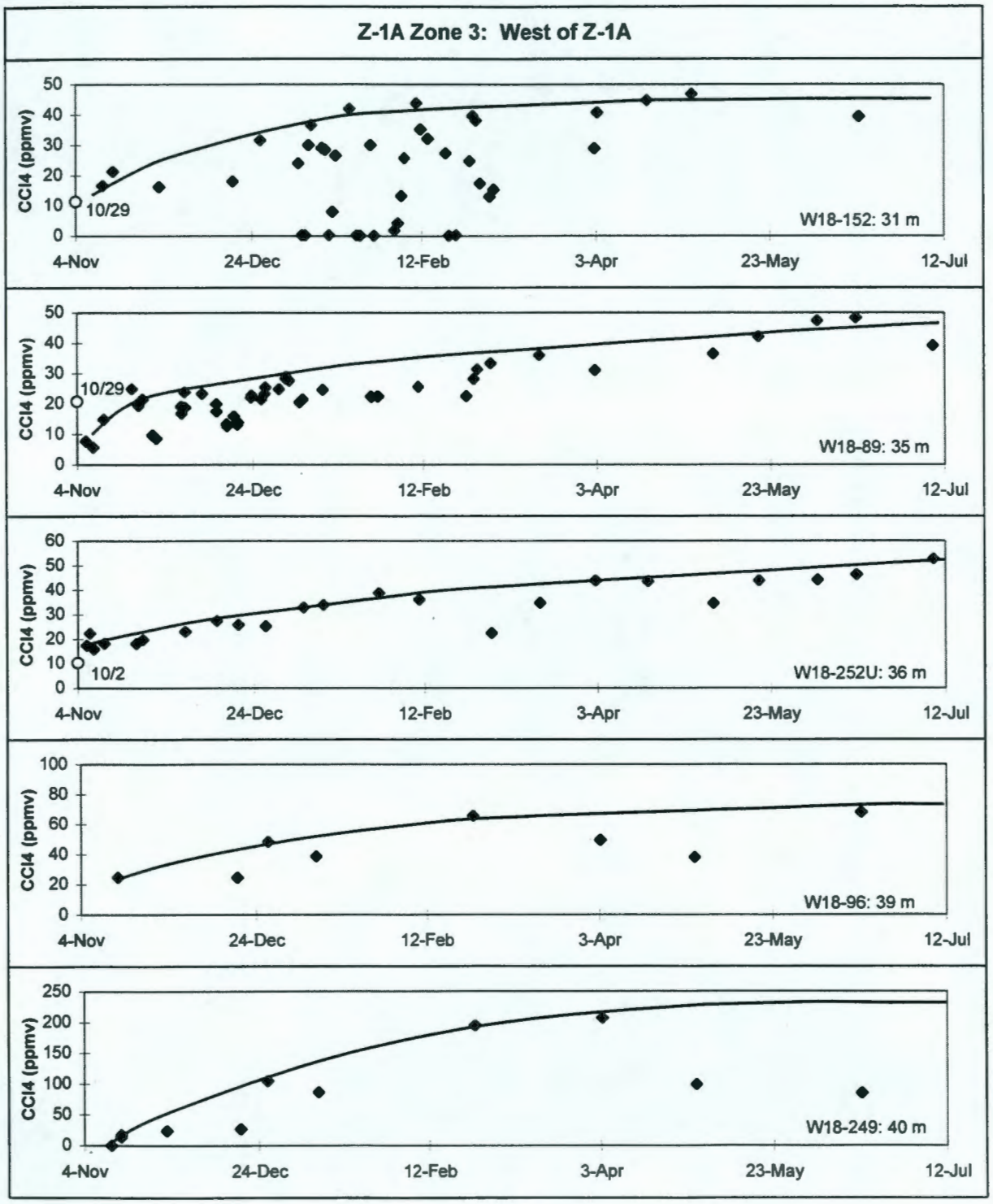


Figure 7-10. Carbon Tetrachloride Rebound Trends for Zone 3 Wells West of the Z-1A Tile Field.



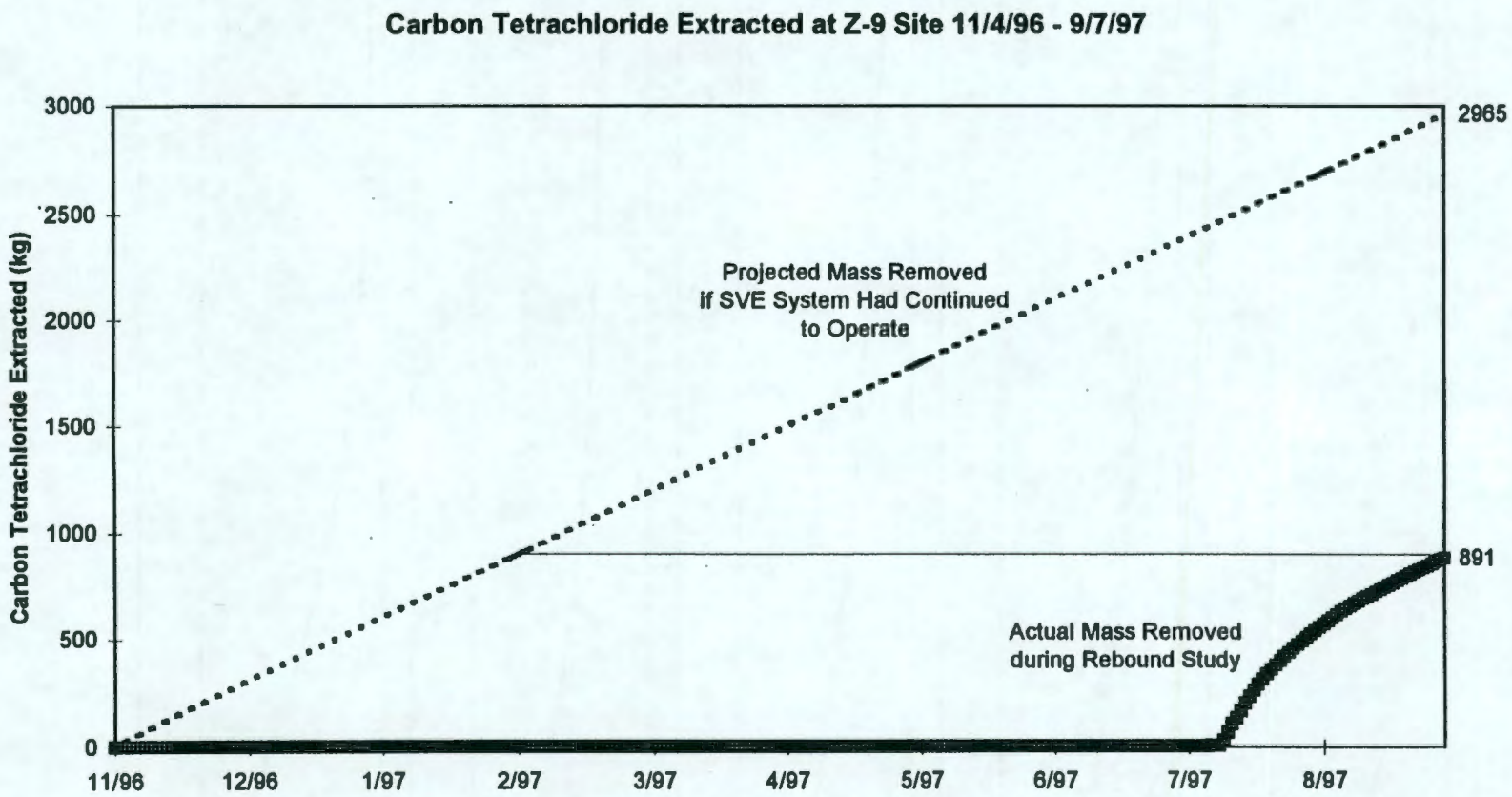


Figure 7-11. Comparison of Actual Mass Removed Using the 42.5-m^3/min Soil Vapor Extraction System After Rebound to the Projected Mass Removed During the Rebound Study.

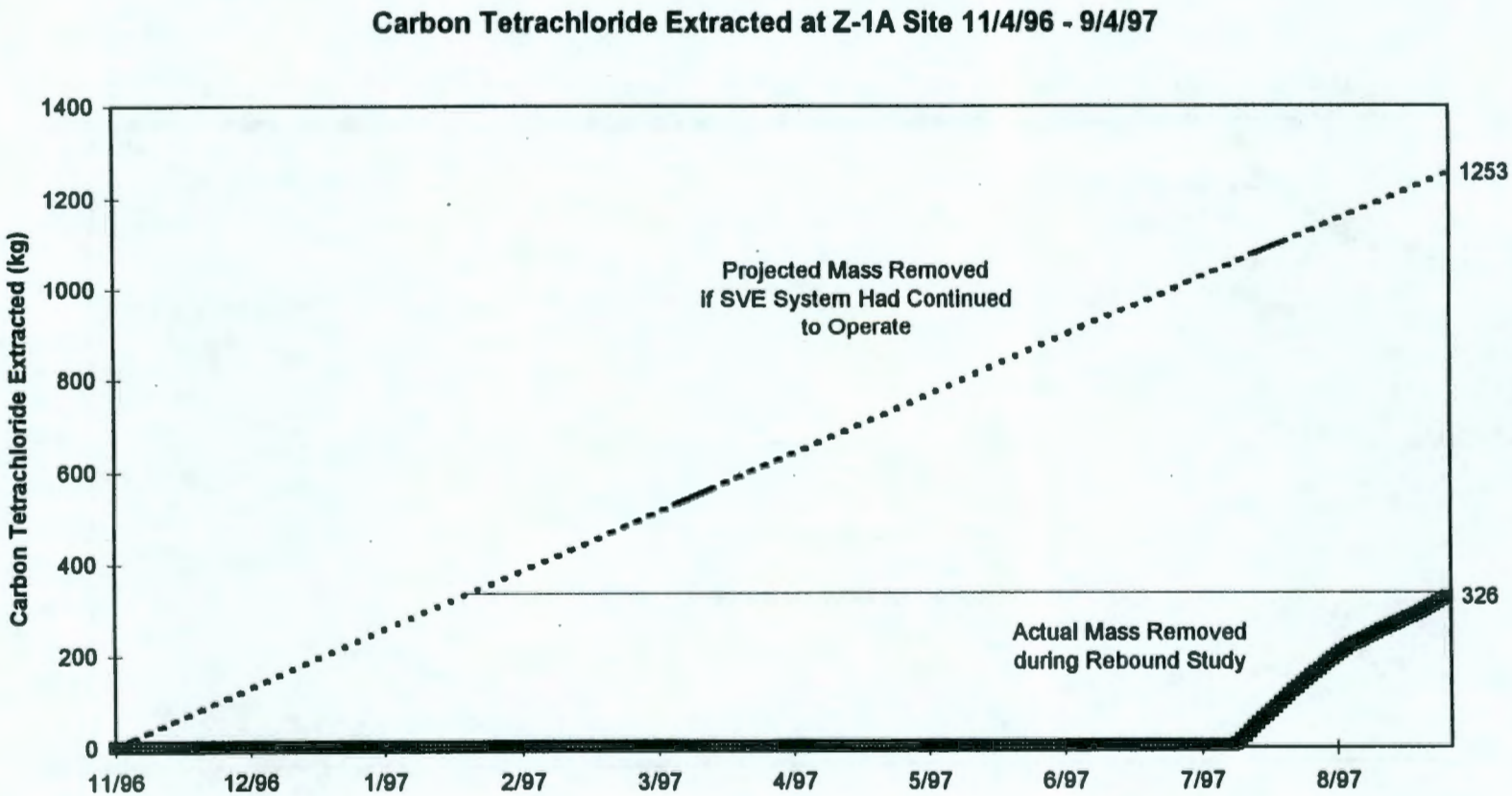


Figure 7-12. Comparison of Actual Mass Removed Using the 28.3-m^3/min Soil Vapor Extraction System After Rebound to the Projected Mass Removed During the Rebound Study.

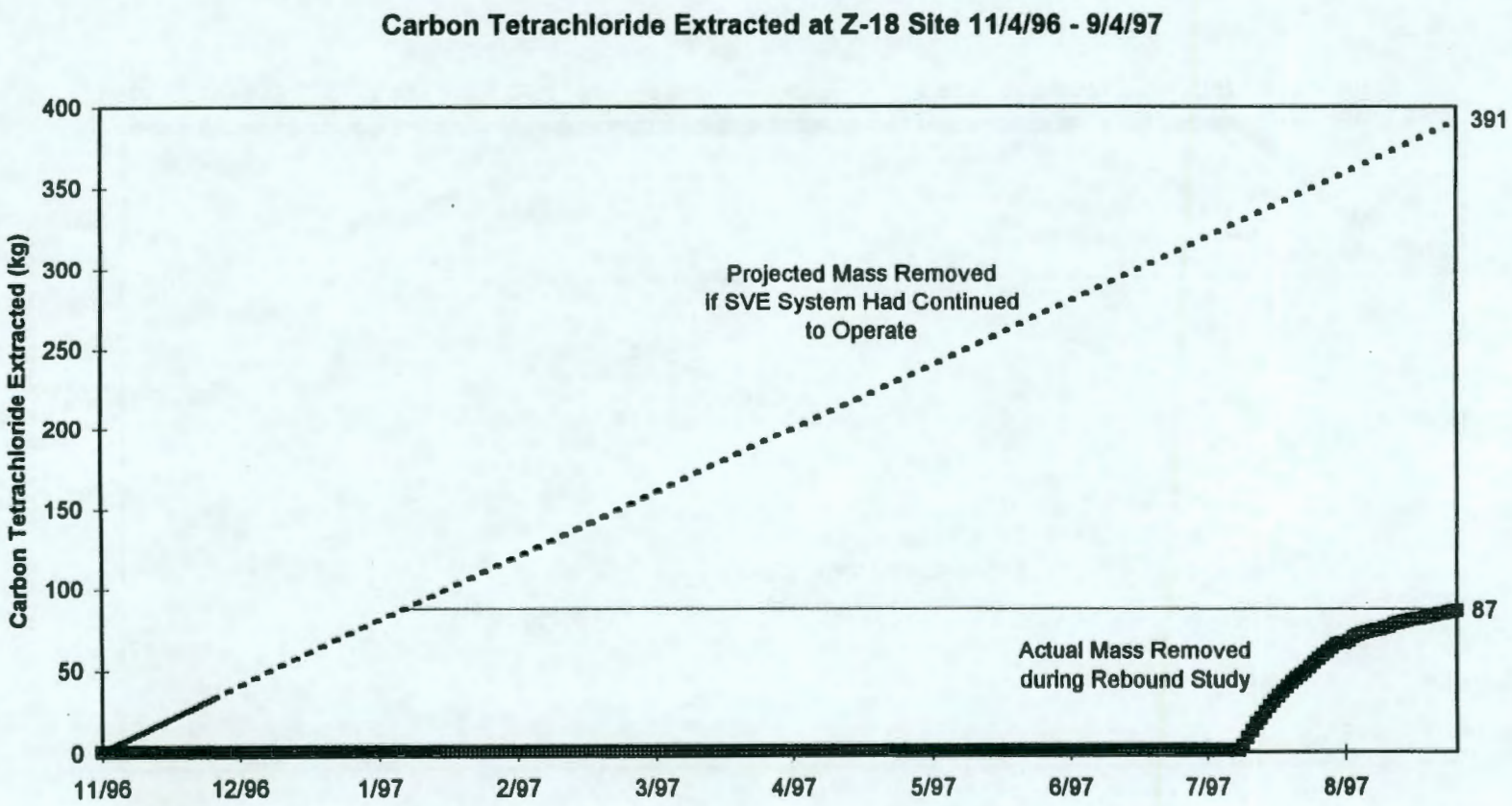


Figure 7-13. Comparison of Actual Mass Removed Using the 14.2-m^3/min Soil Vapor Extraction System After Rebound to the Projected Mass Removed During the Rebound Study.

Table 7-1. Magnitude and Rate of Carbon Tetrachloride Increase During the Rebound Study and Carbon Tetrachloride Decrease During Restart of Soil Vapor Extraction Operations.

Carbon Tetrachloride (ppmv)				Factor	Magnitude	Rate of	Carbon Tetrachloride (ppmv)					Factor	Magnitude	Rate of
Well	10/29/96 Baseline	Maximum Rebound	Date of Rebound	of Increase	of Increase (ppmv)	Increase (ppmv/day)	7/18/97	7/21/97	7/24/97	7/28/97	7/31/97	of Decrease	of Decrease (ppmv)	Decrease (ppmv/day)
W18-152	11.4	46.8	4/30/97	4	35.4	0.19								
W18-252L	14.6	47.7	6/17/97	3	33.1	0.14								
W18-252U	10.4	52.6	7/8/97	5	42.2	0.17		41.5	25.8	11.4	8.4	5	33.1	3.31
W18-6L	15.8	36	6/17/97	2	20.2	0.09		26.8	24.4	30.9	8.6	3	18.2	1.82
W18-7	0.0	28.5	2/27/97		28.5			30.8	3.9	9.8	26.6	1	4.2	0.42
W18-89	20.8	48.3	6/16/97	2	27.5	0.12								
W18-167	18.9	322.8	11/8/97	17	303.9	0.81		20.6	21.2	15.3	1.8	11	18.8	1.88
W18-168	2.8	84.2	4/3/97	31	81.4	0.52								
W18-169	0.0	21.2	6/17/97		21.2									
W18-174		573	12/27/97		573.0			7.0	2.9	0.0	4.0	2	3.0	0.30
W18-248	8.4	288	6/16/97	34	279.6	1.22		59.3	57.9	2.7	26.4	2	32.9	3.29
W15-6L	14.2	22.6	7/7/97	2	8.4	0.03	20.2	20.3	22.6	20.6	20.5	1	-0.3	-0.02
W15-9L	9.7	18.3	5/6/97	2	8.6	0.05	19.8	21.3	21.0	14.8	14.5	1	5.3	0.41
W15-9U	8.1	95.2	6/17/97	12	87.1	0.38								
W15-82	28.5	28.9	11/6/97	1	0.4	0.00	106.0	46.8	170.0	126.0	116.0	1	-10.0	-0.77
W15-86	41.8	284.5	7/7/97	7	242.7	0.97	138.0	111.0	57.8	69.6	62.5	2	75.5	5.81
W15-216L	11.3	16.7	11/15/97	1	5.4	0.01								
W15-217	71.7	797	6/16/97	11	725.3	3.15	256.0	86.3	164.0	129.0	131.0	2	125.0	9.62
W15-218L	13.7	29	1 meas.	2	15.3		20.3	21.9	20.0	20.0	12.4	2	7.9	0.61
W15-218U	15.6	41.4	2/24/97	3	25.8	0.22	21.1	21.8	21.1	22.0	19.1	1	2.0	0.15
W15-219L	12.8	41.1	1 meas.	3	28.3									
W15-220L	12.1	17.7	1 meas.	1	5.6									

Table 7-2. Comparison of Mass of Carbon Tetrachloride Removed Per Week Before and After the Rebound Study.

Week	Carbon Tetrachloride Removed (kg) per Week		
	Z-9 Site	Z-1A/18/12 Site	
	42.5 m^3/min	28.3 m^3/min	14.2 m^3/min
10/15/96-10/21/96	63.3	31.8	8.9
10/22/96-10/28/96	63.7	30.0	8.4
10/29/96-11/4/96	64.1	27.7	8.8
7/18/97-7/24/97	221.7	57.8	26.3
7/25/97-7/31/97	169.8	61.2	18.8
8/1/97-8/7/97	126.7	55.9	16.9
8/8/97-8/14/97	108.6	46.9	9.4
8/15/97-8/21/97	84	33.1[a]	5.9[b]
8/22/97-8/28/97	75.7	30.7	4.0
8/29/97-9/4/97	70.9	36.8	4.3

[a] Wells W18-6L and W18-7 taken off-line 8/14/97 to support passive extraction valve test.
[b] Wells W18-246U&L and W18-252U&L taken off-line 8/14/97 to support passive extraction valve test.

Table 7-3. Average Groundwater Temperatures in the Vicinity of the Carbon Tetrachloride Site, 1996 Through 1997.

Well Number	Years	Average Temperature (°C)
299-W14-9	1996-1997	19.1
299-W15-5	1996	21.3
299-W15-16	1996-1997	19.1
299-W18-1	1996-1997	20.9
299-W18-24	1996-1997	18.4
Average	1996-1997	19.8

8.0 CONCLUSIONS

8.1 CONCLUSIONS

Based on an evaluation of the rebound study data, the following conclusions address the DQO issues identified for the 200-ZP-2 project.

1. Amount of Additional Carbon Tetrachloride Available for Removal Using SVE

- Calculation of carbon tetrachloride soil concentrations or residual mass using measured soil vapor concentrations and empirical relationships to estimate the soil partitioning coefficient can lead to significant error because these relationships do not account for the nonequilibrium partitioning of carbon tetrachloride within soil particles. However, the rebound in vapor concentrations indicates that additional carbon tetrachloride is available for extraction using SVE.

- Since initiation of operations in 1992, SVE has removed 22,000 kg of carbon tetrachloride from the Z-1A site (estimated to be 6% of the remaining mass at Z-1A); and 51,000 kg from the Z-9 site (estimated to be 21% of the remaining mass at Z-9).

- Carbon tetrachloride concentrations rebounded significantly (i.e., by an order of magnitude) at only five locations, indicating that in many areas the readily accessible mass has been removed and the availability of additional carbon tetrachloride is limited by diffusion from lower permeability zones and micropores.

- During the first 3 weeks of SVE operations following 8 months of rebound, the SVE systems were extracting an average of 178 kg/week; but after 7 weeks, SVE extraction is approaching the pre-shutdown rate of 100 kg/week.

2. Distribution of Remaining Carbon Tetrachloride Sources

- The maximum carbon tetrachloride rebound concentrations were detected at sampling locations from 25- to 40-m depth, suggesting that the remaining carbon tetrachloride available for removal using SVE is primarily associated with the lower permeability silt and Plio-Pleistocene zone at approximately 40-m depth.

- The distribution of carbon tetrachloride sources within the silt and Plio-Pleistocene layers is not uniform.

- Carbon tetrachloride dissolved in soil moisture and adsorbed within soil particle micropores in the higher permeability sand and gravel layer represents a potentially significant mass; the availability of this contaminant source for removal using SVE is controlled by diffusion/desorption kinetics.

- Carbon tetrachloride concentrations near the water table increased relatively slowly, suggesting that volatilization of dissolved carbon tetrachloride from the groundwater into the unsaturated zone, and/or the downward migration of carbon tetrachloride from the lower permeability zone toward the groundwater, is occurring slowly relative to the 8-month-long rebound study period.

- A broad, relatively uniform reservoir of relatively low carbon tetrachloride concentrations may exist above the water table.

3. Evaluation of the Carbon Tetrachloride Transport Between the Unsaturated and Saturated Zones

- Based on comparison of measured vapor concentrations to theoretical vapor concentrations that would be in equilibrium with measured groundwater concentrations, the groundwater and vapor do not appear to be in equilibrium.

- The expected direction of carbon tetrachloride migration is from the groundwater to the unsaturated zone, based on the comparison of measured to theoretical vapor concentrations.

- Because carbon tetrachloride concentrations did not increase significantly near the water table, temporarily suspending operation of the SVE systems for 8 months appears to have had no negative impact on groundwater quality.

4. Effectiveness of Using SVE for Plume Control in the Unsaturated Zone

- Because carbon tetrachloride concentrations did not increase significantly at the 1.5-m-deep shallow probes, temporarily suspending operation of the SVE systems for 8 months appears to have caused minimal detectable vertical transport of carbon tetrachloride through the soil surface to atmosphere.

- Because carbon tetrachloride concentrations did not increase significantly at a limited number of laterally distant probes, temporarily suspending operation of the SVE systems for 8 months appears to have caused minimal detectable lateral transport of carbon tetrachloride beyond the area remediated using SVE.

- Carbon tetrachloride soil vapor moves through the subsurface by advection driven by barometric pressure fluctuations and by diffusion, indicating that the subsurface is a dynamic system and that soil vapor concentrations will migrate over time.

- As carbon tetrachloride migrates, it will tend to be redistributed in the subsurface and can be adsorbed in previously uncontaminated or remediated areas.

5. Optimization of Current SVE System Operations

- Carbon tetrachloride concentrations rebounded most rapidly in the 8 to 16 weeks months following SVE shutdown but continued rebounding (at the same rate or more slowly) for 8 months and presumably would continue for years.

- Carbon tetrachloride concentrations decreased most rapidly in first 4 to 8 weeks following SVE restart, after which they continued decreasing more slowly with continued SVE operations.

- To optimize the mass removal rate of carbon tetrachloride using SVE, the minimum operating cycle should be 4 to 8 weeks of SVE operation followed by 8 to 16 weeks of rebound.

- Assuming that concentrations remained at the November 1996 level and that the SVE systems operated continuously, two-and-a-half times more mass would have been removed over the same 8-month period.

- The optimum operating cycle is likely to change as SVE continues and should be re-evaluated for each succeeding period of operations.

6. Identification and Achievement of Cleanup Goals

- The spatial and temporal variability of the magnitude and rate of carbon tetrachloride rebound indicates some of the complexities associated with selecting a single numerical target level.

- The magnitude of the carbon tetrachloride concentration detected is affected by the selection of the sampling location with respect to the SVE radial influence and contaminant residual sources; the monitoring frequency; the meteorological conditions; and the elapsed time since shutdown of the SVE systems.

- The rate of carbon tetrachloride rebound is likely to change as mass and distance to residual sources change.

7. Selection of Final Remedy for Carbon Tetrachloride in the Unsaturated Zone

- The increasingly slower release rate of carbon tetrachloride vapor in the subsurface is consistent with a previous study at the 200-ZP-2 site that suggested that SVE will only remove 10% to 15% of the initial mass in the subsurface under ideal conditions where flow is passing directly through the area of contamination; and that the release of the remaining mass is limited by slow diffusion kinetics.

- Passive SVE, which operates at the same rate that contaminant is released in mass-transfer limited cases, may become a more attractive alternative for continued 200-ZP-2 operations.

- A preliminary review of supplemental testing indicates that the incorporation of a one-way valve in passive soil extraction systems can increase the carbon tetrachloride removal rate.

8.2 DATA GAPS

During data collection and evaluation of the DQO issues for the current rebound study, the following data gaps were identified. The data gaps are identified in this report to help describe some uncertainties in the existing database being used to address the DQO issues.

1. Currently, no shallow concentration data are available to evaluate the vertical transport of carbon tetrachloride toward the soil surface within the Z-1A and Z-9 disposal cribs. The construction features of the cribs may limit the feasibility of installing soil vapor probes to address this data gap.

2. Very few sampling locations exist that would allow depth-discrete soil vapor sampling at the vadose-groundwater interface. This vapor data could potentially be collected using existing wells by installing a downhole packer in a groundwater well to attempt to isolate the sampling interval near the water table. Further evaluation of this option is recommended prior to implementation.

3. Carbon tetrachloride data has not been collected specifically to address the exchange of contaminant between the groundwater and unsaturated zone. This data gap could be potentially addressed by tracer testing.

4. Relatively few sampling locations exist to monitor the lateral transport of carbon tetrachloride away from the vapor extraction site. In addition, carbon tetrachloride vapor concentrations beyond the SVE area are not well characterized. This data gap could be addressed by installing some sampling probes that are relatively distant (based on the SVE radial influence), collecting baseline concentration data, and monitoring the concentrations during a future rebound period.

5. The effect of the time of year on the initial rebound rate is unknown. The current rebound study was initiated during the winter months when barometric pressure fluctuations are highest. This data gap could be addressed by monitoring carbon tetrachloride rebound concentrations following SVE operations planned for April to June at the Z-1A site in 1998.

6. A mechanism has not yet been developed for accurately filtering the effects of barometric pressure from the effects of rebound. The carbon tetrachloride-barometric pressure supplemental test was conducted to determine this mechanism, but the quantitative filter has not yet been delineated. Separating the effects of barometric pressure from the effects of rebound would allow the rebound characteristics to be more clearly defined. This data gap could potentially be addressed by further analysis of the data.

7. The magnitude of the impact of a surface cover on the radial influence of vapor extraction wells has yet to be demonstrated for the 200-ZP-2 site because the surface cover used during the supplemental test did not provide an effective seal. This data gap could be addressed by repeating the test with a more rugged cover. Use of a surface cover would enhance the radial influence of both active and passive SVE wells; would reduce dilution of contaminant concentrations caused by the vertical flow of atmospheric air into the subsurface; would reduce atmospheric emissions of carbon tetrachloride through the soil surface; and would enhance the subsurface-barometric pressure differential that drives passive SVE.

9.0 RECOMMENDATIONS

The primary recommendations regarding the 200-ZP-2 vapor extraction project indicated by the rebound study are as follows.

1. Implement cyclic operations of the SVE systems using a minimum of 4 to 8 weeks of operation followed by 8 to 16 weeks months of rebound to optimize the carbon tetrachloride mass removal rate.

2. Integrate costs into the recommended operating cycle to ensure that SVE system operations are also optimized for cost efficiency.

3. Implement carbon tetrachloride vapor monitoring during future periods of nonoperation of the SVE systems to confirm that groundwater quality and atmospheric emissions are not being negatively impacted.

4. Repeat the measurement of carbon tetrachloride rebound in the first 4 to 8 weeks following SVE operations at Z-1A planned from April through June 1998 and following SVE operations at Z-9 planned from July through September 1998 to evaluate:

    a. The effect of season of the year on initial rebound by comparing concentrations at Z-1A in November-December 1996 with concentrations at Z-1A in July-August 1998

    b. The repeatability of the magnitude and rate of rebound by comparing concentrations at Z-9 in November-December 1996 with concentrations at Z-9 in October-November 1998

5. Refine the remedial action goals and objectives of the 200-ZP-2 vapor extraction project.

6. Consider implementation of passive SVE as an alternative to active SVE operations.

7. Retest the impact of an impermeable surface cover using a material that can maintain a surface seal to quantify the relationship between the radius of the cover and the radial influence of an SVE well at the 200-ZP-2 site.

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APPENDIX A

REBOUND STUDY DATA TABLE
NOVEMBER 4, 1996 THROUGH JULY 10, 1997

216-Z-9 SITE ZONE 1

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
85-01R	5/16/96 13:41	0.000	<0.045	<0.095				
depth = 1.5 m	12/10/96 11:17	0.000	0.1	0.7	1.0	0.0		
zone = 1	1/24/97 11:28	-0.012	0.2	0.4	0.5	0.1		duplicates averaged
	3/4/97 11:10	-0.035	0.2	1.8	0.4	0.0	9,580	
	4/8/97 10:38	-0.022	0.2	1.9	0.1	0.0	9,010	
	5/8/97 14:30	0.012	0.1	2.2	0.3	0.0	14,000	
	6/9/97 12:42	0.015	0.2	2.2	0.0	0.0	15,900	
	7/10/97 10:53	-0.005	0.3	2.0	0.4	0.0	12,600	
86-03	5/16/96 13:20	0.000	<0.045	<0.095				
depth = 1.5 m	12/10/96 11:08	-0.015	0.0	1.6	0.4	0.0		
zone = 1	1/24/97 11:20	-0.007	0.5	0.4	0.7	0.0		
	3/4/97 11:30	-0.010	0.6	0.1	1.2	0.5	10,500	
	4/8/97 10:30	-0.010	0.8	0.1	1.0	0.6	9,590	
	5/8/97 11:40	-0.007	0.6	1.1	0.6	0.0	8,100	
	6/9/97 11:52	0.007	0.2	1.2	0.3	0.0	12,700	
	7/10/97 9:58	-0.002	0.3	1.0	0.6	0.0	11,400	
86-04	5/16/96 13:27	0.000	<0.045	<0.095				
depth = 1.5 m	11/27/96 10:11	-0.005	0.0	0.4	1.3	0.0		
zone = 1	12/10/96 11:22	-0.012	0.2	0.6	1.0	0.0		
	1/24/97 11:24	-0.005	0.1	0.3	0.6	0.0		
	3/4/97 11:35	-0.012	0.4	1.0	0.6	0.0	10,300	
	4/8/97 10:34	-0.010	0.5	1.1	0.4	0.0	9,610	
	5/8/97 11:48	-0.007	0.5	0.4	0.6	0.0	8,200	
	6/9/97 11:58	0.005	0.4	1.1	0.6	0.0	13,500	duplicates averaged
	7/10/97 11:05	-0.002	0.3	1.7	0.3	0.0	13,500	
86-06	5/16/96 13:57	0.000	<0.045	<0.095				
depth = 1.5 m	12/10/96 11:35	-0.010	0.1	0.1	1.1	0.6		
zone = 1	1/24/97 11:51	-0.005	0.1	0.5	0.5	0.0		
	3/4/97 11:15	-0.012	0.2	0.1	1.5	0.6	6,335	duplicates averaged
	4/8/97 12:14	-0.007	0.2	0.0	1.2	0.2	6,220	
	5/8/97 12:52	0.005	1.3	1.3	0.5	0.0	9,400	
	6/9/97 12:19	0.005	0.0	1.5	0.2	0.0	14,900	
	7/10/97 11:00	-0.002	0.1	1.6	0.1	0.0	13,000	
94-02	5/16/96 14:29	0.000	<0.045	<0.095				
depth = 1.5 m	11/27/96 10:32	-0.002	0.0	0.5	0.8	0.0		duplicates averaged
zone = 1	12/10/96 12:08	0.020	0.1	0.6	1.2	0.0		
	1/24/97 11:36	-0.005	0.2	0.1	0.7	0.7		
	3/4/97 11:25	-0.012	0.2	0.9	1.9	0.7	10,300	
	4/8/97 12:02	-0.010	0.3	1.1	1.6	0.7	9,810	
	5/8/97 13:10	0.002	0.2	0.9	1.4	0.0	10,000	
	6/9/97 12:09	0.005	0.1	1.1	0.6	0.0	14,100	
	7/10/97 10:08	-0.005	0.7	0.5	0.4	0.2	11,500	very slow drawing a sample
94-03R	5/16/96 14:38	0.000	0.2	<0.095				duplicates averaged
depth = 1.5 m	12/10/96 11:43	-0.007	0.4	0.0	1.0	0.8		
zone = 1	1/24/97 11:40	-0.010	0.2	0.7	0.6	0.3		
	3/4/97 11:45	-0.010	0.1	2.2	1.5	0.2	6,290	
	4/8/97 12:09	-0.010	0.1	2.2	1.1	0.2	6,110	
	5/8/97 13:16	0.002	0.3	1.2	1.0	0.0	9,450	duplicates averaged
	6/9/97 12:13	0.007	0.4	0.9	0.7	0.0	13,800	
	7/10/97 10:24	-0.002	0.4	1.6	0.2	0.0	11,900	
94-05	5/16/96 15:02	0.000	<0.045	<0.095				
depth = 1.5 m	12/10/96 12:33	-0.012	0.1	0.7	0.7	0.0		duplicates averaged
zone = 1	1/24/97 12:20		0.1	1.1	0.6	0.1		
	3/4/97 10:57	-0.010	0.2	0.6	0.3	0.1	6,740	
	4/8/97 12:30	-0.010	0.2	0.7	0.2	0.1	6,650	
	5/8/97 13:22	0.007	0.6	1.8	0.8	0.0	8,400	
	6/9/97 12:26	0.012	0.3	0.9	0.4	0.0	14,400	
	7/10/97 10:40	-0.007	1.1	1.5	0.2	0.0	11,100	

216-Z-9 SITE ZONE 1

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
94-09	5/16/96 15:12	0.000	<0.045	<0.095				
depth = 1.5 m	11/27/96 10:51	-0.002	0.0	0.7	0.8	0.0		
zone = 1	12/10/96 12:11	0.000	0.2	0.1	1.3	0.3		
	1/24/97 11:58	-0.005	0.2	0.6	0.6	0.0		
	3/4/97 11:05	-0.010	1.1	2.8	0.7	0.3	9,730	
	4/8/97 10:45	-0.010	1.4	3.0	0.5	0.3	9,510	
	5/8/97 14:13	0.002	0.4	0.7	0.9	0.0	12,200	
	6/9/97 12:47	0.007	0.3	1.4	0.7	0.0	16,100	
	7/10/97 10:49	-0.007	0.7	0.8	0.6	0.0	11,800	
95-07	5/16/96 12:13	0.000	0.1	<0.095				
depth = 1.5 m	12/10/96 12:18	0.000	0.2	0.0	1.1	1.0		
zone = 1	1/24/97 12:09	-0.002	0.2	0.3	1.2	0.3		
	3/4/97 10:45	-0.012	0.1	1.3	0.6	0.0	15,000	
	4/8/97 11:03	-0.012	0.2	1.4	0.5	0.0	12,200	
	5/8/97 14:39	0.002	0.1	2.3	0.1	0.0	12,400	
	6/9/97 12:36	0.007	0.3	0.5	0.6	0.0	14,600	
	7/10/97 11:22	-0.005	0.2	1.9	0.1	0.0	14,100	
95-09	5/16/96 15:18	0.000	<0.045	<0.095				
depth = 1.5 m	11/27/96 10:58	0.002	0.0	2.0	1.3	0.0		
zone = 1	12/10/96 12:14	-0.002	0.0	8.1	1.6	0.0		
	1/24/97 12:03	-0.005	0.0	9.0	5.5	0.0		
	3/4/97 10:55	-0.012	0.0	27.1	2.8	0.0	11,400	
	4/8/97 10:52	-0.012	0.0	29.2	2.6	0.0	10,100	
	5/8/97 0:00							unable to sample; tubing broken off below ground
	6/9/97 0:00							unable to sample; tubing broken off below ground
	7/10/97 0:00							tubing broken off below ground
95-11	5/16/96 14:16	0.000	<0.045	<0.095				
depth = 1.5 m	11/27/96 10:23	-0.010	0.0	1.9	1.1	0.3		
zone = 1	12/10/96 11:45	0.000	0.1	0.6	0.8	0.0		
	1/24/97 12:28	-0.007	0.0	7.6	13.6	0.5		
	3/4/97 11:55	-0.010	0.3	1.0	1.2	0.1	11,400	
	4/8/97 11:14	-0.010	0.3	1.2	1.1	0.1	10,400	
	5/8/97 13:00	0.002	0.2	0.8	0.7	0.0	9,000	
	6/9/97 12:06	0.005	0.3	0.5	0.6	0.0	12,300	
	7/10/97 10:28	-0.002	0.3	1.2	0.5	0.0	11,700	
95-12	5/16/96 13:36	0.000	<0.045	<0.095				
depth = 1.5 m	12/10/96 11:27	-0.020	0.0	5.0	1.8	0.0		
zone = 1	1/24/97 12:25	-0.007	0.1	0.7	2.8	1.1		
	3/4/97 11:40	-0.012	0.3	7.3	14.4	0.8	7,660	
	4/8/97 11:09	-0.010	0.3	8.6	13.3	0.9	6,780	
	5/8/97 13:05	-0.002	0.5	3.8	2.4	0.0	9,200	
	6/9/97 12:02	0.007	1.1	1.2	1.1	0.6	13,900	
	7/10/97 10:32	-0.007	1.1	1.3	0.4	0.4	12,150	duplicates averaged
86-08	11/27/96 10:17	-0.005	0.0	0.8	0.4	0.0		
depth = 1.5 m	1/24/97 11:32	-0.007	0.1	0.8	0.4	0.0		
zone = 1								
95-08	11/27/96 11:14	0.007	0.0	4.1	0.9	0.0		
depth = 1.5 m	1/24/97 12:15	-0.007	0.0	8.7	13.3	0.0		
zone = 1	3/4/97 10:40	-0.010	0.1	1.9	1.1	1.2	7,310	
	4/8/97 11:08	-0.010	0.1	2.4	1.0	1.3	7,510	
	6/9/97 0:00							could not find tube
	7/10/97 0:00							tubing broken off below ground
94-04	3/4/97 10:59	-0.010	0.3	0.0	1.1	1.2	6,630	
depth = 1.5 m								
zone = 1								
95-05	1/27/97 11:18	-0.010	0.7	0.0	0.7	0.0	7,400	
depth = 1.5 m								
zone = 1								
95-06	3/4/97 10:50	-0.012	0.3	0.7	1.2	0.1	12,900	
depth = 1.5 m	4/8/97 10:58	-0.010	0.3	0.9	1.1	0.1	10,700	
zone = 1								

CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform
MEK = Methyl Ethyl Ketone
CH2Cl2 = Methylene Chloride

216-Z-9 ZONE 2

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
CPT-17/8	11/18/96 12:08	-0.017	0.2	1.9	0.4	0.0		
yellow	11/21/96 11:24	-0.002	0.6	0.5	1.9	1.1		
depth = 7.6 m	11/25/96 10:47	-0.020	0.6	0.4	1.5	1.5		
zone = 2	12/3/96 9:53	-0.040	0.4	0.4	1.2	0.6		
	12/9/96 11:42	0.015	0.9	0.0	1.1	1.0		
	12/16/96 9:58	-0.040	1.0	1.2	0.4	0.0		
	12/23/96 13:10	-0.032	0.8	1.3	0.0	0.0		
	12/31/96 12:06	0.020	1.5	0.3	0.7	1.7		
	1/2/97 10:26	-0.017	1.6	0.4	1.1	1.8		
	1/27/97 13:40	-0.010	2.6	1.0	1.0	1.8	17,700	
	2/24/97 11:22	0.010	4.2	0.2	0.6	6.7	8,860	
	4/1/97 12:16	-0.017	7.0	0.0	1.3	7.2	8,720	
	5/5/97 9:49	-0.010	6.7	0.9	0.8	5.4	10,200	
	6/5/97 11:17	0.000	5.4	0.6	0.8	5.4	10,900	
	7/7/97 14:07	0.017	4.9	1.3	1.1	2.9	13,000	
CPT-27/10	10/31/96 11:16	-0.052						
red	11/5/96 10:15	-0.012	0.4	0.4	0.4	0.0		duplicates averaged
depth = 10.1 m	11/7/96 13:54	-0.007	0.1	1.7	0.4	0.0		
zone = 2	11/12/96 11:00	-0.007	0.5	0.0	2.0	9.3		
	11/18/96 11:32	0.000	0.6	0.8	1.6	0.0		
	11/21/96 13:25	-0.010	0.1	0.5	0.5	0.0		
	11/25/96 11:19	-0.020	0.3	1.1	0.8	0.0		
	12/3/96 10:44	-0.035	0.5	1.3	0.6	0.0		
	12/9/96 12:04	0.012	0.3	1.1	0.3	0.0		
	12/16/96 10:34	-0.042	0.4	0.0	1.0	3.2		
	12/23/96 9:43	-0.082	0.6	0.0	1.0	0.0		
	1/2/97 11:00	-0.012	0.8	0.0	1.5	6.8		
	1/27/97 10:50	-0.002	0.7	0.5	0.5	1.3	8,200	
	2/24/97 12:45	0.012	0.8	0.0	1.4	4.3	8,980	
	4/1/97 11:00	-0.017	0.7	0.4	1.3	1.0	6,660	
	5/5/97 11:40	0.002	0.8	1.2	0.7	1.9	13,300	
	6/5/97 12:56	-0.005	1.1	0.0	1.1	3.7	11,900	
	7/7/97 13:23	0.015	1.2	1.1	0.8	2.3	11,200	
CPT-18/11	5/15/96 13:09	0.000	0.2	<0.095				
blue	11/18/96 11:50	-0.005	0.2	1.6	0.5	0.0		
depth = 10.7 m	11/21/96 11:34	-0.002	0.5	0.0	2.1	1.9		
zone = 2	11/25/96 10:50	-0.007	0.0	0.0	1.0	1.1		
	12/3/96 9:56	-0.032	0.3	0.4	0.8	0.5		
	12/9/96 11:45	0.005	0.4	0.8	0.7	0.0		
	12/16/96 10:00	-0.030	0.5	0.2	1.0	0.4		
	12/23/96 11:30	-0.020	0.6	1.4	0.6	0.0		flow?
	12/31/96 13:55	0.002	2.7	0.8	0.7	1.1		
	1/2/97 12:20	0.002	1.3	1.0	0.2	0.5		
	1/27/97 14:45	0.000	1.3	1.6	0.2	0.0	16,500	
	2/24/97 12:56	0.017	2.1	0.7	0.4	0.5	18,300	
	4/1/97 11:40	-0.015	1.7	0.0	1.4	2.1	7,560	
	5/5/97 10:25	-0.005	3.4	1.3	0.7	0.0	11,600	
	6/5/97 11:05	0.002	4.8	0.7	1.0	1.1	10,800	
	7/7/97 13:47	0.017	3.6	0.6	1.0	1.2	11,400	

216-Z-9 ZONE 2

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
CPT-28/12	5/15/96 14:14	0.000	99.0	0.5				
green	10/31/96 11:04	-0.065						no cap
depth = 12.2 m	11/5/96 9:50	-0.274	19.0	1.0	0.3	0.6		no cap
zone = 2	11/7/96 14:16	-0.005	23.7	1.0	0.4	0.2		
	11/11/96 15:50	0.022	27.0	0.6	0.9	0.6		
	11/15/96 13:18	0.015	26.6	2.0	0.0	0.0		
	11/21/96 11:12	0.025	24.3	0.6	1.7	1.7		
	11/25/96 10:33	-0.062	24.1	2.1	0.8	0.9		
	12/3/96 9:40	-0.102	23.7	0.8	1.3	6.1		
	12/9/96 11:28	0.065	26.7	0.4	1.0	5.8		
	12/16/96 9:47	-0.100	23.8	1.3	0.4	0.0		
	12/23/96 12:57	-0.060	24.7	0.8	0.4	0.2		
	12/31/96 11:53	-0.010	28.2	1.4	0.3	0.2		
	1/2/97 10:13	-0.027	28.5	0.0	1.6	1.9		
	1/27/97 13:27	0.050	26.4	2.2	0.3	0.0	23,000	
	2/24/97 11:07	0.025	29.5	0.0	1.0	1.6	8,920	
	4/1/97 12:01	-0.062	31.7	1.7	0.2	1.5	8,720	
	5/5/97 9:25	-0.012	33.3	2.3	0.3	0.0	9,600	
	6/5/97 10:43	0.015	37.9	1.0	0.8	1.7	10,900	
	7/7/97 14:19	0.042	40.1	2.0	0.6	1.3	13,000	
CPT-21A/14	5/15/96 14:40	0.000	21.0	0.3				
green	10/31/96 11:11	-0.127						
depth = 13.7 m	11/5/96 10:07	-0.060	4.8	1.9	0.0	0.0		
zone = 2	11/7/96 14:12	-0.017	5.3	2.0	0.5	0.6		
	11/12/96 9:30	-0.122	5.3	0.9	1.2	0.3		
	11/18/96 10:40	0.002	7.0	0.7	1.0	1.0		
	11/21/96 11:20	0.060	8.5	0.7	2.2	2.2		
	11/25/96 10:42	-0.122	6.8	0.0	1.9	3.2		
	12/3/96 9:47	-0.169	10.2	1.2	0.9	1.5		
	12/9/96 11:36	0.107	14.7	0.8	1.0	2.1		
	12/16/96 9:53	-0.184	12.0	1.2	0.3	0.8		
	12/23/96 13:02	-0.117	21.8	1.2	0.5	0.6		
	12/31/96 12:01	-0.020	27.6	1.6	0.6	2.1		
	1/2/97 10:20	-0.045	29.6	0.1	1.7	2.5		
	1/27/97 13:34	0.082	26.5	1.4	0.9	0.1	17,700	
	2/24/97 11:15	0.075	29.0	0.7	0.6	2.5	9,250	
	3/17/97 10:48	-0.177	47.5	0.3	1.4	2.9	12,700	
	4/1/97 12:08	-0.092	49.3	1.2	0.7	2.9	8,750	
	5/5/97 9:37	-0.005	54.5	1.9	1.1	2.5	9,400	
	6/5/97 10:49	0.005	65.3	0.7	1.0	3.9	10,700	
	7/7/97 14:10	0.060	65.6	1.2	1.3	3.9	13,000	
W15-220SST/16	10/31/96 11:30	-0.540						
blue	11/5/96 14:00	0.000	0.6	1.9	0.0	0.0		
depth = 15.9 m	11/8/96 10:38	0.000	0.5	1.1	0.4	0.0		
zone = 2	11/12/96 10:42	-0.022	0.6	0.0	2.0	1.7		
	11/18/96 11:39	-0.169	2.0	0.3	0.8	0.0		
	11/21/96 13:35	0.299	0.7	0.0	2.3	0.5		
	11/25/96 11:29	-0.077	0.4	0.7	1.1	0.5		
	12/3/96 10:46	-0.137	0.4	0.2	1.0	0.5		
	12/9/96 10:38	0.045	0.4	1.0	0.5	0.0		
	12/16/96 10:42	-0.159	0.4	0.8	0.8	0.0		
	12/23/96 10:30	-0.207	0.6	0.9	0.4	0.0		
	12/31/96 13:28	0.824	1.3	0.7	1.1	1.0		
	1/2/97 11:45	-0.010	1.1	0.0	1.5	6.8		
	1/27/97 13:52	0.085	1.1	1.8	0.0	0.0	14,200	
	2/24/97 12:10	0.065	1.3	0.0	0.8	1.4	8,680	
	4/1/97 10:45	-0.102	1.0	0.8	0.5	0.2	6,540	
	5/5/97 10:51	0.017	1.9	0.9	0.7	0.0	10,000	
	6/5/97 13:04	-0.017	1.2	0.1	0.9	1.7	11,500	
	7/7/97 13:29	0.045	1.5	0.7	0.9	1.4	10,800	

216-Z-9 ZONE 2

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
CPT-9A/18	5/15/96 11:40	0.000	18.0	<0.095				
blue	10/31/96 11:48	-0.015						no cap
depth = 18.3 m	11/5/96 14:17	0.000	38.9	1.1	0.5	2.0		no cap
zone = 2	11/8/96 10:53	0.007	40.2	1.1	0.6	2.1		
	11/12/96 11:10	-0.007	40.7	0.0	1.9	5.9		
	11/18/96 11:54	0.025	40.6	0.7	1.0	2.4		
	11/21/96 14:02	0.022	41.3	0.4	1.2	2.3		
	11/25/96 13:00	-0.120	42.7	0.9	1.4	3.8		duplicates averaged
	12/3/96 10:55	-0.110	42.0	0.0	1.3	5.1		
	12/9/96 12:10	0.085	42.7	0.3	0.8	3.6		
	12/16/96 10:43	-0.125	42.4	1.5	0.4	2.1		
	12/23/96 10:12	-0.157	42.4	1.5	0.1	1.7		
	1/2/97 11:30	-0.027	45.5	0.6	0.5	3.4		
	1/27/97 11:12	0.080	35.1	2.3	0.0	0.6	20,100	
	2/24/97 10:37	0.055	43.8	0.2	0.8	3.8	8,360	
	4/1/97 10:32	-0.065	45.1	1.0	0.9	3.1	6,780	
	5/5/97 12:04	0.042	42.0	0.7	0.6	3.1	14,350	duplicates averaged
	6/5/97 13:14	-0.002	42.4	0.9	0.8	3.5	11,800	
	7/7/97 14:33	0.202	44.1	1.2	1.0	3.7	12,600	
CPT-16/20	5/16/96 11:08	0.000	0.2	<0.095				
red	11/18/96 11:18	-0.192	1.7	0.0	1.2	1.7		
depth = 19.8 m	11/21/96 13:04	-0.374	0.0	0.0	0.0	8.1		
zone = 2	11/25/96 11:06	-0.050	1.0	0.4	1.6	1.6		
	12/3/96 10:25	-0.364	1.8	0.9	0.5	0.5		
	12/9/96 11:05	0.087	1.1	1.3	0.3	0.0		
	12/16/96 10:21	-0.259	1.3	1.2	0.5	0.0		reverse pump (water?)
	12/23/96 10:50	-0.274	0.4	0.3	0.5	0.4		
	1/2/97 11:15	-0.070	2.0	0.9	0.8	1.1		flow?
	1/27/97 13:48	-1.395	2.0	0.6	0.8	0.0	8,300	
	2/24/97 11:30	-1.390	2.6	0.9	1.4	1.4	8,580	water in line; low volume
	4/1/97 12:35	-0.187	1.2	1.5	0.5	0.0	14,100	
	5/5/97 11:20	-0.060	4.6	3.4	2.2	1.1	12,000	
	6/5/97 11:33	-0.015	3.1	1.4	1.9	3.5	11,200	
	7/7/97 14:30	0.080	3.0	1.3	0.9	0.7	13,300	
W15-219SST/21	10/31/96 13:23	-1.392						
yellow	11/5/96 13:45	-0.005	1.2	1.2	0.5	2.5		
depth = 21.3 m	11/7/96 14:04	-0.010	0.7	1.8	0.4	1.7		
zone = 2	11/12/96 9:57	-0.080	1.3	2.2	0.3	1.9		
	11/18/96 11:02	0.035	2.0	2.3	0.1	1.3		
	11/21/96 11:40	0.052	1.6	0.9	1.6	2.4		
	11/25/96 10:55	-0.107	1.0	1.3	1.1	2.9		
	12/3/96 10:02	-0.182	1.5	1.0	0.5	2.4		
	12/9/96 11:55	0.130	2.9	1.0	0.6	1.5		
	12/16/96 10:07	-0.194	2.3	0.2	0.7	1.9		
	12/23/96 11:23	-0.052	2.2	1.4	0.4	1.1		flow?
	12/31/96 13:50	0.012	3.8	0.4	1.0	2.3		
	1/2/97 12:10	-0.010	2.1	0.2	1.3	2.5		
	1/13/97 12:37	0.055	2.4	0.3	1.0	1.6		
	1/27/97 14:38	0.030	2.4	0.7	0.9	0.7	12,700	
	2/10/97 11:21	0.037	5.4	0.0	1.1	2.7	9,000	
	2/24/97 11:49	0.107	2.5	0.5	0.6	1.7	16,000	
	3/17/97 11:14	0.010	5.3	0.0	1.4	2.4	10,800	
	4/1/97 11:28	-0.130	3.3	0.9	0.5	1.6	9,400	
	4/2/97 9:49	0.012	3.0	0.2	0.7	1.4	5,330	
	4/17/97 10:33	-0.017	4.5	0.2	1.2	2.1	14,900	
	5/5/97 10:15	-0.007	8.0	1.2	0.7	0.9	10,200	
	5/19/97 10:59	0.169	14.6	1.7	0.5	0.0	8,470	
	6/5/97 10:59	-0.002	5.0	0.6	0.7	2.2	11,000	
	6/16/97 10:54	-0.070	4.1	1.4	0.4	1.2	11,700	
	7/7/97 13:42	0.067	6.6	0.6	0.7	1.8	10,900	

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Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W15-82	10/29/96 13:20	-13.450	28.5	1.2	0.0	0.0		flow = 1.9 m3/min (67 ft3/min)
depth = 25.3 m	11/6/96 11:55	0.130	28.9	1.3	1.0	3.6		approx. 20 ft (12 ft?) extra tubing
zone = 2	11/8/96 9:44	-0.045	21.3	0.0	14.1	303.0		
	11/12/96 10:50	-0.060	19.1	0.0	25.2	0.5		
	11/18/96 11:30	0.062	17.6	0.0	27.1	0.7		
	11/21/96 13:21	0.095	12.9	0.0	21.8	563.0		
	11/25/96 11:17	-0.249	9.8	0.0	23.2	0.5		
	12/3/96 10:38	-0.324	11.2	0.0	17.1	0.4		
	12/9/96 12:00	0.237	21.0	0.0	15.0	350.0		sample time assumed
	12/16/96 10:30	-0.386	8.1	0.0	10.4	230.0		
	12/23/96 9:48	-0.511	14.4	0.0	7.3	0.2		
	1/2/97 11:05	-0.052	16.7	0.0	14.6	285.0		
	1/2/97 14:50		16.4	0.0	9.7	262.0		
	1/3/97 12:30	N/A	15.8	0.0	4.5	88.5		sampled using small portable sample pump
	1/6/97 14:45	N/A	15.1	0.0	8.1	184.5		sampled using small portable pump; duplicates averaged
	1/7/97 11:30	-0.042	19.8	0.0	6.0	181.5		duplicates averaged
	1/13/97 11:45	0.050	19.9	0.0	9.7	213.0		
	1/27/97 10:45	-0.052	7.5	0.0	5.7	108.0	14,100	
	2/10/97 11:09	0.052	22.9	0.0	5.0	127.5	7,700	duplicates averaged
	2/24/97 12:51	0.157	9.2	0.0	9.8	190.0	14,800	
	3/11/97 11:45		24.0	0.0	11.4	249.0	14,600	
	4/1/97 11:05	-0.262	14.8	0.0	3.6	84.9	7,985	duplicates averaged
	5/5/97 11:34	0.017	11.6	0.0	10.2	195.0	11,200	
	6/5/97 12:51	-0.015	22.8	0.0	12.8	245.0	11,500	
	7/7/97 13:18	0.050	27.9	0.0	13.1	243.0	10,900	
CPT-21A/26	5/15/96 15:15	0.000	100.0	0.9				
red	10/31/96 11:09	-0.214						
depth = 26.2 m	11/5/96 13:35	-0.022	22.7	2.0	0.3	0.7		
zone = 2	11/7/96 14:14	-0.030	22.2	0.1	1.2	2.9		
	11/12/96 9:35	-0.167	25.5	0.6	1.6	2.4		
	11/18/96 10:42	0.000	35.4	2.8	0.8	0.8		
	11/21/96 11:22	0.092	38.2	1.6	1.2	2.4		
	11/25/96 10:44	-0.232	0.5	0.0	1.0	1.6		CCl4 result anomalous, excluded from analysis (note a)
	12/3/96 9:49	-0.304	49.9	1.4	1.1	2.4		
	12/9/96 11:38	0.174	59.8	0.4	1.2	3.5		
	12/16/96 9:55	-0.349	59.6	1.7	0.4	1.0		
	12/23/96 13:05	-0.237	68.7	1.7	0.1	1.1		
	12/31/96 12:03	-0.035	83.4	2.3	0.7	1.7		
	1/2/97 10:22	-0.075	87.4	1.9	0.7	2.4		
	1/7/97 11:09	-0.040	84.7	1.4	0.4	2.5		duplicates averaged
	1/13/97 11:40	0.032	86.4	1.0	0.6	2.0		
	1/27/97 13:37	0.149	91.5	2.7	0.6	0.0	20,000	
	2/10/97 10:55	0.035	98.3	1.3	0.4	2.2	7,400	
	2/24/97 11:18	0.122	106.0	0.6	0.8	3.0	9,180	
	3/11/97 11:25		139.0	1.6	0.4	2.6	14,100	High A
	3/17/97 10:52	-0.344	126.0	1.0	1.1	2.7	12,500	High A
	4/1/97 12:12	-0.174	134.0	1.3	1.0	3.4	8,660	High A
	4/17/97 10:10	-0.030	138.5	1.8	1.0	2.9	12,900	High A; duplicates averaged
	5/5/97 9:41	-0.005	157.0	2.6	0.9	2.0	9,500	High A
	5/19/97 10:42	0.259	179.3	2.8	0.6	1.1	10,800	High A calculated
	6/5/97 10:51	-0.012	201.0	1.4	0.7	3.5	10,900	High A
	6/16/97 11:12	-0.122	197.0	2.4	0.1	3.0	14,600	High A
	7/7/97 14:13	0.090	221.0	1.1	1.2	4.5	13,700	High A

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Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
CPT-28/27	5/15/96 14:33	0.000	290.0	0.9				
red	5/16/96 11:24	0.000	350.0	1.3				replicate
depth = 26.5 m	10/31/96 11:04	-0.179						no cap
zone = 2	11/5/96 13:30	-0.025	105.0	3.2	0.0	1.0		no cap?
	11/7/96 14:18	-0.020	136.8	1.8	0.9	2.2		High A calculated
	11/11/96 15:45	0.062	159.6	1.4	0.6	3.5		High A calculated
	11/15/96 13:21	0.080	168.6	3.0	0.2	0.6		High A calculated; duplicates averaged
	11/21/96 11:13	0.062	176.4	1.6	0.0	2.0		High A calculated
	11/25/96 10:35	-0.224	150.0	1.6	1.7	3.4		High A calculated
	12/3/96 9:42	-0.299	159.6	1.6	1.1	2.8		High A calculated
	12/9/96 11:30	0.167	205.2	1.3	1.0	4.3		High A calculated
	12/16/96 9:50	-0.339	148.8	2.0	0.5	1.4		High A calculated
	12/23/96 12:55	-0.224	194.4	2.2	0.2	1.7		High A calculated
	12/31/96 11:55	-0.027	192.0	1.2	1.1	2.8		High A calculated
	1/2/97 10:14	-0.040	219.6	1.2	1.3	3.0		High A calculated
	1/27/97 13:30	0.154	208.0	2.2	0.2	0.0	15,000	High A
	2/24/97 11:10	0.112	207.0	1.4	0.7	2.7	8,580	High A
	4/1/97 12:05	-0.187	189.0	2.8	0.0	2.1	8,740	High A
	5/5/97 9:30	-0.017	249.0	2.7	0.3	1.0	9,750	High A
	6/5/97 10:45	-0.005	277.0	2.3	0.5	2.9	10,800	High A
	7/7/97 14:21	0.097	280.0	2.9	0.3	2.6	12,100	High A
CPT-9A/28	5/15/96 11:25	-0.025	70.0	0.092j				
red	10/31/96 11:49	-0.062						no cap
depth = 27.7 m	11/5/96 14:15	-0.100	87.0	2.0	0.3	4.2		no cap
zone = 2	11/8/96 10:56	0.000	92.9	0.1	1.4	5.4		
	11/12/96 11:15	-0.032	90.4	0.4	1.4	6.4		
	11/18/96 11:52	0.070	93.4	2.6	0.4	4.5		
	11/21/96 14:03	0.097	80.2	1.1	0.8	5.4		
	11/25/96 11:34	-0.184	99.1	0.3	1.5	6.2		
	12/3/96 10:57	-0.301	96.4	1.4	0.8	5.0		
	12/9/96 12:16	0.209	84.5	0.0	1.8	6.7		tight
	12/16/96 10:45	-0.339	94.1	1.3	0.6	4.5		duplicates averaged
	12/23/96 10:14	-0.249	57.5	0.7	0.6	2.9		
	1/2/97 11:35	-0.045	103.0	0.5	1.1	5.6		
	1/27/97 11:15	0.030	40.5	1.7	0.4	1.0	22,800	
	2/24/97 10:40	0.025	36.5	0.8	0.4	2.2	7,360	duplicates averaged
	4/1/97 10:35	-0.197	101.0	1.1	1.8	6.1	6,620	
	5/5/97 12:13	0.080	67.7	1.6	1.1	3.7	15,500	
	6/5/97 13:16	0.002	75.5	0.0	1.1	6.2	12,000	
	7/7/97 14:35	0.040	34.6	1.3	0.8	2.3	13,400	
Barometric Pump	10/29/96 10:30	-8.717	12.0	0.0	0.0	0.0		flow = 5.7 m3/min (202 ft3/min)
W15-216U	11/15/96 10:43	N/A	10.9	0.0	0.0	0.0		
depth = 22.9 m	12/18/96 13:38	0.187	7.9	2.0	0.0	0.0		
zone = 2	12/26/96 10:40	0.294	11.1	0.7	0.6	0.1		
	1/10/97 11:30	0.130	11.5	0.0	1.3	1.3		
	2/25/97 14:56	0.301	11.3	0.3	0.7	0.3	12,300	
	4/3/97 10:10	0.271	18.9	1.2	0.1	0.0	18,200	
	4/30/97 12:18	0.125	15.4	1.4	0.9	0.9	14,900	
	6/17/97 10:29	0.030	15.4	1.2	0.9	1.5	15,100	

(a) analytical result initially recorded [which was similar in magnitude to other results] was crossed out
CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform
MEK = Methyl Ethyl Ketone
CH2Cl2 = Methylene Chloride

216-Z-9 SITE ZONE 3

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W15-218U	10/29/96 14:00	-6.974	15.6	0.0	0.0	2.5		flow = 2.9 m3/min (103 ft3/min)
depth = 32.9 m	11/6/96 14:05	0.217	39.8	3.1	0.3	2.2		
zone = 3	11/8/96 10:23	-0.057	18.0	2.4	0.4	2.3		
	11/12/96 10:10	-0.269	19.0	0.6	1.4	4.1		
	11/18/96 11:06	0.055	17.4	0.4	1.5	3.8		
	11/21/96 12:59	-0.015	19.7	0.0	1.4	5.2		
	11/25/96 11:03	-0.720	19.5	1.7	3.5	3.9		
	12/3/96 10:17	-0.590	18.2	0.4	1.5	3.7		packer < 10 psi
	12/9/96 12:00	0.403	18.6	0.5	1.3	3.8		sample time assumed
	12/16/96 10:15	-0.879	23.2	1.6	0.7	1.3		packer = 10 psi
	12/23/96 11:10	-0.934	14.9	1.5	0.6	1.0		
	12/31/96 13:40	0.169	12.4	8.9	4.8	2.7		
	1/2/97 12:00	-0.122	18.1	0.1	1.5	3.0		
	1/27/97 14:15	-0.476	27.8	1.9	1.3	1.2	16,500	
	2/24/97 13:15	0.037	41.4	1.0	0.6	1.0	17,500	
	4/1/97 11:14	-0.912	27.4	0.0	1.5	4.0	7,790	
	5/5/97 10:37	-0.082	33.6	2.4	1.8	3.4	10,500	
	6/5/97 11:25	-0.232	30.2	2.3	1.4	4.0	11,000	duplicates averaged
	7/7/97 13:36	-0.095	32.2	1.0	1.3	3.9	11,600	
W15-217	10/29/96 14:52	-16.937	71.7	0.0	0.0	2.6		flow = 7.9 m3/min (278 ft3/min)
depth = 35.1 m	11/6/96 13:30	0.219	91.7	1.6	1.3	3.5		
zone = 3	11/8/96 9:34	-0.065	0.6	0.3	1.4	1.3		
	11/12/96 9:40	-0.179	190.8	2.2	1.5	3.9		High A calculated
	11/18/96 10:55	0.025	265.2	16.0	11.9	0.0		High A calculated
	11/21/96 11:00	0.012	93.6	2.2	0.5	2.1		
	11/21/96 14:14	0.112	99.4	1.7	1.3	4.1		
	11/22/96 9:55	-0.174	204.0	3.5	0.8	2.8		High A calculated
	11/22/96 13:23	-0.227	220.8	2.7	0.2	2.9		High A calculated
	11/25/96 10:19	-0.394	75.6	1.9	2.0	2.1		
	11/25/96 13:45	-0.279	63.1	1.4	1.2	2.3		
	11/26/96 10:50	-0.174	51.6	1.6	1.6	2.4		
	12/3/96 9:26	-0.416	270.0	4.6	0.3	2.0		High A calculated
	12/3/96 14:00	-0.274	207.6	3.2	0.7	1.9		High A calculated
	12/4/96 9:32	0.538	136.8	1.9	0.8	2.2		High A calculated
	12/4/96 13:31	0.976	208.8	3.1	0.0	1.9		High A calculated
	12/9/96 10:19	0.217	321.6	2.6	1.0	4.1		High A calculated
	12/13/96 10:17	-0.466	156.0	3.0	0.5	1.1		High A calculated
	12/13/96 13:05	-0.473	156.0	2.7	0.1	0.7		High A calculated
	12/16/96 9:38	-0.536	151.2	2.8	0.1	1.4		High A calculated
	12/16/96 13:18	-0.341	84.4	2.0	0.3	1.7		
	12/18/96 11:21	0.227	145.2	1.8	0.5	1.9		High A calculated
	12/19/96 10:45	0.157	214.8	2.3	0.8	2.0		High A calculated
	12/19/96 14:03	0.456	224.4	2.3	0.5	1.9		High A calculated
	12/23/96 9:30	-0.598	238.8	3.1	0.4	1.7		High A calculated
	12/23/96 13:25	-0.413	177.6	1.9	0.6	2.6		High A calculated
	12/26/96 9:55	0.443	246.0	4.8	0.3	1.3		High A calculated
	12/27/96 9:58	0.222	350.4	3.1	0.4	2.6		High A calculated
	12/27/96 13:45	-0.062	372.0	3.8	0.0	2.0		High A calculated
	12/31/96 12:10	0.082	410.4	3.2	0.1	3.1		High A calculated
	1/2/97 12:30	-0.045	433.2	3.4	0.3	3.7		High A calculated; duplicates averaged
	1/2/97 15:11	-0.097	414.0	3.2	0.0	3.6		High A calculated
	1/3/97 12:50	-0.595	250.8	1.9	0.7	3.3		High A calculated; duplicates averaged
	1/6/97 14:30	0.244	134.4	1.0	0.8	3.1		High A calculated
	1/7/97 11:15	-0.077	272.4	1.6	0.7	3.9		High A calculated
	1/10/97 11:00	0.164	328.8	3.8	0.3	2.4		High A calculated
	1/13/97 12:45	0.072	245.0	2.2	0.3	3.0		High A
	1/27/97 10:28	-0.563	69.3	2.4	0.2	1.0	8,250	duplicates averaged
	1/27/97 14:48	-0.027	94.5	2.4	0.0	1.1	10,600	
	1/29/97 10:15	-0.436	179.0	3.1	0.5	1.0	19,800	High A
	1/29/97 15:15	0.045	186.0	0.9	1.0	2.6	9,800	High A
	2/10/97 11:37	0.122	455.5	4.3	0.2	4.4	7,700	High A; duplicates averaged
	2/24/97 13:03	0.187	169.0	2.2	0.5	2.7	16,400	High A

216-Z-9 SITE ZONE 3

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W15-217	2/26/97 12:20	0.765	532.0	5.1	0.0	3.5	12,100	High A
depth = 35.1 m	2/27/97 13:10	0.087	624.0	6.7	0.0	2.0	9,880	High A
zone = 3	3/3/97 10:45	-0.276	317.5	3.0	0.2	3.2	9,700	High A; duplicates averaged
(continued)	3/11/97 11:35		502.0	5.9	0.0	3.0	14,100	High A
	3/17/97 11:25	-0.513	374.0	4.4	0.3	3.1	10,800	High A
	4/1/97 11:44	-0.394	240.5	1.7	0.7	2.5	8,220	High A; duplicates averaged
	4/2/97 10:05	-0.100	229.0	1.8	0.5	2.1	5,930	High A
	4/3/97 9:55	0.705	421.5	4.6	0.0	1.2	14,150	High A; duplicates averaged
	4/17/97 10:50	-0.085	533.0	3.6	0.7	4.2	16,150	High A; duplicates averaged
	5/5/97 9:57	-0.040	338.0	4.2	0.3	2.2	10,700	High A
	5/6/97 13:15	-0.075	544.0	5.1	0.1	4.5	10,900	High A
	5/19/97 11:08	0.413	666.5	9.6	0.0	1.6	11,350	High A; duplicates averaged
	6/5/97 11:08	-0.065	483.0	3.8	0.2	5.6	10,900	High A
	6/16/97 11:00	-0.204	797.0	7.7	0.0	6.0	12,150	High A; duplicates averaged
	6/19/97 7:35	-0.234	156.5	3.7	0.3	0.7	13,000	High A; duplicates averaged
	6/19/97 12:55	0.125	132.0	2.8	0.1	2.2	26,100	High A
	6/20/97 8:38	0.005	300.0	2.5	0.3	2.9	10,900	High A
	6/20/97 12:40	0.147	290.0	5.5	0.0	0.0	14,600	High A
	6/23/97 10:39	-0.137	283.0	5.6	2.8	1.7	12,700	High A
	6/23/97 14:51	-0.067	213.5	2.8	0.5	3.1	14,100	High A; duplicates averaged
	6/24/97 9:29		167.0	3.1	0.0	1.0	9,840	High A
	6/25/97 13:15	0.294	388.0	5.0	0.0	1.7	11,800	High A
	6/26/97 10:16	-0.122	516.0	5.7	0.0	1.5	10,350	High A; duplicates averaged
	6/30/97 15:28	0.057	741.0	8.2	0.0	2.6	13,900	High A
	7/1/97 16:35	0.002	218.0	3.6	0.0	0.7	17,650	High A; duplicates averaged
	7/2/97 16:25	0.062	238.5	3.1	0.0	1.4	17,650	High A; duplicates averaged
	7/7/97 9:29	-0.115	297.0	3.0	0.0	2.5	12,900	High A
	7/7/97 13:49	0.075	298.0	1.9	0.8	5.5	11,300	High A
CPT-24/36	5/15/96 12:17	-0.050	1.9	<0.095				duplicates averaged
red	10/31/96 13:12	-0.697						climbing
depth = 36.0 m	10/31/96 13:13	-0.847						
zone = 3	11/5/96 10:37	-0.047	27.1	5.2	1.9	1.7		
	11/8/96 11:03	-0.012	26.2	2.8	0.1	0.0		
	11/12/96 10:05	-0.187	27.6	0.7	1.3	2.0		
	11/18/96 11:10	0.032	30.5	0.7	1.7	6.4		duplicates averaged
	11/21/96 11:43	0.125	31.0	1.6	1.0	1.8		
	11/25/96 11:00	-0.299	24.2	2.7	1.8	2.1		
	12/3/96 10:12	-0.461	33.8	1.8	1.1	1.2		
	12/9/96 11:58	0.262	32.8	0.3	1.3	1.8		
	12/16/96 10:11	-0.533	31.7	1.5	0.7	0.6		
	12/23/96 11:15	-0.563	28.7	1.9	0.4	0.0		
	12/31/96 13:45	0.090	39.4	4.9	2.7	2.3		
	1/2/97 12:05	-0.065	35.1	1.2	0.9	1.1		
	1/27/97 13:44	0.192	33.0	1.8	2.1	0.7	14,000	
	2/24/97 11:26	0.174	34.0	0.0	1.4	1.7	10,200	
	4/1/97 12:28	-0.269	37.1	19.6	7.2	3.1	9,270	
	5/5/97 10:30	0.000	41.8	4.5	2.7	1.7	10,100	
	6/5/97 11:22	-0.025	42.7	2.0	1.4	1.8	11,200	
	7/7/97 14:25	0.132	44.6	1.9	1.3	1.4	13,300	
Barometric Pump	10/29/96 13:36	-10.710	8.1	0.0	1.1	1.1		flow = 1.3 m3/min (47 ft3/min)
W15-9U	11/15/96 10:54	N/A	49.7	1.4	0.0	2.6		
depth = 31.1 m	12/18/96 11:32	0.207	0.7	0.6	0.4	0.0		
zone = 2-3	12/26/96 10:15	0.458	53.5	1.9	0.0	1.1		
	1/10/97 11:42	0.189	61.8	2.6	0.8	2.3		
	2/25/97 14:43	0.491	49.9	8.2	0.0	0.0	13,400	
	4/3/97 10:18	N/A	50.4	2.5	0.5	0.0	18,600	
	4/30/97 12:28	0.179	76.4	8.4	1.0	0.0	15,500	
	6/17/97 10:21	0.110	95.2	1.3	0.9	3.3	13,150	duplicates averaged

216-Z-9 SITE ZONE 3

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W15-223	10/29/96 14:06	-8.967	10.0	2.7	0.0	0.0		flow = 3.9 m3/min (137 ft3/min)
depth = 32.9 m	11/15/96 11:01	N/A	16.6	0.8	0.8	3.2		
zone = 3	12/18/96 11:28	0.139	21.5	0.4	0.7	2.6		
	12/26/96 10:00	0.239	18.4	0.4	0.6	2.4		
	1/6/97 16:14	N/A	26.2	0.4	0.3	2.8		
	1/7/97 16:03	N/A	0.0	1.4	0.2	-0.9		
	1/8/97 16:13	N/A	14.5	1.9	-0.5	-0.5		
	1/9/97 16:12	0.037	23.0	1.0	-0.1	1.0		
	1/10/97 11:10	0.125	27.8	0.4	0.9	2.9		duplicates averaged
	1/13/97 16:15	0.045	28.1	1.4	-0.3	2.6		
	1/14/97 16:06	-0.005	20.7	-0.1	0.6	2.3		
	1/15/97 16:06	-0.070	0.4	1.1	-0.1	0.0		
	1/16/97 16:09	0.015	1.9	-0.3	0.6	1.5		
	1/17/97 16:05	0.037	23.2	-0.9	0.9	3.2		
	1/21/97 16:13	0.025	27.9	0.6	0.3	2.2		
	1/23/97 16:10	-0.130	0.1	0.9	-0.1	-1.0		
	1/24/97 16:00	-0.022	0.1	1.2	-0.2	-0.9		
	1/27/97 16:29	0.107	24.6	1.0	0.8	2.0	11,500	
	1/28/97 16:09	-0.142	0.0	1.1	0.3	-0.8	10,600	
	2/3/97 16:12	-0.027	0.2	1.2	-0.2	-1.5	8,800	
	2/4/97 16:15	0.007	0.3	0.3	0.2	-0.5	9,570	
	2/5/97 16:06	-0.010	0.3	0.8	0.1	-0.9	8,710	
	2/6/97 16:18	0.055	24.4	2.0	-0.8	0.5	7,480	
	2/10/97 10:03	0.037	26.8	0.0	0.5	2.7	7,130	
	2/11/97 14:00	0.399	30.9	0.6	0.1	2.3	7,860	
	2/13/97 16:09	0.000	31.2	2.6	-0.6	0.3	13,800	
	2/18/97 16:13	0.115	30.9	1.1	-0.4	1.4	11,800	
	2/19/97 16:16	-0.244	0.1	0.2	0.3	-0.8	11,600	
	2/21/97 16:04	0.015	4.7	0.5	0.0	-0.6	12,000	
	2/25/97 14:35	0.286	0.8	0.0	0.6	0.2	11,700	
	2/26/97 14:40	0.316	6.3	0.4	0.2	0.1	13,400	
	2/27/97 13:02	-0.032	14.5	0.2	0.6	1.1	9,410	
	2/28/97 16:03	0.015	11.6	0.3	0.3	0.4	11,600	
	3/3/97 10:50	-0.144	7.3	0.0	0.7	0.4	9,680	
	3/4/97 11:48	-0.120	8.1	0.3	0.4	0.6	8,590	
	4/2/97 14:02	0.212	4.1	0.9	0.1	0.0	23,100	duplicates averaged
	4/3/97 10:00	0.428	7.1	0.6	0.2	0.0	19,400	
	4/17/97 10:20	-0.002	15.4	0.5	0.2	1.9	12,300	
	4/30/97 12:13	0.139	3.8	1.3	0.4	0.2	14,200	
	6/17/97 10:14	0.097	7.0	1.0	1.0	1.7	14,500	

CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform
MEK = Methyl Ethyl Ketone
CH2Cl2 = Methylene Chloride

216-Z-9 SITE ZONE 4

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W15-220SST/36 red depth = 36.0 m zone = 4	10/31/96 11:31	-0.755						
	11/5/96 13:55	-0.339	8.8	0.9	0.6	0.1		
	11/8/96 10:36	-0.130	13.2	0.5	1.1	0.7		
	11/12/96 10:40	-0.242	16.1	0.8	1.0	0.9		
	11/18/96 11:38	0.082	18.5	1.0	1.2	0.9		
	11/21/96 13:37	-0.710	13.4	0.9	1.1	8.9		
	11/25/96 11:31	-0.795	5.5	1.3	1.8	1.1		
	12/3/96 10:47	-0.658	8.6	1.0	0.7	0.9		
	12/9/96 10:40	0.366	19.4	0.0	1.2	1.2		
	12/16/96 10:38	-0.966	5.2	0.4	0.9	1.0		
	12/23/96 10:33	-1.001	8.3	1.4	0.3	0.0		
	12/31/96 13:30	0.199	21.9	0.5	0.4	1.1		
	1/2/97 11:48	-0.020	0.8	0.1	1.1	2.0		
	1/27/97 13:55	-0.548	3.3	0.2	1.3	0.0	10,600	
	2/24/97 12:14	-0.100	14.0	0.0	1.1	1.0	8,680	
	4/1/97 10:49	-1.029	6.9	0.3	1.1	0.9	6,800	
	5/5/97 10:57	-0.070	16.9	1.3	0.6	0.2	9,900	
	6/5/97 13:07	-0.254	21.3	1.6	0.6	0.8	11,700	
	7/7/97 13:31	-0.134	19.3	2.3	1.2	0.4	10,600	
W15-86 depth = 36.9 m zone = 3-4	10/29/96 14:49	-16.190	41.8	1.2	0.0	1.7		flow = 8.0 m3/min (284 ft3/min)
	11/6/96 13:44	0.443	30.9	5.3	4.3	3.2		
	11/8/96 10:14	-0.149	80.8	3.5	3.3	6.7		
	11/12/96 9:50	-0.306	54.6	0.0	2.5	13.1		
	11/18/96 10:50	0.042	49.6	3.0	4.5	16.9		
	11/21/96 11:28	-0.149	69.9	2.1	2.3	6.3		
	11/25/96 10:24	-0.832	103.0	3.6	3.1	3.9		
	12/3/96 9:24	-0.598	57.7	1.7	0.9	7.5		
	12/9/96 10:17	0.366	59.0	1.3	0.4	7.4		
	12/16/96 9:35	-0.966	107.0	1.9	1.0	5.0		
	12/23/96 13:20	-0.986	91.4	0.6	0.7	4.5		duplicates averaged
	12/31/96 12:25	0.097	83.7	0.2	1.6	12.9		
	1/2/97 12:25	-0.120	94.5	0.8	1.3	10.1		duplicates averaged
	1/3/97 12:58	N/A	96.6	1.0	0.3	6.1		sampled using small portable sample pump
	1/6/97 14:28	0.162	144.0	1.7	0.6	7.2		High A calculated
	1/7/97 11:18	-0.112	140.4	0.0	1.9	22.3		High A calculated
	1/13/97 12:48	0.057	157.0	0.8	1.2	20.1		High A
	1/27/97 10:32	-0.971	151.0	1.5	0.9	5.0	8,800	High A
	2/10/97 11:32	0.157	144.0	0.0	0.9	15.1	7,400	High A; duplicates averaged
	2/24/97 13:07	-0.005	163.0	1.9	0.6	4.0	16,500	High A
	3/11/97 11:55		143.0	0.9	1.1	40.3	13,700	High A
	3/17/97 11:29	-0.966	172.0	2.1	0.6	6.3	11,100	High A
	4/1/97 11:56	-1.029	184.0	1.5	0.8	6.2	8,680	High A
	4/17/97 10:45	-0.299	269.0	1.6	0.8	7.6	17,250	High A; duplicates averaged
	5/5/97 10:03	0.000	5.1	1.5	0.4	0.0	10,900	CCl4 result anomalous, excluded from analysis
	5/19/97 11:12	0.760	209.0	2.3	1.1	12.1	10,400	High A
	6/5/97 11:12	-0.276	275.0	0.6	1.0	8.6	11,000	High A
	6/16/97 11:04	-0.351	278.0	1.4	0.9	12.0	13,400	High A
	7/7/97 13:57	-0.077	284.5	0.8	1.2	9.3	12,850	High A; duplicates averaged

216-Z-9 SITE ZONE 4

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W15-219SST/40	10/31/96 13:21	-0.705						
blue	11/5/96 13:48	-0.344	14.5	1.1	0.5	0.9		
depth = 39.6 m	11/7/96 14:07	-0.675	15.4	0.2	1.0	3.5		
zone = 4	11/12/96 9:55	-0.296	30.9	2.2	0.2	1.2		
	11/18/96 11:03	0.062	52.9	1.5	0.6	0.7		
	11/21/96 11:38	-0.125	49.4	0.6	1.8	2.0		
	11/25/96 10:57	-0.814	37.7	1.0	0.9	1.5		
	12/3/96 10:01	-0.640	63.6	0.3	1.3	2.0		
	12/9/96 11:51	0.486	153.6	0.7	1.0	2.0		High A calculated
	12/16/96 10:05	-0.966	63.0	1.2	0.5	1.5		
	12/23/96 11:25	-0.954	102.0	1.8	0.5	0.0		
	12/31/96 13:52	0.015	244.8	1.9	0.2	2.1		High A calculated
	1/2/97 12:14	-0.144	258.0	0.8	1.0	3.0		High A calculated
	1/2/97 15:07	-0.174	254.4	2.1	0.0	2.4		High A calculated
	1/3/97 12:45	-1.059	196.8	0.5	0.9	2.5		High A calculated
	1/6/97 14:35	0.169	208.8	1.1	0.4	2.7		High A calculated
	1/13/97 12:39	0.055	233.0	1.5	0.5	1.7		High A
	1/27/97 14:41	-0.578	162.1	1.7	0.4	0.1	13,200	High A calculated
	2/10/97 11:24	0.132	244.0	1.5	0.6	2.5	9,300	High A
	2/24/97 11:52	-0.025	212.0	1.2	0.7	2.1	15,200	High A
	3/17/97 11:18	-0.974	212.0	2.7	0.0	2.2	12,700	High A
	4/1/97 11:32	-1.026	182.0	0.8	0.8	2.3	9,680	High A
	4/2/97 9:54	-0.630	141.0	1.5	0.4	1.3	5,040	High A
	4/17/97 10:37	-0.314	298.0	2.1	0.5	2.1	15,500	High A
	5/5/97 10:18	-0.102	64.4	1.0	0.8	0.5	9,750	
	5/19/97 11:03	0.727	246.0	1.9	0.2	1.3	8,200	High A
	6/5/97 11:01	-0.296	218.0	2.0	0.2	2.1	10,800	High A
	6/16/97 10:57	-0.346	295.0	2.0	0.0	2.2	12,100	High A
	7/7/97 13:40	-0.090	218.0	1.1	0.9	2.7	10,500	High A

CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform
MEK = Methyl Ethyl Ketone
CH2Cl2 = Methylene Chloride

216-Z-9 SITE ZONE 5

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W15-219SST/47	10/31/96 13:24	-0.722						
red	11/5/96 10:46	-0.456	9.3	0.9	0.9	0.4		
depth = 47.2 m	11/7/96 14:02	-0.682	2.8	1.2	0.9	1.1		
zone = 5	11/12/96 9:59	-0.299	20.5	0.8	0.8	1.7		
	11/18/96 11:00	0.032	31.1	1.8	0.8	2.7		
	11/21/96 11:41	-0.130	2.8	0.3	1.6	1.2		
	11/25/96 10:54	-0.832	0.6	1.2	0.7	0.4		
	12/3/96 10:04	-0.635	12.0	0.2	1.2	2.5		
	12/9/96 11:53	0.491	30.7	0.8	0.9	2.7		
	12/16/96 10:09	-0.969	5.7	1.1	0.5	0.0		
	12/23/96 11:20	-0.991	11.5	0.1	1.1	0.6		
	12/31/96 13:48	-0.010	0.6	0.5	0.9	0.5		
	1/2/97 12:08	-0.154	32.2	0.7	1.2	3.1		
	1/13/97 12:35	0.037	14.3	1.1	0.4	0.6		
	1/27/97 14:35	-0.085	1.1	0.0	1.1	0.0	10,500	
	2/10/97 11:18	0.115	39.6	1.5	0.7	1.5	8,700	
	2/24/97 11:47	-0.062	1.5	0.7	0.4	0.0	16,800	
	3/17/97 11:10	-0.976	28.6	0.2	1.2	2.1	10,700	
	4/1/97 11:25	-1.051	2.1	3.7	0.0	0.0	8,420	breached bag?
	4/2/97 9:45	-0.643	0.2	0.0	0.6	0.9	5,350	slow fill
	4/17/97 10:30	-0.319	36.8	0.6	1.0	2.1	14,500	
	5/5/97 10:11	-0.117	14.2	1.8	0.2	0.0	10,000	
	5/19/97 10:55	0.725	59.6	1.3	0.6	1.4	8,480	
	6/5/97 10:57	-0.301	30.0	1.5	0.6	1.2	10,700	
	6/16/97 10:52	-0.264	40.2	1.2	0.3	1.6	11,700	
	7/7/97 13:44	-0.110	38.6	2.0	0.5	1.1	11,000	
W15-220SST/56	10/31/96 11:32	-0.872						
yellow	11/5/96 13:57	-0.336	8.3	1.7	0.4	0.0		
depth = 56.4 m	11/8/96 10:45	-0.110	9.5	0.2	0.8	0.4		
zone = 5	11/12/96 10:44	-0.249	12.4	1.2	1.0	0.7		
	11/18/96 11:40	0.095	13.5	0.3	1.8	0.5		
	11/21/96 13:38	0.100	9.5	0.0	1.3	1.3		
	11/25/96 11:28	-0.795	4.1	1.0	1.2	2.3		
	12/3/96 10:48	-0.665	6.8	0.7	0.9	0.6		
	12/9/96 10:43	0.399	14.4	0.4	1.0	1.0		
	12/16/96 10:40	-0.991	4.2	1.3	0.4	0.2		
	12/23/96 10:35	-1.051	7.1	0.0	1.1	0.6		
	12/31/96 13:33	0.498	14.5	1.3	0.4	1.3		
	1/2/97 11:51	-0.147	11.9	0.3	1.4	2.0		
	1/27/97 13:58	-0.545	6.9	1.6	0.0	0.0	10,100	
	2/24/97 12:18	-0.127	9.6	0.0	0.8	1.3	8,430	
	4/1/97 10:53	-1.024	5.9	0.6	1.0	1.5	7,220	
	5/5/97 11:05	-0.080	9.1	1.6	0.8	0.8	9,700	
	6/5/97 13:10	-0.254	9.1	1.8	1.1	0.8	11,600	
	7/7/97 13:33	-0.130	13.3	1.4	1.5	2.1	10,600	
Barometric Pump	10/29/96 13:27	-11.208	12.1	1.2	0.0	0.0		flow = 3.2 m3/min (112 ft3/min)
W15-220L	6/17/97 10:38	0.167	17.7	0.9	0.9	1.8	14,500	
depth = 49.7 m								
zone = 5								
W15-219L	10/29/96 14:33	-13.948	12.8	0.0	0.0	2.9		flow = 2.6 m3/min (91 ft3/min)
depth = 53.3 m	6/17/97 10:50	0.144	41.1	0.9	1.0	3.2	15,400	
zone = 5								

216-Z-9 SITE ZONE 5

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W15-216L	10/29/96 10:28	-14.446	11.3	0.0	0.0	0.0		flow = 1.4 m3/min (50 ft3/min
depth = 54.9 m	11/15/96 10:30	N/A	16.7	0.3	0.6	0.7		
zone = 5	12/5/96 11:35	N/A	14.5	1.9	0.2	0.0		
	12/18/96 13:35	0.177	9.6	0.0	0.9	0.9		
	12/26/96 10:35	0.369	7.9	0.0	1.3	1.2		
	1/10/97 11:34	0.130	10.0	1.0	1.4	1.0		
	2/25/97 14:52	0.309	12.9	0.4	0.5	0.5	13,300	
	4/3/97 10:12	0.411	14.6	1.5	0.0	0.0	19,300	duplicates averaged
	4/30/97 12:23	0.120	14.8	3.3	1.3	0.3	14,400	
	6/17/97 10:26	0.007	14.0	3.2	2.2	2.5	14,600	

CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform
MEK = Methyl Ethyl Ketone
CH2Cl2 = Methylene Chloride

216-Z-9 SITE ZONE 6

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W15-9L	10/29/96 13:34	-9.963	9.7	0.0	0.0	0.0		flow = 2.0 m3/min (71 ft3/min)
depth = 57.6 m	11/6/96 14:20	0.498	14.7	3.6	1.1	0.7		approx. 20 ft extra tubing
zone = 5	11/8/96 9:38	-0.144	5.4	16.6	18.7	0.0		
2 m above zone 6	11/12/96 10:30	-0.257	11.9	1.5	1.7	1.4		duplicates averaged
	11/18/96 11:25	0.067	10.0	17.6	13.7	0.0		
	11/21/96 11:08	-0.169	11.3	3.7	2.5	0.0		
	11/21/96 14:10	-0.012	12.0	0.2	1.7	3.8		
	11/22/96 10:09	-0.075	13.0	2.1	1.3	1.4		
	11/22/96 13:27	-0.252	12.9	0.8	1.3	1.6		
	11/25/96 10:25	-0.822	7.9	5.8	3.8	0.0		
	11/25/96 13:48	-0.790	8.4	1.4	1.2	0.7		
	11/26/96 10:53	-0.682	6.2	3.4	1.8	0.0		
	12/3/96 9:31	-0.608	10.7	2.0	1.5	0.4		
	12/3/96 14:05	-0.640	10.4	2.0	0.2	0.0		
	12/4/96 9:38	0.570	9.7	1.5	1.2	1.1		
	12/4/96 13:34	1.427	11.5	1.2	0.5	0.6		
	12/9/96 10:25	0.364	13.7	0.4	0.9	2.6		
	12/13/96 10:18	-0.633	9.2	2.3	0.3	0.0		
	12/13/96 13:03	-0.797	9.0	2.2	0.0	0.0		
	12/16/96 9:42	-0.951	7.3	1.6	0.5	0.0		
	12/16/96 13:24	-0.937	6.5	1.3	0.5	0.0		
	12/18/96 11:24	0.294	8.2	1.6	1.2	0.8		
	12/19/96 10:50	0.386	10.2	1.5	0.2	2.3		
	12/19/96 14:06	0.787	9.0	0.7	0.5	2.2		
	12/23/96 9:35	-0.956	10.1	1.6	0.2	0.2		
	12/23/96 13:15	-0.966	8.2	0.5	0.8	1.1		
	12/26/96 10:10	1.029	9.0	3.9	2.6	2.0		
	12/27/96 10:02	1.064	11.0	1.5	0.0	1.8		
	12/27/96 13:40	0.670	11.0	0.8	0.2	2.2		
	12/31/96 13:24	0.162	10.6	0.7	1.2	2.7		
	1/2/97 10:30	-0.199	10.5	1.4	1.1	1.4		
	1/2/97 15:00	-0.182	10.2	1.7	0.2	0.3		
	1/3/97 12:40	-1.024	9.2	0.9	0.7	0.9		
	1/6/97 14:40	0.169	5.4	0.0	0.8	4.8		
	1/7/97 11:22	-0.112	7.2	0.0	0.7	1.9		
	1/13/97 11:51	-0.017	6.8	0.3	0.8	2.1		
	1/27/97 10:40	-0.956	5.1	1.4	0.6	0.0	7,800	
	1/27/97 14:06	-0.553	3.9	2.2	0.0	0.0	13,100	
	1/29/97 10:06	-0.130	3.2	0.0	1.3	1.1	6,700	
	1/29/97 15:10	0.002	2.7	2.4	0.0	0.0	15,600	
	2/10/97 11:04	0.110	11.6	0.0	1.0	3.2	8,100	
	2/24/97 11:43	-0.134	2.8	0.0	1.4	1.4	9,970	
	2/26/97 12:15	1.614	14.3	1.5	0.0	0.0	12,400	
	2/27/97 13:06	0.578	12.9	0.9	0.0	1.3	9,170	
	3/3/97 10:55	-0.154	11.3	1.4	0.0	0.0	13,000	
	3/17/97 11:00	-0.959	13.0	0.8	0.6	1.0	11,500	
	4/1/97 11:20	-1.024	6.8	1.1	0.5	0.4	12,100	
	4/17/97 10:25	-0.677	11.5	0.5	1.3	1.2	13,400	
	5/5/97 11:25	-0.057	6.0	10.2	6.6	6.6	11,900	
	5/6/97 13:08	-0.142	18.3	1.2	0.6	1.4	11,100	
	5/19/97 10:50	0.715	18.1	2.2	0.8	0.5	9,090	
	6/5/97 12:47	-0.247	11.6	2.2	0.7	1.6	11,500	
	6/16/97 10:47	-0.344	14.7	1.4	0.8	1.7	12,300	
	7/7/97 13:08	-0.164	11.4	2.0	2.0	3.5	10,600	

216-Z-9 SITE ZONE 6

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W15-6L	10/29/96 13:52	-8.717	14.2	0.0	0.0	2.0		flow = 2.5 m3/min (89 ft3/min)
depth = 57.6 m	11/6/96 12:15	0.062	1.4	2.2	2.6	1.4		very tight; CCl4 result not representative, excluded
zone = 5-6	11/8/96 13:14	0.120	0.5	26.3	23.2	0.0		1 L purge, very tight; CCl4 result not representative, excluded
	11/11/96 0:00							too tight; CCl4 result not representative, excluded
	11/12/96 10:25	0.060	0.0	5.3	4.7	1.0		CCl4 result not representative, excluded from analysis
	11/14/96 11:10	0.326	15.5	2.2	0.4	1.5		note (a)
	11/18/96 11:20	0.065	13.8	5.4	6.1	3.3		
	11/21/96 13:15	-0.045	16.5	0.0	1.6	4.9		
	11/25/96 11:12	-0.800	17.0	1.4	2.1	10.4		
	12/3/96 10:32	-0.658	16.6	3.0	2.6	3.5		
	12/9/96 11:12	0.411	16.0	1.0	1.0	2.8		
	12/16/96 10:25	-0.964	17.5	1.0	0.9	3.4		
	12/23/96 11:05	-1.056	15.3	1.3	1.1	4.5		
	12/31/96 13:22	0.112	15.0	0.4	0.8	3.7		
	1/2/97 11:56	-0.144	15.9	0.5	0.9	3.2		
	1/27/97 14:10	-0.568	18.7	0.6	0.9	2.3	13,700	
	2/24/97 11:38	-0.142	19.0	0.2	1.2	2.4	15,600	duplicates averaged
	4/1/97 12:23	-0.999	18.8	7.5	3.0	3.9	8,900	
	5/5/97 11:12	-0.070	9.1	20.9	13.3	13.3	10,800	CCl4/CHCl3 reversed?; CCl4 result excluded from analysis
	6/5/97 11:29	-0.274	21.9	1.2	1.5	3.8	11,100	
	7/7/97 13:14	-0.162	22.6	1.1	1.0	2.5	10,800	
Barometric Pump	10/29/96 14:02	-7.970	13.7	0.0	0.0	1.8		flow = 1.6 m3/min (55 ft3/min)
W15-218L	6/17/97 10:43	0.199	29.0	1.0	0.9	4.1	15,700	
depth = 57.6 m								
zone = 5								
2 m above zone 6								
W15-32	10/29/96 0:00							not on-line
depth = 61.1 m	11/15/96 10:54	N/A	5.4	1.4	0.0	0.0		
zone = 6	12/5/96 11:40	N/A	4.7	1.1	0.4	0.2		
	12/18/96 11:49	0.134	0.4	0.0	0.8	0.3		
	12/27/96 10:08	0.941	1.5	0.0	0.9	2.5		
	1/10/97 11:22	0.120	2.7	0.2	0.9	0.6		
	2/25/97 14:40	0.142	3.0	0.6	0.5	0.1	13,300	
	4/3/97 0:00							not sampled due to P&T work for ZP-1
	6/17/97 0:00							can't access due to P&T piping for ZP-1

(a) well cap off approx. 45 min. to pull screen/tube up and out of water approx. 8 ft; screen 3 ft above water
CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform
MEK = Methyl Ethyl Ketone
CH2Cl2 = Methylene Chloride

216-Z-1A SITE ZONE 1

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
71-04	5/13/96 10:27	0.000	<0.045	<0.095				
depth = 1.5 m	11/14/96 12:00	0.000	0.0	0.0	1.3	0.0		sample time assumed
zone = 1	12/10/96 10:50	-0.005	0.1	0.8	0.9	0.0		
	1/24/97 10:30	-0.010	0.0	1.1	1.7	0.0		
	3/4/97 12:49	-0.007	0.2	0.2	0.6	0.0	7,720	
	4/8/97 11:25	-0.007	0.2	0.3	0.6	0.0	7,190	
	5/8/97 10:41	-0.005	0.5	1.1	0.5	0.0	7,400	
	6/9/97 11:05	0.005	0.2	0.8	0.7	0.0	11,700	
	7/10/97 9:20	-0.002	0.1	1.6	0.2	0.0	13,100	no longer accessible, area fenced off
79-02	5/13/96 11:19	0.000	<0.045	<0.095				
depth = 1.5 m	11/14/96 12:00	-0.002	0.0	0.0	1.1	0.0		sample time assumed
zone = 1	12/10/96 10:43	-0.007	0.1	0.5	1.0	0.0		
	1/24/97 10:35	-0.007	0.1	0.2	1.7	0.8		
	3/4/97 12:54	-0.020	0.1	0.2	0.8	0.0	7,930	
	4/8/97 11:33	-0.015	0.2	0.3	0.7	0.0	7,990	
	5/8/97 10:29	-0.007	0.6	4.3	1.1	0.0	8,300	
	6/9/97 10:49	0.005	0.7	1.7	0.8	0.0	12,100	
	7/10/97 9:09	-0.005	0.5	0.4	0.8	0.0	11,400	
79-03	5/13/96 10:48	0.000	<0.045	<0.095				
depth = 1.5 m	11/14/96 12:00	-0.002	0.0	0.0	1.2	0.0		sample time assumed
zone = 1	11/27/96 12:00	-0.005	0.0	0.7	0.8	0.0		
	12/10/96 10:46	-0.007	0.3	0.0	1.1	0.0		
	1/24/97 12:40	-0.007	0.2	0.1	2.0	0.8		
	3/4/97 12:58	-0.010	0.1	0.2	0.9	0.0	8,100	
	4/8/97 11:39	-0.010	0.1	0.2	0.9	0.0	7,960	
	5/8/97 10:25	-0.007	0.3	0.8	0.3	0.0	7,600	
	6/9/97 10:57	0.005	0.3	0.7	0.2	0.0	11,300	
	7/10/97 9:12	0.000	0.1	1.8	0.1	0.0	13,800	
79-11	5/13/96 13:57	0.000	<0.045	<0.095				
depth = 1.5 m	11/27/96 11:38	0.007	0.0	1.6	0.0	0.0		
zone = 1	12/10/96 10:55	-0.007	0.1	0.2	0.8	0.0		
	1/24/97 11:10	-0.010	0.1	1.1	0.7	0.0		
	3/4/97 12:08	-0.017	0.1	0.5	0.7	0.0	8,240	
	4/8/97 11:46	-0.015	0.2	0.7	0.7	0.1	8,020	
	5/8/97 11:26	-0.002	0.3	0.9	0.6	0.0	7,970	
	6/9/97 11:41	0.005	0.0	0.8	0.5	0.0	11,400	
	7/10/97 9:47	-0.007	0.1	1.0	0.7	0.0	10,800	
79-13	11/27/96 11:34	0.012	0.0	1.2	0.3	0.0		
depth = 1.5 m	12/10/96 11:00	-0.010	0.1	0.4	0.6	0.0		
zone = 1	1/24/97 11:15	-0.015	0.2	0.3	0.8	0.2		
	3/4/97 12:03	-0.010	0.1	1.4	0.4	0.0	7,850	
	4/8/97 11:53	-0.010	0.1	1.8	0.4	0.0	7,660	
	5/8/97 11:32	-0.002	0.2	2.3	0.2	0.0	8,200	
	6/9/97 11:48	0.012	0.3	0.7	0.6	0.0	12,800	
	7/10/97 9:53	-0.017	0.2	1.1	0.6	0.0	10,800	
87-01R	5/13/96 11:27	0.000	<0.045	<0.095				
depth = 1.5 m	11/14/96 12:00	0.000	0.0	2.0	0.0	0.0		sample time assumed
zone = 1	12/10/96 10:37	-0.010	0.0	21.7	2.7	0.0		
	1/24/97 10:40	-0.010	0.0	6.1	5.6	0.0		
	3/4/97 13:01	-0.017	0.0	11.0	16.7	0.0	8,690	
	4/8/97 12:41	-0.015	0.0	12.2	15.9	0.0	7,980	
	5/8/97 10:20	-0.007	0.0	13.2	7.0	0.0	7,300	
	6/9/97 10:43	0.005	3.5	17.6	6.2	0.0	10,600	
	7/10/97 9:05	-0.005	0.3	1.5	1.0	0.0	10,900	
87-03	5/13/96 13:26	0.000	<0.045	<0.095				
depth = 1.5 m	11/27/96 11:54	-0.002	0.0	0.0	1.0	0.0		
zone = 1	12/10/96 10:22	-0.020	0.2	0.1	1.1	0.0		
	1/24/97 10:52	-0.010	0.3	0.0	2.3	1.8		
	3/4/97 12:36	-0.010	0.2	0.0	1.2	0.3	9,240	
	4/8/97 12:48	-0.010	0.2	0.0	1.0	0.3	9,070	
	5/8/97 11:09	-0.007	0.5	1.9	0.5	0.0	7,900	
	6/9/97 11:25	0.002	0.1	1.1	0.5	0.0	11,300	
	7/10/97 9:28	0.000	0.1	0.8	0.5	0.0	11,300	

216-Z-1A SITE ZONE 1

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
87-04	5/13/96 13:35	0.000	<0.045	<0.095				
depth = 1.5 m	11/22/96 10:25	-0.022	0.4	1.8	0.2	0.0		
zone = 1	11/27/96 11:49	0.005	0.0	0.8	0.6	0.0		
	12/10/96 10:13	-0.025	0.1	0.3	1.1	0.1		
	1/24/97 10:56	-0.010	0.1	0.8	0.9	0.5		
	3/4/97 12:32	-0.012	0.3	0.2	0.9	0.1	8,990	
	4/8/97 12:55	-0.010	0.3	0.2	0.9	0.2	8,630	
	5/8/97 11:16	-0.007	0.7	0.8	0.4	0.3	7,900	
	6/9/97 11:31	0.002	0.5	1.1	0.5	0.0	11,300	
	7/10/97 9:37	-0.005	0.7	1.2	0.5	0.0	11,100	
95-01	5/13/96 11:36	0.000	0.023j	<0.095				
depth = 1.5 m	12/10/96 10:33	-0.032	0.4	0.9	0.7	0.0		
zone = 1	1/24/97 10:43	-0.015	0.3	0.1	1.8	0.8		
	3/4/97 13:05	-0.015	0.2	1.1	2.7	0.1	8,495	duplicates averaged
	4/8/97 13:23	-0.012	0.2	1.5	3.8	0.0	8,250	
	5/8/97 10:13	-0.010	4.4	2.3	0.0	0.0	6,600	
	6/9/97 11:35	0.002	0.6	1.4	0.5	0.0	11,300	
	7/10/97 9:00	-0.007	0.8	1.0	0.7	0.0	10,700	
C-1	5/13/96 10:55	0.000	<0.045	<0.095				water vapor in tubing at point
depth = 1.5 m	11/14/96 12:00	0.005	0.0	0.0	0.0	0.0		sample time assumed
zone = 1	12/10/96 9:57	-0.020	0.1	0.8	0.5	0.0		
	1/24/97 11:05	-0.075	0.2	0.1	1.5	1.6		
	3/4/97 12:20	0.005	0.2	0.1	1.2	1.3	8,475	duplicates averaged
	4/8/97 13:02	0.027	0.2	0.0	1.2	1.7	8,285	duplicates averaged
	5/8/97 10:49	-0.005	0.1	1.5	0.4	0.6	7,250	duplicates averaged
	6/9/97 11:12	0.005	0.0	1.1	0.7	0.5	10,900	
	7/10/97 11:10	-0.010	0.0	1.3	0.3	0.4	13,200	
N-5	5/13/96 11:44	0.000	<0.045	<0.095				water vapor inside tube
depth = 1.5 m	12/10/96 10:09	-0.037	0.7	0.0	1.1	0.0		
zone = 1	1/24/97 10:59	-0.007	0.1	0.5	1.1	0.5		
	3/4/97 12:28	-0.012	0.2	0.0	1.0	0.9	6,920	
	4/8/97 13:10	-0.007	0.2	0.0	0.9	0.9	6,590	
	5/8/97 11:21	-0.005	0.3	1.5	0.4	0.0	8,300	
	6/9/97 11:36	0.010	0.3	1.1	0.6	0.0	11,000	
	7/10/97 9:41	-0.012	0.4	0.9	0.3	0.0	11,000	
N-9	5/13/96 13:13	0.000	<0.045	<0.095				hard to pull purge vacuum
depth = 1.5 m	11/14/96 12:00	0.000	0.0	0.0	0.0	0.0		sample time assumed
zone = 1	12/10/96 10:28	-0.022	0.0	0.8	1.0	0.0		
	1/24/97 10:47	-0.005	0.1	0.0	1.3	0.3		
	3/4/97 12:43	-0.020	0.2	0.0	1.0	0.3	8,200	
	4/8/97 13:17	-0.017	0.2	0.0	1.1	1.7	8,070	
	5/8/97 10:58	-0.005	0.3	1.5	0.5	0.0	7,900	
	6/9/97 11:18	0.002	0.1	1.0	0.5	0.0	10,900	
	7/10/97 9:25	-0.005	0.4	1.2	0.5	0.0	11,200	

j = concentration below established PQL
CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform
MEK = Methyl Ethyl Ketone
CH2Cl2 = Methylene Chloride

216-Z-1A SITE ZONE 2

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
CPT-13A/9	10/31/96 9:30	-0.035						no cap
blue	11/4/96 13:10							pump failure; no data
depth = 9.1 m	11/7/96 13:28	-0.007	0.3	0.0	0.9	0.2		
zone = 2	11/11/96 13:35	0.005	0.6	1.3	0.2	0.0		
	11/15/96 12:41	0.000	0.2	1.4	0.4	0.0		
	11/19/96 12:34	0.007	0.6	0.1	0.9	0.0		
	11/22/96 12:54	-0.032	0.1	0.9	0.6	0.0		
	12/4/96 12:50	0.065	0.2	0.6	0.6	0.0		
	12/13/96 11:32	-0.055	0.2	0.6	0.8	0.0		
	12/19/96 11:00	0.032	0.5	0.3	1.0	0.1		
	12/27/96 10:28	-0.012	0.5	0.6	0.6	0.2		
	1/7/97 14:26	-0.012	0.2	0.6	0.4	0.1		
	1/29/97 9:54	0.025	0.5	1.5	1.3	0.1	5,600	
	3/3/97 13:26	-0.010	0.6	0.9	0.4	0.0	16,700	
	4/2/97 10:20	0.015	2.2	0.0	0.6	0.6	7,890	
	5/6/97 12:14	-0.010	1.0	1.3	0.8	0.3	9,800	
	6/5/97 9:45	-0.005	1.1	1.2	0.7	0.0	10,500	
	7/8/97 15:11	0.002	1.0	1.6	0.5	0.0	14,800	
CPT-1A/11	5/13/96 14:51	0.000	0.5	<0.095				
unmarked/black	10/30/96 13:50	-0.022						no cap
depth = 10.7 m	11/4/96 10:07	-0.199	0.3	0.7		0.3		no cap
zone = 2	11/7/96 11:20	0.000	0.4	0.8	0.5	0.0		
	11/11/96 15:05	0.010	0.5	0.4	0.6	0.2		
	11/13/96 11:20	-0.005	0.4	1.4	0.7	0.0		
	11/19/96 12:56	-0.005	0.8	0.0	1.1	1.1		
	11/22/96 10:41	-0.037	0.6	0.2	1.0	0.0		
	11/26/96 11:21	0.000	0.5	1.3	0.7	0.5		
	12/4/96 10:11	0.077	0.6	0.3	0.8	0.3		
	12/13/96 10:34	-0.072	0.5	0.9	0.4	0.0		
	12/19/96 13:23	0.032	0.5	1.1	0.4	0.0		
	12/27/96 12:30	-0.025	1.1	0.0	0.6	0.8		
	1/7/97 13:28	-0.012	0.6	0.0	0.9	0.6		
	1/29/97 13:56	0.007	0.7	1.6	1.3	0.5	5,700	
	3/3/97 13:23	-0.015	1.0	0.8	0.6	0.0	18,300	
	4/2/97 12:25	0.022	1.7	0.0	0.7	0.0	26,200	
	5/6/97 9:31	-0.015	2.0	1.2	0.7	0.7	7,500	
	6/4/97 12:37	-0.002	1.2	1.2	0.6	0.1	9,540	
	7/8/97 14:18	-0.002	1.3	1.0	0.7	0.6	13,400	
CPT-2EX	10/31/96 10:48	-0.291						climbing
depth = 12.2 m	11/7/96 13:40	-0.007	0.3	0.2	0.5	2.7		
zone = 2	11/11/96 15:40	0.005	0.3	0.8	0.0	0.4		
	11/15/96 12:53	0.005	0.0	1.1	0.0	0.0		
	11/19/96 12:40	0.032	0.9	0.6	0.0	0.3		
	11/22/96 13:05	-0.037	0.2	1.3	0.8	0.0		
	12/4/96 13:00	0.092	0.8	0.0	1.5	1.9		
	12/13/96 11:40	-0.055	0.6	0.7	0.5	0.2		
	12/19/96 10:55	0.037	0.9	0.7	0.7	0.5		
	12/27/96 10:15	-0.010	2.9	0.7	0.5	2.0		
	1/7/97 14:20	-0.002	0.4	0.7	0.6	0.0		
	1/29/97 10:02	0.025	0.8	0.8	1.4	2.2	5,510	duplicates averaged
	3/3/97 13:34	-0.010	0.3	0.8	0.2	0.0	19,700	
	4/2/97 10:34	0.017	2.0	0.0	0.8	2.0	7,320	
	4/30/97 11:35	0.035	5.1	0.0	0.9	3.2	10,900	
	5/6/97 11:25	-0.017	1.1	0.4	0.7	0.7	9,000	
	6/5/97 9:56	0.002	0.3	0.4	0.6	1.1	10,500	
	7/8/97 15:20	0.007	3.4	1.1	0.6	2.1	13,100	

216-Z-1A SITE ZONE 2

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
CPT-34/12	5/14/96 10:26	0.000	0.9	<0.095				
green	11/4/96 9:56	-0.020	0.2	0.9		0.1		
depth = 12.2 m	11/7/96 11:10	0.000	0.5	0.9	0.7	0.0		
zone = 2	11/11/96 15:25	-0.010	0.5	0.6	0.5	0.0		
	11/13/96 11:10	0.000	0.5	0.3	1.4	0.5		
	11/19/96 12:47	0.005	0.6	0.9	1.0	0.0		
	11/22/96 10:34	-0.032	0.6	0.4	1.1	0.0		
	11/26/96 11:10	-0.002	0.4	1.5	0.8	0.0		
	12/4/96 9:47	0.050	0.7	0.1	0.7	0.1		
	12/13/96 10:26	-0.072	0.6	0.0	1.4	0.1		
	12/19/96 12:47	0.032	2.0	0.4	0.5	0.0		
	12/27/96 12:18	-0.015	2.3	0.3	0.4	0.0		
	1/7/97 13:20	-0.012	0.7	0.0	1.1	0.5		
	1/29/97 13:45	0.020	1.0	1.5	1.3	0.0	7,200	
	3/3/97 12:32	-0.017	2.1	3.3	1.7	1.3	8,930	
	4/2/97 12:18	0.030	0.8	1.2	0.2	0.0	22,300	
	5/6/97 9:15	-0.025	1.2	0.1	0.6	0.3	7,370	
	6/4/97 11:50	-0.010	0.6	1.7	0.4	0.0	9,650	
	7/8/97 14:09	-0.017	1.2	1.2	0.6	0.0	14,300	
CPT-7A/16	10/31/96 9:35	-0.050						no cap
red	11/4/96 13:38	0.000	0.3	1.6		0.0		
depth = 15.9 m	11/7/96 13:31	-0.007	0.6	0.0	1.3	1.5		
zone = 2	11/11/96 13:45	0.010	0.3	0.8	0.4	0.3		
	11/15/96 12:47	0.000	0.0	1.5	0.0	0.0		
	11/19/96 12:37	0.022	2.6	1.6	0.1	0.0		
	11/22/96 12:59	-0.035	0.4	0.7	0.5	0.0		
	12/4/96 13:03	0.075	0.5	0.2	1.2	0.5		
	12/13/96 11:37	-0.060	0.6	0.1	1.0	0.0		
	12/19/96 10:57	0.010	1.6	0.0	1.1	0.3		
	12/27/96 10:23	-0.007	1.9	0.5	0.6	0.2		
	1/7/97 14:23	-0.007	1.3	0.1	0.0	0.0		
	1/29/97 9:58	0.022	0.2	0.1	1.5	1.0	5,300	
	3/3/97 13:31	-0.012	1.7	0.5	0.6	0.0	17,700	
	4/2/97 10:28	0.020	2.6	0.0	0.9	1.1	6,970	
	5/6/97 11:30	-0.022	2.2	1.4	1.1	0.5	8,850	
	6/5/97 9:51	0.005	2.3	1.2	0.7	0.8	10,600	
	7/8/97 15:17	-0.002	2.4	1.0	0.8	0.5	15,400	
CPT-30/21	5/14/96 11:41	0.000	0.1	<0.095				
red	11/6/96 14:50	0.060	0.6	1.7	1.0	0.7		
depth = 20.7 m	11/8/96 13:05	0.032	1.0	0.0	1.8	1.7		
zone = 2	11/12/96 9:05	-0.055	0.6	1.2	0.1	1.1		
	11/13/96 11:43	0.020	0.5	1.1	0.5	1.2		
	11/19/96 13:19	0.025	0.9	2.5	0.3	0.0		
	11/22/96 10:53	-0.072	1.7	1.3	1.3	1.7		
	11/26/96 11:29	0.007	0.7	0.5	1.5	2.2		
	12/4/96 10:40	0.237	0.6	2.1	0.8	1.2		
	12/13/96 10:42	-0.174	0.7	1.0	1.1	0.8		
	12/19/96 13:05	0.117	1.1	0.5	1.1	0.9		
	12/27/96 12:38	-0.047	1.4	0.0	1.1	1.5		
	1/7/97 13:40	-0.015	0.8	0.3	0.6	1.3		
	1/29/97 14:04	0.057	38.8	2.0	0.9	0.6	9,100	CCl4 result anomalous, excluded from analysis
	3/3/97 12:38	-0.017	1.2	0.0	1.2	1.7	9,440	
	4/2/97 12:09	0.087	1.1	0.1	1.1	0.5	22,100	
	5/6/97 9:48	-0.411	1.4	19.4	12.0	9.3	7,370	
	6/4/97 12:53	-0.005	1.0	1.4	1.6	2.1	9,710	
	7/8/97 14:28	0.030	1.3	2.9	1.8	2.7	14,700	

216-Z-1A SITE ZONE 2

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
CPT-13A/21	10/31/96 9:30	-0.087						
red	11/4/96 13:26	-0.007	2.1	0.8		1.4		
depth = 21.3 m	11/7/96 13:25	0.000	4.5	0.4	0.7	0.9		
zone = 2	11/11/96 13:40	0.020	4.1	1.1	0.6	0.6		
	11/15/96 12:43	0.015	3.8	2.0	0.0	0.0		
	11/19/96 12:31	0.045	3.8	2.5	0.0	0.0		
	11/22/96 12:53	-0.052	3.8	0.4	0.9	0.6		duplicates averaged
	12/4/96 12:52	0.167	3.9	0.7	0.7	0.7		
	12/13/96 11:33	-0.102	3.6	0.4	1.0	0.7		duplicates averaged
	12/19/96 11:02	0.062	4.1	1.1	0.6	0.7		
	12/27/96 10:30	-0.007	4.5	0.9	0.5	0.8		
	1/7/97 14:28	-0.012	3.2	0.9	0.2	0.9		
	1/29/97 9:52	0.045	4.4	1.5	1.2	1.3	5,900	
	3/3/97 13:28	-0.015	4.3	0.6	0.3	0.1	17,400	
	4/2/97 10:24	0.040	5.2	0.4	1.0	1.1	7,660	
	5/6/97 12:18	-0.022	4.8	1.6	0.6	1.1	11,300	
	6/5/97 9:47	0.000	4.0	0.4	0.9	1.5	10,700	
	7/8/97 15:13	0.015	5.2	0.9	0.8	1.8	16,000	
CPT-32/21	5/14/96 12:07	-0.050	0.2	<0.095				
red	10/30/96 14:00	-0.289						
depth = 21.3 m	11/4/96 11:42	-0.095	0.1	1.4		1.5		
zone = 2	11/6/96 10:40	0.015	0.5	0.8	1.2	1.5		
	11/8/96 12:44	0.047	0.5	0.3	1.5	1.8		
	11/11/96 13:50	0.042	0.5	0.4	0.7	1.4		
	11/19/96 11:27	0.130	1.3	1.0	0.8	0.9		
	11/22/96 10:23	-0.112	0.6	0.5	0.8	1.3		
	12/4/96 13:25	0.399	0.9	1.3	1.3	1.5		
	12/13/96 13:21	-0.199	1.2	1.4	0.3	0.3		
	12/19/96 10:20	0.147	2.7	0.7	1.0	0.3		
	12/27/96 9:40	0.012	2.5	1.1	0.2	1.5		
	1/7/97 14:35	-0.035	0.6	1.7	0.0	0.7		
	1/29/97 9:35	0.042	1.3	1.0	2.1	2.9	5,800	
	2/26/97 12:59	0.247	2.5	0.9	0.2	1.3	12,700	
	3/3/97 10:30	-0.082	2.5	0.1	0.5	1.7	9,650	
	4/2/97 11:10	0.077	5.9	1.0	1.1	1.9	6,980	
	5/6/97 12:40	-0.040	7.4	1.3	1.8	3.4	9,600	
	6/5/97 10:24	-0.002	3.6	1.8	1.1	2.8	10,500	
	7/8/97 15:38	0.027	4.8	0.3	0.9	3.6	16,600	
CPT-4C/23	10/31/96 10:15	-0.493						no cap
yellow	11/4/96 10:46	-0.199	0.2	1.2		5.3		very slow filling
depth = 22.9 m	11/7/96 10:42	-0.115	0.6	0.0	1.0	6.9		
zone = 2	11/11/96 14:55	0.087	0.8	0.2	1.1	7.5		slow fill
	11/20/96 15:06	-0.075	1.0	2.3	0.0	5.2		
	11/22/96 11:28	-0.095	0.8	2.5	0.3	6.5		
	12/4/96 11:20	0.446	1.1	1.0	1.0	6.0		
	12/13/96 11:10	-0.274	1.2	1.0	0.9	5.9		
	12/19/96 13:35	0.237	1.5	0.4	1.0	5.9		
	12/27/96 12:52	-0.045	2.0	0.9	0.6	5.8		
	1/7/97 13:45	-0.020	1.2	0.7	0.5	3.9		
	1/29/97 14:14	0.105	1.6	1.5	1.1	5.5	7,100	
	3/3/97 12:58	-0.015	2.0	1.0	0.4	3.9	12,500	
	4/2/97 11:18	0.102	3.6	0.0	1.2	4.8	11,400	
	5/6/97 10:25	-0.055	4.5	0.3	1.5	6.8	7,600	
	6/5/97 9:35	-0.030	2.6	0.7	1.2	4.4	10,600	
	7/8/97 14:50	0.040	3.3	1.0	1.1	4.8	15,000	

216-Z-1A SITE ZONE 2

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
CPT-4E/23	10/31/96 10:37	-0.139						no cap
yellow	11/4/96 10:40	-0.057	0.1	0.9		1.2		no cap
depth = 22.9 m	11/7/96 10:35	-0.045	0.2	0.2	0.8	1.2		
zone = 2	11/11/96 14:45	0.015	0.4	1.2	0.6	2.9		
	11/20/96 15:00	0.496	0.3	2.6	0.0	0.0		water flowing in line
	11/22/96 11:22	-0.030	1.2	0.8	0.7	2.6		
	12/4/96 11:05	0.134	1.8	0.4	1.0	3.0		
	12/13/96 11:00	-0.120	0.8	0.3	1.2	0.5		
	12/19/96 13:38	0.070	0.9	0.4	0.8	2.5		
	12/27/96 13:00	-0.025	1.1	0.5	0.6	3.2		
	1/7/97 13:52	-0.005	1.6	0.1	0.9	2.5		
	1/29/97 14:19	0.027	2.1	1.5	0.9	2.6	6,600	
	3/3/97 13:01	-0.012	1.6	1.5	0.1	1.0	12,500	
	4/2/97 11:30	-0.010	4.5	0.0	1.0	3.6	14,000	
	5/6/97 10:38	-0.020	3.5	1.6	0.9	3.4	7,700	
	6/5/97 9:28	-0.005	1.9	1.2	0.9	3.5	10,300	
	7/8/97 14:57	0.025	2.0	0.7	1.2	3.4	15,700	
CPT-4F/23	5/14/96 14:13	0.000	<0.045	<0.095				
yellow	10/31/96 12:55	-0.324						climbing
depth = 22.9 m	11/4/96 10:22	-0.085	0.3	1.3		1.3		
zone = 2	11/7/96 10:25	-0.082	0.6	0.0	1.3	1.8		pressure decreasing
	11/11/96 14:35	0.052	0.8	0.0	1.3	3.1		
	11/20/96 14:51	-0.075	0.7	0.7	0.5	2.1		
	11/22/96 11:16	-0.065	22.3	1.4	0.7	0.0		CCl4 result anomalous, excluded from analysis
	12/4/96 10:55	0.391	1.0	0.0	1.8	3.8		
	12/13/96 11:25	-0.264	1.1	0.2	1.1	2.7		
	12/19/96 13:42	0.174	0.8	0.2	0.9	2.3		
	12/27/96 13:07	-0.055	1.2	0.5	0.7	2.9		
	1/7/97 13:58	-0.005	1.2	1.8	0.3	0.6		
	1/29/97 14:26	0.107	1.5	0.9	1.0	3.0	7,700	
	3/3/97 13:07	-0.468	1.8	0.6	0.6	2.5	12,800	
	4/2/97 11:40	0.411	2.4	0.0	1.1	2.5	15,800	
	5/6/97 10:50	-0.052	4.0	0.5	1.6	5.0	7,500	
	6/5/97 9:21	-0.035	3.3	1.0	1.0	2.6	10,300	
	7/8/97 15:03	0.040	2.4	0.5	0.7	3.1	15,400	
CPT-31/23	5/14/96 11:19	-0.050	4.5	0.082j				
red	10/31/96 9:12	-0.705						
depth = 23.2 m	11/4/96 10:15	-0.249	0.7	1.5		1.0		
zone = 2	11/7/96 11:30	-0.050	1.0	0.9	0.6	0.0		
	11/12/96 9:00	-0.075	1.1	0.5	0.7	1.1		
	11/13/96 11:35	0.005	1.2	0.6	1.4	1.3		
	11/19/96 13:14	0.154	1.2	1.9	0.8	0.0		
	11/22/96 10:49	-0.139	1.8	0.9	1.5	0.6		
	12/4/96 10:22	0.381	3.3	1.1	0.7	0.6		
	12/13/96 10:40	-0.296	1.4	0.6	0.7	0.3		
	12/19/96 12:58	0.234	11.9	0.0	0.7	0.7		CCl4 result anomalous, excluded from analysis
	12/27/96 12:44	-0.050	2.0	1.2	0.4	0.3		
	1/7/97 13:35	-0.020	1.8	0.5	0.6	0.4		
	1/29/97 14:08	0.130	1.1	1.9	1.0	0.8	7,200	
	3/3/97 12:41	-0.065	2.2	0.0	0.9	0.7	10,200	
	4/2/97 12:04	0.147	2.8	1.2	0.7	0.0	25,500	
	5/6/97 9:41	-0.085	4.0	1.8	2.2	3.4	7,750	
	6/4/97 12:46	-0.047	3.1	2.5	1.4	1.1	9,640	
	7/8/97 14:23	0.007	3.9	2.1	1.0	1.6	14,600	

216-Z-1A SITE ZONE 2

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
CPT-33/24	5/13/96 14:35	0.025	0.9	0.082j				duplicates averaged
red	5/14/96 10:19	-0.125	0.9	0.092j				replicate
depth = 24.4 m	5/15/96 10:57	-0.249	0.9	0.089j				replicate
zone = 2	5/16/96 10:05	-0.125	0.8	0.076j				replicate
	10/30/96 13:40	-0.765						
	11/4/96 10:01	-0.159	0.3	1.3		0.5		
	11/7/96 11:32	-0.130	0.6	2.2	0.0	0.0		
	11/11/96 15:20	0.087	0.9	0.2	0.6	1.6		
	11/13/96 11:26	-0.022	1.0	0.1	1.6	2.2		
	11/19/96 12:52	0.299	0.9	2.1	0.2	0.0		
	11/22/96 10:39	-0.164	1.1	1.5	0.8	0.5		
	11/26/96 11:14	-0.085	1.0	1.2	1.0	1.5		
	12/4/96 9:53	0.456	1.3	1.6	0.6	0.9		
	12/13/96 10:30	-0.401	1.3	0.6	0.7	1.0		
	12/19/96 12:50	0.294	1.9	1.0	0.7	1.1		
	12/27/96 12:26	-0.025	2.0	0.0	1.2	2.0		
	1/7/97 13:23	-0.015	1.7	0.3	1.2	2.0		
	1/29/97 13:52	0.152	1.7	2.0	0.9	0.6	6,100	
	3/3/97 12:35	-0.139	2.3	0.3	0.5	1.6	8,910	
	4/2/97 12:14	0.162	2.6	0.7	0.3	0.0	25,300	
	5/6/97 9:28	-0.115	5.5	2.5	2.0	2.8	7,500	
	6/4/97 12:27	-0.105	4.5	2.2	0.9	0.7	9,600	
	7/8/97 14:14	0.005	5.8	1.4	1.2	2.2	14,600	
CPT-34/26	5/14/96 10:45	-0.125	0.6	<0.095				
red	10/30/96 13:30	-0.680						
depth = 26.2 m	11/4/96 9:53	-0.224	0.3	0.7		0.6		
zone = 2	11/7/96 11:15	-0.149	0.5	0.8	0.8	0.0		
	11/11/96 15:15	0.075	0.6	0.9	0.3	0.6		duplicates averaged
	11/13/96 11:08	-0.042	0.9	0.3	1.1	0.9		
	11/19/96 12:50	0.289	0.8	1.3	0.6	0.0		
	11/22/96 10:36	-0.154	0.8	0.4	0.9	0.8		
	11/26/96 11:09	-0.070	0.9	3.3	1.8	0.8		
	12/4/96 9:46	0.418	1.0	1.1	0.4	0.1		duplicates averaged
	12/13/96 10:25	-0.379	1.6	0.8	0.7	0.0		
	12/19/96 12:45	0.281	2.2	0.7	0.5	0.0		
	12/27/96 12:20	-0.027	4.0	0.9	0.5	0.1		
	1/7/97 13:17	-0.010	3.8	0.4	0.7	0.7		
	1/29/97 13:48	0.152	6.5	1.8	1.8	1.3	6,700	
	3/3/97 12:30	-0.139	12.9	0.8	0.4	0.0	9,300	
	4/2/97 12:21	0.152	17.3	1.1	0.5	0.0	22,100	
	5/6/97 9:18	-0.115	24.2	2.0	2.0	2.1	7,410	
	6/4/97 11:54	-0.015	29.7	1.1	1.1	0.0	10,500	
	7/8/97 14:11	-0.002	36.3	1.8	0.7	0.6	15,700	
CPT-1A/28	5/13/96 15:17	0.050	0.024j	<0.095				
red	5/13/96 15:17	0.050	<0.045	<0.095				duplicate
depth = 27.7 m	10/30/96 13:52	-0.007						no cap
zone = 2	11/4/96 10:04	-0.007	1.9	1.0		0.3		no cap
	11/7/96 11:22	-0.017	2.6	1.8	0.4	0.0		
	11/11/96 15:10	0.002	2.7	0.3	0.7	0.2		
	11/13/96 11:18	-0.012	3.8	1.1	0.9	0.5		
	11/19/96 12:57	0.000	3.0	0.4	1.0	0.0		
	11/22/96 10:42	-0.075	2.9	1.0	0.8	0.0		
	11/26/96 11:20	0.002	3.2	1.4	0.9	0.0		
	12/4/96 10:10	0.249	3.1	0.2	0.9	0.0		
	12/13/96 10:36	-0.125	3.3	0.9	0.3	0.0		
	12/19/96 13:26	0.047	1.7	0.7	1.0	0.0		
	12/27/96 12:33	-0.017	1.0	0.0	0.8	0.9		
	1/7/97 13:30	-0.010	0.6	0.0	1.1	1.0		
	1/29/97 13:59	0.015	2.2	0.5	1.7	1.5	6,700	
	3/3/97 13:24	-0.010	0.7	0.8	0.5	0.0	19,400	
	4/2/97 12:28	0.120	3.9	0.9	0.4	0.0	25,250	duplicates averaged
	5/6/97 9:35	-0.022	1.3	0.6	0.9	1.5	7,250	
	6/4/97 12:39	-0.005	0.6	1.5	0.9	0.0	9,500	
	7/8/97 14:20	0.000	2.6	0.8	0.8	1.2	12,900	

216-Z-1A SITE ZONE 2

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W18-252SST/31	10/31/96 9:20	-0.461						
red	11/7/96 10:00	-0.075	0.4	0.4	0.8	1.2		
depth = 30.5 m	11/11/96 14:15	0.015	1.7	0.0	1.1	0.9		
zone = 2	11/20/96 14:40	-0.050	4.1	0.3	1.0	0.0		
	11/22/96 11:06	-0.147	5.9	1.5	0.6	0.0		
	12/4/96 10:51	0.610	10.3	0.1	1.6	1.0		
	12/13/96 10:51	-0.428	8.5	0.9	0.8	0.0		
	12/19/96 13:12	0.359	14.0	0.6	1.0	0.5		
	12/27/96 13:18	-0.025	19.8	0.0	1.3	1.6		
	1/7/97 14:07	-0.027	16.4	0.1	1.1	0.9		
	1/29/97 14:34	0.162	20.1	0.4	1.4	1.4	8,000	
	3/3/97 13:16	-0.134	29.4	0.0	1.2	1.2	11,900	
	3/17/97 11:58	-0.384	20.9	1.8	0.2	0.2	18,300	
	4/2/97 11:53	0.147	25.8	0.1	0.2	0.5	23,300	
	4/17/97 11:35	0.010	30.4	0.7	0.4	0.7	14,400	
	5/6/97 10:03	-0.102	20.6	0.1	0.7	0.0	7,360	
	6/5/97 9:11	-0.120	31.6	1.1	0.7	0.8	10,300	
	7/8/97 14:38	0.050	38.2	0.7	0.8	1.4	13,700	
CPT-4E/31	10/31/96 10:41	-1.051						no cap
red	11/4/96 10:33	-0.299	0.4	0.8		2.9		no cap
depth = 31.4 m	11/7/96 10:40	0.005	0.7	0.2	1.0	3.5		
zone = 2	11/11/96 14:40	0.488	1.1	0.6	0.9	3.0		
	11/20/96 14:57	-0.035	3.4	0.0	1.2	2.6		
	11/22/96 11:25	-0.025	3.4	0.6	1.0	2.8		
	12/4/96 11:07	0.411	5.6	0.0	1.8	3.4		
	12/13/96 11:01	-0.354	8.1	0.7	0.9	1.9		
	12/19/96 13:40	-0.015	0.5	0.0	1.1	0.8		
	12/27/96 13:03	-0.010	0.7	0.4	0.9	0.7		? low flow
	1/7/97 13:55	-0.007	8.3	0.4	0.8	2.5		
	1/29/97 14:22	0.000	7.6	0.0	1.9	3.0	7,200	
	3/3/97 13:04	-0.396	10.2	0.9	0.7	0.6	12,900	
	4/2/97 11:34	-0.005	23.2	1.0	0.5	1.1	14,500	
	5/6/97 10:42	0.274						could not get sample; bag would not fill
	6/5/97 9:30	0.005	11.8	0.5	1.5	3.2	10,300	
	7/8/97 15:00	0.025	9.7	1.0	0.6	0.4	14,400	
CPT-4C/33	10/31/96 12:59	-0.777						no cap; climbing
red	11/4/96 10:42	-0.080	0.3	1.3		0.9		no cap; very slow filling
depth = 32.6 m	11/7/96 10:46	-0.184	0.8	0.2	0.8	3.0		duplicates averaged
zone = 2	11/11/96 14:50	0.249	2.0	0.3	1.0	3.3		
	11/20/96 15:08	-0.782	8.4	1.6	0.0	0.6		
	11/22/96 11:31	-0.189	10.3	2.4	0.3	1.0		
	12/4/96 11:22	0.324	11.8	0.0	1.4	1.9		
	12/13/96 11:12	0.050	7.6	1.0	0.8	0.7		water in line
	12/19/96 0:00	0.000						no flow; no sample
	12/27/96 12:54	-0.035	9.2	2.0	0.7	2.0		? low flow
	1/7/97 13:48	-0.012	10.6	0.9	0.5	1.0		
	1/29/97 14:16	-0.187	14.6	0.5	1.3	2.3	6,900	
	3/3/97 12:55	-0.065	19.0	0.0	1.0	1.4	11,400	
	4/2/97 11:24	-0.478	0.3	0.0	1.0	0.0	14,600	
	5/6/97 10:30	-0.112	12.5	3.5	3.7	6.8	7,310	
	6/5/97 9:39	-0.077	31.6	0.4	1.1	2.3	10,800	
	7/8/97 14:53	-0.082	2.8	1.2	1.2	3.6	15,100	

216-Z-1A SITE ZONE 2

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
CPT-4F/33	5/14/96 14:27	0.000	<0.045	<0.095				
red	5/14/96 14:27	0.000	0.1	<0.095				duplicate
depth = 33.2 m	10/31/96 0:00							could not find
zone = 2	11/4/96 10:25	-0.097	0.3	1.0		1.8		
	11/7/96 10:30	-0.286	0.8	0.6	0.9	2.5		
	11/11/96 14:30	0.080	2.3	1.3	0.4	1.1		
	11/20/96 14:53	-0.159	7.4	1.4	0.1	0.5		
	11/22/96 11:18	-0.137	8.0	1.3	0.4	1.0		
	12/4/96 10:57	0.623	10.8	0.0	1.3	1.9		
	12/13/96 10:58	-0.403	12.9	1.5	0.5	0.3		
	12/19/96 13:44	0.209	8.5	0.5	0.7	1.6		
	12/27/96 13:10	-0.015	11.3	0.5	0.7	1.4		
	1/7/97 14:01	-0.007	10.0	0.0	1.2	1.4		
	1/29/97 14:29	0.117	13.0	1.4	0.7	1.1	7,700	
	3/3/97 13:10	-0.060	17.5	1.3	0.0	0.3	13,500	
	4/2/97 11:45	0.122	26.8	0.0	0.8	1.7	15,000	
	5/6/97 10:54	-0.095	13.9	4.2	3.0	4.3	7,540	
	6/5/97 9:23	-0.032	16.1	0.7	1.0	1.7	10,300	
	7/8/97 15:06	0.027	13.0	0.9	0.9	1.2	14,300	
Barometric Pump	10/29/96 7:50	-2.242	11.4	1.7	0.0	0.0		flow = 1.0 m3/min (35 ft3/min)
W18-152	11/11/96 15:00	1.245	16.6	0.8	0.2	2.3		invalid, purge time too short (purged 2 L only)
depth = 31.1 m	11/14/96 13:04	N/A	21.3	0.0	1.5	3.6		
zone = 2	11/27/96 12:55	N/A	16.2	0.3	0.6	1.2		
	12/18/96 10:41	0.110	18.1	0.8	0.6	1.5		
	12/26/96 11:15	0.326	31.6	0.8	0.9	2.1		
	1/6/97 16:22	N/A	24.0	0.3	0.6	1.9		
	1/7/97 16:09	N/A	0.2	0.0	0.7	0.4		
	1/8/97 16:19	N/A	0.2	-0.1	-0.5	-0.3		
	1/9/97 16:24	0.070	30.0	1.0	0.2	0.9		
	1/10/97 12:45	0.130	36.6	1.4	0.5	1.6		
	1/13/97 16:21	0.057	29.1	0.2	0.9	3.1		
	1/14/97 16:16	0.007	28.5	0.7	0.4	2.5		
	1/15/97 16:11	-0.062	0.3	0.5	0.4	0.4		
	1/16/97 16:17	0.015	7.9	0.1	0.5	1.0		
	1/17/97 16:20	0.015	26.6	-0.2	0.4	2.7		
	1/21/97 16:19	0.030	41.9	1.5	-0.3	0.1		
	1/23/97 16:15	-0.112	0.2	0.3	0.2	-0.3		
	1/24/97 16:06	-0.022	0.1	0.1	0.4	-0.3		
	1/27/97 16:31	0.134	29.9	0.8	0.3	1.0	9,270	
	1/28/97 16:23	-0.142	0.1	0.4	0.3	0.1	8,120	
	2/3/97 16:17	-0.020	1.8	1.3	-0.2	-1.4	8,990	
	2/4/97 16:21	0.007	4.2	0.3	0.1	-0.5	9,230	
	2/5/97 16:12	-0.015	13.3	1.0	-0.3	0.1	8,150	
	2/6/97 16:21	0.057	25.7	0.5	0.1	1.7	8,770	
	2/10/97 10:17	0.027	43.8	0.3	0.5	2.8	6,380	
	2/11/97 13:50	0.384	35.2	0.8	0.0	0.6	8,090	
	2/13/97 16:17	-0.005	32.0	2.3	-0.5	-1.5	8,060	
	2/18/97 16:21	0.142	27.3	1.2	-0.2	0.3	10,900	
	2/19/97 16:25	-0.232	0.1	-0.4	0.2	0.1	6,280	
	2/21/97 16:11	0.020	0.2	1.0	-0.2	-1.4	11,200	
	2/25/97 13:24	0.356	24.7	0.5	0.5	1.3	10,700	
	2/26/97 14:28	0.396	39.6	1.0	0.6	0.9	13,450	duplicates averaged
	2/27/97 12:36	-0.040	38.1	2.2	0.0	0.0	8,270	
	2/28/97 16:11	0.015	17.4	1.6	-0.5	-1.4	11,600	
	3/3/97 9:50	-0.172	13.0	1.0	0.0	0.0	10,900	
	3/4/97 12:40	-0.110	15.3	0.6	0.0	0.0	10,700	
	4/2/97 14:09	0.244	28.9	1.6	0.0	0.0	21,250	duplicates averaged
	4/3/97 9:12	0.443	40.7	0.4	0.4	1.1	13,400	
	4/17/97 11:50	0.062	44.7	0.5	0.8	2.5	15,200	
	4/30/97 11:12	0.112	46.8	0.7	0.5	2.2	10,200	
	6/17/97 9:48	0.087	39.3	0.8	1.3	3.8	13,400	

CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform
MEK = Methyl Ethyl Ketone
CH2Cl2 = Methylene Chloride

216-Z-1A SITE ZONE 3

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W18-89	10/29/96 8:00	-3.238	20.8	0.0	1.1	0.0		flow = 3.4 m3/min (120 ft3/min)
depth = 35.1 m	11/6/96 10:47	0.082	7.7	0.0	1.4	4.4		
zone = 2-3	11/8/96 12:48	0.072	5.7	5.2	3.6	2.0		
	11/11/96 13:50	0.085	14.8	1.4	0.8	3.0		
	11/19/96 11:25	0.344	25.0	5.4	4.8	0.0		
	11/21/96 10:46	-0.017	19.4	3.7	1.0	0.6		
	11/21/96 14:17	0.097	20.4	2.4	0.6	2.2		
	11/22/96 10:16	-0.162	21.3	3.2	0.4	1.8		
	11/22/96 13:37	-0.209	21.5	0.3	1.2	2.8		
	11/25/96 10:12	-0.326	9.7	0.8	1.7	4.4		
	11/25/96 13:26	-0.229	9.4	0.7	1.2	2.8		
	11/26/96 10:35	-0.229	8.6	0.7	2.4	5.1		
	12/3/96 9:15	-0.346	19.1	0.7	1.6	3.1		
	12/3/96 13:48	-0.227	16.8	2.8	0.0	1.9		
	12/4/96 9:22	0.446	23.8	2.4	1.4	2.5		
	12/4/96 13:20	0.827	18.8	0.7	0.3	2.7		
	12/9/96 10:01	0.130	23.3	0.3	1.0	3.0		
	12/13/96 10:05	-0.386	19.9	0.2	1.0	3.5		
	12/13/96 13:19	-0.413	17.5	1.9	0.1	1.6		
	12/16/96 9:20	-0.436	13.3	0.5	0.8	3.6		
	12/16/96 13:10	-0.294	12.6	0.9	0.3	2.8		
	12/18/96 10:31	0.127	15.9	0.6	0.6	3.9		
	12/19/96 10:15	0.139	13.1	0.4	0.9	3.2		
	12/19/96 13:54	0.386	13.9	1.1	0.2	2.1		
	12/23/96 9:15	-0.518	22.0	1.4	0.2	1.1		
	12/23/96 12:45	-0.349	22.7	0.0	0.2	1.6		
	12/26/96 9:35	0.381	21.4	0.5	0.9	3.2		duplicates averaged
	12/27/96 9:43	0.179	23.2	0.8	0.6	2.3		
	12/27/96 13:50	-0.100	25.4	0.8	0.5	2.3		
	12/31/96 13:15	0.087	24.8	0.5	0.9	3.2		
	1/2/97 12:35	-0.005	28.3	0.8	0.4	2.4		
	1/2/97 15:20	-0.075	28.9	1.0	0.2	1.8		
	1/3/97 13:12	-0.453	27.6	0.9	0.5	2.0		
	1/6/97 14:07	0.234	20.5	0.1	0.8	3.7		
	1/7/97 11:45	-0.022	21.4	0.5	0.4	2.8		
	1/13/97 13:15	0.097	24.6	1.0	0.8	2.7		duplicates averaged
	1/27/97 10:15	-0.057	22.4	0.0	1.0	4.0	4,800	
	1/27/97 14:54	0.097	22.2	0.4	0.0	1.5	8,100	
	1/29/97 9:40	0.047	22.4	0.4	1.5	4.9	6,200	
	1/29/97 15:20	0.110	22.4	1.9	0.1	2.2	11,800	
	2/10/97 10:41	0.055	25.6	0.1	0.8	4.0	6,400	
	2/24/97 10:48	0.077	22.5	0.0	0.7	3.8	7,820	
	2/26/97 13:05	0.570	28.1	0.7	0.4	2.1	11,950	duplicates average
	2/27/97 13:24	0.000	31.3	0.6	0.6	2.3	10,200	
	3/3/97 10:25	-0.199	33.3	0.0	0.0	2.0	9,870	
	3/17/97 11:47	-0.660	35.9	0.0	1.4	3.0	16,300	
	4/2/97 11:06	0.075	31.0	0.8	0.8	3.6	7,270	
	4/17/97 11:20	0.002						no data recorded
	5/6/97 12:44	-0.085	36.4	2.3	1.7	4.7	9,700	
	5/19/97 11:48	0.356	42.1	2.4	0.8	2.4	9,980	
	6/5/97 10:19	-0.050	47.3	0.9	1.0	4.4	10,600	
	6/16/97 10:18	-0.144	48.3	0.8	0.9	3.2	11,800	
	6/19/97 7:47	-0.157	19.9	1.5	0.7	1.2	12,700	
	6/19/97 13:01	0.117	21.2	1.3	0.4	1.7	26,500	
	6/20/97 8:50	-0.027	18.1	1.1	0.4	1.8	11,100	duplicates averaged
	6/20/97 12:49	0.142	27.3	3.2	0.0	0.1	16,000	
	6/23/97 10:47	-0.115	19.8	2.1	0.0	0.0	13,700	
	6/23/97 14:37	-0.062	23.4	1.0	0.5	2.4	14,400	
	6/24/97 9:22	-0.060	24.7	1.8	0.8	0.6	9,960	
	6/25/97 13:21	0.259	31.2	3.0	0.4	0.2	12,000	
	6/26/97 10:11	-0.095	6.8	1.7	0.0	0.0	10,600	
	6/30/97 15:37	0.015	36.5	2.8	0.1	0.0	15,350	duplicates averaged

216-Z-1A SITE ZONE 3

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W18-89	7/1/97 16:28	0.012	32.5	2.8	0.0	0.0	18,200	duplicates averaged
depth = 35.1 m	7/2/97 16:15	0.052	34.6	3.1	0.0	0.0	17,900	duplicates averaged
zone = 2-3	7/7/97 9:11	-0.092	24.8	1.6	0.3	1.2	12,400	
(continued)	7/8/97 15:41	0.075	39.1	0.3	0.9	3.8	15,250	duplicates averaged
W18-252U	10/29/96 8:20	-4.483	10.4	0.0	0.0	0.0		flow = 10.8 m3/min (380 ft3/min)
depth = 36.0 m	11/6/96 10:57	0.067	17.4	1.7	1.7	0.2		
zone = 3	11/7/96 10:12	-0.316	22.3	1.9	0.3	0.0		
	11/8/96 13:08	0.065	15.9	3.0	1.4	0.2		duplicates averaged
	11/11/96 14:20	0.090	18.2	2.3	0.0	0.0		
	11/20/96 14:45	-0.214	18.1	2.3	0.0	0.0		
	11/22/96 10:58	-0.152	19.8	2.3	1.2	0.0		
	12/4/96 10:50	0.613	23.0	1.0	1.0	0.9		
	12/13/96 10:47	-0.443	27.4	1.3	1.2	0.6		
	12/19/96 13:10	0.374	25.8	1.4	0.4	0.2		
	12/27/96 13:15	-0.012	25.1	1.9	1.1	0.4		
	1/7/97 14:05	-0.030	32.9	1.9	0.8	0.5		
	1/13/97 13:05	0.095	33.9	0.0	1.0	1.6		
	1/29/97 14:32	0.157	38.7	2.1	1.0	1.0	9,300	
	2/10/97 10:31	0.037	36.0	0.0	1.4	7.2	6,700	
	3/3/97 13:15	-0.147	22.3	0.4	0.6	0.7	14,400	
	3/17/97 11:55	-0.403	34.8	1.1	1.0	1.7	15,100	
	4/2/97 11:51	0.125	43.7	0.3	0.7	0.0	24,900	
	4/17/97 11:30	-0.017	43.4	0.2	1.3	1.5	14,500	
	5/6/97 9:56	-0.110	34.4	2.4	1.8	3.2	8,070	duplicates averaged
	5/19/97 11:58	0.359	43.7	1.3	0.8	0.5	10,500	
	6/5/97 9:07	-0.184	44.1	1.7	0.8	0.4	10,200	duplicates averaged
	6/16/97 10:05	-0.169	46.2	0.9	0.4	1.4	11,300	
	7/8/97 14:35	0.060	52.6	0.4	0.7	1.8	13,100	duplicates averaged
	10/29/96 9:40	-0.996	0.0	0.0	0.0	0.0		flow = 0 m3/min (0 ft3/min); CCl4 result not representative
W18-174	11/6/96 11:40	0.080	2.0	7.6	6.2	0.0		very tight; CCl4 result not representative, excluded
depth = 36.9 m	11/8/96 13:23	0.209	7.7	12.9	9.7	0.0		CCl4 result not representative, excluded from analysis
zone = 3	11/12/96 9:15	0.125	5.3	6.1	5.8	0.5		tight; CCl4 result not representative, excluded
	11/13/96 13:40	0.100	154.8	2.8	0.9	1.1		High A calculated; note (a)
	11/19/96 11:21	0.344	302.4	3.7	0.0	2.8		High A calculated
	11/22/96 10:14	-0.164	397.2	5.7	0.5	2.8		High A calculated
	12/4/96 13:15	0.807	424.8	5.6	1.0	3.5		High A calculated
	12/13/96 13:14	-0.423	324.0	3.5	0.6	2.3		High A calculated
	12/19/96 11:14	0.229	402.0	4.5	0.1	2.6		High A calculated
	12/26/96 11:00	0.374	470.4	5.5	0.0	3.0		High A calculated
	12/27/96 10:44	0.122	573.0	6.3	0.0	4.4		High A calculated; duplicates averaged
	1/3/97 13:05	-0.466	424.8	4.4	0.1	5.2		High A calculated
	1/6/97 14:15	0.242	260.4	2.7	0.2	3.2		High A calculated
	1/7/97 13:05	-0.134	328.8	2.5	0.2	3.0		High A calculated
	1/10/97 11:58	0.157	445.2	3.8	0.3	4.9		High A calculated
	1/13/97 12:58	0.085	371.0	3.6	0.0	3.0		High A
	1/29/97 10:31	0.077	281.0	5.1	0.3	2.5	18,150	High A; duplicates averaged
	2/10/97 11:49	0.127	454.0	3.3	0.6	5.0	7,400	High A
	2/25/97 14:25	0.179						no flow
	2/27/97 12:50	0.002	348.0	2.0	0.3	3.4	8,525	High A; duplicates averaged; adjusted tubing up 3 ft
	3/3/97 10:15	-0.209	41.7	0.9	0.5	1.5	9,345	duplicates averaged; CCl4 not representative (note b)
	3/11/97 11:05		457.0	4.3	0.3	3.8	10,000	High A
	3/17/97 11:39	-0.471	320.0	1.3	0.7	1.6	9,250	High A
	4/2/97 10:56	0.067	170.5	2.0	0.5	3.1	6,800	High A; duplicates averaged
	4/3/97 9:49	0.491	379.0	3.7	0.3	2.9	13,150	High A; duplicates averaged
	4/17/97 11:15	-0.017	505.5	3.1	0.8	4.2	16,400	High A; duplicates averaged
	4/30/97 10:23	0.117	394.0	2.9	0.3	4.0	9,030	High A
	5/6/97 12:57	-0.067	425.0	3.3	0.3	5.1	12,400	High A

216-Z-1A SITE ZONE 3

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W18-174	5/19/97 12:26	0.369	519.0	4.1	0.0	4.0	12,100	High A
depth = 36.9 m	6/5/97 10:14	-0.052	462.0	3.4	0.1	4.8	10,500	High A
zone = 3	6/16/97 10:34	-0.152	504.0	3.2	0.2	4.6	11,700	High A
(continued)	7/8/97 15:34	0.062	479.0	3.5	0.0	4.8	16,500	High A
W18-167	10/29/96 9:31	-2.989	18.9	0.0	1.8	0.0		flow = 3.5 m3/min (122 ft3/min)
depth = 38.4 m	11/6/96 11:15	0.125	300.0	3.5	1.6	3.9		High A calculated
zone = 2-3	11/8/96 13:20	0.060	322.8	8.6	4.8	3.5		High A calculated
	11/12/96 9:10	-0.127	234.0	2.0	1.3	3.5		High A calculated
	11/13/96 13:50	0.102	194.4	3.0	0.8	3.5		High A calculated
	11/19/96 11:18	0.341	160.8	4.7	1.0	1.8		High A calculated
	11/22/96 10:12	-0.164	204.0	4.5	1.3	1.2		High A calculated
	12/4/96 13:12	0.795	233.4	2.8	1.3	3.3		High A calculated; duplicates averaged
	12/13/96 13:12	-0.399	259.2	2.6	0.8	3.2		High A calculated
	12/19/96 11:10	0.192	260.4	2.6	0.6	2.4		High A calculated
	12/27/96 10:39	0.130	242.4	2.6	0.6	2.2		High A calculated
	1/3/97 13:00	-0.638	244.8	2.4	0.8	4.4		High A calculated
	1/6/97 14:10	0.222	271.2	3.0	0.7	3.3		High A calculated
	1/7/97 13:00	-0.130	302.4	2.9	0.8	3.3		High A calculated
	1/10/97 11:50	0.147	235.2	2.2	0.3	3.0		High A calculated
	1/13/97 12:55	0.075	230.0	2.5	0.4	3.3		High A
	1/29/97 10:26	0.070	181.0	3.0	1.2	1.9	16,800	High A
	2/10/97 11:45	0.117	220.0	2.2	0.4	3.6	7,500	High A
	2/27/97 12:45	-0.010	282.0	4.3	2.0	4.9	8,525	High A; duplicates averaged
	3/3/97 10:10	-0.199	201.0	1.9	0.6	3.2	10,300	High A
	3/11/97 11:00		216.0	2.1	0.4	3.6	10,200	High A; CH4 = 75 ppm
	3/17/97 11:34	-0.376	231.0	1.6	0.9	4.3	9,840	High A; duplicates averaged
	4/2/97 10:48	0.065	241.0	3.4	0.4	3.5	6,530	High A; duplicates averaged
	4/3/97 9:40	0.528	248.0	2.6	0.5	3.5	12,600	High A; duplicates averaged
	4/17/97 11:10	-0.020	217.0	2.5	0.7	4.1	16,250	High A; duplicates averaged
	4/30/97 10:32	0.117	206.0	1.1	0.7	4.5	8,920	High A
	5/6/97 12:52	-0.060	246.0	2.7	1.1	3.9	9,900	High A
	5/19/97 12:22	0.359	262.0	2.8	0.3	2.2	12,000	High A
	6/5/97 10:10	-0.052	272.0	2.4	0.6	4.3	10,500	High A
	6/16/97 10:24	-0.147	237.0	2.2	1.1	5.0	11,500	High A
	7/8/97 15:30	0.070	247.0	2.0	0.9	4.4	16,300	High A
W18-248	10/29/96 9:05	-5.978	8.4	0.0	0.0	0.0		flow = 0.5 m3/min (19 ft3/min)
depth = 40.2 m	11/6/96 13:18	0.269	48.2	1.1	1.3	1.7		
zone = 3	11/8/96 11:15	-0.017	56.2	2.2	1.5	0.2		
	11/12/96 9:25	-0.194	133.2	3.0	1.5	1.5		High A calculated
	11/15/96 13:04	0.222	105.0	1.1	1.5	3.2		
	11/19/96 11:01	0.583	142.8	9.3	6.2	0.4		High A calculated
	11/22/96 9:49	-0.164	99.5	4.5	1.0	0.5		
	11/26/96 10:38	-0.264	57.6	1.4	2.0	2.5		
	12/3/96 9:12	-0.476	151.2	2.0	1.6	2.4		High A calculated
	12/9/96 9:54	0.199	145.2	2.3	0.4	1.7		High A calculated
	12/13/96 10:12	-0.493	144.0	2.5	0.4	0.8		High A calculated
	12/19/96 10:42	0.204	82.9	1.9	1.2	1.2		
	12/27/96 9:53	0.391	145.2	1.2	1.1	2.5		High A calculated
	12/27/96 13:32	0.087	151.2	2.5	0.0	1.8		High A calculated
	1/2/97 10:09	-0.112	220.8	2.8	1.6	3.5		High A calculated
	1/2/97 15:18	-0.105	226.8	2.1	0.4	2.6		High A calculated
	1/3/97 13:24	-0.682	154.8	2.0	0.1	0.8		High A calculated
	1/6/97 14:22	0.321	146.4	1.5	0.4	2.3		High A calculated
	1/7/97 11:05	-0.077	175.2	1.2	0.5	2.5		High A calculated
	1/13/97 11:35	0.047	198.0	0.8	0.9	2.8		High A
	1/27/97 10:22	-0.301	143.0	2.5	0.9	1.9	5,700	High A
	1/27/97 15:03	0.035	144.0	2.1	0.5	0.0	17,100	High A calculated
	1/29/97 9:48	0.027	170.0	1.4	2.5	3.4	5,800	High A
	2/10/97 10:51	0.070	174.0	1.3	0.6	2.2	7,200	High A
	2/24/97 10:57	-0.030	154.0	1.6	0.2	1.5	8,600	High A
	2/26/97 14:48	0.817	175.0	2.4	1.1	0.6	12,600	High A
	2/27/97 13:18	0.095	188.0	1.8	0.5	1.9	9,020	High A

216-Z-1A SITE ZONE 3

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W18-248	3/3/97 9:58	-0.339	183.0	0.9	1.0	2.7	9,440	High A
depth = 40.2 m	3/11/97 11:15		162.0	2.2	0.2	0.8	10,100	High A
zone = 3	3/17/97 10:43	-0.991	178.0	2.1	0.8	2.8	11,100	High A
(continued)	4/2/97 10:16	-0.077	148.0	1.9	0.9	2.1	6,570	High A
	4/17/97 11:00	-0.095	202.5	2.5	0.4	2.0	17,150	High A; duplicates averaged
	5/6/97 12:33	-0.107	206.0	4.8	2.5	3.8	9,400	High A
	5/19/97 11:40	0.483	194.0	3.4	1.2	2.7	9,060	High A
	6/5/97 10:04	-0.139	231.0	1.4	0.6	3.3	10,700	High A
	6/16/97 10:42	-0.224	288.0	1.8	0.7	3.7	11,800	High A
	7/8/97 15:26	0.100	260.0	1.8	4.1	3.0	14,300	High A
Barometric Pump	10/29/96 9:27	-2.491	2.8	1.3	0.0	0.0		flow = 0.8 m3/min (29 ft3/min)
W18-168	11/13/96 13:51	N/A	8.5	1.5	1.1	3.9		questionable; purge time too short
depth = 32.9 m	12/18/96 11:06	0.144	9.1	1.4	1.2	3.9		
zone = 2-3	12/26/96 10:55	0.359	49.2	0.3	0.8	2.8		
	1/10/97 11:52	0.115	60.5	0.9	0.8	2.9		
	2/25/97 14:15	0.296	53.8	0.7	0.4	2.4	11,050	duplicates averaged
	4/3/97 9:43	0.456	84.2	1.2	0.3	1.6	16,000	
	4/30/97 10:40	0.115	76.7	0.5	0.6	3.1	9,170	duplicates averaged
	6/17/97 9:21	0.082	69.0	2.0	0.8	4.6	12,800	
W18-169	10/29/96 9:20	-3.487	0.0	0.0	0.0	0.0		flow = 3.7 m3/min (132 ft3/min)
depth = 32.9 m	11/13/96 13:56	N/A	6.6	2.6	0.1	0.8		questionable; purge time too short
zone = 2-3	12/18/96 11:04	0.139	8.0	0.9	0.2	0.6		
	12/26/96 10:50	0.366	9.9	0.1	0.9	2.1		
	1/10/97 11:54	0.147	15.8	0.6	0.7	2.1		
	2/25/97 14:18	0.341	14.0	0.1	0.8	1.6	11,250	duplicates averaged
	4/3/97 9:46	0.508	17.6	0.6	0.4	0.8	16,200	
	4/30/97 10:47	0.120	21.0	0.2	0.6	3.3	9,280	
	6/17/96 9:26	0.087	21.2	1.2	0.9	4.0	13,100	
W18-96	10/29/96 0:00							not on-line
depth = 39.0 m	11/14/96 11:36	N/A	24.7	0.0	1.2	0.0		
zone = 3	12/18/96 14:11	0.257	24.6	1.0	0.1	0.0		duplicates averaged
	12/27/96 9:35	0.219	48.2	0.2	0.9	0.3		
	1/10/97 13:10	0.149	38.8	0.6	0.8	2.5		
	2/25/97 13:52	0.399	65.5	0.6	0.8	0.7	10,200	
	4/3/97 9:24	0.585	49.5	0.3	0.5	0.5	14,100	
	4/30/97 12:06	0.167	38.3	0.9	0.7	0.9	13,500	
	6/17/97 8:52	0.072	68.0	1.6	1.1	1.6	11,900	
W18-249	10/29/96 0:00							not on-line
depth = 39.9 m	11/11/96 15:35	0.067	0.0	0.9	0.4	0.3		invalid, purge time too short (purged 2 L only)
zone = 3	11/14/96 11:39	N/A	13.5	2.0	0.0	0.0		
	11/14/96 13:37	N/A	17.1	1.4	0.0	0.0		Re-sample
	11/27/96 13:00	N/A	23.2	1.0	0.3	0.0		
	12/18/96 13:50	0.294	26.3	0.7	0.6	0.0		
	12/26/96 11:30	0.361	104.0	0.2	0.7	0.9		
	1/10/97 13:20	0.172	86.3	1.2	0.4	0.0		
	2/25/97 14:01	0.389	194.0	0.7	0.5	0.8	11,000	High A
	4/3/97 9:33	0.600	206.0	1.6	0.0	0.0	13,700	High A
	4/30/97 12:00	0.162	98.7	1.4	0.2	0.2	11,900	
	6/17/97 9:05	0.082	84.6	1.1	0.8	1.4	11,400	

(a) sample screen was in water in well bottom; pulled tubing up about 8 ft; gas samples collected 1.5 ft above bottom.
(b) air leak where tube exited cap, discovered 3/11
CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform
MEK = Methyl Ethyl Ketone
CH2Cl2 = Methylene Chloride

216-Z-1A SITE ZONE 4

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W18-252SST/44	10/31/96 9:20	-0.249						
blue	11/7/96 10:08	-0.012	87.3	1.1	0.8	0.6		very tight
depth = 44.2 m	11/11/96 14:05	0.050	93.8	3.1	0.7	1.6		tight
zone = 4	11/20/96 14:44	-1.034	32.8	0.0	1.8	1.3		
	11/22/96 11:09	-0.102	76.9	0.6	1.2	0.6		
	12/4/96 10:54	0.762	55.4	0.0	1.7	2.5		
	12/13/96 10:50	-0.685	32.3	0.6	0.9	0.2		
	12/19/96 13:16	0.730	52.4	1.2	0.7	0.3		duplicates averaged
	12/27/96 13:23	0.800	89.0	1.5	0.2	0.8		
	1/7/97 14:12	-0.095	33.7	1.3	0.7	0.0		
	1/13/97 13:09	0.072	53.2	0.7	0.7	1.0		
	1/29/97 14:39	-0.015	40.2	0.8	1.3	0.9	8,500	
	2/10/97 10:34	0.112	60.9	0.0	1.1	2.2	7,700	
	3/3/97 13:20	-0.538	39.2	0.5	0.8	0.2	15,100	
	3/17/97 12:07	-0.874	38.7	0.9	0.5	0.7	21,100	
	4/2/97 11:59	-0.441	33.7	0.4	0.6	0.0	17,900	
	4/17/97 11:45	-0.204	23.2	0.8	0.7	0.3	13,800	
	5/6/97 10:17	-0.137	17.4	1.6	0.5	0.0	7,500	
	5/19/97 11:55	0.737	55.6	1.1	0.4	0.0	10,100	
	6/5/97 9:16	-0.374	25.3	2.0	0.4	0.0	10,300	
	6/16/97 10:13	-0.299	46.6	0.9	0.6	1.0	11,400	
	7/8/97 14:44	0.110	51.7	0.2	1.0	2.2	12,900	
Barometric Pump	10/29/96 0:00							not on-line
W18-247L	11/11/96 15:32	0.187	0.2	0.8	1.1	0.9		invalid, purge time too short (purged 2 L only)
depth = 50.9 m	11/14/96 11:50	N/A	1.5	0.0	0.0	0.0		
zone = 4-5	12/5/96 9:53	N/A	1.0	0.5	0.6	0.3		
	12/18/96 14:05	0.431	0.3	1.1	0.5	0.0		
	12/26/96 11:45	1.151	1.1	0.5	0.6	0.5		
	1/10/97 12:55	0.403	2.1	0.5	1.1	1.6		
	2/25/97 13:45	1.093	2.7	0.7	1.0	1.0	9,960	
	4/3/97 9:18	1.382	1.4	0.7	0.9	1.5	12,100	
	4/30/97 11:55	0.356	1.0	4.2	2.3	1.3	11,800	
	6/17/97 10:06	0.187	2.5	2.4	1.4	1.2	13,750	duplicates averaged

CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform
MEK = Methyl Ethyl Ketone
CH2Cl2 = Methylene Chloride

216-Z-1A SITE ZONE 5

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
Barometric Pump	10/29/96 8:17	-8.967	14.6	0.0	0.0	0.0		flow = 14.2 m3/min (502 ft3/min)
W18-252L	11/11/96 14:25	0.112	0.3	0.0	1.0	0.6		invalid, purge time too short (purged 2 L only)
depth = 53.0 m	11/14/96 12:49	N/A	18.7	0.0	0.0	0.0		
zone = 5	12/5/96 9:46	N/A	21.0	1.8	0.0	0.0		
	12/18/96 14:22	0.311	30.0	0.2	0.7	0.7		
	12/26/96 11:35	0.787	28.4	0.0	1.3	2.7		
	1/7/97 14:15	-0.045	0.5	0.1	0.7	0.3		note negative DP
	1/10/97 12:15	0.249	21.2	0.9	0.3	0.3		
	2/25/97 13:38	0.745	0.7	0.5	0.5	0.0	10,700	
	4/3/97 9:08	0.956	45.9	1.0	0.6	0.0	10,900	
	4/30/97 11:42	0.242	42.3	0.7	0.4	0.6	11,500	
	6/17/97 9:43	0.120	47.7	0.9	1.0	1.6	12,700	

CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform
MEK = Methyl Ethyl Ketone
CH2Cl2 = Methylene Chloride

216-Z-1A SITE ZONE 6

Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W18-7	10/29/96 9:07	-2.989	0.0	0.0	0.0	0.0		flow = 2.8 m3/min (100 ft3/min)
depth = 61.9 m	11/6/96 13:15	0.448	13.0	2.9	1.7	0.5		
zone = 5-6	11/8/96 11:12	-0.110	15.1	4.2	2.5	0.8		
	11/12/96 9:20	-0.324	14.7	2.1	1.1	1.2		
	11/15/96 13:07	0.481	18.0	1.8	0.0	0.9		
	11/19/96 11:03	0.872	16.7	2.9	0.0	0.0		
	11/19/96 13:30	0.932	17.2	1.2	0.9	1.0		duplicates averaged
	11/21/96 10:53	-0.262	10.8	2.3	2.4	1.5		
	11/21/96 14:21	-0.097	11.2	0.6	1.8	2.8		duplicates averaged
	11/22/96 9:50	-0.100	12.8	0.9	1.4	2.7		
	11/22/96 13:33	-0.279	12.3	0.8	0.8	1.9		
	11/25/96 10:15	-0.892	14.4	2.0	1.3	2.4		
	11/25/96 13:40	-0.867	16.4	0.6	1.1	2.8		
	11/26/96 10:40	-0.777	17.6	0.8	2.2	3.6		
	12/3/96 9:10	-0.575	16.1	1.7	1.3	1.3		
	12/3/96 13:56	-0.643	17.2	2.0	0.4	1.4		
	12/4/96 9:28	0.443	16.2	1.5	0.8	1.6		
	12/4/96 13:26	1.377	17.9	1.3	0.4	1.3		
	12/9/96 9:56	0.384	18.6	1.0	0.4	1.7		
	12/13/96 10:15	-0.645	13.2	4.0	0.9	0.8		
	12/13/96 13:08	-0.859	13.6	1.8	0.4	0.3		
	12/16/96 9:25	-0.984	16.2	1.7	0.5	1.5		
	12/16/96 13:15	-0.961	18.6	1.1	0.5	1.5		
	12/18/96 11:16	0.264	18.1	1.8	0.6	1.7		
	12/19/96 10:40	0.421	19.4	1.1	1.2	2.1		
	12/19/96 13:58	0.785	19.9	1.4	0.4	0.4		
	12/23/96 9:24	-0.991	21.9	2.2	0.2	0.3		
	12/23/96 12:50	-0.951	23.1	1.4	0.7	0.2		
	12/26/96 9:50	1.054	19.1	2.8	1.1	2.3		
	12/27/96 9:50	1.166	21.9	1.1	0.3	1.7		
	12/27/96 13:30	0.809	24.9	0.5	0.7	2.1		
	12/31/96 11:49	0.042	22.2	1.0	0.6	1.7		
	1/2/97 10:05	-0.162	18.7	0.7	1.5	2.1		
	1/2/97 15:15	-0.162	20.6	0.7	1.0	2.6		
	1/3/97 13:18	-1.066	19.6	1.0	0.4	2.0		
	1/6/97 14:20	0.120	18.7	0.8	0.5	3.6		
	1/7/97 11:02	-0.077	17.2	0.6	0.4	2.3		
	1/13/97 11:33	0.010	19.4	0.1	0.7	3.0		
	1/27/97 10:20	-1.056	22.3	2.4	0.4	1.8	6,800	
	1/27/97 14:59	-0.745	21.7	1.4	0.7	0.3	7,800	
	1/29/97 9:45	-0.301	20.1	2.3	1.7	3.0	5,900	
	1/29/97 14:45	-0.025	20.7	0.6	1.1	2.9	8,300	
	2/10/97 10:48	0.120	21.5	0.0	1.1	3.2	7,400	
	2/24/97 10:54	-0.267	23.4	1.0	0.2	2.0	8,030	
	2/26/97 14:45	1.761	24.4	1.4	0.0	1.4	14,600	
	2/27/97 13:15	0.735	28.5	0.3	0.9	2.1	9,820	
	3/3/97 9:55	-0.643	24.3	0.5	0.9	1.6	11,400	
	3/17/97 10:39	-0.922	25.3	0.7	0.9	2.1	11,100	
	4/2/97 10:12	-0.690	22.3	8.1	3.6	5.4	6,310	
	4/17/97 10:55	-0.296	28.3	0.6	0.9	2.6	17,600	
	5/6/97 12:24	-0.164	20.9	3.8	2.5	4.4	10,165	duplicates averaged
	5/19/97 11:35	0.787	25.6	2.1	1.0	1.8	10,800	
	6/5/97 10:01	-0.326	24.9	1.5	1.1	2.1	10,600	
	6/16/97 10:39	-0.339	25.4	1.0	0.7	2.3	12,400	
	7/8/97 15:23	0.169	25.8	1.1	1.3	3.5	15,500	

216-Z-1A SITE ZONE 6

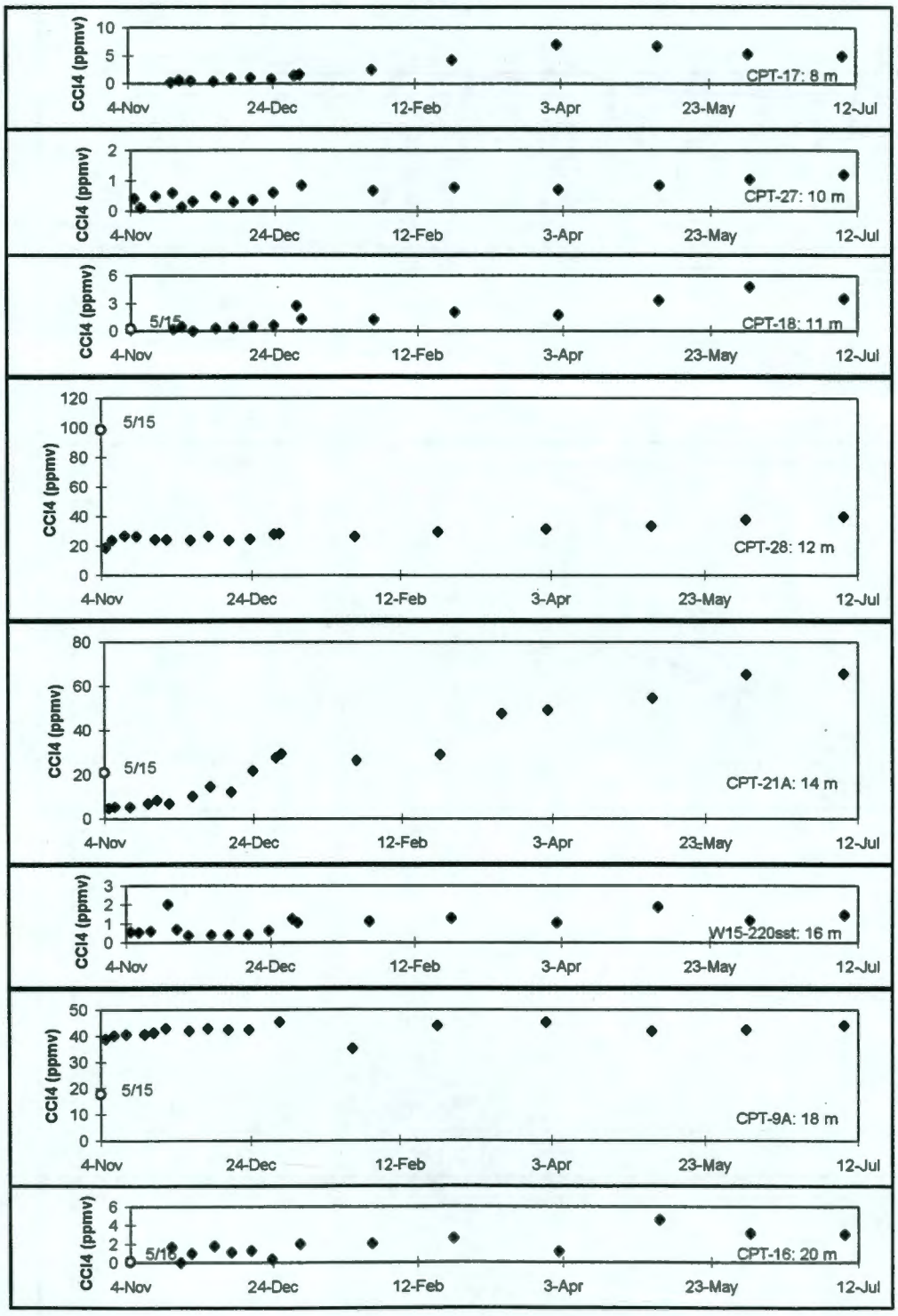
Sample Location	Sample Date/Time	Differential Pressure (kPa)	CCl4 (ppmv)	CHCl3 (ppmv)	MEK (ppmv)	CH2Cl2 (ppmv)	Water (ppmv)	Comment
W18-252SST/64	10/31/96 9:20	-0.199						
yellow	11/7/96 10:05	-0.107	9.5	0.6	0.9	0.0		
depth = 64.0 m	11/11/96 14:10	-0.010	19.7	1.0	0.7	0.2		
zone = 5	11/20/96 14:43	-0.999	18.1	1.1	0.3	0.2		
1 m above zone 6	11/22/96 11:07	-0.012	0.5	0.4	1.0	1.5		
	12/4/96 10:53	0.446						no sample; line frozen
	12/13/96 10:49	-0.685	15.3	1.7	0.2	0.0		
	12/19/96 13:14	0.548	25.3	1.0	0.6	0.8		
	12/27/96 13:20	0.364	29.0	0.4	0.7	1.5		
	1/7/97 14:10	-0.092	29.7	0.5	0.7	1.5		
	1/13/97 13:07	0.067	31.3	0.0	1.3	1.8		
	1/29/97 14:37	-0.010	31.9	1.5	0.8	0.8	8,500	
	2/10/97 10:37	0.090	37.2	0.0	1.5	4.0	7,300	
	3/3/97 13:18	-0.540	31.0	0.4	0.8	0.8	12,500	
	3/17/97 12:03	-0.874	27.1	1.9	0.1	0.1	19,100	
	4/2/97 11:56	-0.436	36.4	0.4	0.7	0.5	18,600	
	4/17/97 11:40	-0.212	26.8	0.0	1.5	1.4	15,100	
	5/6/97 10:12	-0.147	20.4	1.8	0.7	0.0	7,360	
	5/19/97 11:52	0.760	43.4	1.8	0.2	0.0	11,600	
	6/5/97 9:13	-0.369	35.6	1.4	0.6	0.4	10,300	
	6/16/97 10:10	-0.309	37.7	0.5	0.8	1.4	11,500	
	7/8/97 14:41	0.137	47.2	1.7	0.5	1.1	13,700	
Barometric Vent	10/29/96 8:07	-3.487	15.8	0.0	0.0	0.0		flow = 2.4 m3/min (83 ft3/min)
W18-6L	11/14/96 13:11	N/A	15.1	0.0	0.0	1.6		
depth = 61.0 m	11/27/96 13:17	N/A	20.4	0.3	0.4	1.1		
zone = 5-6	12/5/96 10:00	N/A	16.2	1.0	0.6	0.4		
	12/18/96 13:57	0.433	28.9	0.0	0.7	1.8		
	12/26/96 9:42	1.026	28.7	0.4	0.7	0.9		
	1/10/97 12:20	0.374	25.0	2.1	0.9	0.0		
	2/25/97 14:09	1.034	26.4	1.0	0.4	1.6	11,800	
	4/3/97 9:39	1.335	23.1	3.2	0.5	1.6	13,500	
	4/30/97 10:57	0.299	22.3	2.2	0.7	3.8	10,000	
	6/17/97 9:36	0.162	36.0	0.7	1.3	4.5	13,000	
W18-1	10/29/96 0:00							not on-line
depth = 63.1 m	11/14/96 13:20	N/A	7.8	0.0	1.0	0.0		
zone = 5-6	12/5/96 9:35	N/A	13.4	1.2	0.3	0.0		well not completely sealed
	12/18/96 10:58	N/A	0.3	0.0	0.0	0.0		well not completely sealed?; questionable
	12/19/96 10:36	N/A	1.8	0.6	0.6	0.0		resample from 12/18/96
	12/26/96 11:25	N/A	1.7	1.7	0.0	0.0		
	1/10/97 12:10	0.304	3.1	0.8	0.4	0.2		
	2/25/97 13:19	0.630	7.2	0.1	0.7	0.7	9,110	
	4/3/97 9:00	0.785	3.4	0.5	0.4	0.0	12,300	
	4/30/97 11:06	0.137	12.0	0.2	0.6	0.6	9,850	
	6/17/97 10:00	0.072	0.6	0.5	0.8	1.4	11,800	well never completely sealed during rebound study
W18-2	10/29/96 0:00							not on-line
depth = 63.1 m	11/14/96 13:17	N/A	4.4	1.4	0.0	0.0		
zone = 5-6	12/5/96 10:15	N/A	6.5	1.6	0.1	0.0		
	12/18/96 0:00							well maintenance prevented sampling
	12/19/96 10:38	N/A	3.9	1.1	0.1	0.0		
	12/26/96 11:20	N/A	3.2	0.4	0.7	0.6		
	1/10/97 12:35	N/A	5.3	0.0	1.2	1.4		
	2/25/97 13:30	N/A	5.7	0.0	1.1	1.1	8,590	
	4/3/97 9:03	0.344	5.5	0.0	1.3	0.7	10,800	
	4/30/97 11:47	0.027	10.6	0.9	0.4	0.2	10,300	
	6/17/97 9:54	0.030	2.4	0.6	0.8	1.2	11,600	well never completely sealed during rebound study

CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform
MEK = Methyl Ethyl Ketone
CH2Cl2 = Methylene Chloride

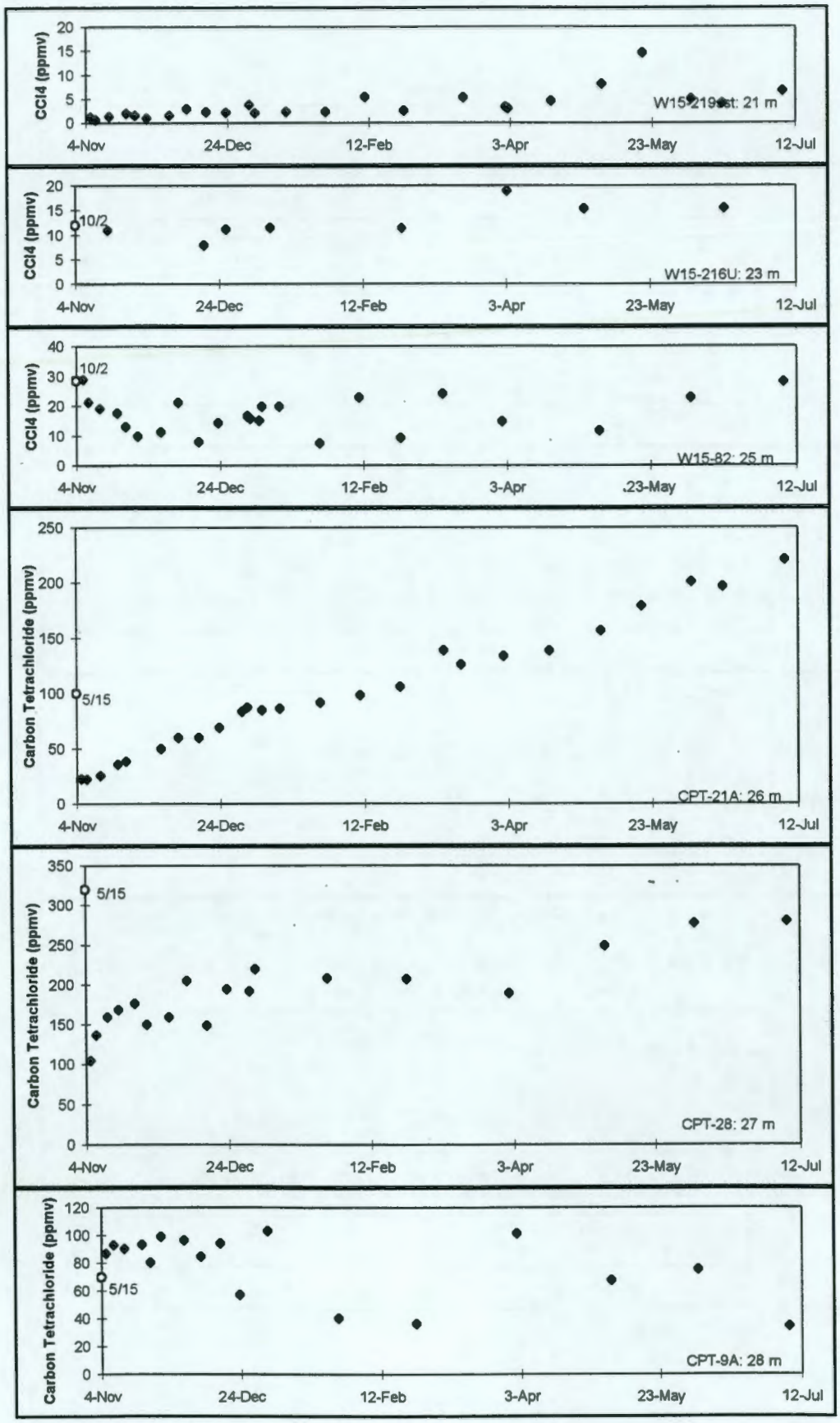
APPENDIX B

REBOUND STUDY DATA PLOTS
NOVEMBER 4, 1996, THROUGH JULY 10, 1997

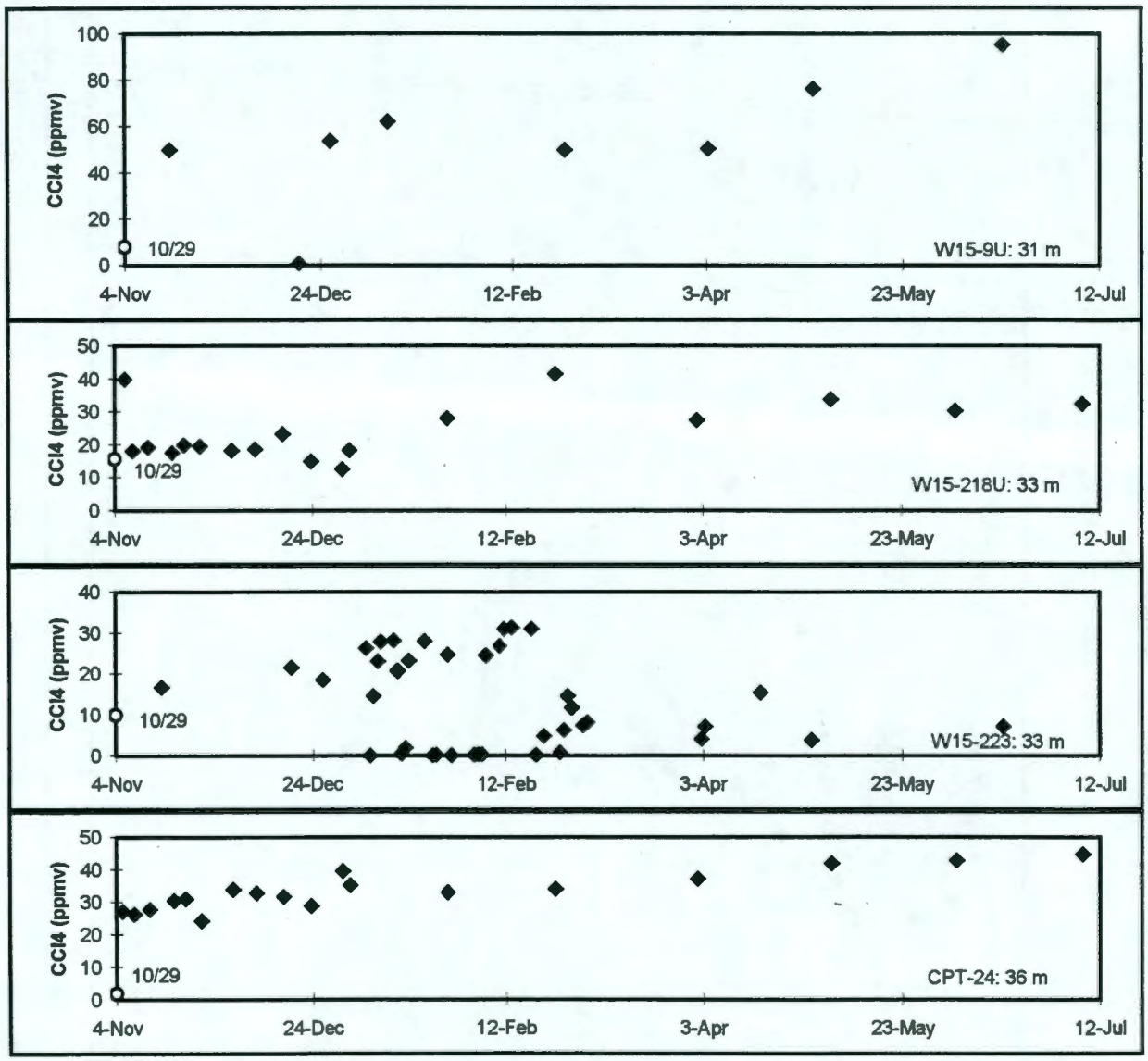
Z-9 Zone 2


CCl4 (ppmv)
CPT-17: 8 m
CPT-27: 10 m
CPT-18: 11 m
CPT-28: 12 m
CPT-21A: 14 m
W15-220sst: 16 m
CPT-9A: 18 m
CPT-16: 20 m
5/15
4-Nov
24-Dec
12-Feb
3-Apr
23-May
12-Jul

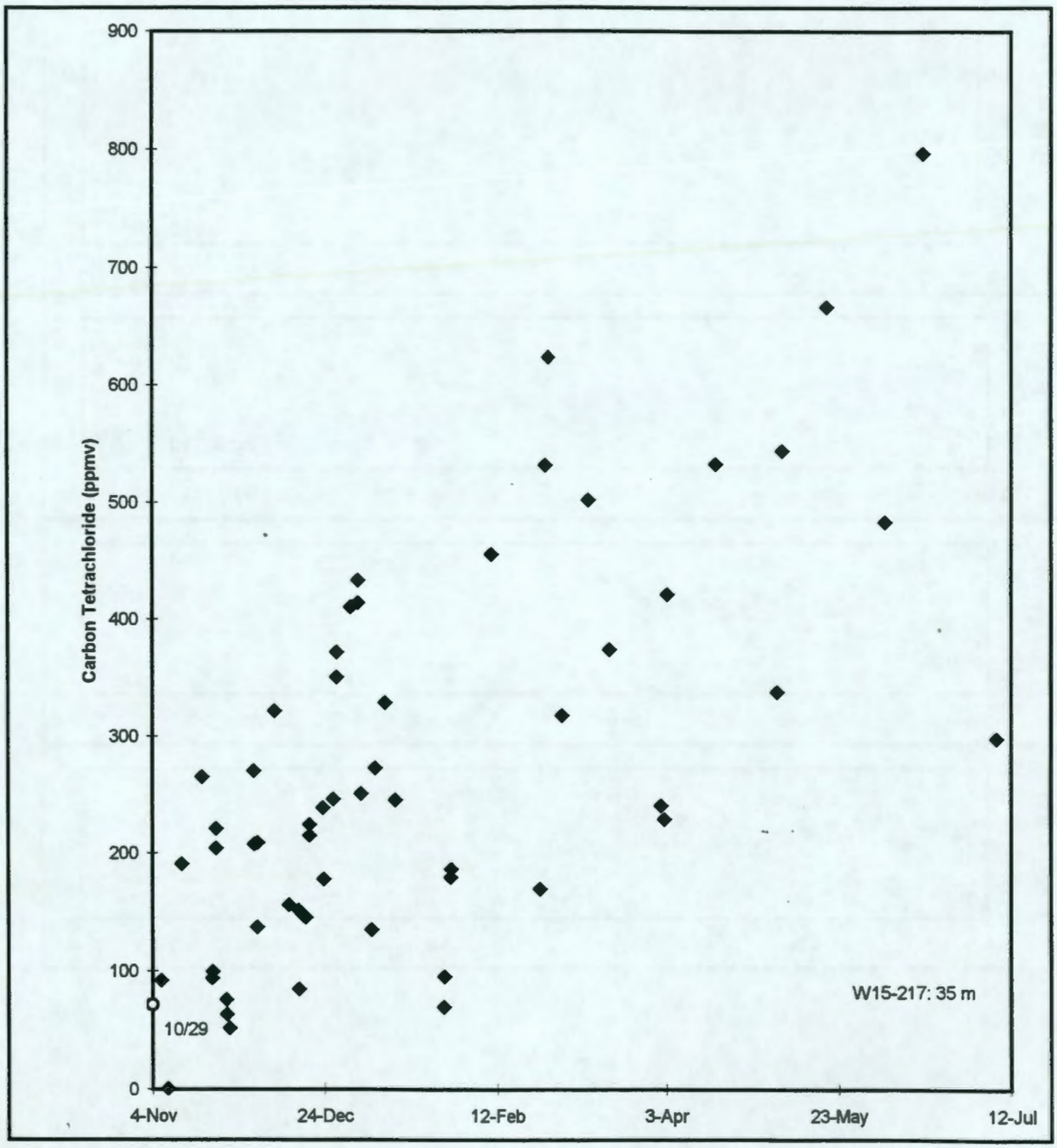
Z-9 Zone 2


CCl4 (ppmv)
W15-219st: 21 m
CCl4 (ppmv)
10/2
W15-216U: 23 m
CCl4 (ppmv)
10/2
W15-82: 25 m
Carbon Tetrachloride (ppmv)
5/15
CPT-21A: 26 m
Carbon Tetrachloride (ppmv)
5/15
CPT-28: 27 m
Carbon Tetrachloride (ppmv)
5/15
CPT-9A: 28 m
4-Nov
24-Dec
12-Feb
3-Apr
23-May
12-Jul

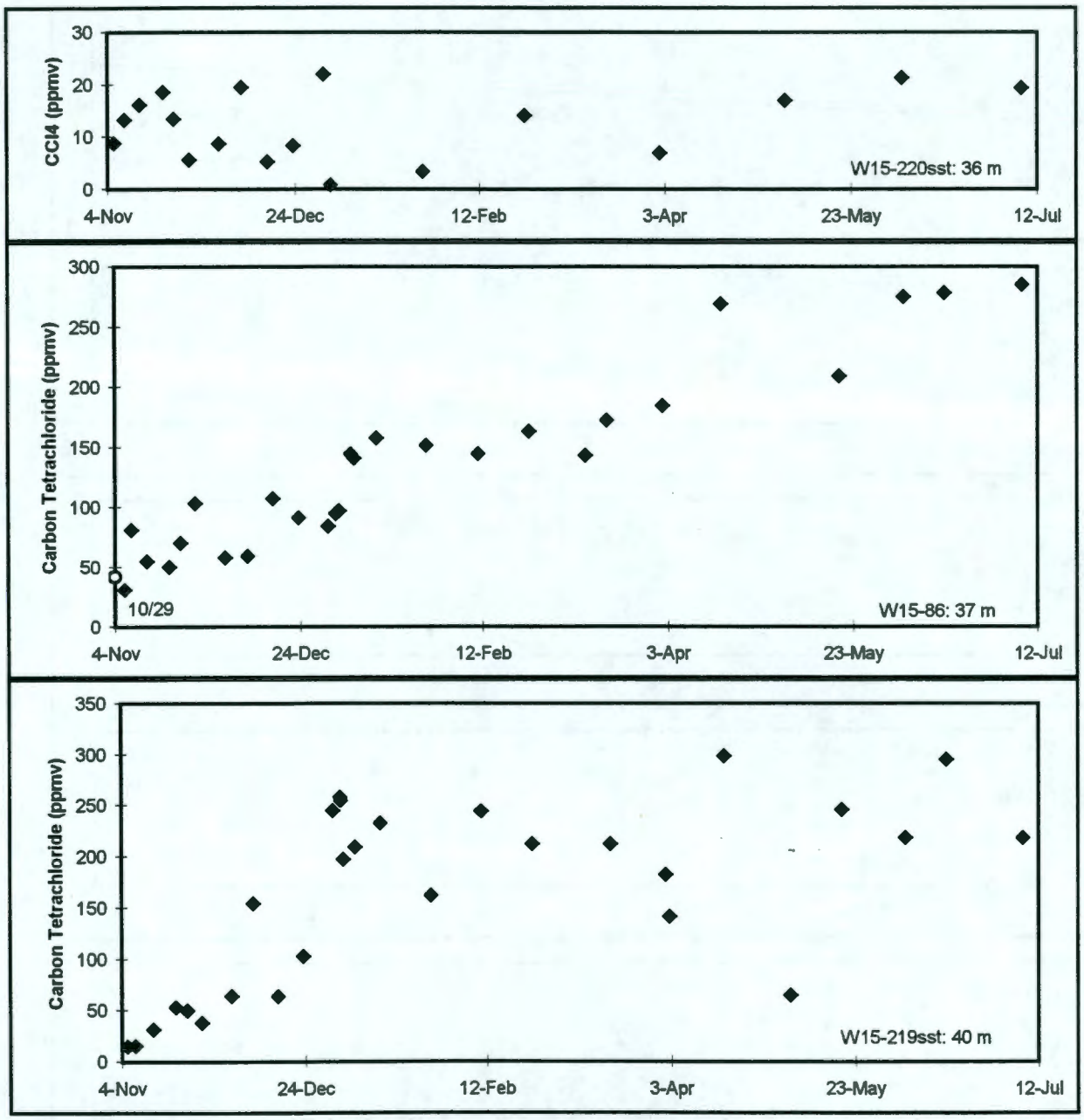
Z-9 Zone 3


CCl4 (ppmv)
10/29
W15-9U: 31 m
W15-218U: 33 m
W15-223: 33 m
CPT-24: 36 m
4-Nov
24-Dec
12-Feb
3-Apr
23-May
12-Jul

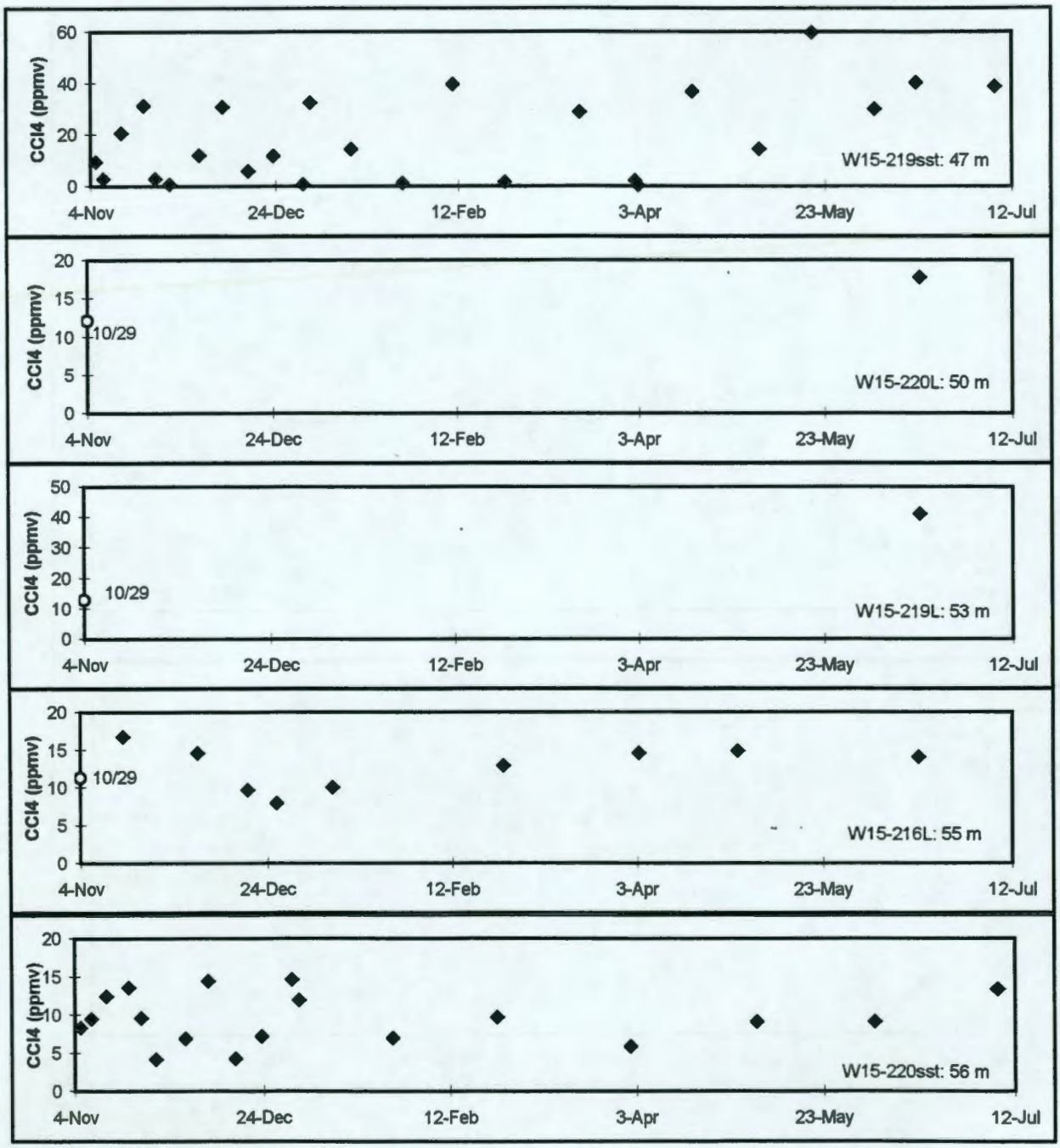
Z-9 Zone 3


900
800
700
600
500
400
300
200
100
0
Carbon Tetrachloride (ppmv)
10/29
W15-217: 35 m
4-Nov
24-Dec
12-Feb
3-Apr
23-May
12-Jul

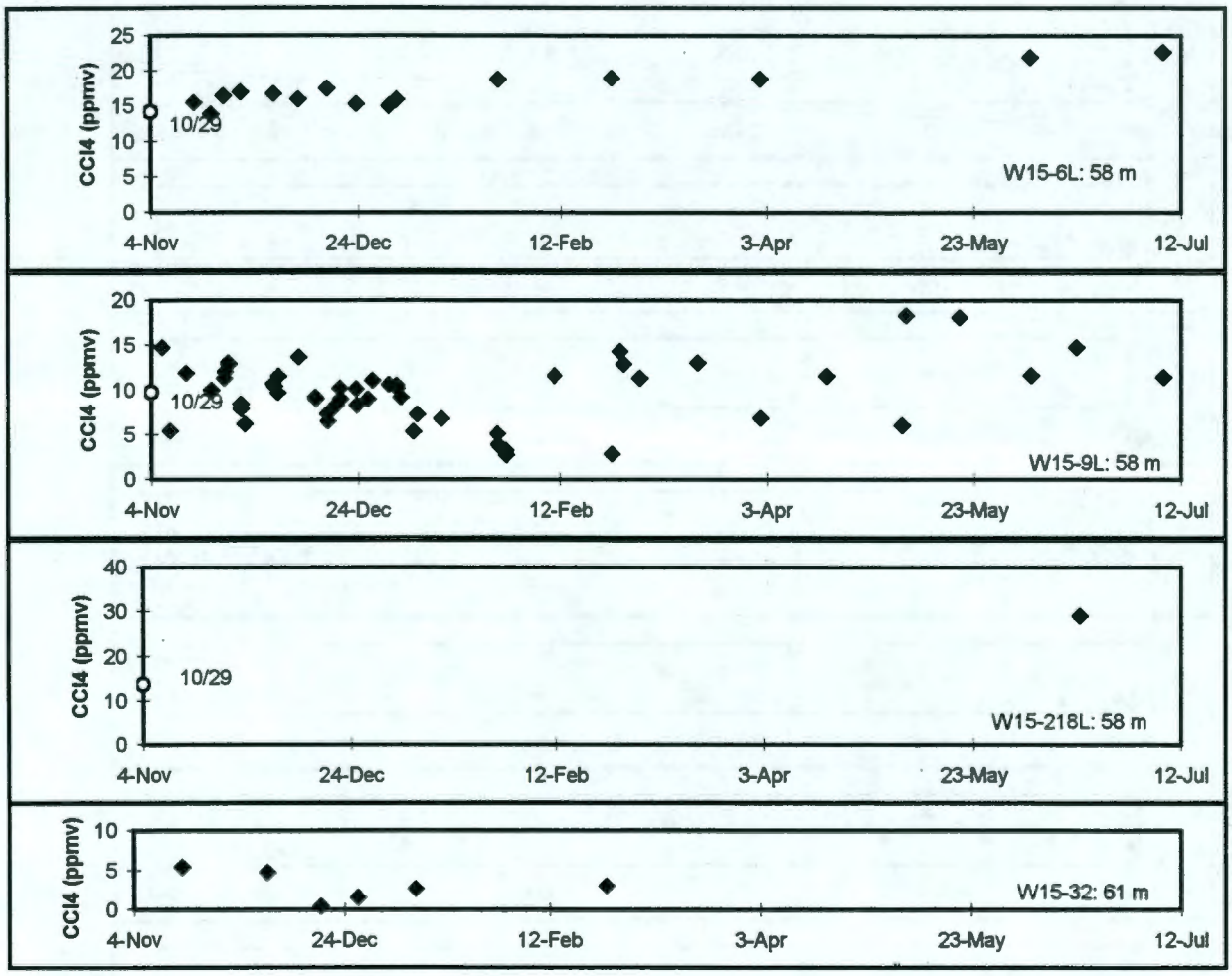
Z-9 Zone 4


CCl4 (ppmv)
30
20
10
0
W15-220sst: 36 m
4-Nov
24-Dec
12-Feb
3-Apr
23-May
12-Jul
Carbon Tetrachloride (ppmv)
300
250
200
150
100
50
0
10/29
W15-86: 37 m
4-Nov
24-Dec
12-Feb
3-Apr
23-May
12-Jul
Carbon Tetrachloride (ppmv)
350
300
250
200
150
100
50
0
W15-219sst: 40 m
4-Nov
24-Dec
12-Feb
3-Apr
23-May
12-Jul

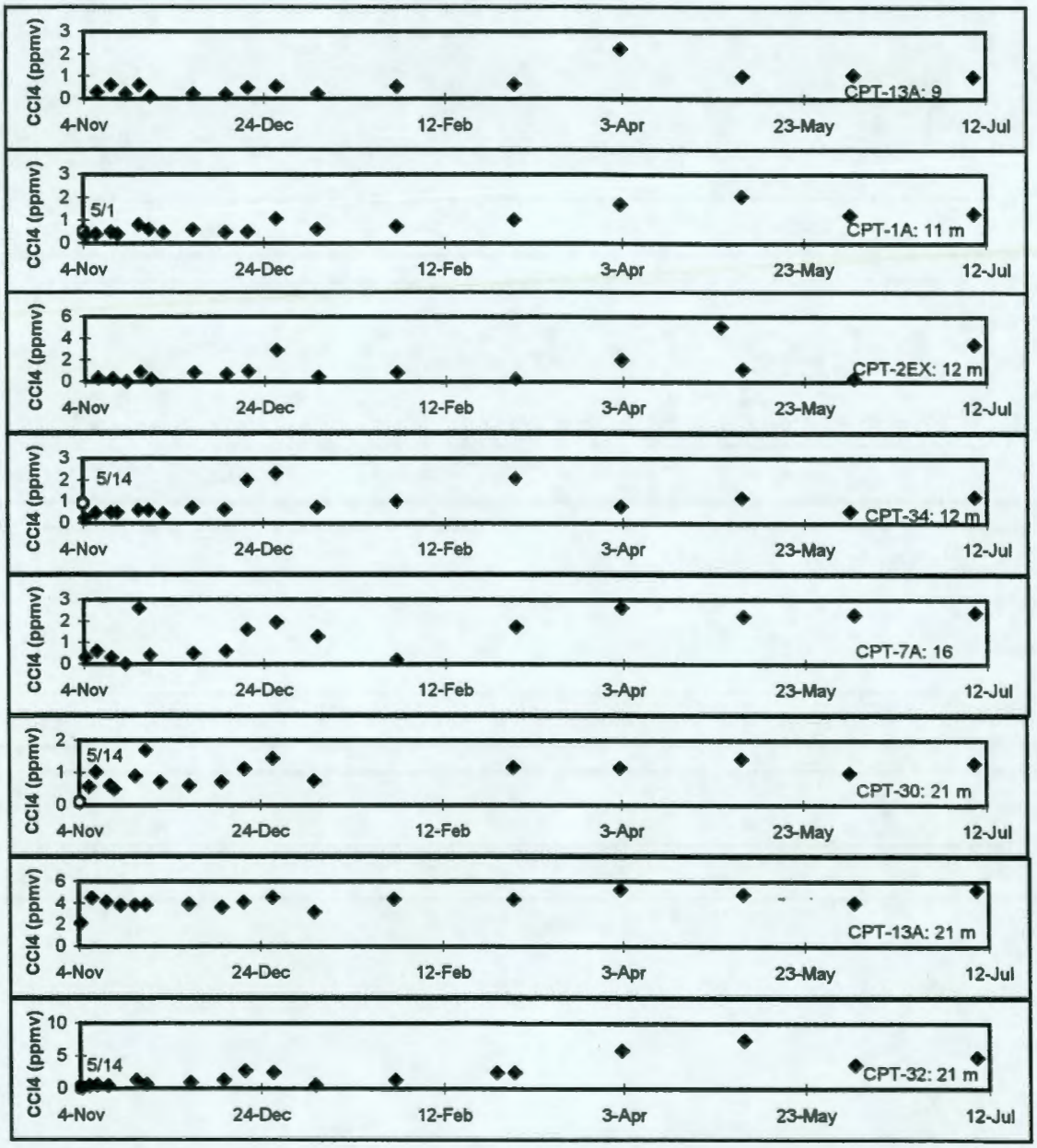
Z-9 Zone 5


CCl4 (ppmv)
W15-219sst: 47 m
W15-220L: 50 m
W15-219L: 53 m
W15-216L: 55 m
W15-220sst: 56 m
10/29
4-Nov
24-Dec
12-Feb
3-Apr
23-May
12-Jul

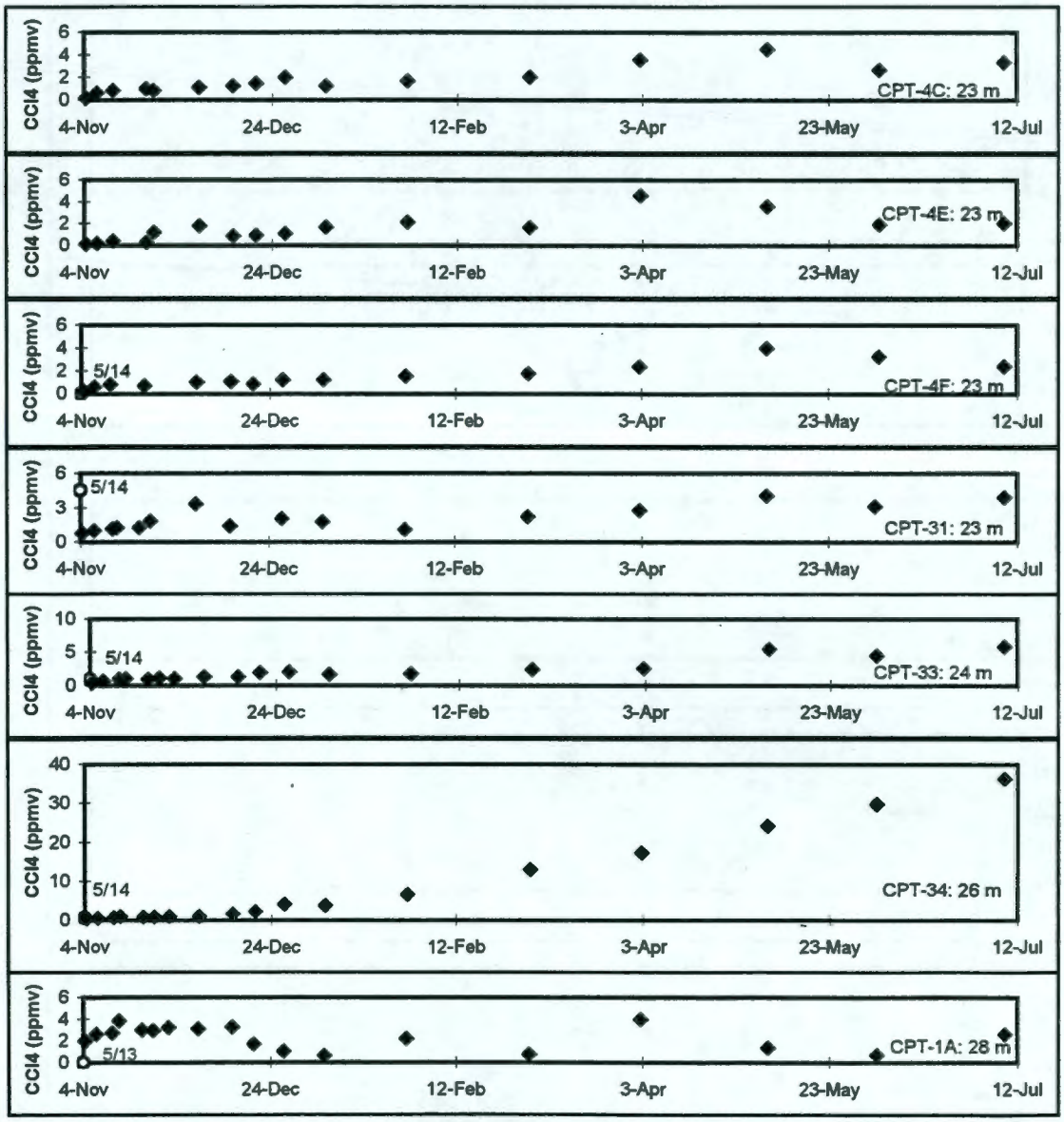
Z-9 Zone 6


CCl4 (ppmv)
10/29
W15-6L: 58 m
W15-9L: 58 m
W15-218L: 58 m
W15-32: 61 m
4-Nov
24-Dec
12-Feb
3-Apr
23-May
12-Jul

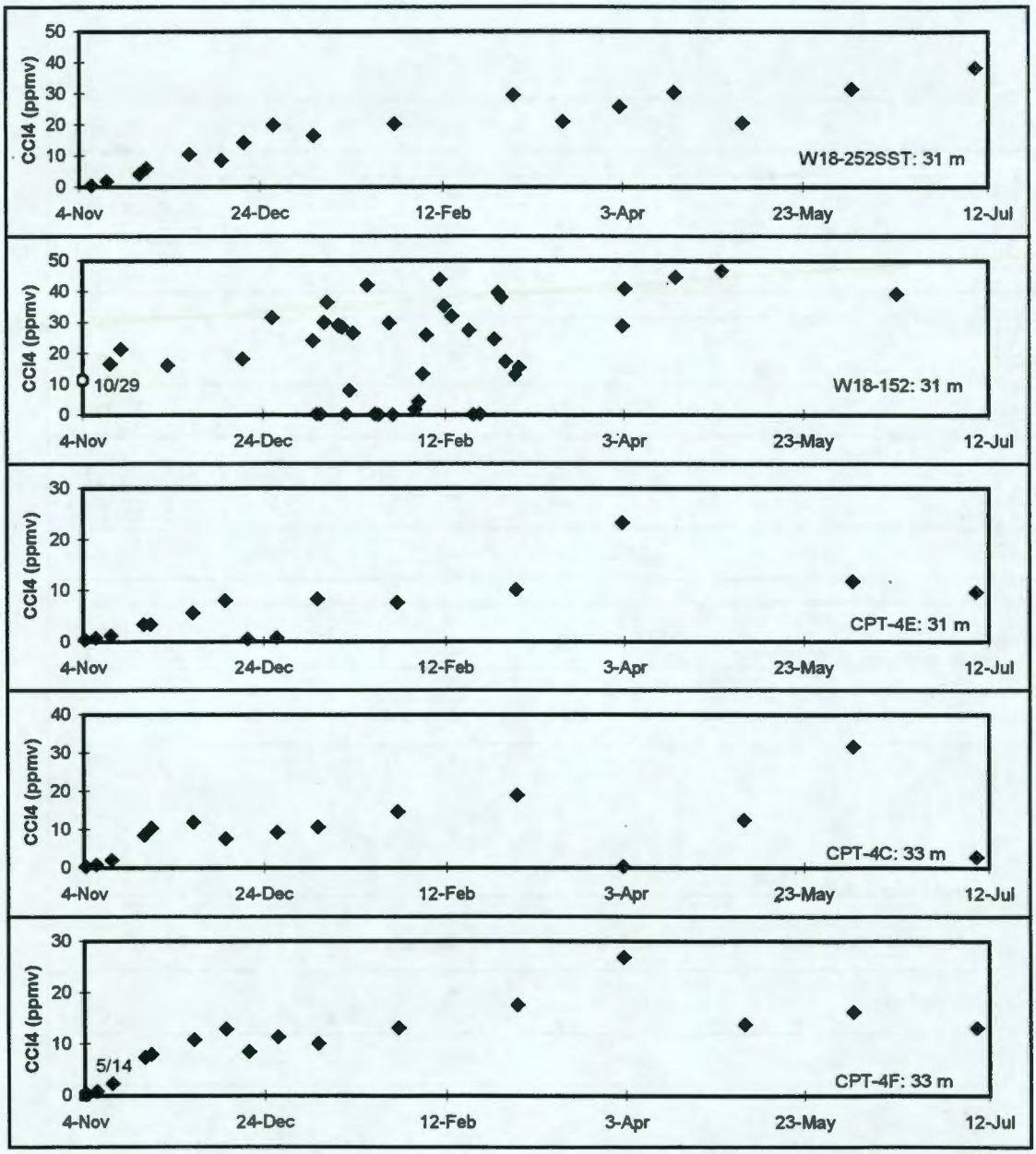
Z-1A Zone 2


CCl4 (ppmv)
CPT-13A: 9
CPT-1A: 11 m
5/1
CPT-2EX: 12 m
CPT-34: 12 m
5/14
CPT-7A: 16
CPT-30: 21 m
CPT-13A: 21 m
CPT-32: 21 m
4-Nov
24-Dec
12-Feb
3-Apr
23-May
12-Jul

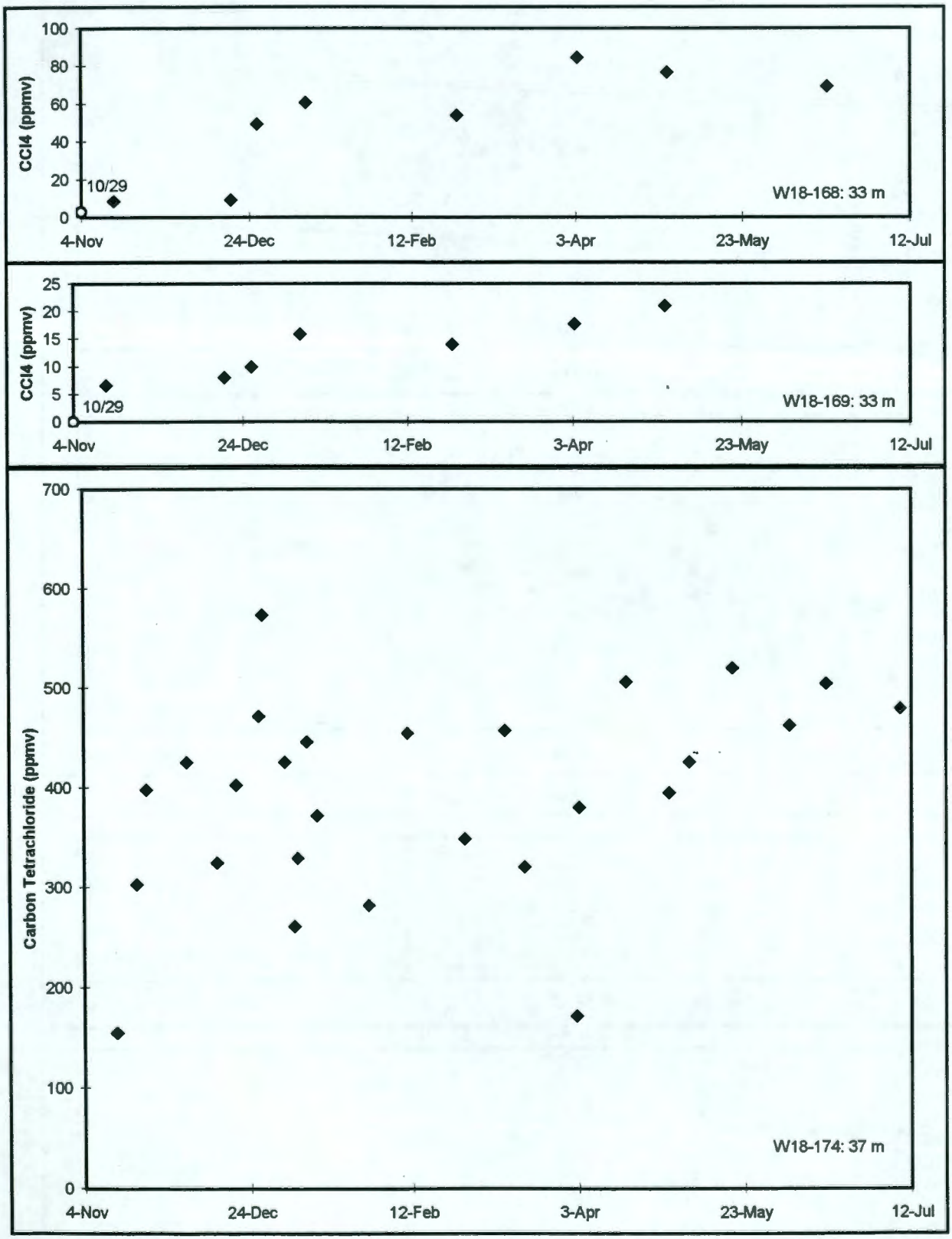
Z-1A Zone 2


CCl4 (ppmv)
CPT-4C: 23 m
CPT-4E: 23 m
CPT-4F: 23 m
CPT-31: 23 m
CPT-33: 24 m
CPT-34: 26 m
CPT-1A: 28 m
5/14
5/13
4-Nov
24-Dec
12-Feb
3-Apr
23-May
12-Jul

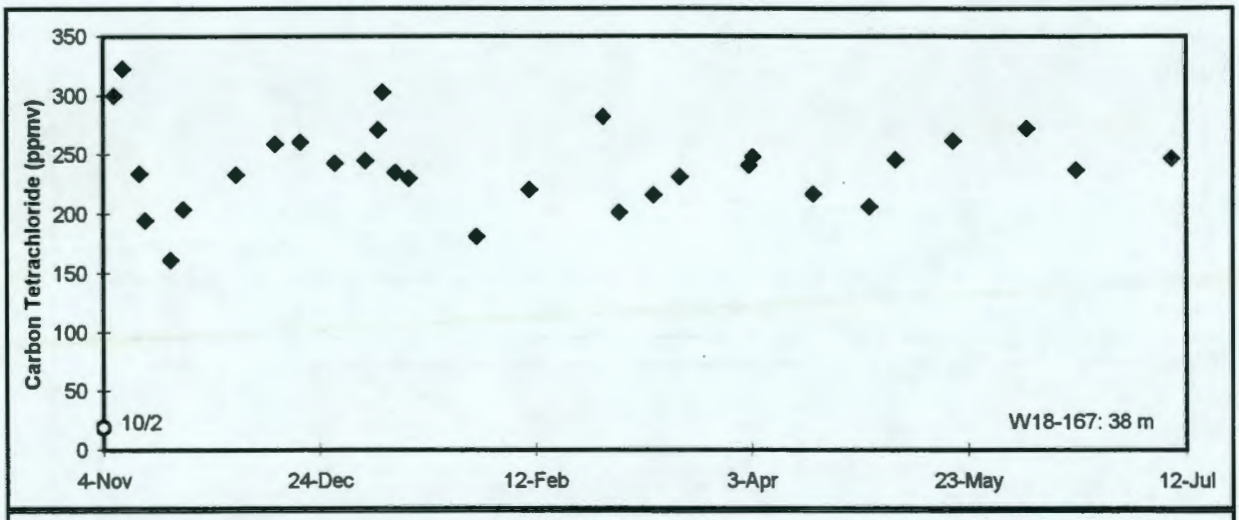
Z-1A Zone 2

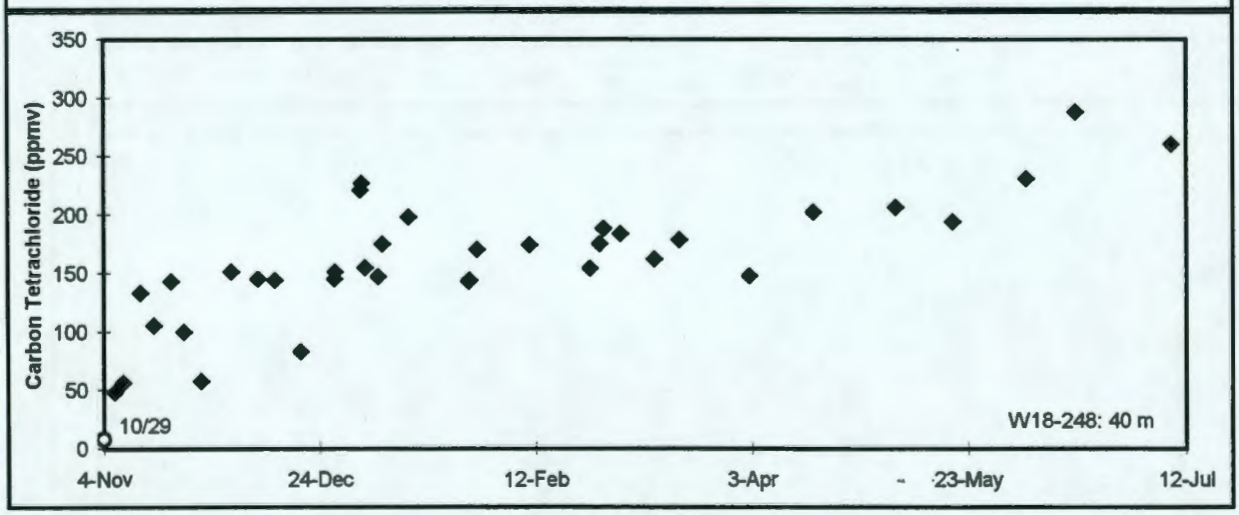

CCl4 (ppmv)
W18-252SST: 31 m
W18-152: 31 m
10/29
CPT-4E: 31 m
CPT-4C: 33 m
CPT-4F: 33 m
5/14
4-Nov
24-Dec
12-Feb
3-Apr
23-May
12-Jul

Z-1A Zone 3: Within Z-1A

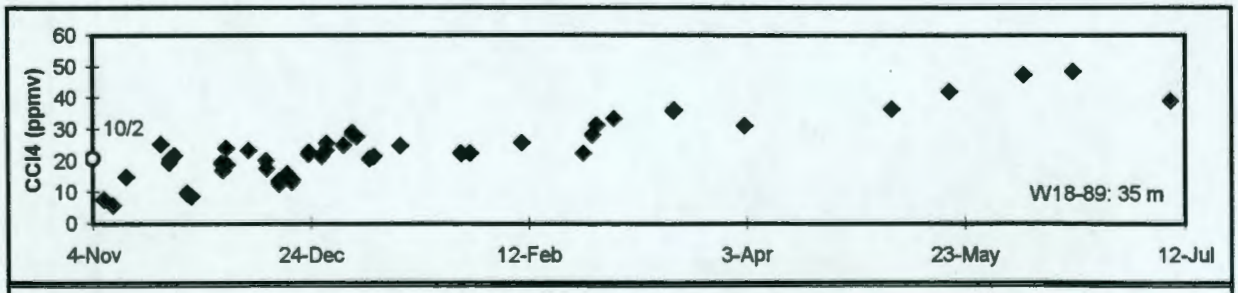


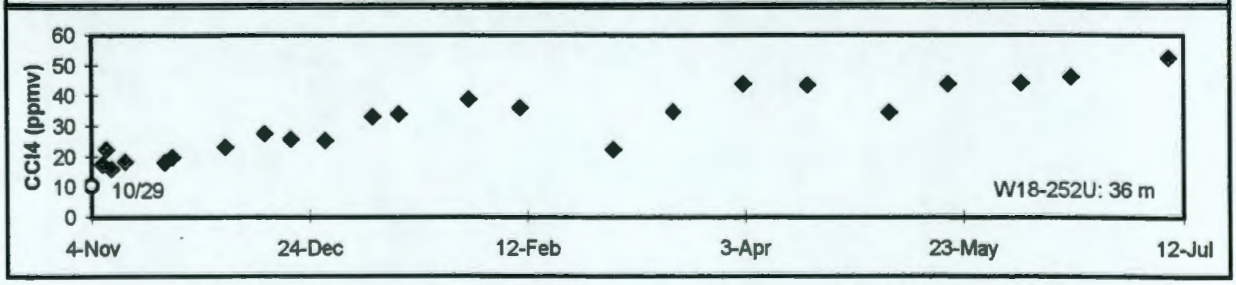
Z-1A Zone 3: Within Z-1A



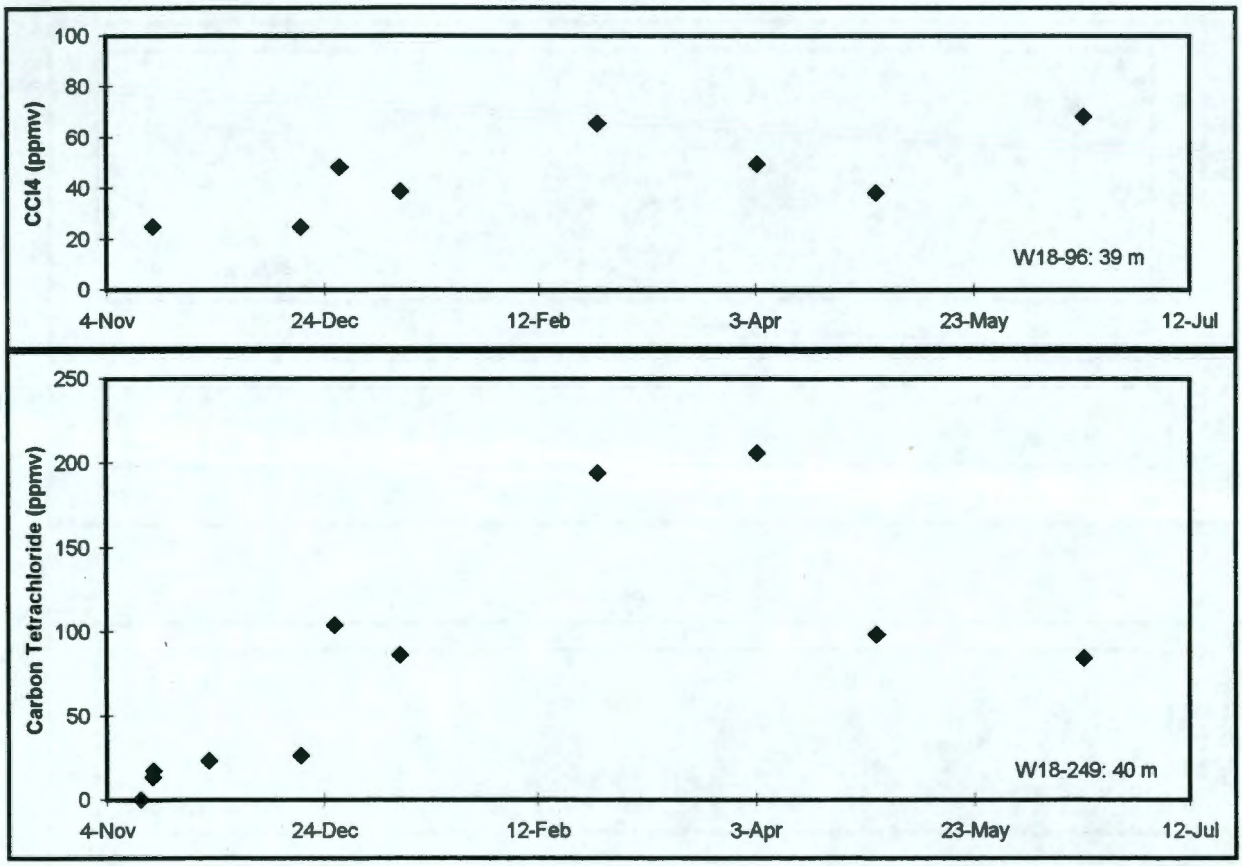


Z-1A Zone 3: West of Z-1A

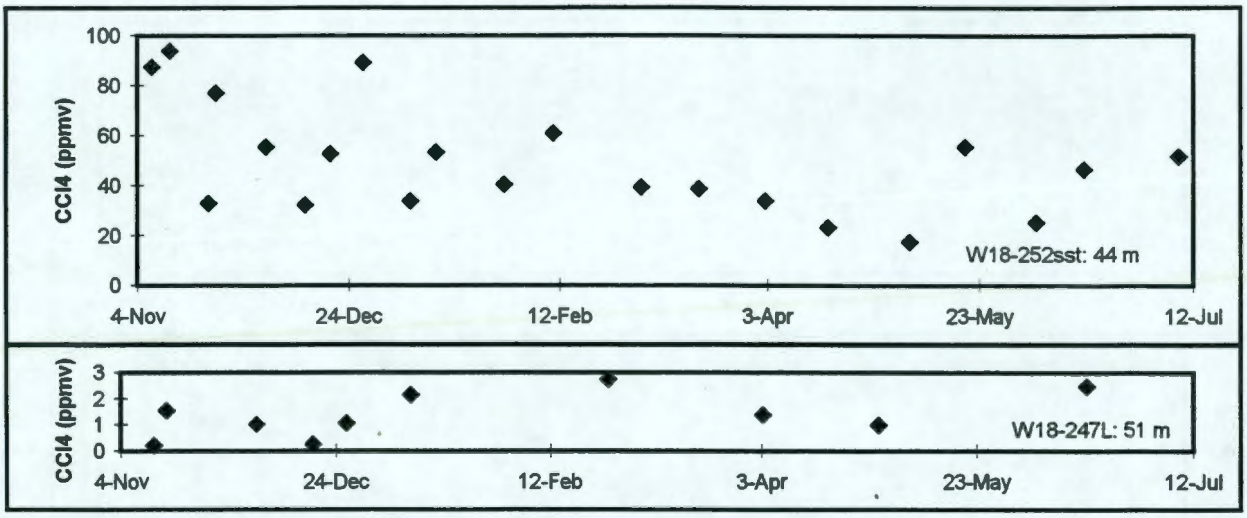




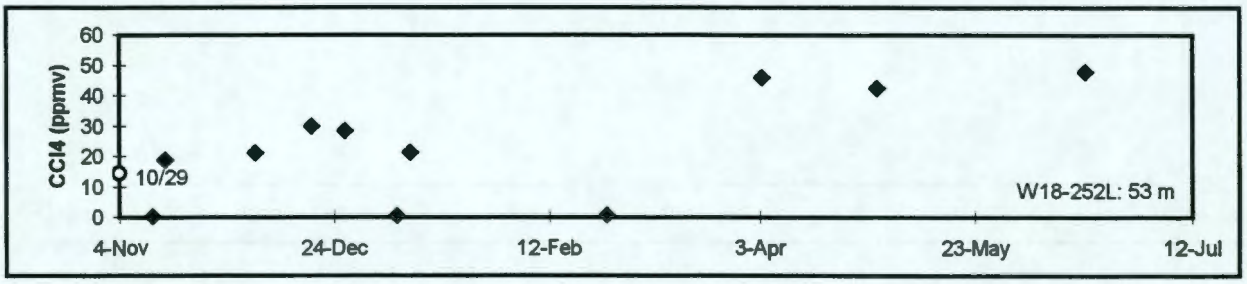
Z-1A Zone 3: Within Z-18



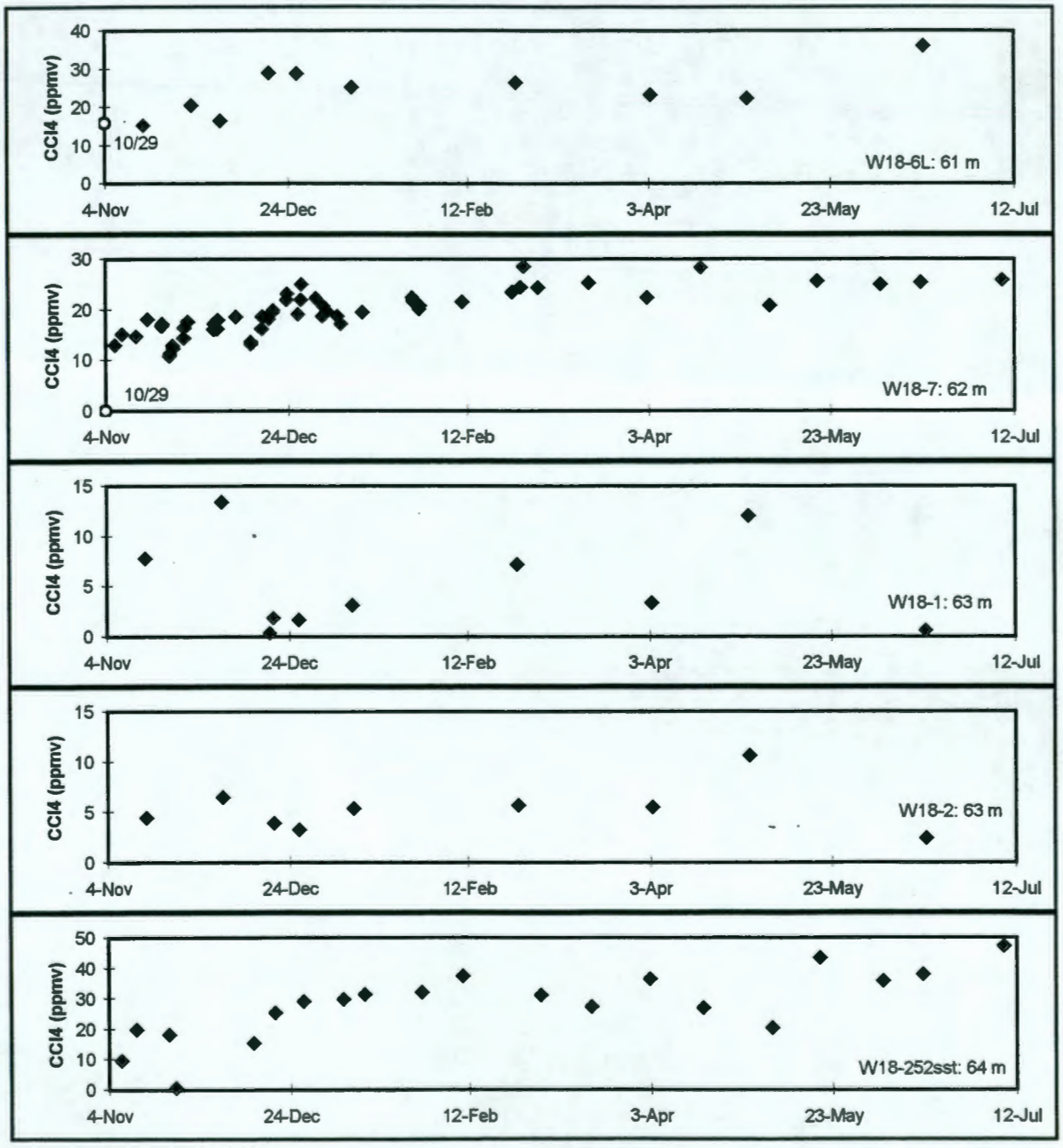
Z-1A Zone 4



Z-1A Zone 5



Z-1A Zone 6


CCl4 (ppmv)
10/29
W18-6L: 61 m
W18-7: 62 m
W18-1: 63 m
W18-2: 63 m
W18-252sst: 64 m
4-Nov
24-Dec
12-Feb
3-Apr
23-May
12-Jul

APPENDIX C

DUPLICATE SAMPLE ANALYSES

Date	Probe	Depth (m bgs)	Zone	CCl4-1 (ppmv)	CCl4-2 (ppmv)
11/5/96	CPT-27/10	10	2	0.37	0.47
11/7/96	CPT-4C/33	33	2	0.85	0.84
11/8/96	W18-252U	36	3	15.6	16.1
11/11/96	CPT-34/26	26	2	0.6	0.6
11/12/96	W15-9L	58	6	11.8	12.0
11/15/96	CPT-28/27	27	2	140	141
11/18/96	CPT-24/36	36	3	30.7	30.2
11/19/96	W18-7	62	6	17.1	17.3
11/21/96	W18-7	62	6	11.1	11.3
11/22/96	CPT-13A/21	21	2	3.9	3.7
11/25/96	CPT-9A/18	18	2	43.3	42.1
11/27/96	94-02	2	1	0	0
12/4/96	CPT-34/26	26	2	1	1
12/4/96	W18-167	38	3	193	196
12/10/96	94-05	2	1	0.155	0
12/13/96	CPT-13A/21	21	2	3.58	3.58
12/16/96	CPT-9A/28	28	2	95.1	93.1
12/18/96	W18-96	39	3	24.7	24.4
12/19/96	W18-252SST/64	64	6	52.6	52.1
12/23/96	W15-86	37	4	88.6	94.1
12/26/96	W18-89	35	3	21.5	21.3
12/27/96	W18-174	37	3	492	463
1/2/97	W15-217	35	3	354	368
1/2/97	W15-86	37	4	96	92.9
1/3/97	W15-217	35	3	209	209
1/6/97	W15-82	25	2	15.6	14.5
1/7/97	W15-82	25	2	18.6	20.95
1/7/97	CPT-21A/26	26	2	84.6	84.8
1/10/97	W15-223	33	3	27.7	27.8
1/13/97	W18-89	35	3	24.5	24.7
1/24/97	85-01R	2	1	0.139	0.215
1/27/97	W15-217	35	3	69.5	69.1
1/29/97	W18-174	37	3	279	283
1/29/97	CPT-2EX	12	2	0.841	0.84
2/10/97	W15-82	25	2	21.5	24.2
2/10/97	W15-86	37	4	147	141
2/10/97	W15-217	35	3	482	429
2/24/97	CPT-9A/28	28	2	36.6	36.3
2/24/97	W15-6L	58	6	19.4	18.5
2/25/97	W18-168	33	2-3	53.6	54
2/25/97	W18-169	33	2-3	13.9	14
2/26/97	W18-89	35	3	27.7	28.5
2/26/97	W18-152	31	2	40.5	38.7
2/27/97	W18-167	38	3	288	276
2/27/97	W18-174	37	3	355	341
3/3/97	W15-217	35	3	315	320
3/3/97	W18-174	37	3	43.1	40.3
3/4/97	C-1	2	1	0.145	0.181

Date	Probe	Depth (m bgs)	Zone	CCl4-1 (ppmv)	CCl4-2 (ppmv)
3/4/97	86-06	2	1	0.172	0.26
3/4/97	95-01	2	1	0.202	0.243
3/17/97	W18-167	38	3	230	232
4/1/97	W15-82	25	2	11.6	18
4/1/97	W15-217	35	3	246	235
4/2/97	W18-167	38	3	242	240
4/2/97	W18-174	37	3	171	170
4/2/97	CPT-1A/28	28	2	4.11	3.7
4/2/97	W15-223	33	3	4.04	4.07
4/2/97	W18-152	31	2	28.6	29.1
4/3/97	W15-217	35	3	449	394
4/3/97	W18-167	38	3	253	243
4/3/97	W18-174	37	3	416	342
4/3/97	W15-216L	55	5	14.3	14.8
4/8/97	C-1	2	1	0.166	0.18
4/17/97	CPT-21A/26	26	2	136	141
4/17/97	W15-86	37	4	268	270
4/17/97	W15-217	35	3	544	522
4/17/97	W18-248	40	3	196	209
4/17/97	W18-167	38	3	210	224
4/17/97	W18-174	37	3	502	509
4/30/97	W18-168	33	2-3	72.6	80.8
5/5/97	CPT-9A/18	18	2	40.8	43.2
5/6/97	W18-252U	36	3	31	37.8
5/6/97	W18-7	62	6	17.6	24.1
5/8/97	94-03R	2	1	0.368	0.327
5/8/97	C-1	2	1	0.212	0.06
5/19/97	W15-217	35	3	661	672
6/5/97	W18-252U	36	3	44	44.1
6/5/97	W15-218U	33	3	30.2	30.1
6/9/97	86-04	2	1	0.447	0.338
6/16/97	W15-217	35	3	798	796
6/17/97	W15-9U	31	2-3	95	95.3
6/17/97	W18-247L	51	4	2.21	2.69
7/7/97	W15-86	37	4	283	286
7/8/97	W18-252U	36	3	52.4	52.8
7/8/97	W18-89	35	3	40	38.2
7/10/97	95-12	2	1	1.05	1.08
Carbon Tetrachloride - Packer Test					
6/19/97	W15-217	35	3	159	154
6/20/97	W18-89	35	3	18.6	17.6
6/23/97	W15-217	35	3	214	213
6/26/97	W15-217	35	3	513	519
6/30/97	W18-89	35	3	36.2	36.7
7/1/97	W15-217	35	3	241	195
7/1/97	W18-89	35	3	32.6	32.4
7/2/97	W15-217	35	3	244	233
7/2/97	W18-89	35	3	34.5	34.7

APPENDIX D

ANALYSES OF STANDARD CARBON TETRACHLORIDE CONCENTRATIONS

CCl_4 Conc. Standard (ppmv)	CCl_4 Conc. Analyzed (ppmv)	Date Analyzed	Time Analyzed	B&K Serial Number	Comment
10.9	10.60	11/4/96		1732791	
10.9	10.50	11/5/96	11:37	1732791	
10.9	10.30	11/6/96	15:10	1732791	
10.9	11.20	11/7/96	15:00	1732791	
10.9	10.60	11/8/96	13:50	1732791	
10.9	10.20	11/11/96	13:25		
10.9	10.20	11/12/96	8:30	1732791	
10.9		11/13/96		1732791	
10.9	10.30	11/14/96		1732791	
10.9	10.90	11/15/96			
10.9	10.60	11/18/96	14:20		
10.9	10.20	11/19/96	14:40		
10.9	10.00	11/20/96			
10.9	10.00	11/21/96		1732791	
10.9	10.10	11/22/96			
10.9	10.80	11/25/96		1732791	
10.9	10.20	11/27/96		1732791	
10.9	10.80	12/3/96		1732791	
10.9	11.40	12/4/96	14:50	1732791	
10.9	10.20	12/5/96	12:15	1732791	
10.9	10.80	12/9/96	14:25	1732791	
10.9	10.10	12/10/96		1732791	
10.9	10.50	12/13/96	14:36	1732791	
10.9	10.80	12/16/96	12:19	1732791	
10.9	10.60	12/18/96	13:04	1732791	
10.9	10.30	12/19/96	11:52	1732791	
10.9	10.60	12/19/96	15:20	1732791	
10.9	10.40	12/23/96	13:35	1732791	
10.9	10.30	12/26/96	11:55	1732791	
10.9	10.50	12/27/96	12:02	1732791	
10.9	10.60	12/27/96	12:11		
10.9	10.70	12/31/96	12:40	1732791	
10.9	10.60	1/2/97	12:44	1732791	
10.9	10.80	1/3/97	13:55	1732791	
10.9	10.90	1/6/97	16:26	1732791	
10.9	10.80	1/7/97	15:00	1732791	
10.9	10.20	1/9/97	16:28	1732791	
10.9	10.40	1/10/97	16:32	1732791	
27.6	25.80	1/10/97	14:18	1732791	
27.6	25.50	1/10/97	14:50	1732791	
546.0	435.00	1/10/97	14:02	1732791	Low B filter
546.0	432.00	1/10/97	15:06	1732791	Low B filter
27.6	27.20	1/13/97	11:05	1732791	
27.6	27.10	1/13/97	16:15	1732791	
10.9	10.70	1/13/97	16:34	1732791	
546.0	551.00	1/13/97	11:10	1732791	High A filter
546.0	432.00	1/13/97	11:10	1732791	Low B filter

CCl_4 Conc. Standard (ppmv)	CCl_4 Conc. Analyzed (ppmv)	Date Analyzed	Time Analyzed	B&K Serial Number	Comment
10.9	10.40	1/14/97	16:26	1732791	
27.6	26.60	1/15/97	16:05	1732791	
10.9	10.70	1/15/97	16:24	1732791	
10.9	10.40	1/16/97	16:27	1732791	
10.9	10.70	1/17/97	16:22	1732791	
10.9	10.30	1/21/97	16:29	1732791	
10.9	10.10	1/23/97	16:24	1732791	
10.9	10.60	1/24/97	15:04	1732791	
27.6	26.40	1/24/97	15:08		
10.9	10.40	1/24/97	16:15	1732791	
10.9	10.50	1/27/97	11:08	1732791	
546.0	579.00	1/27/97	12:38	1732791	High A filter
27.6	26.40	1/27/97	15:52	1732791	(dataform listed standard as 27.9)
10.9	10.90	1/27/97	16:33	1732791	
10.9	10.30	1/28/97	16:25	1732791	
27.6	26.20	1/29/97	12:34	1732791	
546.0	564.00	1/29/97		1732791	High A filter
546.0	454.00	1/29/97		1732791	Low B filter
10.9	10.10	2/3/97	16:28	1732791	
10.9	9.90	2/4/97	16:31	1732791	
10.9	9.93	2/5/97	16:21	1732791	
10.9	10.00	2/6/97	16:31	1732791	
10.9	10.50	2/10/97	14:08		
27.6	26.80	2/10/97	14:10	1732791	
550.0	584.00	2/10/97	14:42		High A filter
280.0	289.00	2/10/97	14:48		High A filter
10.9	10.30	2/11/97	14:20	1732791	
27.6	25.40	2/11/97	14:24		
10.4	10.10	2/24/97	10:25		
27.6	26.70	2/24/97	10:28		
285.0	268.00	2/24/97	10:30		High A filter
285.0	249.00	2/24/97	10:30		Low B filter
10.4	9.96	2/24/97	16:14		
10.9	10.60	2/25/97	15:06	1732791	
10.9	10.00	2/26/97	10:52	1732791	
276.0	265.00	2/26/97	11:06		High A filter
276.0	240.00	2/26/97	11:06		Low B filter
27.6	26.10	2/26/97	10:38		
		2/27/97		1732791	
10.4	10.00	3/3/97	11:58	1732791	
27.6	26.70	3/3/97	11:54		Low B filter
276.0	241.00	3/3/97	9:34		Low B filter
276.0	261.00	3/3/97	9:34		High A filter
10.4	9.87	3/4/97	14:53	1732791	
27.6	26.70	3/11/97	13:30	1732791	
10.4	9.96	3/17/97	14:30	1732791	
27.6	27.30	3/17/97	14:35		

CCl_4 Conc. Standard (ppmv)	CCl_4 Conc. Analyzed (ppmv)	Date Analyzed	Time Analyzed	B&K Serial Number	Comment
276.0	244.00	3/17/97	14:50		Low B filter
276.0	271.00	3/17/97	14:50		High A filter
546.0	456.00	3/17/97	14:56		Low B filter
546.0	540.00	3/17/97	14:56		High A filter
10.4	10.00	4/1/97	14:54	1732791	
10.4	10.00	4/2/97	9:30	1732791	
10.4	9.90	4/3/97	12:02	1732791	
27.6	27.10	4/3/97	11:55		
10.4	9.90	4/8/97	10:20	1732791	
27.6	26.30	4/8/97	10:22		
10.9	10.20	4/17/97	14:00	1732791	
27.6	26.50	4/17/97	13:52		
276.0	277.00	4/17/97	14:20		High A filter
276.0	243.00	4/17/97	14:20		Low B filter
543.0	543.00	4/17/97	14:10		High A filter
543.0	455.00	4/17/97	14:10		Low B filter
27.6	26.40	4/30/97	9:10	1732828	1732791 B&K sent for routine calibration
27.6	26.90	4/30/97	12:58	1732828	
27.6	26.50	5/5/97	12:40	1732828	
276.0	274.00	5/5/97	14:00		High A filter
27.6	27.20	5/6/97	13:40	1732828	
27.6	27.60	5/6/97	14:51		
276.0	274.00	5/6/97	15:06		
27.6	26.80	5/8/97	14:56	1732828	
27.6	26.80	5/19/97	12:47		
276.0	269.00	5/19/97	13:59		
27.6	26.50	6/4/97		1732828	
10.4	9.90	6/5/97	14:16	1732828	
27.6	26.50	6/5/97	14:20	1732828	
276.0	269.00	6/5/97	17:07	1732828	
10.4	9.6	6/9/97	13:36	1732828	
10.4	9.96	6/16/97	13:15	1732828	
27.6	27.50	6/16/97	13:21	1732828	
276.0	283.00	6/16/97	15:00	1732828	
10.4	10.00	6/17/97	12:16	1732828	
27.6	27.50	6/17/97	12:22	1732828	
27.6	27.00	7/7/97	11:09	1732828	
276.0	259.00	7/7/97	11:21	1732828	
27.6	27.40	7/8/97	16:32	1732828	
276.0	288.00	7/8/97	17:49	1732828	
10.4	9.90	7/10/97	13:20	1732828	
10.4	9.90	7/10/97	14:23	1732828	

CCl_4 Conc. Standard (ppmv)	CCl_4 Conc. Analyzed (ppmv)	Date Analyzed	Time Analyzed	B&K Serial Number	Comment
Carbon Tetrachloride - Packer Test					
276.0	267.00	6/19/97	8:50	1732828	
27.6	26.40	6/19/97	9:04	1732828	
27.6	27.2	6/20/97	11:14	1732828	
276.0	281.00	6/20/97	14:12	1732828	
27.6	26.80	6/23/97	12:18	1732828	
276.0	277.00	6/23/97	12:36	1732828	
27.6	27.20	6/24/97	16:30	1732828	
276.0	268.00	6/24/97	16:43	1732828	
27.6	26.60	6/25/97	11:18	1732828	
276.0	266.00	6/25/97	16:27	1732828	
27.6	26.70	6/26/97	13:00	1732828	
276.0	262.00	6/26/97	13:15	1732828	
27.6	26.80	6/30/97	12:02	1732828	
276.0	260.00	6/30/97	16:54	1732828	
27.6	26.60	7/1/97	16:45	1732828	
276.0	268.00	7/1/97	17:14	1732828	
27.6	26.90	7/2/97	16:40	1732828	
276.0	270.00	7/2/97	17:10	1732828	
27.6	27.00	7/7/97	11:09	1732828	
276.0	259.00	7/7/97	11:21	1732828	

APPENDIX E

MORNING AND AFTERNOON SAMPLING RESULTS FOR WELLS W15-9L, W15-217, W18-7, AND W18-89, NOVEMBER 1996 THROUGH JANUARY 1997

W15-217 35 m depth Sample Date	CCl_4 (ppmv)	W18-89 35 m depth Sample Date	CCl_4 (ppmv)	W15-9L 58 m depth Sample Date	CCl_4 (ppmv)	W18-7 62 m depth Sample Date	CCl_4 (ppmv)
						11/19/96 11:03	16.7
						11/19/96 13:30	17.2
11/21/96 11:00	94	11/21/96 10:46	19	11/21/96 11:08	11.3	11/21/96 10:53	10.8
11/21/96 14:14	99	11/21/96 14:17	20	11/21/96 14:10	12.0	11/21/96 14:21	11.2
11/22/96 9:55	204	11/22/96 10:16	21	11/22/96 10:09	13.0	11/22/96 9:50	12.8
11/22/96 13:23	221	11/22/96 13:37	22	11/22/96 13:27	12.9	11/22/96 13:33	12.3
11/25/96 10:19	76	11/25/96 10:12	10	11/25/96 10:25	7.9	11/25/96 10:15	14.4
11/25/96 13:45	63	11/25/96 13:26	9	11/25/96 13:48	8.4	11/25/96 13:40	16.4
12/3/96 9:26	270	12/3/96 9:15	19	12/3/96 9:31	10.7	12/3/96 9:10	16.1
12/3/96 14:00	208	12/3/96 13:48	17	12/3/96 14:05	10.4	12/3/96 13:56	17.2
12/4/96 9:32	137	12/4/96 9:22	24	12/4/96 9:38	9.7	12/4/96 9:28	16.2
12/4/96 13:31	209	12/4/96 13:20	19	12/4/96 13:34	11.5	12/4/96 13:26	17.9
12/13/96 10:17	156	12/13/96 10:05	20	12/13/96 10:18	9.2	12/13/96 10:15	13.2
12/13/96 13:05	156	12/13/96 13:19	18	12/13/96 13:03	9.0	12/13/96 13:08	13.6
12/16/96 9:38	151	12/16/96 9:20	13	12/16/96 9:42	7.3	12/16/96 9:25	16.2
12/16/96 13:18	84	12/16/96 13:10	13	12/16/96 13:24	6.5	12/16/96 13:15	18.6
12/19/96 10:45	215	12/19/96 10:15	13	12/19/96 10:50	10.2	12/19/96 10:40	19.4
12/19/96 14:03	224	12/19/96 13:54	14	12/19/96 14:06	9.0	12/19/96 13:58	19.9
12/23/96 9:30	239	12/23/96 9:15	22	12/23/96 9:35	10.1	12/23/96 9:24	21.9
12/23/96 13:25	178	12/23/96 12:45	23	12/23/96 13:15	8.2	12/23/96 12:50	23.1
12/27/96 9:58	350	12/27/96 9:43	23	12/27/96 10:02	11.0	12/27/96 9:50	21.9
12/27/96 13:45	372	12/27/96 13:50	25	12/27/96 13:40	11.0	12/27/96 13:30	24.9
1/2/97 12:30	433	1/2/97 12:35	28	1/2/97 10:30	10.5	1/2/97 10:05	18.7
1/2/97 15:11	414	1/2/97 15:20	29	1/2/97 15:00	10.2	1/2/97 15:15	20.6
1/27/97 10:28	69	1/27/97 10:15	22	1/27/97 10:40	5.1	1/27/97 10:20	22.3
1/27/97 14:48	95	1/27/97 14:54	22	1/27/97 14:06	3.9	1/27/97 14:59	21.7
1/29/97 10:15	179	1/29/97 9:40	22	1/29/97 10:06	3.2	1/29/97 9:45	20.1
1/29/97 15:15	186	1/29/97 15:20	22	1/29/97 15:10	2.7	1/29/97 14:45	20.7

APPENDIX F

SURVEY DATA FOR THE CPT WELLS AND PROBES

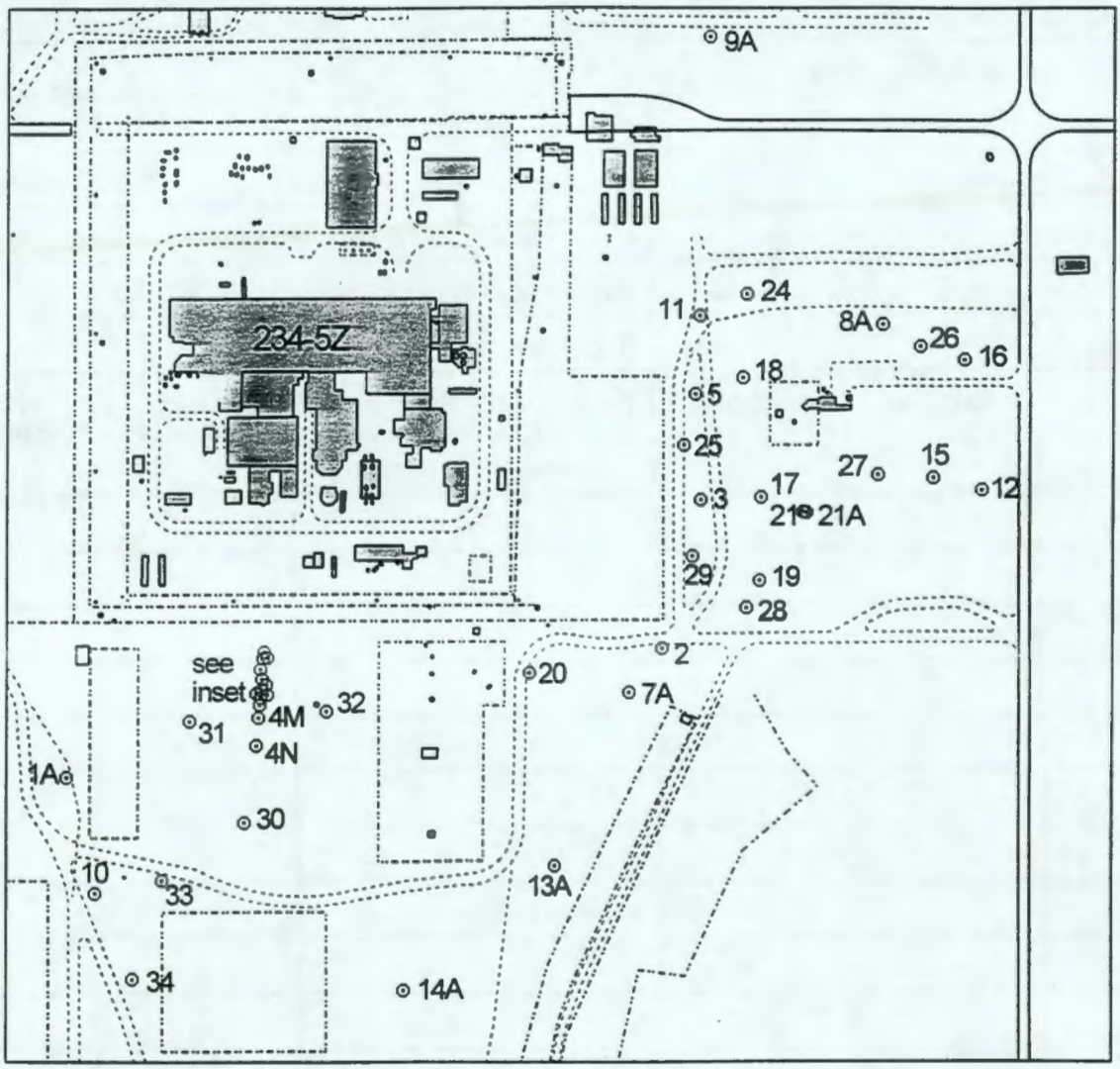
Hanford Geographic Information System
Global Positioning Survey Report

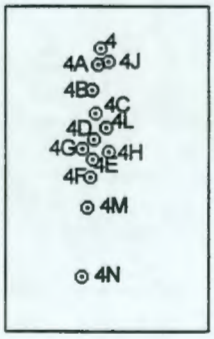
To: Virginia Rohay	**From:** Kathy Prosser	**Date:** 2/20/97
Purpose of Survey: locations & ground surface elevations of core penetrometers		
Project / Operable Unit / Area: 200W		
Job Name: 2WJ033	**Accuracy Horizontal:** 95% error estimate < ± 12 cm *	**GPS-Project#** 83
GPS-Coordinator:	**Accuracy Vertical:** 95% error estimate < ± 20 cm *	**# of points:** 44
Task Leader: K. Prosser	**Coordinate System:** ***State Plane***	**Zone:** ***WAS***
Field Team Leader: K. Prosser	**Datum:** ***NAD83***/91, NAVD88	
Date(s) of Survey: 2/4, 2/7, 2/14, 2/18/97	**Units:** ***meters***	

Point-ID or Name	Latitude	Longitude	Washington State Plane Easting	Washington State Plane Northing	Elevation		HGIS GPS-ID

* Based on the coordinate Adjustment Summary

Cone Penetrometer Locations





Cone penetrometers
Roads
Improved Road
Parking Lot
Railroad
Rock Outcrop, Miscellaneous Concrete & Land Features
Unimproved Dirt & Gravel Road
Unimproved Paved Road
Fences
Buildings, etc.

50 0 50 100 150 Meters

CPT Probe	Easting (m)	Northing (m)	Elevation (m)
CPT-1A	566337.77	135403.26	209.03
CPT-2	566682.31	135476.79	206.65
CPT-3	566704.66	135561.87	205.85
CPT-4	566450.57	135474.92	207.60
CPT-4A	566450.02	135471.13	207.78
CPT-4B	566448.54	135465.11	208.02
CPT-4C	566449.37	135459.52	208.12
CPT-4D	566449.01	135453.39	208.19
CPT-4E	566448.71	135448.68	208.31
CPT-4F	566448.15	135444.52	208.21
CPT-4G	566446.24	135451.15	208.18
CPT-4H	566452.48	135450.43	208.14
CPT-4J	566452.41	135471.82	207.65
CPT-4L	566451.93	135456.11	208.02
CPT-4M	566447.42	135437.32	208.59
CPT-4N	566446.18	135421.24	208.45
CPT-5	566701.33	135621.70	205.78
CPT-7A	566663.28	135451.75	207.04
CPT-8A	566807.28	135661.47	201.98
CPT-9A	566709.29	135825.49	203.76
CPT-10	566354.34	135337.05	209.13
CPT-11	566703.85	135666.36	205.24
CPT-12	566862.90	135567.73	201.12
CPT-13A	566619.10	135352.70	207.52
CPT-14A	566531.48	135281.42	207.20
CPT-15	566835.81	135574.55	200.73
CPT-16	566852.78	135641.26	201.13
CPT-17	566739.28	135563.42	204.84
CPT-18	566728.77	135631.01	204.53
CPT-19	566738.49	135515.85	204.60
CPT-20	566603.81	135462.91	207.12
CPT-21	566763.21	135554.90	204.25
CPT-21A	566765.01	135554.50	204.20
CPT-24	566731.02	135678.80	204.20
CPT-25	566694.70	135592.78	205.83
CPT-26	566828.37	135648.87	201.44
CPT-27	566804.69	135576.23	201.88
CPT-28	566730.97	135500.10	205.04
CPT-29	566699.99	135529.84	206.14
CPT-30	566439.56	135377.43	208.12
CPT-31	566407.76	135435.29	208.29
CPT-32	566486.70	135440.96	208.04
CPT-33	566392.35	135344.51	208.46
CPT-34	566375.56	135288.03	208.78

APPENDIX G

CARBON TETRACHLORIDE-PACKER TEST DATA

APPENDIX G
CARBON TETRACHLORIDE-PACKER TEST DATA

The carbon tetrachloride-packer test was conducted at well W15-217 at the Z-9 site and well W18-89 at the Z-1A site to investigate why significant fluctuations in carbon tetrachloride concentrations were observed in measurements from wells but not from deep soil vapor probes. The test was designed to determine whether the presence of the column of air inside the well casing overlying the sample tube intake was contributing to the concentration fluctuations. Packers were installed downhole to isolate the sample tube intake from the rest of the well column.

Packers were installed at well W15-217 at the Z-9 site and well W18-89 at the Z-1A site on June 18, 1997. These two wells were selected for testing because each had shown significant fluctuations in carbon tetrachloride concentrations during the rebound study (see Figure 6-3). The sample depth in both wells was 35 m below ground surface, in zone 3. The sampling configurations of the wells during the rebound study and during the packer test are shown in Figure G-1. Sampling began on June 19, 1997 and concluded on July 7, 1997. The packers were removed on July 14, 1997. The carbon tetrachloride concentrations measured during the test are reported for each well in Appendix A. The duplicate measurements are included in Appendix C, and the analyses of standard gases during the test are included in Appendix D.

Barometric pressure during the carbon tetrachloride-packer test was obtained from the Hanford Meteorological Station (Figure G-2). At least one barometric pressure inversion occurred during the test (e.g., June 20, 1997 through June 26, 1997), in addition to the diurnal fluctuations. During the installation of the packers on June 18, 1997, when the wells were opened to atmosphere, barometric pressure was near the Hanford Site average of 98.9 kPa (Figure G-2).

Carbon tetrachloride results for all samples from wells W15-217 and W18-89 are shown in Figures G-3 and G-4. On both figures, the data collected during the carbon tetrachloride-packer test are shown as solid symbols, and the data collected during the rebound study are shown as open symbols.

At both wells, the initial samples during the packer test showed a significant concentration drop; this is attributed to the well being opened to atmospheric air during packer installation. The magnitude of concentration fluctuations observed during the rebound study continued during the packer test. Isolation of the sampling tube intake from the overlying column of air inside the well did not eliminate the source of the fluctuations.

The implications of these test results are as follows:

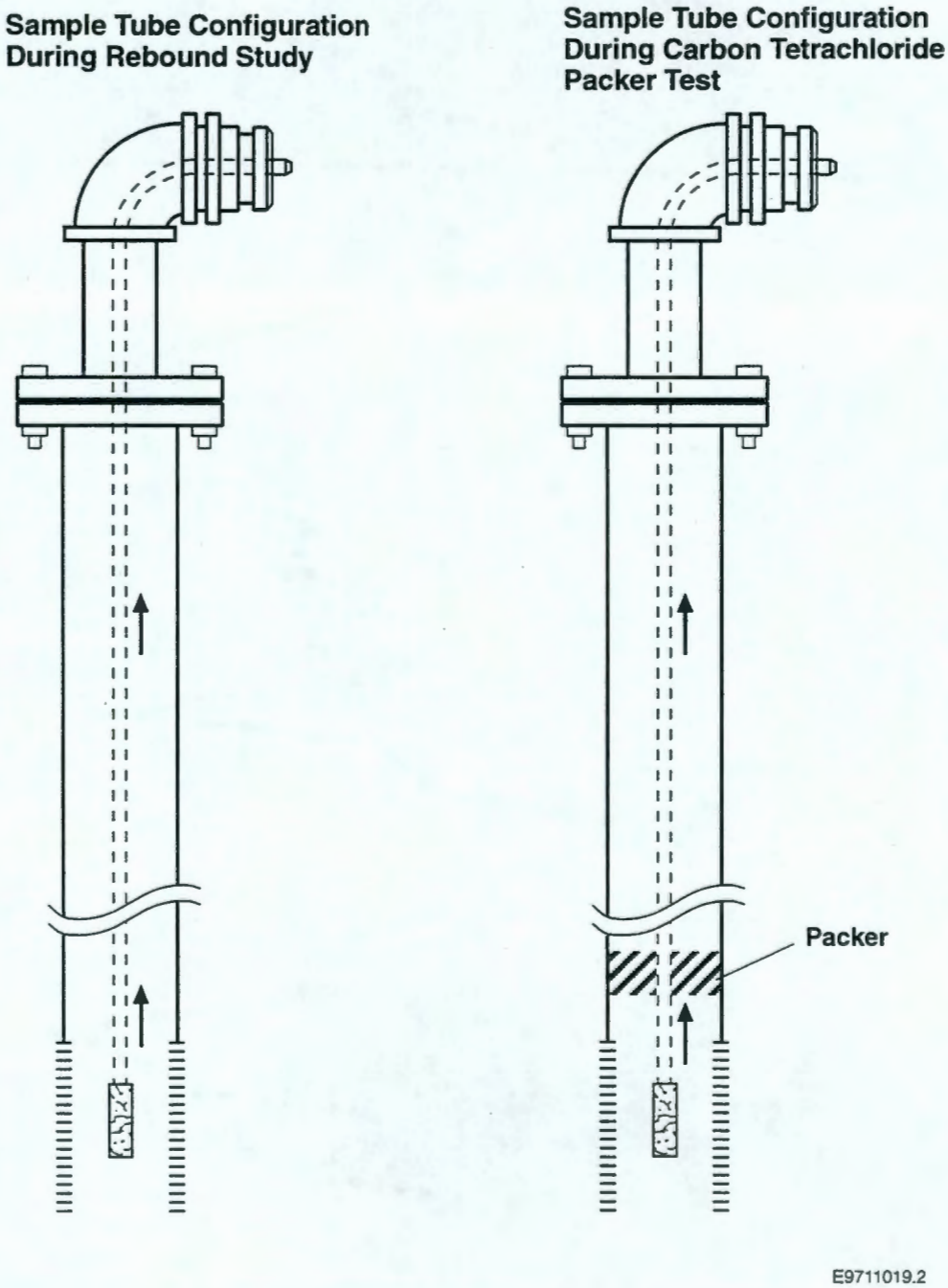
- The wellhead assembly configured during the rebound study (November 1996 through July 1997) was airtight, as designed, at least at these two wells (Figure G-1). If it had contained leaks, isolation of the sampling tube intake by installation of the packer would have eliminated the movement of air between the wellhead and the sample tube intake; but this effect was not observed.

- Packers do not need to be installed as part of the sampling design for future rebound studies.

- Because the pathway for vapor movement resulting in carbon tetrachloride fluctuations was not internal to the well (i.e., the casing and wellhead assembly were not leaking), it must have been outside of the well casing.

As a result of barometric pressure fluctuations, soil vapor in the subsurface is always moving. Preferential pathways for vapor exchange between the atmosphere and the subsurface would allow periodic dilution of the contaminated vapor. Preferential pathways between the surface and the subsurface would also establish subsurface pressure gradients that would drive vapor flow within the subsurface. Although natural vertical preferential pathways occur, cased wells may provide relatively direct communication between the surface and the subsurface. Vapor may have been moving vertically along the annular space between the test well casing and the soil formation; or may have been moving horizontally between the test well and other, nearby wells; or both. The impact on soil vapor concentrations may be enhanced at wells screened in coarser sands and gravels that provide preferential horizontal airflow pathways. It is reasonable to conclude that either the annular space at the test wells may be inadequately sealed for vapor movement, or that other, nearby wells may be inadequately sealed.

Figure G-1. Sampling Configuration During Carbon Tetrachloride-Packer Test.



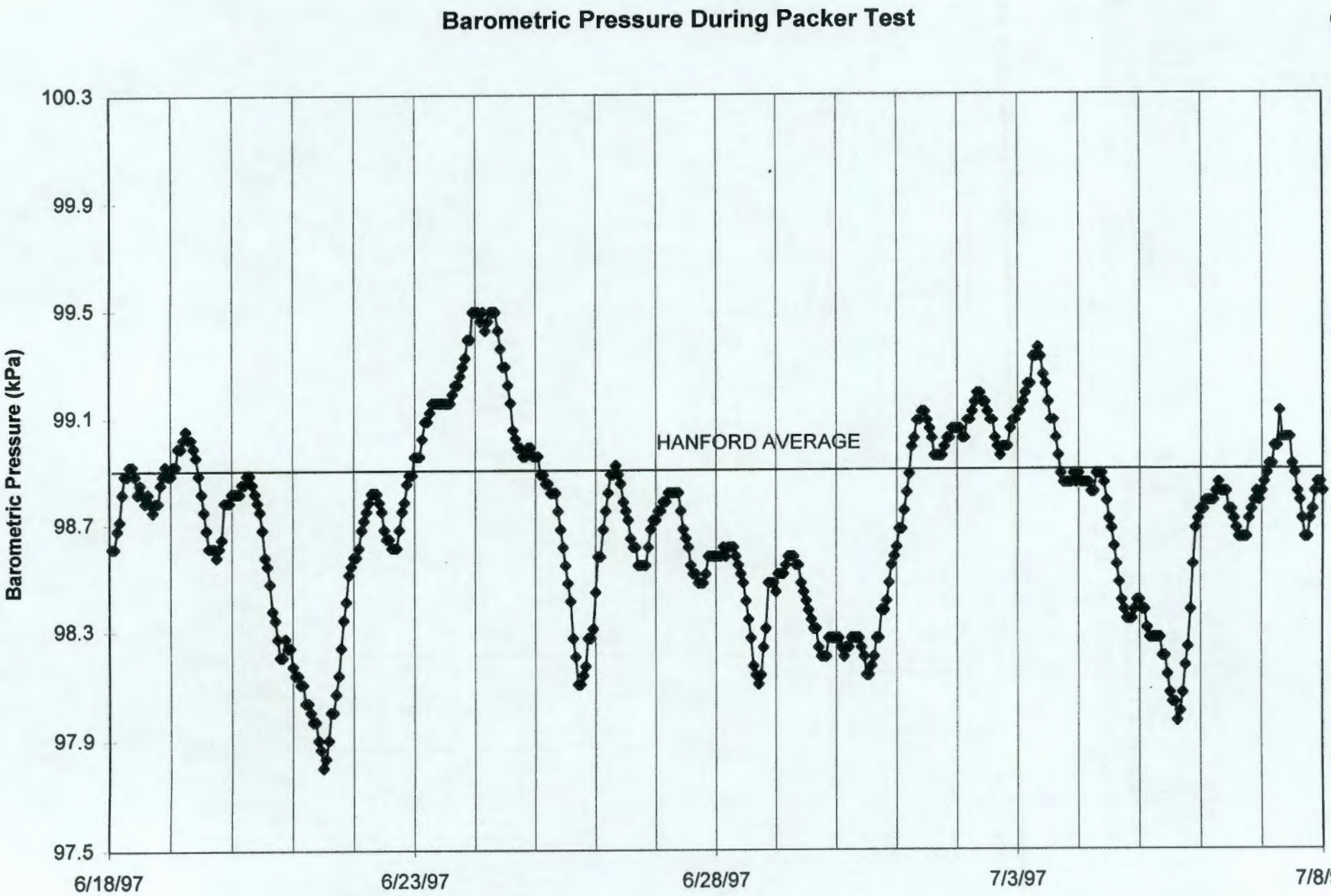


Figure G-2. Barometric Pressure During the Carbon Tetrachloride-Packer Test.

Figure G-3. Carbon Tetrachloride Concentrations Measured at Well W15-217 During Carbon Tetrachloride-Packer Test.

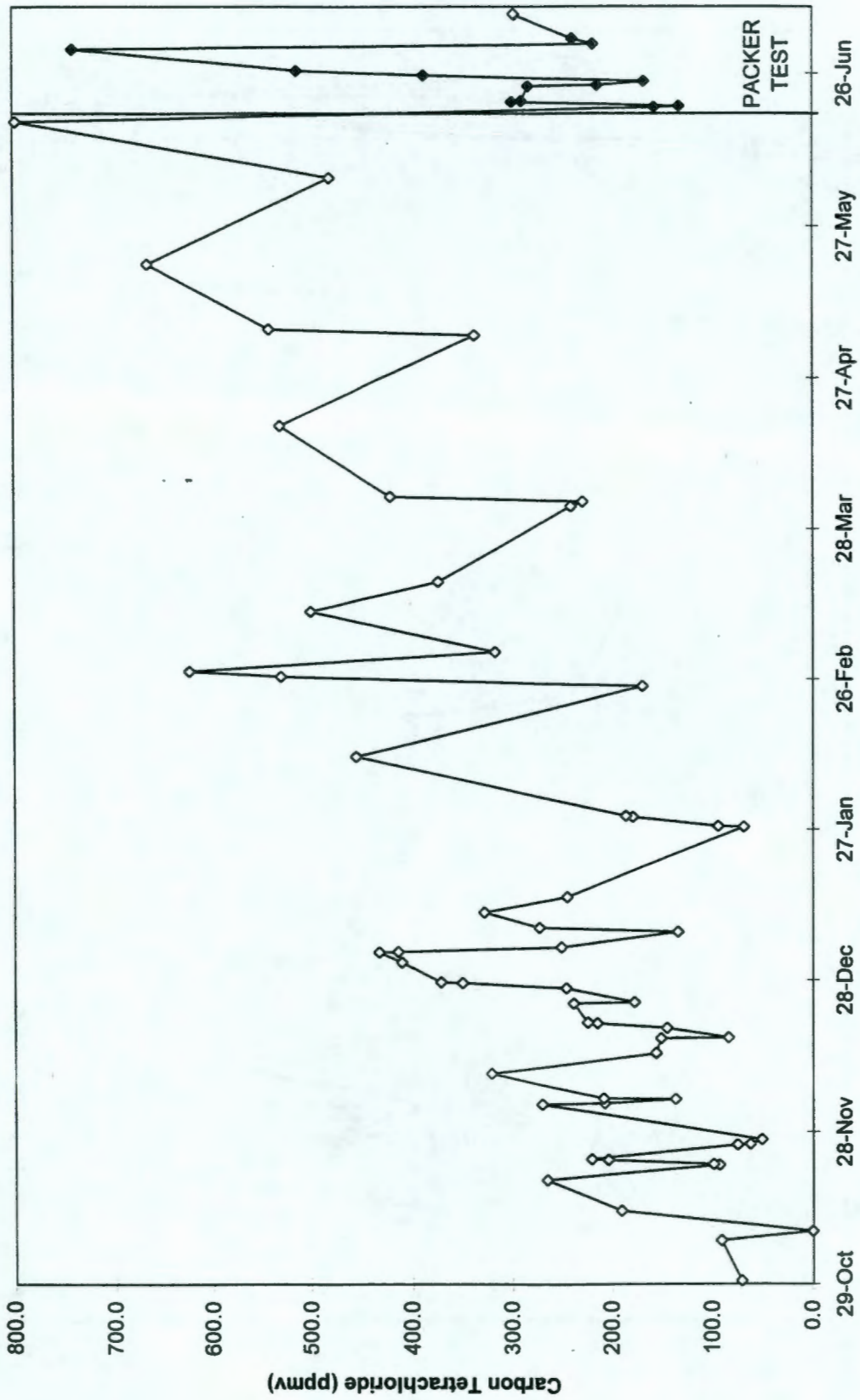
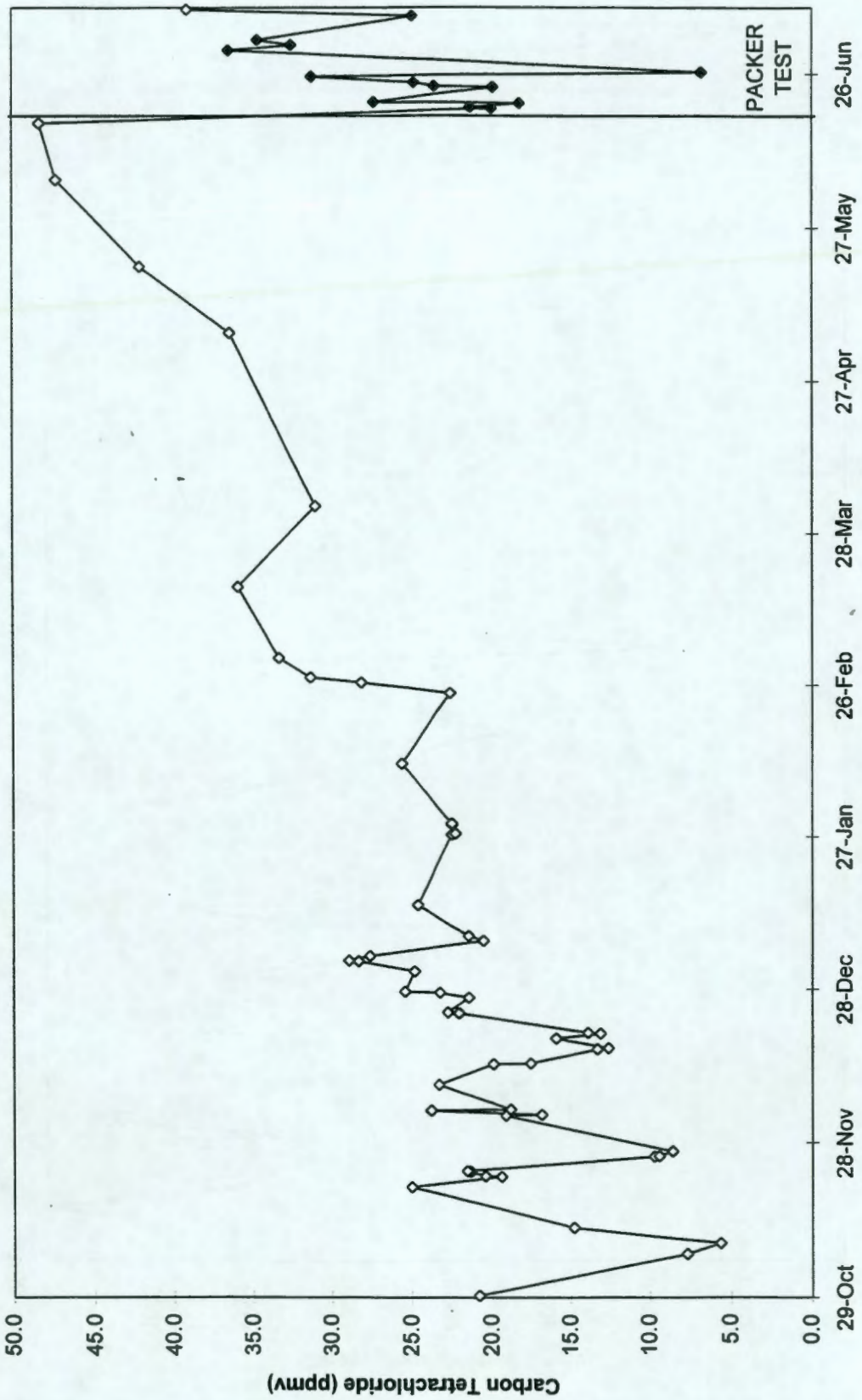


Figure G-4. Carbon Tetrachloride Concentrations Measured at Well W18-89 During Carbon Tetrachloride-Packer Test.



APPENDIX H

CARBON TETRACHLORIDE-BAROMETRIC PRESSURE TEST DATA

APPENDIX H
CARBON TETRACHLORIDE-BAROMETRIC PRESSURE TEST DATA

The carbon tetrachloride-barometric pressure test was conducted at well W18-252U at the Z-1A site to establish the relationship between barometric pressure fluctuations and carbon tetrachloride fluctuations. The well was instrumented to automatically measure and record carbon tetrachloride concentration, barometric pressure, and subsurface-surface pressure. Data collection began on June 25, 1997 and concluded on July 14, 1997. The instrumentation was disconnected from the well on July 14 in preparation for soil vapor extraction (SVE) operations. The carbon tetrachloride-barometric pressure test data are included in this appendix.

The configuration of the well during the test is schematically illustrated in Figure H-1. The surface openings to both the upper and lower intervals of the well were sealed during the test to simulate conditions during the rebound study. (The upper [U] interval is screened from 34.4 to 40.5 m bgs in zone 3, and the lower [L] interval is screened from 50.3 to 56.4 m bgs in zone 5. The two intervals are isolated by a downhole inflatable packer.) The barometric pressure and differential pressure were monitored every 10 seconds and an average value was recorded for each hour. The sample pump was programmed to operate for 5 minutes before the end of each hour to obtain a soil vapor sample from the well for analysis using the B&K. A buffer jar with a pressure relief tube was in-line between the sample pump and the B&K to ensure that the B&K internal pump did not have to pull against downhole pressures (Figure H-1).

At least one barometric pressure inversion occurred during the test (e.g., July 1, 1997 through July 7, 1997), in addition to the diurnal fluctuations (Figure H-2). Detections of carbon tetrachloride occurred during the relatively low barometric pressure periods on a diurnal basis (Figure H-3). Even when barometric pressure was relatively high (e.g., July 1 through July 3), the carbon tetrachloride peak corresponded to the diurnal low. The maximum carbon tetrachloride concentration detected was 50 ppmv, which is in agreement with the rebound study measurements (see Figure 6-8). The carbon tetrachloride detection cycles do not appear to be delayed relative to the barometric pressure cycles at the upper interval of this well.

Although the pattern of relatively high carbon tetrachloride detections during barometric lows was expected, the return of the carbon tetrachloride concentration to 0 ppmv between each detection was unexpected; carbon tetrachloride concentrations were never 0 ppmv during the rebound measurements at this well (see Figure 6-8). The positive detections of carbon tetrachloride correspond to positive differential pressure, i.e., subsurface pressure greater than barometric pressure (Figure H-4). The apparent lack of carbon tetrachloride detections during periods of relatively high barometric pressure and corresponding negative differential pressure probably indicates that the B&K was not receiving a representative sample from the subsurface (Figure H-5). During those times, the sample pump had to withdraw a sample against downhole pressure through the sample tube, and the B&K may have been drawing a sample of essentially atmospheric air through the pressure relief tube.

However, a similar data pattern was collected at well W18-152 in December 1995 and January 1996 by Fancher (1997) in which the sample tube led from the screened interval in the

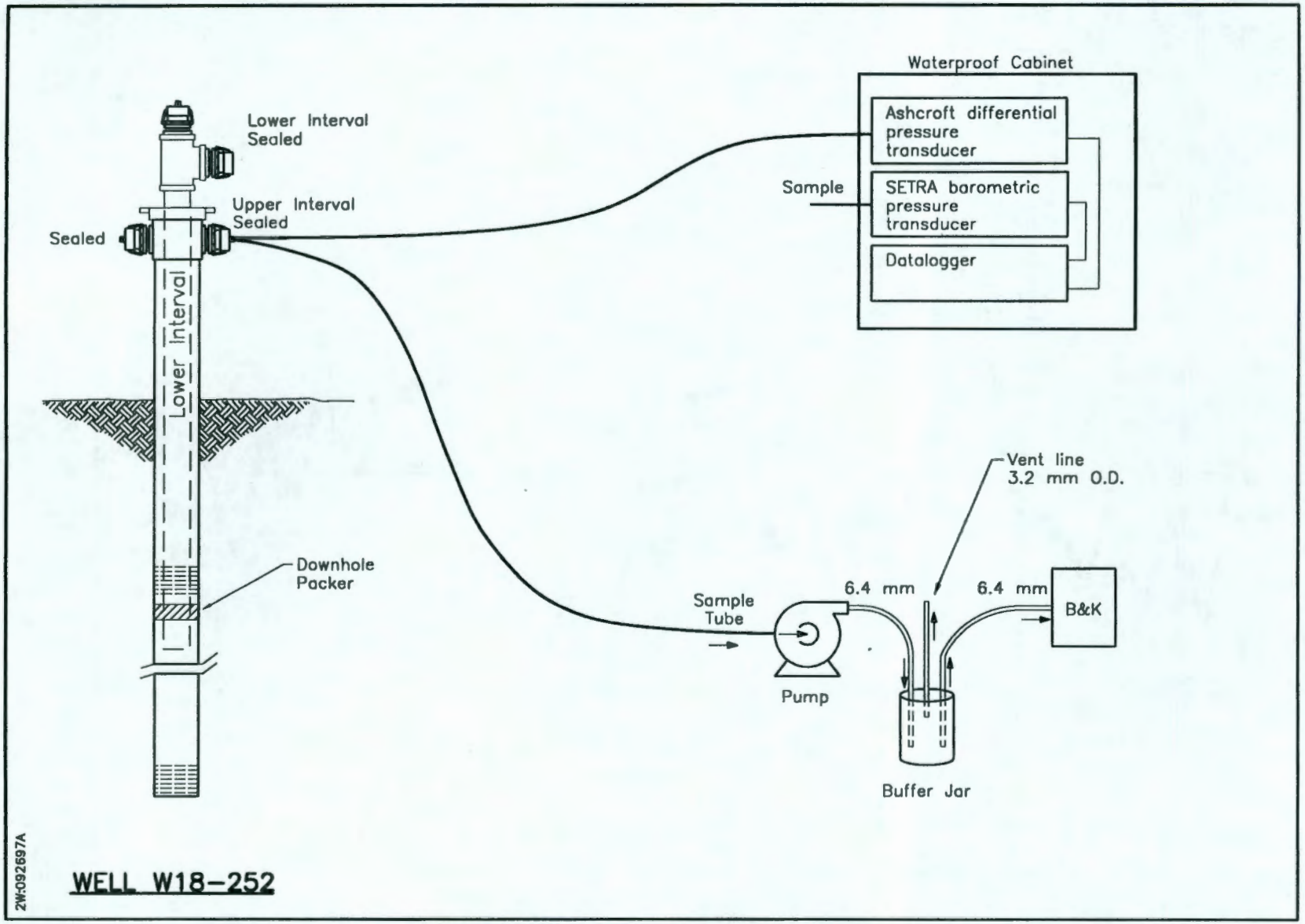
well (30 m deep) directly to the B&K without an intermediate sample pump or buffer jar (Figure H-6). Although concentrations did not return to 0 ppmv when barometric pressure rose, they did plummet from 80 ppmv to 5 ppmv.

Although the carbon tetrachloride concentration varied inversely with barometric pressure during the test, the magnitude of the carbon tetrachloride concentration shows no relationship to the magnitude of barometric pressure (Figure H-7). The numerical relationship between concentration and pressure thus appears to be complex, and a filter has not yet been developed for accurately separating the effects of barometric pressure from the effect of rebound.

REFERENCES

Fancher, J. D., 1997, *Subsurface Volatile Organic Compound Vapor-Phase Rebound and Implications for Vapor Extraction*, M.S. Thesis, Washington State University, Pullman, Washington, 56 p.

Figure H-1. Schematic Drawing of Well Configuration During the Carbon Tetrachloride-Barometric Pressure Test.



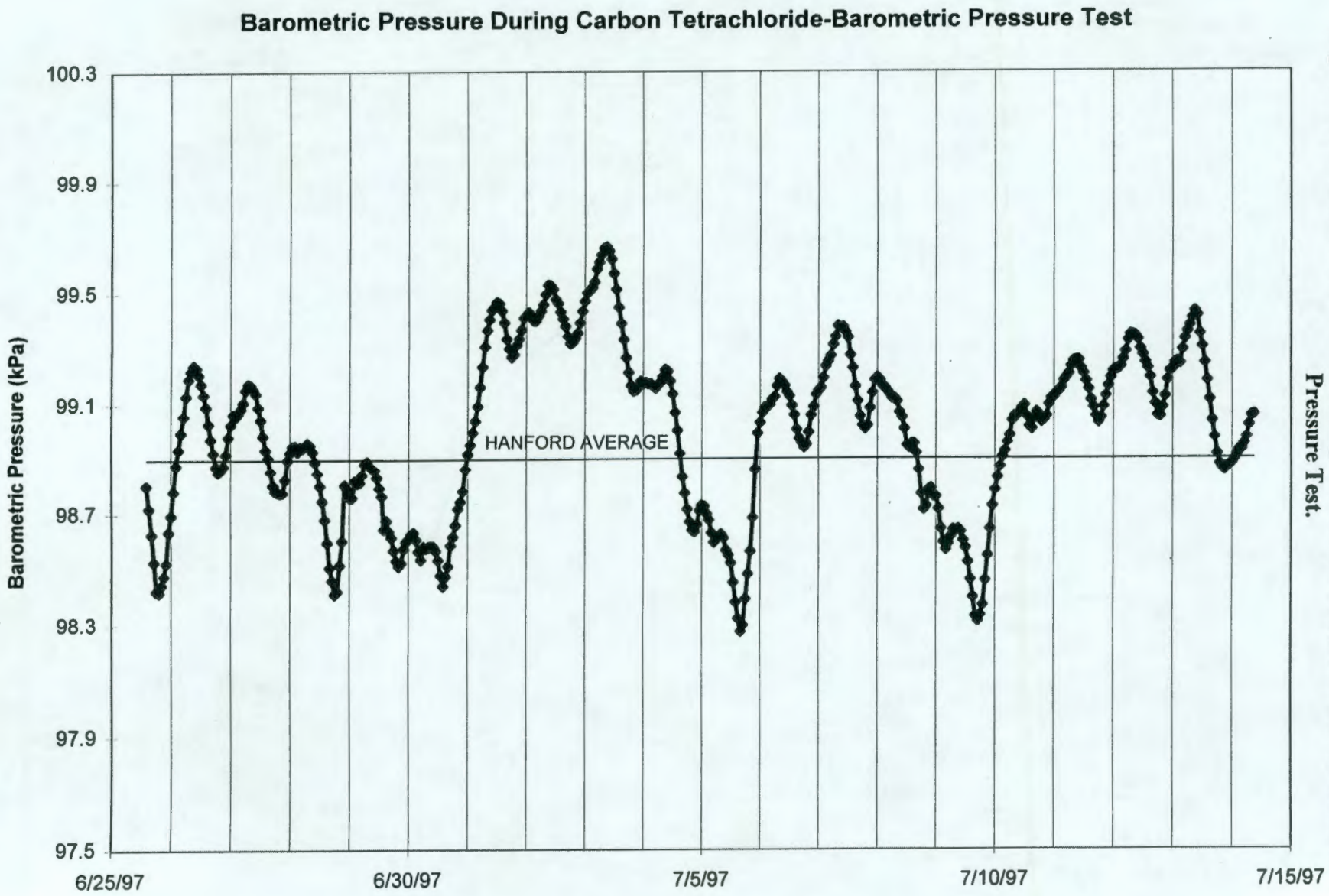


Figure H-2. Barometric Pressure During the Carbon Tetrachloride-Barometric Pressure Test.

Figure H-3. Carbon Tetrachloride Concentrations and Barometric Pressure Measured at Well W18-252U During the Carbon Tetrachloride-Barometric Pressure Test.

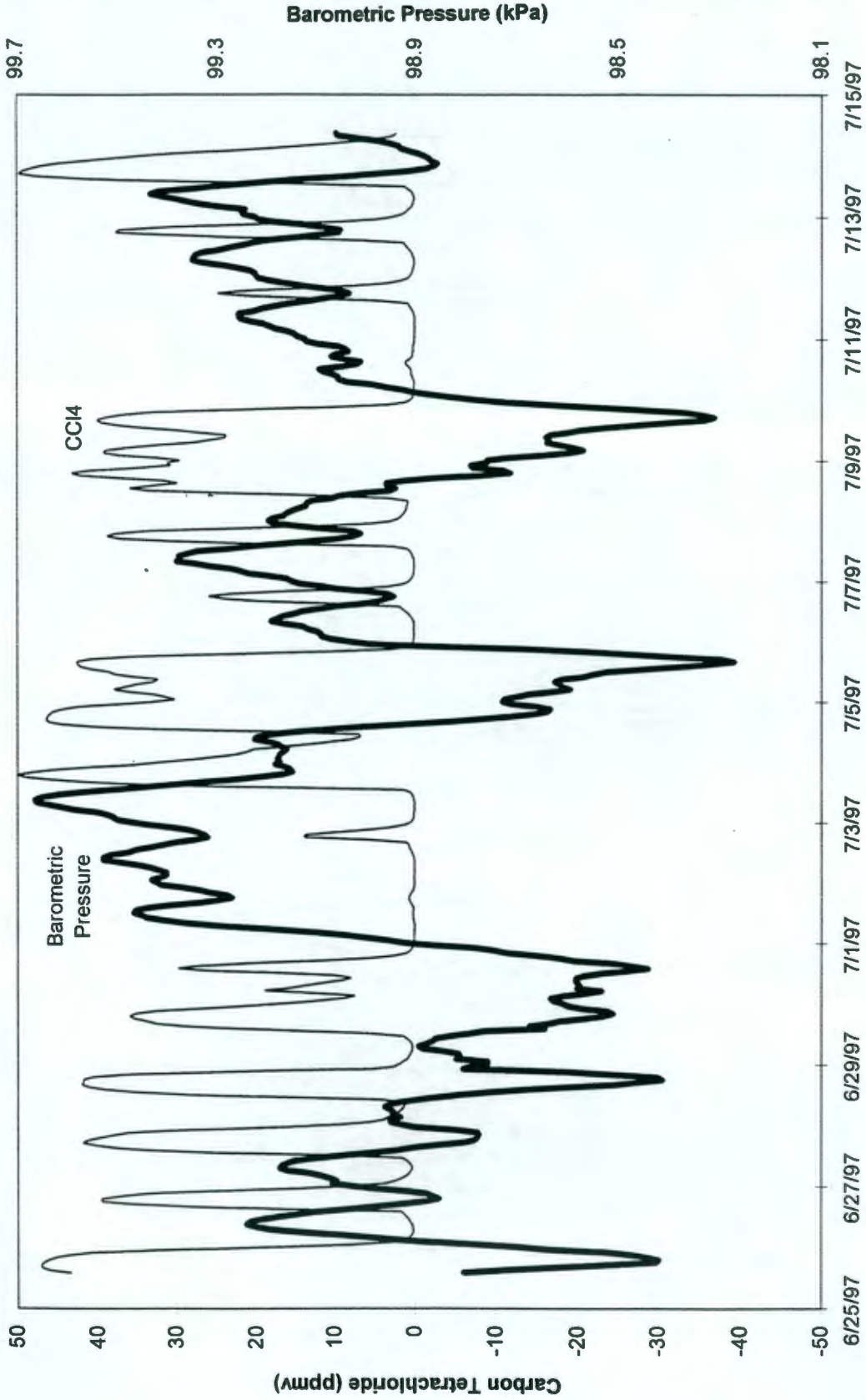


Figure H-4. Relationship of Carbon Tetrachloride Concentration to Differential Pressure During the Carbon Tetrachloride-Barometric Pressure Test.

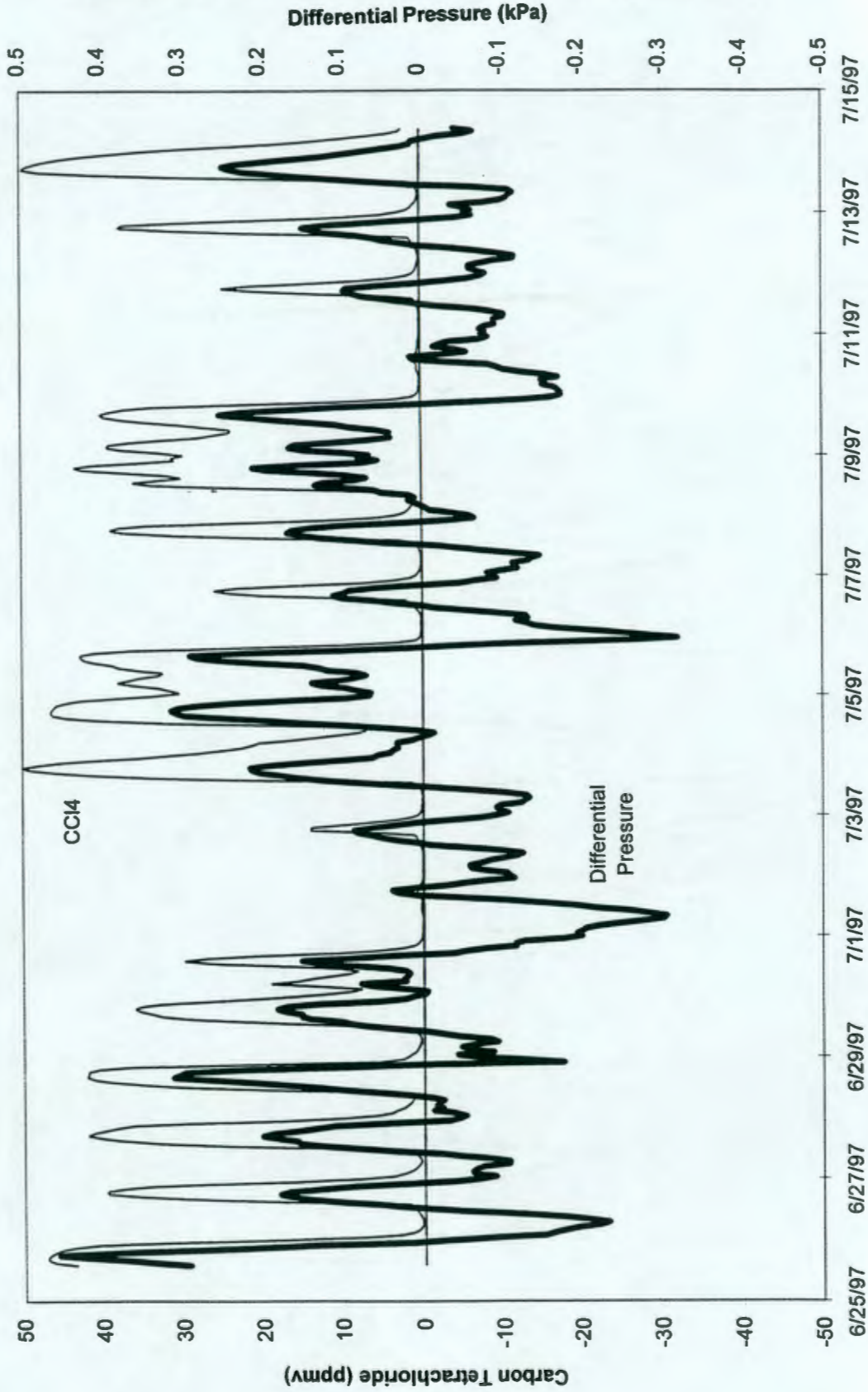


Figure H-5. Relationship of Barometric Pressure and Subsurface-Surface Differential Pressure During the Carbon Tetrachloride-Barometric Pressure Test.

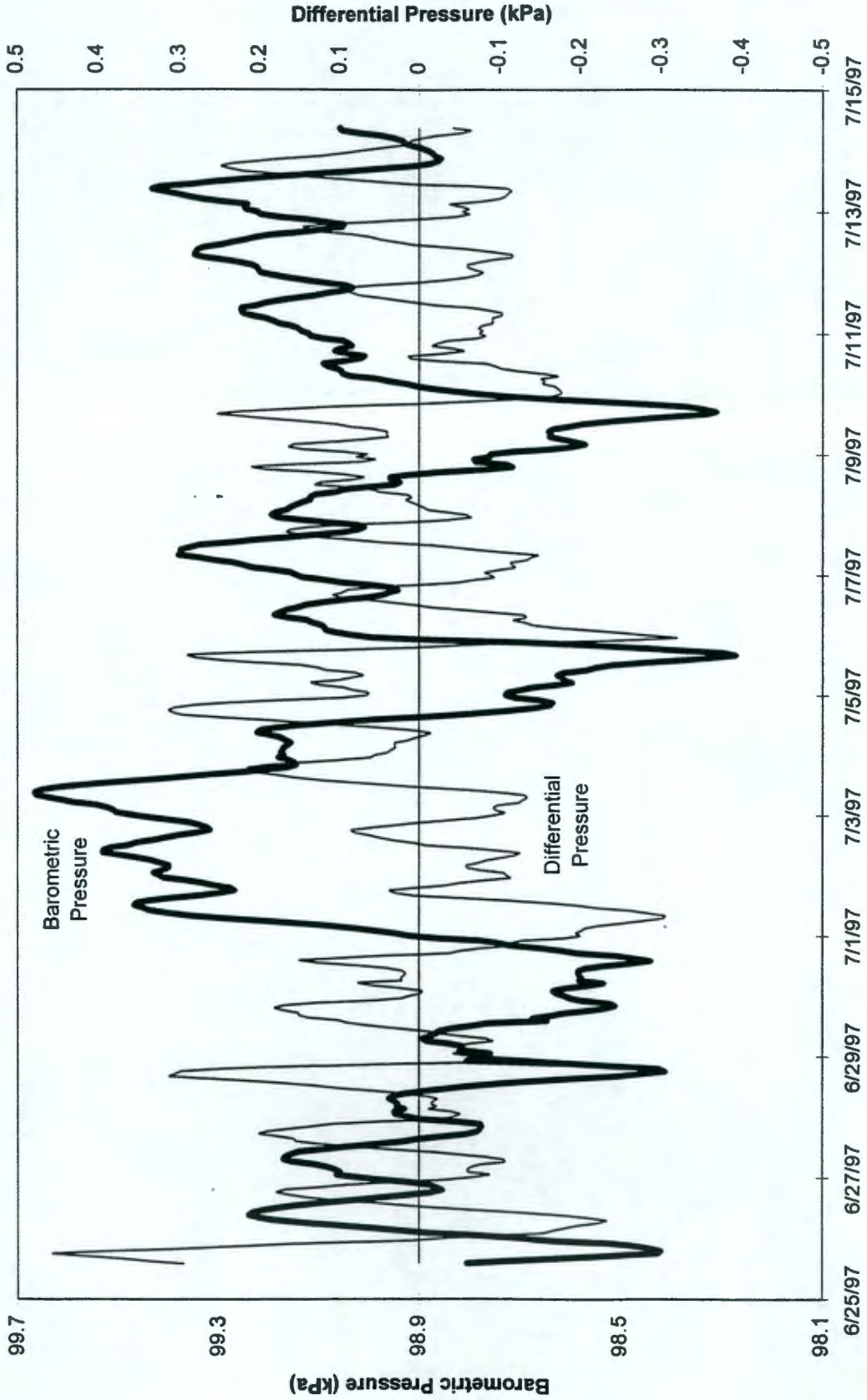


Figure H-6. Carbon Tetrachloride Concentrations and Barometric Pressure Measured at Well W18-152 in December 1995 and January 1996. (Fancher 1997)

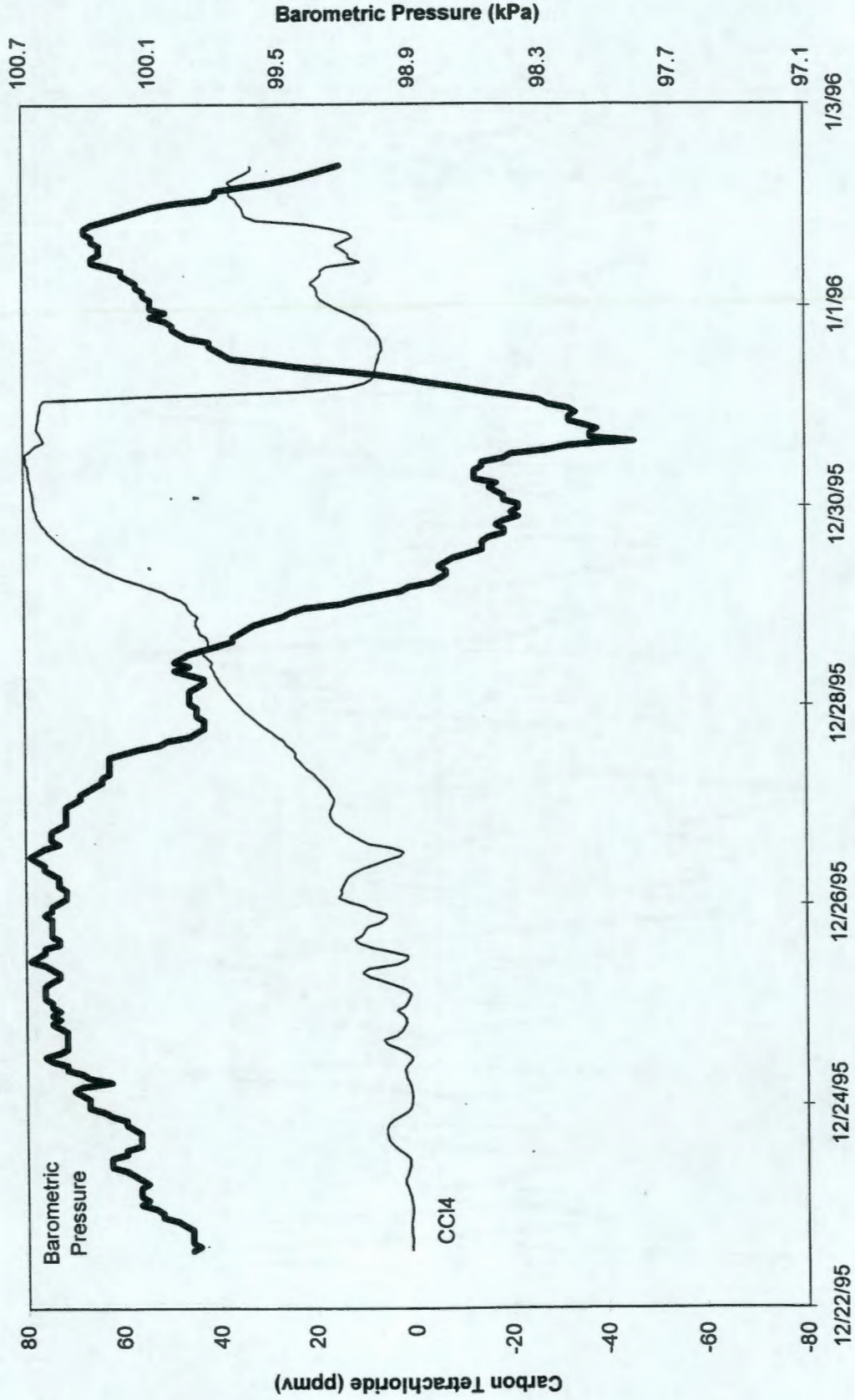
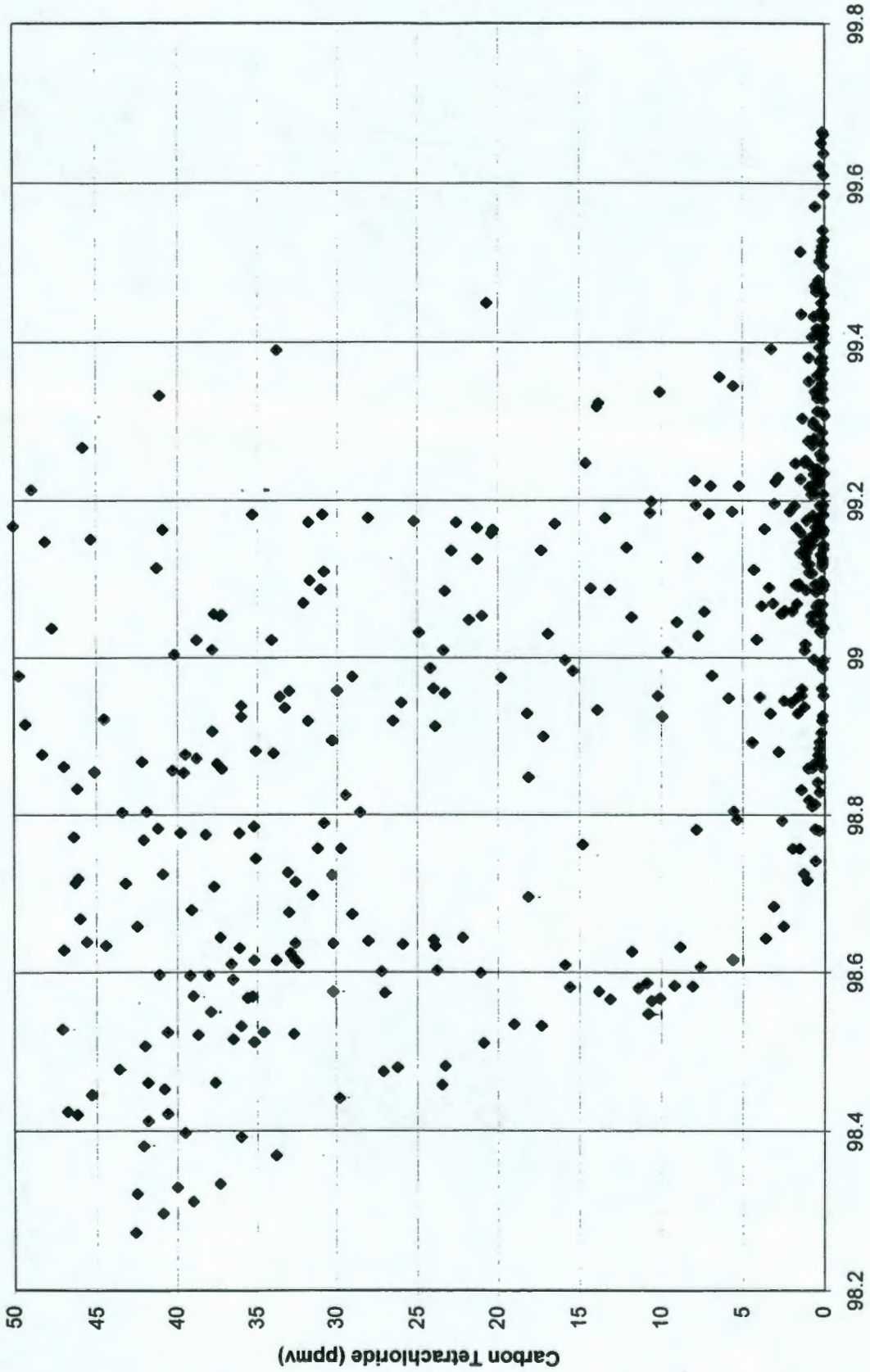


Figure H-7. Relationship of Carbon Tetrachloride Concentration to Magnitude of Barometric Pressure During the Carbon Tetrachloride-Barometric Pressure Test.



APPENDIX I

PASSIVE EXTRACTION VALVE TEST DATA

APPENDIX I
PASSIVE EXTRACTION VALVE TEST DATA

The passive extraction valve test was conducted simultaneously at wells W18-246L, W18-247L, and W18-252L at the Z1-A site to determine the relationship between the type of one-way valve used in passive soil vapor extraction systems and the carbon tetrachloride removal rate. The wells were instrumented to automatically measure and record carbon tetrachloride concentration, flow, barometric pressure, and subsurface-surface pressure. Data collection began on August 15, 1997 and concluded on September 16, 1997. The instrumentation was disconnected from the wells on September 16. The passive extraction valve test data are included in this appendix.

During this test, carbon tetrachloride-laden soil vapor was extracted from the subsurface by the pumping action caused by barometric pressure fluctuations. This naturally occurring phenomenon is referred to as passive soil vapor extraction, or barometric pumping. In general, when barometric pressure falls, wells will exhale soil vapor; and when barometric pressure rises, wells will inhale ambient air. The purpose of this test was to determine whether a one-way valve placed in-line between the well and the atmosphere would impact the removal rate of carbon tetrachloride.

Three types of valves were tested during passive extraction field tests in 1995 (Rohay 1996): (1) no valve, (2) two flow-activated valves, and (3) one differential pressure-activated valve. The tests were all conducted at well W18-247L sequentially. Evaluation of the performance of the different valves was difficult because the barometric pressure fluctuations, which drive passive extraction, were different during each test interval. However, it was clear that using the sign (positive or negative) of the subsurface-surface differential pressure as measured at the wellhead to control the valve was an unsuccessful strategy. Under those conditions, the valve was opened and closed during times that did not correspond to natural venting episodes. It was recommended that the valves be tested simultaneously to eliminate the variable of barometric pressure from the evaluation (Rohay 1996).

I.1.0 DATA COLLECTION

The configuration of the wells during the test is schematically illustrated in Figure I-1. At each well, the surface opening to the upper interval was sealed, and the surface opening to the lower interval was open, during the test (Figure I-1). The barometric pressure, differential pressure, and flow were monitored every 10 seconds and an average value was recorded for each hour. The sample pump was programmed to operate for 5 minutes before the end of each hour to obtain a soil vapor sample for analysis using the B&K. A buffer jar with a pressure relief tube was in-line between the sample pump and the B&K to ensure that the B&K internal pump did not have to pull against downhole pressures.

A canister of granular activated carbon (GAC) was placed at the outlet of each well to absorb carbon tetrachloride from the venting air. A different kind of valve was installed at each well between the GAC outlet and atmospheric air (Figure I-1). At well W18-246L, no valve was

installed; the well was open to atmosphere at all time. At well W18-247L, a flow-activated valve was installed; the well was expected to be open to atmosphere when flow was out of the well and closed to atmosphere when flow would be into the well. At well W18-252L, a differential pressure-activated valve was installed; the well was expected to be open to atmosphere when differential pressure was positive (subsurface greater than barometric) and closed when differential pressure was negative (subsurface less than barometric). The measurement location for the differential pressure was initially at the wellhead, as in the 1995 test. Once correspondence between the 1995 and 1997 testing behavior had been established, the measurement location was to be switched to a subsurface location near the screened interval, where the differential pressure was expected to correspond more closely to venting episodes. The differential pressure signal was fed to the datalogger; when the sign of the pressure changed, the datalogger opened or closed a solenoid valve.

At least one barometric pressure inversion occurred during the test (e.g., August 29, 1997 through September 6, 1997) in addition to the diurnal fluctuations (Figure I-2). During most of the test, barometric pressure was less than the Hanford Site average (98.9 kPa). The August 29 to September 6 interval of the test was selected for analysis because it included pressures greater than and less than the average pressure; and because a complete data record was available for each well during this time.

The carbon tetrachloride, flow, and pressure data collected at well W18-246L are shown in Figures I-3 through I-5. The flow meter measured only the magnitude of the flow; other measured variables were used during the analysis to assign a flow direction. The carbon tetrachloride, flow, and pressure data collected at well W18-247L are shown in Figures I-6 through I-8. The carbon tetrachloride, flow, and pressure data collected at well W18-252L are shown in Figures I-9 through I-11. The maximum and minimum values for these parameters are summarized in Table I-2.

Data collection at wells W18-246L and W18-247L was complete, with two exceptions. The carbon tetrachloride concentrations at well W18-246L were not recorded from September 8 at 5:00 through September 11 at 12:00. The reason no data were stored in the B&K memory for this period is unknown. Unfortunately, the greatest drop in barometric pressure, which should have produced the maximum carbon tetrachloride venting, occurred during this same period. Because of the lack of carbon tetrachloride data for well W18-246L, this test interval was not analyzed. The carbon tetrachloride concentrations at well W18-247L were not measured from August 15 through August 19 at 9:00. During this time, the downhole packer was being repaired and the sampling system was not connected.

Data collection at well W18-252L was incomplete and could not be used for the analysis. The carbon tetrachloride concentration was essentially zero throughout the test with the exception of two very narrow measurement intervals (Figure I-10), suggesting that the valve was not being opened and closed successfully. The location of the differential pressure measurement was changed on September 8, 1997; but all of the data stored in the datalogger after September 5, 1997 could not be retrieved, apparently due to a malfunction of the datalogger recording system. The initial data collected at this well, from August 15 through August 18, was also lost.

I.2.0 DATA EVALUATION

The test data for wells W18-246L and W18-147L were used to evaluate the valves from August 29, 1997 through September 6, 1997 (Figure 1-1). These two wells were installed in 1992 using the same construction, and are 150 m apart (Figure 1-1). In well W18-246L, the screened interval is from 50.3 m to 53.3 m below ground surface (bgs); in well W18-247L, the screened interval is from 49.4 m to 52.4 m bgs (Table I-1). The flow from each well is shown in Figure I-12. The sign of the differential pressure at each well was used to assign the flow direction at that well. At well W18-246L, minor adjustments were made when the sequence of flow data suggested the position of the zero flow line. In this report, negative flow indicates flow into the well and positive flow indicates flow out of the well.

For the same barometric pressure fluctuation, the magnitude of the flow out (positive flow) is similar at the two wells. The magnitude of the flow in (negative flow) is greater at well W18-246L because the one-way valve at W18-247L was designed to prevent in-flow. The fact that there is measured in-flow suggests that the GAC canister was leaking. During the testing in 1995, the GAC canister used at well W18-247L was confirmed to leak (Rohay 1996). For this testing, care was taken to tape all suspected leaks at the GAC canisters used at each well. However, despite this precaution, the GAC canister used at well W18-252L was heard to leak, and these data suggest that the canister at well W18-246L was also leaking. It is recommended that these GAC canisters not be used for further passive testing.

The differential pressure measured at each well was added to the barometric pressure to obtain the subsurface pressure signals (Figure I-13). These data show that the one-way flow-activated valve at well W18-247L was working. When a well is open, the subsurface communicates with the surface through the preferential pathway of the well itself, and subsurface pressure responds rapidly to barometric pressure fluctuations. When a well is open, differential pressure is near-zero and the subsurface pressure tracks barometric pressure closely. When a well is closed, the subsurface and surface communicate through the soil column; a 20-hour lag time was measured at well W18-247L between the subsurface and the lower open interval below the Plio-Pleistocene layer (Rohay 1996). Because well W18-246L was open all the time, the subsurface pressure measured at that well tracks barometric whether barometric pressure is rising or falling. Because well W18-247L was open during falling barometric pressure and closed during rising barometric pressure, its subsurface pressure signal is a hybrid; it tracks barometric during falling pressure and does not track barometric during rising pressure.

In general, measurable in-flow is recorded earlier at well W18-246L than well W18-247L, probably because there is no valve at well W18-246 to restrict flow (Figure I-12). Measurable out-flow occurs at approximately the same time at both wells. Rohay (1996) speculated that out-flow in the well with a flow-activated valve (W18-247L) wold be delayed relative to out-flow in an open well (W18-246L) due to the lag time needed in the valved well for pressure communication through the subsurface when the valve is closed. These test results do not support that hypothesis; however, the results are suspect because of the leak in the system through the GAC canister.

The carbon tetrachloride concentration data measured at each well are compared in Figure I-14. The purpose of the comparison was to evaluate whether carbon tetrachloride concentrations would increase at the same time in a valved well and an open well during a venting episode. When a well is open, it inhales clean ambient air during rising barometric pressure. This clean air is then exhaled when barometric pressure next reverses. During previous testing in an open well, it was found that the lag time between the initiation of venting and the first detections of carbon tetrachloride in the venting air ranged from 3 to 17 hours (Rohay 1996). During this lag time, the volume of clean air exhaled was approximately 9% of the volume of clean air inhaled during the immediately preceding inflow event. However, inclusion of the one-way valve reduced the carbon tetrachloride lag time to essentially zero (Rohay 1996).

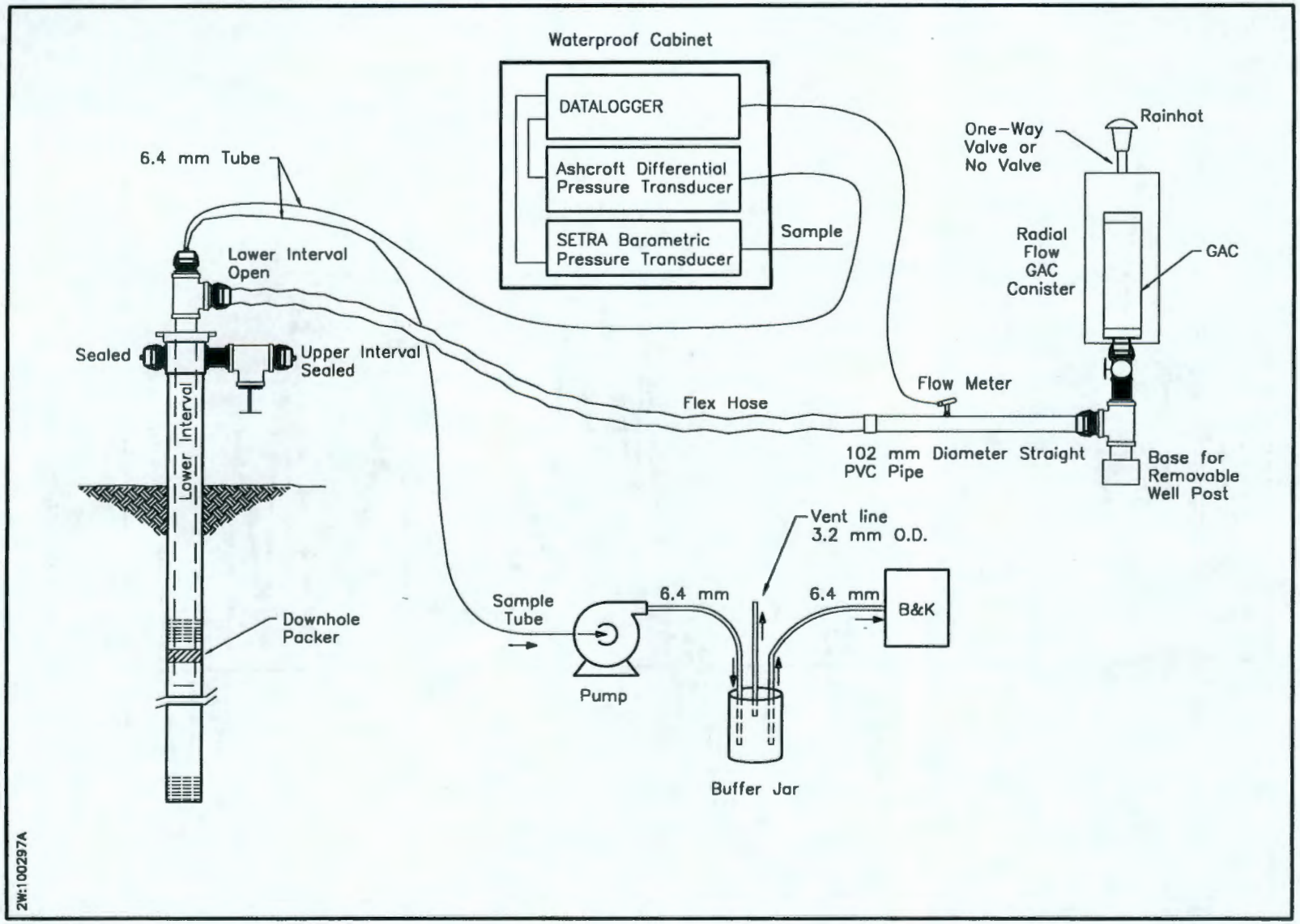
To facilitate comparison of the carbon tetrachloride data, the concentration data for each well were normalized to range between 0 and 1. The plot of the normalized data suggests that the initial detections of carbon tetrachloride occurred at approximately the same time (relative to the 1-hour measurement intervals) in each well. Again, this may reflect the leaking of air through the GAC canister at well W18-247L, making the configuration of this well similar to the open well at W18-246L. The outflow rates and durations at the two wells were similar (Figure I-12), so the mass removal rate will depend on the carbon tetrachloride concentration in the venting air. During the major venting episode beginning approximately August 30, the concentrations in the air venting from the valved well rose slightly more steeply, suggesting less dilution by ambient clean air.

Based on this testing and the 1995 testing, it appears that inclusion of a one-way flow-activated valve can improve the mass removal rate of carbon tetrachloride during passive soil vapor extraction without inducing significant delays in the initiation of vapor outflow. However, there also appears to be sufficient dispersion of the clean air in the subsurface at this site to cause mixing with contaminated air such that the mass removal rate through the open well was similar to that through the valved well. Thus, although inclusion of the one-way valve can increase the removal rate, passive extraction at the carbon tetrachloride site can also be effective without a valve.

I.3.0 REFERENCE

Rohay, V. J., 1996, *Field Tests of Passive Soil Vapor Extraction Systems at the Hanford Site, Washington*, BHI-00766, Bechtel Hanford, Inc., Richland, Washington.

Figure I-1. Schematic Drawing of Well Configuration During the Passive Extraction Valve Test.



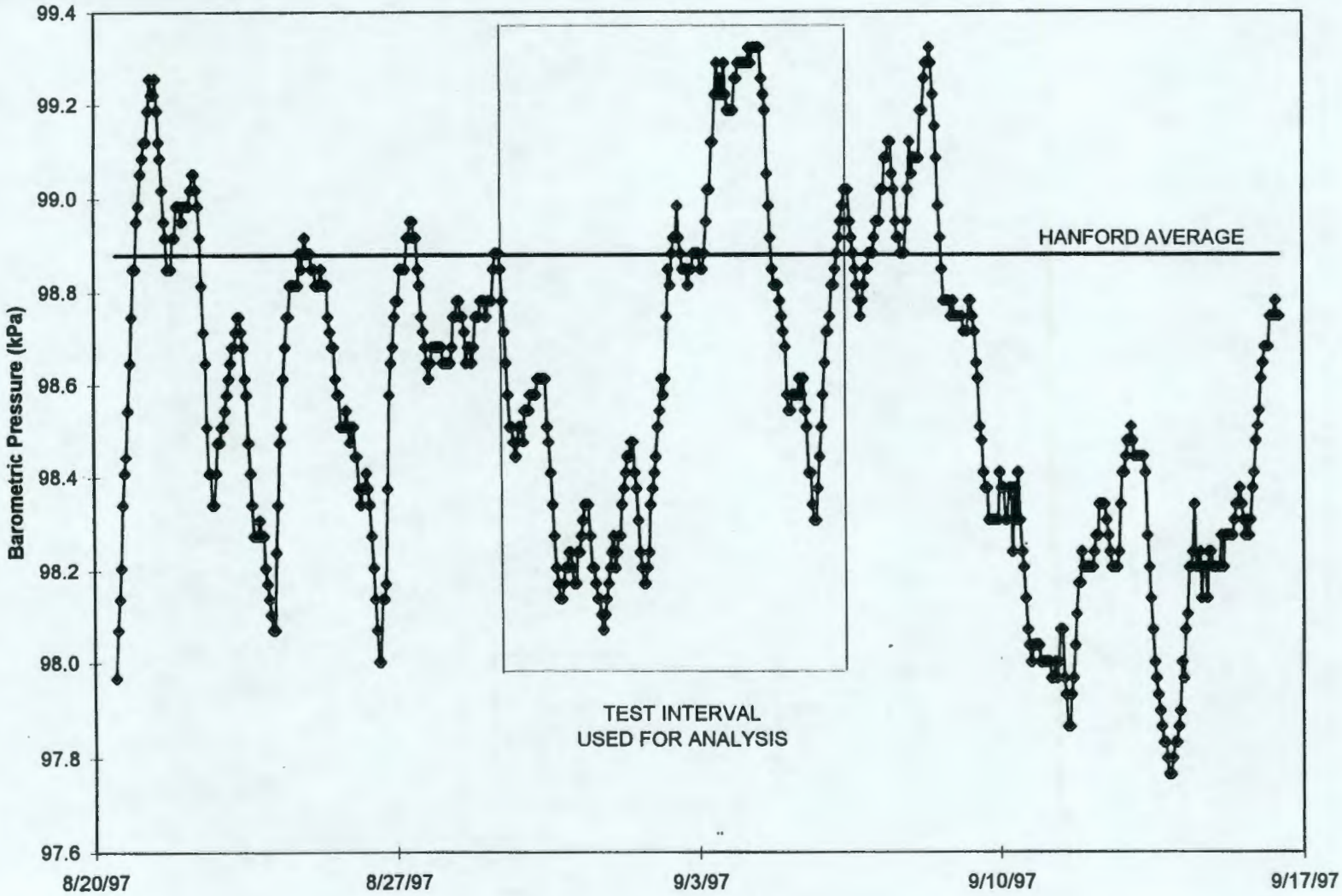


Figure I-2. Barometric Pressure During the Passive Extraction Valve Test.

Figure I-3. Flow and Differential Pressure Measured at Well W18-246L During the Passive Extraction Valve Test.

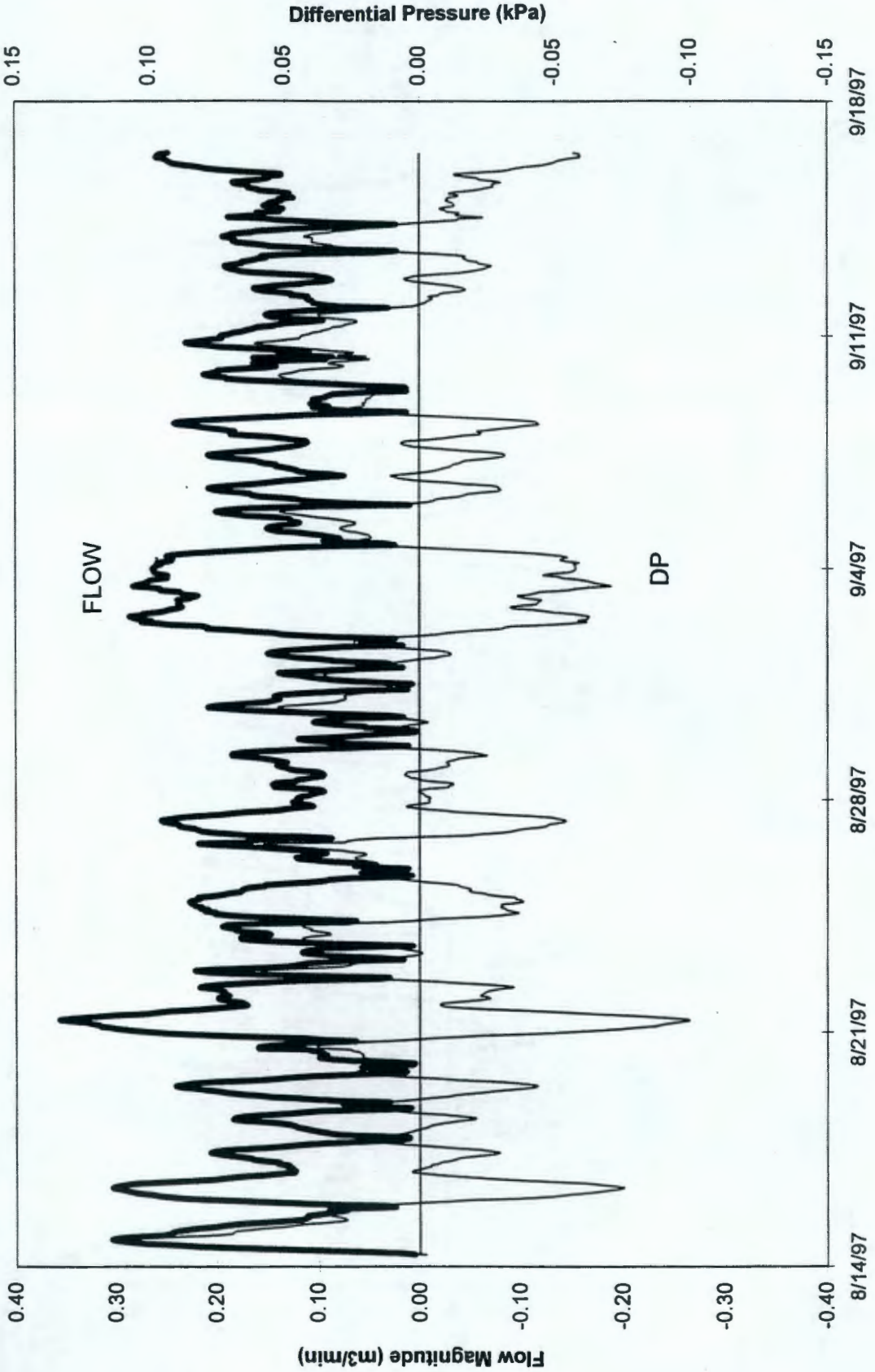


Figure I-4. Carbon Tetrachloride and Barometric Pressure Measured at Well W18-246L During the Passive Extraction Valve Test.

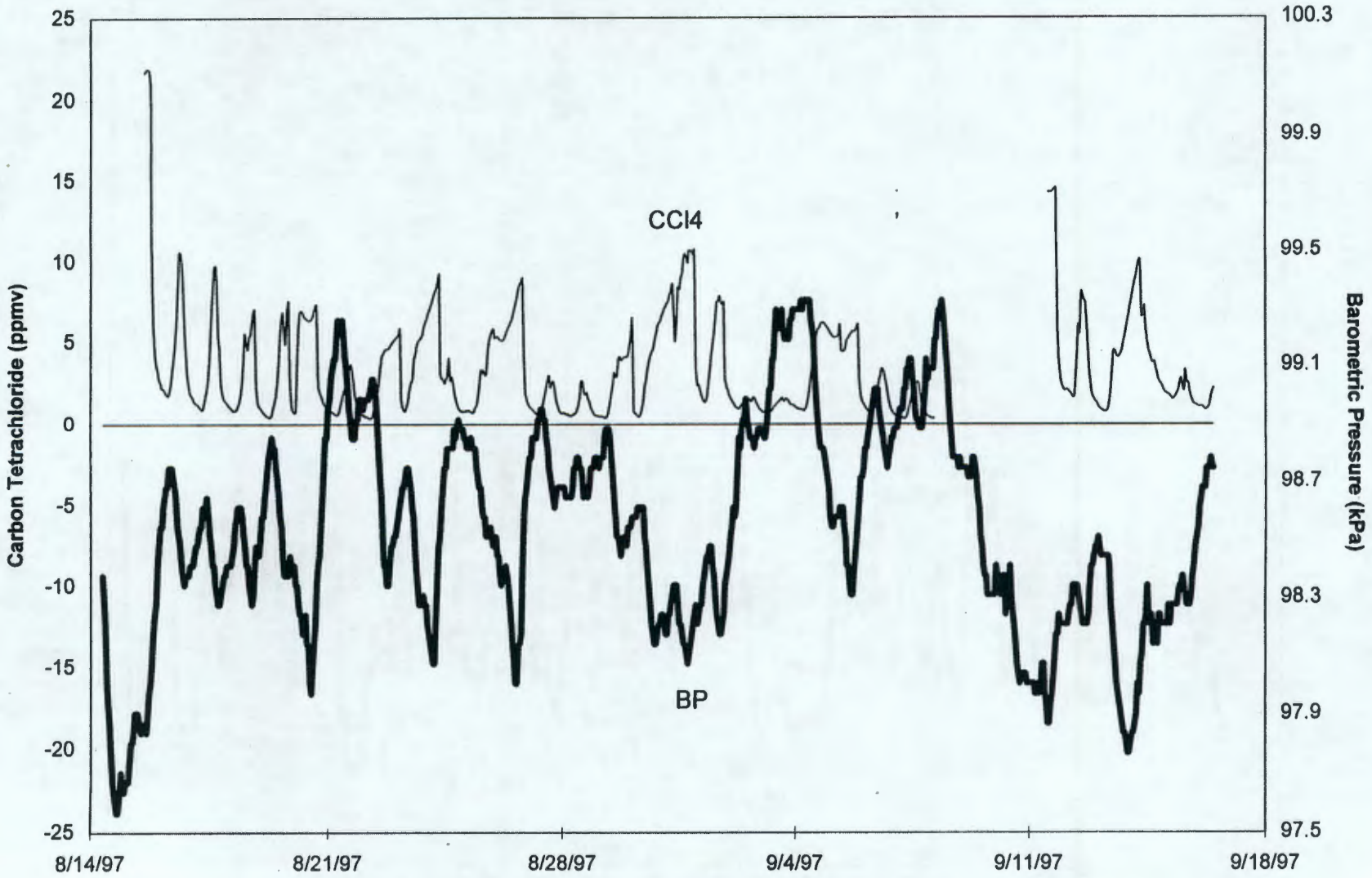


Figure I-5. Barometric and Differential Pressure Measured at Well W18-246L During the Passive Extraction Valve Test.

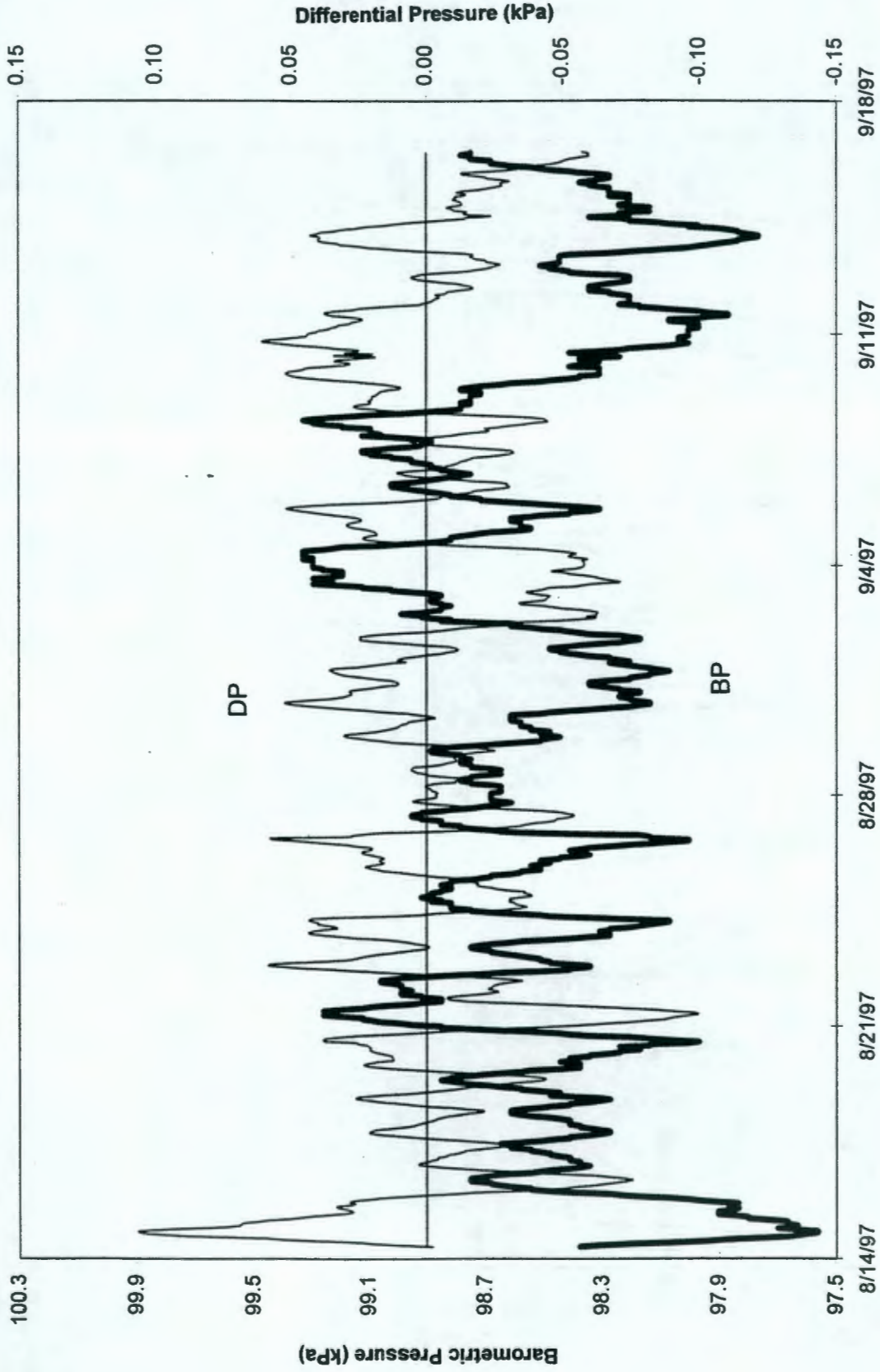


Figure I-6. Flow and Differential Pressure Measured at Well W18-247L During the Passive Extraction Valve Test.

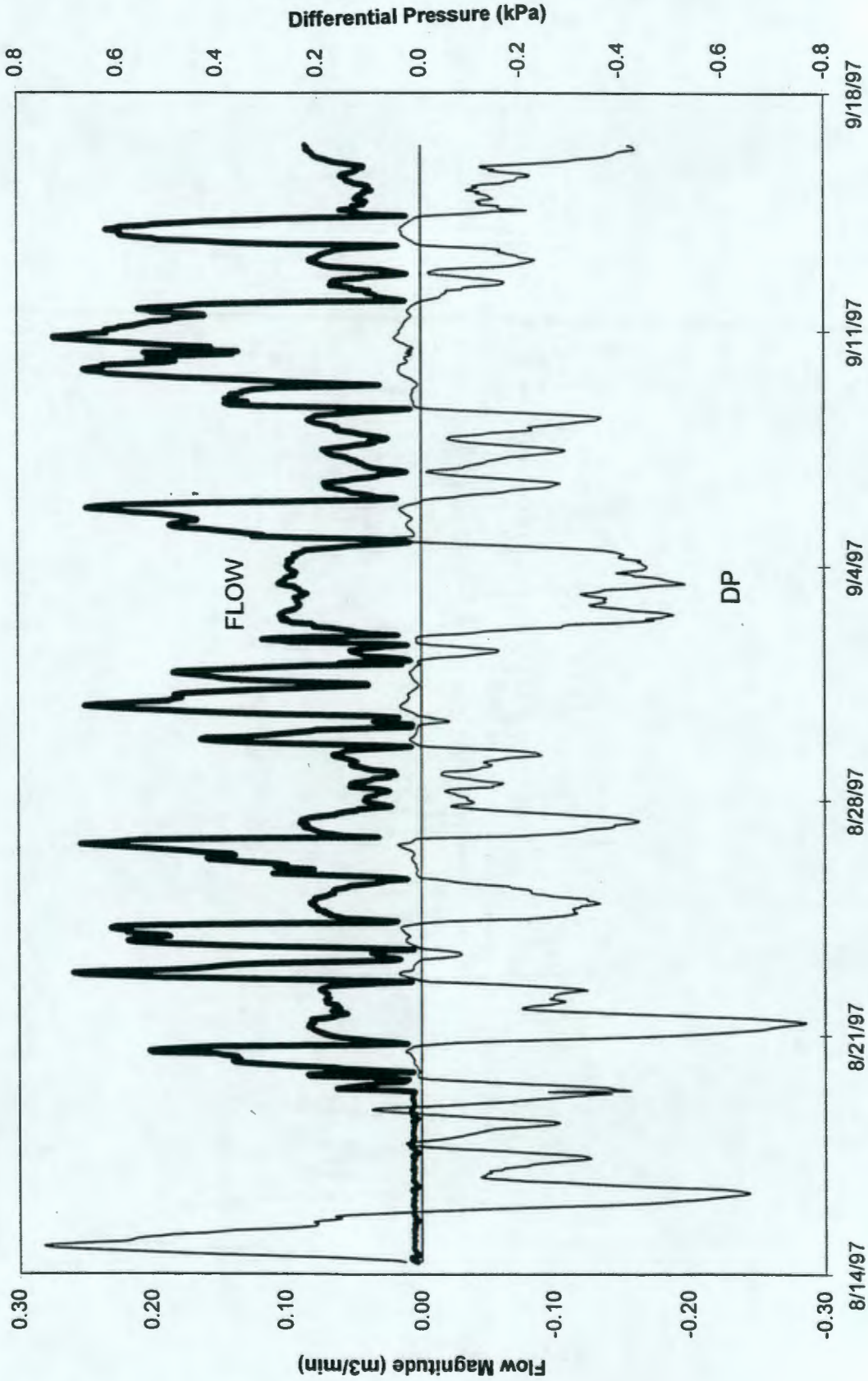


Figure I-7. Carbon Tetrachloride and Barometric Pressure Measured at Well W18-247L During the Passive Extraction Valve Test.

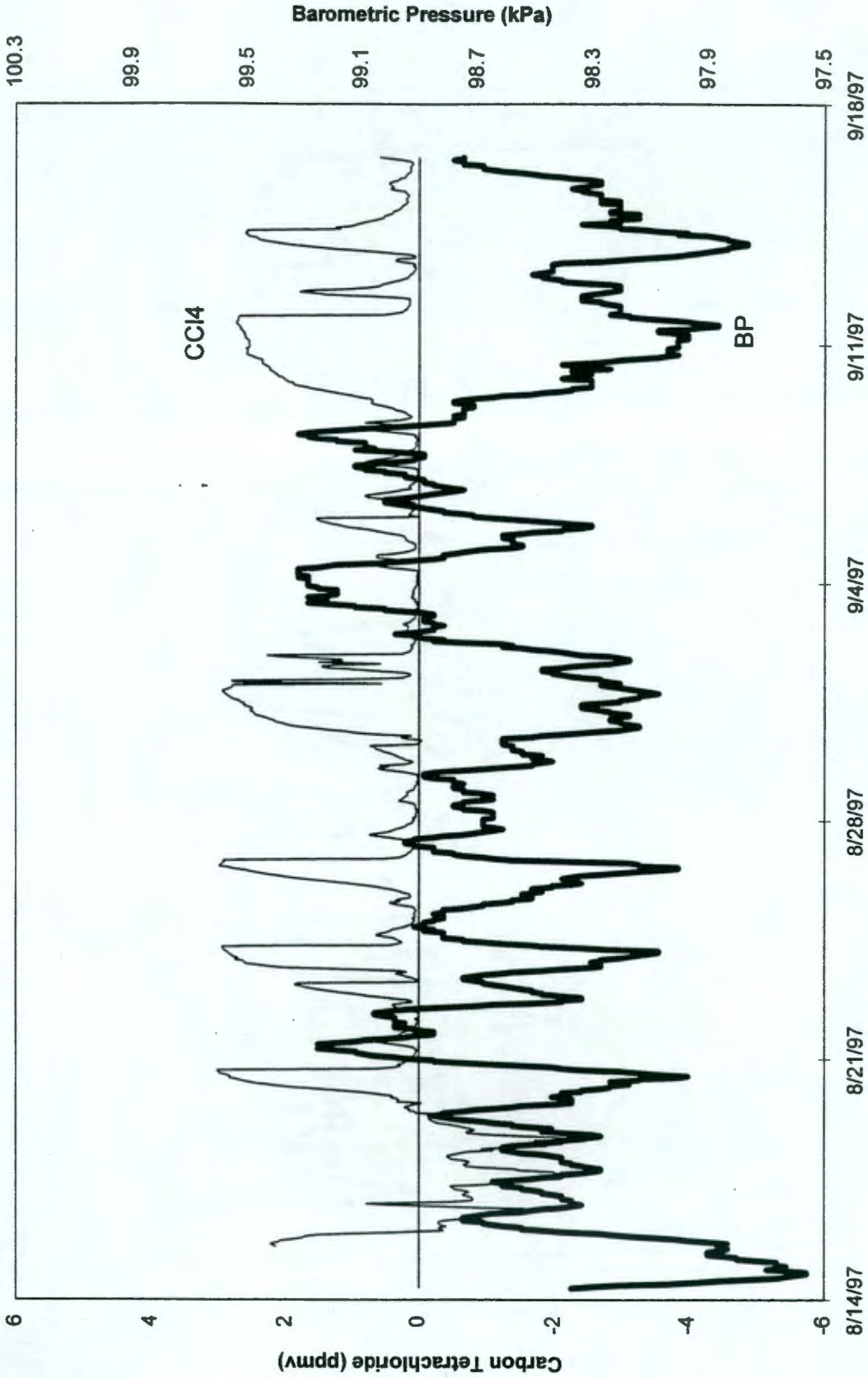


Figure I-8. Barometric and Differential Pressure Measured at Well W18-247L During the Passive Extraction Valve Test.

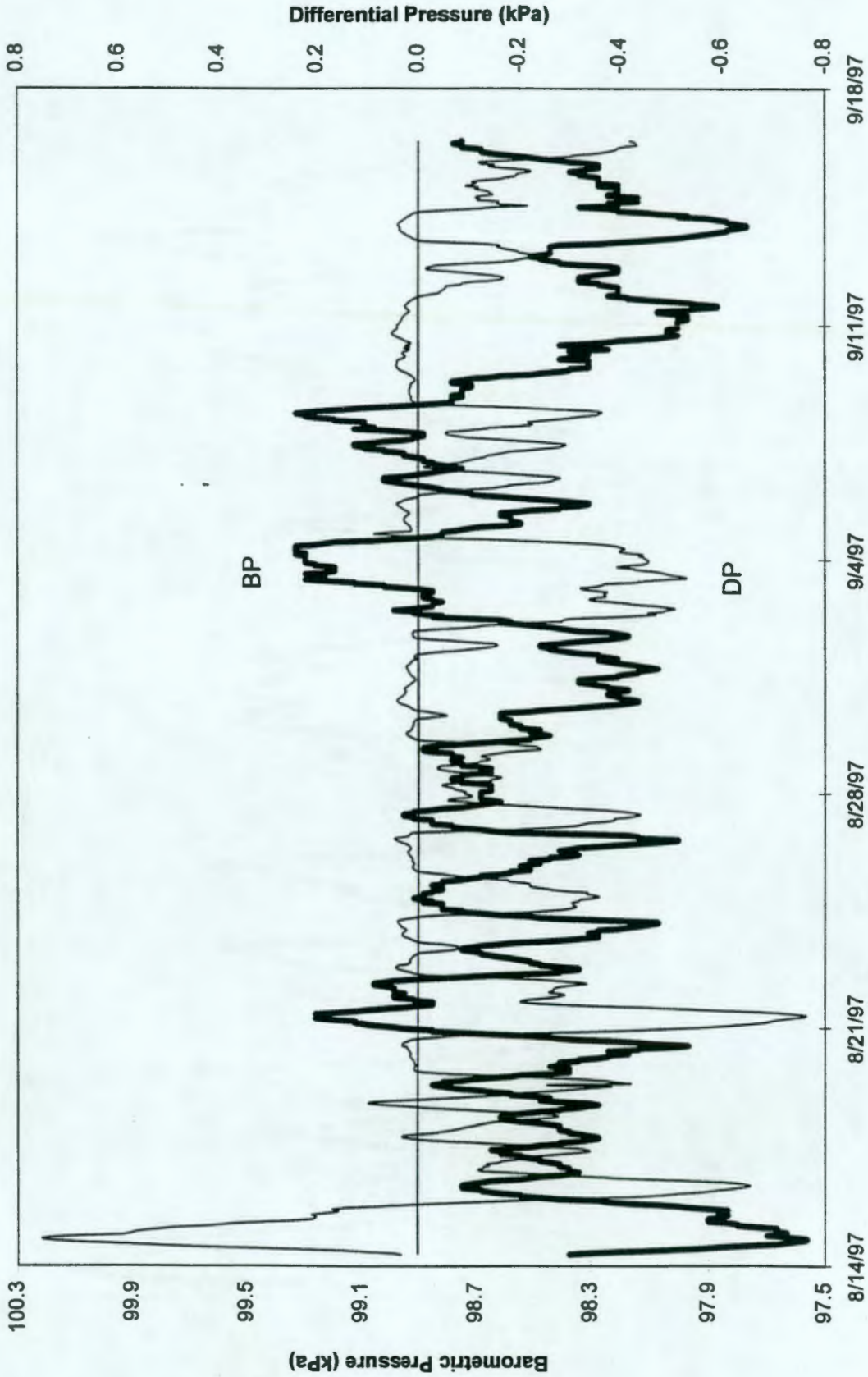


Figure I-9. Flow and Differential Pressure Measured at Well W18-252L During the Passive Extraction Valve Test.

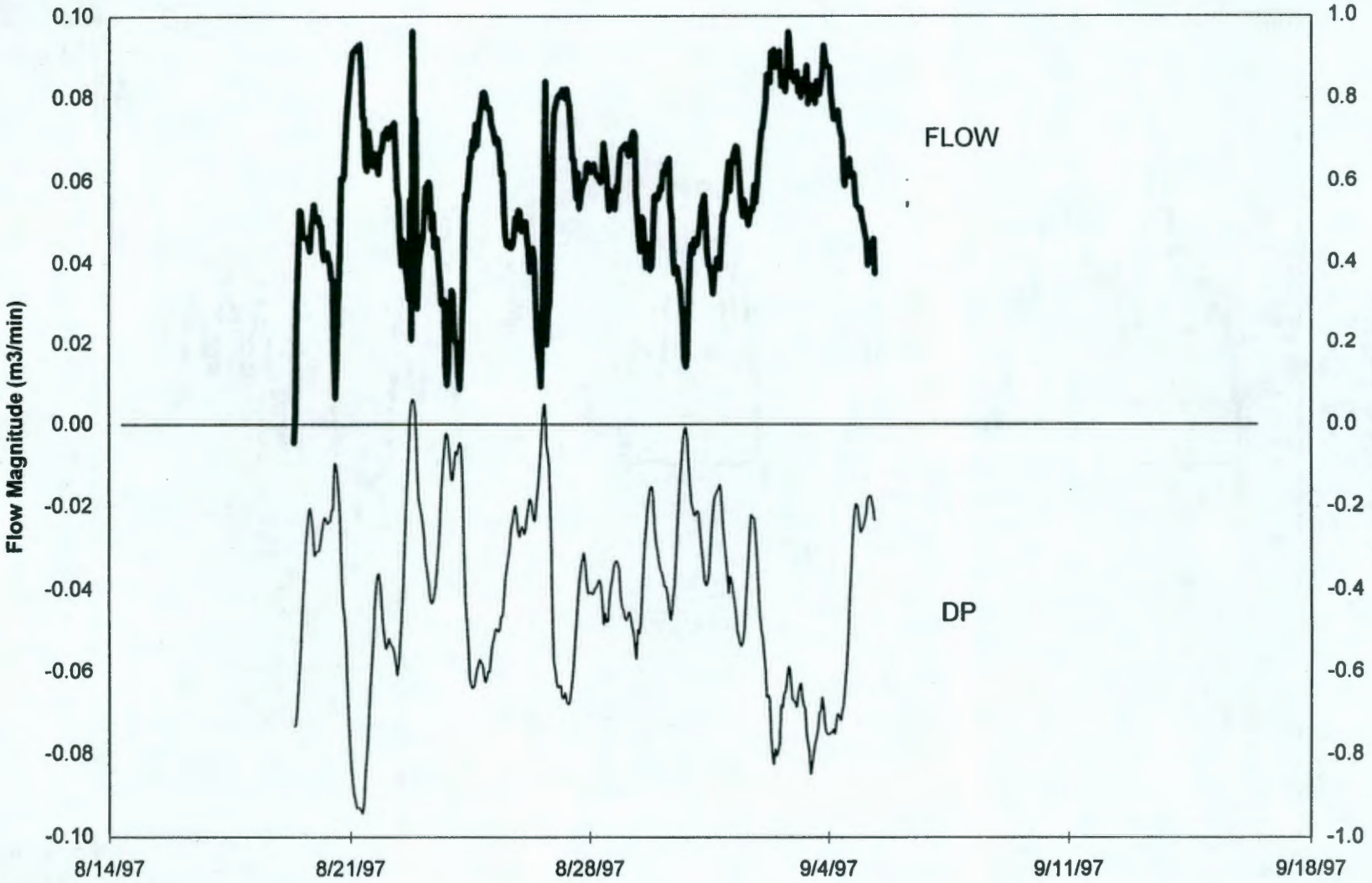


Figure I-10. Carbon Tetrachloride and Barometric Pressure Measured at Well W18-252L During the Passive Extraction Valve Test.

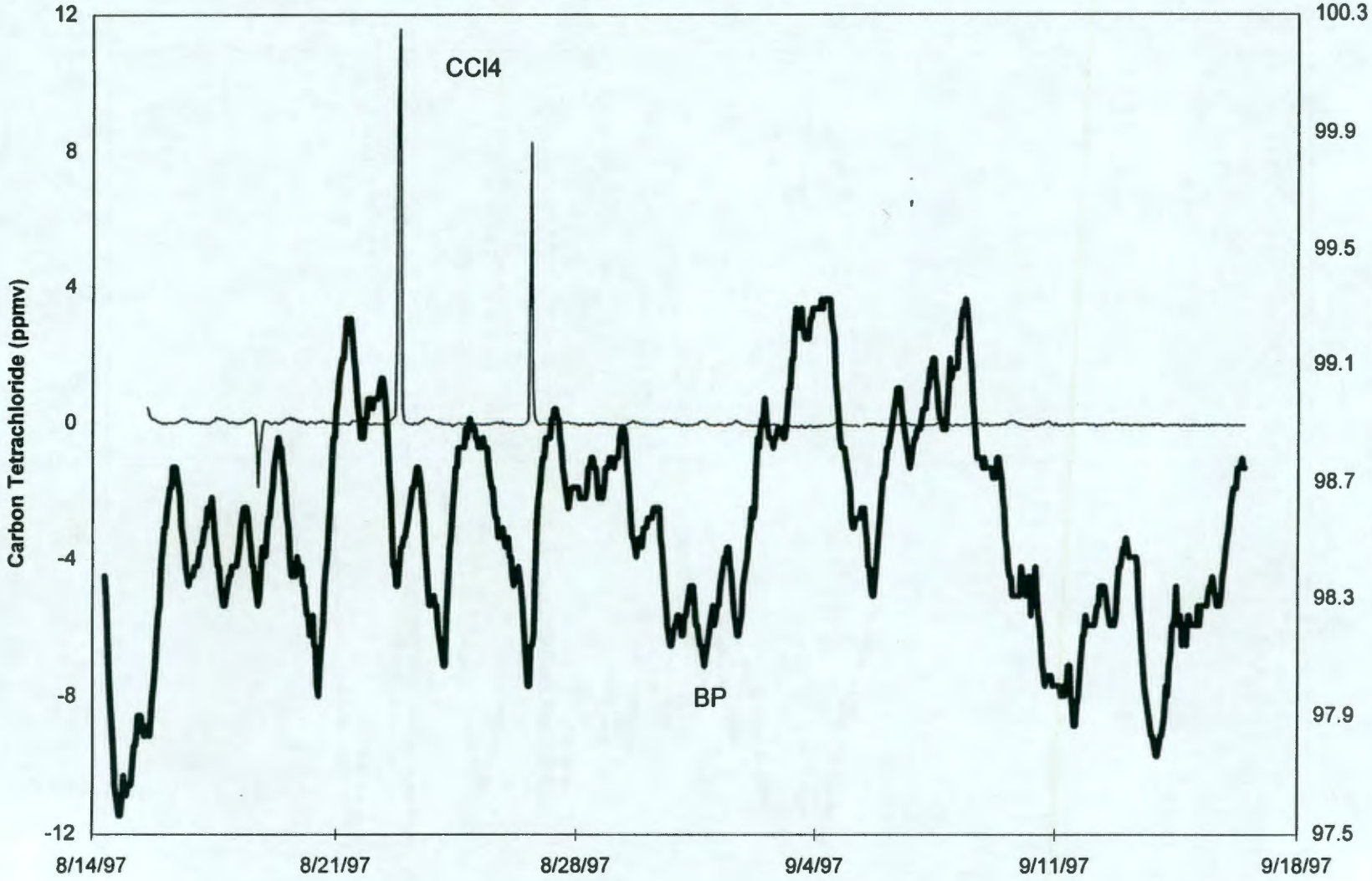
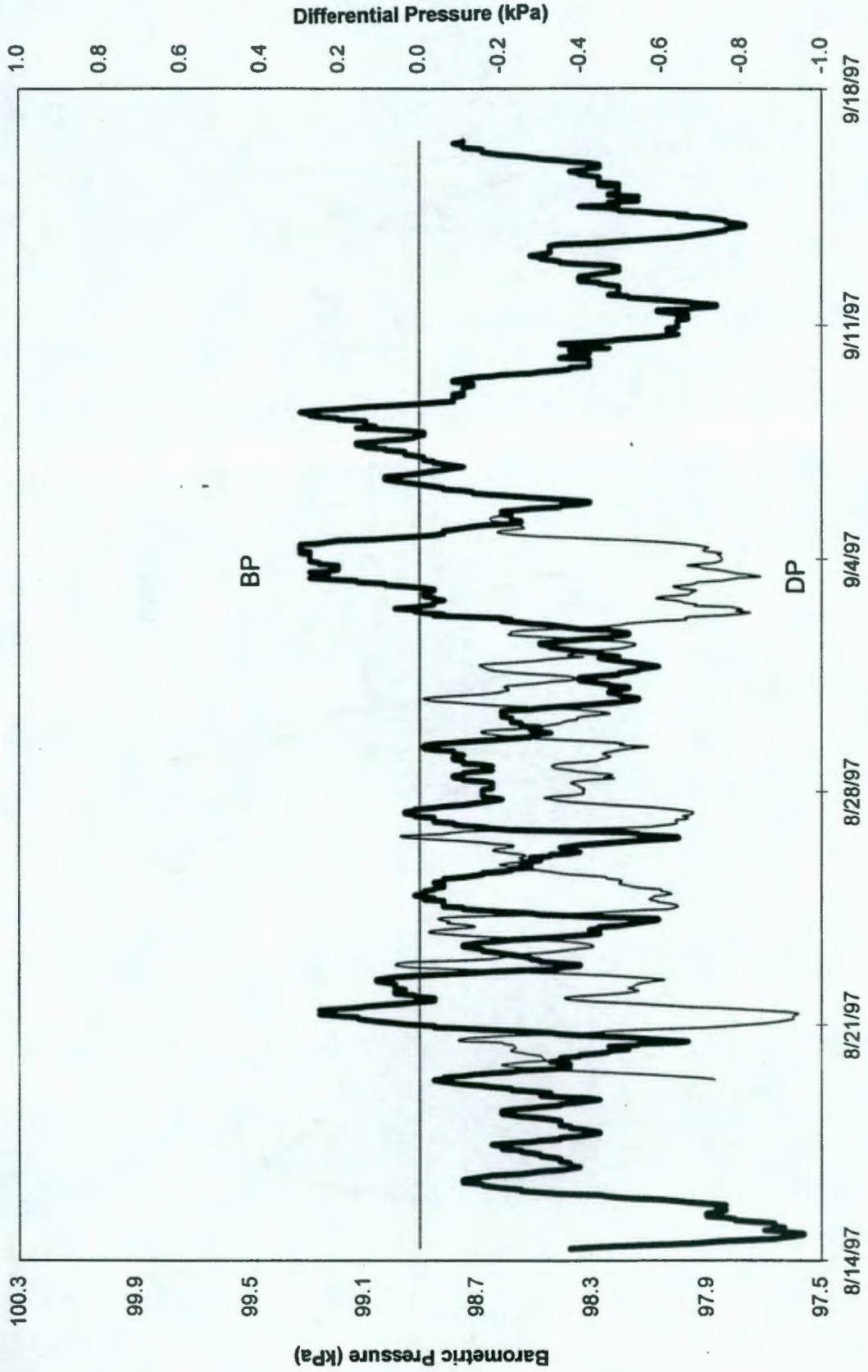


Figure I-11. Barometric and Differential Pressure Measured at Well W18-252L During the Passive Extraction Valve Test.



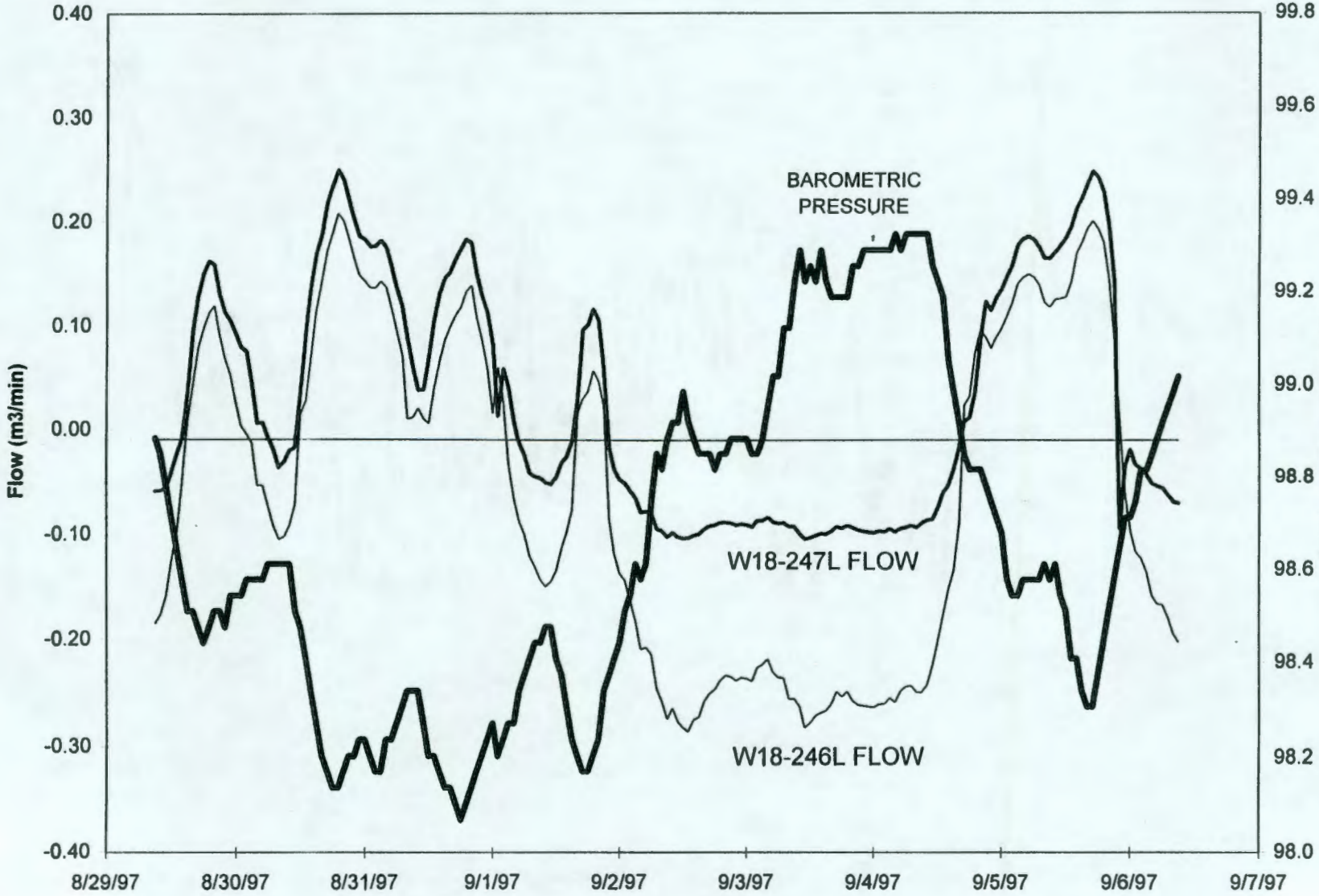


Figure I-12. Comparison of Flow Measured at Wells W18-246L and W18-247L from August 29 through September 6, 1997.

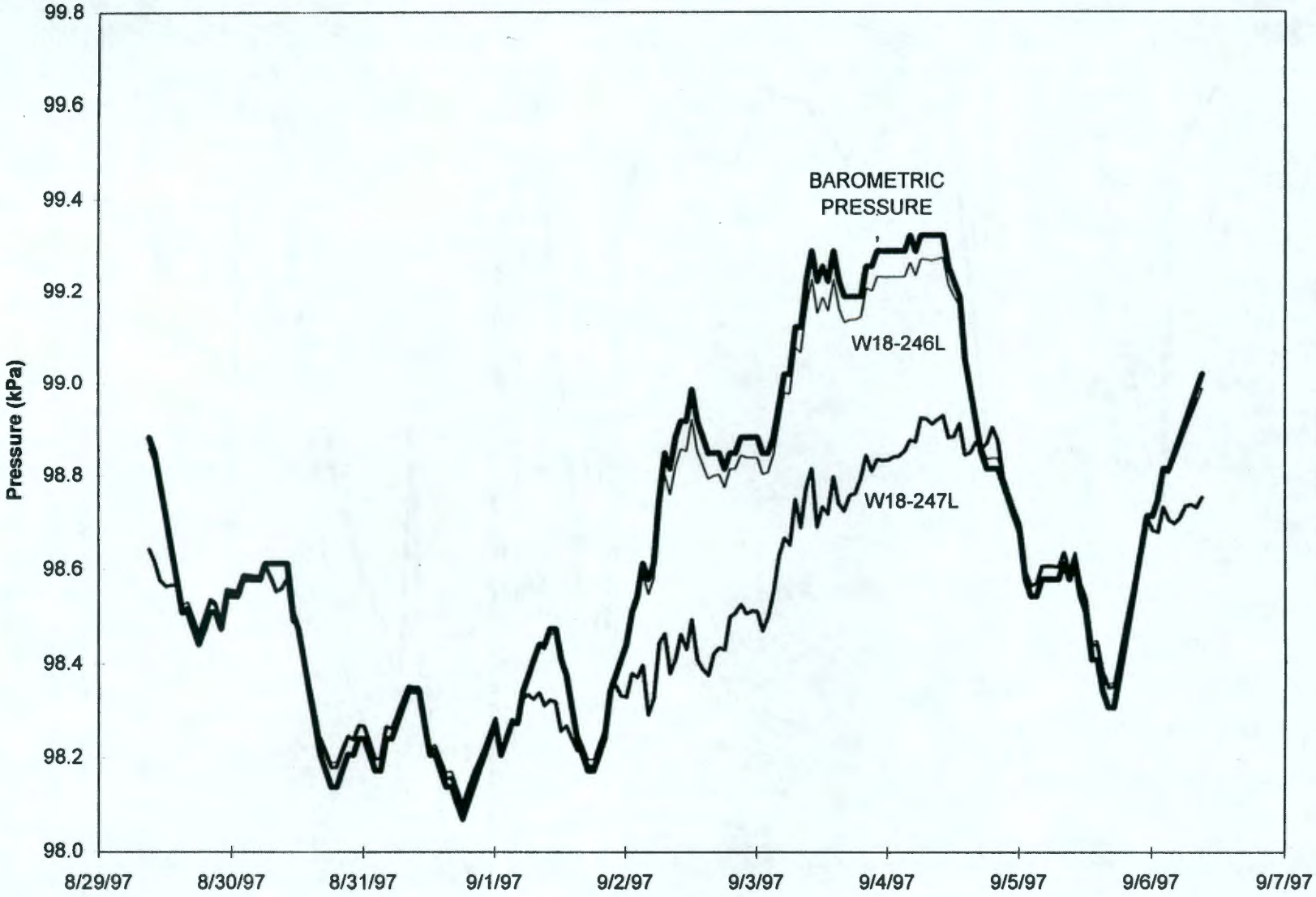


Figure I-13. Comparison of Subsurface Pressure Measured at Wells W18-246L and W18-247L from August 29 through September 6, 1997.

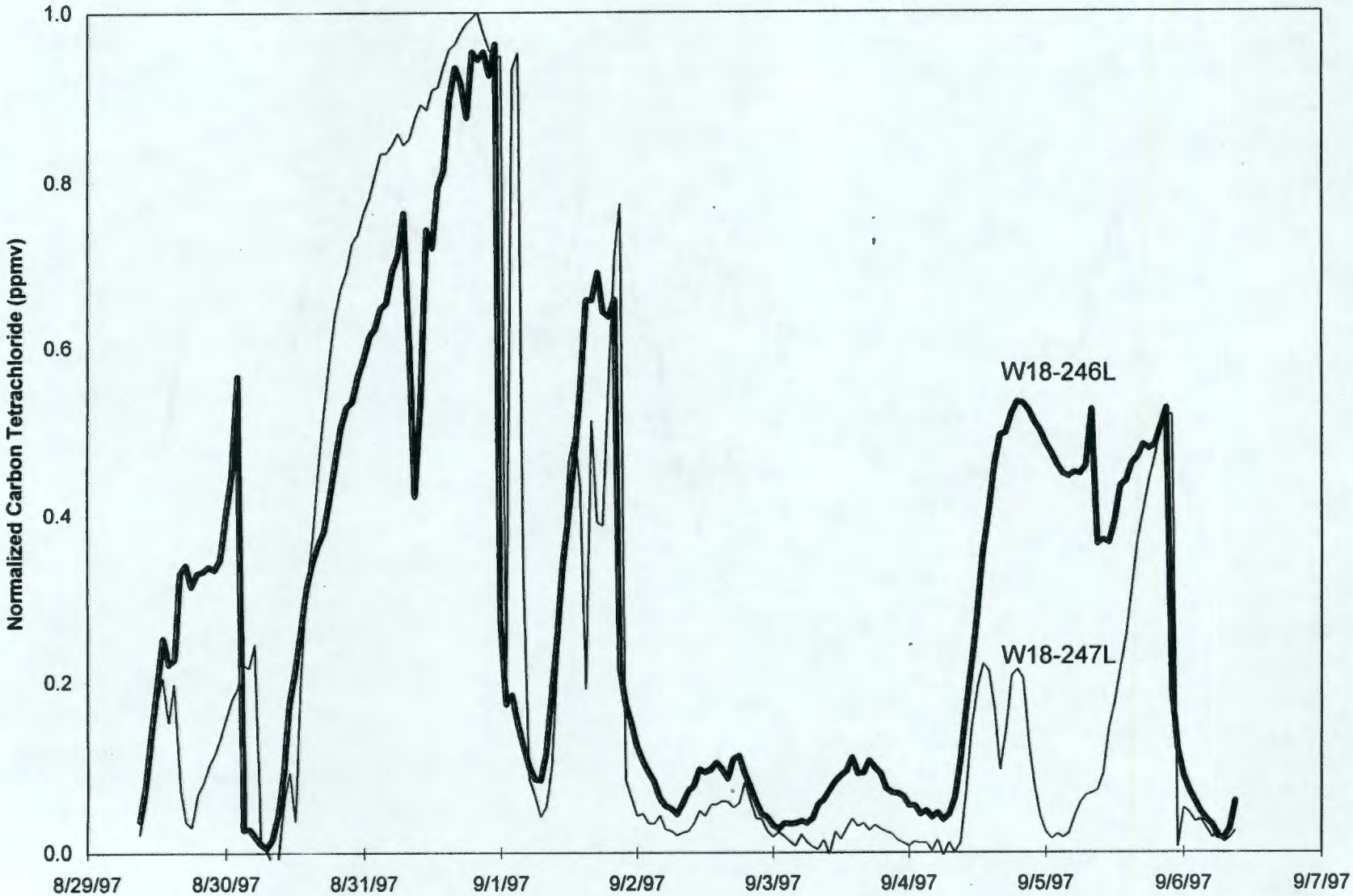


Figure I-14. Comparison of Carbon Tetrachloride Concentrations Measured at Wells W18-246L and W18-247L from August 29 through September 6, 1997.

Table I-1. Screened Intervals in the Passive Extraction Valve Test Wells.

Well	Upper (U) Screened Interval		Lower (L) Screened Interval	
	Depth (m bgs)	Zone	Depth (m bgs)	Zone
299-W18-246	36.6 - 39.6	3	50.3 - 53.3	5
299-W18-247	36.3 - 39.3	3	49.4 - 52.4	4-5
299-W18-252	34.4 - 40.5	3	50.3 - 56.4	5

Table I-2. Comparison of Measurements at Passive Extraction Wells.

Well	Carbon Tetrachloride (ppmv)		Differential Pressure (kPa)		Flow Magnitude (m^3/min)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
W18-246L	0.351	21.9	-0.10	0.11	0.004	0.356
W18-247L	-2.4	3.0	-0.77	0.75	0.002	0.273
W18-252L	-1.9	11.6	-0.94	0.06	-0.005	0.096

APPENDIX J

EVALUATION OF FY 1992 AND FY 1993 IN SITU SOIL VAPOR AND GROUNDWATER CONCENTRATION DATA

APPENDIX J
EVALUATION OF FY 1992 AND FY 1993 IN SITU SOIL VAPOR AND GROUNDWATER CONCENTRATION DATA

Vapor and groundwater samples were collected from different depths at the same location during installation of six soil vapor extraction wells at the carbon tetrachloride site in fiscal year (FY) 1992 and FY 1993. In situ soil vapor and groundwater samples were collected from wells W15-216, W15-218, and W15-220 at the Z-9 site; and from wells W18-246, W18-247, and W18-252 at the Z-1A site in 1992 and 1993. In situ soil vapor samples were also collected from wells W15-217 and W15-223 at the Z-9 site and from wells W18-248 and W18-249 at the Z-1A site; however, groundwater samples were not collected at these wells because the wells did not extend below the Plio-Pleistocene layer. Results of the soil vapor and groundwater analyses are provided in this appendix, in Rohay et al. (1993, Appendix E), and in Rohay (1995, Appendix B).

The soil vapor and groundwater samples were originally collected and analyzed for volatile organic compound (VOC) concentrations to help characterize the carbon tetrachloride distribution in the vadose zone in support of soil vapor extraction operations. The data were evaluated as part of this study to help address the issue of transport to carbon tetrachloride between the unsaturated and saturated zones.

The in situ soil vapor samples were collected using the SEAMIST system (trademark of Flexible Liner Underground Technologies, Ltd. Co., Santa Fe, New Mexico). The SEAMIST system is a downhole membrane sampling system that allows sampling at discrete intervals within the borehole. The membrane is placed within the borehole and inflated against the walls of the borehole, isolating a sample tube that can be used to sample below the membrane.

The potential for transport of carbon tetrachloride between the soil vapor and the groundwater was evaluated using Henry's Law as a guideline. Henry's Law describes the equilibrium partitioning of a compound between the aqueous and vapor phases (Pankow and Cherry 1996). The Henry's Law constant expresses the relationship of the concentration of a compound in the vapor phase to the concentration in the aqueous phase; the constant will be different for each VOC and will also vary with temperature. The Henry's Law constant for carbon tetrachloride was used to calculate a conversion factor to relate a vapor phase concentration in ppmv to an aqueous phase concentration in μg/L (Rohay 1997). The resulting relationship between the carbon tetrachloride concentration in groundwater and in soil vapor is:

$$C_v = 0.151 * C_{aq}$$

where

C_v = concentration of carbon tetrachloride in the soil vapor (ppmv)
C_{aq} = concentration of carbon tetrachloride in the groundwater (μg/L)
0.151 = the aqueous-vapor phase conversion factor for carbon tetrachloride at 20°C.

Groundwater temperature obtained for six groundwater monitoring wells in the vicinity of the carbon tetrachloride site averaged 19.8°C in 1996-1997 (Table J-1). Comparing calculated equilibrium concentrations to measured concentrations provides a reference for evaluating the potential for carbon tetrachloride transport between aqueous and vapor phases.

J.1.0 SOIL VAPOR AND GROUNDWATER CONCENTRATIONS IN Z-9 WELLS

Well 299-W15-216, FY 1992

Soil vapor samples collected at depths ranging from 12.8 to 38.7 m below ground surface (bgs) contained relatively low but consistent concentrations of carbon tetrachloride (Table J-2). The maximum and minimum concentrations measured were 53 and 34 ppmv. No soil vapor samples were collected below 39 m bgs, so the soil vapor concentration of carbon tetrachloride existing just above the water table was not known. Three water samples from different depths in the aquifer (60.6, 61.9, and 63.6 m bgs) were also collected and analyzed for VOC content. The concentration of carbon tetrachloride measured in the three samples ranged between 4,148 and 4,479 μg/L. The equilibrium soil vapor concentration for water containing 4,000 μg/L carbon tetrachloride is 600 ppmv, which is a factor of ten greater than any of the measured values. However, because all the soil vapor measurements were made at least 20 m above the water table, it is unknown whether carbon tetrachloride was exchanging between the vadose zone and groundwater at this location.

Based on the concentration of carbon tetrachloride measured in the soil vapor, the vadose zone does not appear to have contained sufficient carbon tetrachloride to bring the groundwater concentration to 4,000 μg/L. Local contamination must have moved to this location either by transport within the aquifer or by lateral migration in the vadose zone.

Well 299-W15-218, FY 1993

Soil vapor and groundwater samples collected from well 299-W15-218 contained higher concentrations of carbon tetrachloride than samples collected from any other well located near the Z-9 crib during this characterization effort (Table J-3). Soil vapor concentration measurements ranged from about 10 to over 20,000 ppmv; the groundwater concentration measured 6,379 μg/L. Relatively high soil vapor concentrations of carbon tetrachloride were measured in samples collected both above and below the Plio-Pleistocene layer (16,660 to

20,910 ppmv at 34.1 m bgs and 10,380 ppmv at 57.8 m bgs). The equilibrium soil vapor concentration for groundwater containing 6,500 μg/L is 1,000 ppmv, which is a factor of ten less than the measured concentration in soil vapor. The difference between the equilibrium and measured carbon tetrachloride concentration in the soil vapor suggests that the soil vapor and groundwater are not in equilibrium with respect to carbon tetrachloride. For contaminants not in equilibrium, mass transfer occurs from the high to low concentration phase. Since the measured soil vapor concentration of carbon tetrachloride is greater than the equilibrium concentration, mass transfer would have occurred from the soil vapor phase in the vadose zone to the aqueous phase in the aquifer.

Well 299-W15-220, FY 1993

Soil vapor data collected from well 299-W15-220 indicated that most of the carbon tetrachloride present in this area was contained above the Plio-Pleistocene layer (Table J-4). Three soil vapor samples collected between 15.4 and 35.1 m bgs all measured greater than 600 ppmv (up to 1,512 ppmv) carbon tetrachloride; all soil vapor samples collected below 43.3 m bgs measured less than 170 ppmv carbon tetrachloride. The samples collected closest to the water table measured 50 ppmv. For soil vapor containing 50 to 170 ppmv carbon tetrachloride, the equilibrium concentration of carbon tetrachloride in groundwater is 915 μg/L.

The measured concentration of carbon tetrachloride in the groundwater was reasonably consistent with the calculated equilibrium concentration, suggesting that the carbon tetrachloride in the aquifer was in equilibrium with the carbon tetrachloride in the soil vapor. Even if some carbon tetrachloride entered the aquifer in this area, this area is not a primary source of groundwater contamination. The groundwater concentration of carbon tetrachloride was lower in this well than in any of the other wells sampled near the Z-9 crib as part of this characterization effort.

J.2.0 SOIL VAPOR AND GROUNDWATER CONCENTRATIONS IN Z-1A WELLS

Well 299-W18-246, FY 1992

Soil vapor samples were collected from well 299-W18-246 at seven depths ranging from 17.6 to 59.7 m bgs (Table J-5). The carbon tetrachloride concentration ranged between 14 and 280 ppmv, with the maximum concentration measured in the sample collected at 46.3 m bgs. Just above the water table, the vapor concentration of the soil vapor measured 15 to 20 ppmv. The corresponding equilibrium concentration of carbon tetrachloride in groundwater is 130 μg/L. Groundwater samples collected from five different depths in the aquifer showed the highest concentrations of carbon tetrachloride occurring 5.8 to 7.6 m below the water table. These concentrations were on the order of 1,000 μg/L, whereas the shallowest groundwater sample concentrations were less than 10 μg/L.

Based on these sampling results, the aqueous and vapor phases of carbon tetrachloride appear to have not been in equilibrium at the interface between the aquifer and the vadose zone. However, the data also suggest that carbon tetrachloride did not enter the aquifer from the vadose zone at this location because the concentration was greater at lower depths in the aquifer. Although

some carbon tetrachloride may have entered the aquifer from the vadose zone, most of groundwater contamination detected here appears to have resulted from transport occurring in the aquifer.

Well 299-W18-247, FY 1992

Two soil vapor samples were collected from well 299-W18-247 and analyzed for VOC contaminants (Table J-6). The results showed relatively low concentrations (50 to 60 ppmv) of carbon tetrachloride in the soil vapor. At equilibrium, the corresponding groundwater concentration is 330 to 400 μg/L. Concentrations of carbon tetrachloride measured in groundwater samples collected at four depths in the aquifer ranged from 0.2 to 418 μg/L. The shallowest groundwater sample contained 95 μg/L carbon tetrachloride, and the sample collected 1.5 m lower contained 418 μg/L. Therefore, the soil vapor and groundwater appeared to be in equilibrium, but the data also suggest that carbon tetrachloride did not enter the aquifer from the vadose zone at this location. In this case it appears that the carbon tetrachloride detected in the soil vapor resulted from volatilization from the aquifer. The low measured concentrations indicate that this well is located away from the source and outside the primary groundwater travel path of the contamination.

Well 299-W18-252, FY 1993

Soil vapor concentrations of carbon tetrachloride measured in samples collected from well 299-W18-252 at depths between 14.9 and 61.6 m bgs ranged between 1.7 and 1,420 ppmv, but five of the seven measurements were less than 40 ppmv (Table J-7). Near the water table, the soil vapor concentration measured 170 ppmv, and the concentration of carbon tetrachloride in groundwater measured 1,130 μg/L. The equilibrium groundwater concentration for soil vapor concentrations of 170 ppmv is 1,100 μg/L, so the soil vapor and groundwater appear to have been in equilibrium. In general, the pattern of carbon tetrachloride concentrations present in the soil vapor suggested that most of the vapor phase volatilized from the aqueous phase in the aquifer. The measured concentrations in five of the samples were a factor of four less than the equilibrium concentration; thus, vapor phase carbon tetrachloride in the soil vapor at this location does not appear to be the source of carbon tetrachloride in the groundwater. The groundwater contamination detected here appears to have resulted from flow and transport occurring in the aquifer.

J.3.0 SOIL VAPOR CONCENTRATIONS IN Z-9 AND Z-1A WELLS

Carbon tetrachloride concentrations were measured in soil vapor samples collected using the SEAMIST system from well 299-W15-217 at the Z-9 site and wells 299-W18-248 and 299-W18-249 at the Z-1A site (Table J-8, J-9, and J-10). Groundwater samples could not be collected at these wells because they were only drilled to the Plio-Pleistocene layer. Although these data are not being used to evaluate soil vapor-groundwater transport, they are provided here for completeness because they have not been included in any previous reports for the carbon tetrachloride site. Similar data collected using the SEAMIST system at well 299-W15-223 at the Z-9 site are provided in Rohay (1995).

J.4.0 REFERENCES

Pankow, J. F. and J. A. Cherry, 1996, *Dense Chlorinated Solvents and Other DNAPLs in Groundwater: History, Behavior, and Remediation*, Waterloo Press, 522 p.

Rohay, V. J., K. J. Swett, V. M. Johnson, G. V. Last, D. C. Lanigan, and L. A. Doremus, 1993, *FY93 Site Characterization Status Report and Data Package for the Carbon Tetrachloride Site*, WHC-SD-EN-TI-202, Rev. 0, prepared by V. J. Rohay, K. J. Swett, and V. M. Johnson, Westinghouse Hanford Company, and G. V. Last, D. C. Lanigan, and L. A. Doremus, Pacific Northwest Laboratory, for Westinghouse Hanford Company, Richland, Washington.

Rohay, V. J., 1995, *FY 1993 Wellfield Enhancement Status Report and Data Package for the 200 West Area Carbon Tetrachloride Expedited Response Action*, BHI-00105, Rev. 00, Bechtel Hanford, Inc., Richland, Washington.

Rohay, V. J., 1997, *Conceptual Model for the Solid Waste Landfill*, BHI-01063, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

Table J-1. Groundwater Temperature Measured at Wells in the Vicinity of the Carbon Tetrachloride Site.

Well	Sample Date	Temperature (Degrees C)	Well	Sample Date	Temperature (Degrees C)	Well	Sample Date	Temperature (Degrees C)
299-W15-5	7/22/96	21.1	299-W15-16	10/6/88	19.0	299-W18-24	10/7/88	17.0
	5/16/96	21.4		12/29/88	20.0		1/4/89	17.0
Average	1996	21.3		5/9/89	18.0		5/11/89	17.0
299-W14-9	10/4/94	18.7		7/25/89	19.3		7/28/89	18.7
	7/17/96	21.3		9/22/89	19.1		9/25/89	17.8
	11/8/96	18.5		3/15/90	19.5		3/15/90	17.2
	8/25/97	17.6		4/3/90	18.4		4/3/90	18.0
Average	1994-1997	19.0		1/30/91	17.7		8/9/91	21.1
Average	1996-1997	19.1		8/5/91	19.0		10/2/91	15.4
299-W15-6	6/1/81	19.2		3/17/92	18.4		3/18/92	17.7
	11/12/81	17.5		6/10/92	19.5		6/10/92	18.3
	12/14/90	17.4		8/11/92	19.6		8/21/92	18.5
	1/30/91	16.4		2/11/93	18.3		2/11/93	18.3
	2/6/91	17.4		8/16/93	19.0		8/27/93	18.2
	4/9/91	17.5		11/18/93	17.5		11/29/93	18.1
	5/8/91	18.1-		12/6/93	18.2		7/21/94	26.0
	3/11/92	17.1		5/26/94	19.0		9/6/94	23.6
	7/19/93	17.6		5/26/94	19.0		10/10/94	14.8
	10/3/94	19.1		7/1/94	18.3		11/8/94	17.4
	10/24/94	17.6		9/21/94	23.5		1/13/95	16.2
Average	1981-1994	17.7		11/8/94	17.9		5/8/95	18.1
299-W18-1	4/26/93	20.5		5/8/95	19.3		11/8/95	17.8
	3/25/94	18.9		11/10/95	18.2		3/13/96	17.6
	8/9/94	21.3		5/6/96	19.2		5/6/96	19.1
	9/6/94	22.1		6/21/96	19.2		7/3/96	19.1
	2/24/95	19.9		10/10/96	20.3		10/9/96	18.8
	7/16/96	22.3		1/2/97	18.3		1/2/97	16.8
	7/18/96	19.8		4/22/97	19.0		4/22/97	19.0
	8/21/97	20.7		10/20/97	18.6		10/20/97	18.5
Average	1993-1997	20.7	Average	1988-1997	19.0	Average	1988-1997	18.3
Average	1996-1997	20.9	Average	1996-1997	19.1	Average	1996-1997	18.4

Table J-2. Soil Vapor and Groundwater Concentrations of Carbon Tetrachloride Measured in Samples Collected in Well 299-W15-216.

Sample Depth (m)	Concentration of Carbon Tetrachloride	
	Soil Vapor (ppmv)	Groundwater (μg/L)
12.8	39.06	
14.6	52.74	
30.8	33.54	
38.7	41.85	
60.6		4148
61.9		4479
63.6		4437

Table J-3. Soil Vapor and Groundwater Concentrations of Carbon Tetrachloride Measured in Samples Collected in Well 299-W15-218.

Sample Depth (m)	Concentration of Carbon Tetrachloride	
	Soil Vapor (ppmv)	Groundwater (μg/L)
18.3	45.4	
28.0	102.9	
34.1	16,660	
34.1	20,910	
34.1	29.8	
38.6	10.2	
42.5	7.9	
48.4	155.0	
54.4	778.6	
57.8	10,380	
62.5		6379

Table J-4. Soil Vapor and Groundwater Concentrations of Carbon Tetrachloride Measured in Samples Collected in Well 299-W15-220.

Sample Depth (m)	Concentration of Carbon Tetrachloride	
	Soil Vapor (ppmv)	Groundwater (μg/L)
15.4	853.7	
27.4	1511.6	
32.9		200
35.1	633	
43.3	149	
43.3	167.2	
48.8	108.4	
48.8	83.5	
55.5	49.4	
55.5	50.2	
61.0		915

Table J-5. Soil Vapor and Groundwater Concentrations of Carbon Tetrachloride Measured in Samples Collected in Well 299-W18-246.

Sample Depth (m)	Concentration of Carbon Tetrachloride	
	Soil Vapor (ppmv)	Groundwater (μg/L)
17.6	46.86	
25.9	20.8	
32.6	14.5	
44.5	121.0	
46.3	278.7	
59.1	20.85	
59.7	14.52	
61.0		< 1
61.0		9.6
66.2		293
66.7		1009
68.6		919
70.1		30

Table J-6. Soil Vapor and Groundwater Concentrations of Carbon Tetrachloride Measured in Samples Collected in Well 299-W18-247.

Sample Depth (m)	Concentration of Carbon Tetrachloride	
	Soil Vapor (ppmv)	Groundwater (μg/L)
50.9	62.0	
54.8	50.0	
64.0		95
65.5		418
67.1		32
68.6		< 1

Table J-7. Soil Vapor and Groundwater Concentrations of Carbon Tetrachloride Measured in Samples Collected in Well 299-W18-252.

Sample Depth (m)	Concentration of Carbon Tetrachloride	
	Soil Vapor (ppmv)	Groundwater (μg/L)
14.9	1.7	
26.1	16.3	
37.6	5.3	
42.1	36.4	
48.6	1419.6	
56.6	8.9	
61.6	169.7	
69.3		1130

Table J-8. Soil Vapor Concentrations of Carbon Tetrachloride Measured in Samples Collected in Well 299-W15-217.

Sample Depth (m)	Concentration of Carbon Tetrachloride
	Soil Vapor (ppmv)
6.6	26.2
6.6	22.8
6.6	30.7
12.2	491
12.2	344.7
15.8	3207
16.5	2811.7
24.7	6766.9
24.7	7125.2
31.4	78.8
31.4	75.2
35.4	156

Table J-9. Soil Vapor Concentrations of Carbon Tetrachloride Measured in Samples Collected in Well 299-W18-248.

Sample Depth (m)	Concentration of Carbon Tetrachloride
	Soil Vapor (ppmv)
6.1	22.3
12.2	20.4
12.2	23.3
12.2	21.7
18.1	207.9
18.7	209.7
24.4	9.9
24.4	15.8
26.5	247.5
27.1	207
36.6	277.5
43.0	1300

Table J-10. Soil Vapor Concentrations of Carbon Tetrachloride Measured in Samples Collected in Well 299-W18-249.

Sample Depth (m)	Concentration of Carbon Tetrachloride
	Soil Vapor (ppmv)
6.1	0.7
12.8	84.7
19.8	48.3
25.6	5.6

APPENDIX K

EVALUATION OF FY 1995 SURFACE COVER DATA

APPENDIX K
EVALUATION OF FY 1995 SURFACE COVER DATA

Two soil vapor extraction (SVE) tests were conducted at the carbon tetrachloride site to test the effect of a surface cover on the radius of influence during vapor extraction operations. One test included the use of a plastic surface cover to determine if the cover would enhance the radius of influence of a vapor extraction well. A second later test was conducted without the cover for comparison. The cover test was initiated on April 25, 1995, and ran until May 1, 1995. The no-cover test commenced on May 11 and continued until May 15, 1995.

One of the concerns during SVE operations is the preferential movement of clean atmospheric air into the subsurface, interfering with radial movement of contaminated soil vapor toward the vapor extraction well. This effect reduces the overall efficiency and concentration of contaminant removal. By introducing an air-impervious cover, the movement of vertical atmospheric air into the vadose zone is blocked, thereby increasing the radial distance of influence of the extraction well, and providing greater efficiency in the removal of carbon tetrachloride. The purpose of this test, therefore, was to determine the extent to which the use of an impervious plastic cover would increase the radius of influence of the extraction well.

K. 1. TEST SETUP/DESIGN

One vapor extraction well, W18-252U, and multiple monitoring points were used during both of the tests. Figure K-1 shows a plan view of the test site with the extraction well and the relationship to the monitoring points. The plastic cover was placed on the ground surrounding the extraction well. Figure K-2 shows the vertical relationship between the monitoring points (intervals) and the vapor extraction well. During the cover test, a 58.8-m by 46.6-m plastic sheet was used to seal the ground surface to block the vertical flow of clean atmospheric air into the subsurface. The plastic cover was removed for the May 11 test.

Operational parameters were held as constant and equal as possible during both tests to minimize these effects on the test results. The flow rate was maintained at about 7.8 m^3/min for both tests (Figures K-3 and K-4), although some variation was observed in the May no-cover test. One other variable that might cause differences in test results is barometric pressure. Because subsurface pressures respond so dynamically to barometric pressure changes, a difference in the barometric variation between the tests may be misinterpreted as either increasing or decreasing the radius of influence. However, the average barometric pressure during both tests was very similar (98.54 kPa [cover tests] and 98.51 kPa), suggesting that the net effect of this variable should be negligible. The dynamic range was greater during the cover test with a standard deviation of 0.41 kPa compared to 0.24 kPa without the cover.

The cover test was initiated on April 25 at 0700 hours and continued until May 1, 1995 at 1010 hours. On May 2 the west half of the cover was removed, while the east half was removed on May 9. The no-cover test ran from May 11 at 0730 hours to May 15, 1995 at 1515 hours.

It was noted that a "torrential rain" occurred at 1500 hours on May 11 after the start of the no-cover test.

K.2. DESCRIPTION OF RESULTS

To evaluate the effect of the cover on the radius of influence, the following comparisons were made between the cover and no cover tests.

- The change in vacuum with increasing distance from the extraction well at equivalent depth intervals. Two depth intervals were considered: 22.9 m and 27.7-33.2 m. The screened interval at the extraction well W18-252U is completed from 34.4 to 40.5 m.

- The change in vacuum with increasing depth at a given surface location. From previous testing (Rohay et al. 1994) it was estimated that the radial distance of influence is about 38.1 m at this extraction well. For this reason the completed intervals at monitoring location CPT-4A were used to compare the cover and no-cover test results. This location is near the maximum distance of influence expected using no cover. Monitoring depths at this location are 3.1, 7.6, 15.2, 22.9, and 27.7 m bgs. A comparison was also made at the nearer CPT-4M location where the monitoring intervals are at depths of 1.5, 7.6, 14.9, and 24.4 m.

Figures K-5 and K-6 compare the measured vacuums at monitoring points CPT-4A with and without the cover, respectively. Figures K-7 and K-8 compare the vertical distribution of vacuums at the CPT-4M location. Figures K-9 through K-12 show the radial change in vacuums at depths of 22.9 m and 27.7-33.2 m with and without the cover.

A visual inspection between equivalent graphs for the cover and no-cover tests does not readily yield significant differences between test results. The dynamic effects of barometrically induced changes also make comparison difficult. Pressure changes at the monitoring points are highly correlated with barometric pressure changes. Separating the effects of the vapor extraction operations from barometric effects is difficult.

To overcome some of the effects of barometric fluctuations, the average vacuum responses over the entire test periods were compared. The overall differences are not great enough to warrant the conclusion that the cover extended the radius of influence. The expected response would be increased vacuum readings at equivalent distances from the extraction well when the cover was in place. However, no significant differences were observed. Table K-1 lists the mean vacuum with and without the cover for all of the locations and depth intervals.

There are at least two factors that may have influenced the test results negatively. Just prior to the cover test, the southern 6.1 m of the plastic cover was noted as collecting air due to a 4.5 m/sec northerly wind. The wind created a bubble in the plastic about 0.8 m high. Although the plastic was re-seated, there still may have been atmospheric airflow between the cover and ground surface during the test.

Another potentially important factor during the noncover test was a sudden rainstorm that delivered water to the upper soil surface. This water may have sealed the surface, at least temporarily, reducing vertical penetration of atmospheric air. The net result would have been an increased radius of influence.

K.3.0 CONCLUSIONS

The test results did not indicate any increased radial distance of influence using the cover. Horizontal and vertical (depth) changes in vacuums were evaluated both visually and using the average vacuums over the entire test period. Under better field conditions and improved cover integrity, it is expected that a cover would increase the radius of influence and therefore be beneficial for remediation. Several reasons why a greater radius of influence may not have been evident include:

- The cover seal was probably ineffective in preventing vertical movement of air. Noted lifting and bubbling of the plastic just prior to testing lends support to this conclusion.

- A "torrential rainstorm" during the no-cover test may have acted as a natural cover during part of the test. However, the rain did not occur until 7.5 hours into the test, and with no obvious vacuum changes observed at this time, it does not seem that this was a significant factor.

- Barometric changes may have masked more subtle vacuum changes. This situation would be amplified at greater distances where much smaller vacuums are naturally expected. Even at the closer CPT-4M monitoring site, vacuum changes were difficult to distinguish from barometrically induced changes.

K.4.0 REFERENCE

Rohay, V. J., R. J. Cameron, and B. B. Peters, 1994, *Wellfield Strategy and Recommendations for the 200 West Area Carbon Tetrachloride Expedited Response Action*, BHI-00041, Rev. 00, Bechtel Hanford, Inc., Richland, Washington.

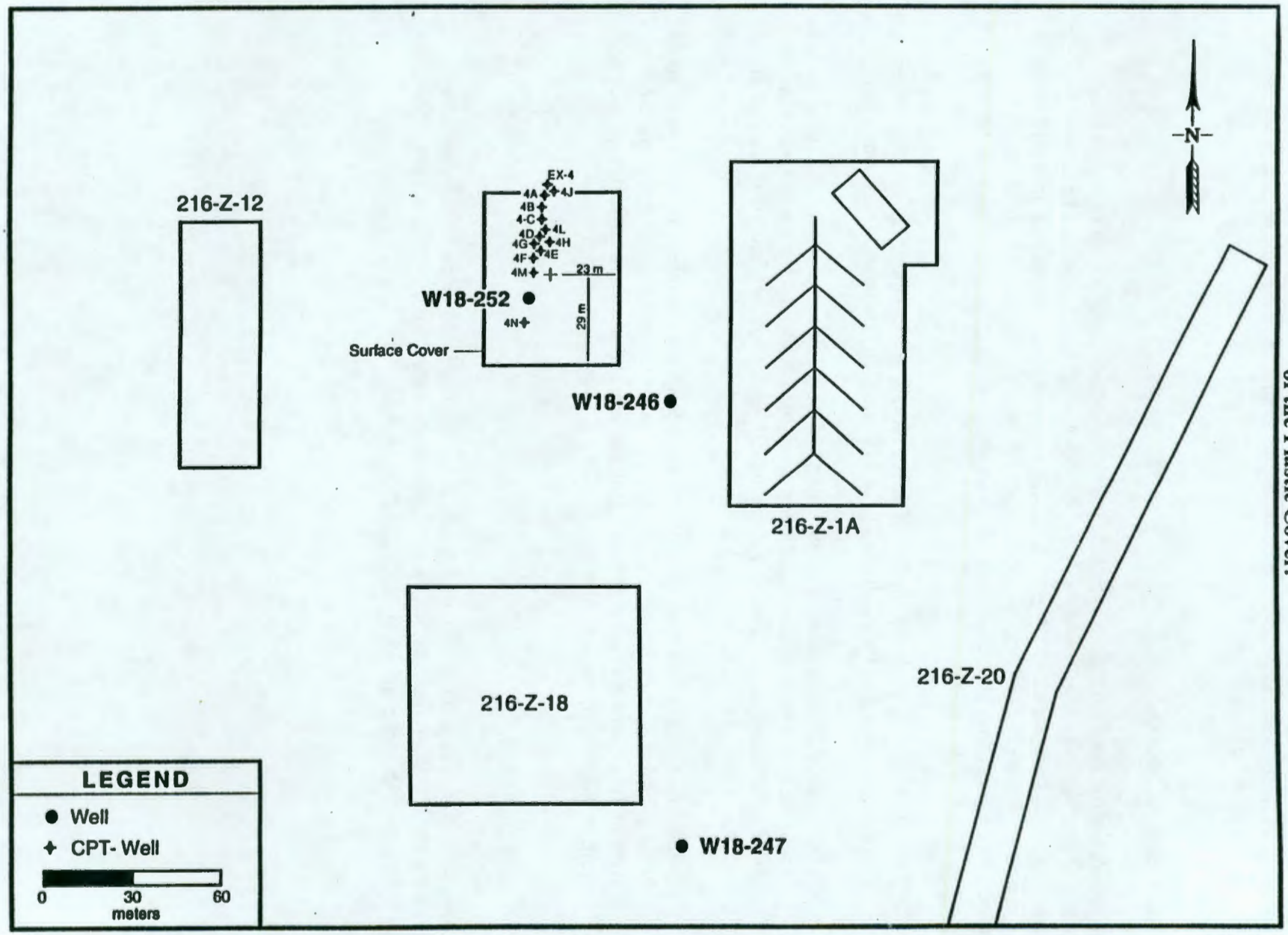


Figure K-1. Plan View Map of the Cover Test Site Showing Well Locations and the Extent of the Plastic Cover.

Figure K-2. Cross Section View of the Cover Test Site Showing the Vertical and Horizontal Distribution of Monitoring Points.

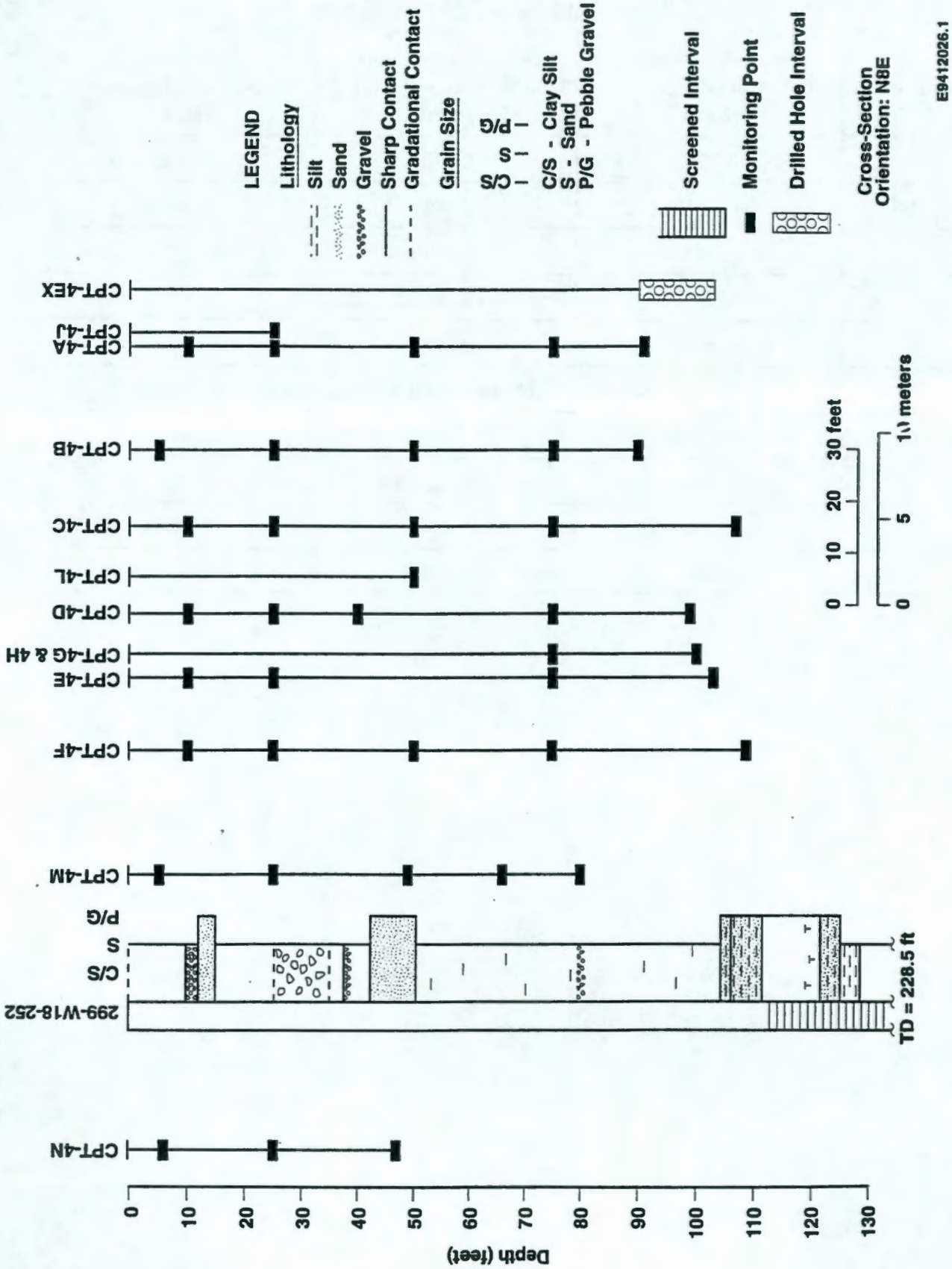


Table K-2. Comparison of Average Vacuums between the Cover and No-Cover Tests for a Specific Depth Interval (Horizontal Vacuum Distribution).

22.9-m Interval between CPT-4F and -4A			
Location	**Average Vacuum (Cover Test) (kPa)**	**Average Vacuum (No-Cover Test) (kPa)**	**Difference Between Means (kPa)**
A	-0.2307	-0.2147	-0.0160
B	-0.4840	-0.4915	+0.0075
D	-0.0337	-0.0313	-0.0024
E	-0.0563	-0.0583	+0.0020
F	-0.2407	-0.2307	-0.0100
27.7 to 33.2-m Interval between CPT-4F and -4A			
A	-0.5098	-0.4909	-0.0190
B	-0.1624	-0.1622	-0.0002
D	-0.3509	-0.3450	-0.0060
E	-0.6627	-0.6598	-0.0028

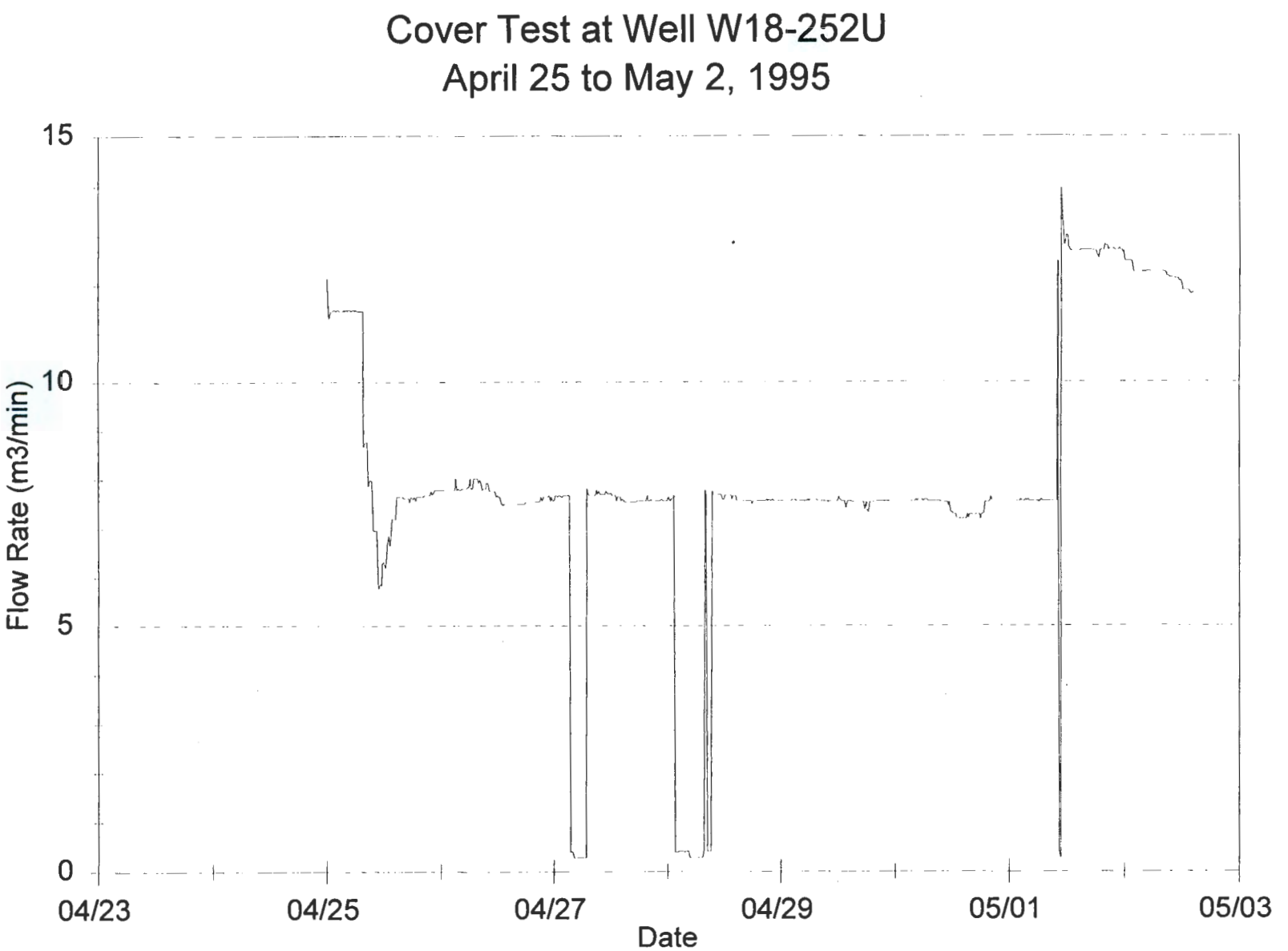


Figure K-3. Flow Rate for the Test with the Cover from April 25 to May 1, 1995.

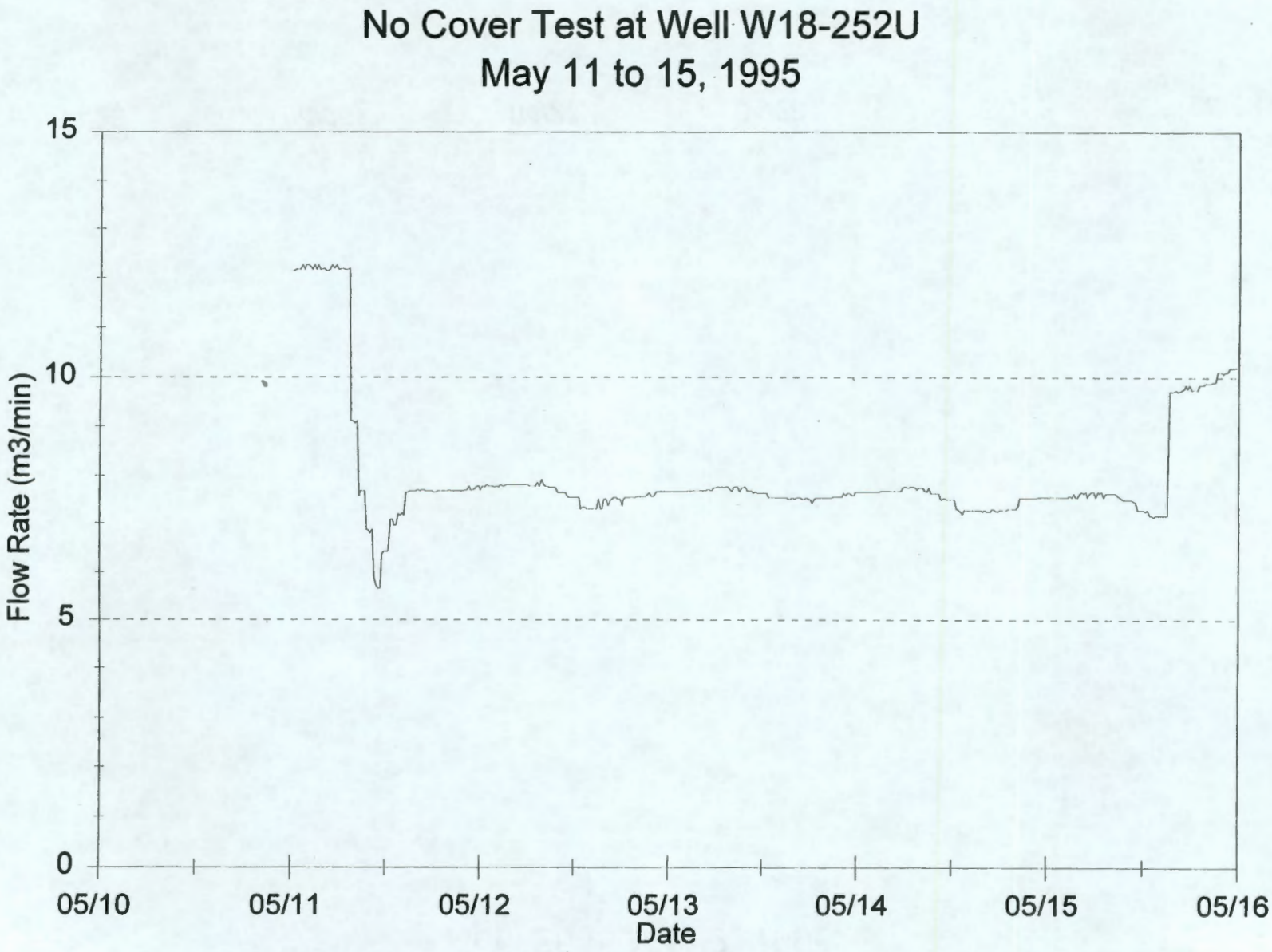


Figure K-4. Flow Rate for the Test without the Cover from May 11 to May 15, 1995.

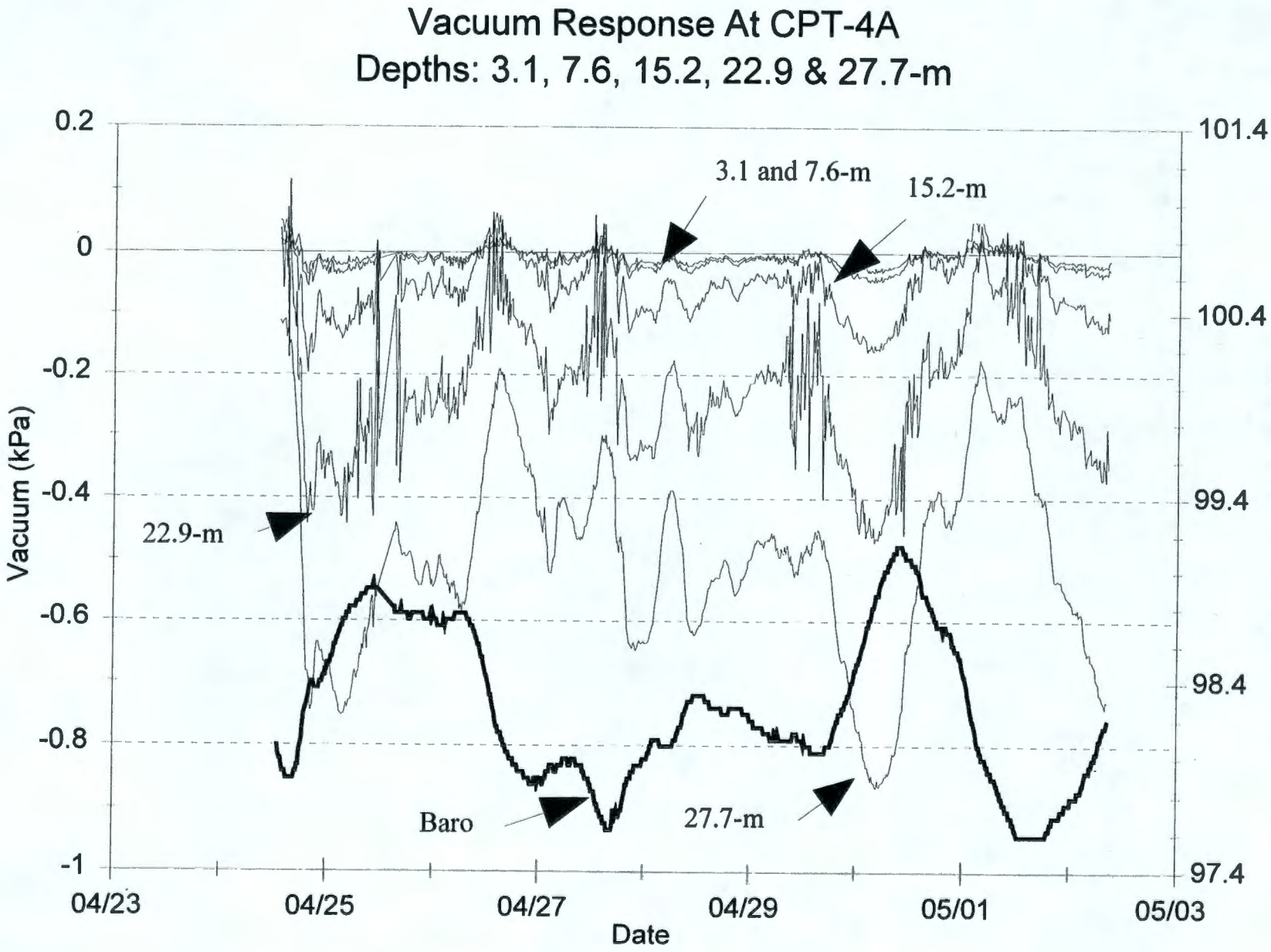


Figure K-5. Time-Series Plot of the Vertical Vacuum Distribution Through Time for the Cover Test at the CPT-4A Location.

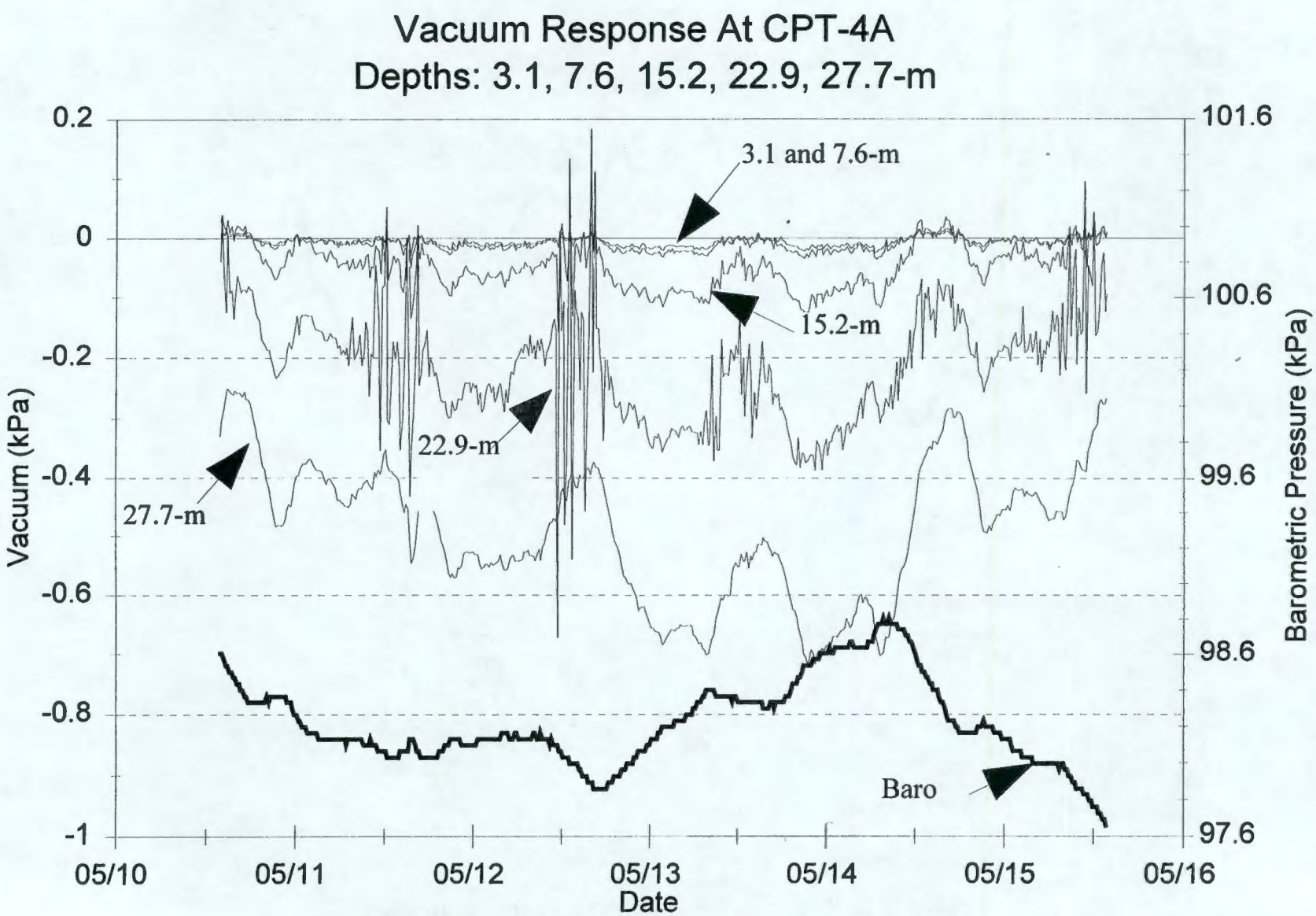


Figure K-6. Time-Series Plot of the Vertical Vacuum Distribution Through Time for the No-Cover Test at the CPT-4A Location.

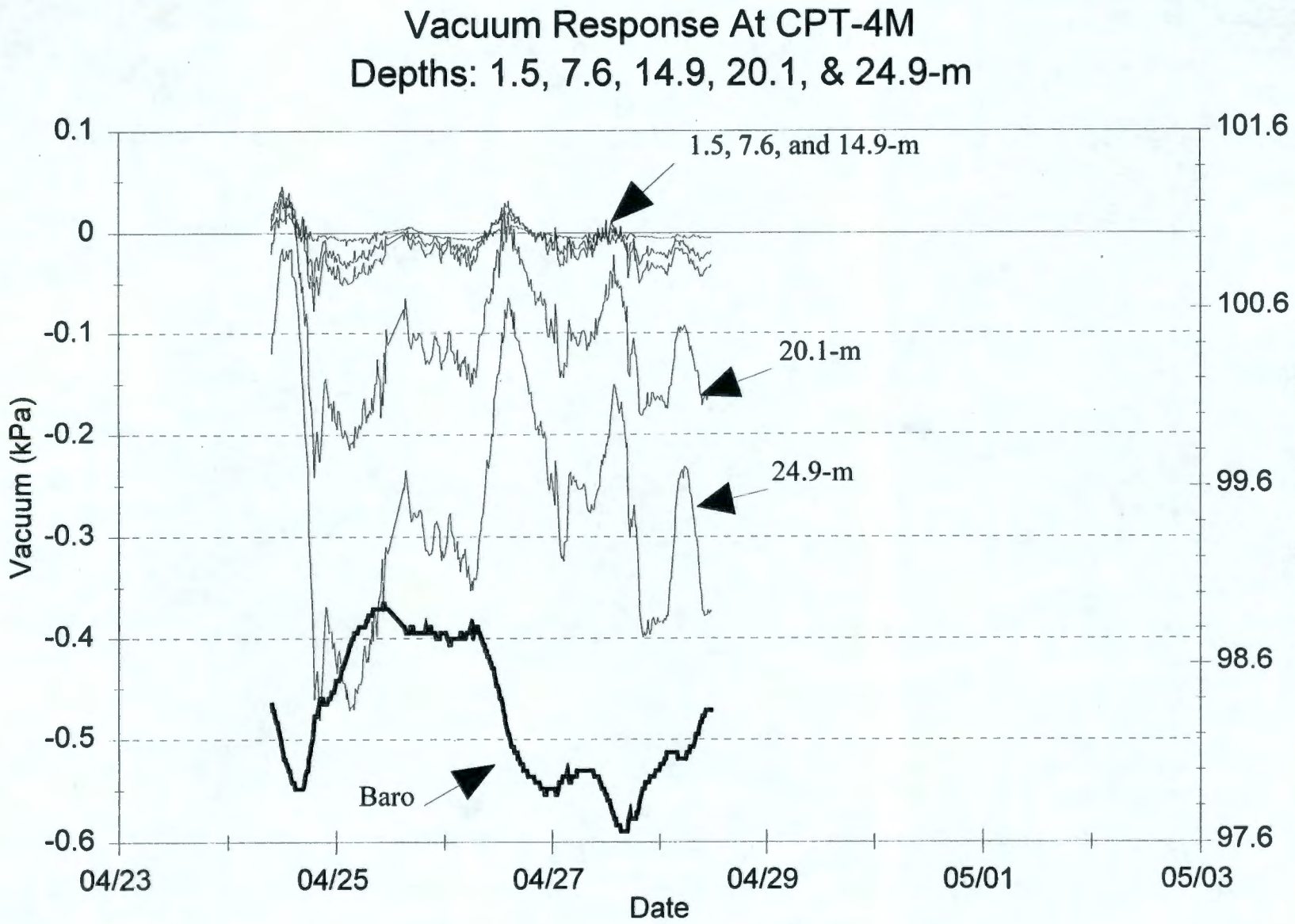


Figure K-7. Time-Series Plot of the Vertical Vacuum Distribution Through Time for the Cover Test at the CPT-4M Location.

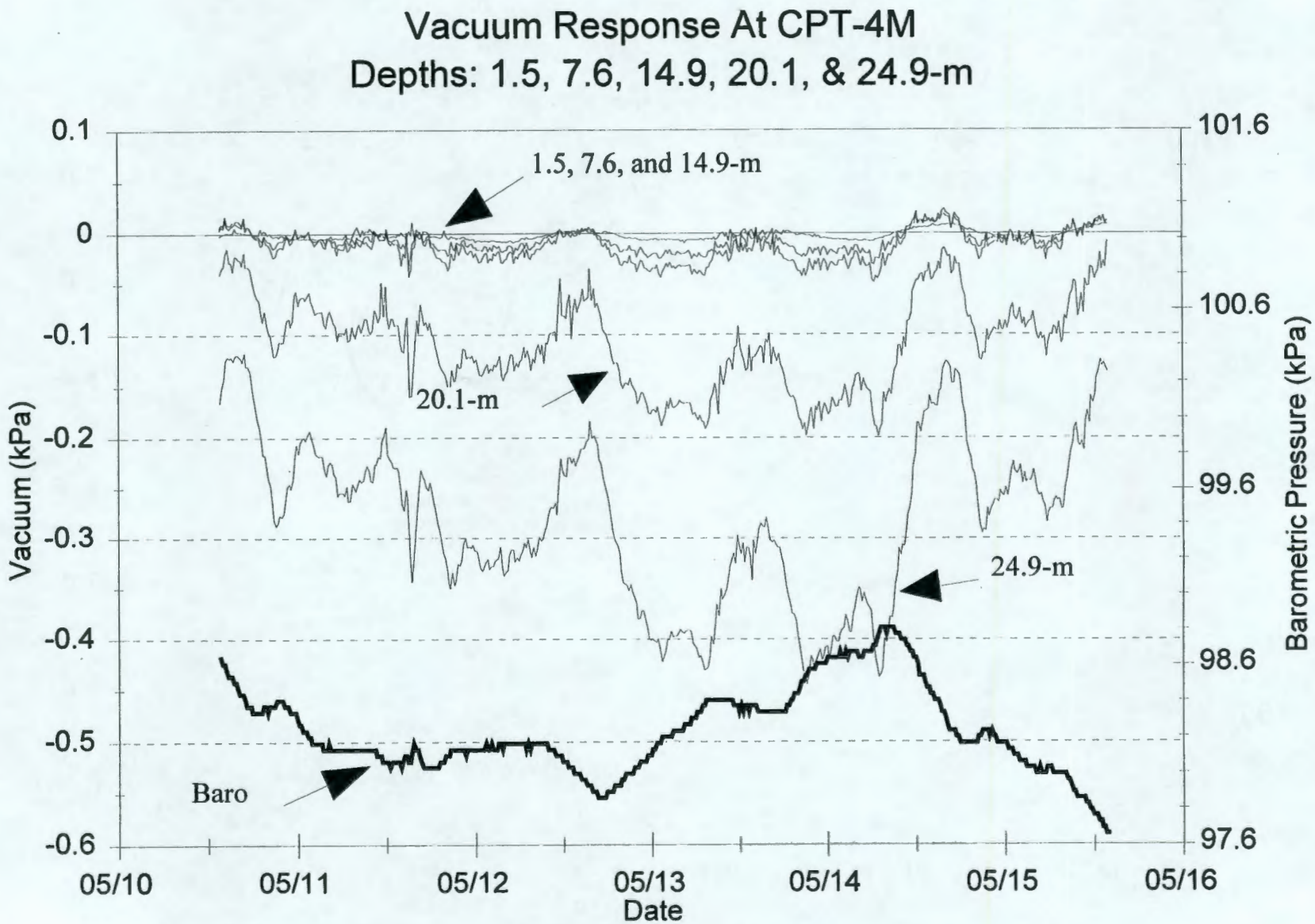


Figure K-8. Time-Series Plot of the Vertical Vacuum Distribution Through Time for the No-Cover Test at the CPT-4M Location.

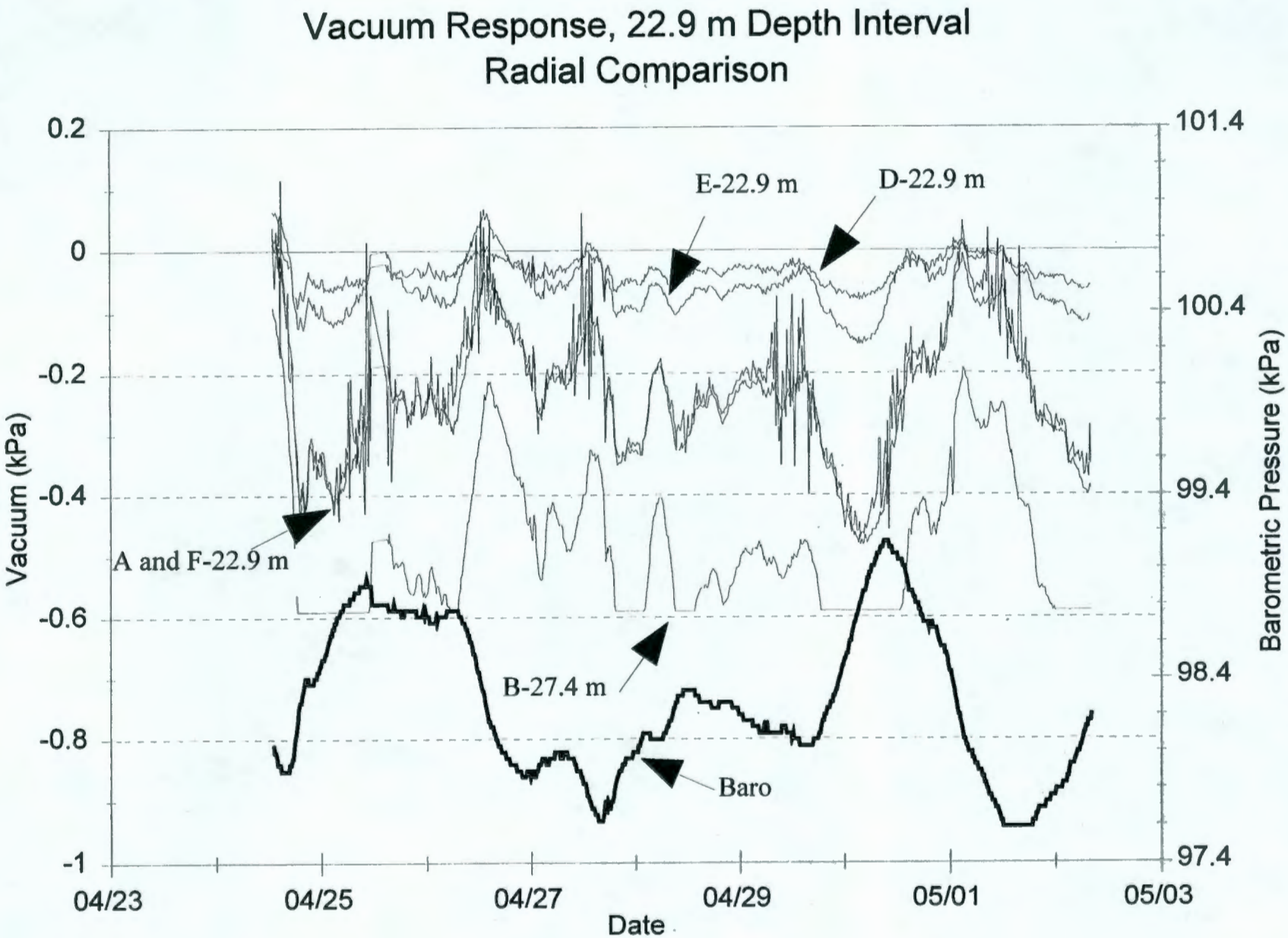


Figure K-9. Time-Series Plot of the Horizontal Vacuum Distribution Through Time for the Cover Test between CPT-4F and CPT-4A: 22.9-m Depth Interval.

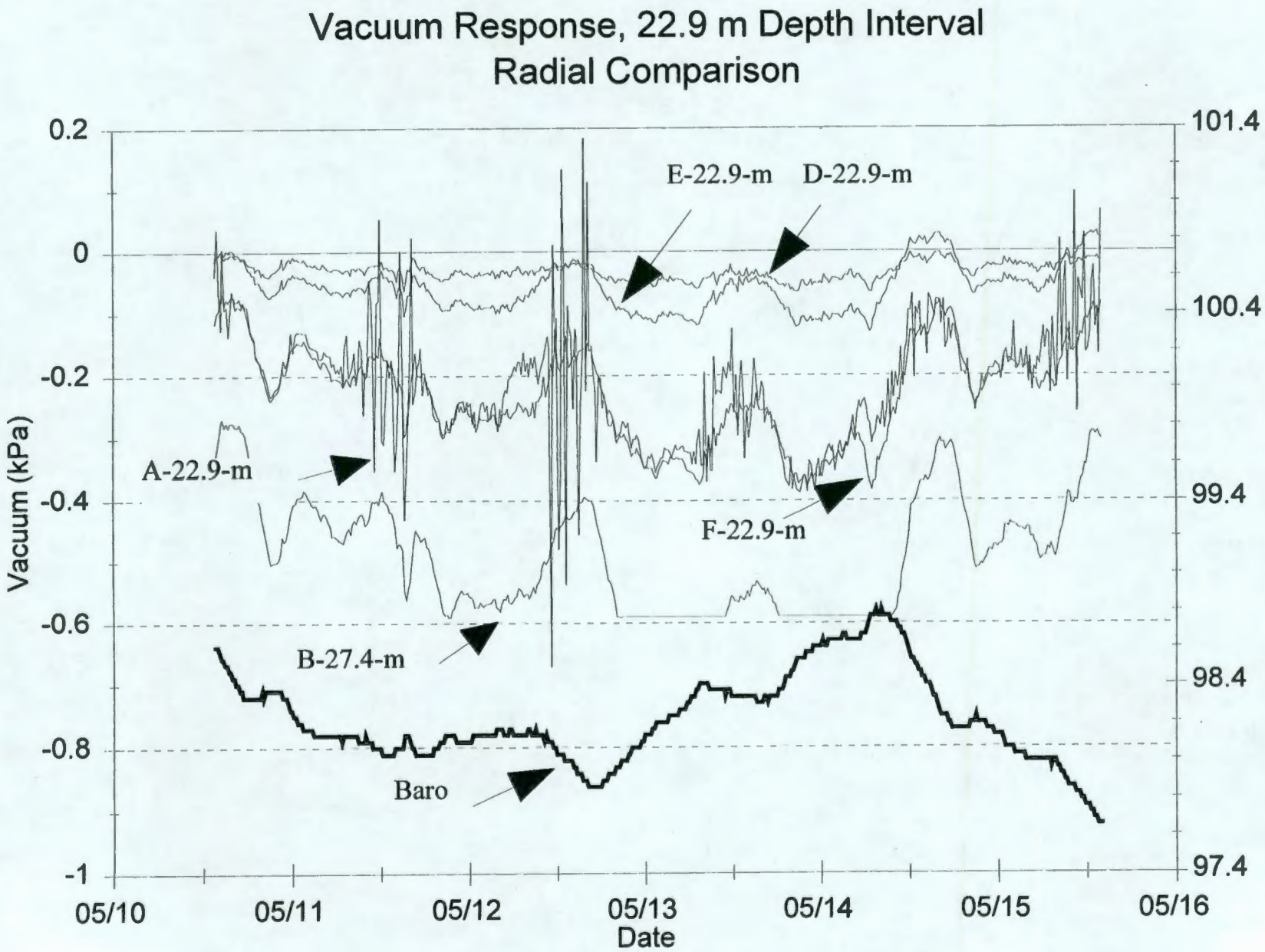


Figure K-10. Time-Series Plot of the Horizontal Vacuum Distribution Through Time for the No-Cover Test between CPT-4F and CPT-4A: 22.9-m Depth Interval.

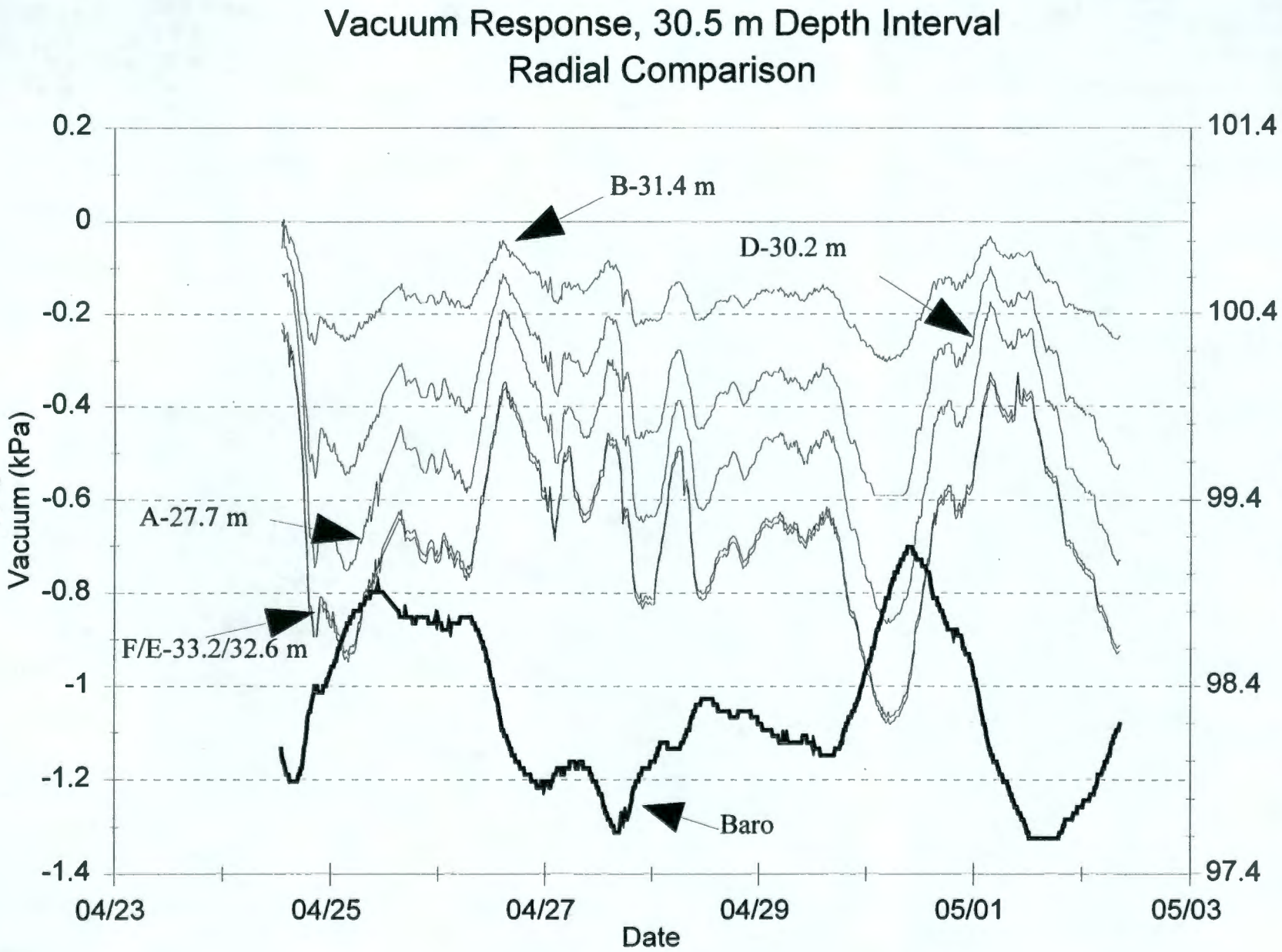


Figure K-11. Time-Series Plot of the Horizontal Vacuum Distribution Through Time for the Cover Test between CPT-4F and CPT-4A: 27.7 - 33.2-m Depth Interval.

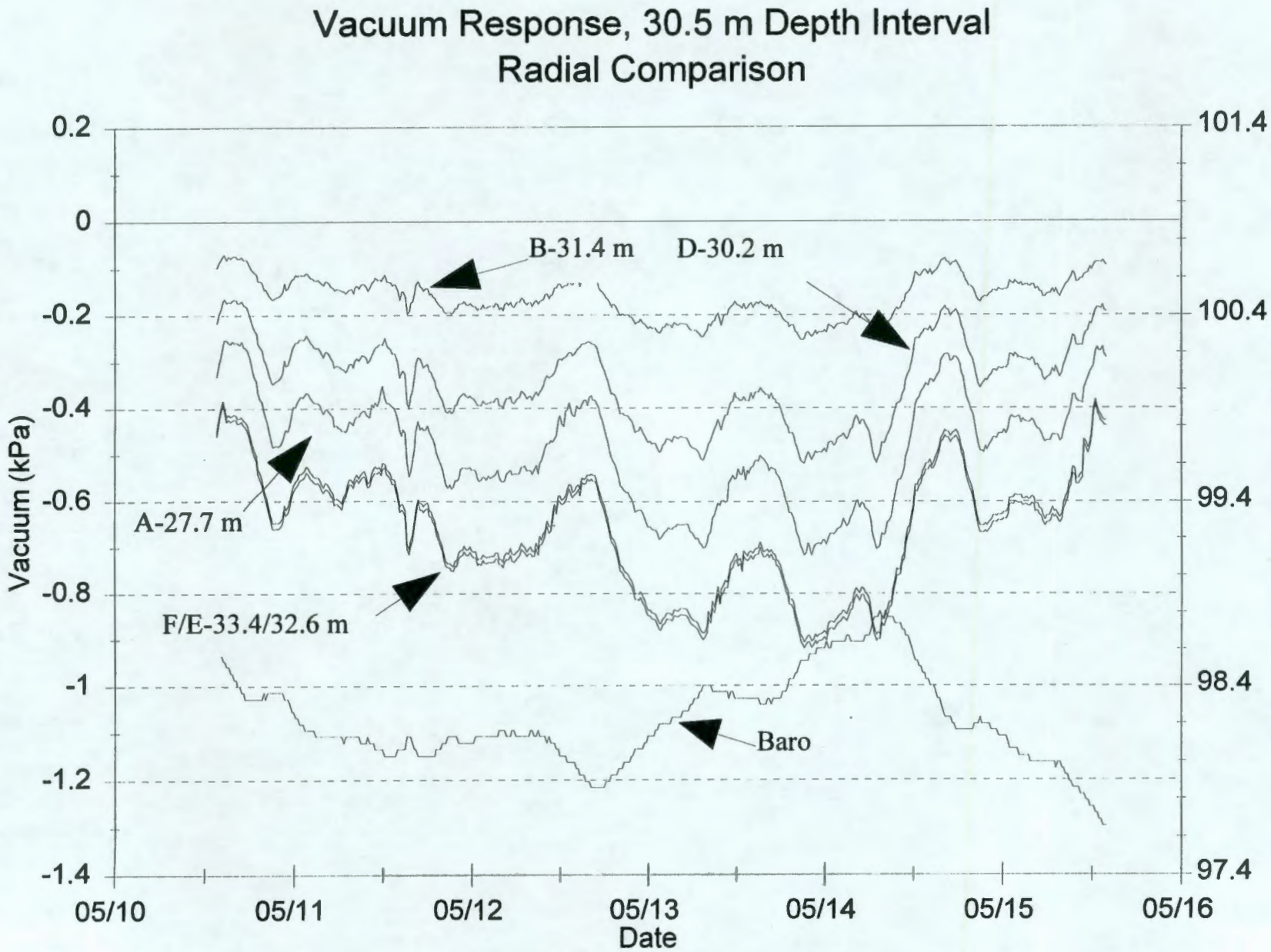


Figure K-12. Time-Series Plot of the Horizontal Vacuum Distribution Through Time for the No-Cover Test between CPT-4F and CPT-4A: 27.7 - 33.2-m Depth Interval.

Table K-1. Comparison of Average Vacuums between the Cover and No-Cover Tests for Specific Locations (Vertical Vacuum Distribution).

CPT-4A Location			
Depth	**Average Vacuum (Cover Test) (kPa)**	**Average Vacuum (No-Cover Test) (kPa)**	**Difference Between Means (kPa)**
15.2	-0.0560	-0.0466	-0.0091
22.9	-0.2307	-0.2147	-0.0160
27.7	-0.5098	-0.4909	-0.0190
CPT-4M Location			
Depth	**Average Vacuum (Cover Test) (kPa)**	**Average Vacuum (No-Cover Test) (kPa)**	**Difference Between Means (kPa)**
20.1	-0.1071	-0.1076	-0.0005
24.4	-0.2727	-1.2811	-0.0084

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