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Final Phase II Report: QuickSite® Investigation, Centralia, Kansas

Environmental Research Division

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Final Phase II Report: QuickSite® Investigation, Centralia, Kansas

Applied Geosciences and Environmental Management Section,
Environmental Research Division,
Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439

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Notation

AGEM	Applied Geosciences and Environmental Management
AMSL	above mean sea level
ASTM	American Society for Testing and Materials
BGL	below ground level
° C	degree(s) Celsius
CCC	Commodity Credit Corporation
CLP	Contract Laboratory Program
COC	chain of custody
cpm	count(s) per minute
DOE	U.S. Department of Energy
ECPT	electronic cone penetrometer
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
GC-MS	gas chromatograph(y)-mass spectrometer(-metry)
KDHE	Kansas Department of Health and Environment
µg/kg	microgram(s) per kilogram
µg/L	microgram(s) per liter
µS/cm	microsiemen(s) per centimeter
MCL	maximum contaminant level
mg/kg	milligram(s) per kilogram
mi	mile(s)
MNA	monitored natural attenuation
NAD	North American Datum
NGVD	National Geodetic Vertical Datum
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RPD	relative percent difference
SDG	sample delivery group
TU	tritium unit(s)
USDA	U.S. Department of Agriculture
VOC	volatile organic compound

Executive Summary

The Environmental Research Division of Argonne National Laboratory has performed a Phase II investigation at Centralia, Kansas, on behalf of the Commodity Credit Corporation of the U.S. Department of Agriculture (CCC/USDA). The results and findings of Argonne's Phase I investigation at Centralia, conducted in March-April 2002, were reported previously (Argonne 2003). On the basis of the findings of the Phase I investigation, the following two technical objectives were developed to guide the Phase II field investigation:

1. Delineate the carbon tetrachloride contamination in the subsurface soils at the former CCC/USDA facility.

2. Evaluate the vertical and lateral extent of the carbon tetrachloride and chloroform contamination in the groundwater associated with the former CCC/USDA facility.

The field work for the Phase II investigation at Centralia was conducted in March-April 2003.

To satisfy the first objective, six vadose zone borings were cored and sampled at 5-ft intervals from the ground surface to approximately 30-50 ft below ground level (BGL), where saturated conditions were encountered. Collected samples were prepared and analyzed for volatile organic compounds (VOCs), including carbon tetrachloride, by using U.S. Environmental Protection Agency (EPA) Methods 5030B and 8260B.

Delineation of carbon tetrachloride in the subsurface soils identified three small areas containing soil concentrations greater than 100 μg/kg. The maximum value detected was 219 μg/kg at 30 ft BGL at location SB12. All concentrations of carbon tetrachloride detected in soils at the former CCC/USDA facility are below the Kansas risk-based standard for direct contact with soil in both the residential scenario (2.5 mg/kg) and the non-residential scenario (7.0 mg/kg) (KDHE 1999). The concentration of carbon tetrachloride detected at SB12 (maximum 219 μg/kg at 30 ft BGL) is on the order of the Kansas risk-based standard of 200 μg/kg in soil for the "Soil-to-Ground Water Protection Pathway." This elevated concentration appears to be limited to a small area in the east-central portion of the former facility.

To satisfy the second objective, groundwater samples were collected in Phase II at eight locations, six off-site and two on-site, to delineate the extent of the contaminant plume. Samples were collected for analysis for VOCs, including carbon tetrachloride and chloroform, with EPA Method 524.2, as well as for tritium analysis.

Results indicate that the groundwater contamination is limited vertically to the shallow aquifer identified within the glacial outwash deposits of the Pleistocene Upper Independence Formation, with the highest values generally being detected in the upper part of that shallow aquifer. Laterally, groundwater contamination is limited to a distance of less than 300 ft from the former facility. Extremely low tritium values detected in the shallow aquifer beneath the former facility indicate little recharge with fresh water and little flux.

The concentrations of chloroform, a primary degradation product of carbon tetrachloride, detected in the groundwater strongly suggest that reductive dechlorination (i.e., the natural biodegradation of carbon tetrachloride) is taking place *in situ* at the former CCC/USDA facility.

On the basis of these findings, no further investigative work is recommended at the former CCC/USDA facility at Centralia, Kansas, at this time.

Final Phase II Report: QuickSite® Investigation, Centralia, Kansas

1 Introduction

The city of Centralia, Kansas, is located in Nemaha County, in the northeastern corner of the state. The town lies about 40 mi northeast of Manhattan, Kansas. The current population of Centralia is approximately 530.

The Commodity Credit Corporation (CCC), an agency of the U.S. Department of Agriculture (USDA), formerly operated a grain storage facility approximately 1,100 ft north of Centralia from 1949 until 1971. Subsequently, a concrete mixing plant operated on the site (FSA 1997). None of the CCC/USDA structures remain, though belowgrade foundations related to structures associated with the concrete mixing operations are evident. Two additional grain storage facilities currently exist in and near Centralia: the Nemaha County Co-op, approximately 4,000 ft south of the former CCC/USDA facility, and a private grain storage facility near the Don Morris residence, 3,500 ft north of the former CCC/USDA facility (Figure 1.1). The property on which the former facility was located is currently owned by Jeanne Burdett Lacky of Seneca, Kansas.

In August-September 1998 the Kansas Department of Health and Environment (KDHE) conducted preliminary investigations at the former CCC/USDA facility, on the basis of the detection of carbon tetrachloride in the domestic well at the Don Morris residence (north of the former CCC/USDA facility). Prior to 1986, commercial grain fumigants containing carbon tetrachloride were commonly used by the CCC/USDA and the grain storage industry to preserve grain. The details of previous investigations in the area and a summary of the findings were reported previously (Argonne 2002a).

Because the KDHE detected carbon tetrachloride in groundwater and soil at the former CCC/USDA facility at Centralia that might be related to historical use of carbon tetrachloride-based grain fumigants at the facility, the CCC/USDA is conducting an environmental site investigation to determine the source(s) and extent of the carbon tetrachloride contamination at the former facility near Centralia and to assess whether the contamination requires remedial action. The town of Centralia and all residents near the former CCC/USDA facility currently obtain their water from Rural Water District #3. Therefore, local residents are not drinking or using the contaminated groundwater detected at the former facility.

The Environmental Research Division of Argonne National Laboratory is performing the investigation at Centralia on behalf of the CCC/USDA. Argonne is a nonprofit, multidisciplinary research center operated by the University of Chicago for the U.S. Department of Energy (DOE). The CCC/USDA has entered into an interagency agreement with DOE, under which Argonne provides technical assistance to the CCC/USDA with environmental site characterization and remediation at its former grain storage facilities. At these former facilities, Argonne is applying its QuickSite® environmental site characterization methodology. QuickSite® is Argonne's proprietary implementation system for the expedited site characterization process. This methodology has been applied successfully at a number of former CCC/USDA facilities in Nebraska and Kansas and has been adopted by the American Society for Testing and Materials (ASTM 1998) as standard practice for environmental site characterization.

Argonne's investigations are conducted with a phased approach. Phase I focuses primarily on the investigation and evaluation of geology, hydrogeology, and hydrogeochemistry to identify potential contaminant pathways at a site. Phase II focuses on delineating the contamination present in both soil and aquifers along the potential migration pathways. Phase I of Argonne's investigation was conducted in March-April 2002. The results and findings of the Phase I investigation at Centralia were reported previously (Argonne 2003).

The following is a summary of the principal findings of Phase I of the investigation at the former CCC/USDA facility at Centralia, on which the Phase II investigation is based:

- Carbon tetrachloride contamination in the subsurface soil at the former CCC/USDA facility was verified by purge-and-trap gas chromatography-mass spectrometry (GC-MS) analysis (EPA Methods 5030B and 8260B).

- No carbon tetrachloride was detected in the upper 5 ft of the soil at the former CCC/USDA facility above the quantitation limit of 10 μg/kg for the purge-and-trap GC-MS method. The maximum vadose zone soil concentration detected during Phase I was 135 μg/kg, at a depth of 27 ft BGL in boring SB06.

- Two aquifer zones were identified at the former facility. The nature and extent of the geologic units composing the shallow and deeper aquifers were characterized. The shallow aquifer is contained in the Pleistocene Upper

Independence Formation, and the deeper aquifer is contained in the Pleistocene Atchison Formation.

- The shallow aquifer, which has been found to be contaminated with carbon tetrachloride, occurs throughout the former facility, but it does not appear to continue to the north (toward the Morris property). The nature of the shallow aquifer varies laterally, from coarser grained sand deposits to finer grained silt and clay material.

- The most likely pathway of contaminant migration at the former CCC/USDA facility involves vertical movement of the contaminant from a source on the property into the shallow aquifer.

- Carbon tetrachloride contamination was not detected in the deeper aquifer.

- There is no evidence for vertical groundwater flow between the shallow and deeper aquifers.

- The results from the Phase I investigation indicate that the horizontal direction of groundwater flow at the former CCC/USDA facility is to the west-southwest. This finding verifies the observation made by the KDHE that groundwater at the former CCC/USDA facility is "expected to move from the topographically higher northeast toward the Black Vermillion River to the southwest" (KDHE 1998). Thus, the former CCC/USDA facility is confirmed to be located hydrogeologically downgradient from the Morris well and is not the source of contamination at the Morris well. To date, no results of investigations conducted at or near the Morris well have been reported to indicate the source area, contaminant distribution, or contaminant level of the Morris plume and the potential effect of that plume on the area upgradient of the former CCC/USDA facility.

- Carbon tetrachloride contamination detected in soils and groundwater at the former CCC/USDA facility is most likely the result of the historical use of carbon tetrachloride-based grain fumigants at the former CCC/USDA facility.

On the basis of the findings of the Phase I investigation, the following two technical objectives were developed to guide the Phase II field investigation:

5 Delineate the carbon tetrachloride contamination in the subsurface soils at the former CCC/USDA facility.

6 Evaluate the vertical and lateral extent of the carbon tetrachloride and chloroform contamination in the groundwater associated with the former CCC/USDA facility.

The field work for Phase II of the investigation at Centralia was conducted in March-April 2003.

This report documents the findings of the Phase II activities at Centralia. Section 1 provides a brief history of the area, a review of the Phase I results and conclusions, technical objectives for the Phase II investigation, and a brief description of the sections contained in this report. Section 2 describes the investigative methods used during the Phase II investigation. Section 3 presents all of the data obtained during the investigation. Section 4 describes the interpretation of the pertinent data used to meet the technical objectives of the investigation. Section 5 presents the conclusions of the investigation relative to the technical objectives and outlines further recommendations.

To streamline the reporting process, material from the site-specific *Work Plan* (Argonne 2002a), the Phase I report (Argonne 2003), and relevant sections of the *Master Work Plan* (Argonne 2002b) are not repeated in detail in this report. Consequently, these documents must also be consulted to obtain the complete details of the investigative program at Centralia.

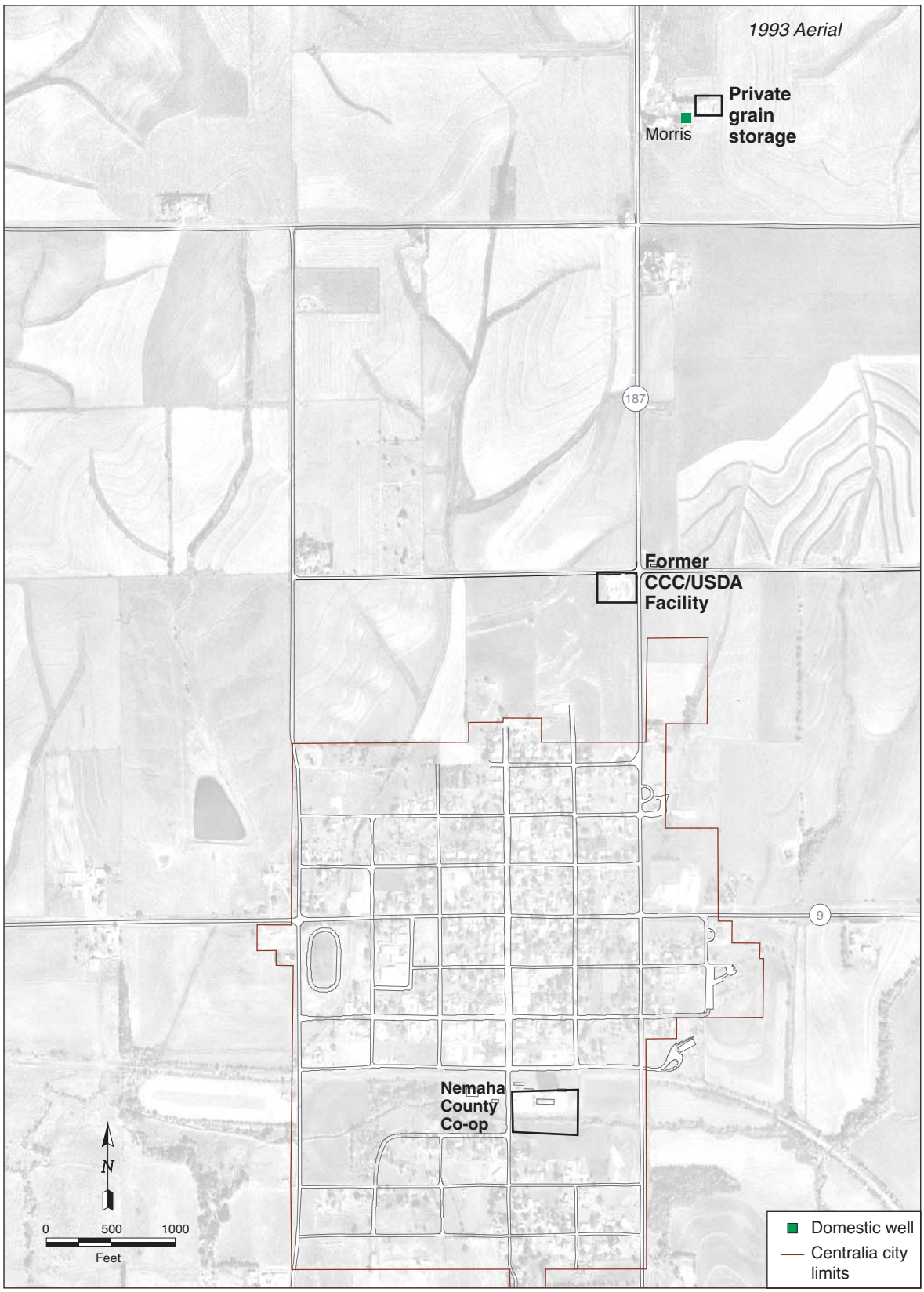

FIGURE 1.1 Locations of the former CCC/USDA grain storage facility at Centralia, other local grain storage facilities, and the contaminated Morris private well.

2 Investigative Methods

The Centralia Phase II investigation was performed by using an iterative process of data collection, evaluation, and interpretation during the field program to ensure that the data necessary and sufficient to achieve the specific technical objectives (Section 1) were obtained. Throughout the field program, a comprehensive quality assurance/quality control (QA/QC) program was implemented to confirm the reliability of all information as it was accumulated. With this procedure, an integrated, technically defensible model of the geologic and hydrogeologic features controlling groundwater flow — and hence potential contaminant migration at the site — was assembled as the specific technical objectives were addressed.

The specific technical objectives and the investigative program developed for the Phase II investigation at Centralia were presented and discussed in Section 6 of the Phase I report (Argonne 2003). Procedures for the individual techniques employed by Argonne at this site are in the *Master Work Plan* (Argonne 2002b). This section provides a brief overview of the methods used to implement Phase II at Centralia, and it identifies certain modifications made to the field program (relative to the work plan presented in the Phase I report [Argonne 2003, Section 5]) in response to new information obtained during the course of the study.

2.1 Methods to Delineate the Carbon Tetrachloride Contamination in the Subsurface Soils at the Former CCC/USDA Facility

In the Phase I investigation, analysis of near-surface soil samples for carbon tetrachloride was conducted with both a headspace method (a modification of U.S. Environmental Protection Agency [EPA] Method 5021) and purge-and-trap GC-MS methods (EPA Methods 5030B and 8260B) on samples collected from depths of approximately 1 ft and 5 ft below ground level (BGL). The combined headspace data for samples collected at 1 ft and 5 ft BGL were used qualitatively to prioritize areas for subsurface soil sampling. Areas of elevated headspace carbon tetrachloride values were selected for additional investigation of subsurface soils during Phase II.

A total of six vadose zone borings, SB11-SB15 and SB24 (Figure 2.1), were sampled. Borings SB11-SB15 were located to address the areas of elevated headspace values identified in Phase I, and location SB24 was selected to investigate the subsurface in the area upgradient from location SB05, where elevated carbon tetrachloride concentrations in groundwater were detected in Phase I (Argonne 2003).

All soil borings were continuously cored by using Argonne's 22-ton track-mounted electronic cone penetrometer (ECPT) from approximately 4 ft BGL to the depth at which the soil appeared to be saturated. The maximum depths of the borings ranged from approximately 30 ft to 50 ft BGL. At each location, discrete soil samples were collected at 5-ft intervals to depth, beginning at 5 ft BGL. Upon collection, the samples were placed in jars, sealed, placed on dry ice, and transported to the Applied Geosciences and Environmental Management (AGEM) Laboratory at Argonne National Laboratory for preparation and analysis for volatile organic compounds (VOCs), including carbon tetrachloride, according to EPA Methods 5030B and 8260B.

Core descriptions for the locations sampled are presented in Appendix A and briefly discussed in Section 3.1. Sample descriptions are in Appendix B. The results of the soil analyses for VOCs are presented in Section 3.3 and are discussed in relation to this technical objective in Section 4.1.

2.2 Methods to Evaluate the Vertical and Lateral Extent of the Carbon Tetrachloride and Chloroform Contamination in the Groundwater Associated with the Former CCC/USDA Facility

Groundwater samples collected in Phase II at eight locations (SB16, SB18-SB22, SB24, and SB24A) were analyzed to delineate the extent of the contaminant plume (Figure 2.2). Two proposed sampling locations, SB21 and SB22, were repositioned toward the former facility during the Phase II field activities on the basis of results obtained during the investigation. In addition, two proposed potential sampling locations, SB17 and SB23, were not sampled because of results obtained (Section 3.4). One additional location, SB24A, was sampled to supplement the results obtained at location SB24 and to provide information on the depth to groundwater.

Water sampling at SB21 and SB22 was intended to identify the lateral extent of the groundwater contamination. On the basis of the results obtained during the field program for samples collected at SB18, SB19, and SB20 (in all of which carbon tetrachloride and chloroform were not detected), it was decided that tighter control on the lateral extent of the zone of groundwater contamination would be achieved by locating SB21 and SB22 closer to the former facility. The relocation of the positions of SB21 and SB22 was consistent with the intent and objective of the sampling program specified in the approved *Work Plan*. This adjustment was discussed in the field with a KDHE representative (Dr. Donna Porter).

Similarly, the decision not to sample SB23, proposed north of the former facility and near KDHE sampling location GW-7, was based on the low contaminant levels detected at SB24 and SB24A. These levels were consistent with the low levels detected previously by the KDHE in GW-7. As with the relocation of SB21 and SB22, the decision not to sample SB23 was discussed with KDHE personnel.

SB17 was intended to be installed as a monitoring well. At this location, a sampling point to assess groundwater quality was not needed, because Phase I sampling at this location (SB03) revealed no contamination. In discussions with the KDHE in March 2003, which led to the addition of sampling point SB24, the parties agreed to postpone the proposed drilling at SB17 until a time when it might prove necessary to constrain limits for groundwater modeling (LaFreniere 2003).

The groundwater sampling locations were first investigated by using Argonne's 22-ton track-mounted ECPT vehicle. Vertical ECPT sensor profiles were collected at seven locations (not including SB24A) in accordance with procedures outlined in the *Master Work Plan* (Argonne 2002b) to assist in the identification of the target depths for groundwater sampling. These data are presented in Appendix A.

Groundwater samples were collected by pushing cone penetrometer rods with a disposable tip to the target depth. The rods were then withdrawn slightly to expose an internal filter screen section into which groundwater passed. Groundwater samples were collected by using a bailer inserted through a polyvinyl chloride (PVC) riser attached to the filter screen. Field parameters (temperature, pH, and conductivity) were measured in the field during groundwater sampling by using a Checkmate Field Meter system after calibration with the appropriate standard solutions.

Samples collected for VOC analyses were preserved in the field (Argonne 2002b, Section 6.2) and shipped to the AGEM Laboratory for analysis for VOCs, including carbon tetrachloride and chloroform, with EPA Method 524.2. Some groundwater samples were also collected for analysis for tritium at the Tritium Laboratory at the University of Miami in Miami, Florida. Results are discussed in Section 3.4.

To aid in characterization of the local groundwater gradient, "temporary" piezometers (sand point wells) were installed at each of the groundwater sampling locations. These

piezometers were installed by using a slight modification of the standard procedure for groundwater sampling with slotted PVC pipe (Argonne 2002b, Section 6.4.6). Sand was placed as a filter pack around the screened interval, and bentonite grout was used to seal the surface of the annulus. These temporary piezometers were left in place less than 10 days, after which the PVC was removed, and the remaining holes were fully grouted by using a tremied, high-solids bentonite slurry grout. Results are discussed in Section 3.5.

2.3 Quality Control for Sample Collection, Handling, and Analysis

The QA/QC procedures for sample collection, handling, and analysis followed during Centralia Phase II activities are described in detail in the *Master Work Plan* (Argonne 2002b). Significant points include the following:

- Sample integrity was preserved throughout the collection, shipping, and analysis activities by the use of custody seals and chain-of-custody records.

- The QA/QC samples collected included equipment rinsates, trip blanks, and blind field replicate samples. Other samples were selected for duplicate analyses as a measure of analytical precision.

- Trip blanks were used to verify that samples collected for organic analyses were not contaminated during shipment.

- Reusable sampling bailers were used during collection of groundwater samples with the ECPT vehicle. Rinsates from the decontaminated bailers were collected periodically to verify that cross-contamination of groundwater samples did not occur during sample collection.

- Subsurface soil profile samples were prepared and analyzed for carbon tetrachloride and chloroform at the AGEM Laboratory with the purge-and-trap method, by following a modification of the protocol in EPA Methods 5030B and 8260B. Replicate samples were sent to Severn-Trent Laboratory, Colchester, Vermont, for verification analysis with the same analytical procedure.

- Groundwater samples were analyzed for carbon tetrachloride and chloroform at the AGEM Laboratory by using EPA Method 524.2. Replicate samples were sent to Clayton Laboratory, Novi, Michigan, for verification analysis with EPA Contract Laboratory Program (CLP) methodology.

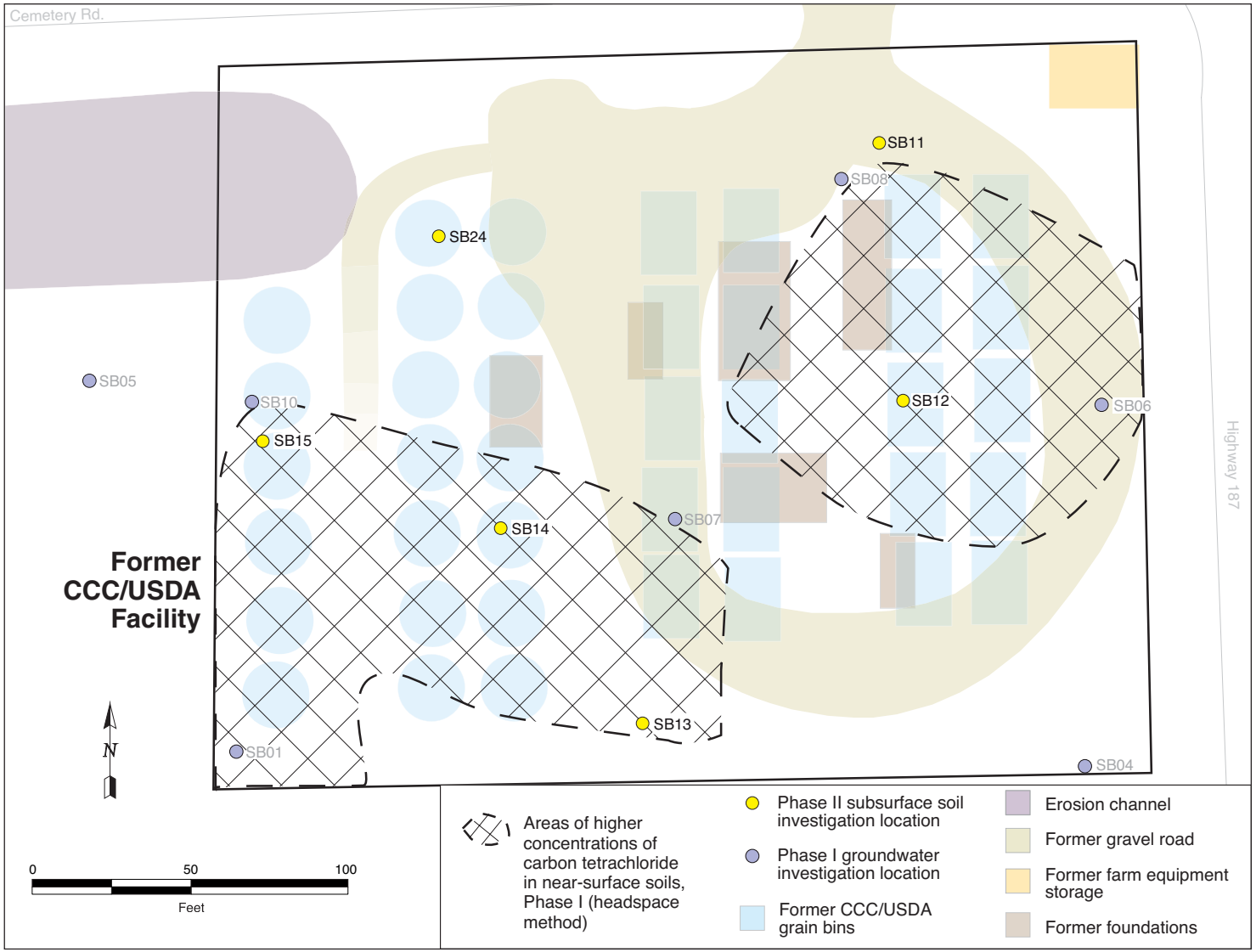

FIGURE 2.1 Locations of Phase II subsurface soil sampling activities at the former CCC/USDA facility and Phase I groundwater sampling locations, in relation to the interpreted pattern of carbon tetrachloride contamination based on Phase I results.

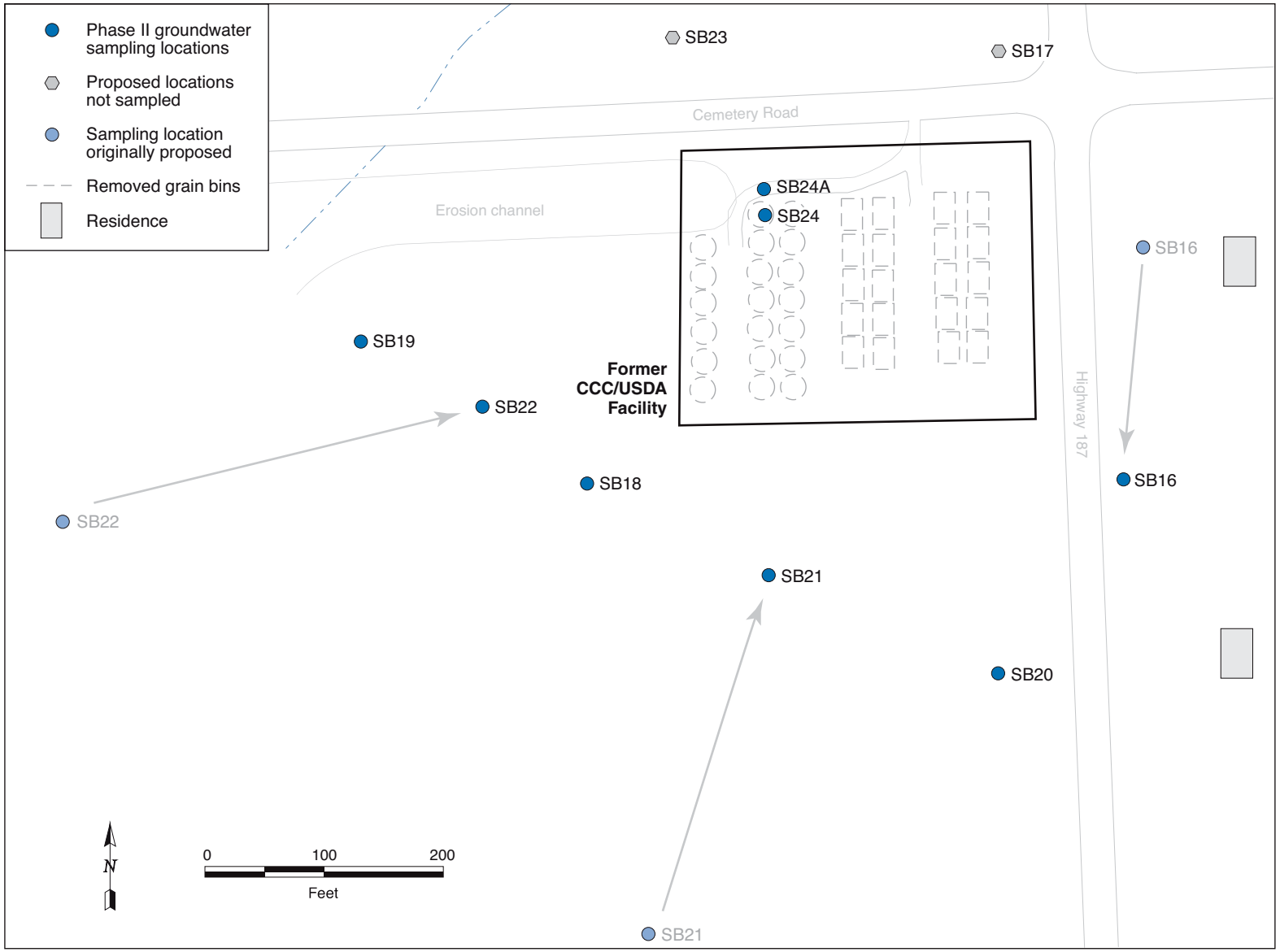

FIGURE 2.2 Locations of Phase II groundwater sampling activities in the investigation area at Centralia.

3 Field and Laboratory Data

This section summarizes the field and laboratory data generated during the Phase II investigation at Centralia. The general techniques and procedures followed are described in detail in the *Master Work Plan* (Argonne 2002b). For organizational simplicity, the data are summarized in this section according to the types of media investigated and the activities performed. These data are interpreted in Section 4 in the context of the specific Phase II technical objectives.

3.1 Cone Penetrometer Sensor Data and Soil Coring Data

Electronic cone penetrometer data, consisting of continuous tip and sleeve stress measurements, were collected at seven locations (SB16, SB18-SB22, and SB24) shown in Figure 3.1. These data were used to identify the target zones for groundwater sampling: the sands within the shallow aquifer contained in the Pleistocene Upper Independence Formation.

Core samples were collected at SB16 to confirm the correlation of ECPT cone sensor response with the site-specific geology recognized in Phase I. This core confirmed the presence of a saturated sand/gravel unit at a depth of approximately 52.5 ft BGL, as indicated by the ECPT sensors.

Continuous core samples were collected from subsurface vadose zone soil borings SB11-SB15 and SB24. The data confirm the generally fine grained, heterogeneous nature of the vadose zone soils identified in Phase I. These soils were interpreted in Phase I as representing the glacial till and outwash deposits of the Pleistocene age Upper Independence Formation. Descriptions of the cores collected during Phase II are in Appendix A.

3.2 Coordinates Survey Data

All subsurface soil and groundwater sampling locations at Centralia (SB11-SB16, SB18-SB22, SB24, and SB24A) were surveyed by Schwab-Eaton, P.A., Manhattan, Kansas, to provide horizontal and vertical control for stratigraphic correlation and water level monitoring. Coordinates survey data are in Appendix C, Table C.1.

3.3 Analytical Data for Subsurface Soils

Subsurface soil samples were collected at six locations (SB11-SB15 and SB24) to assess the degree to which vadose zone soils at the former CCC/USDA facility are contaminated with carbon tetrachloride. The locations of borings SB11-SB15 were based on a review of the distribution pattern of the headspace data for carbon tetrachloride contamination in near-surface soils identified during Phase I. Boring SB24 was located upgradient from SB05, where elevated carbon tetrachloride concentrations in groundwater were detected during Phase I, to investigate whether the contaminant detected at SB05 might have come from a source at the former facility.

Discrete subsurface soil samples were collected at each of the six locations at 5-ft intervals, starting at a depth of 5 ft BGL and continuing to the depth where the soil was saturated. The maximum depths cored ranged from approximately 30 ft to 50 ft BGL. The samples were prepared and analyzed for VOCs by using EPA Methods 5030B and 8260B. Sample descriptions are in Table B.1, Appendix B.

Carbon tetrachloride was detected above the AGEM Laboratory method quantitation limit of 10 µg/kg in 21 of the 55 subsurface soil samples collected and at 5 of the 6 locations sampled (Table 3.1). The highest carbon tetrachloride levels were detected at SB12 and SB24, at depths of approximately 25-30 ft BGL. Maximum carbon tetrachloride values at SB11, SB14, and SB15 ranged from 14 to 28 µg/kg, at depths of approximately 20-30 ft BGL. Carbon tetrachloride was not detected above the method quantitation limit in any of the 9 samples analyzed from SB13, though a trace amount was detected in the sample from approximately 25 ft BGL. The maximum concentrations detected at each boring location (at any depth) are shown in Figure 3.2. A depth profile of carbon tetrachloride values detected at borings SB24 and SB12 is in Figure 3.3. Complete analytical results for VOCs in soil samples are in Table B.2, Appendix B.

Chloroform was detected at or above the AGEM method quantitation limit of 10 µg/kg in only two samples; both of these samples came from SB24 (Table B.2, Appendix B). The maximum concentration detected was 11 µg/kg, at a depth of approximately 20 ft BGL. A concentration of 10 µg/kg was detected at a depth of approximately 15 ft BGL. Trace amounts of chloroform (less than 10 µg/kg) were also detected in samples from SB12.

Subsurface soil samples collected from boring SB15 in Phase II were analyzed for grain size and percent composition. Results are in Tables B.3 and B.4 in Appendix B. In addition,

TABLE 3.1 Maximum carbon tetrachloride values in subsurface soil samples collected at six locations at Centralia during Phase II work.

Location	Depth (ft BGL)	Sample Date	Maximum Carbon Tetrachloride at this Location (µg/kg)
SB11	29.9-30.1	4/5/03	16
SB12	29.9-30.1	4/4/03	219
SB13	24.9-25.1	4/3/03	7.3 J[a]
SB14	29.9-30.1	4/4/03	14
SB15	19.6-19.8	4/2/03	28
SB24	24.9-25.1	4/2/03	121

[a] Qualifier J indicates an estimated concentration below the method quantitation limit of 10 µg/kg for purge-and-trap GC-MS analysis.

subsurface soil samples from several Phase I and Phase II locations were analyzed for moisture content. Results are in Table B.5, Appendix B.

3.4 Analytical Data for Water Samples

Groundwater samples were collected in Phase II at eight locations (SB16, SB18-22, SB24, and SB24A) across the investigation area. These samples were analyzed for VOCs by using EPA Method 524.2. Some groundwater samples were also analyzed for tritium. Descriptions of the groundwater samples are in Table D.1, Appendix D.

3.4.1 Field Measurements

Selected parameters (temperature, pH, and conductivity) were measured in the field during groundwater sampling. The results of these analyses are in Table D.2, Appendix D.

3.4.2 Contaminant Data for Water Samples

Carbon tetrachloride was not detected above the maximum contaminant level (MCL) of 5 μg/L in groundwater from any of the eight locations sampled in Phase II (Figure 3.4). The highest concentration of carbon tetrachloride detected in groundwater during the Phase II investigation was 2.3 μg/L, at 40.9-45.9 ft BGL at SB24. This location is in the northwest section of the former CCC/USDA facility. The groundwater sample from associated location SB24A had a carbon tetrachloride concentration of 1.7 μg/L. Carbon tetrachloride was not detected in groundwater above the AGEM Laboratory method quantitation limit of 1.0 μg/L at any of the other six locations sampled.

Chloroform was detected in groundwater from SB24 and SB24A at concentrations of 6.9 μg/L and 7.1 μg/L, respectively. Chloroform was not detected above the AGEM Laboratory method quantitation limit of 1.0 μg/L in groundwater samples from any of the other six locations sampled (Figure 3.4).

The complete results of the VOC analyses on groundwater samples are in Table D.3, Appendix D.

3.4.3 Tritium Isotope Data for Water Samples

Groundwater samples from seven of the eight locations sampled were analyzed for tritium to aid in the characterization of (1) the relative contribution of rainwater recharge to the groundwater system and (2) the degree of mixing throughout the shallow aquifer. Tritium values ranged from -0.05 to 0.64 TU (tritium units) in five of the seven samples analyzed. The only two samples with tritium values greater than 1 TU were from SB16 at 1.92 TU and from SB19 at 10.5 TU. (Tritium values near zero are characteristic of relatively “old” groundwater, while higher values are characteristic of “younger” [post-1951] water.) The distribution of Phase II tritium values across the study area is shown in Figure 3.5. Complete analytical results are in Table D.4, Appendix D.

3.5 Groundwater Level Data

The groundwater gradient at the former CCC/USDA facility was characterized during the Phase I investigation by the establishment of a groundwater monitoring network consisting of six groundwater piezometers: SB01, SB04, SB05, SB07, SB08, and SB09.

During Phase II, measurements of depth to groundwater in the existing six permanent piezometers were augmented by measurements in an additional seven temporary piezometers at (sand point wells) locations where groundwater quality samples were collected (SB16, SB18-SB22, and SB24A). Water levels in both the permanent piezometers and the temporary piezometers were measured manually on April 5, 2003, to the nearest 0.01 ft from a surveyed reference mark, by using an electronic water level sensor (Argonne 2002b). The data are in Table E.1, Appendix E. The horizontal groundwater gradients determined by using data collected during Phase I and Phase II are compared in Figure 3.6. Groundwater levels measured during Phase II in the shallow aquifer were generally lower than levels measured during Phase I. The direction of the horizontal gradient in Phase II appears to be slightly more southerly than the west-southwest direction interpreted during Phase I. Minor variations in gradients with time are common. The gradient measured in Phase II (which is based on additional monitoring locations at SB16, SB18-SB22, and SB24 in the broader investigation area) is not substantively different from the gradient measured in Phase I.

3.6 Quality Control Data for Soil and Groundwater Analyses

The QA/QC procedures followed for collection, handling, and analysis of soil and groundwater samples during Centralia Phase II work are described in detail in the *Master Work Plan* (Argonne 2002b). A detailed QA/QC report addressing activities related to sample collection, handling, and analysis is in Appendix F. Results of the QA/QC activities are summarized as follows:

- Sample integrity was maintained successfully throughout the collection, shipping, and analysis activities by the use of custody seals and chain-of-custody records. A few minor discrepancies were resolved by comparison of the various records.

- All samples shipped to the AGEM Laboratory and to verification laboratories were received with custody seals intact and at appropriate temperature. All samples were analyzed within the required holding times.

- Contaminants of concern were not detected in the trip blanks analyzed by the AGEM Laboratory. However, one trip blank was not analyzed because of a documentation error. No cross-contamination of the accompanying samples during shipment is indicated by the absence of contamination in 5 of the 11 samples and the 1 replicate in the shipment.

- Contaminants of concern were not detected in the trip blank shipped to Clayton Laboratory with water samples for verification organic analysis.

- Chloroform was detected in the trip blank shipped to Severn-Trent Laboratory with soil samples for verification organic analysis. The reported concentration is qualified because of high recovery in the laboratory QC samples analyzed with the trip blank. The data are accepted with the qualification. The high recovery would not have prevented detection of low levels of the contaminant.

- Carbon tetrachloride and chloroform were not detected in rinsates from decontaminated reusable sampling bailers, indicating that decontamination procedures were followed successfully.

- Sampling difficulties at location SB22 required resampling to assure that the sample collected with the ECPT for organic analysis was representative of the site conditions. No difficulty was encountered in the resampling. Details are in Appendix F, Section F.1.4.

- For the purge-and-trap GC-MS analysis of subsurface soil samples for carbon tetrachloride and chloroform at the AGEM Laboratory with EPA Methods 5030B and 8260B, calibration checks were run with each sample delivery group to verify proper calibration of the gas chromatograph throughout the analyses, and surrogate standard determinations were performed. Results of dual analyses for samples from 13 locations showed

excellent agreement. The data from the AGEM Laboratory are acceptable for quantitative determination of contaminant distribution and for risk analysis.

- Quality control limits were acceptable in verification purge-and-trap GC-MS analyses of replicate soil samples with EPA Methods 5030B and 8260B at Severn-Trent Laboratory. The laboratory qualified the results for two samples. Details are in Appendix F, Section F.2.2. The verification results from Severn-Trent do, however, support the AGEM Laboratory data.

- Groundwater samples were analyzed for carbon tetrachloride and chloroform at the AGEM Laboratory by using EPA Method 524.2 (the purge-and-trap method). Quality control limits were met for the analyses. The results of dual analyses for samples from four locations were consistent, although some variability was evident in secondary analyses of samples from location SB24 (where turbidity in the sample/replicate aliquots was noted during collection). The data are acceptable for quantitative determination of contaminant distribution.

- Quality control limits were met in verification analyses of replicate groundwater samples for carbon tetrachloride and chloroform with CLP methodology at Clayton Laboratory. The results support the AGEM Laboratory data.

- For the tritium analyses, the instrument was calibrated with a standard, and dual analyses of samples gave comparable results. The data are acceptable for age dating of groundwaters.

3.7 Waste Characterization, Handling, and Disposal

Equipment rinsates were free of carbon tetrachloride and chloroform contamination (Table F.2, Appendix F), and the collected wastewater was released to the surface at the site.

3.8 Summary

The following are the key results of the Phase II investigation at Centralia:

- Carbon tetrachloride was detected above the AGEM Laboratory method quantitation limit of 10 µg/kg in 21 of the 55 subsurface soil samples collected and at 5 of the 6 locations sampled. The maximum carbon tetrachloride concentrations detected at SB12 (219 µg/kg) and at SB24 (121 µg/kg) occurred at depths of 25-30 ft BGL. Maximum carbon tetrachloride values at SB11, SB14, and SB15 ranged from 14 to 28 µg/kg, at depths of 20-30 ft BGL. Carbon tetrachloride was not detected above the method quantitation limit of 10 µg/kg in any of nine analyzed samples from SB13.

- Carbon tetrachloride was not detected above the MCL of 5 µg/L in groundwater from any of the eight locations sampled in Phase II.

- The Phase II QA/QC activities demonstrated that the analytical data reported by the various laboratories in Phase II are acceptable for the purposes of this investigation.

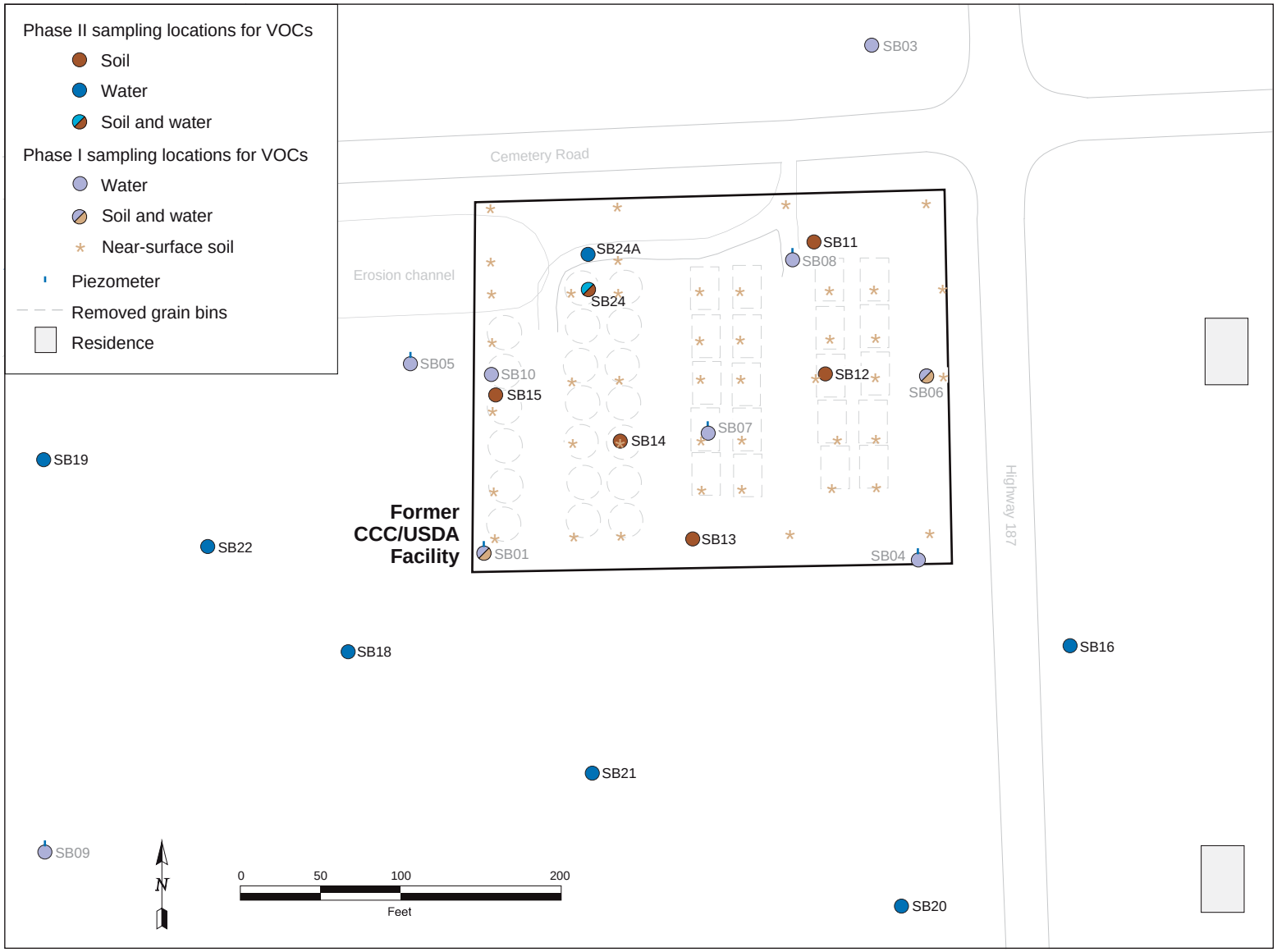

FIGURE 3.1 Locations of Phase II cone penetrometer profiling and soil coring activities in the investigation area at Centralia.

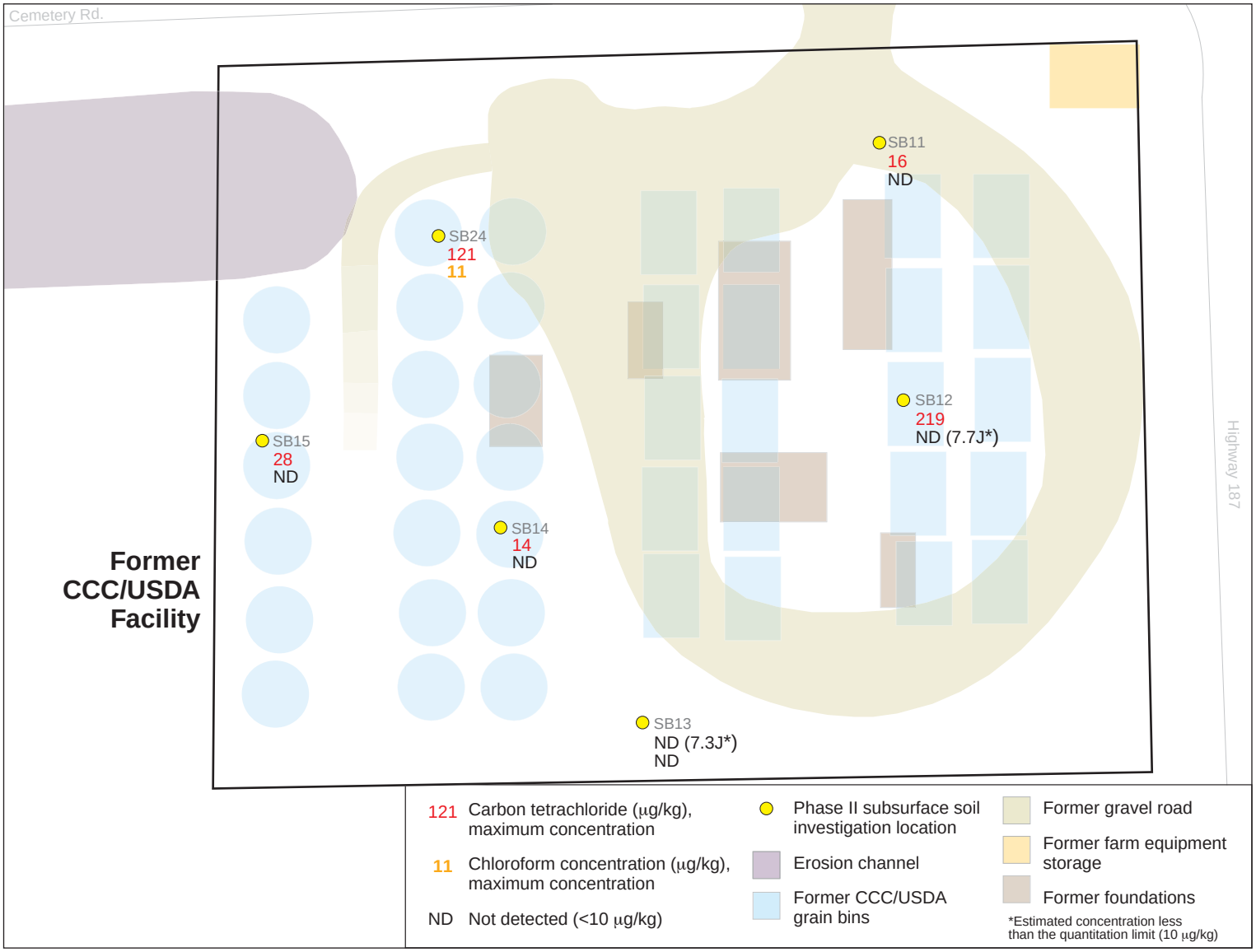

FIGURE 3.2 Maximum carbon tetrachloride and chloroform concentrations detected at any depth in each subsurface vadose zone soil boring in Phase II

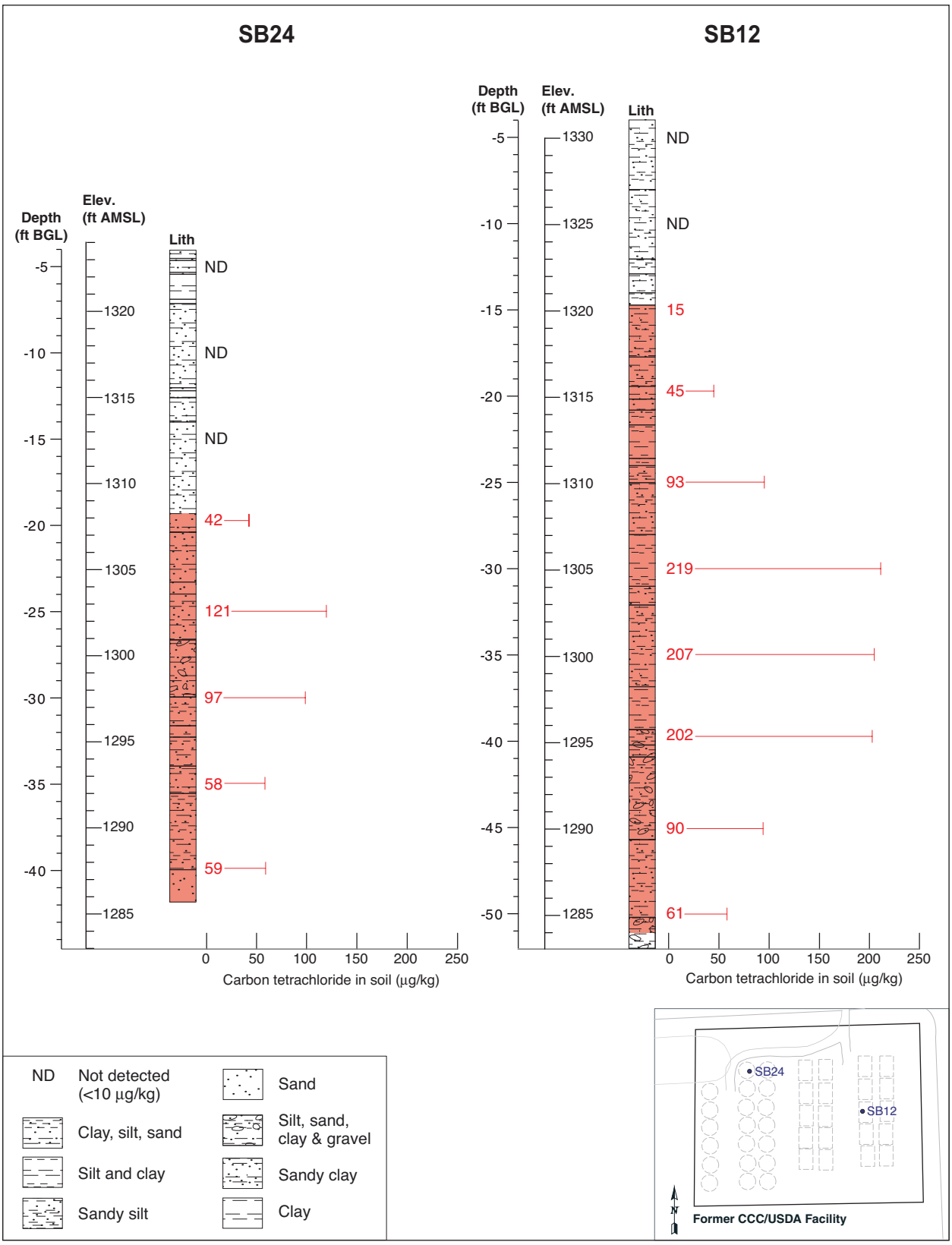

FIGURE 3.3 Depth profiles of carbon tetrachloride concentrations in vadose zone soils at SB24 and SB12.

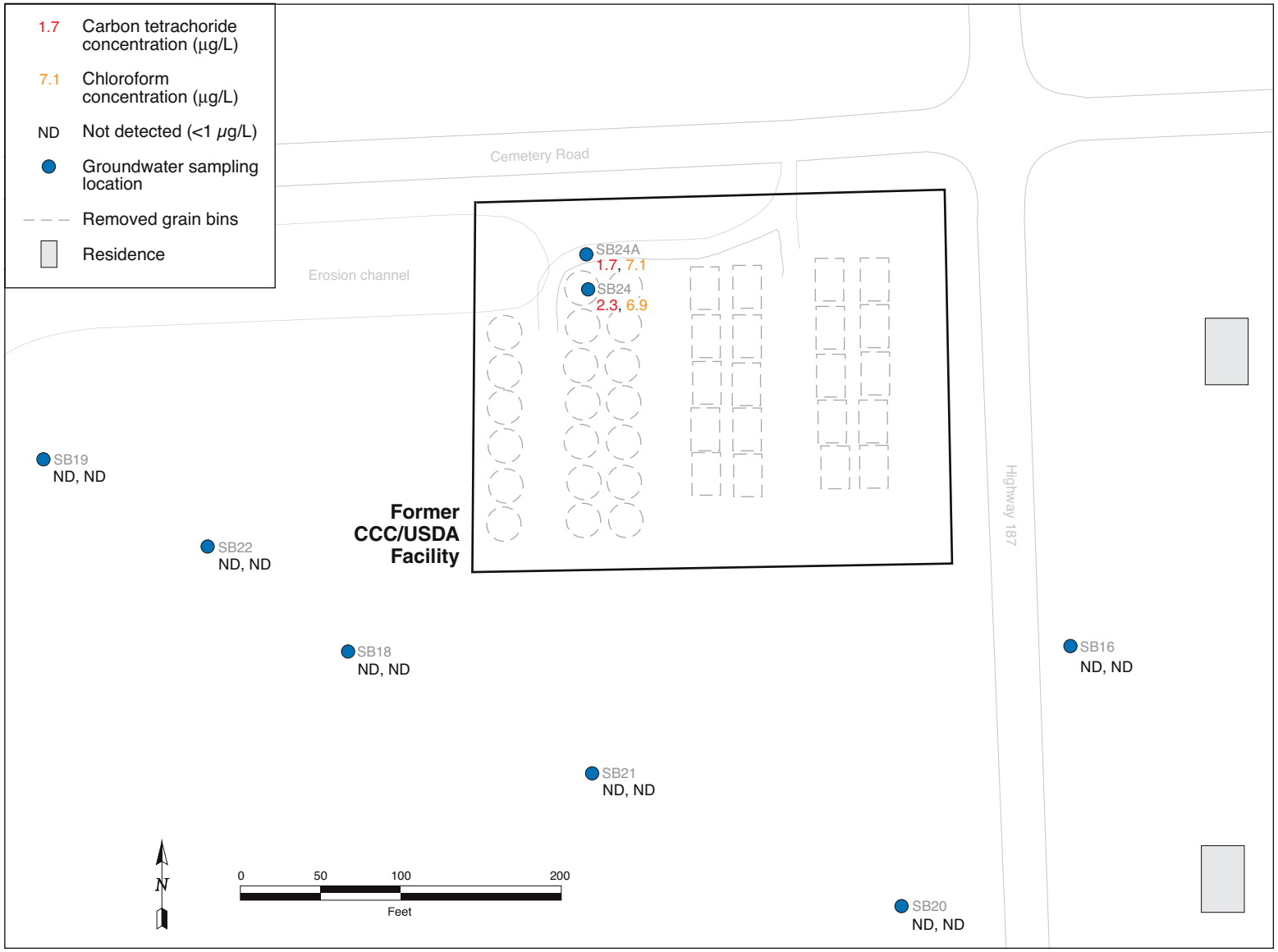

FIGURE 3.4 Carbon tetrachloride and chloroform concentrations detected in groundwater in the investigation area during Phase II.

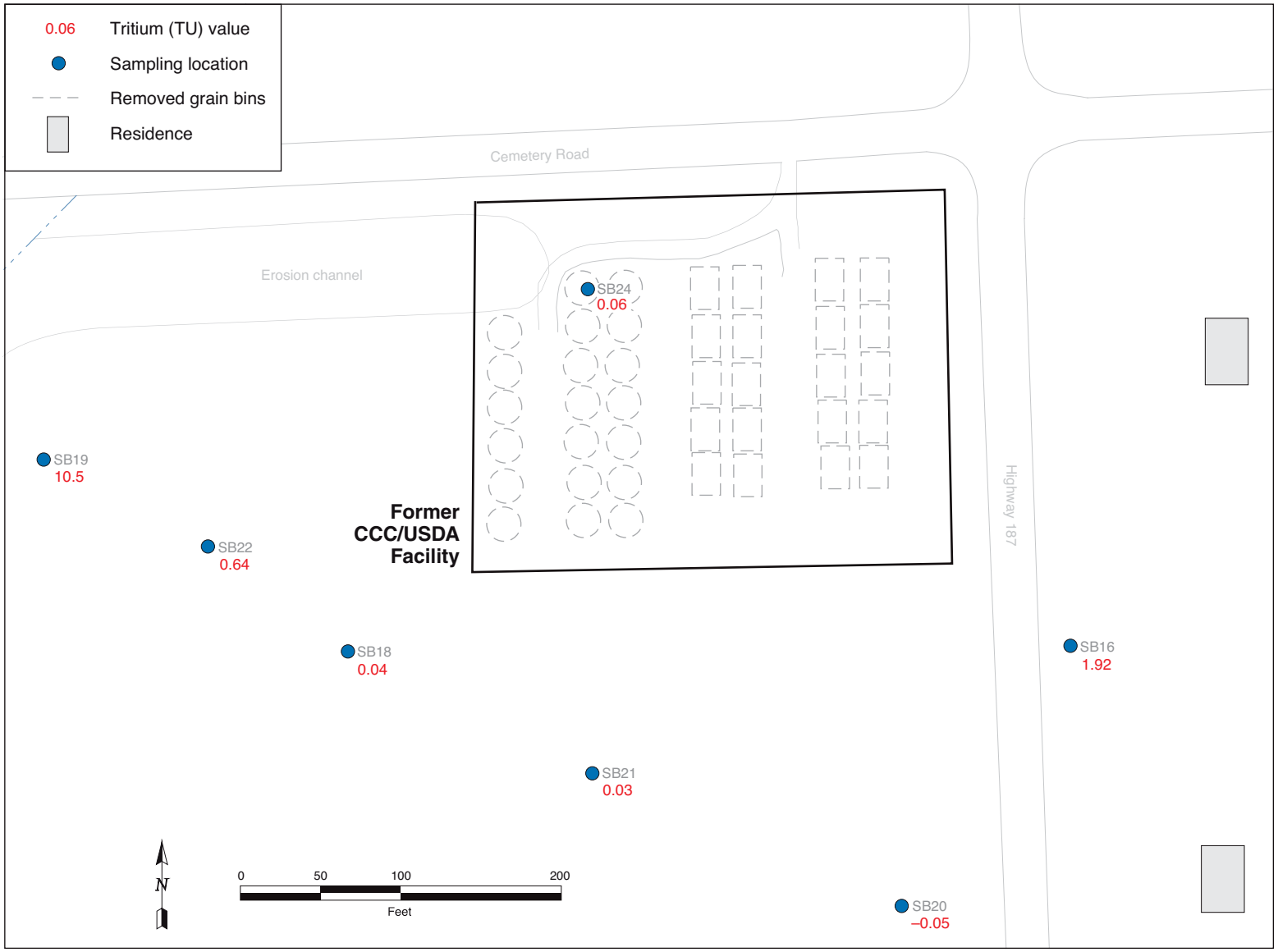

FIGURE 3.5 Tritium values detected in groundwater in the investigation area during Phase II.

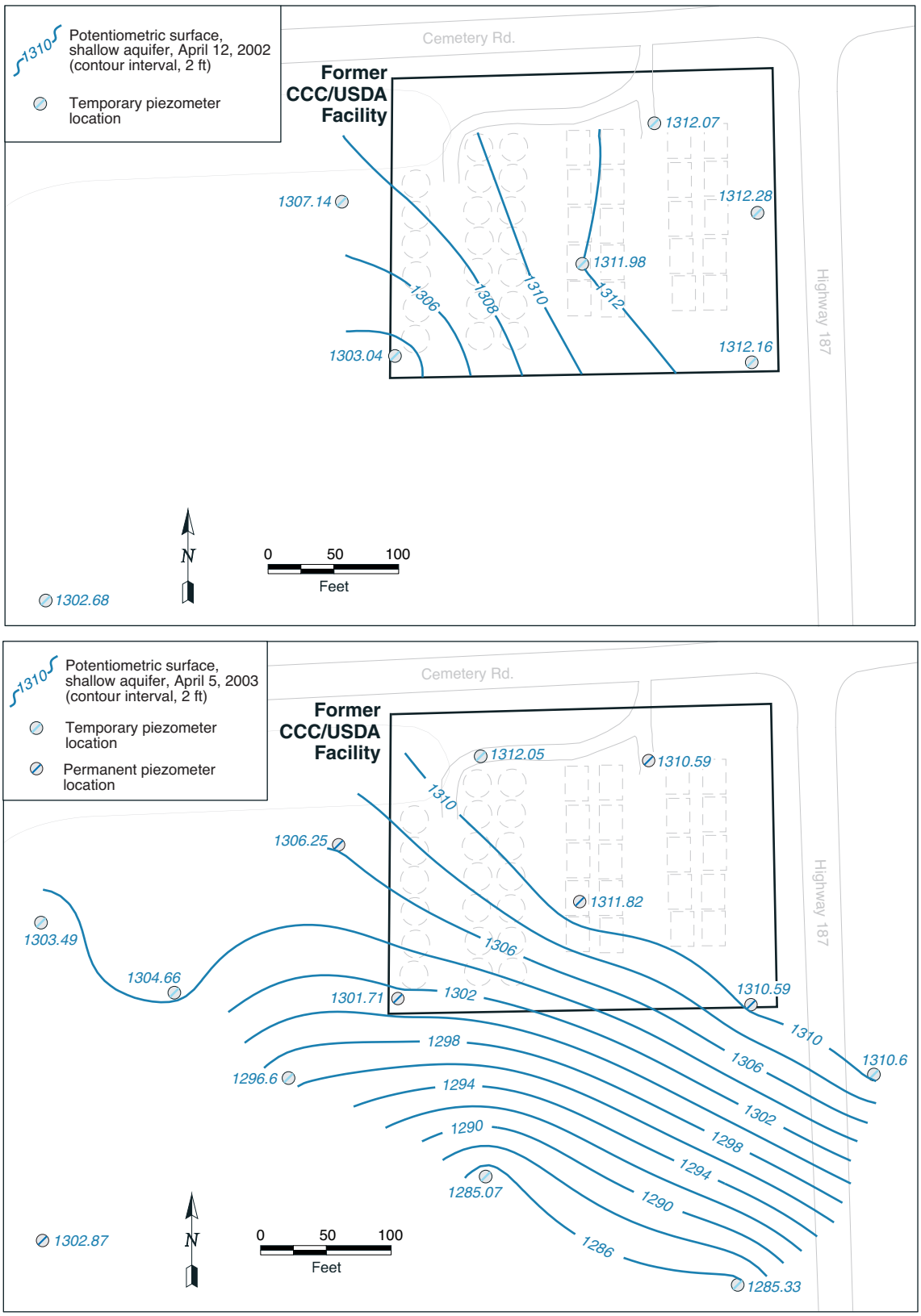

FIGURE 3.6 Phase I (top) and Phase II (bottom) groundwater elevation data and associated interpreted piezometric surface contours of the shallow aquifer in the investigation area.

4 Interpretation of Results

The purpose of the Phase II investigation was to delineate the contamination present in both soil and groundwater at the former CCC/USDA facility at Centralia. To achieve this purpose, two technical objectives were developed to guide the Phase II field investigation. The data gathered during the field investigation were combined with data collected during Phase I to address the two objectives, as follows:

1. Delineate the carbon tetrachloride contamination in the subsurface soils at the former CCC/USDA facility.

2. Evaluate the vertical and lateral extent of the carbon tetrachloride and chloroform contamination in the groundwater associated with the former CCC/USDA facility.

4.1 Carbon Tetrachloride Contamination in the Subsurface Soils at the Former CCC/USDA Facility

The methodology presented in Section 2.1 was used in Phase II to collect the additional data necessary to delineate the carbon tetrachloride contamination in the subsurface vadose zone soils.

4.1.1 Contaminant Levels in Subsurface Soils

Using the methods described in Section 2.1, Argonne conducted subsurface sampling of vadose zone soils to depths of approximately 25-50 ft BGL at six locations (SB11-SB15 and SB24) during Phase II. Two additional locations (SB01 and SB06) were investigated during Phase I. In the two phases (Figure 4.1), no carbon tetrachloride was detected above the AGEM Laboratory method quantitation limit of 10 μg/kg at either SB01 or SB13. Low levels of carbon tetrachloride (below 30 μg/kg) were detected at SB11, SB14, and SB15. Somewhat higher levels were detected at SB12 (219 μg/kg), SB06 (135 μg/kg), and SB24 (121 μg/kg). In the two phases, chloroform was detected above the quantitation limit of 10 μg/kg at only two locations: SB06 (12 μg/kg at 25 ft BGL and 19 μg/kg at 37 ft BGL) and SB24 (10 μg/kg at 15 ft BGL and 11 μg/kg at 20 ft BGL).

Across the former CCC/USDA facility, carbon tetrachloride was detected within the upper 10 ft of the vadose zone only at SB06 (13 µg/kg at 9 ft BGL). In the deeper subsurface, the highest carbon tetrachloride concentrations occurred at depths of approximately 25 to 35 ft BGL, ranging from < 10 µg/kg at SB01 and SB13 to 219 µg/kg at SB12. The interpreted areas of elevated carbon tetrachloride values in subsurface soils (above an arbitrary cutoff of 100 µg/kg) are shown in Figure 4.1.

4.1.2 Human Health Risks Associated with Exposure to Soils

Results obtained from the sampling and analysis of near-surface and subsurface soils to a depth of 10 ft BGL were compared against the Tier 2 risk-based standards for carbon tetrachloride and chloroform presented in the Risk-Based Standards for Kansas (RSK Manual; KDHE 2003). In deriving the presented concentrations for soil, the KDHE evaluated exposure pathways including incidental ingestion of soil, inhalation of airborne particulates, inhalation of chemical volatilizing from soil, and direct dermal contact with soil. The KDHE standards are based on risk to human health, for residential and nonresidential land use settings.

The risk-based standards listed in the Tier 2 Risk-Based Summary Table (Appendix A in RSK Manual; KDHE 2003) for carbon tetrachloride are 2.5 mg/kg or 2,500 µg/kg for a residential setting and 7.0 mg/kg or 7,000 µg/kg for a nonresidential setting. The corresponding risk-based standards for chloroform are 3.9 mg/kg (3,900 µg/kg) and 6.0 mg/kg (6,000 µg/kg).

The maximum concentration of carbon tetrachloride (above the quantitation limit of 10 µg/kg for the purge-and-trap method) detected in soil samples collected in Phase I and Phase II to a depth of 10 ft BGL was 13 µg/kg at SB06. Chloroform was not detected above the method quantitation limit of 10 µg/kg in any Phase I or Phase II soil sample collected to a depth of 10 ft BGL, though a trace (estimated) concentration of 4 µg/kg was detected at SB06. These concentrations of carbon tetrachloride and chloroform are lower by more than two orders of magnitude than the respective risk-based standards. Detailed purge-and-trap analytical results for soil samples are in Appendix D, Table D.3, of the Phase I report and in Appendix B, Table B.2, of this report.

This comparison of detected concentrations of carbon tetrachloride and chloroform with the respective KDHE human-health-protective, risk-based standards indicates that soils at the former CCC/USDA facility do not pose an unacceptable risk to human health.

4.2 Vertical and Lateral Extent of the Carbon Tetrachloride and Chloroform Contamination in the Groundwater Associated with the Former CCC/USDA Facility

The interpretation of the distribution of carbon tetrachloride in groundwater at Centralia is based on the combined results of groundwater sampling during the Phase I and Phase II investigations. This interpretation is displayed on hydrogeologic cross sections constructed at the locations shown in Figure 4.2.

The extensive vertical profiling conducted during Phase I demonstrated that the vertical extent of the carbon tetrachloride contamination is generally limited to the upper 5-10 ft of the shallow aquifer, as shown in cross section G-G´ (Figure 4.3) and cross section H-H´ (Figure 4.4).

Laterally, the extent of groundwater in the shallow aquifer affected by carbon tetrachloride contamination is limited to the immediate vicinity of the former CCC/USDA facility. Carbon tetrachloride was not detected above the AGEM Laboratory method quantitation limit of 1 μg/L in samples from any of the six Phase II locations downgradient from the former CCC/USDA facility. The lateral distribution of carbon tetrachloride in groundwater across the former facility is highly heterogeneous, with three seemingly isolated areas of elevated concentrations. The lateral extent of the affected groundwater mimics the boundary of the former facility and does not exhibit the elongated geometry typically associated with groundwater contaminant plumes. The lateral extent of the carbon tetrachloride is shown in Figure 4.5. Delineation of the extent of the contamination was based on the analysis of groundwater samples collected across the investigation area, together with geologic information collected to evaluate the continuity and extent of the sands identified within the glacial outwash deposits of the Pleistocene Upper Independence Formation.

The discontinuous distribution of carbon tetrachloride observed in the shallow aquifer is consistent with the high degree of heterogeneity within the shallow aquifer. This aquifer was identified in the lower portion of the Upper Independence Formation, which occurs laterally throughout the investigation area; however, the sediments in the lower portion of this unit vary from fine grained, highly plastic clays and silt materials to coarser grained sands and gravelly sands. The interpreted cross sections indicate that lateral transitions between these predominantly coarse grained versus fine grained intervals can occur over distances of 100-200 ft or less (see Figures 4.3 and 4.4). Permeability within the shallow aquifer is expected to vary in association with the grain size of the deposited material. Typical values associated with such sediments

suggest that hydraulic conductivities are likely to vary from a lower range of 10^{-9} to 10^{-4} cm/sec (centimeters per second) for silt, sandy silt, clayey silt, clay, and till to an upper range of 10^{-3} to 10^{-1} cm/sec for well-sorted sands and glacial outwash (Freeze and Cherry 1979; Fetter 1988).

As discussed in detail in Section 4.3.1 of the Phase I report, the magnitude of the gradient also influences the actual flow of groundwater. A relatively flat gradient, like that observed across the eastern and northern portions of the area of investigation, indicates a low potential for flow, even though the material is considered permeable. The Phase I report goes on to state that "if groundwater flow rates are in fact low, there may be little driving force for contaminant transport away from the former facility."

A further indication that groundwater flow in the shallow aquifer may be limited came from the analysis of tritium isotope data. Most of the samples analyzed had tritium values near zero (< 1.0-2.45 TU). Such values are characteristic of relatively "old" groundwater. The tritium data are consistent with the interpretation that little recent (post-1951) water is entering the shallow aquifer beneath the former CCC/USDA facility by vertical infiltration (recharge) of precipitation or by flow within the aquifer from upgradient.

Additional evidence that contaminant migration at the former CCC/USDA facility is limited can be found in the high chloroform concentrations detected at locations SB01, SB05, SB08, SB24, and SB24A. The concentrations of chloroform, a primary degradation product of carbon tetrachloride, detected in the groundwater strongly suggest that reductive dechlorination or natural biodegradation of carbon tetrachloride is taking place *in situ* at the former CCC/USDA facility. This anaerobic process is most likely to occur in groundwater systems with limited recharge of oxygenated waters. Chloroform concentrations exceeded 10 μg/L at both SB01 and SB05, while chloroform concentrations actually exceeded carbon tetrachloride concentrations at both SB24 and SB24A (6.9 μg/L chloroform versus 2.3 μg/L carbon tetrachloride at SB24 and 7.1 μg/L chloroform versus 1.7 μg/L carbon tetrachloride at SB24A).

No receptor close to the plume was identified in either the Phase I or Phase II investigation, and no existing drinking water wells are impacted or immediately threatened. Therefore, under current conditions, no risk to human health is associated with the groundwater contamination identified at the former CCC/USDA facility.

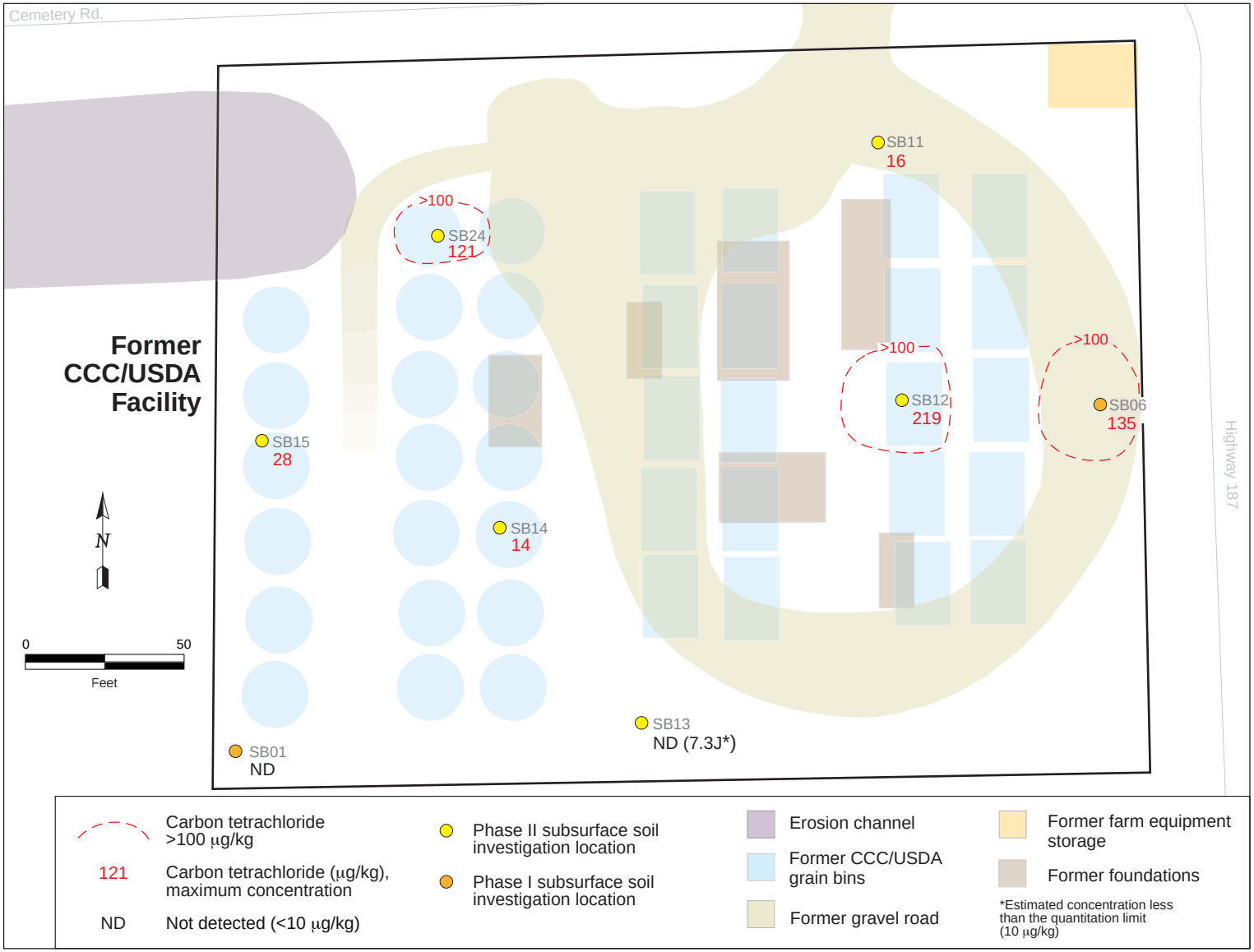

FIGURE 4.1 Areas of carbon tetrachloride concentrations in subsurface soil greater than 100 µg/kg, based on combined Phase I and Phase II results.

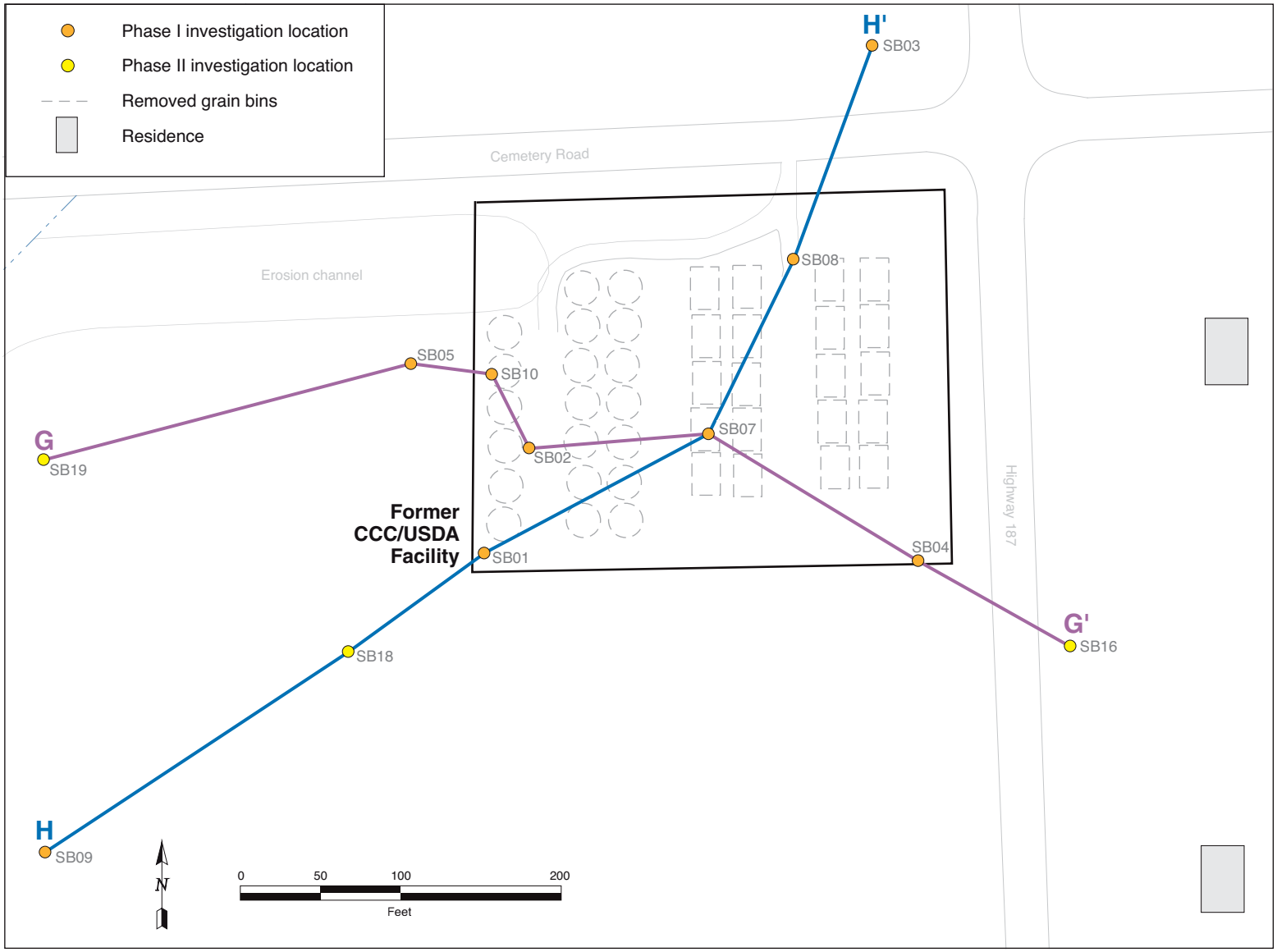

FIGURE 4.2 Locations of interpretive hydrogeologic cross sections G-G´ and H-H´ in the investigation area at Centralia.

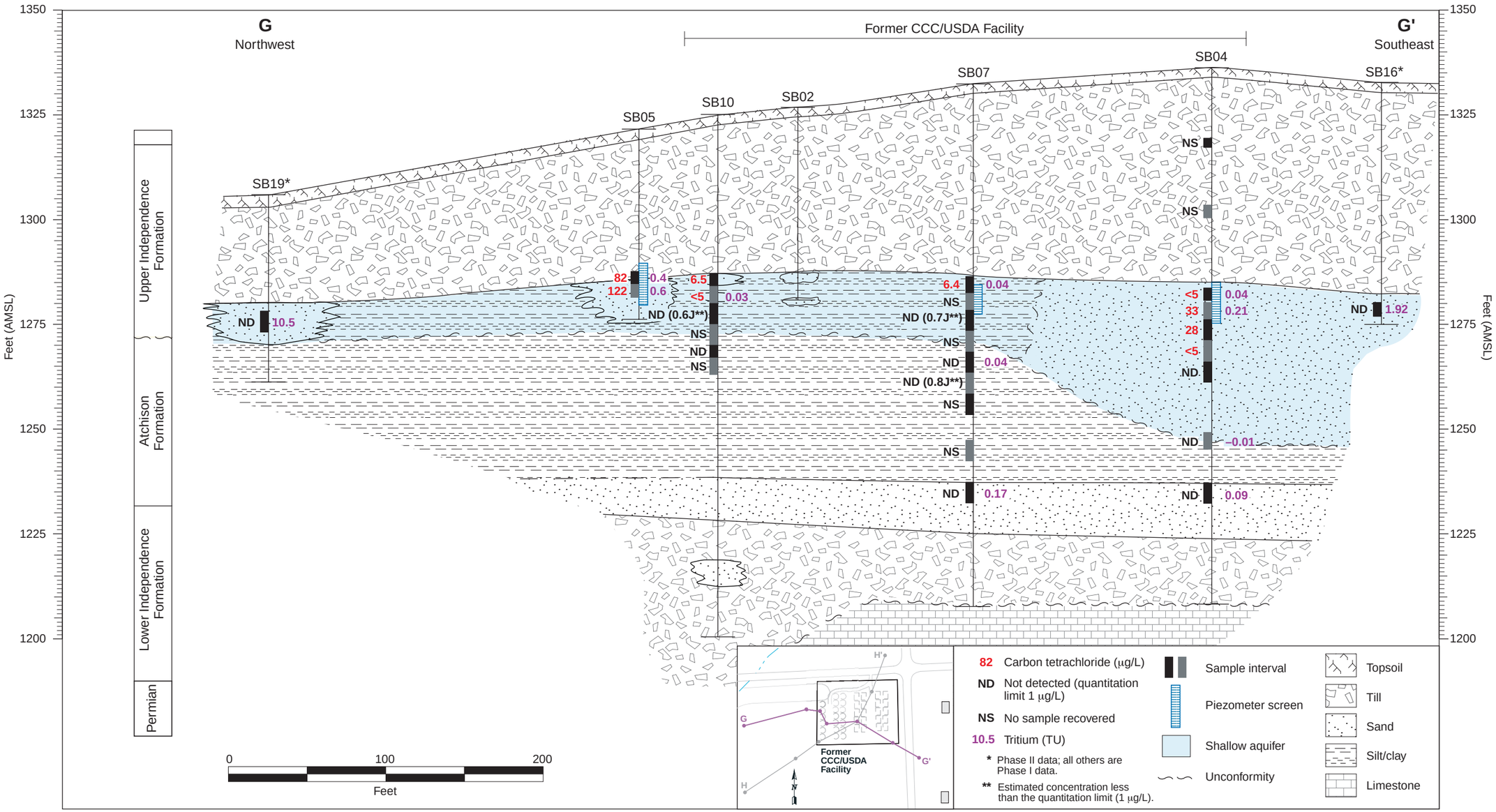

FIGURE 4.3 Interpretive cross section G-G´ (vertically exaggerated), showing the distributions of carbon tetrachloride and tritium in groundwater, based on combined Phase I and Phase II results.

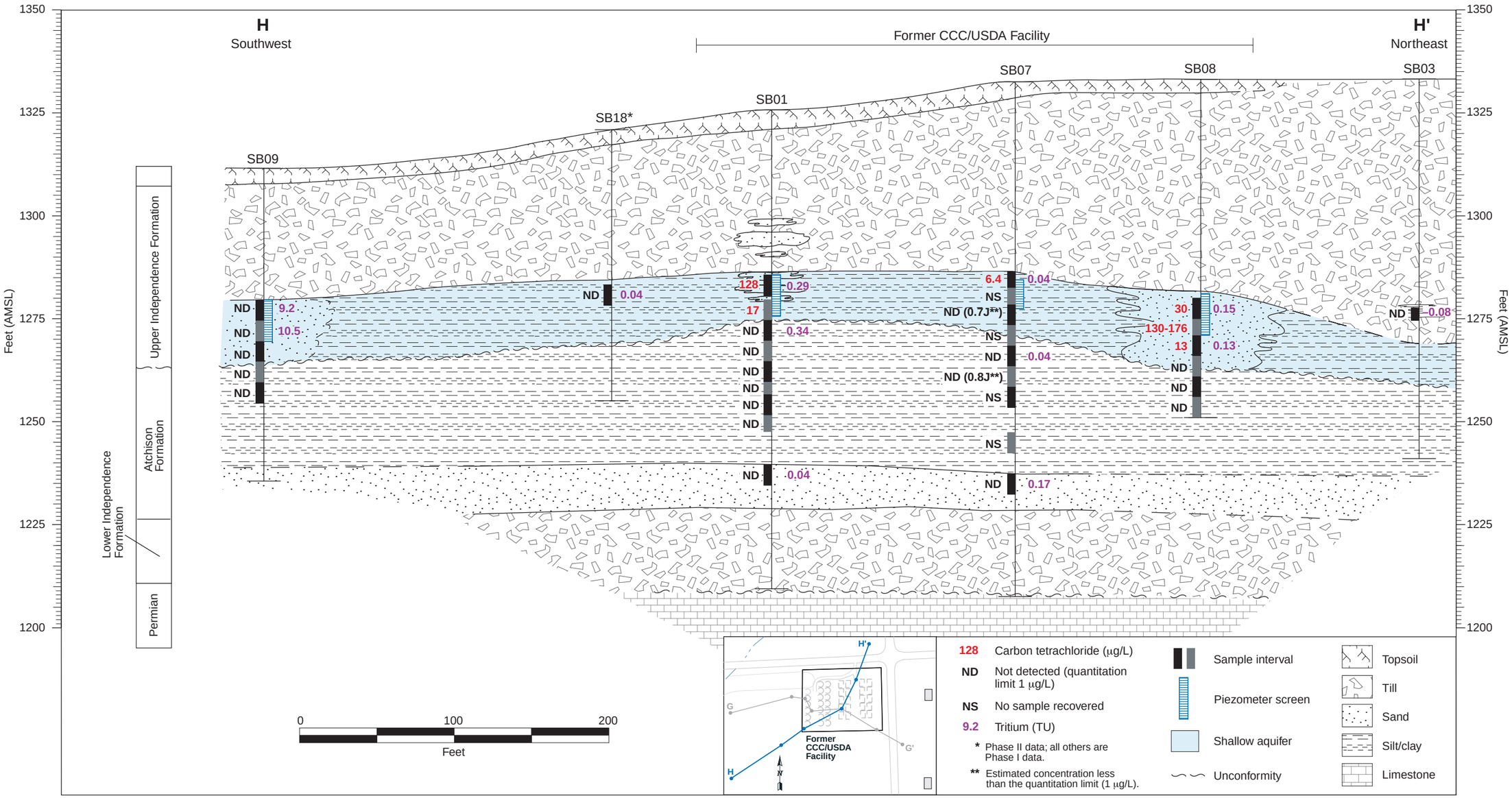

FIGURE 4.4 Interpretive cross section H-H´ (vertically exaggerated), showing the distributions of carbon tetrachloride and tritium in groundwater, based on combined Phase I and Phase II results.

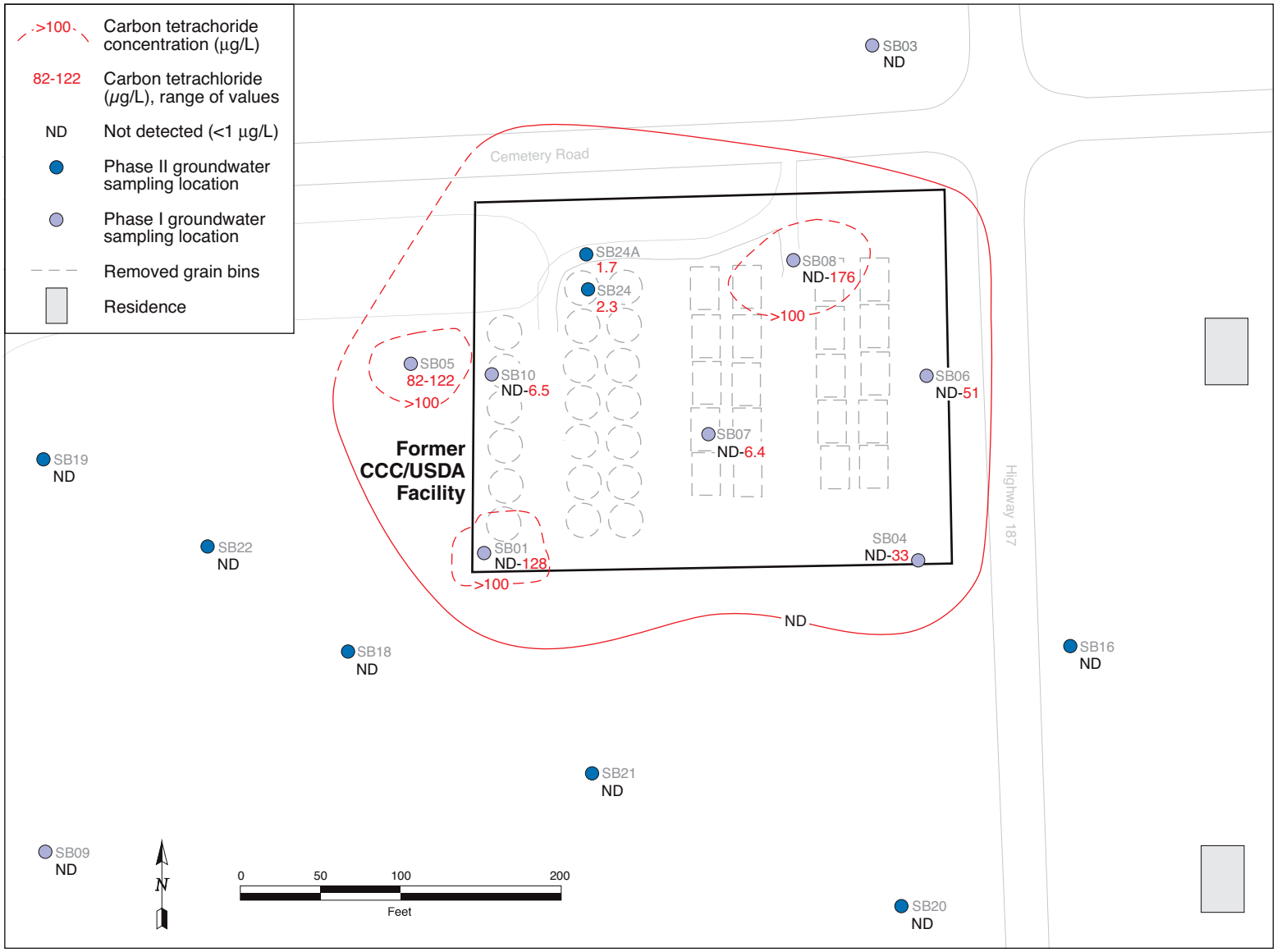

FIGURE 4.5 Lateral extent of carbon tetrachloride contamination in groundwater at Centralia, based on interpretation of Phase I and Phase II results.

5 Conclusions and Recommendations

5.1 Conclusions

The conclusions for the technical objectives of the Phase II investigation at Centralia are as follows:

1. *Delineate the carbon tetrachloride contamination in the subsurface soils at the former CCC/USDA facility.* Vadose zone soils down to a depth of 10 ft BGL are not contaminated (as determined by purge-and-trap GC-MS analysis with a quantitation limit of 10 µg/kg), except for an area along the eastern boundary at SB06, where carbon tetrachloride was detected in Phase I work at 13 µg/kg at 9 ft BGL. In the deeper subsurface, the highest carbon tetrachloride concentrations, occurring at a depth of approximately 25-35 ft BGL, range from not detected (< 10 µg/kg) at SB01 and SB13 to 219 µg/kg at SB12. The general absence of carbon tetrachloride contamination above a detection of 10 µg/kg in vadose zone soils to a depth of 10 ft BGL is consistent with the qualitative results of the headspace analysis of shallow near-surface soil samples (1-6 ft BGL) obtained during Phase I. These qualitative results ranged from less than 0.1 µg/kg to 2.93 µg/kg.

   The concentrations of carbon tetrachloride detected in soils at the former CCC/USDA facility are all below the Kansas risk-based standard for direct contact with soil in both the residential scenario (2.5 mg/kg) and the non-residential scenario (7.0 mg/kg) (KDHE 1999). The concentration of carbon tetrachloride detected at SB12 (maximum 219 µg/kg at 30 ft BGL) is on the order of the Kansas risk-based standard of 200 µg/kg in soil for the "Soil-to-Ground Water Protection Pathway." This elevated concentration appears to be limited to a small area in the east-central portion of the former facility.

2. *Evaluate the vertical and lateral extent of the carbon tetrachloride and chloroform contamination in the groundwater associated with the former CCC/USDA facility.* Contaminated groundwater is generally limited to the former CCC/USDA facility. One area of contaminated groundwater was identified to the immediate west of the former facility. No contamination was

detected at sampling locations downgradient from this location. The lateral extent of the contaminated groundwater has been delineated by the locations of groundwater samples with carbon tetrachloride values below the AGEM Laboratory method quantitation limit of 1.0 μg/L (i.e., not detected), the determination that no water-bearing zone is present, or both.

The vertical extent of the contaminated groundwater is inherently limited to the vertical extent of the upper portion of the shallow aquifer identified within the glacial outwash deposits of the Pleistocene Upper Independence Formation.

5.2 Recommendations

The findings and conclusions of the combined Phase I and Phase II investigations indicate the following:

- Residual carbon tetrachloride concentrations detected in the vadose zone soils at the former CCC/USDA facility near Centralia do not pose a human health risk. In the subsurface, the highest carbon tetrachloride concentrations (up to 219 μg/kg) occur at a depth of approximately 25-35 ft BGL.

- The extent of the carbon tetrachloride contamination in groundwater has been delineated and found to be limited to the general boundary of the former CCC/USDA facility.

- Little, if any, migration of contaminated groundwater from the former facility is evident. Wells in the vicinity of the former CCC/USDA facility are not likely to be threatened by the contaminant.

- The presence of chloroform at the concentrations observed suggests that natural *in situ* biodegradation of carbon tetrachloride is taking place in the groundwater at the former CCC/USDA facility.

- To mitigate any potential future risks to human health that might result from exposure to the contaminated groundwater, installation of drinking water

wells within the delineated area of the plume should be prohibited. In addition, a monitoring well network should be established to monitor any changes in plume dynamics and to collect data necessary to evaluate the suitability of monitored natural attenuation as a remedial option.

- In the event that the affected property is developed, the potential for any impacts associated with vapor intrusion may need to be assessed.

On the basis of these observations, the following preliminary remedial action objectives and potential corrective action alternatives are suggested for consideration at Centralia.

5.2.1 Preliminary Remedial Action Objectives

- Be protective of human health and the environment for current documented land use.

- Be protective of human health and the environment for potential future residential land use.

- Meet applicable state standards and guidelines or the results of a quantitative human health risk assessment approved by KDHE.

5.2.2 Potential Corrective Action Alternatives

- *No Action (always considered)*

- *Groundwater Monitoring with Environmental Use Controls*
  Under this alternative, no remediation occurs but the following actions would take place to be protective of human health and the environment for current documented land use and for potential future residential land use:

  - Groundwater monitoring wells would be installed.

- Wells would be monitored for carbon tetrachloride and chloroform to ensure that the plume is not migrating.

- Environmental use controls would be established to prohibit the drilling of domestic-use water wells on the site.

- *Monitored Natural Attenuation (MNA) with Environmental Use Controls*
  Under this alternative, natural degradation and reduction of contaminant concentrations would need to be demonstrated. The following actions would take place to be protective of human health and the environment for current documented land use and for potential future residential land use:

  - Groundwater monitoring wells would be installed.

  - Wells would be monitored for all geochemical indicators necessary to demonstrate the occurrence of natural degradation. Monitoring would need to be conducted over a minimum of one year to begin to evaluate MNA as a viable alternative.

  - Environmental use controls would be established to prohibit the drilling of domestic-use water wells on the site. Environmental use controls would remain in effect until the groundwater met acceptable goals.

- *Enhanced Natural Biodegradation with Environmental Use Controls*
  This alternative is essentially the same as above except that once natural degradation has been demonstrated, the natural degradation process would be augmented with the addition of nutrients.

- *In-Well Stripping/Vapor Extraction*
  This alternative would attempt to remediate groundwater and associated vadose zone soils that might be impacted. Given what is known about the site, it is hard to assess the effectiveness of this approach without conducting a pilot test.

- Groundwater monitoring wells would be installed near the perimeter of the plume.

- Wells would be monitored for carbon tetrachloride and chloroform to ensure that the plume is not migrating.

- Remediation wells would be installed in the areas of highest concentrations.

- Environmental use controls might be required until groundwater is remediated.

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Appendix A:

Geologic and Cone Penetrometer Logs

Argonne National Laboratory

Boring ID: SB11

Project: Centralia Phase II **Elevation:** 1333.22 ft. **Log Date:** 04/05/2003 **Company:** Argonne

Geologist: LaFreniere **Total Depth:** 52 ft. **Plot Date:** 08/22/03 **Rig:** CPT Crawler

Core Description: -4' to -52' **Driller:** Craig

Depth ft BGL	% Rec	S.S. / W.S.	CCl_4	LITHOLOGY DESCRIPTION	Elev ft AMSL
				NO SAMPLE: 0 to 4 feet	1330
				CLAY, SILTY WITH SAND: <5% sand, dark brown (10 YR), medium plasticity, damp to moist, organic rich, non-calcareous. Sand (fine) and minor granular gravel sampled at 5 feet BGL.	
-5		ND		CLAY, SILTY WITH SAND: Very silty clay with sand (7-10%), damp to moist, slight oxidation of pale brown (10 YR) matrix clays. MN inclusions (small) throughout, moderate plasticity, non- to very slightly calcareous.	
				CLAY,SILT,SAND & GRAVEL: As described above with pebble size (15mm) gravel and areas of weathered, white powdery carbonate precipitate. Damp to moist, moderate plasticity. Seams of thin layers of oxidation (black) MN. Granular gravel, mixed lithology throughout, calcareous light brownish gray (10 YR).	
				CLAY,SILT,SAND & GRAVEL: Silty clay with fine (10%) and medium grained sand scattered throughout. Very calcareous matrix clays. Small granular gravel throughout.	1325
-10		ND			
					1320
				CLAY, SILTY WITH SAND: Highly oxidized, possibly weathered, silty clay with sand, crumbly in appearance. Black MN throughout. Fine to coarse sand in matrix and in areas of concentrated oxidation. Very highly calcareous throughout, some trace evidence of	

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

SB11 Pg. 2

Depth	W.S. % S.S.	CCl_4	LITHOLOGY	Elev
-15		11	carbonate precipitation. Damp.	
			CLAY, SILTY: Highly oxidized, generally fine sand in matrix clays and medium to coarse sand in areas of increased oxidation, variably crumbly in appearance. Damp to moist. Selective oxidation, mottled appearance in some parts of section. Oxidation, moisture content and grain size of sand increase with depth. Medium plasticity, oxidized to yellowish-brown (10 YR), trace of limonite present, calcareous.	
				1315
		14		
-20				
				1310
-25		ND		
			CLAY,SILT,SAND & GRAVEL: Very silty clay with fine to medium grained, sub-angular sand. Damp. Moderate plasticity with scattered granular to pebble sized gravel throughout. Pale brown (10 YR), calcareous, trace larger pebbles (quartzite).	

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

SB11 Pg. 3

Depth	W.S. % S.S. CCl_4	LITHOLOGY	Elev
			1305
-30	16		
		CLAY,SILT,SAND & GRAVEL: Abrupt change in color to dark yelllowish-brown (10 YR). Silty clay with fine sand and granular to pebble sized gravel scattered throughout. Calcareous. Damp. Moderate plasticity, oxidized throughout, some calcareous granular gravel throughout. Increase in sand content (fine to coarse silt) (20+%), from above. Trace limonite. . Coloration deepens down section.	1300
-35	10	CLAY,SILT,SAND & GRAVEL: Gradational contact with above section. Silty clay with fine to medium grained sand. Minor sand clasts (very fine grained with oxidation rims), small granular gravel throughout. Sand in matrix (20%), calcareous.	
		CLAY, SILTY WITH SAND: Mottled, silty clay with sand. Sand in matrix clays fine to medium grained. Pale brown (10 YR) mottled clay oxidized yellowish-brown (10 YR), all highly calcareous. Damp. Moderate plasticity.	
		CLAY,SILT,SAND & GRAVEL: Abrupt contact with oxidation layer at 37.15'. Pale brown (10 YR) very silty clay with sand and gravel, sand 5-10% in matrix. Gravel granular to pebble size scattered throughout. Damp. Moderate plasticity.	1295
	ND		
-40	ND	CLAY, SILT AND GRAVEL: Highly oxidized, silty clay to clayey sand in part crumbly, porous, fine to very coarse sand, MN rich, (black) to dark yellowish-brown (10 YR) to strong brown (5 YR). MN coated coarse quartz grains, very highly calcareous, moderate to non-plastic granular gravel increasing with depth.	

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

SB11 Pg. 4

Depth	W.S. % S.S.	CCl_4	LITHOLOGY	Elev
			CLAY, SILTY WITH SAND: Gradational contact with above unit. Silty clay with sand. Color variation from pale brown (10 YR) to dark yellowish-brown dependent upon degree of oxidation. Highly calcareous with abundant evidence of precipitated calcium carbonate throughout. Granular gravel to pebble sized (15 mm), crumbly in area of calcium carbonate precipitation. Generally damp with moderate plasticity in associated clays.	1290
-45		6.2 J	CLAY, SILTY WITH SAND: As above but more heavily oxidized comparable zone to depth (40' - 41') with abundant, large area of precipitated calcium carbonate. Damp. Highly calcareous.	
			CLAY, SILTY WITH SAND: As above with decrease in sand.	
			CLAY, SILTY: Abrupt contact. Moist to wet with increased percent of clay, dark brown (10 YR). Silty clay, highly calcareous, medium to high plasticity.	1285
-50		6.8 J	CLAY,SILT,SAND & GRAVEL: Sand (15%), pebble size gravel scattered throughout. Abundant precipitated calcium carbonate. Matrix clays highly calcareous. Matrix pale brown (10 YR) oxidized to yellowish-brown (10 YR).	
			SAND, SILT, AND GRAVEL: Oxidized silty sand, fine grained, loose, with granular gravel. Yellowish-brown (10 YR). Wet. Calcareous.	

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

Argonne National Laboratory

Boring ID: SB12

Project: Centralia Phase II **Elevation:** 1335.05 ft. **Log Date:** 04/04/2003 **Company:** Argonne

Geologist: LaFreniere **Total Depth:** 52 ft. **Plot Date:** 08/25/03 **Rig:** CPT Crawler

Core Description: -4' to -52' **Driller:** Craig

Depth ft BGL	% Rec	S.S. / W.S.	CCl_4	LITHOLOGY DESCRIPTION	Elev ft AMSL
				NO SAMPLE: 0 to -4'	
-5			ND	CLAY, SILTY WITH SAND: Non-calcareous, dark brown (10 YR), medium plasticity. Sand fine to medium grained, sub-angular. Sample at 5' organic rich.	1330
-10			ND	CLAY, SILTY WITH SAND: Abrupt contact with above interval. Yellowish-brown (10 YR), calcareous, silty clay with sand. Carbonate nodules, occasionally white, weathered. Medium plasticity. Trace fine sand clasts, minor evidence of selective oxidation. Dark MN. Sample at 10 feet. Sand ~10%.	1325
				CLAY, SILTY WITH SAND: As described above with increasing silt content. Yellowish-brown (10 YR). Sand generally coarser grained than above, fine to coarse and more abundant (10-15%). Calcareous. Pale brown (10 YR). Damp.	
				CLAY, SILTY WITH SAND: Damp to moist silty clay/sand, very silty. Marked evidence of carbonate (white) precipitation in fractures and clasts. Pale brown (10 YR) calcareous matrix, very calcareous clasts.	
				CLAY, SILTY WITH SAND: As above with marked reduction in carbonate precipitation, medium plasticity.	
-15			15	CLAY,SILT,SAND & GRAVEL: Medium plasticity, silty clay with sand (~5-7%) with small granular gravel to 10mm in length. Matrix slightly mottled in appearance due to varying degrees of oxidation. Pale brown matrix clays (10 YR). Damp to slightly moist.	1320
				CLAY, SILTY WITH SAND: Heavily oxidized - silty clay/sand. Black MN abundant. 5-10% sand. Trace tiny granular gravel. Damp, calcareous, mottled in appearance due to varying degrees of oxidation. Matrix clays, pale brown (10 YR), oxidized areas dark	

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

SB12 Pg. 2

Depth	W.S. % S.S.	CCl_4	LITHOLOGY	Elev
			yellowish-brown (10 YR).	
-20		45	CLAY, SILTY WITH SAND: Zone of clay as described above with large calcareous rubble. Highly calcareous, heavily weathered, white powdery in part with indurated carbonate material.	1315
			CLAY, SILTY WITH SAND: as in description for 17.7' to 19.45'.	
			CLAY, SILTY WITH SAND: Zone of heavily oxidized silty clay/sand. Dark yellowish-brown (10 YR). Abundant evidence of vertical carbonate precipitation throughout the zone. White (10 YR), heavily weathered and highly calcareous, damp.	
			SILTY CLAY: Abrupt contact with above. Damp to moist. Heavily oxidized pale brown (10 YR) matrix clays. Very silty clay with some fine to medium grained sand. Heaviest oxidation associated with areas of increased sand content - mottled appearance due to selective oxidation, calcareous. Single layer of calcareous pebbles to 3 - 4 mm in length. White, sub-angular.	
			CLAY, SILTY: As described above with abundant LS pebbles, angular to sub-angular. Increased sand conent. Fine to coarse - predominantly medium grained. Calcareous matrix clays.	
-25		93	SAND, SILTY: Heavily oxidized, pale brown (10 YR), matrix clays, very silty with marked increase in sand content (10-15%). Selective black MN, but predominantly oxidized. White calcareous precipitates.	1310
			SILT, SAND, CLAY & GRAVEL: sand (5-7%) fine grained with granular gravel (occasionally). Damp. Decreased evidence of oxidation from above. Calcareous matrix. Marked decrease in precipitated carbonate material. Pale brown (10 YR). Damp.	
			CLAY,SILT,SAND & GRAVEL: Pale brown (10 YR) silty clay with scattered granular and pebble sized gravel (sub-rounded). Calcareous clay matrix. Predominantly fine grained sand, minor medium grained, sub-angular. Moderately plastic.	
-30		219		1305
			SILT/CLAY/SAND/GRAVEL: Heavily oxidized silty clay with sand (minor). Scattered white calcareous, small granular gravel throughout. Dark yellowish-brown (10 YR). Damp.	
			SILT/CLAY/SAND/GRAVEL: Silty clay/sand and minor granular gravel scattered throughout. Trace of inclusions of fine sand (sub-rounded). Single pebble to 2.5 mm in length. Matrix clays calcareous, light brownish gray (10YR). Moderate plasticity. Damp.	
-35		207		1300

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

SB12 Pg. 3

Depth	W.S. % S.S.	CCl_4	LITHOLOGY	Elev
			CLAY, SILTY WITH SAND: As described above with less sand (<5%) and increased silt and evidence of selective oxidation increasing with depth. Black MN appears to be related to vertical fracture fill.	
-40		202	CLAY,SILT,SAND & GRAVEL: Pale brown (10 YR) very silty clay with fine sand and gravel. Moderate plasticity. Gravel, granular to pebble size of mixed lithology, weathered and sub-rounded. Calcareous matrix. Dry.	1295
			CLAY,SILT,SAND & GRAVEL: As above with 10% sand and mottled appearance due to selective oxidation. Damp. Moderate plasticity, granular to pebble sized grave, single to 20 mm.	
-45		90	CLAY,SILT,SAND & GRAVEL: Marked decrease in oxidation from above. Pale brown (10 YR). Calcareous, very silty clay/minor coarse sand. Granular, mixed lithology gravel throughout. Calcareous clay matrix. Damp. Moderately plastic.	1290
-50		61	CLAY,SILT,SAND & GRAVEL: Highly oxidized, pale brown matrix clays (10 YR). Silty clay with fine to very coarse sand, some friable. Abundant granular gravel in highly oxidized areas. Black MN present throughout, calcareous.	1285
			CLAY,SILT,SAND & GRAVEL: Partially oxidized, silty clay with fine sand and granular to pebble sized gravel scattered throughout. Significant reduction in oxidation. Unit pale brown (10 YR). Damp. Moderate plasticity, calcareous matrix clays. Trace fine sand inclusions.	

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

Argonne National Laboratory

Boring ID: SB13

Project: Centralia Phase II **Elevation:** 1331.45 ft. **Log Date:** 04/03/2003 **Company:** Argonne

Geologist: LaFreniere/Koelsch **Total Depth:** 47.8 ft. **Plot Date:** 08/25/03 **Rig:** CPT Crawler

Core Description: -4' to -47.8' **Driller:** Craig

Depth ft BGL	% Rec	S.S. / W.S.	CCl_4	LITHOLOGY DESCRIPTION	Elev ft AMSL
				NO SAMPLE: 0 to 4 feet	
				SAND, CLAYEY: with granular gravel with occasional concentrations of sand (medium grained). Matrix sand is fine to coarse grained. Dark brown (10 YR). Damp, dense, non-calcareous.	
-5			ND	SAND, CLAYEY: Abrupt change in color to dark yellowish-brown (10 YR). Sandy clay as above with small granular gravel throughout. Non-calcareous, damp.	
				SAND, CLAYEY AND GRAVELLY: Very sandy, very calcareous clay with granular gravel throughout. Matrix sand fine to coarse grained, damp. Dark-yellowish-brown (10 YR) with areas of highly weathered (white), powdery, dry, very highly calcareous material with scattered, loose quartz grains (fine). Sand in matrix rounded to sub-angular. Oxidized light yellowish-brown clays (matrix), very distinctive zone. Damp matrix, stiff clays, sand 30%.	1325
-10			ND	CLAY, SANDY: Abrupt contact- sandy clay - sand in matrix, fine to coarse grained. Predominantly clear quartz/some quartzite (pink) and chert. Occasional granular gravel to 3/4 cm in length. Sand sub-rounded to sub-angular, matrix calcareous, color pale brown (10 YR) with areas of selective oxidation throughout generally associated with zone of increased sand content. Trace carbonaceous material.	
				SAND, CLAYEY AND GRAVELLY: with occasional small granular gravel. Matrix clays pale brown (10 YR); trace of carbonaceous material, calcareous - oxidized, increasing with depth. Highly calcareous, highly weathered, white, sand scattered throughout.	1320
				SAND, CLAYEY: Fine to coarse, selectively oxidized in assoc with medium to coarse grained sand, sub-rounded to sub-angular sand (fine to coarse) matrix. Calcareous.	
				SAND, CLAYEY: Fine-medium grained sand, marked reduction in oxidation, matrix clays pale brown to light yellow-brown (10 YR). Significant reduction in granular gravel. Trace white, weathered, powdery calcareous cemented sand clasts (1 cm. in length). Damp; moisture increases with depth. Calcareous matrix clay.	
-15			ND	SAND, CLAYEY: Extremely sandy clay - oxidized. Sand fine to coarse grained (where oxidized) yellowish to pale brown (10 YR), calcareous.	1315

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

SB13 Pg. 2

Depth	W.S. % S.S. CCl_4	LITHOLOGY	Elev
-20	ND		1310
		SAND, CLAYEY AND GRAVELLY: Heavily oxidized very sandy clay, marked increase in sand content, 35%, dark yellowish-brown (10 YR). Sand fine to coarse grained, predominantly medium grained. Damp, calcareous with some degree of porosity. Minor angular granular gravel. Trace well-rounded, weathered, 2 cm-length gravel.	
		SAND, CLAYEY AND GRAVELLY: As above with increase in sand content and grain size. White carbonate, weathered cemented sand fracture fill. Highly calcareous.	
-25	7.3 J		1305
		SAND, CLAYEY AND GRAVELLY: Marked change in coloration due to loss of oxidation. Sandy clay, fine to medium, occasionally coarse. Pale brown (10 YR), calcareous. Damp. Moderate plasticity. Sand ranges from fine to very coarse grained, sub-angular to sub-rounded, trace very fine grained sand clasts; granular gravel throughout.	
-30	ND		1300

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

SB13 Pg. 3

Depth	W.S. % S.S. CCl_4	LITHOLOGY	Elev
-35	ND ND	CLAY, SANDY: Damp to moist. Sandy clay, very highly oxidized, fine to coarse grained with minor small granular gravel. Dry/friable, crumbly, dark yellowish-brown to black (MN) (10 YR). Highly calcareous. Some areas of increased oxidation assoc with increased grain size and large, very fine grain sand clasts.	1295
-40	ND		1290
		CLAY,SILT,SAND & GRAVEL: Pale brown (10 YR) silty clay/sand. Granular to pebble sized gravel throughout. Minor heavily oxidized areas with fine to coarse grained sand, sub-rounded to sub-angular. Moderately calcareous with the degree of oxidation increasing with depth. Minor evidence of calcium carbonate, precipitation.	
-45		NO SAMPLE	1285
		SAND: Fine grained with trace of very coarse grains of mixed lithology. Saturated. Minor pebbles to 20 mm in length. Highly calcareous, fairly poorly sorted.	

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

Argonne National Laboratory

Boring ID: SB14

Project: Centralia Phase II **Elevation:** 1329.57 ft. **Log Date:** 04/04/2003 **Company:** Argonne

Geologist: LaFreniere **Total Depth:** 44 ft. **Plot Date:** 08/26/2003 **Rig:** CPT Crawler

Core Description: -4' to -44' **Driller:** Craig

Depth ft BGL	% Rec	S.S. / W.S.	CCl_4	LITHOLOGY DESCRIPTION	Elev ft AMSL
				NO SAMPLE: 0 to 4 feet	
				SAND, SILT, AND CLAY: Oxidized, sandy, silty clay, yellowish-brown (10 YR), non-calcareous matrix with highly weathered, occasional white, highly calcareous inclusions. Damp. Fine to medium grained sand.	1325
-5			ND		
				CLAY, SILTY WITH SAND: Evidence of selective oxidation. Damp. Intermittent zones of highly weathered, white, powdery, very highly calcareous cemented lenses. These calcareous areas (lenses) increase with depth. Matrix clays pale brown (10 YR), oxidized areas, yellowish-brown to dark yellowish-brown (10 YR).	1320
-10			ND	CLAY,SILT,SAND & GRAVEL: Minor granular gravel. Selective oxidization increasing with depth. Matrix clays pale brown (10 YR), oxidized to yellowish-brown (10 YR). Sand generally fine to medium grained, calcareous.	
				CLAY, SILTY WITH SAND: Contact marked by white (10 YR), calcareous, highly weathered zone of carbonate precipitation. Contact with silty clay with sand as above section except section highly oxidized, and contains high percentage of silt, some evidence of white (10 YR) precipitated carbonate, some in nodular form, all weathered.	

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

SB14 Pg. 2

Depth	W.S. % S.S. CCl_4	LITHOLOGY	Elev
			1315
-15	ND	CLAY,SILT,SAND & GRAVEL: Oxidized silty clay with sand with occasional gravel, sub-rounded, 25mm in length. Calcareous. Oxidation increases with depth. Areas of carbonate precipitation (white, powdery). Damp. Matrix clays, pale brown (10 YR), oxidized to dark yellowish-brown (10 YR), moderate plasticity, large calcareous pebbles present.	
	ND	CLAY,SILT,SAND & GRAVEL: Abrupt contact with above. Pale brown (10 YR) interval with little to no oxidation. Silty clay with sand (15%), fine to medium grained, small, scattered granular gravel throughout calcareous matrix. Zone of slight mottling due to variations in oxidation.	1310
-20	ND		
		CLAY, SILTY WITH SAND: Increased evidence of oxidation, yellowish-brown (10 YR). Matrix remains pale brown (10 YR). Inclusions (large), calcareous, partially cemented sand. Predominantly fine grained and well sorted. Mottled matrix clays.	
		CLAY, SILTY WITH SAND: Pale brown (10 YR) silty clay with sand (10-15%). Damp. Moderate plasticity, very calcareous, trace pebble sized gravel, 30 mm diameter, sub-angular.	

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

SB14 Pg. 3

Depth	W.S. % S.S.	CCl_4	LITHOLOGY	Elev
				1305
-25		8.8 J	CLAY,SILT,SAND & GRAVEL: Highly oxidized, dark yellowish-brown, calcareous, silty clay with sand and small granular gravel.	
			CLAY,SILT,SAND & GRAVEL: Highly oxidized, dark, as above with white, weathered, calcium carbonate precipitation. Highly calcareous. Trace of sandy, clay clasts near base of this unit.	
			CLAY, SILTY WITH SAND: Heavily oxidized mottled silty clay, dark yellowish-brown (10 YR) to pale brown (10 YR), with fine to medium, sub-rounded to sub-angular sand. Calcareous, moderately plastic clay.	
			CLAY, SILT AND GRAVEL: Pale brown (10 YR) calcareous, silty clay with granular to pebble sized gravel of mixed lithology scattered throughout. Slightly to moderately calcareous, sub-angular gravel. Damp. Basal contact very thin light gray, very fine grained sand lense. Highly calcareous and moist.	1300
-30		14		
			SAND: Damp, oxidized, fine sand. Highly calcareous, loose, some clayey clasts, light yellowish-brown (10 YR).	
			CLAY, SILTY WITH SAND: Moderately oxidized, very silty sandy clay. Damp to moist with gray, very fine grained thin sand lenses increasing in occurrence with depth. Basal contact almost entirely sand with rip-up clasts.	
			CLAY,SILT,SAND & GRAVEL: Pale brown (10 YR) silty clay with sand and granular to pebble sized gravel in a very silty clay matrix. Highly calcareous, some fine sand in matrix. Vertical fracture planes lined with thin coating of black MN.	
			CLAY,SILT,SAND & GRAVEL: Pale brown (10 YR), silty clay with sand, damp, moderately plastic, trace fine sand clasts, minor oxidation, granular pebble size gravel throughout, calcareous.	1295
		11		
		ND		
-35				

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

SB14 Pg. 4

Depth	W.S. % S.S. CCl_4	LITHOLOGY	Elev
		CLAY,SILT,SAND & GRAVEL: Highly oxidized silty clay with sand. Sand fine to medium grained (sub-angular), calcareous, oxidized to dark yellowish-brown (10 YR). Some calcareous precipitation scattered throughout. Damp. Granular gravel throughout.	
		CLAY, SILTY WITH SAND: Abrupt lithology change from a less oxidized silty clay with sand to a zone abundant in calcium carbonate precipitation. Medium to coarse sand present, crumbly texture, highly calcareous. Damp. Matrix clays continue as pale brown (10 YR) where not oxidized to yellowish-brown (10 YR).	
	8.8 J	CLAY, SILTY WITH SAND: Pale brown (10 YR) with marked reduction in oxidation and only minor carbonate precipitation. Calcareous, damp. Moderately plastic, sand 10-15%, fine grained in matrix.	1290
		CLAY, SILTY WITH SAND: As in 38' to 39.2' zone.	
-40		CLAY,SILT,SAND & GRAVEL: Pale brown (10 YR) variably oxidized associated with increase in sand content and grain size. Granular to pebble sized gravel of mixed lithology, trace calcareous material. Fine grained sand clasts.	
	8.4 J		
		SAND, GRAVELLY: Medium to very coarse grained, highly calcareous sand and small sub-angular gravel, highly calcareous. Saturated/wet, oxidized. Different sand than at SB11 base.	

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

Argonne National Laboratory

Boring ID: SB15

Project: Centralia Phase II **Elevation:** 1325.65 ft. **Log Date:** 04/02/2003 **Company:** Argonne

Geologist: LaFreniere **Total Depth:** 32 ft. **Plot Date:** 08/26/2003 **Rig:** CPT Crawler

Core Description: -4' to -32' **Driller:** Toby Hinz

Depth ft BGL	% Rec	S.S. / W.S.	CCl_4	LITHOLOGY DESCRIPTION	Elev ft AMSL
				NO SAMPLE: 0 to 4 feet.	
-5			ND	SAND, CLAYEY AND GRAVELLY: Highly oxidized clay, sandy with scattered granular gravel throughout, moderately calcareous, yellowish-brown (10 YR). Zones of extremely heavy oxidation associated with areas of increased sand content in matrix. Oxidation increases with depth, size of gravel increased also with depth to 1/2 inch in length. Mixed lithology.	1320
-10			ND	SAND, CLAYEY AND GRAVELLY: As described above with marked increase in oxidation associated with areas of increased sand content, gravel (minor) to 3/4 inch in length. Sampled at 15 feet for VOC's. Large, cemented, rounded limestone gravel to 1.5 inch in length at base of this section. Very slightly damp.	1315
-15			11		
				SAND: Abrupt color change, damp. Marked reduction in oxidation. Moderate plasticity. Fine grained sand. Increase in sand contents almost sucrosic. Trace of granular gravel of mixed lithology. Moderately calcareous matrix. Occasional clasts of cemented, gray (10 YR) fine sand with oxidation rims.	1310

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

SB15 Pg. 2

Depth	W.S. % S.S.	CCl_4	LITHOLOGY	Elev
			CLAY, SANDY: Predominantly fine sand with trace granular gravel, highly calcareous. Less oxidation than above, continued reduction in oxidation with depth (sampled for grain size). Damp. Pale brown (10 YR). Trace very fine sand to silt clasts (very pale brown with minor oxidation), moderately calcareous.	
-20		28		1305
			CLAY, SANDY: As above with marked increase in oxidation increasing with depth. Highly calcareous.	
			CLAY, SANDY: Sample taken at base. Highly calcareous. Damp to moist (possibly wet). Sand fine to medium grained, minor coarse grained sand, light yellowish-brown (10 YR).	
-25		6.6 J ND	CLAY, SANDY	
			CLAY, SAND AND GRAVEL: Oxidized, sandy clay with minor small granular gravel. Damp to moist. Very highly calcareous zones of highly weathered, white sandy carbonate, highly calcareous, light yellowish-brown (10 YR).	1300
			CLAY, SAND AND GRAVEL: Gravel from minute to 1/2 inch in length, very highly calcareous. Damp. Light yellowish-brown (10 YR), predominantly fine to medium grained sand.	
			CLAY, SANDY: Abrupt change at 28.0 feet. Oxidized, wet sandy clay, yellowish-brown (10 YR), calcareous.	
			CLAY, SANDY: Clay, very sandy, moist to wet, oxidized with trace limonite. Areas of sand concentration (fine to medium grained), in a matrix of highly calcareous clay.	
-30			SAND, CLAYEY: Oxidized, wet, fine to very coarse grained, very poorly sorted yellowish-brown (10 YR).	
			CLAYEY SAND: Very silty, very poorly sorted, fine to coarse grained, very highly calcareous, trace granular gravel. Yellowish-brown (10 YR).	1295
			CLAY, SILTY WITH SAND: Very sandy clay to clayey sand with high percent of silt. Trace medium grained sand. Oxidized, wet, very highly calcareous. Yellowish-brown (10 YR).	

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

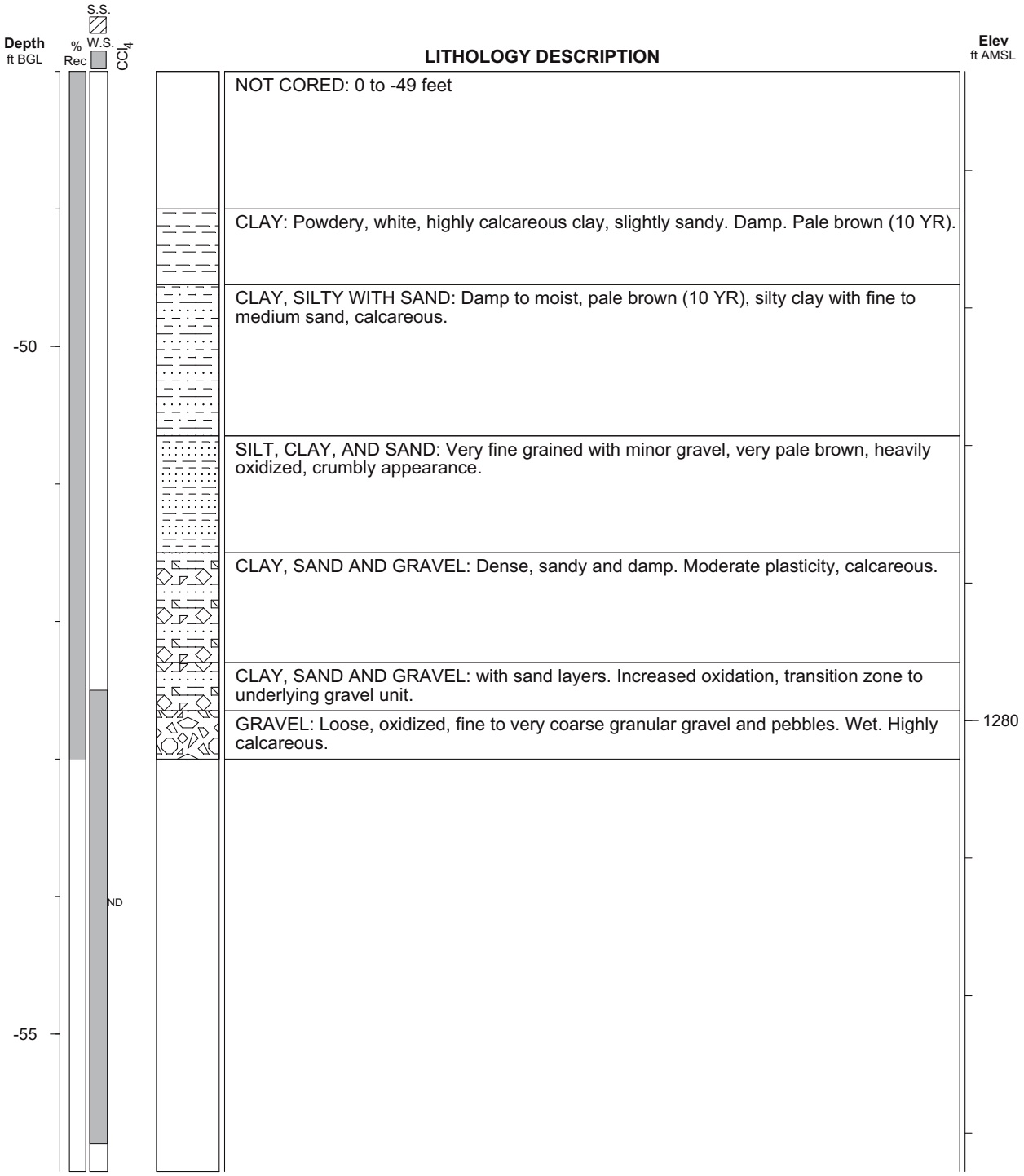
Argonne National Laboratory

Boring ID: SB16

Project: Centralia Phase II **Elevation:** 1332.72 ft. **Log Date:** 03/31/2003 **Company:** Argonne

Geologist: LaFreniere/Koelsch **Total Depth:** 57.74 ft. **Plot Date:** 08/25/03 **Rig:** CPT Crawler

Core Description: -49' to -53' **Driller:** Toby Hinz



NOT CORED: 0 to -49 feet

CLAY: Powdery, white, highly calcareous clay, slightly sandy. Damp. Pale brown (10 YR).

CLAY, SILTY WITH SAND: Damp to moist, pale brown (10 YR), silty clay with fine to medium sand, calcareous.

SILT, CLAY, AND SAND: Very fine grained with minor gravel, very pale brown, heavily oxidized, crumbly appearance.

CLAY, SAND AND GRAVEL: Dense, sandy and damp. Moderate plasticity, calcareous.

CLAY, SAND AND GRAVEL: with sand layers. Increased oxidation, transition zone to underlying gravel unit.

GRAVEL: Loose, oxidized, fine to very coarse granular gravel and pebbles. Wet. Highly calcareous.

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

ARGONNE NATIONAL LABORATORY

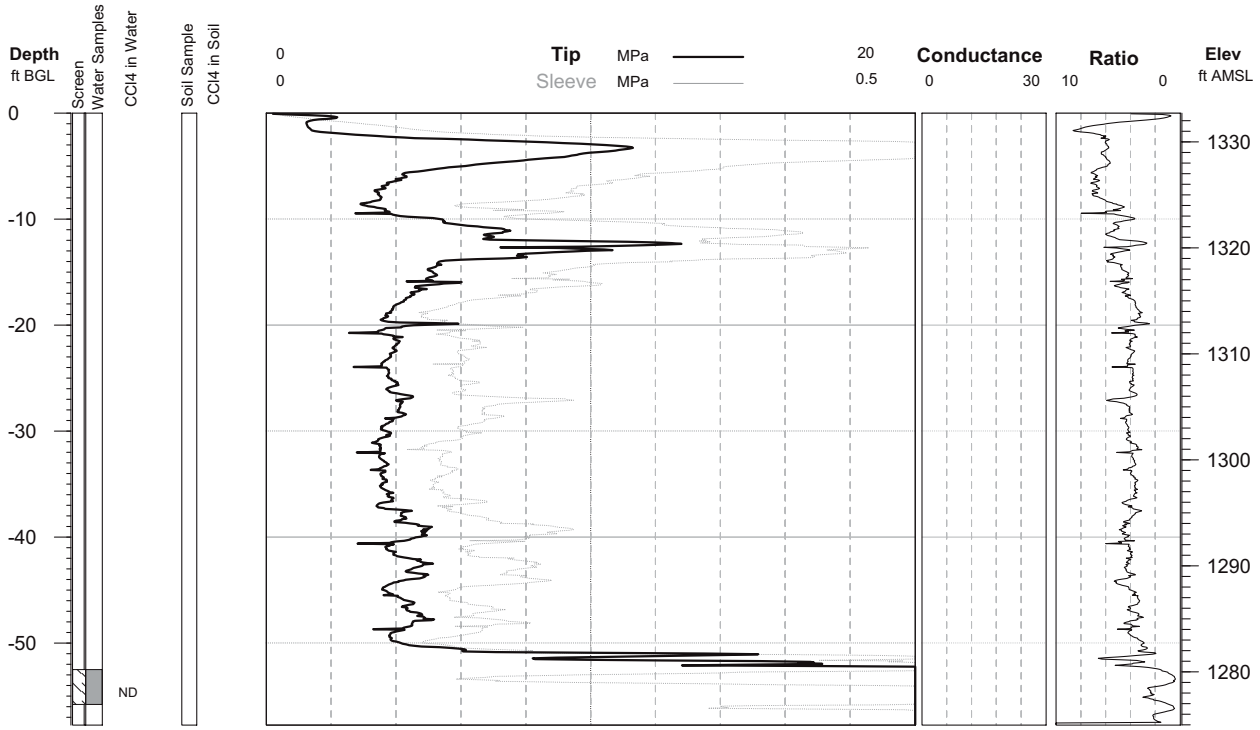
Boring ID: SB16

Project: Centralia Phase II
Geologist: LaFreniere/Koelsch

Elevation: 1332.72 ft.
Depth: 57.74 ft.

Log Date: 03/31/2003
Plot Date: 05/23/2003

Rig: CPT Crawler
Driller: Toby Hinz
Company: Argonne



ARGONNE NATIONAL LABORATORY

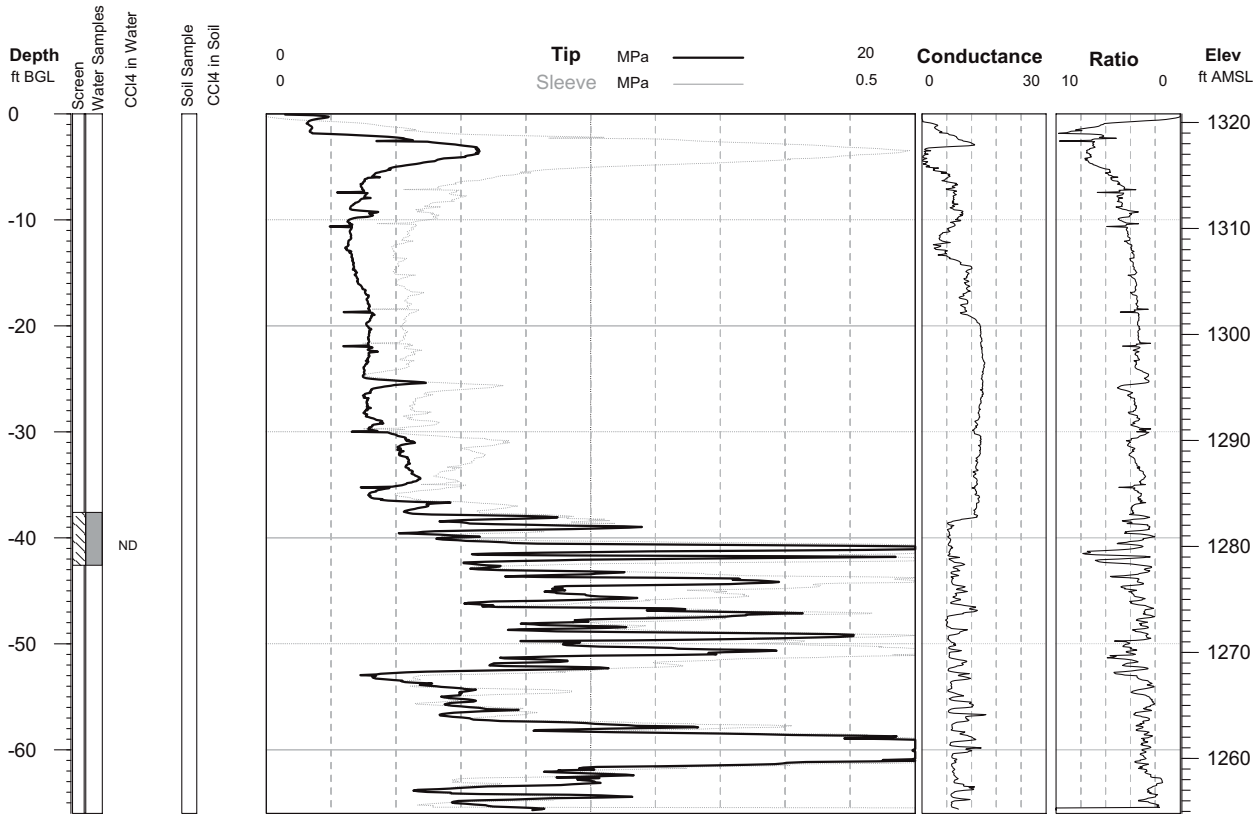
Boring ID: SB18

Project: Centralia Phase II
Geologist: Ted Koelsch

Elevation: 1320.81 ft.
Depth: 65.68 ft.

Log Date: 04/01/03
Plot Date: 05/23/03

Rig: CPT Crawler
Driller: Toby Hinz
Company: Argonne



ARGONNE NATIONAL LABORATORY

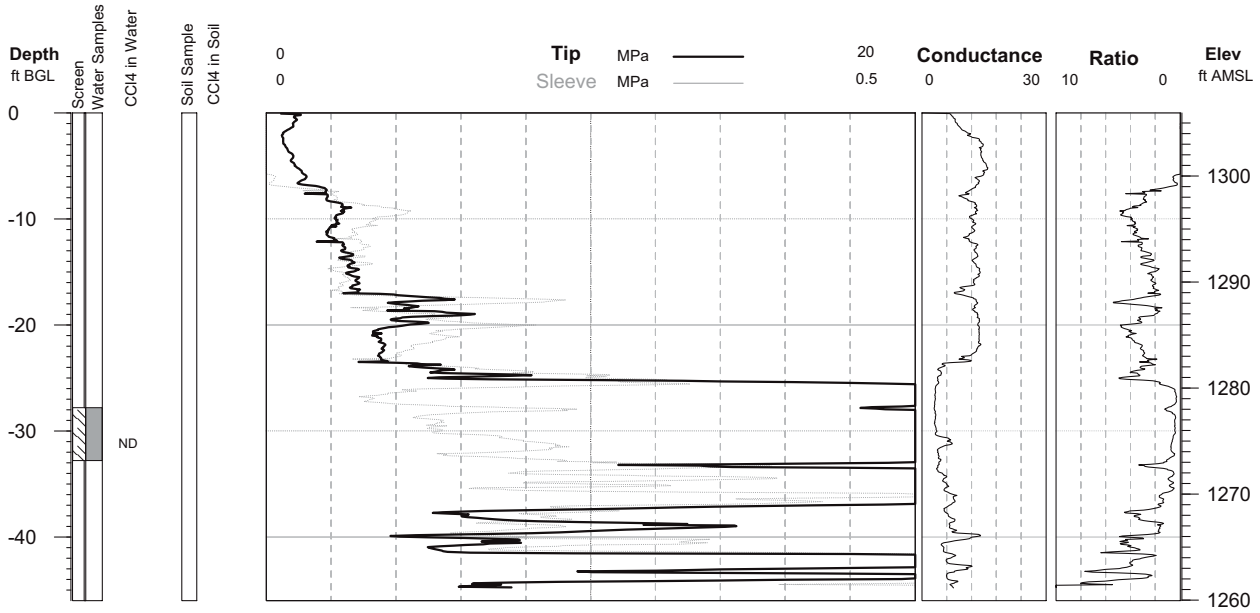
Boring ID: SB19

Project: Centralia Phase II
Geologist: Ted Koelsch

Elevation: 1305.95 ft.
Depth: 44.75 ft.

Log Date: 04/01/03
Plot Date: 05/23/03

Rig: CPT Crawler
Driller: Toby Hinz
Company: Argonne



ARGONNE NATIONAL LABORATORY

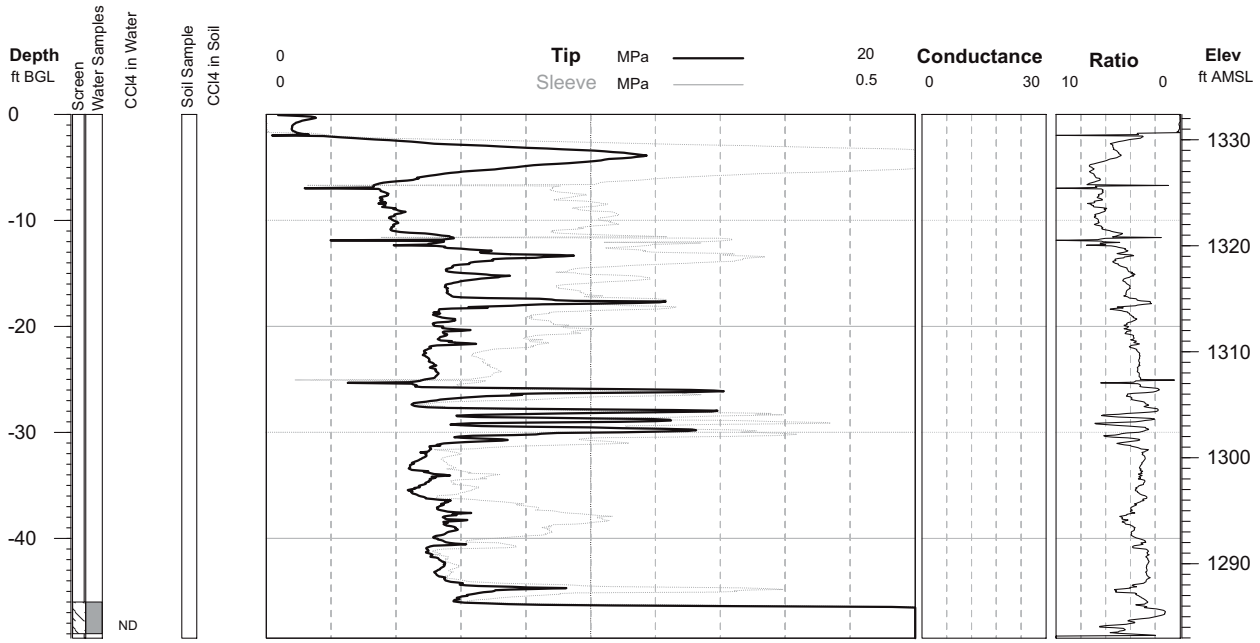
Boring ID: SB20

Project: Centralia Phase II
Geologist: Ted Koelsch

Elevation: 1332.38 ft.
Depth: 49.41 ft.

Log Date: 04/01/03
Plot Date: 05/23/03

Rig: CPT Crawler
Driller: Toby Hinz
Company: Argonne



ARGONNE NATIONAL LABORATORY

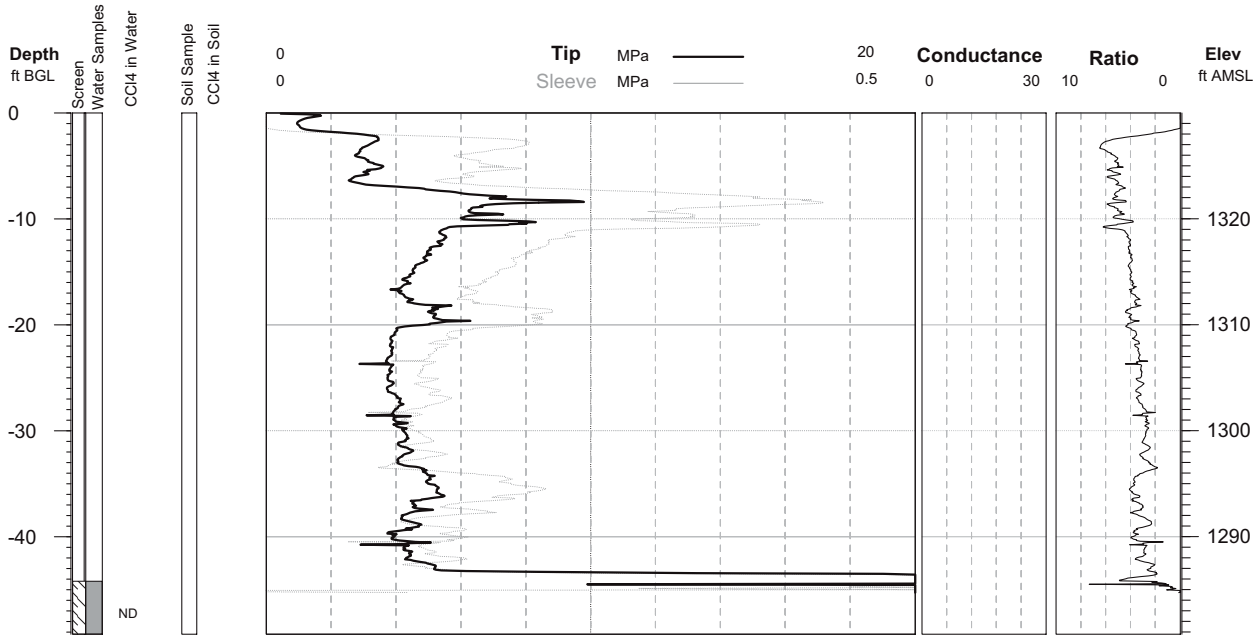
Boring ID: SB21

Project: **Centralia Phase II**
Geologist: LaFreniere/Koelsch

Elevation: 1329.99 ft.
Depth: 49.2 ft.

Log Date: 04/03/03
Plot Date: 05/23/03

Rig: CPT Crawler
Driller: Toby Hinz
Company: Argonne



ARGONNE NATIONAL LABORATORY

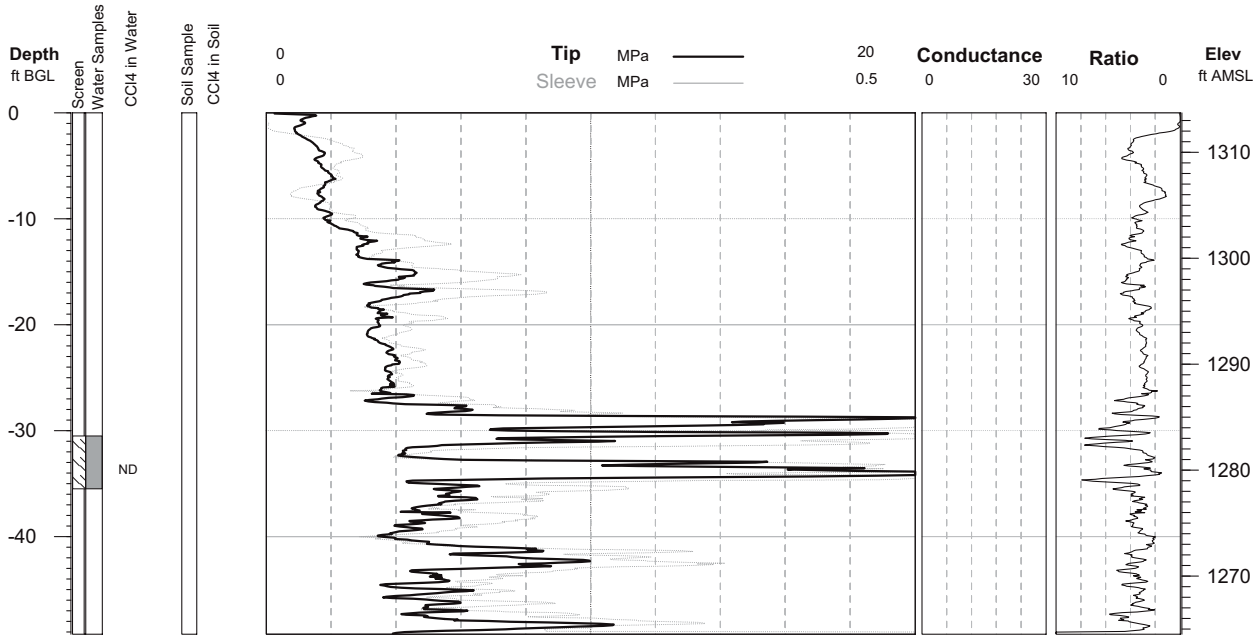
Boring ID: SB22

Project: **Centralia Phase II**
Geologist: LaFreniere/Koelsch

Elevation: 1313.72 ft.
Depth: 49.21 ft.

Log Date: 04/03/03
Plot Date: 04/03/03

Rig: CPT Crawler
Driller: Toby Hinz
Company: Argonne



Argonne National Laboratory

Boring ID: SB24

Project: Centralia Phase II **Elevation:** 1327.54 ft. **Log Date:** 03/31/2003 **Company:** Argonne

Geologist: LaFreniere **Total Depth:** 45.9 ft. **Plot Date:** 08/25/03 **Rig:** CPT Crawler

Core Description: -4' to -41.86' **Driller:** Hinz

Depth ft BGL	% Rec	S.S. / W.S.	CCl_4	LITHOLOGY DESCRIPTION	Elev ft AMSL
				NO SAMPLE: 0 to 4 feet	
				SAND, CLAYEY: with minor mixed lithology gravel. Sand fine to coarse grained, poorly sorted, oxidized, slightly calcareous. Damp, yellowish-brown (10 YR)	
				SILT, CLAYEY: White (10 YR), very clayey silt, highly weathered, highly calcareous zone. Damp.	
-5			ND	CLAY, SANDY: with minor granular gravel. Sand fine to very coarse grained, very poorly sorted, oxidized, highly calcareous and damp (yellowish-brown, 10 YR).	
				SAND, CLAYEY: Zone of white, weathered, highly calcareous sandy clay. Damp.	
				CLAY, SANDY: Very sandy, with minor granular gravel, very highly oxidized in patches. Damp.	
				CLAY, SAND AND GRAVEL: As above, very highly oxidized with limestone gravel to 2 cm in length. Very sandy with increased gravel content. Damp.	
				SAND, CLAYEY AND GRAVELLY: Less evidence of oxidation. Minor granular gravel of mixed lithology. Highly calcareous matrix clays. 2 cm length gravel at 9.35 feet.	1320
-10			ND		
				SILT, CLAY, AND SAND: Black (10 YR) reduced area, silty clay with sand. Root fragments, minor angular gravel. Calcareous.	
				SAND, CLAYEY: Minor oxidation, minor granular gravel of mixed lithology. Slightly calcareous matrix clays, damp.	1315
				SAND, CLAYEY AND GRAVELLY: As described above with increase in sand content and associated oxidation. Damp, highly calcareous matrix clays. Minor angular granular gravel. Some veining due to variations in oxidation (white) yellowish-brown (10 YR). Fine to coarse grained sand.	
				SAND, CLAYEY: Very sandy clay, abundant sand generally fine grained sand in matrix clays, sand fine to coarse grained with small granular gravel. Highly calcareous clay matrix. Minor evidence of oxidation. Damp. Grayish-brown (10 YR).	
-15			ND		

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

SB24 Pg. 2

Depth	W.S. % S.S. CCl_4	LITHOLOGY	Elev
			1310
-20	42		
		SAND, CLAYEY: As above with slight increase in oxidation at definite points associated with pyrite. General overall increase in oxidation with planar black seams of oxidation. Increase in sand content with depth. Damp. Grayish-brown (10 YR).	1305
		CLAY, SANDY: Damp grayish-brown clay with lenses of clear, quartz sand to very coarse grained. Mica associated with quartz sand lenses. Matrix clays as described above.	
		CLAY, SANDY: Silty, oxidized, mottled, grayish-brown to dark yellowish-brown (10 YR). Small, poorly sorted and mixed lithology granular gravel. Highly calcareous.	
-25	121		
		SAND, CLAY AND GRAVEL: Abrupt change in color to pale brown (10 YR) from marked reduction in oxidation. Sandy clay with small granular gravel throughout. Highly calcareous.	1300
-30	97		
		CLAY, SILTY WITH SAND: Marked increase in sand content, sand fine to medium grained, becoming increasingly oxidized with depth. Small granular gravel throughout.	

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

SB24 Pg. 3

Depth	W.S. % S.S.	CCl_4	LITHOLOGY	Elev
			CLAY, SILTY WITH SAND: Zone as described above with marked increase in calcium carbonate precipitated material.	
			CLAY, SILTY WITH SAND: Very high sand content, fine to medium grained. Occasional evidence of calcium carbonate precipitation. Dark yellowish-brown (10 YR). Fine to medium grained.	1295
-35		58	CLAY, SILT AND GRAVEL: Highly oxidized (black MN) pale brown (10 YR) matrix clays with sand. Pockets of sand fine and damp. Coarse silt with crumbly appearance, highly oxidized. Granular gravel scattered throughout. Highly calcareous.	
			CLAY, SILTY WITH SAND: Damp. Pale brown (10 YR) silty clay with fine to medium grained sand in matrix, moderate granular to pebble sized gravel of mixed lithology throughout. Moderate plasticity, slightly mottled base of unit due to variation in oxidation with yellowish-brown (10 YR).	1290
-40		59	SAND: Uncertain of end depth. Wet sand at base, oxidized, fine and medium to very coarse grained, predominantly quartz. Subangular to angular, loose, sandy clay clasts, oxidized throughout. Yellowish-brown (10 YR), calcareous.	
				1285
		2.3		
-45				

Carbon tetrachloride in water sample = µg/L
Carbon tetrachloride in soil sample = µg/kg

ARGONNE NATIONAL LABORATORY

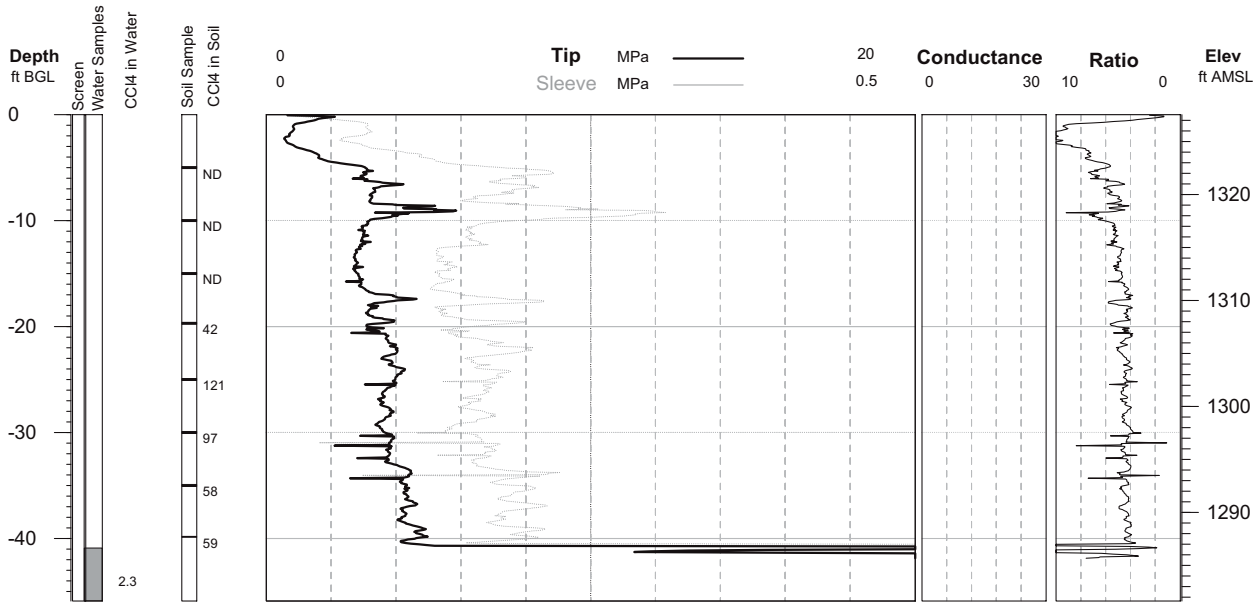
Boring ID: SB24

Project: Centralia Phase II
Geologist: LaFreniere

Elevation: 1327.54 ft.
Depth: 45.9 ft.

Log Date: 03/31/2003
Plot Date: 04/17/2003

Rig: CPT Crawler
Driller: Hinz
Company: Argonne



Appendix B:

Soil Sample Data

TABLE B.1 Soil samples collected during the Phase II field investigation at Centralia, Kansas.

Location	Sample	Sample Depth (ft BGL)	Sample Date	Sample Description
SB11	CNSB11-S-16293	4.9-5.1	04/05/03	Grayish brown, silty clay with sand; noncalcareous.
SB11	CNSB11-S-16294	9.9-10.1	04/05/03	Yellowish brown silty clay with sand; calcareous. Iron oxide and manganese oxide pockets, some coarse sand.
SB11	CNSB11-S-16295	14.9-15.1	04/05/03	Yellowish brown, silty clay with sand and granular gravel; oxidized; calcareous.
SB11	CNSB11-S-16296	19.6-19.8	04/05/03	Same as above, darker in color.
SB11	CNSB11-S-16297	24.9-25.1	04/05/03	Same as above.
SB11	CNSB11-S-16298	29.9-30.1	04/05/03	Light olive-brown clay with scattered coarse sand and some small gravel. Some iron oxide.
SB11	CNSB11-S-16299	34.9-35.1	04/05/03	Same as above. Material above and below target sample depth appears more oxidized.
SB11	CNSB11-S-16300	39.6-39.8	04/05/03	Same as above.
SB11	CNSB11-S-16301	40.1-40.3	04/05/03	Very dark brown to strong brown clayey sand. Shift to highly oxidized material.
SB11	CNSB11-S-16302	44.9-45.1	04/05/03	Same as above, with precipitated carbonate material.
SB11	CNSB11-S-16303	50.9-51.1	04/05/03	Sampled just above sand.
SB12	CNSB12-S-16283	4.9-5.1	04/04/03	Dark brown, silty clay with sand, noncalcareous.
SB12	CNSB12-S-16284	9.9-10.1	04/04/03	Yellowish brown, sandy clay with substantial calcium carbonate precipitate.
SB12	CNSB12-S-16285	14.9-15.1	04/04/03	Yellowish brown, silty clay with sand and rounded gravel to approximately 1 in.; calcareous.
SB12	CNSB12-S-16286	19.6-19.8	04/04/03	Silty clay with sand; selectively oxidized; calcareous with heavy precipitated carbonate material.
SB12	CNSB12-S-16287	24.9-25.1	04/04/03	Same as above.
SB12	CNSB12-S-16288	29.9-30.1	04/04/03	Pale brown, silty clay with sand; calcareous; damp to moist.
SB12	CNSB12-S-16289	34.9-35.1	04/04/03	Same as above.
SB12	CNSB12-S-16290	39.6-39.8	04/04/03	Pale brown, silty clay with sand, fine to coarse grained; highly calcareous; medium plasticity.
SB12	CNSB12-S-16291	44.9-45.1	04/04/03	Brown, sandy clay.
SB12	CNSB12-S-16292	49.9-50.1	04/04/03	Same as above with occasional calcium carbonate inclusions. Some black manganese staining. Moist (tip wet).

TABLE B.1 (Cont.)

Location	Sample	Sample Depth (ft BGL)	Sample Date	Sample Description
SB13	CNSB13-S-15456	4.9-5.1	04/03/03	Fine, dark grayish brown, sandy clay.
SB13	CNSB13-S-15457	9.9-10.1	04/03/03	Brown clay, sandy.
SB13	CNSB13-S-15458	14.9-15.1	04/03/03	Very fine, brown, sandy clay.
SB13	CNSB13-S-16258	19.6-19.8	04/03/03	Brown clay with some very fine sand.
SB13	CNSB13-S-15459	24.9-25.1	04/03/03	Grayish brown, sandy clay with manganese and iron stains and calcium carbonate precipitate. Porous.
SB13	CNSB13-S-16259	29.9-30.1	04/03/03	Brown, sandy (very fine) clay with occasional iron oxide staining and calcium carbonate precipitate. Some rounded gravel.
SB13	CNSB13-S-16261	34.8-34.9	04/03/03	Same as above. Bottom of unit.
SB13	CNSB13-S-16260	34.9-35.1	04/03/03	Yellowish brown clay marked by substantial iron oxide pockets and stains.
SB13	CNSB13-S-16262	39.6-39.8	04/03/03	Same as above but moist. Core stuck in rod at 45 ft depth. No sample collected at that depth. Refusal at depth of 47.4 ft BGL in wet sand.
SB14	CNSB14-S-16268	4.9-5.1	04/04/03	Yellowish brown, sandy clay. Noncalcareous with trace of calcareous inclusions.
SB14	CNSB14-S-16269	9.9-10.1	04/04/03	Yellowish brown, sandy clay. Calcareous with white powdery calcareous inclusions.
SB14	CNSB14-S-16270	14.9-15.1	04/04/03	Very sandy clay, coarser grained than above with some small gravel. Weathered, highly calcareous.
SB14	CNSB14-S-16271	19.7-19.8	04/04/03	Sample collected at transition to zone of less sand, less oxidized.
SB14	CNSB14-S-16272	19.8-20.0	04/04/03	Pale brown clay with fine to medium grained sand, less calcareous. Sand is predominately medium grained.
SB14	CNSB14-S-16273	24.9-25.1	04/04/03	Same as above, damp.
SB14	CNSB14-S-16278	29.9-30.1	04/04/03	Pale brown, calcareous, sandy clay with minor small granular gravel. Damp.
SB14	CNSB14-S-16280	34.5-34.6	04/04/03	Same as above.
SB14	CNSB14-S-16279	34.7-34.8	04/04/03	Oxidized pocket, sandy.
SB14	CNSB14-S-16281	39.6-39.8	04/04/03	Yellowish brown clay with occasional small gravel. Some iron oxide and calcium carbonate precipitates.
SB14	CNSB14-S-16282	41.9-42.1	04/04/03	Same as above.
SB15	CNSB15-S-15441	4.9-5.1	04/02/03	Oxidized, very sandy, yellowish brown clay with small, angular, granular gravel; calcareous.
SB15	CNSB15-S-16274	7.0-7.5	04/02/03	Subsurface soil sample collected for grain size analysis.

TABLE B.1 (Cont.)

Location	Sample	Sample Depth (ft BGL)	Sample Date	Sample Description
SB15	CNSB15-S-15442	9.9-10.1	04/02/03	Same as above, with lenses of medium to coarse grained loose quartz sand.
SB15	CNSB15-S-16275	14.5-14.8	04/02/03	Subsurface soil sample collected for grain size analysis.
SB15	CNSB15-S-15423	14.9-15.1	04/02/03	Damp, very heavily oxidized, yellowish brown, sandy clay with gravel to 0.5 in. diameter. Highly calcareous, darker yellowish brown where oxidized.
SB15	CNSB15-S-16276	18.5-19.0	04/02/03	Subsurface soil sample collected for grain size analysis.
SB15	CNSB15-S-15443	19.6-19.8	04/02/03	Light brownish gray, sandy clay with medium coarse sand. Marked reduction in oxidation, still highly calcareous.
SB15	CNSB15-S-15444	24.9-25.0	04/02/03	Same as above.
SB15	CNSB15-S-15465	25.0-25.1	04/02/03	Yellowish brown, sandy clay; decrease in sand content and coarser than above.
SB24	CNSB24-S-15437	4.9-5.1	04/02/03	Sandy calcareous clay with manganese flecks.
SB24	CNSB24-S-15438	9.9-10.1	04/02/03	Pale brown fine to medium sandy clay with minor granular gravel; highly calcareous.
SB24	CNSB24-S-15439	14.9-15.1	04/02/03	Same as above, but slightly damp, oxidized.
SB24	CNSB24-S-15440	19.6-19.8	04/02/03	Same as above, but slightly calcareous.
SB24	CNSB24-S-15418	24.9-25.1	04/02/03	Same as above, with higher sand content, still slightly damp.
SB24	CNSB24-S-15419	29.9-30.1	04/02/03	Same as above.
SB24	CNSB24-S-15420	34.9-35.1	04/02/03	Very sandy, highly oxidized, highly calcareous, brown to dark brown clay, slightly damp, crumbly in part.
SB24	CNSB24-S-15421	39.8-39.9	04/02/03	Same as above, very sandy clay with increase in size of gravel.

TABLE B.2 Results of organic analyses by the purge-and-trap method at the AGEM Laboratory on soil samples collected during the Phase II investigation at Centralia.

				Concentration (µg/kg)	
Location	Sample	Depth (ft BGL)	Sample Date	Carbon Tetrachloride	Chloroform
SB11	CNSB11-S-16293	4.9-5.1	4/5/03	ND[a]	ND
SB11	CNSB11-S-16294	9.9-10.1	4/5/03	ND	ND
SB11	CNSB11-S-16295	14.9-15.1	4/5/03	11	ND
SB11	CNSB11-S-16296	19.6-19.8	4/5/03	14	ND
SB11	CNSB11-S-16297	24.9-25.1	4/5/03	ND	ND
SB11	CNSB11-S-16298	29.9-30.1	4/5/03	16	ND
SB11	CNSB11-S-16299	34.9-35.1	4/5/03	10	ND
SB11	CNSB11-S-16300	39.6-39.8	4/5/03	ND	ND
SB11	CNSB11-S-16301	40.1-40.3	4/5/03	ND	ND
SB11	CNSB11-S-16302	44.9-45.1	4/5/03	6.2 J[b]	ND
SB11	CNSB11-S-16303	50.9-51.1	4/5/03	6.8 J	ND
SB12	CNSB12-S-16283	4.9-5.1	4/4/03	ND	ND
SB12	CNSB12-S-16284	9.9-10.1	4/4/03	ND	ND
SB12	CNSB12-S-16285	14.9-15.1	4/4/03	15	5.1 J
SB12	CNSB12-S-16286	19.6-19.8	4/4/03	45	7.1 J
SB12	CNSB12-S-16287	24.9-25.1	4/4/03	93	7.7 J
SB12	CNSB12-S-16288	29.9-30.1	4/4/03	219	6.4 J
SB12	CNSB12-S-16289	34.9-35.1	4/4/03	207	3.2 J
SB12	CNSB12-S-16290	39.6-39.8	4/4/03	202	3.3 J
SB12	CNSB12-S-16291	44.9-45.1	4/4/03	90	ND
SB12	CNSB12-S-16292	49.9-50.1	4/4/03	61	ND
SB13	CNSB13-S-15456	4.9-5.1	4/3/03	ND	ND
SB13	CNSB13-S-15457	9.9-10.1	4/3/03	ND	ND
SB13	CNSB13-S-15458	14.9-15.1	4/3/03	ND	ND
SB13	CNSB13-S-16258	19.6-19.8	4/3/03	ND	ND
SB13	CNSB13-S-15459	24.9-25.1	4/3/03	7.3 J	ND
SB13	CNSB13-S-16259	29.9-30.1	4/3/03	ND	ND
SB13	CNSB13-S-16261	34.8-34.9	4/3/03	ND	ND
SB13	CNSB13-S-16260	34.9-35.1	4/3/03	ND	ND
SB13	CNSB13-S-16262	39.6-39.8	4/3/03	ND	ND
SB14	CNSB14-S-16268	4.9-5.1	4/4/03	ND	ND
SB14	CNSB14-S-16269	9.9-10.1	4/4/03	ND	ND
SB14	CNSB14-S-16270	14.9-15.1	4/4/03	ND	ND
SB14	CNSB14-S-16271	19.7-19.8	4/4/03	ND	ND
SB14	CNSB14-S-16272	19.8-20.0	4/4/03	ND	ND
SB14	CNSB14-S-16273	24.9-25.1	4/4/03	8.8 J	ND
SB14	CNSB14-S-16278	29.9-30.1	4/4/03	14	ND
SB14	CNSB14-S-16280	34.5-34.6	4/4/03	11	ND
SB14	CNSB14-S-16279	34.7-34.8	4/4/03	ND	ND

TABLE B.2 (Cont.)

Location	Sample	Depth (ft BGL)	Sample Date	Concentration (µg/kg) Carbon Tetrachloride	Chloroform
SB14	CNSB14-S-16281	39.6-39.8	4/4/03	8.8 J	ND
SB14	CNSB14-S-16282	41.9-42.1	4/4/03	8.4 J	ND
SB15	CNSB15-S-15441	4.9-5.1	4/2/03	ND	ND
SB15	CNSB15-S-15442	9.9-10.1	4/2/03	ND	ND
SB15	CNSB15-S-15423	14.9-15.1	4/2/03	11	ND
SB15	CNSB15-S-15443	19.6-19.8	4/2/03	28	ND
SB15	CNSB15-S-15444	24.9-25.0	4/2/03	6.6 J	ND
SB15	CNSB15-S-15465	25.0-25.1	4/2/03	ND	ND
SB24	CNSB24-S-15437	4.9-5.1	4/2/03	ND	ND
SB24	CNSB24-S-15438	9.9-10.1	4/2/03	ND	ND
SB24	CNSB24-S-15439	14.9-15.1	4/2/03	ND	10
SB24	CNSB24-S-15440	19.6-19.8	4/2/03	42	11
SB24	CNSB24-S-15418	24.9-25.1	4/2/03	121	7.3 J
SB24	CNSB24-S-15419	29.9-30.1	4/2/03	97	ND
SB24	CNSB24-S-15420	34.9-35.1	4/2/03	58	ND
SB24	CNSB24-S-15421	39.8-39.9	4/2/03	59	ND

[a] ND, contaminant not detected.

[b] J, estimated concentration below quantitation limit of 10 µg/kg for the purge-and-trap method.

TABLE B.3 Results of soil particle size analyses on subsurface soils collected during the Phase II field investigation at Centralia, Kansas.

Location	Depth (ft BGL)	Particles Passing through Sieve Size (%)															
		1 in.	3/4 in.	1/2 in.	3/8 in.	#4	#10	#18	#35	#40	#60	#100	#120	#140	#200	#230	#270
SB15	7.0-7.5	100	100	100	100	99.7	99.0	97.0	93.9	92.6	86.8	80.4	78.9	77.0	76.2	75.1	73.2
SB15	14.5-14.8	100	95.4	95.4	95.4	95.0	94.0	92.5	89.7	88.4	82.9	76.1	74.6	72.8	70.8	68.2	65.9
SB15	18.5-19.0	100	100	100	100	99.4	98.5	96.8	93.7	92.3	86.1	79.0	77.4	75.5	71.6	70.1	67.9

TABLE B.4 Compositions of soil samples collected during the Phase II field investigation at Centralia, Kansas.

Location	Depth (ft BGL)	Composition (%)			
		Gravel	Sand	Silt	Clay
SB15	7.0-7.5	0.3	23.5	35.8	40.4
SB15	14.5-14.8	5.0	24.2	33.7	37.1
SB15	18.5-19.0	0.6	27.8	34.6	37.0

TABLE B.5 Percent moisture in subsurface soil samples collected during the Phase I and Phase II investigations at Centralia, Kansas.

Location	Sample	Depth (ft BGL)	Weight (g) Vial	Vial + Wet Sample	Wet Sample	Vial + Dry Sample	Dry Sample	Water	Moisture (%)
Phase I subsurface soil samples									
SB01	CNSB01-S-15245	2	29.488	47.252	17.764	42.715	13.227	4.537	25.54
SB01	CNSB01-S-15246	4	30.25	55.819	25.569	51.605	21.355	4.214	16.48
SB01	CNSB01-S-15247	6	29.563	48.818	19.255	45.893	16.33	2.925	15.19
SB01	CNSB01-S-15248[a]	6	30.578	47.183	16.605	44.723	14.145	2.46	14.81
SB01	CNSB01-S-15249	8	29.369	59.391	30.022	54.819	25.45	4.572	15.23
SB01	CNSB01-S-15250	10	29.718	55.334	25.616	51.344	21.626	3.99	15.58
SB01	CNSB01-S-15251[a]	10	29.518	50.748	21.23	47.276	17.758	3.472	16.35
SB01	CNSB01-S-15252	12	29.929	56.453	26.524	52.039	22.11	4.414	16.64
SB01	CNSB01-S-15253	14	28.952	51.107	22.155	47.164	18.212	3.943	17.80
SB01	CNSB01-S-15254	16	29.973	54.566	24.593	50.15	20.177	4.416	17.96
SB01	CNSB01-S-15255	18	29.802	51.532	21.73	47.903	18.101	3.629	16.70
SB01	CNSB01-S-15256	20	30.07	55.791	25.721	51.145	21.075	4.646	18.06
SB01	CNSB01-S-15257	22	29.629	68.116	38.487	61.997	32.368	6.119	15.90
SB01	CNSB01-S-15258[a]	22	29.266	57.576	28.31	52.785	23.519	4.791	16.92
SB01	CNSB01-S-15259	24	29.929	50.667	20.738	47.484	17.555	3.183	15.35
SB01	CNSB01-S-15260	26	29.369	51.706	22.337	47.29	17.921	4.416	19.77
SB01	CNSB01-S-15261	28	29.807	55.347	25.54	50.909	21.102	4.438	17.38
SB06	CNSB06-S-15327	1.0-1.2	29.223	44.546	15.323	42.201	12.978	2.345	15.30
SB06	CNSB06-S-15189	1.9-2.0	30.205	39.98	9.775	37.959	7.754	2.021	20.68
SB06	CNSB06-S-15328	4.6-4.8	29.512	46.978	17.466	44.057	14.545	2.921	16.72
SB06	CNSB06-S-15188	6.9-7.1	29.411	45.059	15.648	42.077	12.666	2.982	19.06
SB06	CNSB06-S-15331	9.0-9.2	30.017	51.89	21.873	47.577	17.56	4.313	19.72
SB06	CNSB06-S-15332	10.9-11.1	28.965	44.93	15.965	42.021	13.056	2.909	18.22
SB06	CNSB06-S-15333	12.8-12.9	30.59	48.225	17.635	45.613	15.023	2.612	14.81
SB06	CNSB06-S-15334	14.9-15.1	29.624	47.185	17.561	44.674	15.05	2.511	14.30
SB06	CNSB06-S-15335	17.0-17.2	29.488	38.425	8.937	37.009	7.521	1.416	15.84

TABLE B.5 (Cont.)

Location	Sample	Depth (ft BGL)	Weight (g) Vial	Vial + Wet Sample	Wet Sample	Vial + Dry Sample	Dry Sample	Water	Moisture (%)
Phase I subsurface soil samples (Cont.)									
SB06	CNQCDU-S-15313[a]	17.0-17.2	29.562	37.897	8.335	36.599	7.037	1.298	15.57
SB06	CNSB06-S-15336	18.9-19.1	28.666	42.383	13.717	40.191	11.525	2.192	15.98
SB06	CNSB06-S-15337	21.0-21.2	28.145	51.965	23.82	47.983	19.838	3.982	16.72
SB06	CNSB06-S-15338	23.0-23.2	29.35	51.562	22.212	48.04	18.69	3.522	15.86
SB06	CNSB06-S-15339	25.0-25.2	29.593	50.564	20.971	47.045	17.452	3.519	16.78
SB06	CNSB06-S-15340	27.0-27.2	30.431	48.718	18.287	45.954	15.523	2.764	15.11
SB06	CNQCDU-S-15314[a]	27.0-27.2	29.928	40.32	10.392	38.81	8.882	1.51	14.53
SB06	CNSB06-S-15341	29.0-29.2	30.13	37.098	6.968	36.05	5.92	1.048	15.04
SB06	CNSB06-S-15342	31.0-31.2	30.245	47.946	17.701	45.192	14.947	2.754	15.56
SB06	CNSB06-S-15343	33.0-33.2	29.939	47.169	17.23	44.456	14.517	2.713	15.75
SB06	CNSB06-S-15344	35.0-35.2	30.063	37.26	7.197	36.141	6.078	1.119	15.55
SB06	CNSB06-S-15190	37.0-37.2	29.487	52.167	22.68	48.33	18.843	3.837	16.92
SB06	CNSB06-S-15191	39.0-39.2	29.799	46.76	16.961	43.984	14.185	2.776	16.37
SB06	CNSB06-S-15192	41.0-41.2	28.969	49.411	20.442	46.219	17.25	3.192	15.61
SB06	CNSB06-S-15193	43.0-43.2	29.58	41.857	12.277	39.698	10.118	2.159	17.59
SB06	CNSB06-S-15194	45.0-45.2	30.317	43.522	13.205	41.428	11.111	2.094	15.86
SB06	CNQCDU-S-15180[a]	45.0-45.2	29.89	34.206	4.316	33.6	3.71	0.606	14.04
SB06	CNSB06-S-15177	47.0-47.2	30.16	48.261	18.101	45.631	15.471	2.63	14.53
SB06	CNQCDU-S-15181[a]	47.0-47.2	30.173	57.317	27.144	53.295	23.122	4.022	14.82
SB06	CNSB06-S-15178	49.0-49.2	29.995	59.192	29.197	54.988	24.993	4.204	14.40
SB06	CNSB06-S-15179	51.0-51.2	28.008	43.475	15.467	41.296	13.288	2.179	14.09
SB06	CNSB06-S-15182	53.0-53.2	29.802	44.278	14.476	42.177	12.375	2.101	14.51
SB06	CNSB06-S-15183	55.0-55.2	29.561	35.882	6.321	34.778	5.217	1.104	17.47

TABLE B.5 (Cont.)

Location	Sample	Depth (ft BGL)	Weight (g) Vial	Vial + Wet Sample	Wet Sample	Vial + Dry Sample	Dry Sample	Water	Moisture (%)
Phase II subsurface soil samples									
SB11	CNSB11-S-16293	4.9-5.1	29.892	53.493	23.601	48.687	18.795	4.806	20.36
SB11	CNSB11-S-16294	9.9-10.1	29.555	58.83	29.275	54.168	24.613	4.662	15.92
SB11	CNSB11-S-16295	14.9-15.1	29.348	49.2	19.852	45.702	16.354	3.498	17.62
SB11	CNSB11-S-16296	19.6-19.8	29.591	56.235	26.644	50.895	21.304	5.34	20.04
SB11	CNSB11-S-16297	24.9-25.1	28.143	54.582	26.439	49.626	21.483	4.956	18.75
SB11	CNQCDU-S-15462[a]	24.9-25.1	28.009	58.754	30.745	52.996	24.987	5.758	18.73
SB11	CNSB11-S-16298	29.9-30.1	28.957	51.27	22.313	47.442	18.485	3.828	17.16
SB11	CNSB11-S-16299	34.9-35.1	29.799	63.583	33.784	57.577	27.778	6.006	17.78
SB11	CNSB11-S-16300	39.6-39.8	29.514	57.069	27.555	52.215	22.701	4.854	17.62
SB11	CNSB11-S-16301	40.1-40.3	29.999	49.084	19.085	45.697	15.698	3.387	17.75
SB11	CNSB11-S-16302	44.9-45.1	30.022	57.226	27.204	52.711	22.689	4.515	16.60
SB11	CNSB11-S-16303	50.9-51.1	29.623	62.891	33.268	57.568	27.945	5.323	16.00
SB12	CNSB12-S-16283	4.9-5.1	30.166	55.969	25.803	52.657	22.491	3.312	12.84
SB12	CNSB12-S-16284	9.9-10.1	30.322	54.943	24.621	51.81	21.488	3.133	12.72
SB12	CNSB12-S-16285	14.9-15.1	29.805	54.621	24.816	51.138	21.333	3.483	14.04
SB12	CNSB12-S-16286	19.6-19.8	30.611	54.959	24.348	51.207	20.596	3.752	15.41
SB12	CNSB12-S-16287	24.9-25.1	28.009	52.869	24.86	48.749	20.74	4.12	16.57
SB12	CNQCDU-S-15461[a]	24.9-25.1	30.015	55.412	25.397	51.193	21.178	4.219	16.61
SB12	CNSB12-S-16288	29.9-30.1	29.175	50.122	20.947	47.157	17.982	2.965	14.15
SB12	CNSB12-S-16289	34.9-35.1	28.5	62.386	33.886	58.011	29.511	4.375	12.91
SB12	CNSB12-S-16290	39.6-39.8	30.433	60.335	29.902	56.299	25.866	4.036	13.50
SB12	CNSB12-S-16291	44.9-45.1	28.972	57.55	28.578	53.611	24.639	3.939	13.78
SB12	CNSB12-S-16292	49.9-50.1	29.565	62.982	33.417	58.501	28.936	4.481	13.41
SB13	CNSB13-S-15456	4.9-5.1	30.168	52.083	21.915	48.013	17.845	4.07	18.57
SB13	CNSB13-S-15457	9.9-10.1	30.015	55.057	25.042	50.984	20.969	4.073	16.26
SB13	CNSB13-S-15458	14.9-15.1	29.881	55.672	25.791	51.158	21.277	4.514	17.50

TABLE B.5 (Cont.)

Location	Sample	Depth (ft BGL)	Weight (g) Vial	Vial + Wet Sample	Wet Sample	Vial + Dry Sample	Dry Sample	Water	Moisture (%)
Phase II subsurface soil samples (Cont.)									
SB13	CNQCDU-S-16267[a]	14.9-15.1	29.175	66.257	37.082	59.669	30.494	6.588	17.77
SB13	CNSB13-S-16258	19.6-19.8	28.972	53.715	24.743	49.628	20.656	4.087	16.52
SB13	CNSB13-S-15459	24.9-25.1	30.611	62.345	31.734	56.755	26.144	5.59	17.62
SB13	CNSB13-S-16259	29.9-30.1	29.515	50.377	20.862	46.768	17.253	3.609	17.30
SB13	CNSB13-S-16261	34.8-34.9	30.58	59.799	29.219	54.915	24.335	4.884	16.72
SB13	CNSB13-S-16260	34.9-35.1	29.565	54.003	24.438	49.965	20.4	4.038	16.52
SB13	CNSB13-S-16262	39.6-39.8	28.656	54.748	26.092	50.175	21.519	4.573	17.53
SB14	CNSB14-S-16268	4.9-5.1	28.5	50.645	22.145	45.86	17.36	4.785	21.61
SB14	CNSB14-S-16269	9.9-10.1	30.122	59.378	29.256	54.417	24.295	4.961	16.96
SB14	CNSB14-S-16270	14.9-15.1	30.166	56.747	26.581	51.56	21.394	5.187	19.51
SB14	CNSB14-S-16271	19.7-19.8	29.805	58.194	28.389	53.293	23.488	4.901	17.26
SB14	CNSB14-S-16272	19.8-20.0	30.472	55.792	25.32	51.428	20.956	4.364	17.24
SB14	CNSB14-S-16273	24.9-25.1	29.579	60.125	30.546	54.981	25.402	5.144	16.84
SB14	CNQCDU-S-15460[a]	24.9-25.1	30.322	61.549	31.227	56.19	25.868	5.359	17.16
SB14	CNSB14-S-16278	29.9-30.1	29.515	49.385	19.87	46.686	17.171	2.699	13.58
SB14	CNSB14-S-16280	34.5-34.6	29.579	40.867	11.288	39.339	9.76	1.528	13.54
SB14	CNSB14-S-16279	34.7-34.8	29.892	47.679	17.787	45.109	15.217	2.57	14.45
SB14	CNSB14-S-16281	39.6-39.8	29.514	47.98	18.466	45.059	15.545	2.921	15.82
SB14	CNSB14-S-16282	41.9-42.1	30.168	50.926	20.758	47.843	17.675	3.083	14.85
SB15	CNSB15-S-15441	4.9-5.1	28.009	54.457	26.448	50.65	22.641	3.807	14.39
SB15	CNSB15-S-15442	9.9-10.1	28.972	56.591	27.619	51.496	22.524	5.095	18.45
SB15	CNQCDU-S-15422[a]	9.9-10.1	29.514	50.799	21.285	46.742	17.228	4.057	19.06
SB15	CNSB15-S-15423	14.9-15.1	29.579	59.822	30.243	54.89	25.311	4.932	16.31
SB15	CNSB15-S-15443	19.6-19.8	30.166	58.428	28.262	53.905	23.739	4.523	16.00
SB15	CNSB15-S-15444	24.9-25.0	30.015	57.151	27.136	52.373	22.358	4.778	17.61

TABLE B.5 (Cont.)

Location	Sample	Depth (ft BGL)	Weight (g) Vial	Vial + Wet Sample	Wet Sample	Vial + Dry Sample	Dry Sample	Water	Moisture (%)
Phase II subsurface soil samples (Cont.)									
SB15	CNQCDU-S-15424[a]	24.9-25.0	29.565	49.851	20.286	46.374	16.809	3.477	17.14
SB15	CNSB15-S-15465	25.0-25.1	28.5	55.266	26.766	50.494	21.994	4.772	17.83
SB24	CNSB24-S-15437	4.9-5.1	30.433	56.542	26.109	52.524	22.091	4.018	15.39
SB24	CNSB24-S-15438	9.9-10.1	30.611	51.528	20.917	48.01	17.399	3.518	16.82
SB24	CNSB24-S-15439	14.9-15.1	29.175	51.956	22.781	48.281	19.106	3.675	16.13
SB24	CNSB24-S-15440	19.6-19.8	30.168	49.202	19.034	46.22	16.052	2.982	15.67
SB24	CNSB24-S-15418	24.9-25.1	29.515	51.93	22.415	48.346	18.831	3.584	15.99
SB24	CNSB24-S-15419	29.9-30.1	29.805	66.671	36.866	60.788	30.983	5.883	15.96
SB24	CNSB24-S-15420	34.9-35.1	29.892	56.912	27.02	52.543	22.651	4.369	16.17
SB24	CNSB24-S-15421	39.8-39.9	30.322	56.868	26.546	52.977	22.655	3.891	14.66

[a] Replicate sample.

Appendix C:

Coordinates Survey Data

TABLE C.1 Coordinates survey data for Phase II sampling locations at Centralia.

Location	Horizontal Location[a] (ft)		Elevation[b] (ft AMSL)	
	Northing	Easting	Representative Ground Surface	Reference[c]
SB11	515178.2	1839133.0	1333.22	1333.22
SB12	515096.6	1839139.9	1335.05	1335.05
SB13	514995.4	1839056.3	1331.45	1331.45
SB14	515057.8	1839011.7	1329.57	1329.57
SB15	515086.2	1838936.7	1325.65	1325.65
SB16	514926.6	1839289.3	1332.72	1333.27
SB17[d]				
SB18	514928.1	1838842.3	1320.81	1321.61
SB19	515049.1	1838655.2	1305.95	1306.85
SB20	514766.3	1839183.2	1332.38	1333.03
SB21	514850.8	1838992.6	1329.99	1330.52
SB22	514994.2	1838756.1	1313.72	1314.42
SB23[d]				
SB24	515150.3	1838993.4	1327.54	1327.54
SB24A	515172.0	1838992.4	1327.51	1328.05

[a] Horizontal coordinates are target location centers. Northings and eastings are Kansas State Plane Coordinates. Horizontal datum is North American Datum (NAD) 83.

[b] Vertical datum is National Geodetic Vertical Datum (NGVD) 88.

[c] Location for measurement of water level.

[d] Location not surveyed.

Appendix D:

Water Sample Data

TABLE D.1 Groundwater water samples collected during the Phase II investigation at Centralia, Kansas.

Location	Sample	Depth (ft BGL)	Sample Date	Description
SB16	CNSB16-W-15427	52.5-55.8	03/31/03	Oxidized, turbid water; good recovery.
SB18	CNSB18-W-15429	37.6-42.6	04/01/03	Water very dirty, brown. Slow recharge. Initial water level at 51 ft BGL with TOC then about 7 ft above ground surface. VOA sample collected by bailing when water level reached 48.5 ft BGL. Tritium sample collected April 2 using Watera pump.
SB19	CNSB19-W-15435	27.8-32.8	04/01/03	Screened hole; 1.5 in. diameter.
SB20	CNSB20-W-15432	46.0-49.0	04/01/03	Screened hole.
SB21	CNSB21-W-15468	44.2-49.2	04/04/03	ECPT push sample. Very little water present. Tritium sample collected using Watera pump.
SB22	CNSB22-W-15467	30.5-35.5	04/03/03	Sampled after screen was allowed to sit due to limited water recovery. No field measurements.
SB22	CNSB22A-W-16306	30.5-35.5	04/05/03	Sample from temporary piezometer. Depth to water from top of casing (TOC) = 9.76 ft. Depth of well = 35.80 ft BGL. TOC is 0.7 ft above ground level.
SB24	CNSB24-W-15425	40.9-45.9	03/31/03	Abundant water recovery. Depth sampled on the basis of electronic data recovery. Upper part of Upper Independence Formation.
SB24A	CNSB24A-W-16304	41.1-46.1	04/05/03	Abundant water in screen but limited recovery because of high turbidity. Oxidized silt and fine sand.

TABLE D.2 Field measurements made during collection of groundwater samples in the Phase II investigation at Centralia, Kansas.

Location	Sample	Depth (ft BGL)	Sample Date	Temper-ature (°C)	pH	Conductivity (µS/cm)
SB16	CNSB16-W-15427	52.5-55.8	3/31/03	18.6	6.33	640
SB18	CNSB18-W-15429	37.6-42.6	4/1/03	21.8	6.71	620
SB19	CNSB19-W-15435	27.8-32.8	4/1/03	19.2	6.39	983
SB20	CNSB20-W-15432	46.0-49.0	4/1/03	20.2	6.75	705
SB21	CNSB21-W-15468	44.2-49.2	4/4/03	NR[a]	NR	NR
SB22	CNSB22A-W-16306	30.5-35.5	4/5/03	NR	NR	NR
SB24	CNSB24-W-15425	40.9-45.9	3/31/03	16.1	6.28	824
SB24A	CNSB24A-W-16304	41.1-46.1	4/5/03	13.9	6.84	947

[a] NR, not recorded.

TABLE D.3 Results of organic analyses at the AGEM Laboratory on water samples collected during the Phase II investigation at Centralia, Kansas.

				Concentration (µg/L)	
Location	Sample	Depth (ft BGL)	Sample Date	Carbon Tetrachloride	Chloroform
SB16	CNSB16-W-15427	52.5-55.8	3/31/03	ND[a]	ND
SB18	CNSB18-W-15429	37.6-42.6	4/1/03	ND	ND
SB19	CNSB19-W-15435	27.8-32.8	4/1/03	ND	ND
SB20	CNSB20-W-15432	46.0-49.0	4/1/03	ND	ND
SB21	CNSB21-W-15468	44.2-49.2	4/4/03	ND	ND
SB22	CNSB22A-W-16306	30.5-35.5	4/5/03	ND	ND
SB24	CNSB24-W-15425	40.9-45.9	3/31/03	2.3	6.9
SB24A	CNSB24A-W-16304	41.1-46.1	4/5/03	1.7	7.1

[a] ND, not detected at the quantitation limit of 1 µg/L for the purge-and-trap method.

TABLE D.4 Results of tritium analyses at the University of Miami Tritium Laboratory on groundwater samples collected during the Phase II field investigation at Centralia, Kansas.

Location	Sample	Depth (ft BGL)	Sample Date	Analysis Date	Tritium ± Uncertainty (TU)[a]
SB16	CNSB16-W-15427	52.5-55.8	3/31/03	3/31/03	1.92 ± 0.09
SB18	CNSB18-W-15429	37.6-42.6	4/1/03	4/2/03	0.04 ± 0.09
SB19	CNSB19-W-15435	27.8-32.8	4/1/03	4/1/03	10.5 ± 0.3
SB20	CNSB20-W-15432	46.0-49.0	4/1/03	4/2/03	-0.05 ± 0.09
SB21	CNSB21-W-15468	44.2-49.2	4/4/03	4/5/03	0.03 ± 0.09
SB22	CNSB22-W-15467	30.5-35.5	4/3/03	4/3/03	0.64 ± 0.09
SB24	CNSB24-W-15425	40.9-45.9	3/31/03	3/31/03	0.06 ± 0.09

[a] TU, tritium unit; 1 TU = 1 atom of tritium per 10^{18} atoms of hydrogen.

Appendix E:

Water Level Data

TABLE E.1 Water level measurements collected during the Phase II investigation at Centralia, Kansas.

Piezometer	Elevation (ft AMSL)		Measured Well Depth (ft BGL)	Screen Interval (ft BGL)	Measurement		Water Level	
	Ground Surface	Reference[a]			Date	Time	Depth (ft BGL)	Elevation (ft AMSL)
SB01	1325.60	1325.16	NM[b]	40-50	4/5/03	17:23	23.45	1301.71
SB04	1336.20	1335.73	NM	51-61	4/5/03	17:20	25.14	1310.59
SB05	1321.60	1321.28	NM	32-42	4/5/03	17:30	15.03	1306.25
SB07	1332.40	1331.94	NM	48-55	4/5/03	17:17	20.12	1311.82
SB08	1333.00	1332.56	NM	52-62	4/5/03	NR[c]	21.97	1310.59
SB09	1311.50	1311.04	NM	32-42	4/5/03	17:26	8.17	1302.87
SB16	1332.72	1333.27	55.70	52.5-55.8	4/5/03	NR	22.67	1310.60
SB18	1320.81	1321.61	42.80	37.6-42.6	4/5/03	NR	25.01	1296.60
SB19	1305.95	1306.85	28.85	27.8-32.8	4/5/03	NR	3.36	1303.49
SB20	1332.38	1333.03	49.70	46.0-49.0	4/5/03	NR	47.70	1285.33
SB21	1329.99	1330.52	49.40	44.2-49.2	4/5/03	NR	45.45	1285.07
SB22	1313.72	1314.42	35.80	30.5-35.5	4/5/03	NR	9.76	1304.66
SB24A	1327.51	1328.05	45.30	40.9-45.9	4/5/03	NR	16.00	1312.05
SB01[d]	1325.60	1325.16	46.00	40-50	4/21/03	16:10	22.82	1302.34
SB04[d]	1336.20	1335.73	58.86	51-61	4/21/03	16:05	24.56	1311.17
SB05[d]	1321.60	1321.28	41.30	32-42	4/21/03	16:23	13.87	1307.41
SB07[d]	1332.40	1331.94	54.67	48-55	4/21/03	16:30	18.35	1313.59
SB08[d]	1333.00	1332.56	62.66	52-62	4/21/03	16:00	21.36	1311.20
SB09[d]	1311.50	1311.04	41.97	32-42	4/21/03	16:17	6.16	1304.88

[a] Reference point for measuring water level depth.

[b] NM, not measured.

[c] NR, not recorded.

[d] Resampling of permanent piezometers after a rain event.

Appendix F:

Quality Control for Sample Collection, Handling, and Analysis

Appendix F:

Quality Control for Sample Collection, Handling, and Analysis

Soil and groundwater were sampled during the Phase II investigation at Centralia, Kansas, to delineate carbon tetrachloride contamination in the subsurface soils at the former CCC/USDA facility and to evaluate the vertical and lateral extent of carbon tetrachloride and chloroform contamination in the study area. Throughout the investigation, QA/QC samples were used to monitor sample collection, handling, and analysis. The QA/QC procedures followed are described in detail in the *Master Work Plan* (Argonne 2002b) and the site-specific Phase I *Work Plan* (Argonne 2002a). Evaluation of the organic analytical data was consistent with regulatory guidelines (EPA 1994).

F.1 Samples Used to Monitor Sample Collection, Handling, and Analysis Procedures

Sample collection and handling activities were monitored by the documentation of samples as they were collected and the use of chain-of-custody (COC) forms and custody seals to ensure sample integrity during the handling and shipment of samples for analysis. Minor discrepancies in sample identifiers for some samples as shown on the COC records, sample containers, or analytical data reports were resolved by comparison of the various documentation records.

The QA/QC samples collected included equipment rinsates and trip blanks. Blind field replicate samples were collected, and samples were selected for duplicate analysis as a measure of analytical precision. The QA/QC samples are listed in Table F.1. Analytical results for carbon tetrachloride and chloroform in QA/QC samples collected to monitor sample collection and handling activities are in Table F.2.

F.1.1 Equipment Rinsates

Reusable sampling bailers were used during the collection of groundwater samples with the ECPT vehicle. Rinsates from the decontaminated bailers were collected periodically to verify that cross-contamination of groundwater samples did not occur during sample collection. Disposable sampling equipment was used during the collection of other samples. Neither carbon tetrachloride nor chloroform was detected in the rinsate samples.

F.1.2 Trip Blanks

Trip blanks were prepared and included in shipments of soil or water samples for organic analysis as an indicator of cross-contamination of samples during shipment. Significant results are as follows:

- Contaminants of concern were not detected in the trip blanks analyzed at the AGEM Laboratory. However, trip blank CNQCTB-S-15464, included with soil samples sent to the AGEM Laboratory and listed under COC 987, was not analyzed because of a documentation error when the samples were received and logged. Samples associated with the trip blank included the 11 subsurface soil samples and 1 replicate from sampling location SB11. Five of the samples and the replicate contained no detectable contaminants, and cross-contamination of the samples during shipment is not indicated.

- Contaminants of concern were not detected in the trip blank shipped to Clayton Laboratory with water samples for verification organic analysis.

- Chloroform was detected in the trip blank shipped to Severn-Trent Laboratory with soil samples for verification organic analysis. The reported concentration is qualified (Table F.2) because of high recovery in analyzed laboratory QC samples, as discussed in Section F.2.3.

F.1.3 Replicate Samples and Duplicate Analyses

As an indicator of the consistency of the sampling methodology followed and to provide a measure of analytical precision, blind replicate soil and groundwater samples were collected. In addition, samples were selected by the AGEM Laboratory for duplicate organic analyses. Selected samples were also shipped to a second laboratory for verification analysis. Blind replicate samples, samples selected for duplicate analyses, and samples selected for verification organic analysis are listed in Table F.1.

F.1.4 Sample Representativeness

Sampling difficulties at location SB22 required resampling to ensure that the sample collected with the ECPT for organic analysis was representative of the site conditions. During the initial sampling attempt at location SB22 on April 3, 2003, difficulty was encountered in placing the screen at the desired depth interval of 30.5-35.5 ft BGL. When the ECPT rods were withdrawn to open the screen, the screen did not open. The rods were repositioned and withdrawn. This time the screen opened successfully, but water recovery was very limited. After some delay, aliquots of the groundwater were recovered for organic and tritium analyses. However, because of the potential for volatilization during the prolonged collection of the sample for organic analysis, resampling was conducted with the ECPT on April 5, 2003, adjacent to the initial sampling location (within 2 ft). No difficulty was encountered in placing the screen at the depth interval used previously, and sufficient water for organic analysis (sample CNSB22A-W-16306) was collected with little delay.

F.2 Quality Control for Organic Analysis of Soil Samples

At 6 soil boring locations (SB11-SB15 and SB24), 55 subsurface soil samples (plus 6 blind field replicate samples) were collected. The subsurface soils were prepared at the AGEM Laboratory and analyzed for VOCs, including carbon tetrachloride and chloroform, by using a modification of EPA Methods 5030B and 8260B (the purge-and-trap preparation method with analysis by GC-MS), as referenced in the EPA's SW-846 (EPA 1986), to achieve a method quantitation limit of 10 µg/kg. To verify accuracy of these analytical results, random soil samples were split and prepared for verification analysis at Severn-Trent Laboratory with the same analytical method.

The following sections describe the QC measures followed during analysis of the soil samples and discuss the quality of the organic analytical data from each laboratory. Analytical data from the AGEM Laboratory are discussed in Section F.2.1, and analytical data from Severn-Trent Laboratory are discussed in Section F.2.2. The analytical results from the two laboratories are compared in Section F.2.3.

F.2.1 Organic Analysis of Soil Samples at the AGEM Laboratory

Soil samples were quick-frozen on dry ice as they were collected. In the laboratory, the VOCs in each soil sample were extracted with methanol from the sample matrix.

For the purge-and-trap soil analyses, an aliquot of the methanol extract was purged, and the volatile species were transferred to a sorbent tube. After purging, the sorbent tube was heated and backflushed with an inert gas to desorb the components into the GC-MS system. The compounds eluting from the GC column were identified by retention time and by comparison with reference library spectra. The concentration of each component was calculated by comparison of the MS response for the quantitation ion to the response for internal standards.

Soil samples were analyzed at the AGEM Laboratory with the purge-and-trap method in seven sample delivery groups (SDGs), as shown in Table F.3. The QA/QC procedures followed included initial and continuing calibration of instruments, analysis of laboratory blanks, monitoring of surrogate spike recovery, analysis of replicate samples, and duplicate analyses of selected samples. Significant results include the following:

- Soil samples were received with custody seals intact and at the appropriate temperature. All samples were analyzed within required holding times.

- Carbon tetrachloride was not detected in the laboratory method blanks.

- For each SDG, analytical instrument calibration was monitored by the analysis of calibration check standards. Table F.3 shows the relative percent difference (RPD) values between the known and calculated concentrations of the standards. The concentrations of calibration check standards measured in the SDGs were within the acceptable range of ±20%, with the following two exceptions:

  - In the initial calibration check run with SDG 03-4-14, the RPD for carbon tetrachloride (at 13.7%) was within the range of ±20%, while the RPD for chloroform (at 33.4%) was outside that range. To verify instrument calibration for chloroform, a second calibration check standard was run with an RPD

value of 1.1%. Therefore, qualification of the results for samples analyzed in SDG 03-4-14 is not warranted.

- In the calibration check run with SDG 03-4-16, the RPD value for carbon tetrachloride was 22.2%, while that for chloroform was 0.2%. No second calibration check standard was run with the SDG to verify instrument calibration for carbon tetrachloride within the range of ±20%. Results for the samples analyzed in SDG 03-4-16, which are secondary QC analyses (as shown in Table F.4 and discussed below), are therefore qualified.

- Surrogate standard determinations were performed on the samples and blanks by using the surrogate spike compounds fluorobenzene, 4-bromofluorobenzene, and 1,2-dichlorobenzene-d_4. Table F.3 shows the percent recoveries of these system-monitoring compounds for each of the analyses. Reanalysis was conducted when the initial analysis was outside the surrogate recovery limit of 80-120%.

- As a measure of consistency in the sampling and analytical methodologies, dual analyses of soil samples collected at 13 sampling locations were accomplished through the analysis of blind replicate samples submitted to the laboratory or duplicate analysis of samples selected by the laboratory. Table F.4 summarizes the analytical results for the primary samples and their replicate or duplicate analyses. Agreement is excellent, indicating consistency in both the sampling and analytical methodologies. Five secondary analyses reported by the laboratory in SDG 03-4-16 with instrument calibration for carbon tetrachloride above the QC range of ±20% are qualified.

The analytical data from the AGEM Laboratory are acceptable for quantitative determination of contaminant distribution in the subsurface soils.

F.2.2 Organic Analysis of Soil Samples at Severn-Trent Laboratory

In accordance with the QA/QC procedures defined in the *Master Work Plan* (Argonne 2002b), selected soil samples analyzed for VOCs at the AGEM Laboratory with the purge-and-trap GC-MS method (EPA Methods 5030B and 8260B) were subjected to verification analysis at a

second laboratory with the same analytical procedure. The analytical results from the two laboratories are compared in Section F.2.3. Below is a discussion of the quality of the organic analytical data from Severn-Trent Laboratory.

Eight replicate soil samples were sent with a trip blank to Severn-Trent Laboratory. A complete data package was provided as SDG 93017. The QA/QC procedures followed included initial and continuing calibration of instruments, analysis of laboratory blanks, monitoring of surrogate spike recovery, and spike analyses of one soil sample and a laboratory control sample. Significant results include the following:

- Soil samples shipped to the Severn-Trent Laboratory were received with custody seals intact and at the appropriate temperature. All samples were analyzed within required holding times.

- Analytical instruments were tuned properly; initial and continuing calibration checks remained within the allowable range.

- Trace concentrations of naphthalene and 1,2,3-trichlorobenzene were detected in an instrument blank associated with the samples. Carbon tetrachloride and chloroform, the contaminants of concern in the investigation, were not detected.

- Surrogate standard determinations were performed on samples and blanks by using the surrogate spike compounds toluene-d_8, 1,2-dichloroethane-d_4, 4-bromofluorobenzene, and 1,2-dichlorobenzene-d_4. Table F.5 shows the percent recoveries of the system-monitoring compounds for each of the analyses. Surrogate recoveries were within the specified limits.

- To evaluate the matrix effect of samples on the analytical methodology, a suite of spike compounds including carbon tetrachloride and chloroform was used to perform a matrix spike/matrix spike duplicate analysis of a laboratory QC sample and a subsurface soil sample, as well as a matrix spike analysis of a second laboratory QC sample. Table F.6 shows the percent recovery and RPD values for carbon tetrachloride and chloroform in the spike/spike duplicate analyses. Recovery of chloroform was above the QC limit of 106% in the spike/spike duplicate analyses of the laboratory control sample and the

subsurface soil sample, and recovery of carbon tetrachloride was above the QC limit in the spike duplicate analysis of the subsurface soil sample. The results from Severn-Trent Laboratory are qualified to reflect high recovery for the contaminants of concern.

- The laboratory acknowledged the potential for carryover in the analysis of certain samples preceded by spiked laboratory QC samples prepared with spike concentrations as much as five times those normally used for the requested low-level analyses. Specifically qualified by the laboratory were the results for samples CNSB24-S-15420 and CNSB12-S-16286 (Table F.7). These samples were preceded by spiked samples unrelated to the Argonne investigation's verification samples (not included in the SDG).

The organic analytical data from Severn-Trent Laboratory for the replicate soil samples are acceptable for comparison with the AGEM Laboratory data.

F.2.3 Verification Organic Analysis of Soil Samples

In accordance with the QA/QC procedures defined in the *Master Work Plan* (Argonne 2002b), selected soil samples analyzed at the AGEM Laboratory with the purge-and-trap GC-MS method were subjected to verification analysis at a second laboratory. Split replicates of 8 of the 55 soil samples analyzed at the AGEM Laboratory (14% of the soil samples) were prepared for the verification analysis at Severn-Trent Laboratory. Table F.7 compares the results for carbon tetrachloride and chloroform in the soil samples analyzed at both laboratories.

Analytical data for soils from the AGEM Laboratory are supported by the data from Severn-Trent Laboratory. No contamination was detected by either laboratory in sample CNSB13-S-16258. Similar consistency is evident for the other samples over the range of reported contaminant concentrations. The somewhat higher concentrations reported by Severn-Trent than by the AGEM Laboratory for carbon tetrachloride (and especially for chloroform) in some samples are consistent with the expected heterogeneity of the soil matrix and the high recoveries reported by Severn-Trent for associated laboratory control samples.

F.3 Quality Control for Organic Analysis of Water Samples

Eight groundwater samples (and one additional blind field replicate sample) were collected at eight ECPT locations (SB16, SB18-SB22, SB24, and SB24A). These samples and the associated QC samples were shipped immediately to the AGEM Laboratory for analysis with EPA Method 524.2 (EPA 1986). As one measure of the precision of the analytical process, samples were selected by the laboratory for duplicate analyses. To verify the accuracy of the analytical results obtained with EPA Method 524.2, duplicate (split) samples were collected for verification analysis at Clayton Laboratory with CLP methodology (EPA 1989). On the basis of the results it obtained, the AGEM Laboratory selected duplicate samples for the verification analysis.

The following sections describe QC measures followed during analysis of the water samples and the quality of the organic analytical data from each laboratory. Analytical data from the AGEM Laboratory are discussed in Section F.3.1, and analytical data from Clayton Laboratory are discussed in Section F.3.2. Analytical results from the two laboratories are compared in Section F.3.3.

F.3.1 Organic Analysis of Water Samples at the AGEM Laboratory

Water samples shipped to the AGEM Laboratory were analyzed by the purge-and-trap GC-MS method. For these analyses, the VOCs present in the groundwater sample were extracted (purged) from the sample matrix by bubbling an inert gas through the sample. The purged components were trapped in a specified sorbent tube. After the purging, the sorbent tube was heated and backflushed with an inert gas to desorb the components into the GC-MS system. The compounds eluting from the GC column were identified by retention time and by comparison with reference library spectra. The concentration of each component was calculated by comparison of the MS response for the quantitation ion to the response for corresponding calibration curves and/or internal standards. The internal standard recovery limits were 80-120%. If the internal standard recovery was outside these limits, the data were flagged accordingly. Calibration checks with each SDG were required to be within ±20% of the standard.

Water samples submitted to the AGEM Laboratory for organic analysis were analyzed in six SDGs, as shown in Table F.8. The QA/QC procedures followed included analysis of

instrument calibration check standards, analysis of laboratory blanks, monitoring of surrogate spike recovery, and duplicate laboratory analyses. Significant results include the following:

- Samples shipped to the AGEM Laboratory were received with custody seals intact and at the appropriate temperature. All samples were analyzed within required holding times.

- Contaminants of concern were not detected in laboratory method blanks analyzed with the samples.

- For each SDG, analytical instrument calibration was monitored by the analysis of calibration check standards. Table F.8 shows the RPD values between the known and calculated concentrations of the standards. The concentrations of calibration check standards measured in all SDGs were within the acceptable range of ±20%.

- Surrogate standard determinations were performed on samples and blanks by using the surrogate spike compounds fluorobenzene, 1,2-dichlorobenzene-d_4, and 4-bromofluorobenzene. Table F.8 shows the percent recovery values for these system-monitoring compounds for each of the analyses. With the exceptions described below, the surrogate recoveries were within the specified range of 80-120% for all water samples, either in the initial analysis of the sample or in a successful reanalysis.

  - In the secondary QC analyses of sample CNSB24-W-15425 (vial 2) in SDG 03-4-2 and sample CNSB24-W-15426 (vial 2) in SDG 03-4-3, recovery of two of the three surrogate compounds was below 80%. The results for these analyses were not used in the QA/QC evaluation of the reported analytical data.

  - In the analysis of trip blank CNQCTB-W-16307 in SDG 03-4-8, the recovery of all of the three surrogate compounds was below the QC limit of 80%. A second aliquot of the trip blank was broken during shipment. Because no contamination was detected in two of the three water samples shipped with the trip blank, cross-contamination during shipment is not indicated. The data for the trip blank are accepted without qualification. Samples shipped under

COC 3618 with trip blank CNQCTB-W-16307 included groundwater samples CNSB24A-W-16304 and CNSB22A-W-16306 (Table D.3) and rinsate CNSB24A-W-16305 (Table F.2).

- As a measure of consistency in the sampling and analytical methodologies, dual analyses of water samples collected at four sampling locations were accomplished through the analysis of blind replicate samples submitted to the laboratory or the duplicate analysis of samples selected by the laboratory. Table F.9 summarizes the analytical results for the primary samples and their associated replicate or duplicate analyses. Agreement is acceptable in general, indicating consistency in both the sampling and analytical methodologies. Noteworthy results are as follows:

  - For groundwater samples from locations SB20, SB21, and SB22, carbon tetrachloride or chloroform were detected in neither the primary analyses nor the associated duplicate analyses.

  - In the primary analysis of the groundwater sample and replicate from location SB24, similar contaminant concentrations were detected (2.3 µg/L in sample CNSB24-W-15425 and 3.9 µg/L in replicate CNSB24-W-15426). However, in subsequent secondary QC analyses of different aliquots of the sample and replicate, variability was evident in the detected concentrations. This variability is considered to be related to the excessive turbidity noted during sample collection rather than to analytical methodology.

The analytical data from the AGEM Laboratory are acceptable for quantitative determination of contaminant distribution in groundwater.

F.3.2 Organic Analysis of Water Samples at Clayton Laboratory

In accordance with the QA/QC procedures defined in the *Master Work Plan* (Argonne 2002b), the analyses of water samples at the AGEM Laboratory with EPA Method 524.2 were verified by analyses with EPA-defined CLP methodology. On the basis of its results, the AGEM Laboratory selected replicate samples (identified in Table F.1) for the CLP verification analysis.

The results from the two laboratories are compared in Section F.3.3. Below is a discussion of the quality of the organic analytical data obtained with CLP methodology.

Two groundwater samples (the primary sample from location SB24 and its blind field replicate) were shipped to Clayton Laboratory for organic analysis with CLP methodology. The samples were sent in one shipment with a trip blank. A complete data package was provided as SDG 3040144-AR164. The QA/QC procedures followed in the CLP analysis included initial and continuing calibration of instruments, analysis of laboratory blanks, monitoring of surrogate spike recovery, and matrix spike/matrix spike duplicate analyses. Significant results include the following:

- Samples shipped to the CLP laboratory were received with custody seals intact and at the appropriate temperature. All samples were analyzed within required holding times.

- Analytical instruments were tuned properly; initial and continuing calibration checks remained within the allowable range.

- Contaminants of concern were not detected in the trip blank or the laboratory method blanks. Acetone and 2-butanone were present at low concentrations in the trip blank. Bromomethane, acetone, methyl acetate, and 2-butanone were present at low concentrations in laboratory blanks.

- Surrogate standard determinations were performed on samples and blanks by using the surrogate spike compounds toluene-d_8, 4-bromofluorobenzene, and 1,2-dichloroethane-d_4. Table F.10 shows the percent recovery of the system-monitoring compounds for each of the CLP analyses. For all analyses, recovery of the surrogate spikes was within the acceptable range (identified in Table F.10) specific to each surrogate.

- To evaluate the matrix effect of samples on the analytical methodology, a matrix spike/matrix spike duplicate analysis was performed in accordance with CLP protocol by using matrix spike compounds 1,1-dichloroethene, trichloroethene, chlorobenzene, toluene, and benzene. Table F.11 shows the percent recovery of each spike compound in this analysis, as well as the calculated RPD values

between the spike and spike duplicate results. The QC limits were met for the analyses.

Organic analytical data from Clayton Laboratory for the replicate groundwater samples are acceptable for comparison with the AGEM Laboratory data.

F.3.3 Verification Organic Analysis of Water Samples

In accordance with the QA/QC procedures defined in the *Master Work Plan* (Argonne 2002b), selected replicates of the groundwater samples analyzed at the AGEM Laboratory with EPA Method 524.2 were subjected to verification analysis with EPA-defined CLP methodology. Two of the nine groundwater samples analyzed at the AGEM Laboratory (22% of the groundwater samples) were subjected to this verification analysis. Table F.12 compares the results for carbon tetrachloride and chloroform obtained by the two laboratories for these samples.

Analytical results for water samples analyzed at the AGEM Laboratory with EPA Method 524.2 are supported by the analytical results for replicate samples analyzed at Clayton Laboratory with EPA CLP methodology.

F.4 Quality Control for Tritium Analyses of Groundwater Samples

Selected groundwater samples were analyzed for tritium at the University of Miami Tritium Laboratory. Tritium concentrations were reported on the basis of the U.S. National Institute of Science and Technology tritium water standard #4926, as measured on September 3, 1961, and again on September 3, 1978, with a half-life of 12.32 years (revised January 2002). Concentrations were reported in tritium units (TU), equivalent to 3.193 picocuries per kilogram of water. Because counting efficiency and background concentration are different for each instrument, the reported concentrations were corrected for cosmic intensity and gas pressure. Typical efficiencies are equivalent to 1 count per minute (cpm) per TU. Background is about 0.3 cpm, known to ±0.02 cpm. The tritium data are acceptable for age-dating of groundwaters.

TABLE F.1 Quality control samples collected during the Phase II investigation at Centralia, Kansas.

Location	Sample	Depth (ft BGL)	Sample Date	Sample Description
Equipment rinsates				
QC	CNSB16-W-15428	-	03/31/03	Rinsate of ECPT sampling bailer after collection of sample CNSB16-W-15427.
QC	CNQCRI-W-15430	-	04/01/03	Rinsate of ECPT sampling bailer after collection of sample CNSB18-W-15429.
QC	CNSB24A-W-16305	-	04/05/03	Rinsate of ECPT sampling bailer after collection of sample CNSB24A-W-16304.
Trip blanks sent to AGEM Laboratory with soil samples for organic analysis				
QC	CNQCTB-S-15417	-	04/02/03	Trip blank sent to AGEM Laboratory with soil samples listed on COCs 1088 and 3617.
QC	CNQCTB-S-16266	-	04/03/03	Trip blank sent to AGEM Laboratory with soil samples listed on COCs 983 and 984.
QC	CNQCTB-S-16264	-	04/04/03	Trip blank sent to AGEM Laboratory with soil samples listed on COCs 985 and 986.
QC	CNQCTB-S-15464	-	04/05/03	Trip blank sent to AGEM Laboratory with soil samples listed on COC 987.
Trip blank sent to Severn Trent Laboratory with soil samples for verification organic analysis				
QC	CNTB-041003	-	04/10/03	Trip blank sent to Severn Trent Laboratory with soil samples listed on COC 123.
Trip blanks sent to AGEM Laboratory with water samples for organic analysis				
QC	CNQCTB-W-15436	-	04/01/03	Trip blank sent to AGEM Laboratory with water samples listed on COC 3225.
QC	CNQCTB-W-15431	-	04/01/03	Trip blank sent to AGEM Laboratory with water samples listed on COC 2210.
QC	CNQCTB-W-15433	-	04/03/03	Trip blank sent to AGEM Laboratory with water samples listed on COC 2211.
QC	CNQCTB-W-15469	-	04/04/03	Trip blank sent to AGEM Laboratory with water samples listed on COC 998.
QC	CNQCTB-W-16307	-	04/07/03	Trip blank sent to AGEM Laboratory with water samples listed on COC 3618.
Trip blank sent to Clayton Laboratory with water samples for verification organic analysis				
QC	CNTB-040303	-	04/03/03	Trip blank sent to Clayton Laboratory with water samples listed on COC 130.

TABLE F.1 (Cont.)

Location	Sample	Depth (ft BGL)	Sample Date	Sample Description
Blind field replicate soil samples				
SB11	CNQCDU-S-15462	24.9-25.1	04/05/03	Replicate of sample CNSB11-S-16297.
SB12	CNQCDU-S-15461	24.9-25.1	04/04/03	Replicate of sample CNSB12-S-16287.
SB13	CNQCDU-S-16267	14.9-15.1	04/03/03	Replicate of sample CNSB13-S-15458.
SB14	CNQCDU-S-15460	24.9-25.1	04/04/03	Replicate of sample CNSB14-S-16273.
SB15	CNQCDU-S-15422	9.9-10.1	04/02/03	Replicate of sample CNSB15-S-15442.
SB15	CNQCDU-S-15424	24.9-25.0	04/02/03	Replicate of sample CNSB15-S-15444.
Soil samples selected by the AGEM Laboratory for duplicate organic analysis				
SB11	CNSB11-S-16298	29.9-30.1	04/05/03	Light olive-brown clay with scattered coarse sand and some small gravel. Some iron oxide.
SB12	CNSB12-S-16286	19.6-19.8	04/04/03	Silty clay with sand; selectively oxidized; calcareous with heavy precipitated carbonate material.
SB12	CNQCDU-S-15461	24.9-25.1	04/04/03	Replicate of sample CNSB12-S-16287, described as silty clay with sand; selectively oxidized; calcareous with heavy precipitated carbonate material.
SB12	CNSB12-S-16288	29.9-30.1	04/04/03	Pale brown silty clay with sand; calcareous, damp to moist.
SB12	CNSB12-S-16290	39.6-39.8	04/04/03	Pale brown silty clay with sand, fine to coarse grained; highly calcareous, medium plasticity.
SB13	CNSB13-S-15456	4.9-5.1	04/03/03	Fine, dark grayish brown sandy clay.
SB14	CNSB14-S-16269	9.9-10.1	04/04/03	Yellowish brown, sandy clay; calcareous with white powdery calcareous inclusions.
SB15	CNSB15-S-15443	19.6-19.8	04/02/03	Light brownish, gray sandy clay with medium coarse sand. Marked reduction in oxidation, but still highly calcareous.
Soil samples selected for verification organic analysis at Severn-Trent Laboratory				
SB11	CNSB11-S-16295	14.9-15.1	04/05/03	Yellowish brown, silty clay with sand and granular gravel; oxidized; calcareous.
SB12	CNSB12-S-16286	19.6-19.8	04/04/03	Silty clay with sand; selectively oxidized; calcareous with heavy precipitated carbonate material.
SB12	CNSB12-S-16290	39.6-39.8	04/04/03	Pale brown silty clay with sand, fine to coarse grained; highly calcareous, medium plasticity.

TABLE F.1 (Cont.)

Location	Sample	Depth (ft BGL)	Sample Date	Sample Description
Soil samples selected for verification organic analysis at Severn-Trent Laboratory (Cont.)				
SB13	CNSB13-S-16258	19.6-19.8	04/03/03	Brown clay with some very fine sand.
SB14	CNSB14-S-16278	29.9-30.1	04/04/03	Pale brown, calcareous, sandy clay with minor small granular gravel. Damp.
SB24	CNSB24-S-15419	29.9-30.1	04/02/03	Pale brown, fine to medium sandy clay with minor granular gravel; slightly calcareous; slightly damp.
SB24	CNSB24-S-15420	34.9-35.1	04/02/03	Very sandy, highly oxidized, highly calcareous brown to dark brown clay; slightly damp, crumbly in part.
SB24	CNSB24-S-15421	39.8-39.9	04/02/03	Very sandy, highly oxidized, highly calcareous, brown to dark brown clay and gravel; slightly damp, crumbly.
Blind field replicate groundwater sample				
SB24	CNSB24-W-15426	40.9-45.9	03/31/03	Replicate of sample CNSB24-W-15425.
Water samples selected by the AGEM Laboratory for duplicate organic analysis				
SB20	CNSB20-W-15432	46.0-49.0	04/01/03	Screened ECPT hole.
SB21	CNSB21-W-15468	44.2-49.2	04/04/03	ECPT push sample.
SB22	CNSB22A-W-16306	30.5-35.5	04/05/03	Sample from temporary piezometer.
SB24	CNSB24-W-15425	40.9-45.9	03/31/03	Primary sample from location; all four aliquots analyzed.
SB24	CNSB24-W-15426	40.9-45.9	03/31/03	Replicate of sample CNSB24-W-15425. All four aliquots of sample analyzed.
Water samples selected for verification organic analysis at Clayton Laboratory				
SB24	CNSB24-W-15425	40.9-45.9	03/31/03	Abundant water recovery.
SB24	CNSB24-W-15426	40.9-45.9	03/31/03	Replicate of sample CNSB24-W-15425.

TABLE F.2 Results of organic analyses on quality control samples collected to monitor sample collection and handling activities during the Phase II field investigation at Centralia, Kansas.

		Concentration (µg/L in water; µg/kg in soil)		
Sample	Sample Date	Carbon Tetrachloride	Chloroform	Quantitation Limit
Equipment rinsates				
CNSB16-W-15428	3/31/03	ND[a]	ND	1.0
CNQCRI-W-15430	4/1/03	ND	ND	1.0
CNSB24A-W-16305	4/5/03	ND	ND	1.0
Trip blanks sent to the AGEM Laboratory with soil samples for organic analysis				
CNQCTB-S-15417	4/2/03	ND	ND	10.0
CNQCTB-S-16266	4/3/03	ND	ND	10.0
CNQCTB-S-16264	4/4/03	ND	ND	10.0
CNQCTB-S-15464	4/5/03	NA[b]	NA	10.0
Trip blank sent to Severn-Trent Laboratory with soil samples for verification organic analysis				
CNTB-041003	4/10/03	ND	11[c]	10.0
Trip blanks sent to the AGEM Laboratory with water samples for organic analysis				
CNQCTB-W-15431	4/1/03	ND	ND	1.0
CNQCTB-W-15436	4/1/03	ND	ND	1.0
CNQCTB-W-15433	4/3/03	ND	ND	1.0
CNQCTB-W-15469	4/4/03	ND	ND	1.0
CNQCTB-W-16307 [d]	4/7/03	ND	ND	1.0
Trip blank to Clayton Laboratory with water samples for verification organic analysis				
CNTB-040303	4/3/03	ND	ND	5.0

[a] ND, not detected at the quantitation limit indicated.

[b] NA, trip blank not analyzed because of a documentation error.

[c] Recovery of chloroform above QC limit in QC analysis.

[d] Recovery of surrogate compounds below QC limit during sample analysis.

TABLE F.3 Results of organic analyses on quality control samples collected to monitor soil analyses by the purge-and-trap method at the AGEM Laboratory.

				Measured Values for Calibration Check Standards			
	Recovery of Surrogate Compounds[a] (%)			Carbon Tetrachloride		Chloroform	
Sample	Fluorobenzene	1,2-Dichloro-benzene-d_4	4-Bromo-fluorobenzene	Concentration (µg/kg)	RPD[b]	Concentration (µg/kg)	RPD[b]
SDG 03-4-7, analysis date April 7, 2003							
20-µg/kg standard	100	109	96	18.57	7.4	20.6	2.9
Methanol blank	94	93	93				
CNQCDU-S-15424	101	104	104				
CNSB15-S-15442	101	104	105				
CNQCDU-S-15422	99	108	105				
CNSB15-S-15465	96	105	102				
CNSB15-S-15441	105	112	109				
CNSB15-S-15443	92	98	95				
CNSB15-S-15443DUP	87	94	90				
CNSB24-S-15419	80	75[c]	76[c]	Reanalyzed on April 10 without error.			
CNSB24-S-15421	90	100	98				
CNSB15-S-15444	87	96	92				
CNSB24-S-15420	90	101	98				
CNSB15-S-15423	84	89	85				
CNSB24-S-15440	83	89	86				
CNSB24-S-15439	82	88	85				
SDG 03-4-8, analysis date April 8, 2003							
20-µg/kg standard	91	86	93	18.7	6.7	21.55	7.5
Methanol blank	100	100	100				
CNSB24-S-15418	102	103	101				
CNSB24-S-15438	98	98	97				

TABLE F.3 (Cont.)

Sample	Recovery of Surrogate Compounds[a] (%)			Measured Values for Calibration Check Standards			
				Carbon Tetrachloride		Chloroform	
	Fluorobenzene	1,2-Dichloro-benzene-d_4	4-Bromo-fluorobenzene	Concentration (µg/kg)	RPD[b]	Concentration (µg/kg)	RPD[b]
SDG 03-4-8, analysis date April 8, 2003 (Cont.)							
CNSB24-S-15437	94	100	98				
CNQCTB-S-15417	101	111	112				
SDG 03-4-9, analysis date April 9, 2003							
20-µg/kg standard	100	105	112	18.67	6.9	21.67	8
Methanol blank	118	113	116				
CNSB11-S-16302	132[c]	113	123[c]	Reanalyzed on April 10 without error.			
CNSB11-S-16294	101	105	104				
CNSB13-S-16262	76[c]	81	79[c]	Reanalyzed on April 10 without error.			
CNSB11-S-16301	114	115	115				
CNSB11-S-16295	108	104	105				
CNSB11-S-16296	105	103	103				
CNSB14-S-16269	111	104	107				
CNSB14-S-16269DUP	102	105	108				
CNSB11-S-16297	87	66[c]	74[c]	Reanalyzed on April 10 without error.			
CNSB11-S-16303	100	101	103				
CNSB13-S-16260	95	91	93				
CNSB13-S-16258	100	102	102				
CNSB11-S-16300	86	90	87				
CNSB14-S-16268	100	108	101				

TABLE F.3 (Cont.)

Sample	Recovery of Surrogate Compounds[a] (%)			Measured Values for Calibration Check Standards			
				Carbon Tetrachloride		Chloroform	
	Fluorobenzene	1,2-Dichloro-benzene-d_4	4-Bromo-fluorobenzene	Concentration (µg/kg)	RPD[b]	Concentration (µg/kg)	RPD[b]
SDG 03-4-10, analysis date April 10, 2003							
20-µg/kg standard	100	129[c]	120	17.5	13.3	21.16	5.6
Methanol blank	100	100	100				
CNQCDU-S-15462	99	92	93				
CNSB14-S-16270	108	106	105				
CNSB14-S-16271	100	105	103				
CNQCDU-S-15460	104	106	104				
CNSB13-S-15457	95	93	93				
CNSB11-S-16293	98	95	94				
CNSB14-S-16273	93	91	91				
CNSB13-S-15456	98	95	95				
CNSB13-S-15456DUP	107	114	111				
CNSB11-S-16302	104	105	102				
CNSB13-S-16262	92	93	90				
CNSB11-S-16297	95	94	91				
CNSB24-S-15419	100	108	102				
SDG 03-4-11, analysis date April 11, 2003							
20-µg/kg standard	95	92	119	17.88	11.2	21.6	7.7
Methanol blank	100	100	100				
CNQCDU-S-16267	97	92	94				
CNSB13-S-16259	90	93	93				
CNSB13-S-15459	111	99	104				
CNSB14-S-16272	96	94	98				
CNSB13-S-15458	91	92	92				

TABLE F.3 (Cont.)

Sample	Recovery of Surrogate Compounds[a] (%)			Measured Values for Calibration Check Standards			
				Carbon Tetrachloride		Chloroform	
	Fluorobenzene	1,2-Dichloro-benzene-d_4	4-Bromo-fluorobenzene	Concentration (µg/kg)	RPD[b]	Concentration (µg/kg)	RPD[b]
SDG 03-4-11, analysis date April 11, 2003 (Cont.)							
CNSB11-S-16299	105	101	106				
CNSB11-S-16298	89	92	91				
CNSB11-S-16298DUP	90	93	92				
CNSB13-S-16261	108	99	105				
CNSB12-S-16289	91	94	95				
CNSB12-S-16292	94	99	96				
CNSB12-S-16291	95	102	103				
CNSB14-S-16281	94	100	101				
CNSB12-S-16287	81	86	85				
SDG 03-4-14, analysis date April 14, 2003							
20-µg/kg standard	99	109	127[c]	22.95	13.7	28.02	33.4[c]
20-µg/kg standard #2	99	109	109	(Not applicable)		19.79	1.1
Methanol blank	100	100	100				
CNQCTB-S-16266	99	107	111				
CNSB12-S-16283	98	107	106				
CNSB12-S-16285	105	112	110				
CNSB12-S-16284	94	98	99				
CNQCDU-S-15461	89	95	94				
CNSB14-S-16279	103	110	110				
CNSB14-S-16280	90	97	95				
CNSB14-S-16280DUP	78[c]	83	81	Not reported. Surrogate out of range.			
CNSB12-S-16288	86	92	90				
CNSB14-S-16282	90	96	93				
CNSB14-S-16278	86	91	89				

TABLE F.3 (Cont.)

Sample	Recovery of Surrogate Compounds[a] (%)			Measured Values for Calibration Check Standards			
				Carbon Tetrachloride		Chloroform	
	Fluorobenzene	1,2-Dichloro-benzene-d_4	4-Bromo-fluorobenzene	Concentration (µg/kg)	RPD[b]	Concentration (µg/kg)	RPD[b]
SDG 03-4-14, analysis date April 14, 2003 (Cont.)							
CNSB12-S-16286	84	92	90				
CNSB12-S-16290	84	89	86				
CNQCTB-S-16264	87	91	92				
SDG 03-4-16, analysis date April 16, 2003							
20-µg/kg standard	100	104	122[c]	16	22.2[c]	20.05	0.2
Methanol blank	100	100	100				
CNQCDU-S-15461RE	102	103	101				
CNQCDU-S-15461REDUP	97	101	99				
CNSB12-S-16288DUP	101	106	104				
CNSB12-S-16286DUP	97	100	98				
CNSB12-S-16290DUP	96	101	96				

[a] Quality control limits for recovery of surrogate compounds: 80-120%.

[b] Quality control limits for RPD for calibration check standards: ±20%.

[c] Surrogate recovery outside quality control limit.

TABLE F.4 Results of dual organic analyses on soil samples by the purge-and-trap method at the AGEM Laboratory.

				Concentration (µg/kg)	
Location	Depth (ft BGL)	Sample	Analysis Type	Carbon Tetrachloride	Chloroform
SB11	24.9-25.1	CNSB11-S-16297	Primary sample	ND[a]	ND
		CNQCDU-S-15462	Replicate	ND	ND
SB11	29.9-30.1	CNSB11-S-16298	Primary sample	16	ND
		CNSB11-S-16298DUP	Duplicate analysis	18	ND
SB12	19.6-19.8	CNSB12-S-16286	Primary sample	45	7.1 J[b]
		CNSB12-S-16286DUP	Duplicate analysis[c]	48	6.5 J
SB12	24.9-25.1	CNSB12-S-16287	Primary sample	93	7.7 J
		CNQCDU-S-15461	Replicate	124	7.2 J
		CNQCDU-S-15461RE	Duplicate analysis[c]	142	6.9 J
		CNQCDU-S-15461REDUP	Duplicate analysis[c]	143	7.5 J
SB12	29.9-30.1	CNSB12-S-16288	Primary sample	219	6.4 J
		CNSB12-S-16288DUP	Duplicate analysis[c]	223	5 J
SB12	39.6-39.8	CNSB12-S-16290	Primary sample	202	3.3 J
		CNSB12-S-16290DUP	Duplicate analysis[c]	196	1.9 J
SB13	4.9-5.1	CNSB13-S-15456	Primary sample	ND	ND
		CNSB13-S-15456DUP	Duplicate analysis	ND	ND
SB13	14.9-15.1	CNSB13-S-15458	Primary sample	ND	ND
		CNQCDU-S-16267	Replicate	ND	ND
SB14	9.9-10.1	CNSB14-S-16269	Primary sample	ND	ND
		CNSB14-S-16269DUP	Duplicate analysis	ND	ND
SB14	24.9-25.1	CNSB14-S-16273	Primary sample	8.8 J	ND
		CNQCDU-S-15460	Replicate	6.3 J	ND
SB15	9.9-10.1	CNSB15-S-15442	Primary sample	ND	ND
		CNQCDU-S-15422	Replicate	ND	ND
SB15	19.6-19.8	CNSB15-S-15443	Primary sample	28	ND
		CNSB15-S-15443DUP	Duplicate analysis	31	ND
SB15	24.9-25.0	CNSB15-S-15444	Primary sample	6.6 J	ND
		CNQCDU-S-15424	Replicate	7.1 J	ND

[a] ND, contaminant not detected.

[b] J, estimated concentration below quantitation limit of 10 µg/kg for purge-and-trap GC-MS analysis.

[c] Instrument calibration above 120% QC limit.

TABLE F.5 Recovery of system-monitoring compounds in verification organic analyses of soil samples with EPA Method 8260B at Severn-Trent Laboratory.

Sample	Analysis Date	Sample Delivery Group	Recovery[a] (%)			
			Toluene-d_8	1,2-Dichloro-ethane-d_4	Bromofluoro-benzene	1,2-Dichloro-benzene-d_4
LAQD LCS	4/22/03	93017	93	101	92	94
LAQD LCSD	4/22/03	93017	98	107	95	98
VBLKT7	4/22/03	93017	99	112	98	99
MEOH LCS	4/22/03	93017	97	110	98	96
MEOH BLANK	4/22/03	93017	96	105	100	96
CNTB-041003	4/22/03	93017	100	109	104	102
CNSB24-S-15419	4/22/03	93017	97	107	97	96
CNSB11-S-16295	4/22/03	93017	96	103	98	96
CNSB13-S-16258	4/22/03	93017	97	102	99	96
CNSB24-S-15420	4/22/03	93017	90	99	92	93
CNSB24-S-15420MS	4/22/03	93017	96	100	100	96
CNSB24-S-15420MSD	4/22/03	93017	94	104	98	93
CNSB12-S-16286	4/22/03	93017	96	100	101	94
CNSB12-S-16290	4/22/03	93017	94	104	100	96
CNSB14-S-16278	4/23/03	93017	96	103	99	95
CNSB24-S-15421	4/23/03	93017	95	101	99	95

[a] Quality control limits for recovery are as follows:

Analyte	QC Limits (%)
Toluene-d_8	81-117
1,2-Dichloroethane-d_4	80-120
Bromofluorobenzene	74-121
1,2-Dichlorobenzene-d_4	80-120

TABLE F.6 Recovery and relative percent difference values for spike/spike duplicate organic analyses of soil samples in SDG 93017 at Severn-Trent Laboratory.

Compound	Concentration (µg/kg)				Recovery (%)			Difference (%)	
	Sample	Spike Added	Spike Analysis	Duplicate Analysis	Spike Analysis	Duplicate Analysis	Q C Limit	R PD	Q C Limit
Spike/spike duplicate analysis of laboratory sample LAQD LCS									
Chloroform	0	10	11	11	110[a]	110[a]	74-106	0	40
Carbon tetrachloride	0	10	10	10	100	98	62-106	2	40
Spike analysis of laboratory sample MEOH LCS									
Chloroform	0	1,000	1,053	NA[b]	105	NA	74-106	NA	40
Carbon tetrachloride	0	1,000	970	NA	97	NA	62-106	NA	40
Spike/spike duplicate analysis of subsurface soil sample CNSB24-S-15420									
Chloroform	0	87	94	96	108[a]	110[a]	74-106	2	40
Carbon tetrachloride	78	87	170	180	103	109[a]	62-106	6	40

[a] Outside specified quality control limit.

[b] NA, spike duplicate analysis not performed.

TABLE F.7 Results of organic analyses on soil samples analyzed at both the AGEM Laboratory and Severn-Trent Laboratory.

Location	Sample	Depth (ft BGL)	Carbon Tetrachloride (µg/kg)		RPD (%)	Chloroform (µg/kg)		RPD (%)
			AGEM	STL[a]		AGEM	STL[a]	
SB11	CNSB11-S-16295	14.9-15.1	11	11	0	ND[b]	1.7 J[c]	-
SB12	CNSB12-S-16286	19.6-19.8	45	64[d]	34.8	7.1 J	17[d]	82
SB12	CNSB12-S-16290	39.6-39.8	202	240	17.2	3.3 J	12	114
SB13	CNSB13-S-16258	14.9-15.1	ND	ND	0	ND	ND	0
SB14	CNSB14-S-16278	29.9-30.1	14	18	25	ND	10	-
SB24	CNSB24-S-15419	29.9-30.1	97	170	54.7	ND	7.5 J	-
SB24	CNSB24-S-15420	34.9-35.1	58	78[d]	29.4	ND	ND[d]	0
SB24	CNSB24-S-15421	39.8-39.9	59	46	24.7	ND	1.8 J	-

[a] High recovery in spike/spike duplicate quality control samples.

[b] ND, contaminant not detected.

[c] J, estimated concentration below quantitation limit of 10 µg/kg for the purge-and-trap method.

[d] Potential for carryover because of prior analysis of spiked quality control sample at a higher concentration than recommended for low-level analysis.

TABLE F.8 Results of organic analyses on quality control samples collected to monitor water analyses at the AGEM Laboratory by the purge-and-trap method.

				Measured Values for Calibration Check Standards			
	Recovery of Surrogate Compounds[a] (%)			Carbon Tetrachloride		Chloroform	
Sample	Fluorobenzene	1,2-Dichloro-benzene-d_4	4-Bromo-fluorobenzene	Concentration (µg/L)	RPD[b]	Concentration (µg/L)	RPD[b]
SDG 03-4-2, analysis date April 2, 2003							
20-µg/L standard	82	84	81	20.57	2.8	22.43	11.5
Laboratory blank	91	87	86				
CNSB24-W-15425-V1	106	108	105				
CNSB16-W-15427	112	117	114				
CNSB19-W-15435	91	99	96				
CNSB24-W-15426-V1	103	115	112				
CNQCTB-W-15436	85	88	86				
CNSB16-W-15428	104	110	107				
CNSB24-W-15425-V2	86	91	87				
CNSB24-W-15425-V2DUP	76[c]	80	73[c]	Not reported. Surrogate out of range.			
CNSB24-W-15425-V3	94	94	92				
CNSB24-W-15425-V3DUP	96	99	95				
CNSB24-W-15425-V4	106	115	112				
CNSB24-W-15425-V4DUP	93	95	94				
SDG 03-4-3, analysis date April 3, 2003							
20-µg/L standard	96	98	85	17.59	12.8	20.56	2.8
Laboratory blank	101	98	97				
CNSB20-W-15432	104	102	106				
CNSB18-W-15429	94	101	99				
CNQCRI-W-15430	97	100	97				
CNQCTB-W-15431	84	85	83				
CNSB20-W-15432DUP	87	93	90				
CNSB24-W-15426-V2	91	103	97				
CNSB24-W-15426-V2DUP	85	73[c]	75[c]	Not reported. Surrogate out of range.			

TABLE F.8 (Cont.)

Sample	Recovery of Surrogate Compounds[a] (%)			Measured Values for Calibration Check Standards			
				Carbon Tetrachloride		Chloroform	
	Fluorobenzene	1,2-Dichloro-benzene-d_4	4-Bromo-fluorobenzene	Concentration (µg/L)	RPD[b]	Concentration (µg/L)	RPD[b]
SDG 03-4-3, analysis date April 3, 2003 (Cont.)							
CNSB24-W-15426-V3	107	118	113				
CNSB24-W-15426-V3DUP	88	94	90				
CNSB24-W-15426-V4	103	118	111				
CNSB24-W-15426-V4DUP	87	97	93				
SDG 03-4-4, analysis date April 4, 2003							
20-µg/L standard	112	108	93	20.85	4.2	24.08	18.5
Laboratory blank	92	95	95				
CNSB22-W-15467	101	102	105	Sample rejected as potentially nonrepresentative.			
CNSB22-W-15467DUP	96	101	100	Sample rejected as potentially nonrepresentative.			
CNQCTB-W-15433	102	103	106				
SDG 03-4-5, analysis date April 5, 2003							
20-µg/L standard	99	93	92	20.06	0.3	21.99	9.5
Laboratory blank	92	95	95				
CNSB21-W-15468	91	93	96				
CNSB21-W-15468DUP	93	100	97				
CNQCTB-W-15469	94	0[c]	0[c]	Reanalyzed on April 7 without error.			

TABLE F.8 (Cont.)

Sample	Recovery of Surrogate Compounds[a] (%)			Measured Values for Calibration Check Standards			
				Carbon Tetrachloride		Chloroform	
	Fluorobenzene	1,2-Dichloro-benzene-d_4	4-Bromo-fluorobenzene	Concentration (µg/L)	RPD[b]	Concentration (µg/L)	RPD[b]
SDG 03-4-7, analysis date April 7, 2003							
20-µg/L standard	100	109	96	18.57	7.4	20.6	2.9
Laboratory blank	95	107	99				
CNQCTB-W-15469	101	112	105				
SDG 03-4-8, analysis date April 8, 2003							
20-µg/L standard	91	86	93	18.7	6.7	21.55	7.5
Laboratory blank	100	100	100				
CNSB24A-W-16304	97	101	101				
CNSB22A-W-16306	96	99	97				
CNSB22A-W-16306DUP	98	96	98				
CNSB24A-W-16305	90	94	93				
CNQCTB-W-16307	71[c]	75[c]	70[c]	Not reanalyzed. Accepted.			

[a] Quality control limits for recovery of surrogate compounds: 80-120%.

[b] Quality control limits for RPD for calibration check standards: ±20%.

[c] Surrogate recovery outside quality control limit.

TABLE F.9 Results of dual organic analyses on groundwater samples at the AGEM Laboratory by the purge-and-trap method.

				Concentration (µg/L)	
Location	Depth (ft BGL)	Sample	Analysis Type	Carbon Tetrachloride	Chloroform
SB20	46-49	CNSB20-W-15432	Primary sample	ND[a]	ND
		CNSB20-W-15432DUP	Duplicate analysis	ND	ND
SB21	44.2-49.2	CNSB21-W-15468	Primary sample	ND	ND
		CNSB21-W-15468DUP	Duplicate analysis	ND	ND
SB22	30.5-35.5	CNSB22A-W-16306	Primary sample	ND	ND
		CNSB22A-W-16306DUP	Duplicate analysis	ND	ND
SB24	40.9-45.9	CNSB24-W-15425-V1	Primary sample	2.3	6.9
		CNSB24-W-15425-V2	Duplicate analysis	27	2.5
		CNSB24-W-15425-V3	Duplicate analysis	3.4	7.4
		CNSB24-W-15425-V3DUP	Duplicate analysis	3.2	7.7
		CNSB24-W-15425-V4	Duplicate analysis	20	2.7
		CNSB24-W-15425-V4DUP	Duplicate analysis	22	3.1
SB24	40.9-45.9	CNSB24-W-15426-V1	Replicate	3.9	7.5
		CNSB24-W-15426-V2	Duplicate analysis	12	7.8
		CNSB24-W-15426-V3	Duplicate analysis	24	4.3
		CNSB24-W-15426-V3DUP	Duplicate analysis	28	5.1
		CNSB24-W-15426-V4	Duplicate analysis	7.4	8.8
		CNSB24-W-15426-V4DUP	Duplicate analysis	8.4	10

[a] ND, contaminant not detected at the quantitation limit of 1.0 µg/L for the purge-and-trap method.

TABLE F.10 Recovery of system-monitoring compounds in organic analyses of water samples at Clayton Laboratory.

Sample	Analysis Date	Sample Delivery Group	Recovery[a] (%)		
			Toluene-d_8	Bromofluoro-benzene	1,2-Dichloro-ethane-d_4
VBLKBH	4/7/03	3040144-ARG167	104	94	102
CNSB24-W-15426	4/7/03	3040144-ARG167	104	98	108
CNSB24-W-15426MS	4/7/03	3040144-ARG167	104	98	104
CNSB24-W-15426MSD	4/7/03	3040144-ARG167	100	102	102
CNSB24-W-15425	4/7/03	3040144-ARG167	100	102	106
CN-TB-040303	4/7/03	3040144-ARG167	102	96	110
VHBLKBA	4/7/03	3040144-ARG167	106	98	110

[a] Quality control limits for recovery are as follows:

Analyte	QC Limits (%)
Toluene-d_8	88-110
Bromofluorobenzene	86-115
1,2-Dichloroethane-d_4	76-114

TABLE F.11 Recovery and relative percent difference values for spike/spike duplicate organic analyses of water samples at Clayton Laboratory with CLP methodology.

	Concentration (µg/L)				Recovery (%)			Difference (%)	
Compound	Sample	Spike Added	Spike Analysis	Duplicate Analysis	Spike Analysis	Duplicate Analysis	Q C Limit	R PD	Q C Limit
Spike/spike duplicate analysis of groundwater sample CNSB24-W-15426									
1,1-Dichloroethene	0	50	40	45	80	90	61-145	12	14
Trichloroethene	0	50	43	43	86	86	71-120	0	14
Benzene	0	50	46	47	92	94	76-127	2	11
Toluene	0	50	49	48	98	96	76-125	2	13
Chlorobenzene	0	50	48	48	96	96	75-130	0	13

TABLE F.12 Verification organic analyses on soil samples analyzed at both the AGEM Laboratory and Clayton Laboratory.

Location	Sample	Depth (ft BGL)	Carbon Tetrachloride (µg/L)		RPD (%)	Chloroform (µg/L)		RPD (%)
			AGEM	Clayton		AGEM	Clayton	
SB24	CNSB24-W-15425	40.9-45.9	2.3	5	73.9	6.9	11	45.8
SB24	CNSB24-W-15426	40.9-45.9	3.9	5	24.7	7.5	11	37.8