ANL/ER/TR-04/011

Final Report: 2004 Monitoring Well Installation and Sampling at Centralia, Kansas

prepared by
Environmental Research Division
Argonne National Laboratory

Argonne National Laboratory is managed by
The University of Chicago for the U. S. Department of Energy

United States Department of Agriculture
Work sponsored by Commodity Credit Corporation,
United States Department of Agriculture

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by
Applied Geosciences and Environmental Management Section
Environmental Research Division, Argonne National Laboratory

October 2005

Contents

Contents (Cont.)

Tables

Figures

Notation

AGEM	Applied Geosciences and Environmental Management
AMSL	above mean sea level
BGL	below ground level
°C	degrees Celsius
CCC	Commodity Credit Corporation
CLP	Contract Laboratory Program
COC	chain of custody
cpm	count(s) per minute
DO	dissolved oxygen
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
gal	gallon(s)
GC-MS	gas chromatograph(y)-mass spectrometer(-metry)
gpm	gallon(s) per minute
in.	inch(es)
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
mg/L	milligram(s) per liter
mi	mile(s)
mV	millivolt(s)
MW	monitoring well
ORP	oxidation-reduction potential
QA/QC	quality assurance/quality control
RPD	relative percent difference
SDG	sample delivery group
TOC	top of casing
TU	tritium unit(s)
USDA	U.S. Department of Agriculture
VOC	volatile organic compound

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Executive Summary

This document reports on monitoring well installation and sampling in 2004 at the location of a grain storage facility formerly operated in Centralia, Kansas, by the Commodity Credit Corporation (CCC) of the U.S. Department of Agriculture (USDA). Argonne National Laboratory is conducting environmental investigations of carbon tetrachloride contamination in groundwater at this site for the CCC/USDA.

With the approval of the Kansas Department of Health and Environment (KDHE), Argonne installed six monitoring wells at the former facility in July 2004 to supplement existing monitoring points (piezometers) installed during Argonne's Phase I investigation in 2002. Together, the monitoring wells and piezometers constitute a monitoring network designed to (1) confirm the lateral distribution of carbon tetrachloride in the groundwater, (2) track any migration of contaminants that might take place, and (3) monitor aquifer geochemical characteristics.

To verify that the six new monitoring wells had been developed adequately, they were sampled after their installation in July 2004 for analysis for volatile organic compounds (VOCs). The monitoring wells were sampled again in August 2004, after a stabilization period of four weeks. Five of the Phase I piezometers were also sampled in August 2004.

Results of analysis of the August 2004 groundwater samples for VOCs confirmed the Phase II investigation's findings (based on sampling in March and April 2003) that carbon tetrachloride contamination in groundwater is generally confined to the boundary of the former CCC/USDA facility. Little migration of contamination from the former facility has been evident. Nevertheless, the network of monitoring wells now in place may not be adequate to delineate the extent of the plume. Future expansion of the network will proceed per agreement between the CCC/USDA and the KDHE.

The groundwater samples collected in August 2004 were also analyzed for attenuation parameters that are helpful in determining whether the subsurface environment is suitable for natural *in situ* biodegradation of carbon tetrachloride. A preliminary screening of the results with

a protocol of the U.S. Environmental Protection Agency showed limited evidence for active reductive dechlorination, one of the anaerobic processes by which carbon tetrachloride is biodegraded. These results indicate that additional monitoring of the groundwater contamination at the former CCC/USDA facility at Centralia is merited.

On the basis of the findings and conclusions of the Phase I and Phase II investigations, as well as the results of the 2004 well sampling, a program of twice yearly groundwater monitoring in the expanded network is recommended to collect the data necessary to (1) monitor changes in plume dynamics and (2) evaluate the suitability of monitored natural attenuation as a remedial option for the Centralia site. This monitoring program should be conducted for a minimum of two years.

After completion of the two-year monitoring program, remedial action objectives and potential corrective action alternatives are to be developed to address the groundwater contamination at Centralia.

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 (Figure 1.1). This report documents the activities associated with the installation of six groundwater monitoring wells at Centralia and the subsequent groundwater sampling event in 2004. These activities were conducted as part of an ongoing environmental investigation being performed by the Environmental Research Division of Argonne National Laboratory. Argonne is a nonprofit, multidisciplinary research center operated by the University of Chicago for the U.S. Department of Energy (DOE). The Commodity Credit Corporation (CCC), an agency of the U.S. Department of Agriculture (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.

1.1 Background

In August–September 1998, the Kansas Department of Health and Environment (KDHE) conducted preliminary investigations at the former CCC/USDA facility at Centralia because carbon tetrachloride had been detected in the domestic well at the Don Morris residence, approximately 3,500 ft north-northeast (upgradient) of the former CCC/USDA facility (Figure 1.2). Carbon tetrachloride had also been detected in soil and groundwater at the former CCC/USDA facility south-southwest (downgradient) of the Morris residence. The details of this investigation and a summary of the findings were reported previously (Argonne 2002a).

In 2002, Argonne (on behalf of the CCC/USDA) initiated an investigation of the former CCC/USDA grain storage facility, because carbon tetrachloride detected there by the KDHE might, in part, be linked to historic use of grain fumigants on the property. Phase I of the investigation was conducted in March–April 2002. The results confirmed the presence of carbon tetrachloride in soils and groundwater at the former CCC/USDA facility (Argonne 2003). The groundwater gradient, as determined by measurements of depth to groundwater in the six piezometers installed during Phase I, was found to be to the west-southwest. This finding, which places the former CCC/USDA facility downgradient of the Morris well, was the driver for subsequent work to confirm that the contamination in the Morris well has a local source.

Phase II of the investigation, conducted in March–April 2003, focused on delineating the soil and groundwater contamination detected during Phase I (Argonne, 2004a). The principal Phase II findings with regard to contaminated groundwater were as follows:

1. The lateral extent of the contaminated groundwater at the former CCC/USDA facility is generally limited to the former facility's boundary. The margins of the contaminant plume were delineated by the locations of groundwater samples with carbon tetrachloride values not detected above a method quantitation limit of 1.0 μg/L (Figure 1.3).

2. The vertical extent of the contaminated groundwater is limited to the upper portion of the shallow aquifer within the glacial outwash deposits of the Pleistocene Upper Independence Formation. The highest concentrations of carbon tetrachloride in the shallow aquifer were generally detected in the upper 10 ft of the aquifer.

3. The concentrations of chloroform — a primary degradation product of carbon tetrachloride — detected in the groundwater suggest that reductive dechlorination or natural biodegradation of carbon tetrachloride is taking place *in situ* at the former CCC/USDA facility.

These findings resulted in the Phase II recommendation that monitoring wells be installed to (1) confirm the lateral distribution of carbon tetrachloride in the groundwater; (2) track any migration of contaminants that might take place; and (3) serve as monitoring points, together with the existing piezometers, for the collection of geochemical data. These data could be used to characterize *in situ* conditions and provide information for the evaluation of monitored natural attenuation as a viable corrective action alternative (Argonne 2004a).

1.2 The 2004 Well Installation Project

To carry out the Phase II recommendations, a draft work plan for the installation of five monitoring wells was prepared and submitted in May 2004 to the KDHE for review and comment (Argonne 2004b). The draft work plan was approved by the KDHE on June 23, 2004 (KDHE 2004a), contingent on an increase in the number of monitoring wells to be installed from

five to six. A final work plan incorporating the additional well requested by the KDHE was issued in July 2004 (Argonne 2004c).

The six monitoring wells installed in 2004 at Centralia supplement six existing groundwater piezometers installed at and downgradient of the former CCC/USDA facility during the Phase I investigation (Argonne 2003) and establish a KDHE-approved network of monitoring wells and piezometers at the former CCC/USDA facility. Data collected through sampling of the monitoring wells and piezometers will be used to (1) confirm the lateral distribution of carbon tetrachloride in the groundwater, (2) track any migration of contaminants that might take place, and (3) monitor aquifer geochemical characteristics, as recommended in the Phase II report (Argonne 2004a).

Procedures for the individual techniques employed by Argonne at this site are Section 2 of this report and in the *Master Work Plan* (Argonne 2002b). Field work associated with the installation of the monitoring wells occurred on July 19–28, 2004. Sampling of the monitoring wells and piezometers occurred on August 24–27, 2004.

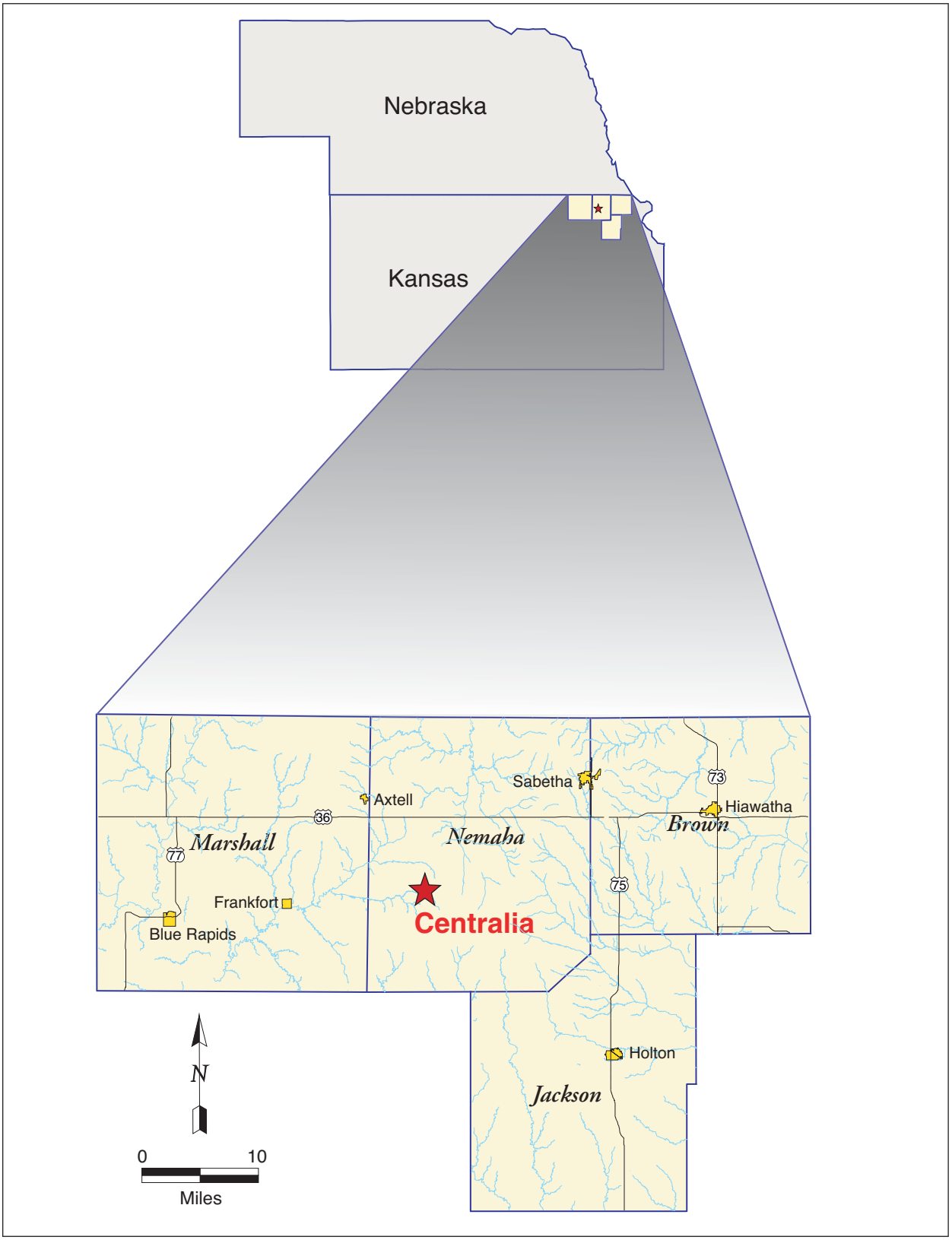

FIGURE 1.1 Location of Centralia, Kansas.

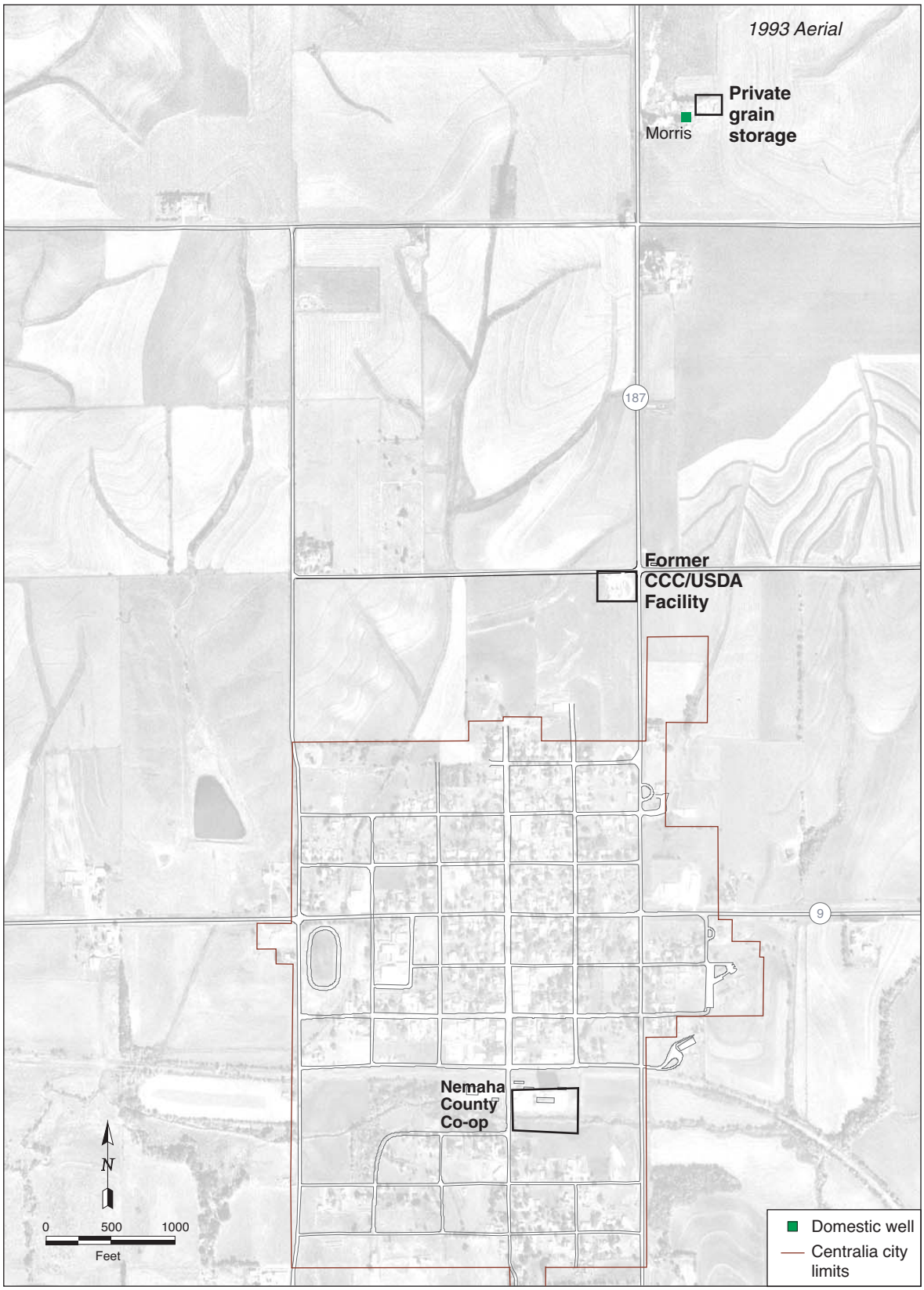

FIGURE 1.2 Locations of the contaminated Morris well and current and former grain storage facilities at Centralia. Source: USDA (1993).

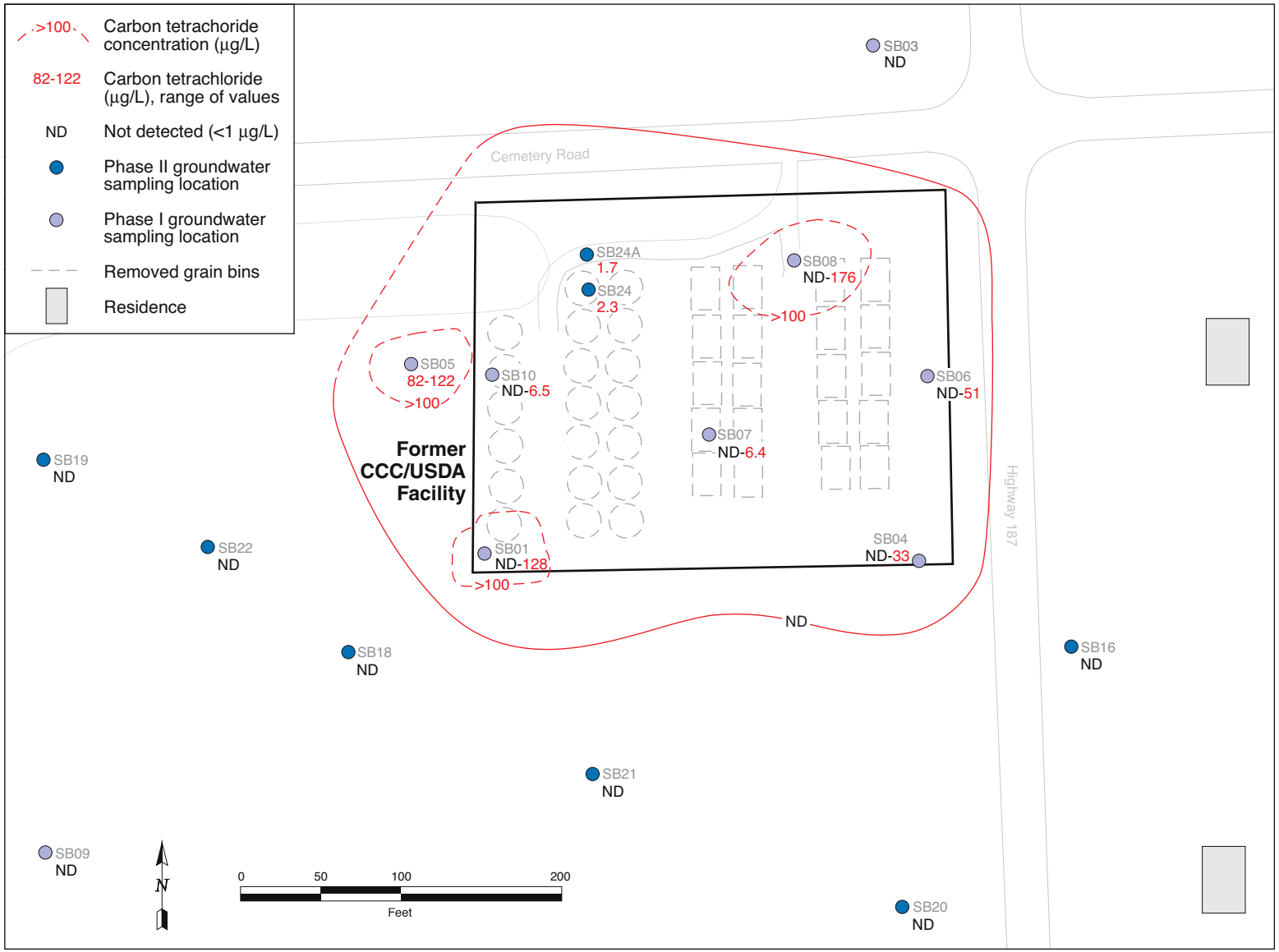

FIGURE 1.3 Lateral extent of the carbon tetrachloride contamination in groundwater at Centralia, as interpreted after Phase II.

2 Field Activities

2.1 Installation of Monitoring Wells

Six monitoring wells, MW01–MW06, were installed in July 2004 at the locations shown in Figure 2.1. The purposes of these wells are to (1) provide for both upgradient and downgradient monitoring of the contaminant distribution and (2) establish locations for the long-term monitoring of groundwater elevations and gradients. One well, MW02, was installed on the former facility, in an area identified in the Phase II investigation as having elevated levels of carbon tetrachloride in soil (Argonne 2004a).

2.1.1 Well Installation

The six monitoring wells were installed according to the general procedures presented in Section 6.4.3 of the *Master Work Plan* (Argonne 2002b) and approved by the KDHE. All six wells were installed in the upper portion of the shallow aquifer identified within the glacial outwash deposits of the Pleistocene Upper Independence Formation. The wells consist of 4-in. polyvinyl chloride casing installed in 11.5-in.-diameter boreholes. The boreholes were drilled by Associated Environmental, Inc., with a hollow-stem-auger drill rig. Screens consist of 0.010-slot screen with a 10/20 sand filter pack. The bottom of each well consists of a 2.5-ft section of blank casing to serve as a silt trap. Specific details about well construction are in Table 2.1.

2.1.2 Well Construction and Development

All wells were constructed in accordance with applicable KDHE guidelines. The surface completion for well MW01 is a KDHE-approved stick-up design, as shown in the specifications for a 4-in. casing in Figure F.2, Appendix F, of the *Master Work Plan* (Argonne 2002b). Surface completions for wells MW02–MW06 consist of KDHE-approved flush mounts, as shown in the specifications for a 4-in. casing in Figure F.4, Appendix F, of the *Master Work Plan* (Argonne 2002b). The appropriate variances were obtained from the state of Kansas for the flush-mount completions. Completion diagrams and well registration forms for wells MW01–MW06 are in Appendix A.

TABLE 2.1 Construction details for monitoring wells MW01–MW06 at Centralia, Kansas.

Well	Surveyed Surface Elevation (ft AMSL)[b]	Depth (ft BGL)[a]		
		Filter Pack Interval	Screen Interval	Total
MW01	1326.6	52–67	54.5–64.5	67
MW02	1335.2	47–62	49.5–59.5	62
MW03	1334.9	48–63	50.5–60.5	63
MW04	1323.1	35–50	37.5–47.5	50
MW05	1318.5	32–47	34.5–44.5	47
MW06	1330.1	44–59	46.5–56.5	59

[a] BGL, below ground level.

[b] AMSL, above mean sea level.

Wells were developed by surging and bailing for 2 hr and then pumped with an electric submersible pump. Development water was placed in plastic storage tanks at the investigation site. Waste characterization, handling, and disposal are discussed in Section 3.6.

2.2 Soil Sampling

As specified in the work plan for monitoring well installation (Argonne 2004c), soil samples from the boring at MW02 were collected to confirm the geology of the vadose zone and for analysis for volatile organic compounds (VOCs). Samples from auger cuttings were collected every 5 ft, beginning at approximately 20 ft BGL (below ground level) and continuing until water was encountered at 51 ft BGL. The sample at 50 ft BGL was the deepest soil sample collected for VOCs analysis. Drilling progressed with 5-ft flights, so that the bottom of one advance or the top of the next could be taken as a given target depth.

When the geologist confirmed that the rig had reached material representing the target depth, the rig was shut down, and the sampled material was placed manually in soil jars. Samples were immediately placed on dry ice and shipped at the end of the day to the Applied Geosciences and Environmental Management (AGEM) Laboratory at Argonne for analysis in the appropriate time frame. Further details about soil sampling, handling, and preservation are in the *Master Work Plan* (Argonne 2002b), Sections 6.1 and 6.2.

2.3 Sampling of Monitoring Wells and Piezometers

The new monitoring wells were sampled twice for VOCs. In the sampling procedure,

- The wells were purged of at least three well volumes;
- Samples were taken after stabilization of field parameters; and
- Samples were collected with a Teflon-lined sampling hose or with a bailer.

The first sampling occurred in July 2004, immediately after well installation and development. Purge water generated from wells MW01–MW06 was placed in the same containers used for the development water, for characterization, handling, and disposal as indicated in Section 3.6.

Approximately three weeks after installation, when the six new monitoring wells had stabilized, groundwater samples were collected again from them and from five of the six piezometers installed in Phase I (SB01, SB04, SB05, SB08, and SB09). Piezometer SB07 was obstructed and could not be sampled in August 2004. Sampling at this location in the future is desirable; options for correcting the problem are under evaluation. The samples were subjected to off-site laboratory analysis for VOCs, including carbon tetrachloride and chloroform, and for other groundwater parameters to aid in the evaluation of reductive dechlorination processes (EPA 1998; ITRC 2002). Samples from the newly installed monitoring wells were also analyzed for tritium, for age-dating to aid in characterizing (1) the relative contribution of rainwater recharge to the local groundwater system and (2) the degree of mixing within the shallow aquifer.

Parameters analyzed or measured in the field were the following:

- Temperature
- pH
- Dissolved oxygen (DO)
- Oxidation-reduction potential (ORP)
- Conductivity
- Iron, specifically Fe(II)
- Carbon dioxide
- Turbidity

Other analyses conducted off-site to aid in evaluating the potential for reductive dechlorination processes were as follows:

- Alkalinity
- Total organic carbon
- Manganese
- Phosphate
- Nitrate/nitrite
- Chloride
- Sulfate
- Methane

All well sampling was in accordance with procedures in the *Master Work Plan* (Argonne 2002b), Section 6.1.2.4. Quality control for sample collection, handling, and analysis is discussed in Section 2.4 of the present report.

After sampling was complete, long-term recording transducers were installed in each monitoring well to track and record seasonal variations in groundwater levels. These data will be analyzed to monitor the groundwater gradient and assess the magnitude of seasonal variations. The results will aid in understanding plume dynamics and will be incorporated into potential future modeling that might be required for the Centralia site.

2.4 Quality Control for Sample Collection, Handling, and Analysis

Quality assurance/quality control (QA/QC) procedures for sample collection, handling, and analysis are described in detail in the *Master Work Plan* (Argonne 2002b). Significant points for the monitoring well installation at Centralia include the following:

- Sample integrity was preserved during sample collection, shipping, and analysis through the use of custody seals and chain-of-custody records.

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

- Groundwater samples were analyzed for carbon tetrachloride and chloroform at the AGEM Laboratory by using EPA Method 524.2. Replicate samples were sent to Envirosystems, Inc., in Columbia, Maryland, for verification analysis with the Contract Laboratory Program (CLP) methodology of the U.S. Environmental Protection Agency (EPA).

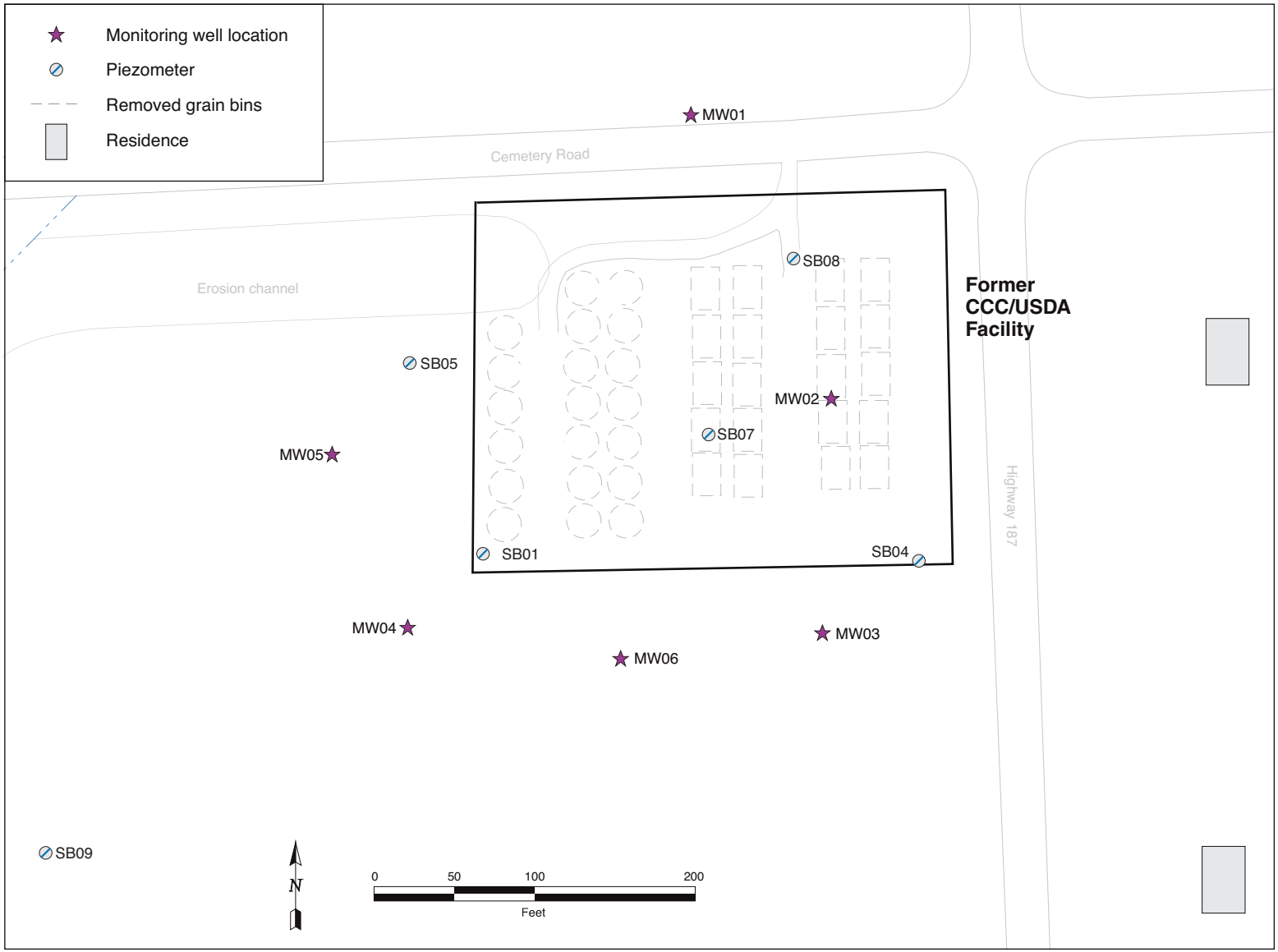

FIGURE 2.1 Locations of the Phase I piezometers sampled in 2004 and the monitoring wells installed and sampled in 2004.

3 Field and Laboratory Data

3.1 Coordinates Survey Data

To provide horizontal and vertical control for water level monitoring, the six newly installed monitoring wells, MW01–MW06, were surveyed by Schwab-Eaton, P.A., Manhattan, Kansas. Elevations of both the ground and the top of the casing were surveyed. Coordinates survey data for the monitoring wells are in Appendix B, Table B.1.

3.2 Analytical Data for Groundwater

Groundwater samples were collected from monitoring wells MW01–MW06 and from five piezometers (SB01, SB04, SB05, SB08, and SB09). Piezometer SB07 could not be sampled at this time. Descriptions of the groundwater samples are in Table C.1, Appendix C.

The samples were analyzed for VOCs by using EPA Method 524.2 (EPA 1995). To aid in the evaluation of *in situ* conditions, the samples were analyzed for parameters including anions, cations, alkalinity, total organic carbon, and methane at Severn-Trent Laboratory in Colchester, Vermont. Samples from the monitoring wells were analyzed for tritium at the University of Miami Tritium Laboratory in Miami, Florida.

3.2.1 Field Measurements

Field measurements of temperature, pH, electrical conductivity, DO, ORP, carbon dioxide, Fe(II), and turbidity were made during collection of groundwater samples in both July and August 2004. The results are in Table C.2, Appendix C.

3.2.2 Contaminant Data

In August 2004, after the new wells had been allowed to stabilize, carbon tetrachloride was detected above the quantitation limit of 1 µg/L in monitoring wells MW02 and MW03 and in piezometers SB01, SB04, SB05, and SB08 (Figure 3.1). All of these locations except SB05 and MW03 are on the property leased for the former CCC/USDA facility; SB05 is approximately

40 ft west of the property boundary. A carbon tetrachloride concentration of 215 µg/L was detected in MW02, and a concentration of 1.2 µg/L was detected in MW03. No carbon tetrachloride was detected in the other four monitoring wells or in piezometer SB09 in the August sampling.

Also in August 2004, chloroform, a degradation product of carbon tetrachloride, was detected above the quantitation limit of 1 µg/L in MW02 (6.2 µg/L) and in piezometers SB01 (6.5 µg/L), SB05 (5.5 µg/L), and SB08 (3.1 µg/L). Chloroform was not detected above the quantitation limit of 1 µg/L in any of the other wells or piezometers sampled in August (Figure 3.1).

During the initial sampling of the monitoring wells immediately after installation (in July 2004), carbon tetrachloride and chloroform were detected in MW02 at concentrations of 300 µg/L and 8.4 µg/L, respectively. The contaminants were not detected in any other well in the initial sampling in July.

Complete results of organic analyses on well and piezometers samples are in Table C.3 in Appendix C.

3.2.3 Groundwater Characterization Data

The groundwater samples were sent to Severn-Trent Laboratory for analyses to aid in the characterization of the groundwater and *in situ* conditions at the former CCC/USDA facility. Target analytes included cations (EPA Method 6010), anions (EPA Method 300), alkalinity (EPA Method 310.1), total organic carbon (EPA Method 415.1), and methane (Method RSK 175). The EPA methods are online at http://www.epa.gov/epahome/index. Method RSK 175 was discussed by Kampbell and Vandegrift (1998). No analysis for sulfide was conducted because of miscommunication with the testing laboratory. The analytical results are in Tables C.4 and C.5 in Appendix C.

3.2.4 Tritium Data

Groundwater samples from the six newly installed monitoring wells were analyzed for tritium to aid in characterizing the relative contribution of rainwater recharge to the local

groundwater system and the degree of mixing within the shallow aquifer. Tritium values in the six wells were 0.09-0.78 TU (tritium units). Complete analytical results are in Table C.6 in Appendix C.

3.3 Groundwater Level Data

The depth to groundwater was measured in each monitoring well prior to installation of the long-term recording transducer. The water level data for the six wells and five piezometers are in Table D.1 in Appendix D. Data from the long-term recording transducers will be analyzed to determine the groundwater gradient and assess the magnitude of seasonal variations.

3.4 Analytical Data for Soil Samples

Soil samples collected during the drilling of well MW02 were prepared and analyzed for VOCs by using EPA Methods 5030B and 8260B. Neither carbon tetrachloride nor chloroform was detected in any of the samples analyzed. Because the auger cuttings from which these samples were taken had been disturbed, the results may not be totally representative of subsurface concentrations. Sample descriptions are in Table E.1 in Appendix E. Complete analytical results are in Table E.2 in Appendix E.

3.5 Results of Quality Control Activities

The QA/QC procedures followed during collection, handling, and analysis of soil and groundwater samples are described in detail in the *Master Work Plan* (Argonne 2002b) and the site-specific work plan for monitoring well installation (Argonne 2004c). A detailed QA/QC report addressing activities related to sample collection, handling, and analysis during the July–August 2004 sampling 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.

- All samples were received with custody seals intact and at the appropriate preservation conditions. All samples were analyzed within the required holding times. Contaminants of concern were not detected in laboratory method blanks.

- Carbon tetrachloride and chloroform were not detected in trip blanks shipped with soil or water samples for analysis of VOCs. Ethane, ethene, and methane were not detected in trip blanks shipped with groundwater samples for analysis of attenuation parameters.

- Three field blanks were collected to represent waters used during well installation and equipment decontamination. Carbon tetrachloride and chloroform were not detected in the field blanks.

- Three equipment rinsates were collected to monitor decontamination procedures for reusable sampling equipment. Neither carbon tetrachloride nor chloroform was detected in the rinsate samples, indicating that cross-contamination of groundwater samples did not occur during sample collection.

- Quality control limits were met in analyses of soil and groundwater samples for carbon tetrachloride and chloroform at the AGEM Laboratory with the purge-and-trap method. Excellent agreement in dual analyses of samples collected at four sampling locations indicated consistency in both the sampling and analytical methodologies, with relative percent difference (RPD) values of 0–10.7% for carbon tetrachloride and 0–1.8% for chloroform. The data are acceptable for quantitative determination of contaminant distribution.

- The analyses of water samples at the AGEM Laboratory by EPA Method 524.2 were verified at a second laboratory with EPA-defined CLP methodology. One of the 11 groundwater samples analyzed at the AGEM Laboratory (9% of the groundwater samples) was also analyzed with CLP methodology by Envirosystems, Inc. Quality control limits were met in the verification analysis. The results support the AGEM Laboratory data.

- Inorganic and total organic carbon analyses of the groundwater samples were conducted at Severn-Trent Laboratory. Accuracy in the analytical methodology was measured by the analysis of QC samples with each sample delivery group. The recovery in these spiked laboratory control samples was within prescribed limits. Good analytical precision was indicated by the low RPD value between the reported concentrations in groundwater sample CNMW05-W-16183 and blind replicate CNQCDU-W-16187. The inorganic and total organic carbon data are acceptable for geochemical characterization.

- Ethane, ethene, and methane analyses of groundwater samples were conducted at Severn-Trent Laboratory with EPA Method RSK-175. Recoveries of target analytes in QC samples analyzed in duplicate with the investigative samples to evaluate the accuracy and precision the analytical methodology were within QC limits. The data are acceptable for evaluation of natural attenuation.

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

3.6 Waste Characterization, Handling, and Disposal

Drill cuttings derived from installation of monitoring wells MW01–MW06 in July 2004 were accumulated in a roll-off container. A composite sample of the cuttings (CNQC-S-16175) was free of carbon tetrachloride contamination. The soil was taken to the Rolling Meadows Recycling and Disposal Facility in Topeka, Kansas, under the KDHE special waste disposal authorization number 04-0799 (KDHE 2004b).

Development water from the six monitoring wells was accumulated in a roll-off container. Initial sampling of the development water (CNQC-W-16177) indicated that carbon tetrachloride was present at a concentration of 8.5 µg/L. Analysis of a second sample collected after the wastewater was allowed to volatilize (CNQCWASTE-W-16179) indicated that the concentration had decreased to 1 µg/L. Therefore, the development water was released at the site.

During groundwater sampling in August 2004, purge water from contaminated monitoring well MW02 was accumulated in two 55-gal drums. A composite sample from the two drums (CNQCDR01-W-16196) contained carbon tetrachloride at a concentration of 133 µg/L. Purge water from contaminated piezometers SB01, SB02, SB05, and SB06 was accumulated in one 55-gal drum. A sample from this drum (CNQCDR02-W-16197) contained carbon tetrachloride at a concentration of 14 µg/L. The containerized purge water was taken to the publicly owned treatment works in Sabetha, Kansas, for disposal. The maximum carbon tetrachloride concentration for the other monitoring locations (MW01, MW03–MW06, and SB09) was 1.2 µg/L at MW03. Purge water from these locations was released to the ground at each sampling location.

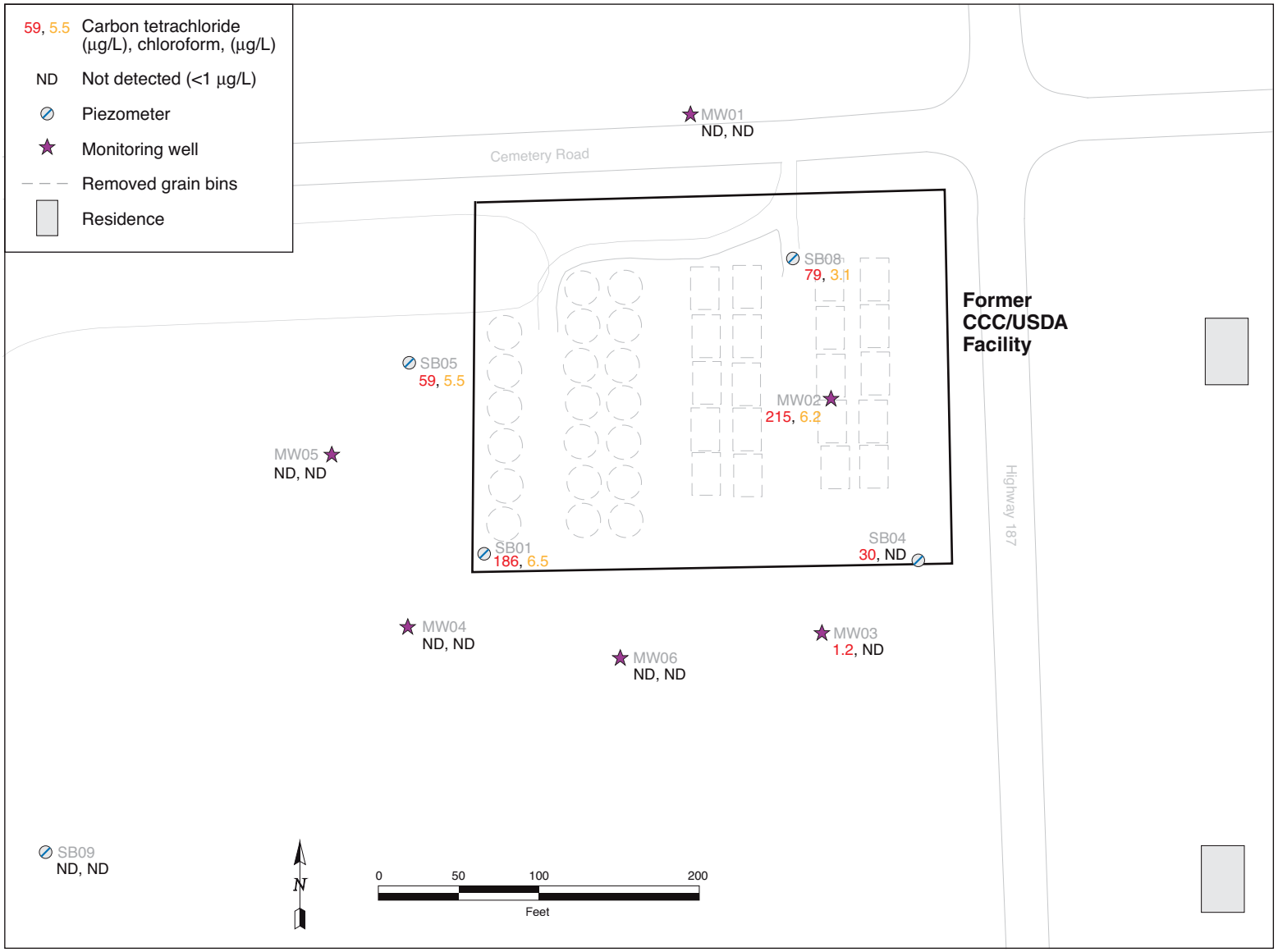

FIGURE 3.1 Analytical results for carbon tetrachloride and chloroform in groundwater samples collected in August 2004.

4 Interpretation of Field and Laboratory Data

4.1 Groundwater Gradient

The potentiometric surface of the investigation area is depicted in Figure 4.1. The contours presented are based on manual readings taken in the six monitoring wells on August 31, 2004 (Table D.1, Appendix D). The resulting contour pattern indicates a south-southwesterly gradient in the vicinity of the former CCC/USDA facility.

4.2 Delineation of the Groundwater Plume

The distribution of carbon tetrachloride in groundwater at Centralia, as characterized during sampling in August 2004, is shown in Figure 4.2. As Figure 4.3 indicates, the extent of the contamination identified through sampling of the current network of monitoring wells and piezometers is consistent with the results of previous groundwater sampling conducted during the Phase I and Phase II investigations at Centralia.

Contaminated groundwater is generally limited to the boundary of the former CCC/USDA facility. Laterally, groundwater contamination extends a distance less than 300 ft from the former facility. Review of the data indicates that the upgradient, downgradient, and lateral extents of the contaminated zone may not be adequately delineated by the monitoring well network installed in 2004. Future expansion of the network will proceed per agreement between the CCC/USDA and the KDHE.

4.3 Evidence for Anaerobic Biodegradation

Results for the analytical parameters identified in Section 2.3 were used in a preliminary screening of the site to aid in determining whether the *in situ* conditions there are appropriate for anaerobic biodegradation. Long-term monitoring data would be required for a definitive determination of the importance of biodegradation at Centralia, but examining the results of this initial sampling for evidence that *in situ* conditions are amenable to biodegradation is valuable nevertheless.

The methodology used in this preliminary evaluation of biodegradation for the Centralia site was presented by the EPA (1998). This protocol examines the results of the groundwater parameter analyses to establish evidence that anaerobic biodegradation is taking place via reductive dechlorination — only one of the processes by which carbon tetrachloride is biodegraded. Degradation of carbon tetrachloride is also known to take place via a reductive denitrification cometabolic pathway, as discussed by the ITRC (2002). However, this initial examination evaluates the evidence for reductive dechlorination on the basis of the EPA (1998) protocol.

The commonly used EPA (1998) protocol is based on the premise that biodegradation causes predictable changes in groundwater chemistry. The August 2004 analytical results for samples from MW01, MW02, MW03, MW04, MW05, MW06, SB01, SB04, SB05, SB08, and SB09 were evaluated by using the EPA protocol. The results are in Table 4.1.

The results in Table 4.1 show limited evidence for reductive dechlorination at MW01, MW02, MW03, MW06, and MW08. Additional monitoring of the groundwater contamination at the former CCC/USDA facility at Centralia is merited to complete delineation of the carbon tetrachloride plume and to evaluate monitored natural attenuation as a potential remedial option.

TABLE 4.1 Scoring of Biodegradation Processes at Centralia[a]

		MW01		MW02		MW03		MW04		MW05		MW06		SB01		SB04		SB05		SB07[b]		SB08		SB09	
Constituent	Units	Conc.	Points	Conc.	Points	Conc.	Points	Conc.	Points	Conc.	Points	Conc.	Points	Conc.	Points	Conc.	Points	Conc.	Points	Conc.	Points	Conc.	Points	Conc.	Points
Dissolved Oxygen	mg/L	0.06	3	0.16	3	0.1	3	0.11	3	0.08	3	0.05	3	5.21	-3	3.78	0	NR[c]	NR	Unk[d]	Unk	0.16	3	0.26	3
Nitrate	mg/L	0.46	2	7.92	0	6.43	0	4.28	0	2.46	0	0.38	2	2.32	0	1.84	0	2.42	0	Unk	Unk	1.12	0	4.92	0
Iron II	mg/L	0	0	0.12	0	0.21	0	0.04	0	0.06	0	0	0	0	0	0.37	0	0.06	0	Unk	Unk	0.53	0	0	0
Sulfate	mg/L	5.83	2	5.45	2	8.63	2	10.7	2	4.56	2	5.72	2	10.6	2	5.89	2	6.07	2	Unk	Unk	8.51	2	32	0
Methane	mg/L	< 0.002	0	< 0.002	0	< 0.002	0	< 0.002	0	< 0.002	0	< 0.002	0	< 0.002	0	< 0.002	0	< 0.002	0	Unk	Unk	< 0.002	0	< 0.002	0
Oxidation-Reduction Potential	mV	230	0	235	0	230	0	210	0	215	0	215	0	210	0	230	0	220	0	Unk	Unk	235	0	185	0
pH	—	7.39	0	7.31	0	7.28	0	7.39	0	7.14	0	7.5	0	7.46	0	7.14	0	7.25	0	Unk	Unk	7.31	0	7.09	0
Total Organic Carbon	mg/L	< 1	0	1.84	0	1.14	0	< 1	0	< 1	0	1.62	0	4	0	3	0	2.26	0	Unk	Unk	1.88	0	1.94	0
Carbon Dioxide[e]	mg/L	25	0	20	0	55	1	40	0	25	0	15	0	30	0	55	1	25	0	Unk	Unk	20	0	75	1
Alkalinity[e]	mg/L	324	0	354	0	353	0	337	0	315	0	334	0	292	0	375	0	326	0	Unk	Unk	322	0	449	0
Chloride[e]	mg/L	12.3	0	7.95	0	20.6	0	10.1	0	4.58	0	9.25	0	61.8	1	40.3	1	51.9	1	Unk	Unk	17.9	0	14.8	0
Chloroform	µg/L	< 1	0	6.2	2	< 1	0	< 1	0	< 1	0	< 1	0	6.5	2	< 1	0	5.5	2	Unk	Unk	3.1	2	0	0
Dichloromethane (methylene chloride)	µg/L	< 1	0	< 1	0	< 1	0	< 1	0	< 1	0	< 1	0	< 1	0	< 1	0	< 1	0	Unk	Unk	< 1	0	< 1	0
	Total points =>		7		7		6		5		5		7		2		4		5		—		7		4

[a] Scoring is based on results for samples collected in August 2004. Points are interpreted as follows (EPA 1998):
0–5 Inadequate evidence for reductive dechlorination.
6–14 Limited evidence for reductive dechlorination.
15–20 Adequate evidence for reductive dechlorination.
> 20 Strong evidence for reductive dechlorination.

[b] SB07 was not sampled, because the casing was blocked by a long-term water level recorder.

[c] NR, not recorded.

[d] Unk, unknown.

[e] For evaluation of alkalinity, carbon dioxide, and chloride, MW01 (because of its location) was selected to represent background levels. For these constituents, points are awarded when the concentration is greater than twice the background concentration.

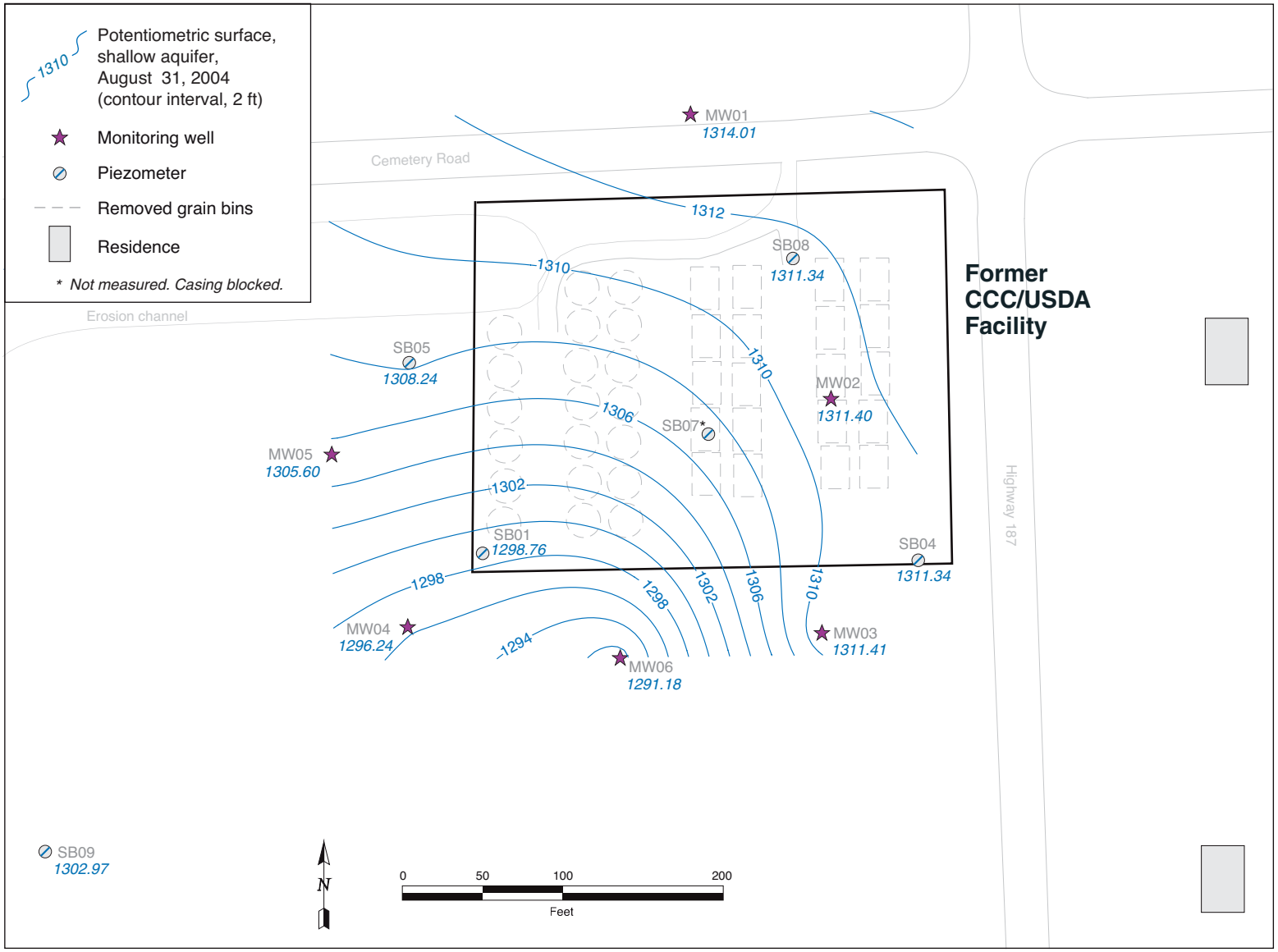

FIGURE 4.1 Potentiometric surface of the shallow aquifer at the former CCC/USDA facility at Centralia, based on hand-measured water levels on August 31, 2004.

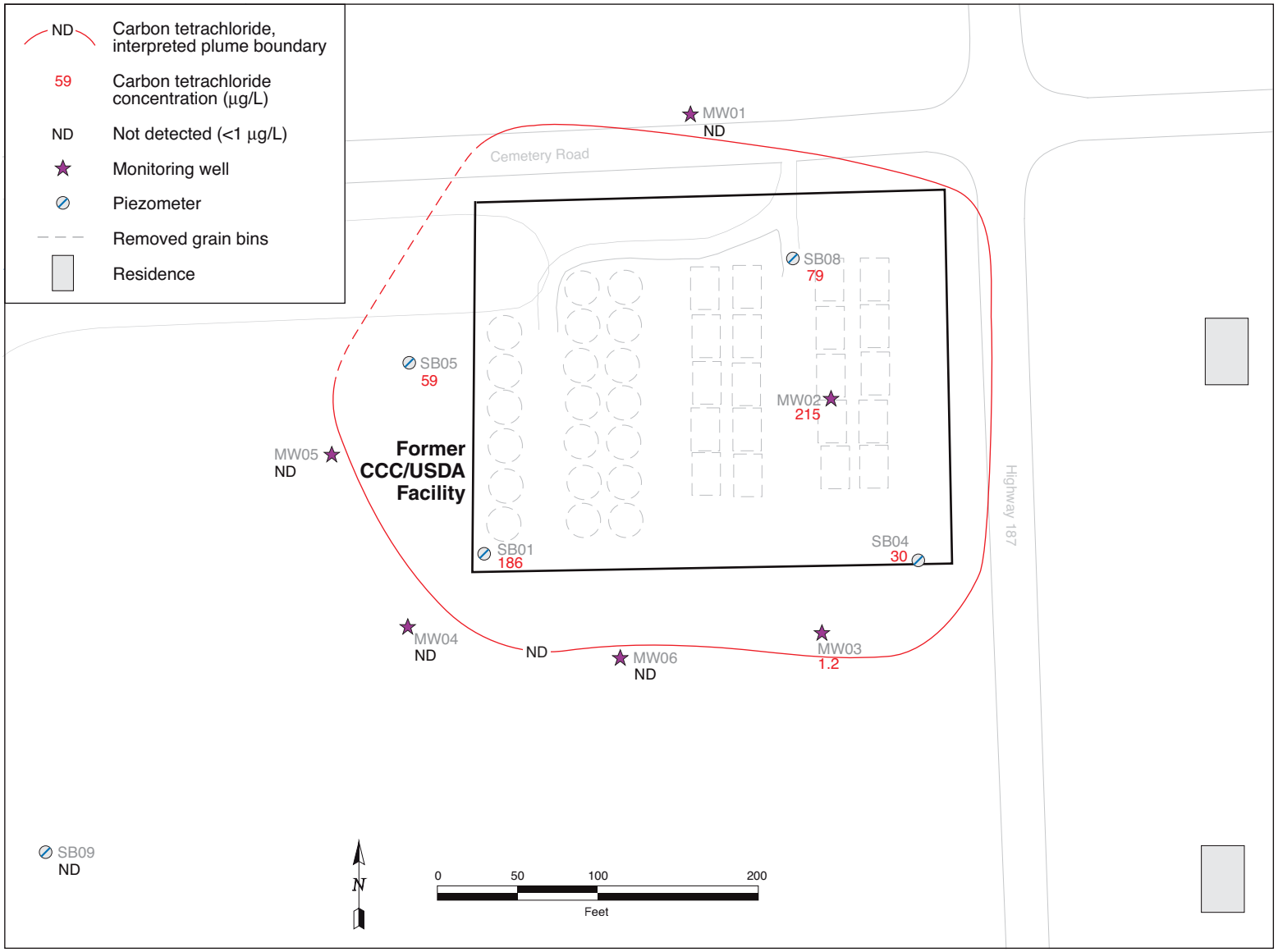

FIGURE 4.2 Distribution of carbon tetrachloride in groundwater in the shallow aquifer at Centralia in August 2004.

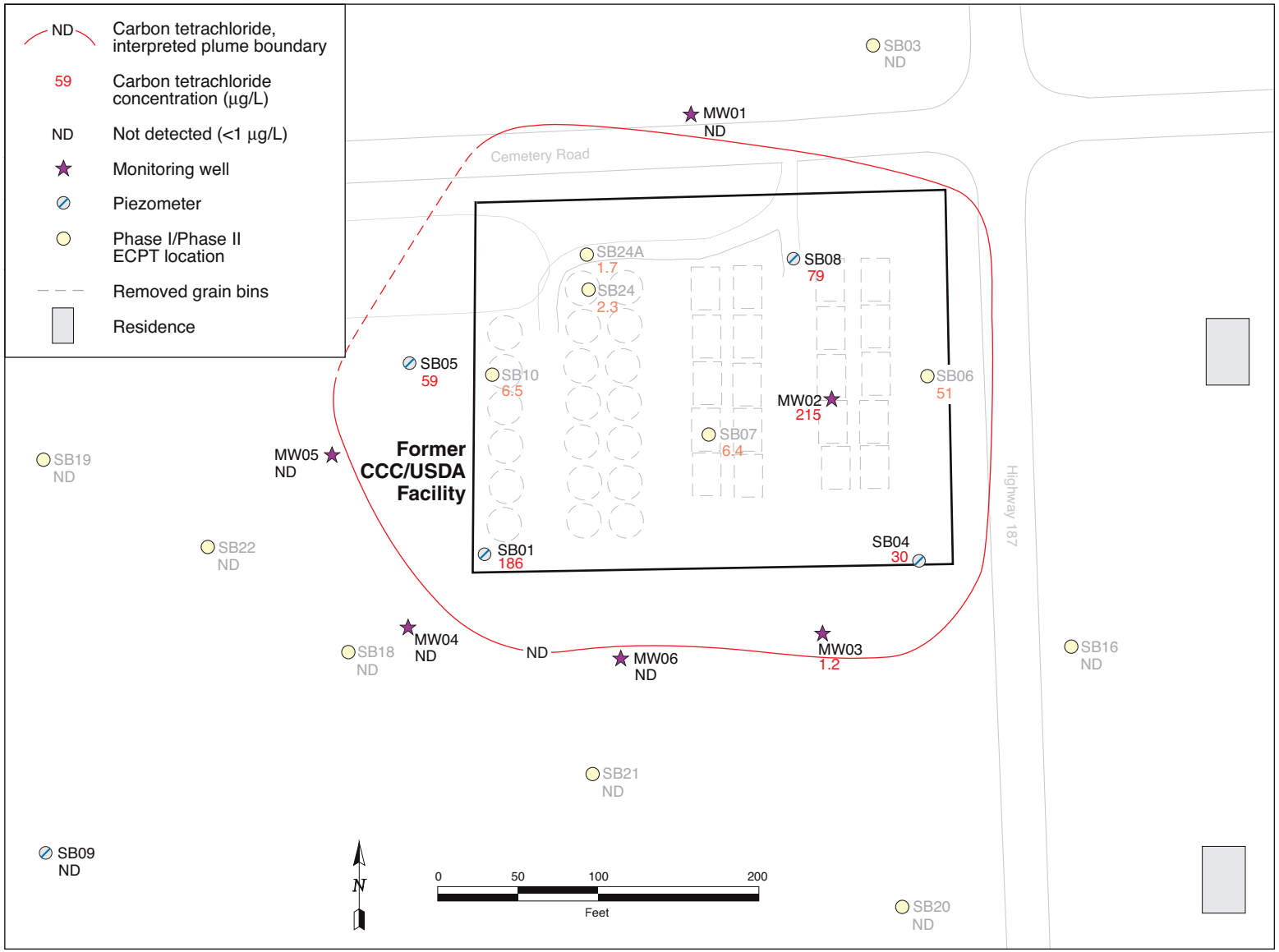

FIGURE 4.3 Distribution of carbon tetrachloride in groundwater in the shallow aquifer at Centralia in August 2004, shown in relation to Phase I or Phase II results at other locations.

5 Conclusions and Recommendations

5.1 Conclusions

The findings of the combined Phase I and Phase II investigations at Centralia support the following conclusions:

- Residual carbon tetrachloride concentrations detected in the vadose zone soils at the former CCC/USDA facility near Centralia do not pose an unacceptable human health risk. In the subsurface, the highest carbon tetrachloride concentrations occur at depths of approximately 25–35 ft BGL.

- The maximum concentration of carbon tetrachloride detected in soil is on the order of the Kansas risk-based standard 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.

- The extent of the carbon tetrachloride contamination in groundwater has been found to be generally confined within the boundary of the former CCC/USDA facility.

- Little migration of contaminated groundwater from the former facility has been evident.

- The preliminary screening of groundwater parameters provides limited evidence that reductive chlorination of carbon tetrachloride is taking place in the groundwater at some locations at the former CCC/USDA facility.

- The network of groundwater monitoring wells now in place may not be adequate to delineate the extent of the plume. Future expansion of the network will proceed per agreement between the CCC/USDA and the KDHE.

5.2 Recommendations

On the basis of the findings and conclusions of the Phase I and Phase II investigations, as well as the activities conducted in association with the 2004 well installation and sampling, expansion of the monitoring well network and a program of twice yearly groundwater monitoring in the expanded network are recommended to collect the data necessary to (1) monitor changes in plume dynamics and (2) evaluate the suitability of monitored natural attenuation as a remedial option for the Centralia site. This monitoring program should be conducted for a minimum of two years. The semiannual sampling frequency is recommended in view of the limited contaminant migration evident at this site.

After completion of the two-year monitoring program, remedial action objectives and potential corrective action alternatives are to be developed to address the groundwater contamination at Centralia.

6 References

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KDHE, 2004a, letter from L. Gotto (Bureau of Environmental Remediation, Kansas Department of Health and Environment, Topeka, Kansas) to Caroline Roe (Commodity Credit Corporation, U.S. Department of Agriculture, Washington, D.C.) regarding monitoring well network at Centralia, Kansas, June 23.

KDHE, 2004b, letter from R. Bronaugh (Special Waste Department, Kansas Department of Health and Environment, Topeka, Kansas) to C. Dennis (Argonne National Laboratory, Argonne, Illinois), regarding special waste disposal authorization number 04–0799, August 6.

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Appendix A:

Well Completion Diagrams

Monitor Well MW01: Centralia, KS

SE 1/4 of SE 1/4 of NE 1/4 of Section 1, Twp. 4 South, Rge. 11 East
Nemaha County, State of Kansas

Date: 08/27/04

WELL HEAD PROTECTION
A 3' stick-up with a locking lid and padlock. Top of casing is fitted with a Morrison Brothers, Co., lockable J-plug.

CONCRETE PAD
8" thick and extends 8" larger than the stick-up (28" minimum). Sloped to prevent pooling of water and vegetation around well and to allow for placement of a surveyor pin.

IMPERVIOUS GROUT
The well is grouted with cement grout as required, mixed with clean fresh water.

WELL CASING
Well casing is terminated as high as possible inside the stick-up and is capped with a Morrison Brothers, Co. Model 678XA lockable J-plug.

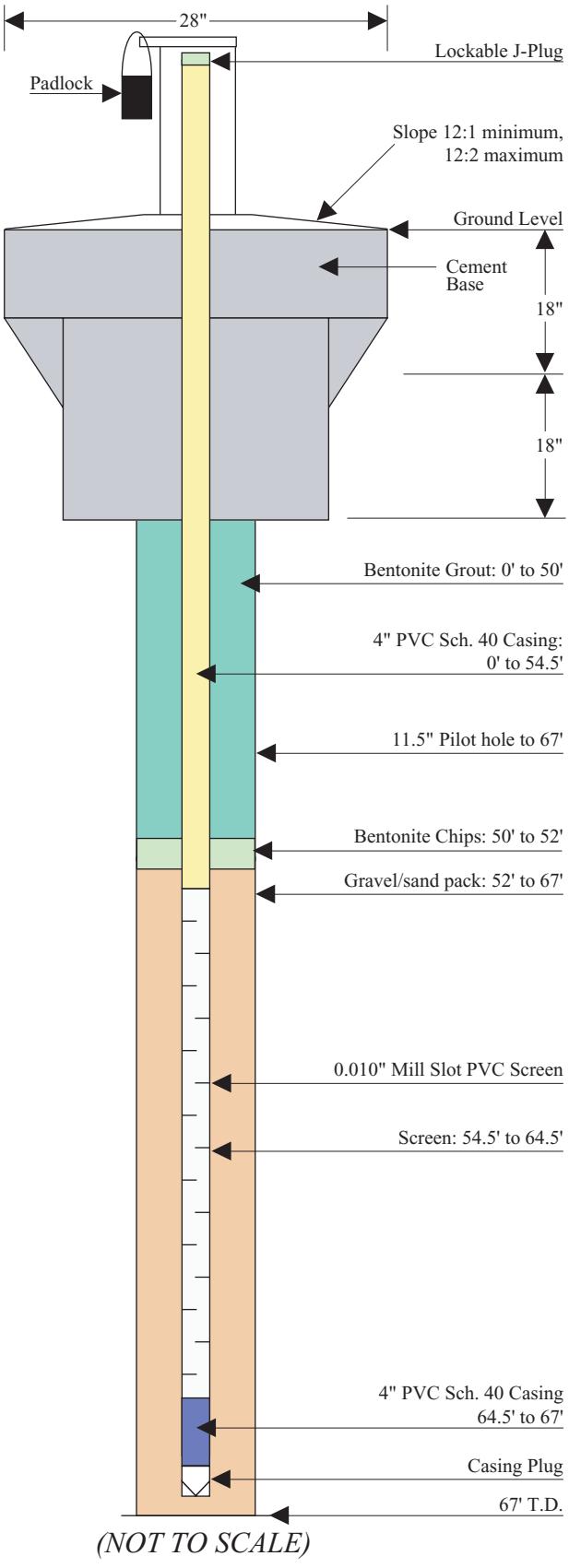
4" PVC Sch 40, threaded casing and PVC, Mill Slot (0.010") well screen.

HOLE SIZE
The hole is 11.5" in diameter from the surface to (67') T.D. and grouted from the top of the sand pack to the ground surface.

GRAVEL / SAND PACK
Gravel/sand pack is designed to stabilize the aquifer material and permit the fine fraction to move into the well during development. Gravel/sand pack extends to at least 2' above screen.

CONTRACTOR LICENSING
The well was constructed under the direction of a licensed water well contractor as specified under the Kansas Department of Health and Environment regulation.

REGISTRATION
The well was registered with the Kansas Department of Health and Environment on form WWC-5.



(NOT TO SCALE)

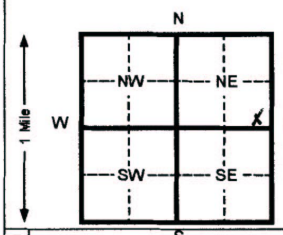
WATER WELL RECORD Form WWC-5 KSA 82a-1212

1 LOCATION OF WATER WELL: County: **Nemaha** | Fraction: **SE ¼ SE ¼ NE ¼** | Section Number: **1** | Township Number: T **4** S | Range Number: R **11** E

Distance and direction from nearest town or city street address of well if located within city?
Centralia Kansas

2 WATER WELL OWNER: **USDA, CEPD,/FSA/CCC c/o Argonne Laboratories, Argonne, Illinois**
RR#, St. Address, Box # : **1400 Independence Ave.**
City, State, ZIP Code : **Washington, DC 20250-0513**
Board of Agriculture, Division of Water Resources
Application Number:

3 LOCATE WELL'S LOCATON WITH AN "X" IN SECTION BOX:



4 DEPTH OF COMPLETED WELL **67** ft. ELEVATION:
Depth(s) Groundwater Encountered 1 **11.5** ft. 2 **55** ft. 3 ft.
WELL'S STATIC WATER LEVEL **NA** ft. below land surface measured on mo/day/yr
Pump test data: Well water was ft. after hours pumping Gpm
Est. Yield Gpm: Well water was ft. after Hours pumping Gpm
Bore Hole Diameter **11.5** In. to **67** ft. and in. to Ft.
WELL WATER TO BE USED AS: 1 Domestic 3 Feed lot 5 Public water supply 6 Oil field water supply 8 Air conditioning 9 Dewatering 11 Injection well 12 Other (Specify below)
2 Irrigation 4 Industrial 7 Lawn and garden (domestic) 10 **Monitoring well** **MW-1**
Was a chemical/bacteriological sample submitted to Department? Yes No **X** If yes, mo/day/yr sample was Submitted
Water Well Disinfected? Yes No **X**

OFFICE USE ONLY

5 TYPE OF BLANK CASING USED: 1 **Steel** 2 **PVC** 3 RMP (SR) 4 ABS 5 Wrought Iron 6 Asbestos-Cement 7 Fiberglass 8 Concrete tile 9 Other (specify below)
CASING JOINTS: Glued Clamped Welded **Threaded** **X**

Blank casing diameter **4** in. to **54.5** Ft., Dia **4** In. to **64.5 to 67** ft., Dia in. to ft.
Casing height above land surface **2.5' above grade** In., weight **SCH 40** Lbs./ft. Wall thickness or gauge No.

TYPE OF SCREEN OR PERFORATION MATERIAL: 1 Steel 2 Brass 3 Stainless steel 4 Galvanized steel 5 Fiberglass 6 Concrete tile 7 **PVC** 8 RMP (SR) 9 ABS 10 Asbestos-cement 11 Other (specify) 12 None used (open hole)

SCREEN OR PERFORATION OPENINGS ARE: 1 Continuous slot 2 Louvered shutter 3 **Mill slot** 4 Key punched 5 Gauzed wrapped 6 Wire wrapped 7 Torch cut 8 Saw cut 9 Drilled holes 10 Other (specify) 11 None (open hole)

SCREEN-PERFORATED INTERVALS: From **54.5** ft. to **64.5** ft. From ft. to ft.
From ft. to ft. From ft. to Ft.
SAND PACK INTERVALS: From **52** ft. to **67** ft. From ft. to Ft.
From ft. to ft. From ft. to Ft.

T

R

6 GROUT MATERIAL: 1 Neat cement **2 Cement grout** **3 Bentonite** 4 Other
Grout Intervals From3 **50** Ft. to **52** Ft. From2 **0** Ft. to **50** ft. From ft. to ft.

What is the nearest source of possible contamination:
1 Septic tank 2 Sewer lines 3 Watertight sewer lines 4 Lateral lines 5 Cess pool 6 Seepage pit 7 Pit privy 8 Sewage lagoon 9 Feedyard 10 Livestock pens 11 Fuel storage 12 Fertilizer storage 13 Insecticide storage 14 Abandoned water well 15 Oil well/ Gas well 16 Other (specify below) **Contaminated Site**
Direction from well? How many feet?

FROM	TO	CODE	LITHOLOGIC LOG	FROM	TO	PLUGGING INTERVALS
0	2		Soil			
2	55		Silty Clay, brown			
55	67		Sand, fine grained			
67	TD		End of Borehole			

RECEIVED
OCT 0 1 2004
BUREAU OF WATER

SEC

7 CONTRACTOR'S OR LANDOWNER'S CERTIFICATION: This water well was (x) constructed, (2) reconstructed, or (3) plugged under my jurisdiction and w
Completed on (mo/day/yr) **07/19/04** And this record is true to the best of my knowledge and belief. Kansas
Water Well Contractor's License No. **585** This Water Well Record was completed on (mo/day/yr) **08/27/04**
under the business name of **Associated Environmental, Inc.** By (signature) **Darin R Duncan**

INSTRUCTIONS:. Please fill in blanks and circle the correct answers. Send three copies to Kansas Department of Health and Environment, Bureau of Water, Topeka, Kansas 66620-0001. Telephone: 913-296-5545. Send one to WATER WELL OWNER and retain one for your records.

Monitor Well MW02: Centralia, KS

NE 1/4 of NE 1/4 of SE 1/4 of Section 1, Twp. 4 South, Rge. 11 East
Nemaha County, State of Kansas

Date: 08/27/04

WELL HEAD PROTECTION
12" Morrison Brothers, Co. Model 418XA flush mount cover. Top of casing fitted with a (J-Plug) Morrison Brothers, Co. Model 678XA and a padlock.

CONCRETE PAD
8" thick and extends 8" larger than the flush mount (28" minimum). Sloped to prevent pooling of water and vegetation around well and to allow for placement of a surveyor pin.

IMPERVIOUS GROUT
The well is grouted with cement grout as required, mixed with clean fresh water.

WELL CASING
Well casing is terminated as high as possible inside the flush mount and is capped with a (J-Plug) Morrison Brothers, Co. Model 678XA locking plug and padlock.

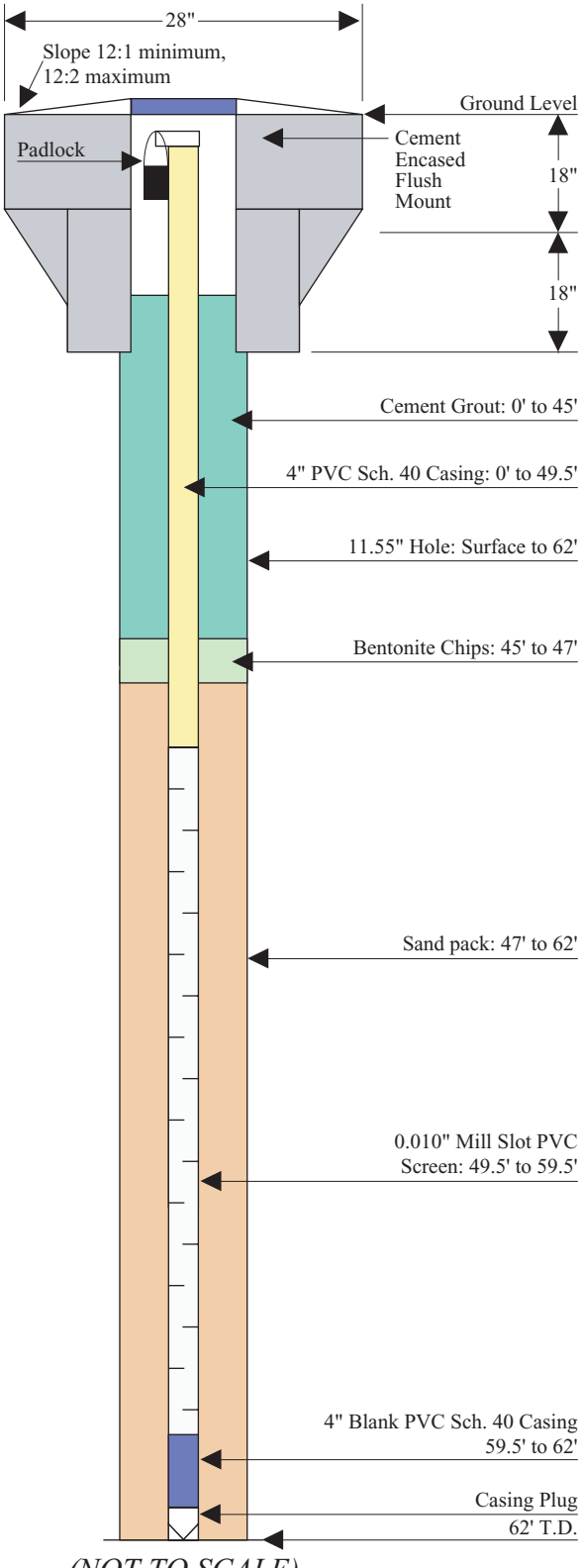
4" PVC Sch 40, threaded casing and PVC, Mill Slot (0.010") well screen.

HOLE SIZE
The hole is 11.5" in diameter from the surface to (62') T.D. and grouted from the top of the sand pack to the base of the flush mount.

GRAVEL / SAND PACK
Gravel/sand pack is designed to stabilize the aquifer material and permit the fine fraction to move into the well during development. Gravel/sand pack extends to at least 2' above screen.

CONTRACTOR LICENSING
The well was constructed under the direction of a licensed water well contractor as specified under the Kansas Department of Health and Environment regulation.

REGISTRATION
The well was registered with the Kansas Department of Health and Environment on form WWC-5.



(NOT TO SCALE)

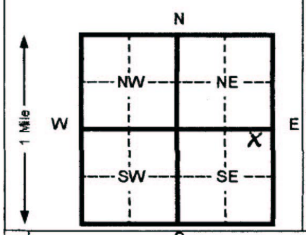
WATER WELL RECORD Form WWC-5 KSA 82a-1212

1 LOCATION OF WATER WELL: County: **Nemaha** | Fraction: **NE ¼ NE ¼ SE ¼** | Section Number: **1** | Township Number: T **4** S | Range Number: R **11** E

Distance and direction from nearest town or city street address of well if located within city?
Centralia Kansas

2 WATER WELL OWNER: **USDA, CEPD,/FSA/CCC c/o Argonne Laboratories, Argonne, Illinois**
RR#, St. Address, Box # : **1400 Independence Ave.**
City, State, ZIP Code : **Washington, DC 20250-0513**
Board of Agriculture, Division of Water Resources
Application Number:

3 LOCATE WELL'S LOCATON WITH AN "X" IN SECTION BOX:



4 DEPTH OF COMPLETED WELL **62** ft. ELEVATION:
Depth(s) Groundwater Encountered 1 **11.5** ft. 2 **51** ft. 3 ft.
WELL'S STATIC WATER LEVEL **NA** ft. below land surface measured on mo/day/yr
Pump test data: Well water was ft. after hours pumping Gpm
Est. Yield **1** Gpm: Well water was ft. after Hours pumping Gpm
Bore Hole Diameter **11.5** In. to **62** ft. and in. to Ft.
WELL WATER TO BE USED AS: 1 Domestic 3 Feed lot 5 Public water supply 6 Oil field water supply 8 Air conditioning 9 Dewatering 11 Injection well 12 Other (Specify below)
2 Irrigation 4 Industrial 7 Lawn and garden (domestic) 10 **Monitoring well** **MW-2**
Was a chemical/bacteriological sample submitted to Department? Yes No **X** If yes, mo/day/yr sample was Submitted
Water Well Disinfected? Yes No **X**

OFFICE USE ONLY

5 TYPE OF BLANK CASING USED: 1 Steel 2 **PVC** 3 RMP (SR) 4 ABS 5 Wrought Iron 6 Asbestos-Cement 7 Fiberglass 8 Concrete tile 9 Other (specify below)
CASING JOINTS: Glued Clamped Welded Threaded **X**

Blank casing diameter **4** in. to **49.5** Ft., Dia **4** In. to **62** ft., Dia in. to ft.
59.5 to
Casing height above land surface **Flush** In., weight **SCH 40** Lbs./ft. Wall thickness or gauge No.

TYPE OF SCREEN OR PERFORATION MATERIAL: 1 Steel 2 Brass 3 Stainless steel 4 Galvanized steel 5 Fiberglass 6 Concrete tile 7 **PVC** 8 RMP (SR) 9 ABS 10 Asbestos-cement 11 Other (specify) 12 None used (open hole)

SCREEN OR PERFORATION OPENINGS ARE: 1 Continuous slot 2 Louvered shutter 3 **Mill slot** 4 Key punched 5 Gauzed wrapped 6 Wire wrapped 7 Torch cut 8 Saw cut 9 Drilled holes 10 Other (specify) 11 None (open hole)

SCREEN-PERFORATED INTERVALS: From **49.5** ft. to **59.5** ft. From ft. to ft.
From ft. to ft. From ft. to ft.
SAND PACK INTERVALS: From **47** ft. to **62** ft. From ft. to ft.
From ft. to ft. From ft. to ft.

T

R

6 GROUT MATERIAL: 1 Neat cement 2 **Cement grout** 3 **Bentonite** 4 Other
Grout Intervals From3 **45** Ft. to **47** Ft. From2 **0** Ft. to **45** ft. From ft. to ft.

What is the nearest source of possible contamination:
1 Septic tank 2 Sewer lines 3 Watertight sewer lines 4 Lateral lines 5 Cess pool 6 Seepage pit 7 Pit privy 8 Sewage lagoon 9 Feedyard 10 Livestock pens 11 Fuel storage 12 Fertilizer storage 13 Insecticide storage 14 Abandoned water well 15 Oil well/ Gas well 16 Other (specify below) **Contaminated Site**
Direction from well? How many feet?

FROM	TO	CODE	LITHOLOGIC LOG	FROM	TO	PLUGGING INTERVALS
0	2		Soil			
2	51		Silty Clay, brown			
51	62		Sand, fine grained			
62	TD		End of Borehole			

SEC

RECEIVED
OCT 0 1 2004
BUREAU OF WATER

7 CONTRACTOR'S OR LANDOWNER'S CERTIFICATION: This water well was (x) constructed, (2) reconstructed, or (3) plugged under my jurisdiction and w
Completed on (mo/day/yr) **07/21/04** And this record is true to the best of my knowledge and belief. Kansas
Water Well Contractor's License No. **585** This Water Well Record was completed on (mo/day/yr) **08/27/04**
under the business name of **Associated Environmental, Inc.** By (signature) **Darin R Duncan**

INSTRUCTIONS:. Please fill in blanks and circle the correct answers. Send three copies to Kansas Department of Health and Environment, Bureau of Water, Topeka, Kansas 66620-0001. Telephone: 913-296-5545. Send one to WATER WELL OWNER and retain one for your records.

Monitor Well MW03: Centralia, KS

NE 1/4 of NE 1/4 of SE 1/4 of Section 1, Twp. 4 South, Rge. 11 East
Nemaha County, State of Kansas

Date: 08/27/04

WELL HEAD PROTECTION
12" Morrison Brothers, Co. Model 418XA flush mount cover. Top of casing fitted with a (J-Plug) Morrison Brothers, Co. Model 678XA and a padlock.

CONCRETE PAD
8" thick and extends 8" larger than the flush mount (28" minimum). Sloped to prevent pooling of water and vegetation around well and to allow for placement of a surveyor pin.

IMPERVIOUS GROUT
The well is grouted with cement grout as required, mixed with clean fresh water.

WELL CASING
Well casing is terminated as high as possible inside the flush mount and is capped with a (J-Plug) Morrison Brothers, Co. Model 678XA locking plug and padlock.

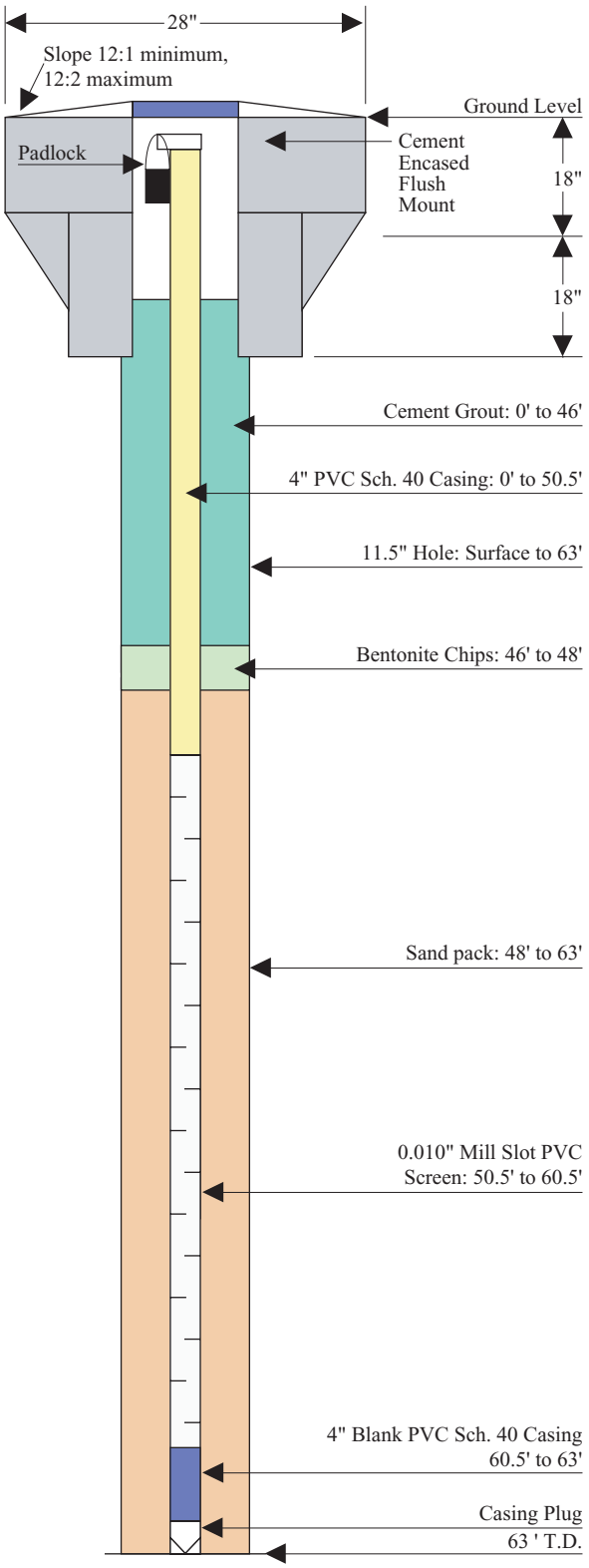
4" PVC Sch 40, threaded casing and PVC, Mill Slot (0.010") well screen.

HOLE SIZE
The hole is 11.5" in diameter from the surface to (63') T.D. and grouted from the top of the sand pack to the base of the flush mount.

GRAVEL / SAND PACK
Gravel/sand pack is designed to stabilize the aquifer material and permit the fine fraction to move into the well during development. Gravel/sand pack extends to at least 2' above screen.

CONTRACTOR LICENSING
The well was constructed under the direction of a licensed water well contractor as specified under the Kansas Department of Health and Environment regulation.

REGISTRATION
The well was registered with the Kansas Department of Health and Environment on form WWC-5.



(NOT TO SCALE)

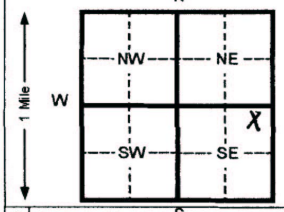
WATER WELL RECORD Form WWC-5 KSA 82a-1212

1 LOCATION OF WATER WELL: County: **Nemaha** | Fraction: **NE ¼ NE ¼ SE ¼** | Section Number: **1** | Township Number: T **4** S | Range Number: R **11** E

Distance and direction from nearest town or city street address of well if located within city?
Centralia Kansas

2 WATER WELL OWNER: **USDA, CEPD,/FSA/CCC c/o Argonne Laboratories, Argonne, Illinois**
RR#, St. Address, Box # : **1400 Independence Ave.** Board of Agriculture, Division of Water Resources
City, State, ZIP Code : **Washington, DC 20250-0513** Application Number:

3 LOCATE WELL'S LOCATON WITH AN "X" IN SECTION BOX:



4 DEPTH OF COMPLETED WELL **63** ft. ELEVATION:
Depth(s) Groundwater Encountered 1 **11.5** ft. 2 **49** ft. 3 ft.
WELL'S STATIC WATER LEVEL **NA** ft. below land surface measured on mo/day/yr
Pump test data: Well water was ft. after hours pumping Gpm
Est. Yield Gpm: Well water was ft. after Hours pumping Gpm
Bore Hole Diameter **11.5** In. to **63** ft. and in. to Ft.
WELL WATER TO BE USED AS: 5 Public water supply 8 Air conditioning 11 Injection well
1 Domestic 3 Feed lot 6 Oil field water supply 9 Dewatering 12 Other (Specify below)
2 Irrigation 4 Industrial 7 Lawn and garden (domestic) 10 **Monitoring well** **MW-3**
Was a chemical/bacteriological sample submitted to Department? Yes No **X** If yes, mo/day/yr sample was Submitted Water Well Disinfected? Yes No **X**

5 TYPE OF BLANK CASING USED: 5 Wrought Iron 8 Concrete tile CASING JOINTS: Glued Clamped
1 Steel 3 RMP (SR) 6 Asbestos-Cement 9 Other (specify below) Welded
2 **PVC** 4 ABS 7 Fiberglass Threaded **X**

Blank casing diameter **4** in. to **50.5** Ft., Dia **4** in. to **63** ft., Dia in. to ft.
Casing height above land surface **Flush** In., weight **SCH 40** Lbs./ft. Wall thickness or gauge No.

60.5 to

TYPE OF SCREEN OR PERFORATION MATERIAL: 7 **PVC** 10 Asbestos-cement
1 Steel 3 Stainless steel 5 Fiberglass 8 RMP (SR) 11 Other (specify)
2 Brass 4 Galvanized steel 6 Concrete tile 9 ABS 12 None used (open hole)

SCREEN OR PERFORATION OPENINGS ARE: 5 Gauzed wrapped 8 Saw cut 11 None (open hole)
1 Continuous slot 3 **Mill slot** 6 Wire wrapped 9 Drilled holes
2 Louvered shutter 4 Key punched 7 Torch cut 10 Other (specify)

SCREEN-PERFORATED INTERVALS: From **50.5** ft. to **60.5** ft. From ft. to ft.
From ft. to ft. From ft. to Ft.
SAND PACK INTERVALS: From **48** ft. to **63** ft. From ft. to Ft.
From ft. to ft. From ft. to Ft.

6 GROUT MATERIAL: 1 Neat cement **2 Cement grout** **3 Bentonite** 4 Other
Grout Intervals From3 **46** Ft. to **48** Ft. From2 **0** Ft. to **46** ft. From ft. to ft.

What is the nearest source of possible contamination:
1 Septic tank 4 Lateral lines 7 Pit privy 10 Livestock pens 14 Abandoned water well
2 Sewer lines 5 Cess pool 8 Sewage lagoon 11 Fuel storage 15 Oil well/ Gas well
3 Watertight sewer lines 6 Seepage pit 9 Feedyard 12 Fertilizer storage 16 Other (specify below)
13 Insecticide storage **Contaminated Site**
Direction from well? How many feet?

FROM	TO	CODE	LITHOLOGIC LOG	FROM	TO	PLUGGING INTERVALS
0	4		Soil			
4	15		Clay, dark brown			
15	43		Silty Clay, light brown			
43	49		Clay			
49	52		Sand			
52	63		Gravel with fine sand			
63	TD		End of Borehole			

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7 CONTRACTOR'S OR LANDOWNER'S CERTIFICATION: This water well was (x) constructed, (2) reconstructed, or (3) plugged under my jurisdiction and w
Completed on (mo/day/yr) **07/22/04** And this record is true to the best of my knowledge and belief. Kansas
Water Well Contractor's License No. **585** This Water Well Record was completed on (mo/day/yr) **08/27/04**
under the business name of **Associated Environmental, Inc.** By (signature) **Darin R Duncan**

INSTRUCTIONS:. Please fill in blanks and circle the correct answers. Send three copies to Kansas Department of Health and Environment, Bureau of Water, Topeka, Kansas 66620-0001. Telephone: 913-296-5545. Send one to WATER WELL OWNER and retain one for your records.

OFFICE USE ONLY T R SEC

Monitor Well MW04: Centralia, KS

NE 1/4 of NE 1/4 of SE 1/4 of Section 1, Twp. 4 South, Rge. 11 East
Nemaha County, State of Kansas

Date: 08/27/04

WELL HEAD PROTECTION
12" Morrison Brothers, Co. Model 418XA flush mount cover. Top of casing fitted with a (J-Plug) Morrison Brothers, Co. Model 678XA and a padlock.

CONCRETE PAD
8" thick and extends 8" larger than the flush mount (28" minimum). Sloped to prevent pooling of water and vegetation around well and to allow for placement of a surveyor pin.

IMPERVIOUS GROUT
The well is grouted with cement grout as required, mixed with clean fresh water.

WELL CASING
Well casing is terminated as high as possible inside the flush mount and is capped with a (J-Plug) Morrison Brothers, Co. Model 678XA locking plug and padlock.

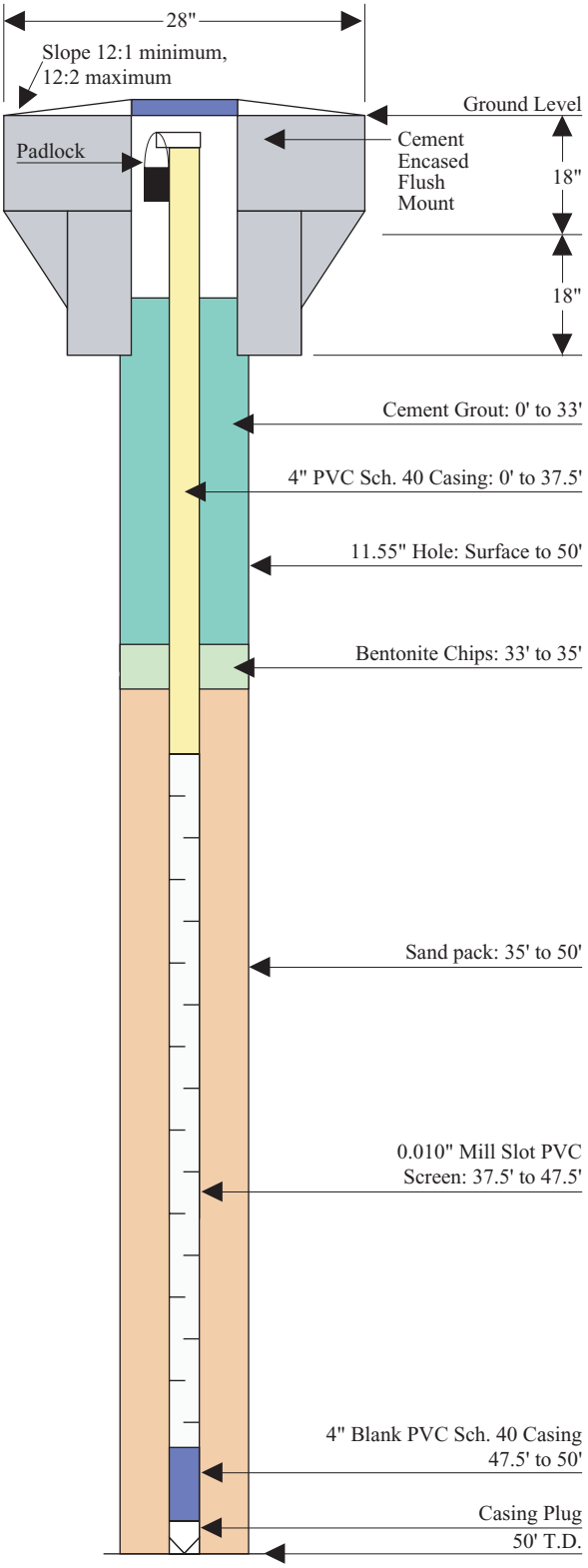
4" PVC Sch 40, threaded casing and PVC, Mill Slot (0.010") well screen.

HOLE SIZE
The hole is 11.5" in diameter from the surface to (50') T.D. and grouted from the top of the sand pack to the base of the flush mount.

GRAVEL / SAND PACK
Gravel/sand pack is designed to stabilize the aquifer material and permit the fine fraction to move into the well during development. Gravel/sand pack extends to at least 2' above screen.

CONTRACTOR LICENSING
The well was constructed under the direction of a licensed water well contractor as specified under the Kansas Department of Health and Environment regulation.

REGISTRATION
The well was registered with the Kansas Department of Health and Environment on form WWC-5.



(NOT TO SCALE)

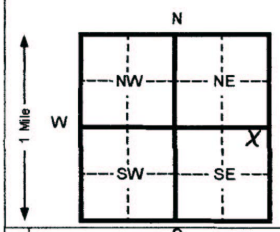
WATER WELL RECORD Form WWC-5 KSA 82a-1212

1 LOCATION OF WATER WELL: County: **Nemaha** | Fraction: **NE** ¼ **NE** ¼ **SE** ¼ | Section Number: **1** | Township Number: T **4** S | Range Number: R **11** E

Distance and direction from nearest town or city street address of well if located within city?
Centralia Kansas

2 WATER WELL OWNER: **USDA, CEPD,/FSA/CCC c/o Argonne Laboratories, Argonne, Illinois**
RR#, St. Address, Box # : **1400 Independence Ave.**
City, State, ZIP Code : **Washington, DC 20250-0513**
Board of Agriculture, Division of Water Resources
Application Number:

3 LOCATE WELL'S LOCATON WITH AN "X" IN SECTION BOX:



4 DEPTH OF COMPLETED WELL **50** ft. ELEVATION:
Depth(s) Groundwater Encountered 1 **38** ft. 2 ft. 3 Ft.
WELL'S STATIC WATER LEVEL **NA** ft. below land surface measured on mo/day/yr
Pump test data: Well water was Ft. after hours pumping Gpm
Est. Yield Gpm: Well water was Ft. after Hours pumping Gpm
Bore Hole Diameter **11.5** In. to **50** ft. and in. to Ft.
WELL WATER TO BE USED AS: 5 Public water supply 8 Air conditioning 11 Injection well
1 Domestic 3 Feed lot 6 Oil field water supply 9 Dewatering 12 Other (Specify below)
2 Irrigation 4 Industrial 7 Lawn and garden (domestic) 10 Monitoring well **MW-4**
Was a chemical/bacteriological sample submitted to Department? Yes No **X** If yes, mo/day/yr sample was Submitted
Water Well Disinfected? Yes No **X**

OFFICE USE ONLY

5 TYPE OF BLANK CASING USED: 5 Wrought Iron 8 Concrete tile CASING JOINTS: Glued Clamped
1 Steel 3 RMP (SR) 6 Asbestos-Cement 9 Other (specify below) Welded
2 **PVC** 4 ABS 7 Fiberglass Threaded **X**
Blank casing diameter **4** in. to **37.5** Ft., Dia **4** In. to **47.5 to 50** ft., Dia in. to ft.
Casing height above land surface **Flush** In., weight **SCH 40** Lbs./ft. Wall thickness or gauge No.
TYPE OF SCREEN OR PERFORATION MATERIAL: 7 **PVC** 10 Asbestos-cement
1 Steel 3 Stainless steel 5 Fiberglass 8 RMP (SR) 11 Other (specify)
2 Brass 4 Galvanized steel 6 Concrete tile 9 ABS 12 None used (open hole)
SCREEN OR PERFORATION OPENINGS ARE: 5 Gauzed wrapped 8 Saw cut 11 None (open hole)
1 Continuous slot 3 **Mill slot** 6 Wire wrapped 9 Drilled holes
2 Louvered shutter 4 Key punched 7 Torch cut 10 Other (specify)
SCREEN-PERFORATED INTERVALS: From **37.5** ft. to **47.5** ft. From ft. to ft.
From ft. to ft. From ft. to Ft.
SAND PACK INTERVALS: From **35** ft. to **50** ft. From ft. to Ft.
From ft. to ft. From ft. to Ft.

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6 GROUT MATERIAL: 1 Neat cement 2 Cement grout 3 Bentonite 4 Other
Grout Intervals From3 **33** Ft. to **35** Ft. From2 **0** Ft. to **33** ft. From ft. to ft.
What is the nearest source of possible contamination:
1 Septic tank 4 Lateral lines 7 Pit privy 10 Livestock pens 14 Abandoned water well
2 Sewer lines 5 Cess pool 8 Sewage lagoon 11 Fuel storage 15 Oil well/ Gas well
3 Watertight sewer lines 6 Seepage pit 9 Feedyard 12 Fertilizer storage 16 Other (specify below)
13 Insecticide storage **Contaminated Site**
Direction from well? How many feet?

FROM	TO	CODE	LITHOLOGIC LOG	FROM	TO	PLUGGING INTERVALS
0	3		Soil			
3	38		Silty Clay, light brown			
38	50		Silty Sand			
50	TD		End of Borehole			

SEC

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7 CONTRACTOR'S OR LANDOWNER'S CERTIFICATION: This water well was (x) constructed, (2) reconstructed, or (3) plugged under my jurisdiction and w
Completed on (mo/day/yr) **07/23/04** And this record is true to the best of my knowledge and belief. Kansas
Water Well Contractor's License No. **585** This Water Well Record was completed on (mo/day/yr) **08/27/04**
under the business name of **Associated Environmental, Inc.** By (signature) **Darin R Duncan**

INSTRUCTIONS:. Please fill in blanks and circle the correct answers. Send three copies to Kansas Department of Health and Environment, Bureau of Water, Topeka, Kansas 66620-0001. Telephone: 913-296-5545. Send one to WATER WELL OWNER and retain one for your records.

Monitor Well MW05: Centralia, KS

NE 1/4 of NE 1/4 of SE 1/4 of Section 1, Twp. 4 South, Rge. 11 East
Nemaha County, State of Kansas

Date: 08/27/04

WELL HEAD PROTECTION
12" Morrison Brothers, Co. Model 418XA flush mount cover. Top of casing fitted with a (J-Plug) Morrison Brothers, Co. Model 678XA and a padlock.

CONCRETE PAD
8" thick and extends 8" larger than the flush mount (28" minimum). Sloped to prevent pooling of water and vegetation around well and to allow for placement of a surveyor pin.

IMPERVIOUS GROUT
The well is grouted with cement grout as required, mixed with clean fresh water.

WELL CASING
Well casing is terminated as high as possible inside the flush mount and is capped with a (J-Plug) Morrison Brothers, Co. Model 678XA locking plug and padlock.

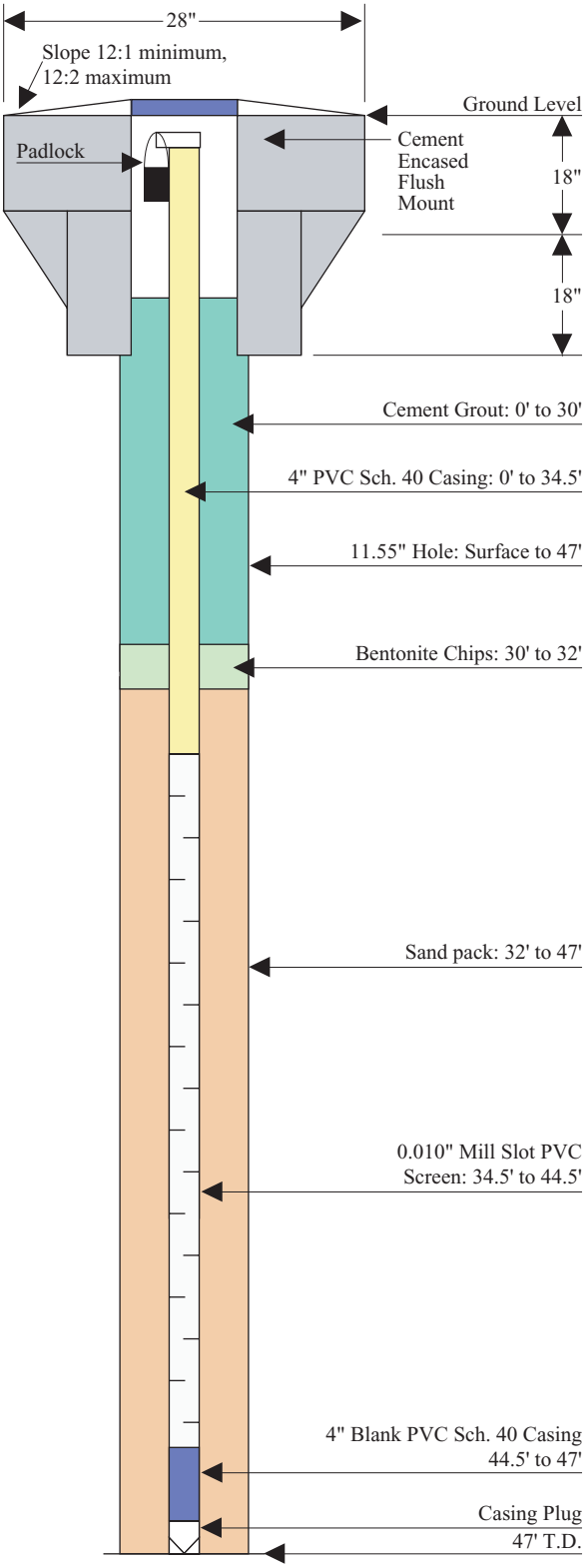
4" PVC Sch 40, threaded casing and PVC, Mill Slot (0.010") well screen.

HOLE SIZE
The hole is 11.5" in diameter from the surface to (47') T.D. and grouted from the top of the sand pack to the base of the flush mount.

GRAVEL / SAND PACK
Gravel/sand pack is designed to stabilize the aquifer material and permit the fine fraction to move into the well during development. Gravel/sand pack extends to at least 2' above screen.

CONTRACTOR LICENSING
The well was constructed under the direction of a licensed water well contractor as specified under the Kansas Department of Health and Environment regulation.

REGISTRATION
The well was registered with the Kansas Department of Health and Environment on form WWC-5.



(NOT TO SCALE)

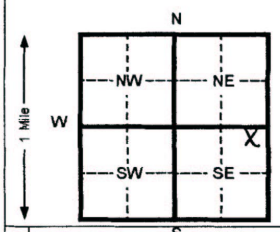
WATER WELL RECORD Form WWC-5 KSA 82a-1212

1 LOCATION OF WATER WELL: County: **Nemaha** | Fraction: **NE ¼ NE ¼ SE ¼** | Section Number: **1** | Township Number: T **4** S | Range Number: R **11** E

Distance and direction from nearest town or city street address of well if located within city?
Centralia Kansas

2 WATER WELL OWNER: **USDA, CEPD,/FSA/CCC c/o Argonne Laboratories, Argonne, Illinois**
RR#, St. Address, Box # : **1400 Independence Ave.**
City, State, ZIP Code : **Washington, DC 20250-0513**
Board of Agriculture, Division of Water Resources
Application Number:

3 LOCATE WELL'S LOCATON WITH AN "X" IN SECTION BOX:



4 DEPTH OF COMPLETED WELL **47** ft. ELEVATION:
Depth(s) Groundwater Encountered 1 **34** ft. 2 ft. 3 Ft.
WELL'S STATIC WATER LEVEL **NA** ft. below land surface measured on mo/day/yr
Pump test data: Well water was Ft. after hours pumping Gpm
Est. Yield Gpm: Well water was Ft. after Hours pumping Gpm
Bore Hole Diameter **11.5** In. to **47** ft. and in. to Ft.
WELL WATER TO BE USED AS: 5 Public water supply 8 Air conditioning 11 Injection well
1 Domestic 3 Feed lot 6 Oil field water supply 9 Dewatering 12 Other (Specify below)
2 Irrigation 4 Industrial 7 Lawn and garden (domestic) 10 **Monitoring well** **MW-5**
Was a chemical/bacteriological sample submitted to Department? Yes No **X** If yes, mo/day/yr sample was Submitted
Water Well Disinfected? Yes No **X**

OFFICE USE ONLY

5 TYPE OF BLANK CASING USED: 5 Wrought Iron 8 Concrete tile CASING JOINTS: Glued Clamped
1 Steel 3 RMP (SR) 6 Asbestos-Cement 9 Other (specify below) Welded
2 **PVC** 4 ABS 7 Fiberglass Threaded **X**

Blank casing diameter **4** in. to **34.5** Ft., Dia **4** In. to **44.5 to 47** ft., Dia in. to ft.
Casing height above land surface **Flush** In., weight **SCH 40** Lbs./ft. Wall thickness or gauge No.

TYPE OF SCREEN OR PERFORATION MATERIAL: 7 **PVC** 10 Asbestos-cement
1 Steel 3 Stainless steel 5 Fiberglass 8 RMP (SR) 11 Other (specify)
2 Brass 4 Galvanized steel 6 Concrete tile 9 ABS 12 None used (open hole)

SCREEN OR PERFORATION OPENINGS ARE: 5 Gauzed wrapped 8 Saw cut 11 None (open hole)
1 Continuous slot 3 **Mill slot** 6 Wire wrapped 9 Drilled holes
2 Louvered shutter 4 Key punched 7 Torch cut 10 Other (specify)

SCREEN-PERFORATED INTERVALS: From **34.5** ft. to **44.5** ft. From ft. to ft.
From ft. to ft. From ft. to Ft.
SAND PACK INTERVALS: From **32** ft. to **47** ft. From ft. to Ft.
From ft. to ft. From ft. to Ft.

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6 GROUT MATERIAL: 1 Neat cement **2 Cement grout** **3 Bentonite** 4 Other

Grout Intervals From3 **30** Ft. to **32** Ft. From2 **0** Ft. to **30** ft. From ft. to ft.

What is the nearest source of possible contamination:
1 Septic tank 4 Lateral lines 7 Pit privy 10 Livestock pens 14 Abandoned water well
2 Sewer lines 5 Cess pool 8 Sewage lagoon 11 Fuel storage 15 Oil well/ Gas well
3 Watertight sewer lines 6 Seepage pit 9 Feedyard 12 Fertilizer storage 16 Other (specify below)
13 Insecticide storage **Contaminated Site**
Direction from well? How many feet?

FROM	TO	CODE	LITHOLOGIC LOG	FROM	TO	PLUGGING INTERVALS
0	2		Soil			
2	22		Silty Clay , dark brown			
22	47		Sand, fine grain, some silt,			
47	TD		End of Borehole			

SEC

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7 CONTRACTOR'S OR LANDOWNER'S CERTIFICATION: This water well was (x) constructed, (2) reconstructed, or (3) plugged under my jurisdiction and w
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Water Well Contractor's License No. **585** This Water Well Record was completed on (mo/day/yr) **08/27/04**
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Monitor Well MW06: Centralia, KS

NE 1/4 of NE 1/4 of SE 1/4 of Section 1, Twp. 4 South, Rge. 11 East
Nemaha County, State of Kansas

Date: 08/27/04

WELL HEAD PROTECTION
12" Morrison Brothers, Co. Model 418XA flush mount cover. Top of casing fitted with a (J-Plug) Morrison Brothers, Co. Model 678XA and a padlock.

CONCRETE PAD
8" thick and extends 8" larger than the flush mount (28" minimum). Sloped to prevent pooling of water and vegetation around well and to allow for placement of a surveyor pin.

IMPERVIOUS GROUT
The well is grouted with cement grout as required, mixed with clean fresh water.

WELL CASING
Well casing is terminated as high as possible inside the flush mount and is capped with a (J-Plug) Morrison Brothers, Co. Model 678XA locking plug and padlock.

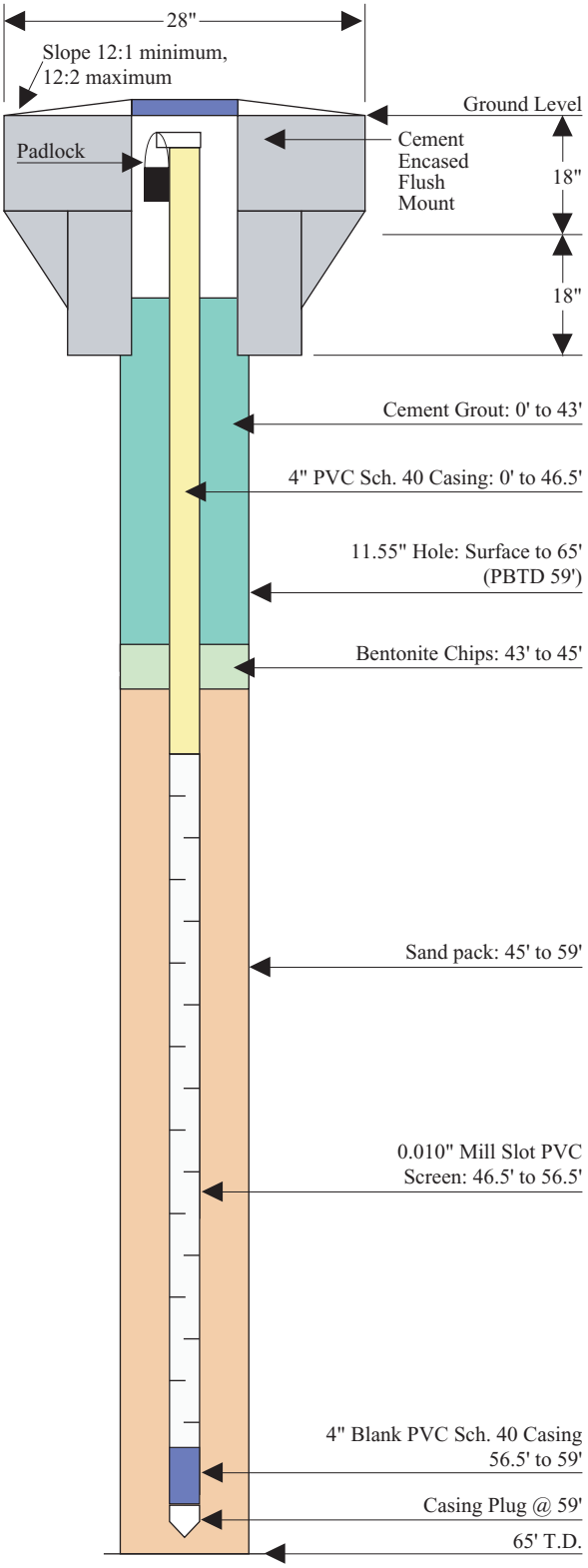
4" PVC Sch 40, threaded casing and PVC, Mill Slot (0.010") well screen.

HOLE SIZE
The hole is 11.5" in diameter from the surface to (65') T.D. and grouted from the top of the sand pack to the base of the flush mount.

GRAVEL / SAND PACK
Gravel/sand pack is designed to stabilize the aquifer material and permit the fine fraction to move into the well during development. Gravel/sand pack extends to at least 2' above screen.

CONTRACTOR LICENSING
The well was constructed under the direction of a licensed water well contractor as specified under the Kansas Department of Health and Environment regulation.

REGISTRATION
The well was registered with the Kansas Department of Health and Environment on form WWC-5.



(NOT TO SCALE)

WATER WELL RECORD Form WWC-5 KSA 82a-1212

1 LOCATION OF WATER WELL: County: **Nemaha** | Fraction: **NE** ¼ **NE** ¼ **SE** ¼ | Section Number: **1** | Township Number: T **4** S | Range Number: R **11** E

Distance and direction from nearest town or city street address of well if located within city?
Centralia Kansas

2 WATER WELL OWNER: **USDA, CEPD,/FSA/CCC c/o Argonne Laboratories, Argonne, Illinois**
RR#, St. Address, Box # : **1400 Independence Ave.**
City, State, ZIP Code : **Washington, DC 20250-0513**
Board of Agriculture, Division of Water Resources
Application Number:

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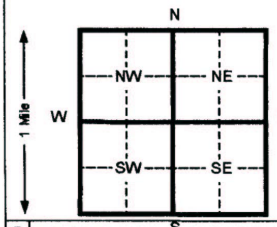

4 DEPTH OF COMPLETED WELL **59** ft. ELEVATION:
Depth(s) Groundwater Encountered 1 **11.5** ft. 2 **43** ft. 3 ft.
WELL'S STATIC WATER LEVEL **NA** ft. below land surface measured on mo/day/yr
Pump test data: Well water was ft. after hours pumping Gpm
Est. Yield Gpm: Well water was ft. after Hours pumping Gpm
Bore Hole Diameter **11.5** In. to **65** ft. and in. to Ft.
WELL WATER TO BE USED AS: 1 Domestic 2 Irrigation 3 Feed lot 4 Industrial 5 Public water supply 6 Oil field water supply 7 Lawn and garden (domestic) 8 Air conditioning 9 Dewatering 10 **Monitoring well** 11 Injection well 12 Other (Specify below) **MW-6**
Was a chemical/bacteriological sample submitted to Department? Yes No **X** If yes, mo/day/yr sample was Submitted
Water Well Disinfected? Yes No **X**

OFFICE USE ONLY

5 TYPE OF BLANK CASING USED: 1 Steel 2 **PVC** 3 RMP (SR) 4 ABS 5 Wrought Iron 6 Asbestos-Cement 7 Fiberglass 8 Concrete tile 9 Other (specify below)
CASING JOINTS: Glued Clamped Welded Threaded **X**
Blank casing diameter **4** in. to **46.5** Ft., Dia **4** In. to **59** ft., Dia in. to ft.
56.5 to
Casing height above land surface **Flush** In., weight **SCH 40** Lbs./ft. Wall thickness or gauge No.
TYPE OF SCREEN OR PERFORATION MATERIAL: 1 Steel 2 Brass 3 Stainless steel 4 Galvanized steel 5 Fiberglass 6 Concrete tile 7 **PVC** 8 RMP (SR) 9 ABS 10 Asbestos-cement 11 Other (specify) 12 None used (open hole)
SCREEN OR PERFORATION OPENINGS ARE: 1 Continuous slot 2 Louvered shutter 3 **Mill slot** 4 Key punched 5 Gauzed wrapped 6 Wire wrapped 7 Torch cut 8 Saw cut 9 Drilled holes 10 Other (specify) 11 None (open hole)
SCREEN-PERFORATED INTERVALS: From **46.5** ft. to **56.5** ft. From ft. to ft.
From ft. to ft. From ft. to Ft.
SAND PACK INTERVALS: From **45** ft. to **59** ft. From ft. to Ft.
Backfill From **59** ft. to **65** ft. From ft. to Ft.

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6 GROUT MATERIAL: 1 Neat cement 2 Cement grout **3 Bentonite** 4 Other
Grout Intervals From3 **43** Ft. to **45** Ft. From2 **0** Ft. to **43** ft. From ft. to ft.
What is the nearest source of possible contamination:
1 Septic tank 2 Sewer lines 3 Watertight sewer lines 4 Lateral lines 5 Cess pool 6 Seepage pit 7 Pit privy 8 Sewage lagoon 9 Feedyard 10 Livestock pens 11 Fuel storage 12 Fertilizer storage 13 Insecticide storage 14 Abandoned water well 15 Oil well/ Gas well 16 Other (specify below) **Contaminated Site**
Direction from well? How many feet?

FROM	TO	CODE	LITHOLOGIC LOG	FROM	TO	PLUGGING INTERVALS
0	2		Soil			
2	43		Silty Clay, brown trace calcite			
43	50		Silt, brown, very moist			
50	65		Silty Clay			
65	TD		End of Borehole			

SEC

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7 CONTRACTOR'S OR LANDOWNER'S CERTIFICATION: This water well was (x) constructed, (2) reconstructed, or (3) plugged under my jurisdiction and w
Completed on (mo/day/yr) **07/28/04** And this record is true to the best of my knowledge and belief. Kansas
Water Well Contractor's License No. **585** This Water Well Record was completed on (mo/day/yr) **08/27/04**
under the business name of **Associated Environmental, Inc.** By (signature) **Darin R Duncan**

INSTRUCTIONS:. Please fill in blanks and circle the correct answers. Send three copies to Kansas Department of Health and Environment, Bureau of Water, Topeka, Kansas 66620-0001. Telephone: 913-296-5545. Send one to WATER WELL OWNER and retain one for your records.

Appendix B:

Coordinates Survey Data

TABLE B.1 Coordinates survey data for 2004 sampling events at Centralia, Kansas.

Location	Horizontal Location[a] (ft)		Elevation[b] (ft AMSL)	
	Northing	Easting	Representative Ground Surface	Reference[c]
MW01	515257.2	1839058.4	1326.6	1329.30
MW02	515079.9	1839143	1335.2	1334.82
MW03	514935.9	1839135.8	1334.9	1334.70
MW04	514942.5	1838880.5	1323.1	1322.71
MW05	515049.6	1838835	1318.5	1318.11
MW06	514922.3	1839011.2	1330.1	1329.82

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

[b] Vertical datum is National Geodetic Vertical Datum 88.

[c] Location for measurement of water level.

Appendix C:

Groundwater Sample Data

TABLE C.1 Groundwater samples collected in July–August 2004 at Centralia, Kansas.

Location	Sample	Depth (ft BGL)	Sample Date	Description
Sampling in July 2004				
MW01	CNMW01-W-16168	54.5–64.5	7/29/04	Initial sample collected after installation and development of 4-in. monitoring well (with approximately 2.5-ft stick-up surface completion). Measured depth to water below top of casing (TOC) = 16.90 ft. Measured depth of well = 69.55 ft.
MW02	CNMW02-W-16169	49.5–59.5	7/29/04	Initial sample collected after installation and development of 4-in. monitoring well (flush mount). Measured depth to water from TOC = 22.98 ft. Measured depth of well = 61.85 ft.
MW03	CNMW03-W-16170	50.5–60.5	7/29/04	Initial sample collected after installation and development of 4-in. monitoring well (flush mount). Measured depth to water from TOC = 22.90 ft. Measured depth of well = 62.60 ft.
MW04	CNMW04-W-16171	37.5–47.5	7/29/04	Initial sample collected after installation and development of 4-in. monitoring well (flush mount). Measured depth to water from TOC = 27.00 ft. Measured depth of well = 49.25 ft.
MW05	CNMW05-W-16172	34.5–44.5	7/29/04	Initial sample collected after installation and development of 4-in. monitoring well (flush mount). Measured depth to water from TOC = 10.07 ft. Measured depth of well = 48.10 ft.
MW06	CNMW06-W-16173	46.5–56.5	7/29/04	Initial sample collected after installation and development of 4-in. monitoring well (flush mount). Measured depth to water from TOC = 41.88 ft. Measured depth of well = 60.00 ft.
Sampling in August 2004				
MW01	CNMW01-W-16158	54.5–64.5	8/24/04	Measured depth to water from TOC = 14.73 ft. Depth of well from TOC = 69.3 ft. Sample collected after purging approximately 100 gal at 2 gpm.
MW02	CNMW02-W-16159	49.5–59.5	8/26/04	Measured depth to water from TOC = 23.10 ft. Depth of well from TOC = 61.1 ft. Sample collected after purging 74 gal at 1–2 gpm. Purged into 55-gal drum.
MW03	CNMW03-W-16178	50.5–60.5	8/24/04	Measured depth to water from TOC = 22.80 ft. Depth of well from TOC = 62.3 ft. Sample collected after purging approximately 80 gal at 2 gpm.
MW04	CNMW04-W-16180	37.5–47.5	8/24/04	Measured depth to water from TOC = 26.20 ft. Depth of well from TOC = 67 ft. Sample collected after purging approximately 50 gal. Well pumped dry twice during purge with rate reduced from 2 gpm to 0.5 gpm.
MW05	CNMW05-W-16183	34.5–44.5	8/25/04	Measured depth to water from TOC = 12.00 ft. Depth of well from TOC = 47.5 ft. Sample collected after purging approximately 69 gal at 1–0.5 gpm.
MW06	CNMW06-W-16184	46.5–56.5	8/25/04	Measured depth to water from TOC = 38.38 ft. Depth of well from TOC = 59.8 ft. Sample collected after purging 29 gal. Pumped dry three times. Sampled after recharge.
SB01	CNSB01-W-16188	40.0–50.0	8/26/04	Measured depth to water from TOC = 21.31 ft. Depth of well from TOC = 50 ft. Sample collected after purging 1.5 gal. Well purged dry, then sampled after recharge.
SB04	CNSB04-W-16189	51.0–61.0	8/26/04	Measured depth to water from TOC = 24.52 ft. Depth of well from TOC = 61 ft. Sample collected after purging 5 gal.
SB05	CNSB05-W-16190	32.0–42.0	8/26/04	Measured depth to water from TOC = 12.58 ft. Depth of well from TOC = 41 ft. Sample collected after purging 3.4 gal.

TABLE C.1 (Cont.)

Location	Sample	Depth (ft BGL)	Sample Date	Description
Sampling in August 2004 (Cont.)				
SB07	CNSB07 — no sample	48.0–55.0	8/27/04	Not sampled.
SB08	CNSB08-W-16192	52.0–62.0	8/26/04	Measured depth to water from TOC = 21.37 ft. Depth of well from TOC = 62 ft. Sample collected after purging 5 gal.
SB09	CNSB09-W-16193	32.0–42.0	8/26/04	Measured depth to water from TOC = 7.60 ft. Depth of well from TOC = 41 ft. Well purged dry after purging 2 gal. Sampled after recharge. Bottom of well seemed to be filling with sand during recharge.

TABLE C.2 Field measurements made during collection of groundwater samples in July–August 2004 at Centralia, Kansas.

Location	Sample	Depth (ft BGL)	Sample Date	Temperature (°C)	pH	Conductivity (µS/cm)	Carbon Dioxide (mg/L)	Fe(II) (mg/L)	Oxygen (mg/L)	ORP[a] (mg/L)
Sampling in July 2004										
MW01	CNMW01-W-16168	54.5–64.5	7/29/04	13.7	6.75	720	NA[b]	NA	NA	NA
MW02	CNMW02-W-16169	49.5–59.5	7/29/04	14.0	6.91	772	NA	NA	NA	NA
MW03	CNMW03-W-16170	50.5–60.5	7/29/04	13.9	7.06	782	NA	NA	NA	NA
MW04	CNMW04-W-16171	37.5–47.5	7/29/04	14.7	7.41	902	NA	NA	NA	NA
MW05	CNMW05-W-16172	34.5–44.5	7/29/04	13.7	6.76	645	NA	NA	NA	NA
MW06	CNMW06-W-16173	46.5–56.5	7/29/04	13.9	7.16	648	NA	NA	NA	NA
Sampling in August 2004										
MW01	CNMW01-W-16158	54.5–64.5	8/24/04	16.3	7.39	652	25	0	0.06	230
MW02	CNMW02-W-16159	49.5–59.5	8/26/04	14.4	7.31	729	20	0.12	0.16	235
MW03	CNMW03-W-16178	50.5–60.5	8/24/04	13.1	7.28	783	55	0.21	0.1	230
MW04	CNMW04-W-16180	37.5–47.5	8/24/04	16.2	7.39	717	40	0.04	0.11	210
MW05	CNMW05-W-16183	34.5–44.5	8/25/04	14.3	7.14	613	25	0.06	0.08	215
MW06	CNMW06-W-16184	46.5–56.5	8/25/04	15.9	7.50	637	15	0	0.05	215
SB01	CNSB01-W-16188	40.0–50.0	8/26/04	NA	7.46	699	30	0	5.21	210
SB04	CNSB04-W-16189	51.0–61.0	8/26/04	17.9	7.14	765	55	0.37	3.78	230
SB05	CNSB05-W-16190	32.0–42.0	8/26/04	15.7	7.25	761	25	0.06	NA	220
SB08	CNSB08-W-16192	52.0–62.0	8/26/04	19.5	7.31	635	20	0.53	0.16	235
SB09	CNSB09-W-16193	32.0–42.0	8/26/04	NA	7.09	910	75	0	0.26	185

[a] ORP, oxidation-reduction potential.

[a] NA, parameter not analyzed.

TABLE C.3 Results of analyses for carbon tetrachloride and chloroform in groundwater samples collected in July–August 2004 at Centralia, Kansas.

Location	Sample	Depth (ft BGL)	Sample Date	Concentration (µg/L) Carbon Tetrachloride	Chloroform	Methylene Chloride
Sampling in July 2004						
MW01	CNMW01-W-16168	54.5–64.5	7/29/04	ND[a]	ND	NR[b]
MW02	CNMW02-W-16169	49.5–59.5	7/29/04	300	8.4	NR
MW03	CNMW03-W-16170	50.5–60.5	7/29/04	ND	ND	NR
MW04	CNMW04-W-16171	37.5–47.5	7/29/04	ND	ND	NR
MW05	CNMW05-W-16172	34.5–44.5	7/29/04	ND	ND	NR
MW06	CNMW06-W-16173	46.5–56.5	7/29/04	ND	ND	NR
Sampling in August 2004						
MW01	CNMW01-W-16158	54.5–64.5	8/24/04	ND	ND	ND
MW02	CNMW02-W-16159	49.5–59.5	8/26/04	215	6.2	ND
MW03	CNMW03-W-16178	50.5–60.5	8/24/04	1.2	ND	ND
MW04	CNMW04-W-16180	37.5–47.5	8/24/04	ND	ND	ND
MW05	CNMW05-W-16183	34.5–44.5	8/25/04	ND	ND	ND
MW06	CNMW06-W-16184	46.5–56.5	8/25/04	ND	ND	ND
SB01	CNSB01-W-16188	40.0–50.0	8/26/04	186	6.5	ND
SB04	CNSB04-W-16189	51.0–61.0	8/26/04	30	ND	ND
SB05	CNSB05-W-16190	32.0–42.0	8/26/04	59	5.5	ND
SB08	CNSB08-W-16192	52.0–62.0	8/26/04	79	3.1	ND
SB09	CNSB09-W-16193	32.0–42.0	8/26/04	ND	ND	ND

[a] ND, contaminant not detected at a quantitation limit of 1.0 µg/L.

[b] NR, not recorded.

TABLE C.4 Results of inorganic analyses on groundwater samples collected in July–August 2004 at Centralia, Kansas.

Location	Sample	Depth (ft BGL)	Sample Date	Concentration (mg/L) Total Alkalinity	Aluminum	Calcium	Chloride	Iron	Magnesium	Manganese	Nitrate as Nitrogen	Nitrite Nitrogen
MW01	CNMW01-W-16158	54.5–64.5	8/24/04	324	< 0.2	66.2	12.30	< 0.1	27.2	< 0.015	0.46	< 0.005
MW02	CNMW02-W-16159	49.5–59.5	8/26/04	354	< 0.2	71.7	7.95	< 0.1	27.5	< 0.015	7.92	0.018
MW03	CNMW03-W-16178	50.5–60.5	8/24/04	353	< 0.2	77.2	20.60	< 0.1	27.6	< 0.015	6.43	0.005
MW04	CNMW04-W-16180	37.5–47.5	8/24/04	337	< 0.2	61.1	10.10	< 0.1	23.3	< 0.015	4.28	0.025
MW05	CNMW05-W-16183	34.5–44.5	8/25/04	315	< 0.2	77.2	4.58	< 0.1	27.2	< 0.015	2.46	0.016
MW06	CNMW06-W-16184	46.5–56.5	8/25/04	334	< 0.2	73.4	9.25	< 0.1	23.9	< 0.015	0.38	< 0.005
SB01	CNSB01-W-16188	40.0–50.0	8/26/04	292	< 0.2	75.0	61.80	< 0.1	30.6	0.106	2.32	< 0.005
SB04	CNSB04-W-16189	51.0–61.0	8/26/04	375	< 0.2	78.8	40.30	< 0.1	30.2	< 0.015	1.84	< 0.005
SB05	CNSB05-W-16190	32.0–42.0	8/26/04	326	< 0.2	98.5	51.90	< 0.1	37.0	< 0.015	2.42	< 0.005
SB08	CNSB08-W-16192	52.0–62.0	8/26/04	322	< 0.2	74.9	17.90	< 0.1	30.1	< 0.015	1.12	< 0.005
SB09	CNSB09-W-16193	32.0–42.0	8/26/04	449	< 0.2	108.0	14.80	< 0.1	39.1	< 0.015	4.92	0.009

Location	Sample	Depth (ft BGL)	Sample Date	Concentration (mg/L) Nitrate/ Nitrite Nitrogen	Phosphate	Phosphorus	Potassium	Silicon	Sodium	Sulfate	Zinc
MW01	CNMW01-W-16158	54.5–64.5	8/24/04	0.3	< 0.2	NA[a]	< 5	14.9	23.4	5.83	< 0.02
MW02	CNMW02-W-16159	49.5–59.5	8/26/04	8.3	< 0.2	< 0.25	< 5	15.1	49.8	5.45	< 0.02
MW03	CNMW03-W-16178	50.5–60.5	8/24/04	6.8	< 0.2	NA	< 5	15.1	44.7	8.63	< 0.02
MW04	CNMW04-W-16180	37.5–47.5	8/24/04	4.4	0.28	NA	< 5	15.4	59.3	10.70	< 0.02
MW05	CNMW05-W-16183	34.5–44.5	8/25/04	2.6	< 0.2	NA	< 5	15.1	13.5	4.56	< 0.02
MW06	CNMW06-W-16184	46.5–56.5	8/25/04	0.3	< 0.2	NA	< 5	13.6	26.7	5.72	< 0.02
SB01	CNSB01-W-16188	40.0–50.0	8/26/04	1.9	< 0.2	< 0.25	< 5	14.2	44.0	10.6	< 0.02
SB04	CNSB04-W-16189	51.0–61.0	8/26/04	1.9	< 0.2	< 0.25	< 5	15.4	57.8	5.89	< 0.02
SB05	CNSB05-W-16190	32.0–42.0	8/26/04	2.3	< 0.2	< 0.25	< 5	15.3	34.0	6.07	< 0.02
SB08	CNSB08-W-16192	52.0–62.0	8/26/04	0.9	< 0.2	< 0.25	< 5	15.9	27.1	8.51	< 0.02
SB09	CNSB09-W-16193	32.0–42.0	8/26/04	5.1	< 0.2	< 0.25	< 5	14.7	52.5	32.00	< 0.02

[a] NA, not analyzed.

TABLE C.5 Attenuation parameters and total organic carbon in groundwater samples collected in July–August 200 at Centralia, Kansas.

				Concentration (µg/L)			
Location	Sample	Depth (ft BGL)	Sample Date	Ethane	Ethene	Methane	Total Organic Carbon
MW01	CNMW01-W-16158	54.5–64.5	8/24/04	< 4	< 3	< 2	< 1,000
MW02	CNMW02-W-16159	49.5–59.5	8/26/04	< 4	< 3	< 2	1,840
MW03	CNMW03-W-16178	50.5–60.5	8/24/04	< 4	< 3	< 2	1,140
MW04	CNMW04-W-16180	37.5–47.5	8/24/04	< 4	< 3	< 2	< 1,000
MW05	CNMW05-W-16183	34.5–44.5	8/25/04	< 4	< 3	< 2	< 1,000
MW06	CNMW06-W-16184	46.5–56.5	8/25/04	< 4	< 3	< 2	1,620
SB01	CNSB01-W-16188	40.0–50.0	8/26/04	< 4	< 3	< 2	4,040
SB04	CNSB04-W-16189	51.0–61.0	8/26/04	< 4	< 3	< 2	3,000
SB05	CNSB05-W-16190	32.0–42.0	8/26/04	< 4	< 3	< 2	2,260
SB08	CNSB08-W-16192	52.0–62.0	8/26/04	< 4	< 3	< 2	1,880
SB09	CNSB09-W-16193	32.0–42.0	8/26/04	< 4	< 3	< 2	1,940

TABLE C.6 Results of tritium analyses on groundwater samples collected in July–August 2004 at Centralia, Kansas.

Location	Sample	Depth (ft BGL)	Sample Date	Tritium (TU)
MW01	CNMW01-W-16158	54.5–64.5	8/24/04	0.11 ± 0.09
MW02	CNMW02-W-16159	49.5–59.5	8/26/04	0.78 ± 0.09
MW03	CNMW03-W-16178	50.5–60.5	8/24/04	0.09 ± 0.09
MW04	CNMW04-W-16180	37.5–47.5	8/24/04	0.15 ± 0.09
MW05	CNMW05-W-16183	34.5–44.5	8/25/04	0.16 ± 0.09
MW06	CNMW06-W-16184	46.5–56.5	8/25/04	0.10 ± 0.09

Appendix D:

Water Level Data

TABLE D.1 Hand-measured water levels at Centralia, Kansas, on August 31, 2004.

Well	Elevation (ft AMSL)		Well Depth (ft BGL)	Screen Interval (ft BGL)	Measurement		Water Level	
	Ground	Reference[a]			Date	Time	Depth (ft)	Elevation (ft, AMSL)
SB01	1325.6	1325.16	45.0	40.0–45.0	8/31/04	11:45	27.37	1297.79
SB01	1325.6	1325.16	45.0	40.0–45.0	8/31/04	12:42	26.40	1298.76
SB04	1336.2	1335.73	60.0	56.0–60.0	8/31/04	10:51	24.39	1311.34
SB05	1321.6	1321.28	37.0	32.0–37.0	8/31/04	12:47	13.04	1308.24
SB07	1332.4	1331.94	56.0	46.0–56.0	–[b]	–	–	–
SB08	1333.0	1332.56	58.0	53.0–58.0	8/31/04	11:15	21.22	1311.34
SB09	1311.5	1311.04	41.5	36.5–41.5	8/31/04	12:16	8.07	1302.97
MW01	1326.6	1329.30	67.0	54.5–64.5	8/31/04	13:00	15.29	1314.01
MW02	1335.2	1334.82	62.0	49.5–59.5	8/31/04	10:01	23.42	1311.40
MW03	1334.9	1334.70	63.0	50.5–60.5	8/31/04	10:30	23.29	1311.41
MW04	1323.1	1322.71	50.0	37.5–47.5	8/31/04	11:51	26.47	1296.24
MW05	1318.5	1318.11	47.0	34.5–44.5	8/31/04	12:21	12.51	1305.60
MW06	1330.1	1329.82	59.0	46.5–56.5	8/31/04	11:20	38.64	1291.18

[a] Reference point for measuring water level depth.

[b] Not measured.

Appendix E:

Soil Sample Data

TABLE E.1 Soil samples collected in July 2004 during drilling of MW02 at the former CCC/USDA facility at Centralia, Kansas.

Location	Sample	Depth (ft BGL)	Sample Date	Description
MW02	CNMW02-S-16150	20	7/21/04	Grayish brown clay with some silt and very fine sand. Substantial rounded limestone, up to gravel size.
MW02	CNMW02-S-16151	25	7/21/04	Dark grayish brown clay with some silt and very fine sand. Occasional limestone up to size of course sand.
MW02	CNMW02-S-16152	30	7/21/04	Grayish brown clay with some silt and very fine sand. Occasional limestone up to size of course sand.
MW02	CNMW02-S-16153	35	7/21/04	Same as above.
MW02	CNMW02-S-16154	40	7/21/04	Same as above.
MW02	CNMW02-S-16155	45	7/21/04	Same as above with occasional small, rounded, irregular grains of feldspar.
MW02	CNMW02-S-16156	50	7/21/04	Last sample collected, same as above. Water at 51 ft BGL.

TABLE E.2 Results of analyses for carbon tetrachloride and chloroform in soil samples collected in July 2004, during the drilling of MW02 at the former CCC/USDA facility at Centralia, Kansas.

				Concentration (µg/kg)	
Location	Sample	Depth (ft BGL)	Sample Date	Carbon Tetrachloride	Chloroform
MW02	CNMW02-S-16150	20	7/21/04	ND[a]	ND
MW02	CNMW02-S-16151	25	7/21/04	ND	ND
MW02	CNMW02-S-16152	30	7/21/04	ND	ND
MW02	CNMW02-S-16153	35	7/21/04	ND	ND
MW02	CNMW02-S-16154	40	7/21/04	ND	ND
MW02	CNMW02-S-16155	45	7/21/04	ND	ND
MW02	CNMW02-S-16156	50	7/21/04	ND	ND

[a] ND, contaminant not detected at a quantitation limit of 10 µg/kg.

Appendix F:

Quality Control for Sample Collection, Handling, and Analysis

Appendix F:

Quality Control for Sample Collection, Handling, and Analysis

Soil and groundwater samples were collected in July–August 2004 at Centralia, Kansas, to complete approved work related to monitoring well installation (Argonne 2004c). The QA/QC procedures used for sample collection, handling, and analysis are described in detail in the *Master Work Plan* (Argonne 2002b) and in the site-specific work plan (Argonne 2004c).

The following sections discuss the quality of the analytical data generated. Evaluation of the analytical data was consistent with EPA guidance (EPA 1994a,b, 2002).

F.1 Sampling to Monitor Sampling 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 handling and shipment. The QA/QC samples collected included field blanks, equipment rinsates, and trip blanks. Blind field replicate samples were also collected, and samples were selected for duplicate analyses 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 are in Table F.2.

F.1.1 Field Blanks

Three field blanks were collected to represent waters used during well installation and equipment decontamination. Carbon tetrachloride and chloroform, the contaminants of concern in the investigation, were not detected in the field blanks.

F.1.2 Equipment Rinsates

Three equipment rinsates were collected to monitor decontamination procedures for reusable sampling equipment. Neither carbon tetrachloride nor chloroform was detected in the rinsate samples, indicating that cross-contamination of groundwater samples did not occur during sample collection.

F.1.3 Trip Blanks

As an indicator of cross-contamination during shipment, trip blanks were prepared and included in shipments of soil or water samples sent to the laboratory for organic analysis. Carbon tetrachloride and chloroform were not detected in trip blanks shipped with samples designated for VOCs analyses. Ethane, ethene, and methane were not detected in trip blanks shipped with groundwater samples designated for analysis of attenuation parameters.

F.1.4 Replicate Samples and Duplicate Analyses

As an indicator of the consistency of the sampling methodology 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. One groundwater sample was shipped to a second laboratory for verification analysis with CLP methodology. Blind replicate samples, samples selected for duplicate analyses, and the sample selected for verification organic analysis are listed in Table F.1.

F.2 Quality Control for Organic Analyses of Soil and Water Samples at the AGEM Laboratory

In subsurface soil sampling in July 2004 at soil boring location MW02, seven soil samples (and one additional blind field replicate sample) were collected. The subsurface soils were analyzed at the AGEM Laboratory for VOCs, including carbon tetrachloride and chloroform, by using a modification of EPA Method 8260B (a purge-and-trap method), as referenced in the EPA's SW-846 (EPA 2004), to achieve a quantitation limit of 10 µg/kg.

Soil samples were quick-frozen on dry ice as they were collected. At the laboratory, the VOCs present 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 gas chromatograph-mass spectrometer (GC-MS) system.

Groundwater sampling was conducted at 11 monitoring locations, including newly installed monitoring wells MW01–MW06 and existing piezometers SB01, SB04, SB05, SB08, and SB09. The six monitoring wells were initially sampled in July 2004 to verify adequate development. In August 2004 the monitoring wells were resampled, and the five piezometers were also sampled. The samples and associated QC samples were shipped immediately to the AGEM Laboratory for analysis with EPA Method 524.2 (EPA 1995) to achieve a quantitation limit of 1 µg/L.

Water samples shipped to the AGEM Laboratory were analyzed by the purge-and-trap method with a GC-MS system. In these analyses, VOCs present in a 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.

For both the soil and water analyses, 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, internal standards, or both. 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 sample delivery group (SDG) were required to be within ±20% of the standard.

Samples submitted to the AGEM Laboratory for organic analysis were analyzed in six SDGs, as shown in Table F.3. 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.

- Carbon tetrachloride and chloroform, the contaminants of concern in this investigation, 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.3 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 surrogate spike compounds fluorobenzene, 1,2-dichlorobenzene-d_4, and 4-bromofluorobenzene. Table F.3 shows the percent recovery of these system-monitoring compounds for each of the analyses. With two exceptions described below, the surrogate recoveries were within the specified range of 80–120% for all samples in either the initial analysis of the sample or in a successful reanalysis.

  - In the analysis of trip blank CNQCTB-W-16165 in SDG 04-7-23, the recovery of surrogate compound fluorobenzene was 79.4%. The absence of contamination in the associated samples indicates that cross-contamination of the samples did not occur. The result for trip blank CNQCTB-W-16165 is accepted without qualification. Samples shipped under COC 3677 with trip blank CNQCTB-W-16165 included waste characterization sample CNMW01-W-16148, field blanks CNFB01-W-16149 and CNFB02-W-16167, and equipment rinsate CNRI01-W-16166.

  - In the analysis of subsurface soil sample CNMW02-S-16154 in SDG 04-7-26, the recovery of surrogate compound fluorobenzene was 75.4%. No contamination was detected in adjacent samples. The result for sample CNMW02-S-16154 is accepted without qualification.

- As a measure of consistency in the sampling and analytical methodologies, dual analyses of samples collected at four sampling locations were accomplished through the analysis of blind replicate samples submitted to the laboratory or duplicate analyses of samples selected by the laboratory. Table F.4 summarizes the analytical results for the primary samples and their associated replicate or duplicate analyses. Agreement is excellent, indicating consistency in both the sampling and analytical methodologies, with RPD values of 0–10.7% for carbon tetrachloride and 0–1.8% for chloroform.

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

F.3 Quality Control for Verification Organic Analysis of Groundwater Sample by Envirosystems, Inc.

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 at a second laboratory with EPA-defined CLP methodology. Groundwater sampling was conducted at 11 monitoring locations, including newly installed monitoring wells MW01–MW06 and existing piezometers SB01, SB04, SB05, SB08, and SB09. One of the 11 groundwater samples analyzed at the AGEM Laboratory (9% of the groundwater samples) was also analyzed according to CLP methodology by Envirosystems, Inc. The analytical results for groundwater sample CNSB01-W-16188 and trip blank CN-MU-TB-11200 were reported by the laboratory as SDG 409261. Below is a discussion of the quality of the organic analytical data obtained with CLP methodology.

The QA/QC procedures followed in the CLP analyses 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 properly tuned; initial and continuing calibration checks remained within the allowable limits.

- Contaminants of concern were not detected in the trip blank or laboratory method blanks. Methylene chloride was present at low concentrations in laboratory blanks.

- Surrogate standard determinations were performed on samples and blanks by using the surrogate spike compounds toluene-d8, 4-bromofluorobenzene, and 1,2-dichloroethane-d4. Table F.5 shows the percent recoveries of the system-monitoring compounds for each CLP analysis. For all analyses, recoveries of the surrogate spikes were within the acceptable range (identified in Table F.5) 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.6 shows the percent recovery of each spike compound in the spike/spike duplicate analysis, as well as the calculated RPD between the spike and spike duplicate analytical results. Quality control limits were met in the analyses.

Analytical results obtained at the AGEM Laboratory with EPA Method 524.2 for groundwater sample CNSB01-W-16188 are supported by the results from Envirosystems, Inc., obtained with EPA CLP methodology. The analysis at the AGEM Laboratory, at fivefold dilution, measured carbon tetrachloride in this sample at 186 µg/L. Analysis by Envirosystems, Inc., at twofold dilution, gave a value of 250 µg/L, for an value RPD of 27%. Chloroform was detected in the groundwater sample at 6.5 µg/L in analysis at the AGEM Laboratory and 8 µg/L in analysis by Envirosystems, Inc., for an RPD value of 15%.

F.4 Quality Control for Inorganic and Total Organic Carbon Analyses of Groundwater Samples at Severn-Trent Laboratory

Groundwater samples were collected for inorganic analysis to aid in geochemical characterization of the water-bearing zone. These samples were shipped immediately to Severn-

Trent Laboratory for filtration and analysis. The analyses included total alkalinity by EPA Method 310.1, dissolved anion concentrations (chloride, sulfate, nitrate, and phosphate) by EPA Method 300, nitrite nitrogen by EPA Method 354.1, nitrate/nitrite nitrogen by EPA Method 353.2, dissolved metals (aluminum, calcium, iron, magnesium, manganese, phosphorus, potassium, silicon, sodium, and zinc) by EPA Method 6010, and total organic carbon by EPA Method 415.1. The EPA methods are online at http://www.epa.gov/epahome/index.

Inorganic and total organic carbon analyses of the groundwater samples were conducted in two SDGs. The QA/QC procedures included instrument calibration through analysis of spiked calibration check standards, verification of interelement and background correction factors through the analysis of inductively coupled plasma interference check samples, and the analysis of QC samples and a blind replicate sample. Significant points are the following:

- Initial and continuing calibration of analytical equipment was verified according to method protocol by the analysis of instrument check standards to determine instrument drift. Accuracy was measured as the percent recovery of known concentrations of the metals and anions of concern added to calibration check standards.

- Accuracy in the analytical methodology was measured by the analysis of QC samples with each SDG. The recoveries of known concentrations of the metals and anions of concern in spiked QC samples, shown in Table F.7, were within the desired range of 80–120%.

- Good analytical precision is indicated by the low RPD values between the reported concentrations in groundwater sample CNMW05-W-16183 and blind replicate CNQCDU-W-16187, as shown in Table F.8.

The inorganic and total organic carbon results from Severn-Trent Laboratory for groundwater samples are judged acceptable for geochemical characterization on the basis of the recovery of known concentrations of the analytes of concern in QC samples analyzed with the groundwater samples and the low RPD value in the analysis of a sample and blind replicate.

F.5 Quality Control for Analyses of Groundwater Samples for Attenuation Parameters at Severn-Trent Laboratory

As an indicator of the potential for natural attenuation at the Centralia site, 11 groundwater samples (and 1 additional blind field replicate) were analyzed at Severn-Trent Laboratory for dissolved methane, ethane, and ethane by Method RSK-175 (Kampbell and Vandegrift 1998). In this method an inert gas is injected into the sample analysis vial to create headspace. After equilibration, the headspace is analyzed for the target gases by using a GC equipped with a flame ionization detector. The concentration of the gas in the water is calculated by using Henry's law. The concentration of the gas in the liquid is proportional to the partial pressure of the gas above the liquid.

Analysis of the groundwater samples for attenuation parameters was conducted in two SDGs. The QA/QC procedures followed included initial and continuing calibration of instruments, analysis of laboratory blanks, and analysis of QC samples. Significant results include the following:

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

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

- Contaminants of concern were not detected in the trip blanks or laboratory method blanks associated with the samples.

- To evaluate the accuracy and precision the analytical methodology, a QC sample was prepared and analyzed in duplicate with the samples. Table F.9 shows the percent recovery of each spike compound in these analyses, as well as the calculated RPD values between the spike and spike duplicate results. Recovery of the target analytes in these analyses was acceptable, and correlation of the results in the interanalysis comparison was good.

- The analytes of concern were not detected in groundwater sample CNMW05-W-16183 or blind replicate CNQCDU-W-16187.

Analytical data for the groundwater samples obtained at Severn-Trent Laboratory with Method RSK-175 are acceptable for evaluation of the potential for natural attenuation.

F.6 Quality Control for Tritium Analyses of Groundwater Samples at the University of Miami Tritium Laboratory

Groundwater samples from the six monitoring wells were analyzed for tritium at the University of Miami Tritium Laboratory. Tritium concentrations reported were based on 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 12.43 years. Concentrations were reported in tritium units, 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 cpm/TU (count per minute per tritium unit). Background is about 0.3 cpm, known to ± 0.02 cpm. Good precision in the tritium results is indicated by a standard deviation of 0.05 TU between the result for sample CNMW05-W-16183 and two analyses of the blind replicate CNQCDU-W-16187. The tritium analytical data are accepted for age-dating of groundwater.

F.7 Quality Control for Organic Analysis of Waste Soil Sample at Clayton Laboratory

A composite sample of the drill cuttings generated during drilling of the monitoring wells was collected for VOCs analyses by Clayton Laboratory with EPA Method 8260. A trip blank shipped with the waste soil sample and method blanks analyzed with the sample were free of carbon tetrachloride and chloroform contamination. Recoveries of the analytes of concern in spike/spike duplicate analyses, shown in Table F.10, were within method limits. The soil was taken to the Rolling Meadows Recycling and Disposal Facility in Topeka, Kansas, under the KDHE special waste disposal authorization number 04-0799 (KDHE 2004b).

TABLE F.1 Quality control samples collected in July–August 2004 at Centralia, Kansas.

Location	Sample	Depth (ft BGL)	Sample Date	Sample Description
Field blanks				
QC	CNFB01-W-16149	–	7/20/04	Blank of water used for equipment decontamination and well construction; obtained from city water source.
QC	CNFB02-W-16167	–	7/21/04	Deionized water used for equipment decontamination.
QC	CNQCFB-W-16161	–	8/26/04	Blank of water used for equipment decontamination during August 2004 field event.
Equipment rinsates				
QC	CNRI01-W-16166	–	7/21/04	Rinsate of auger after decontamination.
QC	CNQCRI-W-16185	–	8/26/04	Rinsate of tube used during well purging and sampling.
QC	CNQCRI-W-16194	–	8/26/04	Rinsate of decontaminated valve used to sample the SB05 piezometer.
Trip blanks				
QC	CNQCTB-S-16164	–	7/22/04	Trip blank sent to the AGEM Laboratory for organic analysis with soil samples listed on chain-of-custody form (COC) 3678.
QC	CNQCTB-W-16165	–	7/22/04	Trip blank sent to the AGEM Laboratory for organic analysis with water samples listed on COC 3677.
QC	CNQC-W-16174	–	7/29/04	Trip blank sent to the AGEM Laboratory for organic analysis with water samples listed on COC 3664.
QC	CNQC-W-16176	–	7/29/04	Trip blank sent to Clayton Group Services for organic analysis with waste sample listed on COC 3665.
QC	CNQCTB-W-16181	–	8/24/04	Trip blank sent to the AGEM Laboratory for organic analysis with water samples listed on COC 3679.
QC	CNQCTB-W-16182	–	8/24/04	Trip blank sent to Severn-Trent Laboratory for attenutation parameter analysis with groundwater samples listed on COC 3680.
QC	CNQCTB-W-16160	–	8/26/04	Trip blank sent to the AGEM Laboratory for organic analysis with water samples listed on COC 1616.
QC	CNQCTB-W-16162	–	8/26/04	Trip blank sent to Severn-Trent Laboratory for attenutation parameter analysis with groundwater samples listed on COC 1618.
QC	CN-MU-TB-11200	–	8/31/04	Trip blank sent to Envirosystems, Inc., for verification organic analysis with groundwater sample listed on COC 4012.
Blind replicate soil sample				
MW02	CNQCDU-S-16163	45.0	7/21/04	Replicate of subsurface soil sample CNMW02-S-16155, collected during drilling of MW02.

TABLE F.1 (Cont.)

Location	Sample	Depth (ft BGL)	Sample Date	Sample Description
Soil samples selected by the AGEM Laboratory for duplicate organic analyses				
MW02	CNMW02-S-16155	45.0	7/21/04	Subsurface soil sample collected during drilling of MW02.
MW02	CNQCDU-S-16163	45.0	7/21/04	Replicate of subsurface soil sample CNMW02-S-16155.
Blind replicate groundwater samples				
MW05	CNQCDU-W-16187	34.5–44.5	8/25/04	Replicate of monitoring well sample CNMW05-W-16183, collected for volatile organic, inorganic, total organic carbon, attenuation parameter, and tritium analyses.
SB05	CNQCDU-W-16195	32.0–42.0	8/26/04	Replicate of sand point well sample CNSB05-W-16190, collected for organic analysis.
Water samples selected by the AGEM Laboratory for duplicate organic analyses				
QC	CNMW01-W-16148	54.5–64.5	7/20/04	Sample of development water from monitoring well MW01.
MW05	CNMW05-W-16183	34.5–44.5	8/25/04	Monitoring well sample
Water sample selected for verification organic analysis by Envirosystems, Inc.				
SB01	CNSB01-W-16188	40.0–50.0	8/26/04	Groundwater sample from piezometer SB01.
Waste characterization samples				
QC	CNMW01-W-16148	54.5–64.5	7/20/04	QC sample collected to determine requirements for disposal of future purge water from monitoring well MW01. Sample collected after installation of casing and sand, prior to installation of grout and purging of the well.
QC	CNQC-S-16175	–	7/29/04	Composite sample of drill cuttings from monitoring well installation in roll-off container.
QC	CNQC-W-16177	–	7/29/04	Composite sample of development water from MW01–MW06 accumulated in roll-off container during July 2004 development and sampling.
QC	CNQCWASTE-W-16179	–	8/24/04	Second sampling of containerized development water from monitoring wells after time for volatilization. Initially sampled as CNQC-W-16177.
QC	CNQCDR01-W-16196	–	8/27/04	Composite sample from two drums of purge wastewater from contaminated monitoring well MW02 during August 2004 sampling. Other uncontaminated monitoring wells were purged to the ground.
QC	CNQCDR02-W-16197	–	8/27/04	Sample from third drum containing purge wastewater from sampling of contaminated piezometers SB01, SB04, SB05, and SB08 in August 2004. Purge water from uncontaminated SB09 was released to the ground.

TABLE F.2 Results of organic analyses on samples collected to monitor sample collection and handling activities.

Sample	Sample Date	Sample Matrix	Analytical Method	Analytical Laboratory[a]	Concentration (µg/L for water; µg/kg for soil)				
					Carbon Tetrachloride	Chloroform	Ethane	Ethene	Methane
Field blanks									
CNFB01-W-16149	7/20/04	Water	EPA 524.2	AGEM	1 U[b]	1 U	NA[c]	NA	NA
CNFB02-W-16167	7/21/04	Water	EPA 524.2	AGEM	1 U	1 U	NA	NA	NA
CNQCFB-W-16161	8/26/04	Water	EPA 524.2	AGEM	1 U	1 U	NA	NA	NA
Equipment rinsates									
CNRI01-W-16166	7/21/04	Water	EPA 524.2	AGEM	1 U	1 U	NA	NA	NA
CNQCRI-W-16185	8/26/04	Water	EPA 524.2	AGEM	1 U	1 U	NA	NA	NA
CNQCRI-W-16194	8/26/04	Water	EPA 524.2	AGEM	1 U	1 U	NA	NA	NA
Trip blanks									
CNQCTB-S-16164	7/22/04	Soil	SW8260B	AGEM	10 U	10 U	NA	NA	NA
CNQCTB-W-16165	7/22/04	Water	EPA 524.2	AGEM	1 U	1 U	NA	NA	NA
CNQC-W-16174	7/29/04	Water	EPA 524.2	AGEM	1 U	1 U	NA	NA	NA
CNQC-W-16176	7/29/04	Water	SW8260	CLTP	1 U	1 U	NA	NA	NA
CNQCTB-W-16181	8/24/04	Water	EPA 524.2	AGEM	1 U	1 U	NA	NA	NA
CNQCTB-W-16182	8/24/04	Water	RSK-175	STL	NA	NA	4 U	3 U	2 U
CNQCTB-W-16160	8/26/04	Water	EPA 524.2	AGEM	1 U	1 U	NA	NA	NA
CNQCTB-W-16162	8/26/04	Water	RSK-175	STL	NA	NA	4 U	3 U	2 U
CN-MU-TB-11200	8/31/04	Water	SW8260	ESIC	5 U	5 U	NA	NA	NA
Waste characterization samples									
CNMW01-W-16148	7/20/04	Water	EPA 524.2	AGEM	1 U	1 U	NA	NA	NA
CNQC-S-16175	7/29/04	Soil	SW8260	CLTP	12 U	12 U	NA	NA	NA
CNQC-W-16177	7/29/04	Water	EPA 524.2	AGEM	8.5	1 U	NA	NA	NA

TABLE F.2 (Cont.)

Sample	Sample Date	Sample Matrix	Analytical Method	Analytical Laboratory[a]	Concentration (µg/L for water; µg/kg for soil) Carbon Tetrachloride	Chloroform	Ethane	Ethene	Methane
Waste characterization samples (Cont.)									
CNQCWASTE-W-16179	8/24/04	Water	EPA 524.2	AGEM	1	1 U	NA	NA	NA
CNQCDR01-W-16196	8/27/04	Water	EPA 524.2	AGEM	133	13	NA	NA	NA
CNQCDR02-W-16197	8/27/04	Water	EPA 524.2	AGEM	14	0.9 J[d]	NA	NA	NA

[a] Analytical Laboratories: AGEM, Applied Geosciences and Environmental Management Laboratory; CLTP, Clayton Laboratory; STL, Severn-Trent Laboratory; ESIC, Envirosystems, Inc.

[b] U, contaminant not detected at the indicated method quantitation limit.

[c] NA, sample not analyzed for this constituent.

[d] J, estimated concentration below the method quantitation limit of 1 µg/L.

TABLE F.3 Results of organic analyses on quality control samples collected to monitor 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/L)	RPD[b]	Concentration (µg/L)	RPD[b]
SDG 04-7-23, analysis date July 23, 2004							
20-µg/L standard	97	92	92	17.11	15.5	16.51	19.1
Laboratory blank	100	100	100				
CNMW01-W-16148	99	97	99				
CNFB02-W-16167	92	93	92				
CNRI01-W-16166	86	87	90				
CNFB01-W-16149	90	93	94				
CNQCTB-W-16165	79.4[c]	80	83	Accepted. No contamination in associated samples.			
CNMW01-W-16148DUP	94	93	95				
SDG 04-7-26, analysis date July 26, 2004							
20-µg/L standard	96	108	104	23.5	16.1	22.5	11.7
Methanol blank	100	100	100				
CNMW02-S-16150	82	90	90				
CNMW02-S-16151	104	107	108				
CNMW02-S-16152	104	111	112				
CNMW02-S-16153	92	100	101				
CNMW02-S-16154	75.4[c]	88	86	Accepted. No contamination in associated samples.			
CNMW02-S-16155	94	102	102				
CNMW02-S-16155DUP	87	95	96				
CNMW02-S-16156	83	89	91				
Meoh blank	82	81	81				
CNQCDU-S-16163	84	91	92				
CNQCDU-S-16163DUP	93	103	103				
CNQCTB-S-16164	84	96	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/L)	RPD[b]	Concentration (µg/L)	RPD[b]
SDG 04-7-30, analysis date July 30, 2004							
20-µg/L standard	103	102	81	18.11	9.9	18.99	5.2
Laboratory blank	100	100	100				
CNQC-W-16177	106	112	112				
CNMW01-W-16168	101	105	104				
CNMW02-W-16169	97	102	102	Outside calibration range for carbon tetrachloride at zero dilution.			
CNMW03-W-16170	99	101	101				
CNMW04-W-16171	100	102	103				
CNMW05-W-16172	95	95	95				
CNMW06-W-16173	101	101	103				
CNQC-W-16174	101	97	98				
Laboratory blank2	97	95	98				
CNMW02-W-16169	97	102	103				
SDG 04-8-26, analysis date August 26, 2004							
20-µg/L standard	81	81	85	16.3	20	18.22	9.3
Laboratory blank	100	100	100				
CNQCWASTE-W-16179	99	94	94				
CNMW01-W-16158	103	103	102				
CNMW03-W-16178	89	92	90				
CNMW04-W-16180	95	93	91				
CNMW06-W-16184	95	98	95				
CNMW05-W-16183	90	90	89				
CNMW05-W-16183DUP	88	92	88				
CNQCDU-W-16187	91	96	91				
CNQCTB-W-16181	85	84	80				

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/L)	RPD[b]	Concentration (µg/L)	RPD[b]
SDG 04-8-27, analysis date August 27, 2004							
20-µg/L standard	89	84	88	16.24	20	18.54	7.5
Laboratory blank	100	100	100				
CNMW02-W-16159	92	94	94	Outside calibration range for carbon tetrachloride at zero dilution.			
CNSB01-W-16188	92	92	93	Outside calibration range for carbon tetrachloride at zero dilution.			
CNSB04-W-16189	93	96	95				
CNSB05-W-16190	92	94	94				
CNSB08-W-16192	90	87	90				
CNSB08-W-16192DUP	91	90	91				
CNSB09-W-16193	89	88	90				
CNQCDU-W-16195	88	85	86				
CNQCDR01-W-16196	88	89	87				
CNQCDR02-W-16197	88	89	89				
CNQCTB-W-16160	82	83	84				
SDG 04-8-31, analysis date August 31, 2004							
20-µg/L standard	105	108	94	16.77	17.5	18.37	8.5
Laboratory blank	100	100	100				
CNQCFB-W-16161	104	99	102				
CNQCRI-W-16185	105	103	105				

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/L)	RPD[b]	Concentration (µg/L)	RPD[b]
SDG 04-8-31, analysis date August 31, 2004 (Cont.)							
CNQCRI-W-16194	104	101	102				
CNMW02-W-16159	102	96	99	Analysis at DF 5 for carbon tetrachloride and chloroform.			
CNSB01-W-16188	104	99	102	Analysis at DF 5 for carbon tetrachloride and chloroform.			

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

[b] Quality control limits for relative percent difference (RPD) for calibration check standards: ±20%.

[c] Surrogate recovery outside the quality control limit.

TABLE F.4 Carbon tetrachloride and chloroform results for secondary quality control analyses at the AGEM Laboratory with the purge-and-trap method.

Location	Sample Date	Depth (ft BGL)	Sample Matrix	Sample	Analysis Type	Concentration (µg/L for water; µg/kg for soil)	
						Carbon Tetrachloride	Chloroform
QC	7/20/04	54.5–64.5	Water	CNMW01-W-16148	Sample	1 U[a]	1 U
				CNMW01-W-16148DUP	Duplicate analysis	1 U	1 U
MW02	7/21/04	45.0	Soil	CNMW02-S-16155	Sample	10 U	10 U
				CNMW02-S-16155DUP	Duplicate analysis	10 U	10 U
				CNQCDU-S-16163	Blind replicate	10 U	10 U
				CNQCDU-S-16163DUP	Duplicate analysis	10 U	10 U
MW05	8/25/04	34.5–44.5	Water	CNMW05-W-16183	Sample	1 U	1 U
				CNMW05-W-16183DUP	Duplicate analysis	1 U	1 U
				CNQCDU-W-16187	Blind replicate	1 U	1 U
SB05	8/26/04	32.0–42.0	Water	CNSB05-W-16190	Sample	59	5.5
				CNQCDU-W-16195	Blind replicate	53	5.4

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

TABLE F.5 Recovery of system-monitoring compounds in verification organic analyses of water samples at Envirosystems, Inc.

Sample	Analysis Date	Sample Delivery Group	Recovery[a] (%)		
			Toluene-d_8	Bromofluoro-benzene	1,2-Dichloro-ethane-d_4
CN-MU-TB-11200	9/2/04	409261	104	90	95
CNSB01-W-16188	9/2/04	409261	103	92	102
CNSB01-W-16188DL	9/2/04	409261	100	94	96
VHBLKBR	9/2/04	409261	104	92	101
WA-11-16737MS	9/2/04	409261	102	91	102
WA-11-16737MSD	9/2/04	409261	98	91	101
VBLKBR	9/2/04	409261	103	91	95

[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.6 Recovery and relative percent difference values for spike/spike duplicate organic analyses at Envirosystems, Inc., with CLP methodology.

	Concentration (µg/L)				Recovery (%)			Difference (%)	
Compound	Sample	Spike Added	Initial Analysis	Duplicate Analysis	Initial Analysis	Duplicate Analysis	QC Limit	RPD	QC Limit
Spike/spike duplicate analysis of groundwater sample WA-11-16737									
1,1-Dichloroethene	0	50	49.56	49.91	99	100	61–145	1	14
Trichloroethene	0	50	49.14	52.03	98	104	71–120	6	14
Benzene	0	50	49.53	52.20	99	104	76–127	5	11
Toluene	0	50	53.98	53.59	108	107	76–125	1	13
Chlorobenzene	0	50	50.26	52.55	101	105	75–130	4	13

TABLE F.7 Percent recovery of known analyte concentrations during inorganic analysis and total organic carbon analysis of quality control samples at Severn-Trent Laboratory.

		SDG 102004		SDG 102069	
Compound	Actual Concentration (µg/L)	Detected Concentration (µg/L)	Recovery[a] (%)	Detected Concentration (µg/L)	Recovery[a] (%)
Total alkalinity	100,000	98,700	98.7	98,700	98.7
Chloride	5,000	4,810	96.2	4,750	95.0
Sulfate	10,000	9,860	98.6	10,100	101.0
Nitrate as nitrogen	3,000	2,780	92.7	2,860	95.3
Phosphate	2,000	1,730	86.5	2,060	103.0
Chloride	5,000	4,640	92.8	4,940	98.8
Sulfate	10,000	10,090	100.9	10,400	104.0
Nitrite nitrogen	20	20.7	103.5	21.2	106.0
Nitrate/nitrite nitrogen	13,000	13,100	100.8	13,900	106.9
Nitrate/nitrite nitrogen	13,000	13,000	100.0	13,900	106.9
Total organic carbon	14,800	16,200	109.5	16,200	109.5
Aluminum	51,000	48,270	94.6	54,570	107.0
Calcium	50,000	46,670	93.3	50,620	101.2
Iron	50,500	47,120	93.3	51,350	101.7
Magnesium	50,000	46,300	92.6	52,030	104.1
Manganese	500	454.3	90.9	489.2	97.8
Phosphorus	1,000	NA[b]	NA	943.2	94.3
Potassium	50,000	46,110	92.2	49,170	98.3
Silicon	1,000	926.6	92.7	1,021	102.1
Sodium	50,000	46,650	93.3	51,310	102.6
Zinc	500	454.7	90.9	472.4	94.5

[a] Quality control limit for percent recovery = 80–120%.

[b] NA, not analyzed.

TABLE F.8 Calculated relative percent difference in inorganic analysis and total organic carbon analysis of groundwater sample and replicate at Severn-Trent Laboratory.

Analyte	Concentration (µg/L)		Relative Percent Difference
	Sample CNMW05-W-16183	Replicate CNQCDU-W-16187	
Chloride	4,580	4,300	6.3
Sulfate	4,560	4,500	1.3
Nitrate as nitrogen	2,460	2,460	0
Phosphate	< 200	< 200	–[a]
Nitrate/nitrite nitrogen	2,550	2,530	0.8
Nitrite nitrogen	15.8	14.7	7.2
Total organic carbon	< 1,000	< 1,000	–
Total alkalinity	315,000	315,000	0
Aluminum	< 200	< 200	–
Calcium	77,200	73,100	5.5
Iron	< 100	< 100	–
Magnesium	27,200	25,800	5.3
Manganese	< 15	< 15	–
Phosphorus	NA[b]	NA	–
Potassium	< 5,000	< 5,000	–
Silicon	15,100	14,300	5.4
Sodium	13,500	12,200	10.1
Zinc	< 20	< 20	–

[a] Analyte not detected at indicated reporting limit in either sample or replicate. Relative percent difference not calculated.

[b] NA, not analyzed.

TABLE F.9 Recovery and relative percent difference values for analyses of laboratory control samples for attenuation parameters at Severn-Trent Laboratory.

Compound	Concentration (µg/L)			Recovery[a] (%)		RPD[b]
	Spike Added	Initial Analysis	Duplicate Analysis	Initial Analysis	Duplicate Analysis	
Sample delivery group 102004						
Methane	73	58	73	79	100	23
Ethane	140	120	150	86	107	22
Ethene	130	110	140	85	108	24
Sample delivery group 102069						
Methane	73	73	68	100	93	7
Ethane	140	150	130	107	93	14
Ethene	130	140	120	108	92	16

[a] Quality control limit for percent recovery = 70–130%.

[b] Quality control limit for relative percent difference = 30%.

TABLE F.10 Recovery and relative percent difference values for spike/spike duplicate organic analyses at Clayton Laboratory with CLP methodology.

	Concentration				Recovery (%)			Difference (%)	
Compound	Spike Added	Initial Analysis	Duplicate Analysis	Units	Initial Analysis	Duplicate Analysis	QC Limits	RPD	QC Limit
Spike/spike duplicate analysis of groundwater sample WA-11-16737									
Carbon tetrachloride	60.98	57.94	51.27	µg/kg	95.0	84.1	48.6–147.0	12.2	19.9
Chloroform	60.98	60.73	59.39	µg/kg	99.6	97.4	73.0–129.0	2.2	14.2
Carbon tetrachloride	50	45.69	44.09	µg/L	91.4	88.2	54.7–134.0	3.5	21.4
Chloroform	50	46.32	43.60	µg/L	92.6	87.2	75.4–121.0	6.1	16.6