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Final Work Plan: Phase I QuickSite℠ Investigation, Adams, Nebraska

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Notation

AMSL	above mean sea level
ASTM	American Society for Testing and Materials
BGL	below ground level
BTEX	benzene, toluene, ethylbenzene, and xylene
CCC	Commodity Credit Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CSD	Conservation and Survey Division
d	day(s)
DOE	U.S. Department of Energy
ECPT	electronic cone penetrometer
EPA	U.S. Environmental Protection Agency
ESC	Expedited Site Characterization
ESI	expanded site investigation
°F	degree(s) Fahrenheit
FS	feasibility study
FSI	focused site investigation
ft	foot (feet)
gal	gallon(s)
gpm	gallon(s) per minute
HRS	hazard ranking system
in.	inch(es)
LUST	leaking underground storage tank
µg/L	microgram(s) per liter
MCL	maximum contaminant level
mg/L	milligram(s) per liter
mi	mile(s)
NDEQ	Nebraska Department of Environmental Quality (formerly Nebraska Department of Environmental Control)
NDH	Nebraska Department of Health (now Nebraska Health and Human Services, NHHS)
NHHS	Nebraska Health and Human Services (formerly Nebraska Department of Health, NDH)

PA	preliminary assessment
ppm	part(s) per million
PWS	public water supply
RI	remedial investigation
RPD	relative percent difference
SARA	Superfund Amendments and Reauthorization Act
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VOC	volatile organic compound

Final Work Plan: Phase I QuickSite^{SM} Investigation, Adams, Nebraska

1 Introduction

The village of Adams, Nebraska, is a small rural community with a population of 472, located in the southeastern part of the state (Figure 1.1). The nearest city is Beatrice (population 12,357), located about 27 mi to the southwest. Figure 1.2 is a plan of the village showing the locations of former and existing grain storage facilities and the three public water supply wells. From 1950 to 1975, the Commodity Credit Corporation (CCC), an agency of the U.S. Department of Agriculture (USDA), operated a grain storage facility in Adams. During this time, commercial grain fumigants containing carbon tetrachloride were commonly used by the CCC/USDA and the private grain storage industry to preserve grain in their facilities.

In 1990, carbon tetrachloride was detected in a sampling event in one of the three Adams public water supply (PWS) wells during routine screening conducted by Nebraska Health and Human Services (NHHS), formerly the Nebraska Department of Health (NDH). Carbon tetrachloride was reportedly detected at 12.9 μg/L in a sample collected in February 1990 from Adams municipal well PWS 64-1. This level exceeds the maximum contaminant level (MCL) of 5 μg/L promulgated by the U.S. Environmental Protection Agency (EPA) for drinking water. Carbon tetrachloride was again detected in the well at levels above the MCL (13.1 μg/L) in follow-up sampling by NHHS in March 1990. The well was disconnected from the municipal water system in May 1991 because of the concentrations of carbon tetrachloride. Even though well PWS 64-1 is no longer used for drinking water supply, the village has continued to use the well for other purposes. During the past several years, water from the well has been used extensively by road construction crews working in the area and by nearby farmers for irrigation.

Initial sampling of well PWS 70-1, conducted in February 1990 by NHHS, revealed no carbon tetrachloride. A sample collected from the well in October 1990 reportedly contained carbon tetrachloride at 0.4 μg/L, but two samples collected in 1991 showed no contamination. Subsequent sampling from well PWS 70-1 and from the treatment plant has resulted in periodic detections of carbon tetrachloride, always at levels well below the MCL. Well PWS 70-1 continues to serve as an active production well for the village. Carbon tetrachloride has never been detected in the village's third well (PWS 79-1), which is located just north of the village limits.

Because the carbon tetrachloride found in the wells might, in part, be linked to historical use of carbon tetrachloride-based grain fumigants at the former CCC/USDA facility, the CCC/USDA is conducting an environmental site investigation to determine the source(s) and extent of the carbon tetrachloride contamination at the Adams site and to assess whether the contamination requires remedial action.

The investigation at Adams is 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 CCC/USDA has entered into an interagency agreement with DOE, under which Argonne provides technical assistance to the CCC/USDA with environmental site characterization and remediation at its former grain storage sites.

At these sites, Argonne is applying its QuickSite^{SM} environmental site characterization methodology. QuickSite^{SM} is Argonne's proprietary implementation system for the Expedited Site Characterization (ESC) process (ASTM 1998). Argonne's Environmental Research Division developed the ESC process to optimize preremedial site characterization work at hazardous waste sites by obtaining and then exploiting a thorough understanding of a site's geology, hydrogeology, and hydrogeochemistry (e.g., Burton 1994). This approach is fundamental to successful site characterization, because the geology and hydrogeology of a site largely govern the mobility and fate of contaminants there. Throughout the ESC process, a conceptual model of a site's geology, hydrogeology, and hydrogeochemistry guides investigative work. The conceptual model is developed initially by appraising existing data from the site within a regional geologic, hydrogeologic, and hydrogeochemical framework. This preliminary conceptual model is tested and revised during the first phase of the ESC investigation. The revised conceptual model is then used to guide the second phase of investigation, which focuses primarily on delineation of contamination at the site. The results of the investigation provide a technically defensible basis for evaluating potential health risks and hence the possible remediation needs of the site. Argonne's QuickSite^{SM} methodology has been applied successfully at a number of former CCC/USDA sites in Nebraska and Kansas and has been adopted by the American Society for Testing and Materials (ASTM 1998) as standard practice for environmental site characterization.

A preliminary assessment (PA) (Jacobs 1992) and a focused site investigation (FSI) (NDEQ 1997) were performed at Adams for the EPA. The FSI concluded that a release of carbon tetrachloride to groundwater had occurred. The report also stated that the contaminant source had not been identified and recommended that an expanded site investigation (ESI) be conducted. The

EPA initiated an ESI in 1999 but has not yet issued an ESI report. However, field sheets indicating the sampling program performed for the ESI and the analytical results were provided to Argonne. Soil and groundwater samples were collected at numerous locations, including the former CCC/USDA site and the Farmers Elevator Company. According to the FSI, the commercial elevator facility used fumigants containing carbon tetrachloride. The preliminary results from the ESI indicate the presence of carbon tetrachloride in the groundwater near the former CCC/USDA facility and in the groundwater at the Farmers Elevator site. The former CCC/USDA site is located approximately 500 ft west of well PWS 70-1 and approximately 2,000 ft west of PWS 64-1 (see Figure 1.2). The Farmers Elevator Company is located approximately 2,000 ft east of the former CCC/USDA facility, near PWS 64-1. Thus, two separate potential source areas for carbon tetrachloride contamination exist at Adams. The focus of the Argonne investigation will be determining whether the former CCC/USDA site is a source of carbon tetrachloride contamination at Adams and, if so, delineating the extent of the contamination originating at that site.

This *Work Plan* describes the preliminary conceptual model of the Adams site, then outlines the scope of and provides technical guidance for the initial phase of the investigation. In addition to this *Work Plan*, Argonne has issued a *Master Work Plan: Expedited Site Characterizations at CCC/USDA Sites in Nebraska* (Argonne 1994) that describes the general scope of investigations at all former CCC/USDA sites in Nebraska and provides general guidance for those investigations. The *Master Work Plan* contains the materials common to investigations at all sites. Both documents must be consulted for the complete details of plans of Phase I work at the former CCC/USDA site in Adams.

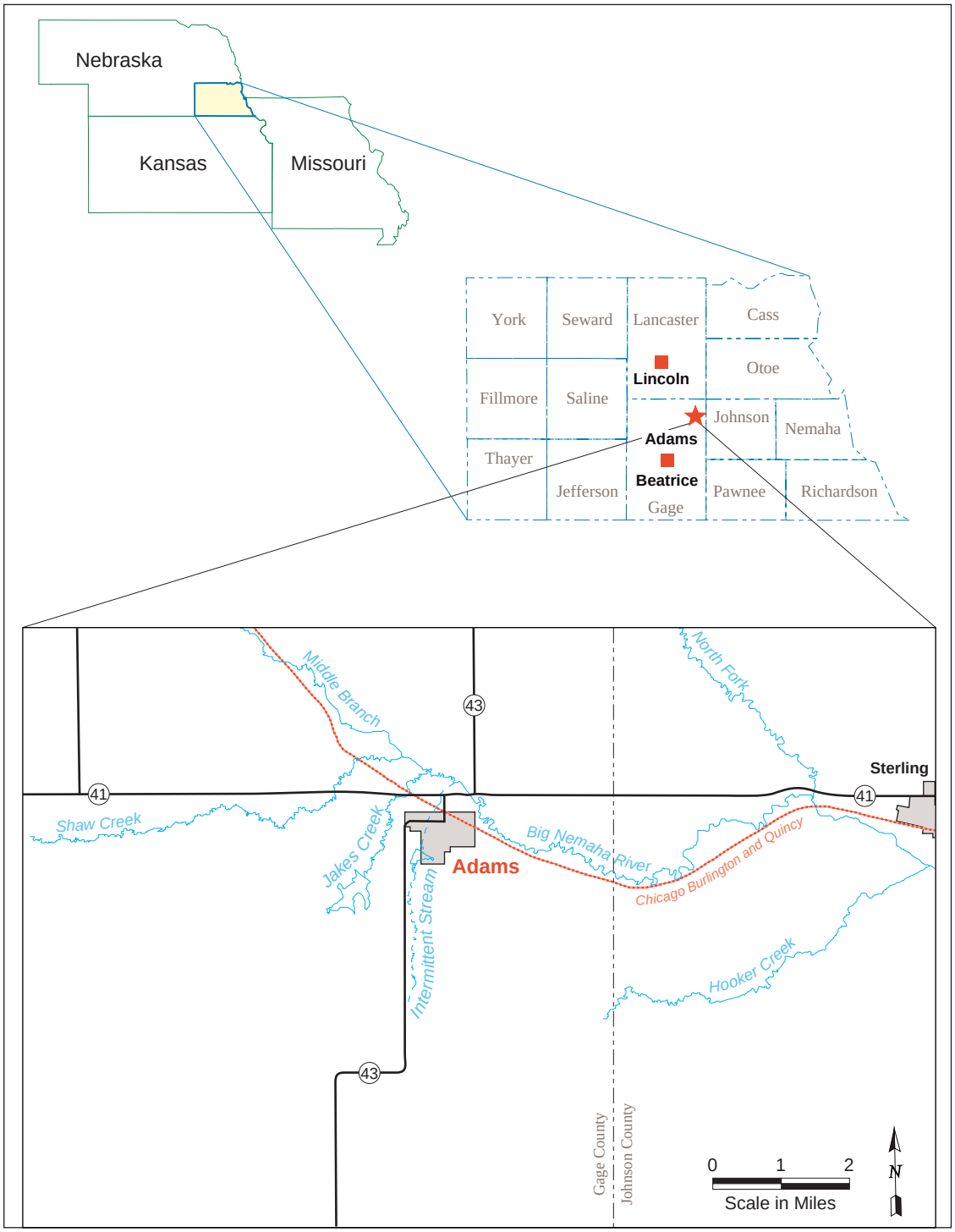

FIGURE 1.1 Map Showing the Location of Adams, Gage County, Nebraska

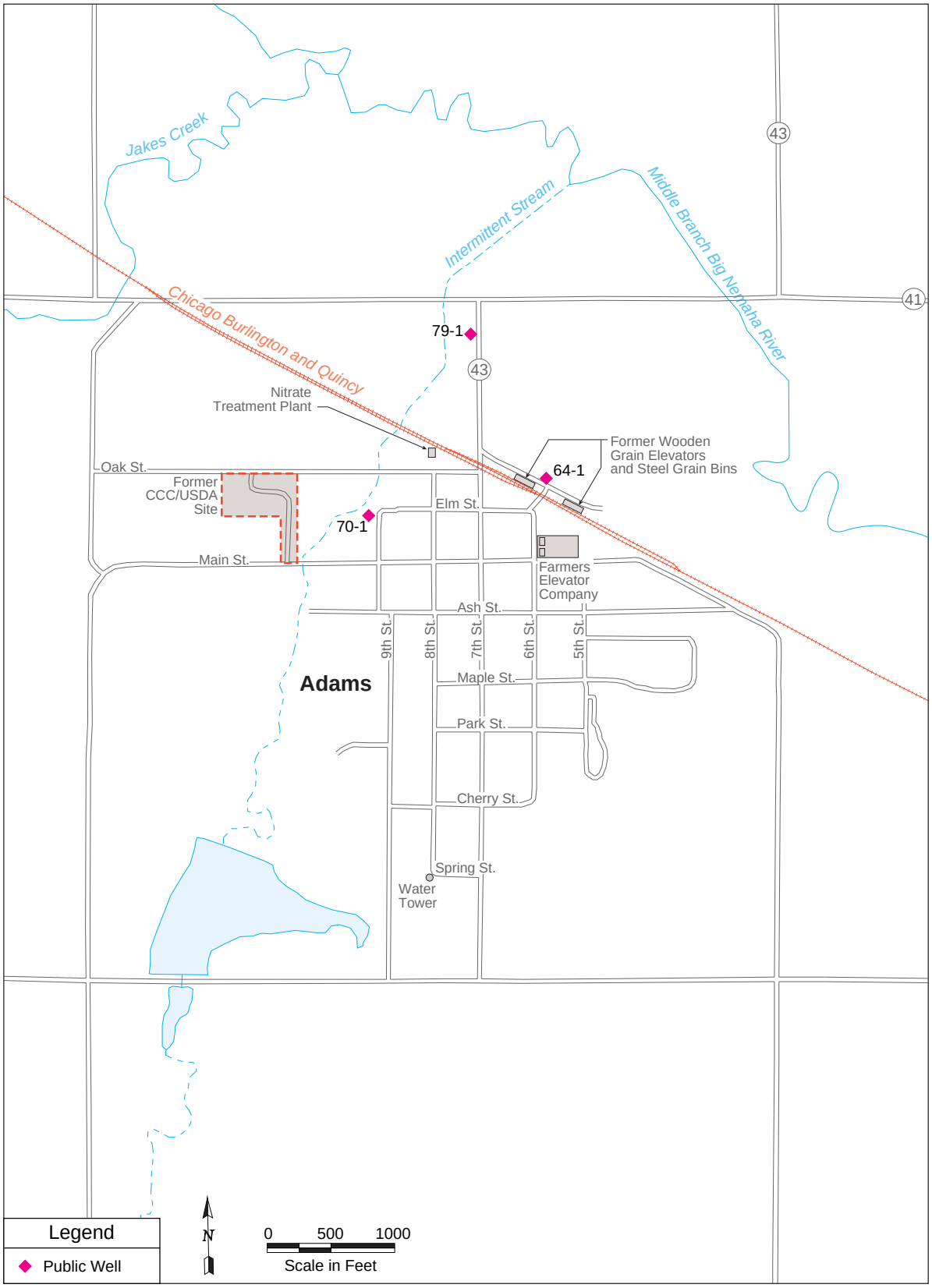

FIGURE 1.2 Map Showing the Locations of Existing Public Wells and Existing and Former Grain Storage Facilities at Adams, Nebraska

2 Background Information and Previous Studies

2.1 Site Features and History

2.1.1 Area Description

Adams, Nebraska, is a small rural community of approximately 472 persons located in southeastern Nebraska, in northeast Gage County (Figure 1.1). Located on State Highway 43, near the intersection of State Highways 41 and 43, Adams is approximately 27 mi northeast of Beatrice and 33 mi southeast of Lincoln. The village is located within Section 27, Township 6 North, Range 8 East, at approximate latitude 40°27′42″ North and longitude 96°30′29″ West.

Agriculture is the primary industry of the region, and Adams serves as an agricultural market town for area farmers. Related businesses in the village include the Farmers Elevator Company and Service Station, Veerhusen Feed and Seed (formerly Lloyd's Feed and Seed), and Purina (Figures 2.1 and 2.2). The CCC/USDA operated a grain storage facility on the west side of the village in 1950-1975. In addition, a wooden grain elevator of unknown ownership was formerly located north of the Farmers Elevator Company. The Chicago Burlington and Quincy Railroad runs through the northeast corner of the village, between the Farmers Elevator Company and the former wooden elevators. The town also has a bank, a post office, churches, a public school, and a nursing home.

Residents of Adams are supplied with water by a municipal water system (discussed in Section 2.1.2). Surrounding farms use irrigation wells and private drinking water wells (Figure 2.1). Available lithologic logs and well construction details for pertinent regional wells are in Appendix A. The village is not within an established wellhead protection area (page 8 in NDEQ 1997).

Adams is located along the southern edge of the Big Nemaha River floodplain, less than 0.5 mi south of the Middle Branch of the Big Nemaha River (Figure 2.1). Jakes Creek, approximately 0.5 mi northwest of the village, flows east toward the river. An intermittent stream along the western edge of the village flows north and empties into the Middle Branch of the river. The terrain of the village slopes toward the river, with surface drainage on the west side of the village toward the intermittent stream and drainage from the remainder of the village toward the northeast. East of Adams, the Big Nemaha River flows southeast toward the Missouri River.

Neither the river nor the creeks are used as a source of drinking water for human consumption, although they may be used by livestock (page 9 in NDEQ 1997).

Several species of sport fish, including crappie, catfish, and bluegill, inhabit the Middle Branch of the Big Nemaha River. Federally listed threatened and endangered species that might occur in the area include the American burying beetle, the American bald eagle, and the peregrine falcon (page 9 in NDEQ 1997).

The climate in the Adams area is continental and subhumid, with hot summers and cold winters (Jacobs 1992). The average summer high temperature is 90.6°F, and the average winter low is 13.2°F. The average annual precipitation for the area is approximately 30 in.

2.1.2 Site Description and History

Residents of Adams are supplied with water by a municipal system that is currently served by public supply wells PWS 79-1 and PWS 70-1. Figure 2.1 is a map of the village showing the locations of the public wells and nearby irrigation wells, test holes, and domestic wells. Table 2.1 summarizes the available construction details for the public wells.

Well PWS 64-1 was disconnected from the municipal water system in May 1991, following detection of carbon tetrachloride at a concentration of 12.90 μg/L in February 1990 and 13.10 μg/L in March 1990 during sampling by the NDH. Use of well PWS 64-1 has continued since that time, however, with large volumes of water being pumped for nondrinking purposes such as road work and irrigation. Livestock are not given water from the well (Topp 1997). Carbon tetrachloride was detected at a concentration of 0.4 μg/L in PWS 70-1 in October 1990. Three older public wells, PWS 30-1, PWS 49-1, and PWS 56-1, were abandoned by the village before the detection of carbon tetrachloride in PWS 64-1.

Sampling of the Adams municipal water supply and nearby domestic wells to investigate the carbon tetrachloride contamination is summarized in Table 2.2; sample locations are shown in Figure 2.1. Analytical data are reported as given in the original source documents (see references to sources in Table 2.2). Quality control data were not provided in documentation of the sampling events, so no judgment can be made regarding the accuracy of the data.

TABLE 2.1 Construction Details for Adams Municipal Wells

	Well					
	30-1	49-1	56-1	64-1	70-1	79-1
Registration number	NA[a]	G-29814	G-29815	G-29816	NA	NA
Status	Out of service	Out of service	Out of service	Occasional pumping	Production	Production
Well depth (ft BGL[b])	65	65	58	70	NA	105
Depth to water (ft BGL)	NA	26	26	26	NA	20
Pumping capacity (gpm)	80	160	160	240	NA	818
Water level, pumping (ft BGL)	NA	40	40	40	NA	54
Gravel pack (ft)	NA	NA	NA	NA	NA	To 20 ft BGL
Screen interval (ft)	12	16	NA	NA	NA	27.58
Screen depth (ft)	NA	NA	NA	NA	NA	NA
Screen material	Bronze	NA	NA	NA	NA	Stainless steel
Casing diameter (in.)	16	12	12	18	NA	10
Casing length (ft)	NA	NA	NA	NA	NA	77.58
Drilling company	NA	Layne-Western	Olsen Drilling	NA	NA	Blue Valley Drilling

[a] NA, not available.

[b] BGL, below ground level.

TABLE 2.2 Organic Analytical Results for Previous Sampling of Adams Wells

Sample Date	Sample Location	Concentration (µg/L) Carbon Tetrachloride	Chloroform	Volatile Organic Compounds	Source
2/5/90	PWS 64-1	12.9	ND[a]	ND	Jacobs 1992
3/2/90	PWS 64-1	13.1	ND	ND	Jacobs 1992
6/14/99	PWS 64-1	2.2	ND	ND	Topp 1999
2/5/90	PWS 70-1	ND	ND	ND	Jacobs 1992
10/9/90	PWS 70-1	0.4	ND	ND	Jacobs 1992
12/17/90	PWS 70-1	ND	ND	ND	Jacobs 1992
3/11/91	PWS 70-1	ND	ND	ND	Jacobs 1992
9/3/91	PWS 70-1	ND	ND	ND	Jacobs 1992
4/14/93	PWS 70-1	0.3	ND	ND	NDEQ 1997
6/14/99	PWS 70-1	1.3	ND	ND	Topp 1999
2/5/90	PWS 79-1	ND	ND	ND	Jacobs 1992
10/9/90	PWS 79-1	ND	ND	ND	Jacobs 1992
12/17/90	PWS 79-1	ND	ND	ND	Jacobs 1992
4/14/93	PWS 79-1	ND	ND	ND	NDEQ 1997
10/17/95	Distribution	ND	ND	ND	Topp 1999
10/31/95	Distribution	ND	ND	1,2-Dichloro-propane = 0.2	Topp 1999
1/23/96	Distribution	ND	ND	1,2-Dichloro propane = 0.2	Topp 1999
5/14/96	Distribution	0.8	ND	ND	Topp 1999
12/9/96	Distribution	1.2	0.3	ND	Topp 1999
12/9/97	Distribution	0.4	0.2	Bromodichloro methane = 0.3	Topp 1999
2/2/98	Distribution	NA[b]	0.2	ND	Topp 1999
2/9/99	Distribution	ND	ND	ND	Topp 1999
4/12/99	Distribution	ND	ND	ND	Topp 1999
7/20/99	Distribution	ND	ND	ND	Topp 1999
8/2/99	Distribution	ND	ND	Chlorodibromo-methane = 0.7	Topp 1999
				Bromoform = 0.7	Topp 1999
9/26/95	Behrens Excavating	ND	ND	ND	NDEQ 1997
9/26/95	Wingate residence	ND	ND	ND	NDEQ 1997

[a] ND, not detected.

[b] NA, not analyzed for this compound.

2.2 Previous Investigations

Previous investigations of the carbon tetrachloride contamination of the Adams groundwater for the EPA Region VII are a PA conducted by Jacobs Engineering Group, Inc. (Jacobs 1992); an FSI report prepared by the Nebraska Department of Environmental Quality (NDEQ 1997); and an ESI conducted by Ecology and Environment, Inc. The ESI report had not been released at the time of this writing, but preliminary data from the investigation were supplied to Argonne by the EPA (Curry 1999).

Although it was not directed toward an investigation of the carbon tetrachloride contamination of the Adams groundwater, an investigation of leaking underground fuel storage tanks (LUSTs) at the Farmers Elevator Company Service Station provided additional information on the area. Reports are available on a hydrogeologic and physical investigation (Coranco 1990) and a pump test performed in conjunction with the installation of the LUST remediation system now in place (Coranco 1991). These documents provided useful information in the formulation of the regional hydrogeologic model discussed in Section 3.

Technical and pertinent historical data from these previous investigations are summarized below.

2.2.1 Preliminary Assessment of the Adams Groundwater Contamination

After detection of carbon tetrachloride in well PWS 64-1 by the NDH in 1990, the EPA Region VII, under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and the Superfund Amendments and Reauthorization Act (SARA) of 1986, engaged Jacobs Engineering Group, Inc. (Jacobs) to conduct a PA of the Adams groundwater contamination. The purpose of the 1992 PA was to gather sufficient information pertaining to the detected contamination and hydrogeologic setting to evaluate the threat to human health and the environment and to determine appropriate action under CERCLA/SARA. The investigation included a review of historical file information, a site reconnaissance, and a comprehensive target survey (Jacobs 1992).

Sampling was not conducted as part of the PA. Potential sources of the carbon tetrachloride contamination identified in the PA included (1) the former CCC/USDA grain storage facility, (2) a former wooden grain elevator of unknown ownership, (3) the Farmers

Elevator Company, (4) Veerhusen Feed and Seed (formerly Lloyd's Feed and Seed), and (5) the Farmers Elevator Company Service Station. Figure 2.2 is a 1965 aerial photograph of the village showing the locations of these sites, as identified by Argonne. The PA did not examine the legal property descriptions or determine the existence of leases. Each of the potential contaminant sources is discussed in Section 2.3. A chronological description of the sequence of activities conducted for the PA is in Appendix B, Section B.1.

Jacobs completed its PA of the Adams groundwater contamination on September 29, 1992, concluding that the hazard ranking system (HRS) score of 51.38 warranted further investigation to determine the source of carbon tetrachloride contamination in well PWS 64-1. Periodic sampling of the municipal water supply was recommended. Noting that the CCC/USDA planned to conduct a remedial investigation/feasibility study, Jacobs recommended to the EPA Region VII that further work by the EPA be deferred to avoid duplication of effort (Aston 1992).

2.2.2 Focused Site Investigation of the Adams Water Supply System

Under a multisite cooperative agreement between the state of Nebraska and the EPA Region VII, an FSI was conducted in 1995 by the NDEQ under CERCLA/SARA. The scope of the FSI included a soil gas survey around the potential source areas identified by the PA and the collection of additional information. Two domestic wells were sampled (at the Wingate residence and at the Behrens Excavating Company north of the former CCC/USDA site, Figure 2.1); both wells were found to be free of carbon tetrachloride. A chronological description of the sequence of activities conducted for the FSI is in Appendix B, Section B.2.

The soil gas survey was conducted by Roy F. Weston, Inc., in July 1995 to investigate the potential source areas identified in the PA. Carbon tetrachloride was not detected in any of the samples collected during the soil gas survey. Other halogenated volatile organic compounds (VOCs) detected in two samples included 1,1,1-trichloroethane and chloromethane (a degradation by-product of carbon tetrachloride). These compounds were detected near the Farmers Elevator Company and Veerhusen Feed and Seed. Constituents of the BTEX group (benzene, toluene, ethylbenzene, and xylene) were also detected at the Farmers Elevator Company and at the former CCC/USDA facility. Groundwater samples from two private wells located on and to the north of the former CCC/USDA facility (at the Wingate residence and Behrens Excavation Company) were also collected in July 1995 by the NDH at the request of the NDEQ. No contamination was detected at either location. Quality control data were not provided

in the documentation of the sampling events, so no judgment can be made regarding the accuracy of these data.

2.2.3 Monitoring of the Adams Municipal Water Supply

Periodic monitoring of the Adams municipal water supply for the presence of VOCs has continued since completion of the FSI. The analytical results are in Table 2.2. A chronological description of the sequence of monitoring activities is in Appendix B, Section B.3. None of the water samples had carbon tetrachloride levels above the MCL (5 µg/L). The highest values recorded during this period were 2.2 µg/L in PWS 64-1 and 1.3 µg/L in PWS 70-1 on June 14, 1999, and 1.2 µg/L in the distribution system at the treatment plant on December 9, 1996. Before the level of 1.3 µg/L was reported in PWS 70-1 in 1999, the well had been mostly free of contamination, with a highest previously recorded carbon tetrachloride value of only 0.4 µg/L (Table 2.2). In view of the low analytical levels reported for carbon tetrachloride in the municipal wells, rigorous evaluation of the analytical methodology and quality control is critically important in establishing the accuracy of the results. Quality control data were not provided in documentation of the sampling events, so no judgment can be made regarding the accuracy of these data.

2.2.4 Expanded Site Investigation

In June 1999, sampling for the ESI was carried out for the EPA by Ecology and Environment Inc. The ESI report has not been completed, but preliminary data in the form of field sheets and analytical results were supplied by the EPA (Curry 1999). A review of the data indicates that sampling included the collection of (1) 4 sediment samples and 3 surface water samples from the intermittent stream adjacent to the former CCC/USDA facility, (2) subsurface soils at 16 locations, (3) groundwater samples with the Geoprobe system at 23 locations, (4) groundwater samples from public wells and the distribution system, (5) groundwater samples from monitoring wells at the Farmers Elevator Company Service Station, and (6) groundwater samples from 4 domestic wells. The subsurface soils were collected at the former CCC/USDA site, at the Farmers Elevator Company, at the location of the former wooden grain elevators, at the Behrens Excavation Company, and near a body shop south of the Farmers Elevator Company. The groundwater sampling locations were determined from the field sheets and facsimile copies of maps from the unpublished report (Curry 2000). Groundwater sample locations and analytical results for carbon tetrachloride and chloroform are shown in Figure 2.3.

Quality control data were not provided in documentation of the sampling events, so no judgment can be made regarding the accuracy of these data. Geoprobe sample depths were generally 30-40 ft BGL (below ground level), in the shallow portion of the aquifer. Both shallow (< 40 ft BGL) and deep (> 50 ft BGL) Geoprobe groundwater samples were collected at locations G8, G20, and G22 (Figure 2.3).

The preliminary data indicate the following:

1. Carbon tetrachloride was not detected above the analytical quantitation limit in any of the soil samples.

2. Carbon tetrachloride was not detected in surface water collected from the intermittent stream adjacent to the former CCC/USDA facility.

3. Carbon tetrachloride was not detected in the three LUST monitoring wells sampled by the EPA, which lie between the former CCC/USDA site and contaminated well PWS 64-1. These wells are designated as MW1-MW3 in Figure 2.3.

4. Carbon tetrachloride was detected in groundwater samples from well PWS 64-1 at 2.2 μg/L and well PWS 70-1 at 1.3 μg/L. Well PWS 79-1 and the distribution system were found to be free of contamination (Table 2.2 and Figure 2.3).

5. Carbon tetrachloride was detected in shallow groundwater from locations G23 and G24 at the Farmers Elevator Company at concentrations of 6.6 and 0.76 μg/L, respectively (Figure 2.3). Samples from the deeper part of the aquifer at location G22 (immediately adjacent to the northern boundary of the property) and at G20 (between the property and contaminated well PWS 64-1) were free of contamination.

6. Carbon tetrachloride was detected in shallow groundwater at locations G2, G3, G4, and G6 at the former CCC/USDA site at concentrations of 1.6, 9.2, 18, and 4.1 μg/L, respectively (Figure 2.3). No samples were collected from the deeper part of the aquifer at the former CCC/USDA site, but at location G8, immediately to the east, both shallow- and deep-aquifer samples were free of contamination. In addition, carbon tetrachloride was not detected in the

Wingate private well, which fully penetrates the aquifer near the northern boundary of the former grain storage facility.

The preliminary data suggest that contamination is restricted to the shallow part of the aquifer at the former CCC/USDA facility and at the Farmers Elevator Company property and is present at low concentrations in samples from PWS 64-1 and PWS 70-1. Analysis of samples collected between these two properties and the contaminated public wells revealed no carbon tetrachloride (Figure 2.3).

2.2.5 Site Assessment of the Farmers Elevator Company Service Station

A hydrogeologic and physical investigation of the Farmers Elevator Company Service Station in Adams was conducted by Coranco, Inc., in 1990, after removal of LUSTs and fuel distribution lines in October 1989. Lithologic logs of soil borings and well construction details of monitoring wells installed for this investigation (included in Appendix A) provided useful information for formulating the local hydrogeologic model in Section 3.

Two underground storage tanks for diesel fuel (1,000- and 560-gal capacity) and one gasoline tank (1,000-gal capacity) were removed from the Farmers Elevator Company Service Station in October 1989. On May 7, 1990, approximately 1 ft of free product was observed in wells drilled at the site for the initial site assessment. Subsequently, 17 boreholes were drilled, and soil sampling was conducted at 5-ft intervals. Monitoring wells were installed in all 17 boreholes, at locations shown in Figure 2.4. Systems for free-product recovery and soil vapor extraction were installed at the Farmers Elevator Company Service Station in 1991. A chronological description of the sequence of activities at the LUST site is in Appendix B, Section B.4.

2.3 Potential Contaminant Sources

On the basis of known or suspected past use of carbon tetrachloride, the PA report identified several potential sources for the carbon tetrachloride contamination at Adams (Jacobs 1992). These potential sources included (1) the former CCC/USDA grain storage facility, (2) a former wooden grain elevator of unknown ownership, (3) the Farmers Elevator Company, (4) Veerhusen Feed and Seed (formerly Lloyd's Feed and Seed), and (5) the Farmers Elevator Company Service Station. As described in Section 2.2.2, a soil gas investigation conducted during the FSI failed to detect carbon tetrachloride contamination in the postulated source areas

(NDEQ 1997). However, during the more recent ESI, carbon tetrachloride and chloroform were detected in shallow groundwater at the former CCC/USDA facility and at the Farmers Elevator Company property (Curry 1999).

2.3.1 Former CCC/USDA Grain Storage Facility

The former CCC/USDA grain storage facility, located in the northwest corner of Adams and west of public well PWS 70-1 (Figure 2.2), was in operation from 1950 until 1975. The approximately 5.1-acre property was leased by the CCC/USDA for a period of 99 years, beginning on September 1, 1950 (State of Nebraska 1950). The lease was terminated on May 13, 1975 (State of Nebraska 1975). The property was described in the lease as a tract of land located in the southern half of the northwest quarter of Section 27, Range 6, Township 8, commencing at a point 19 rods and 4 ft (or 317.5 ft) west of the southwest corner of Lot 3, Wyman's Addition to Adams, thence north 663 ft, thence west 583 ft, thence south 305 ft, thence east 463 ft, thence south 358 ft, thence east to the point of beginning. This legal description coincides with the location of the site as shown in Figure 2.2. The original landowners were George V. Trostle and Nettie M. Trostle, and the current owner is Bill Wingate of Adams.

Records of the CCC/USDA (FSA 1997) and a 1965 aerial photo (USDA 1965) show that 7 large Quonset huts (35,000-bushel capacity each), 10 circular bins (3,300-bushel capacity each), and 1 small storage building were located on the 220,775-ft^2 property. Although it had a 310,000-bushel storage capacity, the CCC/USDA facility was used only when other local grain storage facilities lacked adequate storage. All bins and buildings were removed after the CCC/USDA lease was terminated in 1975, and the property is now an open field.

2.3.2 Former Wooden Grain Elevators

A wooden grain storage facility of unknown ownership, located on the north side of the railroad tracks and adjacent to contaminated well PWS 64-1, ceased operation in the mid-1970s and was demolished in the 1980s. Argonne determined the location of this property from the 1965 aerial photograph (USDA 1965; Figure 2.2) and from Figure 2 in the PA report (Jacobs 1992). No search of property records for this site has been made.

2.3.3 Farmers Elevator Company

The Farmers Elevator Company, located in the northeast portion of Adams and south of the railroad tracks, has been in operation for over 80 years. Fumigation products containing carbon tetrachloride were used by the company to preserve stored grain (Jacobs 1992). Argonne determined the location of this property from the 1965 aerial photograph (USDA 1965; Figure 2.2) and from Figure 2 in the PA report (Jacobs 1992). No search of property records for this site has been made.

2.3.4 Veerhusen Feed and Seed

Veerhusen Feed and Seed (formerly Lloyd's Feed and Seed) is located at Sixth and Main Streets. Information recorded in an NDEQ spill report (NDEQ [no date]) indicates that a spill of unknown material or quantity occurred at the site. Response action taken, if any, is unknown. Argonne determined the location of this property from the 1965 aerial photograph (USDA 1965; Figure 2.2) and from Figure 2 in the PA report (Jacobs 1992). No search of property records for this site has been made.

2.3.5 Farmers Elevator Company Service Station

The Farmers Elevator Company Service Station is located at Seventh and Elm Streets. In 1989, LUSTs were removed from this site, and a remediation system was installed in 1991 (see Section 2.2.5). The system is currently on standby because of financial problems with the LUST program (NDEQ 1997). Argonne determined the location of this property from the 1965 aerial photograph (USDA 1965; Figure 2.2) and from Figure 2 in the PA report (Jacobs 1992). No search of property records for this site has been made.

2.4 Water Supply Issues

Nearly all residents of Adams obtain their drinking water from the municipal water system. Two public supply wells (PWS 70-1 and PWS 79-1) previously pumped alternately for approximately one week each; now the wells are pumped in tandem. Because of high nitrate levels in the region, water from both wells is piped to a nitrate treatment plant. This plant,

located near former public supply wells PWS 56-1 and PWS 30-1, began operation on July 9, 1991 (Olmsted 1992). Results of nitrate analyses on monitoring samples are in Table 2.3.

Two private wells located within the Adams village boundary, near the former CCC/USDA grain storage facility and four residences/farmsteads outside the village, have been tested and show no carbon tetrachloride contamination (Table 2.2).

2.5 Summary of Previous Findings

The principal findings from previous work can be summarized as follows:

- Sampling by the NDH in 1990 detected carbon tetrachloride at a maximum level of 13.10 μg/L in public well PWS 64-1 and at a concentration of 0.4 μg/L in public well PWS 70-1. Quality control data were not provided in documentation of the sampling events, so no judgment can be made regarding the accuracy of these data.

- Use of public well PWS 64-1 as a drinking water source was discontinued in May 1991, although the well has been used frequently since that time for purposes such as roadwork and irrigation.

- In 1992, a PA was conducted to evaluate the threat to human health and the environment posed by the carbon tetrachloride contamination. Sampling was not conducted as part of the PA. Potential sources of the contamination were identified on the basis of historical use of carbon tetrachloride. These potential sources were the former CCC/USDA grain storage facility, located west of public well PWS 70-1, and former and current private grain storage facilities and a former gas station located near contaminated public well PWS 64-1 (Figure 2.2).

- Argonne obtained the lease and lease termination documents drawn up between the landowner and the CCC/USDA, covering the period of grain storage from 1950 to 1975. The leases confirmed the duration of the former grain storage

TABLE 2.3 Nitrate Analytical Results for Water Samples Collected from the Adams Water Distribution System

Sample Date	Nitrate (mg/L)
10/16/95	10.4
2/1/96	10.2
4/24/96	12
5/8/96	5.7
5/16/96	5.4
9/9/96	3.1
10/22/96	5.2
1/27/97	7.2
4/7/97	4
8/12/97	7.8
11/3/97	10.4
2/9/98	9.8
5/18/98	7.5
7/28/98	6.5
10/19/98	7.3
4/27/99	6.8
8/30/99	7.8

Source: Topp 1999.

operations and the legal property description of the site identified in the PA report. The lease boundaries were used to delineate accurately the former CCC/USDA facility on all maps for this report.

- An *in situ* soil gas survey was conducted in 1995 to investigate the potential contaminant sources identified in the PA report. Carbon tetrachloride was not detected in any of the soil gas samples. Other halogenated volatile organic compounds (VOCs) detected in two samples included 1,1,1-trichloroethane and chloromethane (a degradation by-product of carbon tetrachloride). These compounds were detected near the Farmers Elevator Company and Veerhusen Feed and Seed.

- An FSI report completed in 1997 evaluated the results from the soil gas survey, compliance monitoring of the municipal water supply, and domestic well sampling. An ESI was recommended to obtain data on the potential source(s) of low concentrations of carbon tetrachloride detected intermittently in the municipal water supply.

- Sampling for the ESI was conducted in June 1999, but the report was not issued before the completion of the present *Work Plan*. Preliminary data obtained from the EPA suggest that contamination is restricted to the shallow part of the aquifer at the former CCC/USDA facility and at the Farmers Elevator Company property and is present at low concentrations in samples from PWS 64-1 and PWS 70-1. Groundwater samples collected between the potential source properties and the contaminated PWS wells failed to reveal the presence of a carbon tetrachloride plume (Figure 2.3). Quality control data were not provided in documentation of the sampling events, so no judgment can be made regarding the accuracy of these data.

- Since 1990, sampling has intermittently revealed low concentrations of carbon tetrachloride (below the MCL) in public well PWS 70-1, located 500 ft east of the former CCC/USDA facility. The highest value recorded in PWS 70-1 during this period was 1.3 µg/L on June 14, 1999. Before this, the well was mostly free of contamination, with a highest recorded carbon tetrachloride value of only 0.4 µg/L (Table 2.2). In view of the low analytical levels reported for carbon tetrachloride in this well, rigorous evaluation of the analytical methodology and quality control is critically important in establishing the accuracy of the results. Quality control data were not provided in documentation of the sampling events, so no judgment can be made regarding the accuracy of these data.

- Sufficient water is presently supplied to the village by public wells PWS 70-1 (located in the northwestern portion of the village, east of the former CCC/USDA site) and PWS 79-1 (located north of the village). Water from both wells is directed to a treatment plant in the north-central portion of the village that removes nitrate contamination and softens the water.

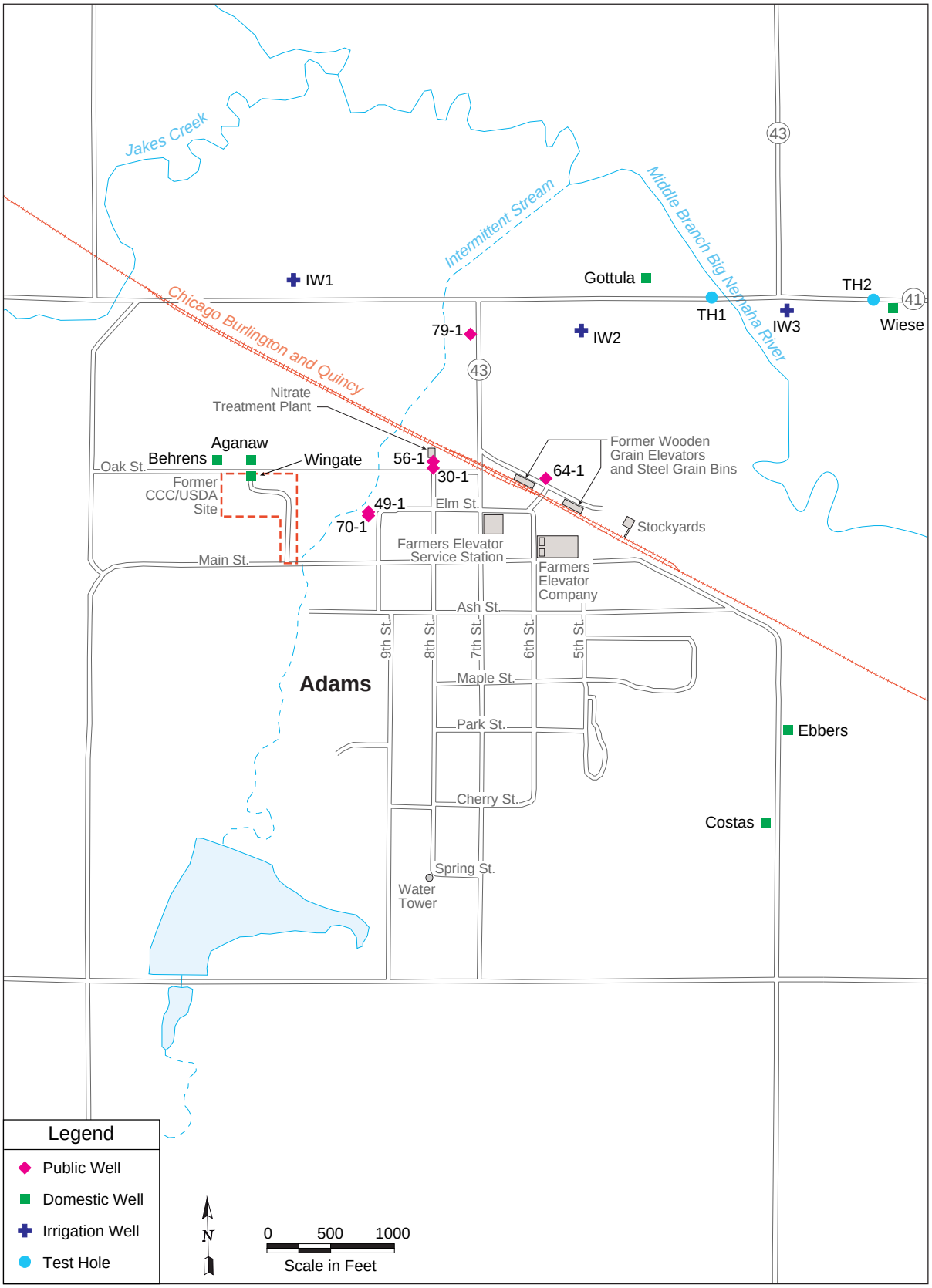

FIGURE 2.1 Map Showing the Locations of Public Wells, Domestic Wells, Irrigation Wells, and Test Holes, Adams, Nebraska

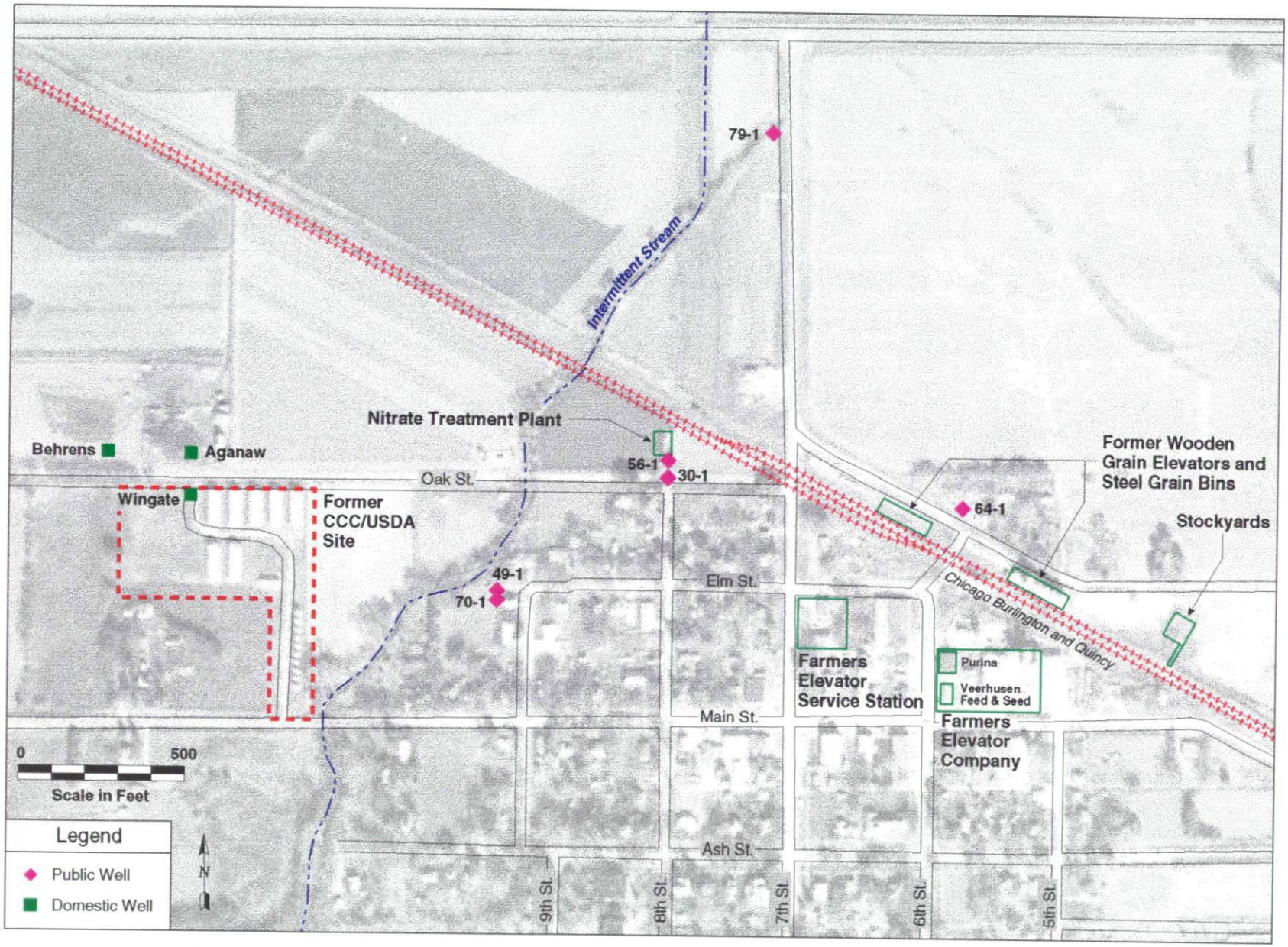

FIGURE 2.2 Potential Sources of Groundwater Contamination at Adams, Nebraska (Source: Jacobs 1992; photograph: USDA 1965)

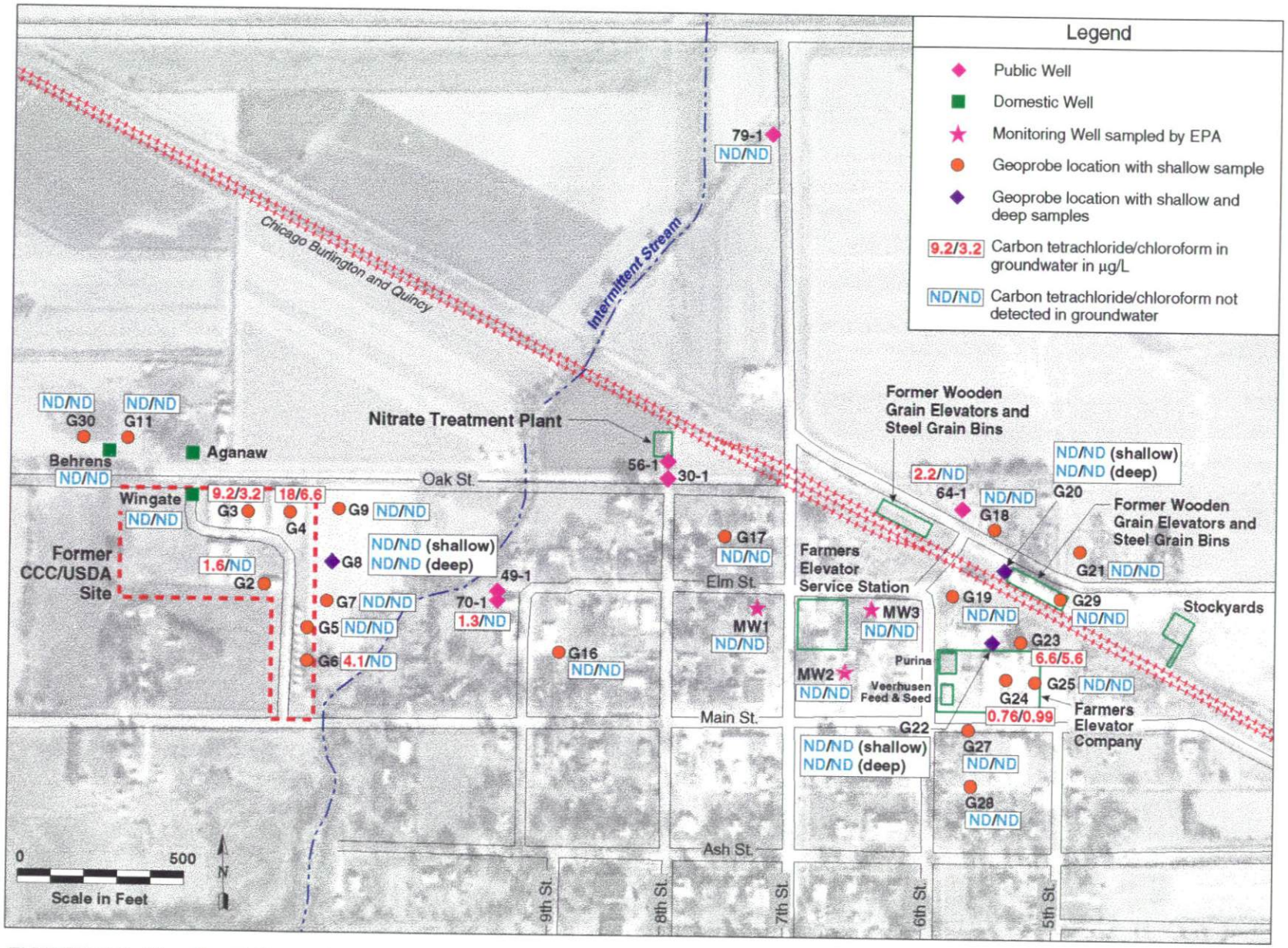

FIGURE 2.3 Results of Groundwater Sampling Conducted for the ESI (Source: Curry 1999, 2000)

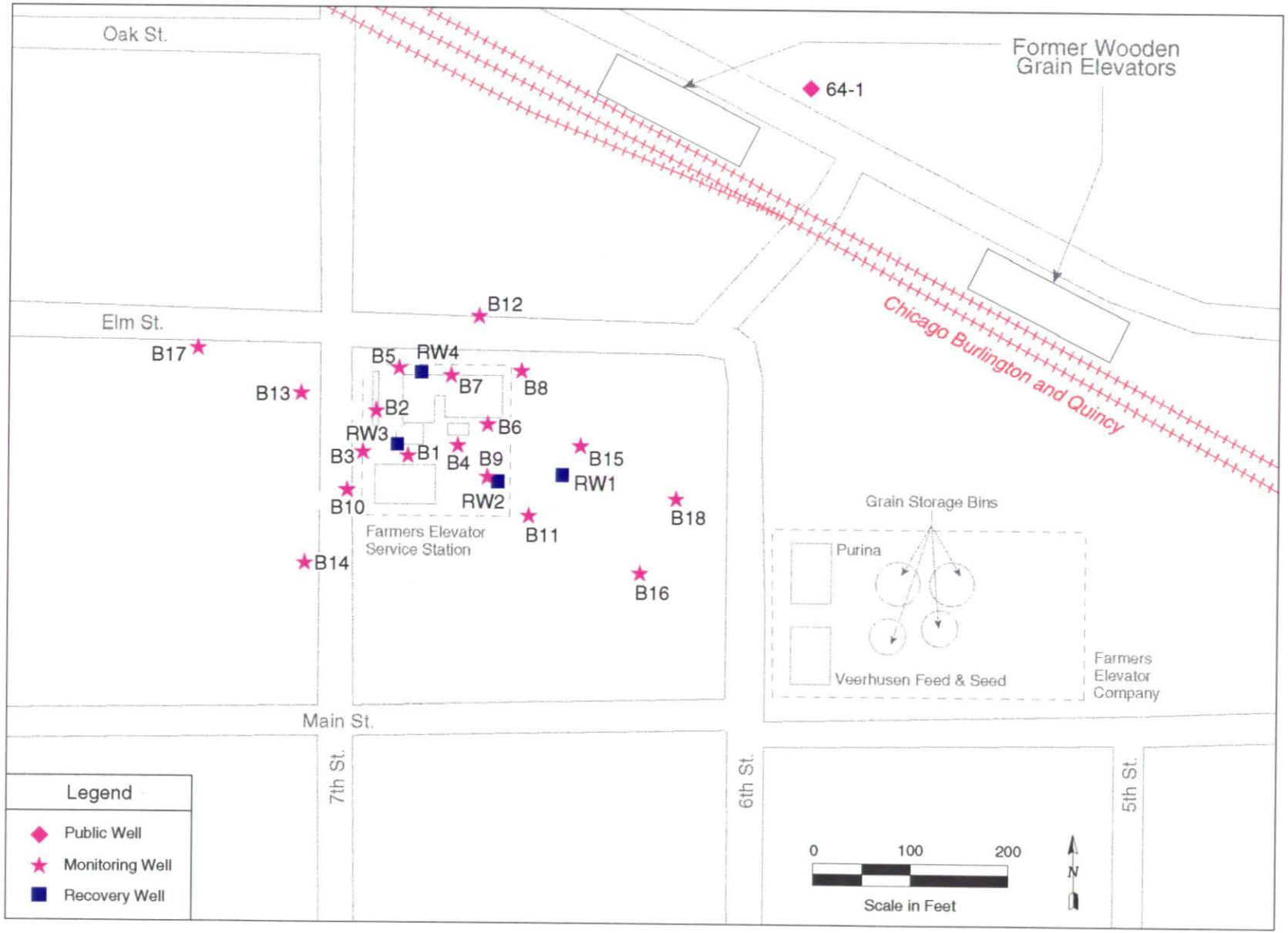

FIGURE 2.4 Locations of Wells Installed for the Farmers Elevator Company Service Station Investigation and Remediation (Source: Coranco 1990)

3 Environmental Setting

3.1 Introduction

An integrated conceptual model of the geology, hydrogeology, and hydrogeochemistry of a site guides investigations in the QuickSite^{SM} program. The conceptual model evolves from a critical review and integration of all existing data for the site, together with pertinent local and regional geologic, hydrogeologic, and hydrogeochemical data. Phase I field investigations are designed to test, revise, and finalize the preliminary conceptual model. The revised model is then used to direct the Phase II investigations, which focus on delineation of any groundwater contaminant plumes present.

This section presents the results of an initial critical review of existing regional, local, and site-specific geologic, hydrogeologic, and hydrogeochemical information pertinent to the groundwater contamination at Adams. The objectives of this review are as follows:

- To compile and then evaluate the quality of the geologic, hydrogeologic, and hydrogeochemical information available

- To establish a regional geologic and hydrogeologic framework as a basis for interpreting local geologic, hydrogeologic, and hydrogeochemical data from the Adams site

- To use the site-specific data to construct the preliminary conceptual model for the site

- To use the preliminary conceptual model to identify critical issues and define investigative objectives to be addressed during Phase I of the QuickSite^{SM} investigation

3.1.1 Organization

Section 3 has five parts. Section 3.1 describes the objectives of Section 3 in the context of the QuickSite^{SM} investigation and identifies and evaluates the regional, local, and site-specific data used to construct the preliminary conceptual model.

Section 3.2 reviews the geologic and physiographic data for Gage County and its vicinity to establish a regional framework for the area and provide the context for comparison and evaluation of the local and site-specific data. Data judged to be of good quality are used in the development of the preliminary conceptual model of the site (see Section 3.4).

Section 3.3 describes the regional groundwater aquifers in Gage County. Information on the properties of the primary aquifer units is summarized, along with production rates, groundwater flow directions, and hydrogeochemistry or water quality characteristics. The discussion in Section 3.3 then shifts from regional to local hydrogeology, derived from data, information, and interpretations for the area within 1 mi of the site. The quality and quantity of the local data and the relationships between the regional and local information define the hydrogeologic framework for the preliminary conceptual model of the site.

Section 3.4 discusses the development of the geologic and hydrogeologic model of the site from regional and local information. The preliminary working model stems from compilation and interpretation of the best available regional and local data. Questions about the model provide the basis for the Phase I QuickSite^{SM} investigation. The preliminary conceptual model will subsequently be tested and revised on the basis of high-quality data obtained in Phase I.

Section 3.5 reviews the major findings of the section, including the quality of geologic, hydrogeologic, and hydrogeochemical data; the regional and local geologic and hydrogeologic framework; and the preliminary conceptual model.

3.1.2 Regional Data

Regional geologic data came from various sources, including well registration forms and drilling records for irrigation wells, irrigation and public supply well test holes, and municipal wells. The University of Nebraska, Conservation and Survey Division (CSD), compilations of test hole logs for Gage County (Burchett and Smith 1989a) and Johnson County (Burchett and

Smith 1989b) were the primary source of subsurface geologic data for the Pleistocene. Additional documents consulted included published reports by the U.S. Geological Survey on groundwater quality in the Nemaha Natural Resources District (Tanner and Steele 1991) and the USDA Soil Conservation Service report on Gage County soils (USDA 1959). Geologic logs for the test holes used to construct the regional cross sections discussed in Section 3.2.1 are in Appendix A.

The regional geologic and drillers' logs were compared to the descriptions of the expected lithologies and the thicknesses of the lithologic units in the established stratigraphic section for southeastern Nebraska (Tanner and Steele 1991; Reed et al. 1965). The Nebraska CSD test hole log descriptions were judged to be complete and consistent with the established stratigraphy and were selected for use in construction of the regional cross sections.

3.1.3 Local Data

The term "local data" here indicates data from an area within 1 mi of the former CCC/USDA facility. Local geologic data include drillers' logs from several irrigation wells, Adams municipal well PWS 79-1, and a test hole drilled for former municipal well PWS 64-1. Geologic logs were obtained from a detailed LUST site assessment at a service station owned by the Farmers Elevator Company (Coranco 1990). Unfortunately, drillers' logs for most of the existing and former public supply wells at Adams are unavailable, because they are missing from the well registration forms filed with the Nebraska Department of Water Resources. The single municipal well driller's log available, for PWS 79-1, was obtained by Argonne directly from the drilling company. General descriptions of the local geology are found in the PA report on the contaminated public water supply (Jacobs 1992), in the FSI report (NDEQ 1997), and in the LUST report (Coranco 1990). Useful hydrogeologic data are in the report of a pump test conducted at the LUST site (Coranco 1991) and in a quarterly monitoring report on the pump-and-treat system (Coranco 1992). Copies of the geologic and drillers' logs from Adams are in Appendix A, together with the well registration forms for former wells PWS 49-1, PWS 56-1, and PWS 64-1.

The local drillers' logs were compared to the expected lithologies and the thicknesses of the lithologic units in the established stratigraphic section for southeastern Nebraska (Tanner and Steele 1991; Reed et al. 1965). The logs were also compared to the Nebraska CSD test hole logs (discussed in Section 3.1.2) for completeness and consistency. In addition, the way the soil and rock samples were obtained was taken into consideration. For example, the lithologic description of a sample from a continuously cored hole is more likely to be accurate and complete than a

description based on drill cuttings, if a competent person is making the descriptions in both cases. The geologic test holes used for the regional cross sections are the only continuously cored holes near Adams, the closest being 3 mi away. Unfortunately, no continuously cored holes exist at Adams to serve as controls for constructing a detailed local stratigraphy. The most detailed descriptions of the local stratigraphy were found in geologic logs based on split-spoon sampling of soil borings drilled for the LUST investigation at the Farmers Elevator Company Service Station (Coranco 1990). Although the data are of good quality, the split-spoon samples are not a continuous record of the stratigraphy, because the 2-ft cores that were described were collected at 5-ft intervals. The overall scarcity of detailed geologic logs at Adams required inclusion of drillers' logs and well registration records in the local database. The drillers' logs provide only the most general description of the local lithology and depth to bedrock, and in most cases the well registrations give only an assumed depth to bedrock.

3.1.4 Site Data

The former CCC/USDA site (Figure 2.1) is located on the Wingate property, as discussed in Section 2.3.1. One domestic well has been reported on the property, and another well lies across the street to the north (NDEQ 1997). The driller's log for the Wingate well provides a broadly generalized description of the site lithology to a depth of 138 ft BGL. A copy of this log is in Appendix A.

As reported in Section 2, both a former grain storage and transportation site with a wooden elevator and steel bins and the Farmers Elevator Company site are located in the northeast part of Adams, near the railroad track (Figure 2.1). Contaminated municipal well PWS 64-1 is within 500 ft of both the former wooden elevator and the Farmers Elevator Company. These existing and former grain storage sites represent potential carbon tetrachloride source areas that are not related to the former CCC/USDA facility. The geologic logs for 17 monitoring wells installed for the LUST investigation are a reliable source of information in this area.

3.2 Geologic Setting

3.2.1 Regional Geology and Physiography

Gage and Johnson Counties lie in the Southeastern Nebraska Glacial Drift topographic region (CSD 1986). The region consists of rolling hills formed by glacial deposition of a series of morainic ridges that were modified by postglacial erosion (Dreeszen 1970). The glacial deposits consist largely of low-permeability boulder-clay tills. Alluvial deposits are found in valleys formed by streams cutting into the drift hills, and loess of variable thickness mantles the entire region. Figure 3.1 is a map showing the drainage pattern in the region. The Big Blue River drains most of Gage County. However, the northeastern corner of Gage County, which includes the area around Adams, drains to the Middle Branch of the Big Nemaha River. The drainage divide between the Big Blue River basin and the Big Nemaha River basin follows the axis of the Cedar Bluffs moraine (Dreeszen 1970).

The topographic map in Figure 3.2 shows the area around Adams in Gage County. Adams lies at 1,250-1,320 ft above mean sea level (AMSL), on the boundary between the drift hills and the 2,000- to 3,000-ft-wide alluvial flats of the Middle Branch of the Big Nemaha River lying to the north. Nearby drift hills reach a height of 1,360 ft AMSL. From the hills, the ground slopes gently northeast toward the Middle Branch of the Big Nemaha River at about 1,240 ft AMSL. Soils on the uplands are principally clay loam to silt loam formed on loess and glacial till. These soils are part of the Sharpsburg, Wymore-Pawnee, and Marshall-Ponca associations (Tanner and Steele 1991). Lowland soils are Kennebec-Nodaway-Zook association silt loams that formed on clayey and silty alluvial and colluvial parent material. Surface drainage in the area near Adams is from southwest to northeast, toward the Middle Branch of the Big Nemaha River. A detailed discussion of the drainage and climate at Adams is in Section 2.1.1.

A generalized stratigraphy of northeastern Gage County and western Johnson County is in Table 3.1. During the Pleistocene, continental glaciers advanced into eastern Nebraska from the northeast. Multiple tills of Nebraskan age and two tills of Kansan age, related to major advances in southeastern Nebraska (Reed et al. 1965), are mantled by undifferentiated loess of Illinoian, Wisconsinan, or Holocene age. Nebraskan age tills are difficult to identify because they were partly eroded and overridden by Kansan age glaciers. Tills of Kansan age (Nickerson and Cedar Bluffs tills) are the most extensive of all tills in southeastern Nebraska. In general, loess-mantled

TABLE 3.1 Generalized Geologic Units and Their Water-Bearing Properties, Northeastern Gage County and Western Johnson County

Period	Epoch			Possible Units	Characteristics	Water-Bearing Properties
Quaternary	Holocene			Undifferentiated loess, soil, and surficial alluvium; floodplain deposits	Widespread soils; eolian silt and clay; terrace and floodplain deposits of clay, silt, sand, and gravel	Significant only because it transmits recharge to the groundwater reservoir
	Pleistocene	Wisconsinan and Illinoian				
		Kansan	Medial	Cedar Bluffs till and alluvium	Glacial till deposits of clayey, sandy, to gravelly silt; fluvial deposits of sand and gravel lenses	Shallow aquifers consisting of sand and gravel lenses, unconfined to semiconfined; yields to wells 10-700 gpm
			Early	Nickerson till and alluvium	Valley and terrace deposits of sand and gravel; glacial till deposits of clayey, sandy, to gravelly silt	Major aquifers, generally unconfined to confined, possibly hydraulically connected to local shallow aquifers; yields to wells 500-1,500 gpm
		Nebraskan		Fullerton loess, Iowa Point till, and Elk Creek till	Eolian silt and clay; glacial till deposit of clayey, sandy, to gravelly silt in a deep part of valley	Forming part of major alluvial aquifers where present
Cretaceous	Early Cretaceous			Dakota Group (undivided)	Predominantly massive to cross-bedded friable sandstone with interbedded red to light gray, argillaceous to slightly sandy shales	Secondary aquifer, confined or semiconfined; yields 50-750 gpm
Permian				Chase Group	Predominantly gray argillaceous shale with interbedded to massive limestone; some massive red shale; some geodal, fossiliferous, or cherty limestone	Not a major aquifer; secondary porosity possibly developed from fractured limestone where wells can yield 20-50 gpm
				Council Grove Group	Predominantly gray and red argillaceous shale with interbedded, massive, blocky, argillaceous limestone	
				Admire Group	Predominantly gray shale with interbedded, porous, argillaceous limestone and red shale	
Pennsyl-vanian				Wabaunsee Group	Predominantly shale with some beds of limestone	

Source: Generalized from Reed and Dreeszen (1964); Dreeszen (1970); Tanner and Steele (1991); and Burchett and Smith (1989a,b).

Kansan till forms the present-day drift hills lying between the Big Blue River and the Missouri River in southeastern Nebraska (Reed et al. 1965). However, alluvial sand and gravel were deposited within bedrock valleys during retreats of the Nickerson and Cedar Bluff glaciers. These alluvial deposits reach a thickness of more than 200 ft in the paleovalley that lies beneath and to the north of the Middle Branch of the Big Nemaha River. The locations of the bedrock valleys are shown in Figure 3.1.

The Pleistocene deposits lie unconformably on bedrock that increases in age from west to east, from Early Cretaceous to Pennsylvanian. Figure 3.3 is a map of the bedrock geology in northeastern Gage County and western Johnson County. In the western part of the region, the bedrock is interbedded sandstone and shale of the Lower Cretaceous Dakota Group. Farther to the east, the bedrock is interbedded limestones and shales of the Permian Chase and Council Grove Groups. In the deepest parts of the paleovalleys, farther to the east, erosion cut into interbedded limestones and shales of the Permian Admire Group and the underlying Pennsylvanian Wabaunsee Group. Generally, the bedrock formations dip gently to the west.

Stratigraphic relationships within the Quaternary section and relief on the bedrock surface in northeastern Gage County and western Johnson County are illustrated schematically in three geologic cross sections. The locations of the sections are shown in Figure 3.4. South-to-north section A-A´ (Figure 3.5) is located approximately 3 mi west of Adams, west-to-east section B-B´ (Figure 3.6) is approximately 3 mi south of Adams, and south-to-north section C-C´ (Figure 3.7) is about 7 mi east of Adams. All cross sections were constructed by using geologic logs for test holes drilled by the Nebraska CSD. Copies of the logs are in Appendix A.

3.2.1.1 Regional Geologic Cross Section A-A´

The regional pre-Pleistocene bedrock topography demonstrates the effects of considerable erosion. Test hole drilling conducted by the Nebraska CSD across the region indicates that relief on the bedrock surface exceeds 375 ft (see cross section A-A´, Figure 3.5). The preglacial drainage pattern of eastern Nebraska was altered considerably by glaciers during the Pleistocene. Before the glacial advance, drainage in southeastern Nebraska was to the east via an ancient stream network that flowed generally eastward to the Missouri River valley. (See location of upper reaches of the paleovalley network in Figure 3.1.) During the period of glacial advances, this east-flowing stream system was blocked by glacial ice and till, and drainage was rerouted southeastward. As the glaciers retreated, the ancient valleys were backfilled with alluvial deposits (sand and gravel), and the drainage pattern developed during glaciation was preserved. The present southeast-flowing drainage reflects these glacial modifications.

Geologic cross section A-A´ (Figure 3.5) intersects two of the paleovalleys. In both, the Nebraskan and early Kansan glacial tills were removed by erosion, and the valleys were filled with alluvial deposits that lie directly on Permian limestone and shale. An exception occurs where a remnant of Nebraskan-age Fullerton loess and silt lies beneath alluvium at the location of test hole 70-A-49. Erosion cut down through the Permian Chase Group into the underlying Council Grove and Admire Groups in both paleovalleys. The alluvium is overlain by a regional till sequence mantled by undifferentiated loess. The tills form low-lying hills in the upland areas. A 40-ft-thick sand lens occurs within the till sequence to the south of the Middle Branch of the Big Nemaha River.

3.2.1.2 Regional Geologic Cross Section B-B´

A west-to-east transect (B-B´) connecting cross sections A-A´ and C-C´ is shown in Figure 3.6. Near the eastern end of the section, test hole 05-A-56 penetrates a paleovalley filled with about 90 ft of sand and sand-gravel that lies directly on interbedded limestone and shale of the Pennsylvanian Wabaunsee Group. The western side of the paleovalley is cut into rocks of the Permian Admire and Council Grove Groups. The paleovalley alluvial fill and the intervening bedrock surface are overlain by till with a mantle of loess. A relatively extensive lens of sand and sand-gravel is encountered within the till sequence in test holes 66-A-49, 30-B-44, and 77-B-49.

3.2.1.3 Regional Geologic Cross Section C-C´

Stratigraphic relationships along south-to-north section C-C´ (Figure 3.7) are as previously described for sections A-A´ and B-B´. A major paleovalley is evident on cross section C-C´. This 12-mi-wide paleovalley results from the downstream convergence of the two paleovalleys shown in section A-A´ (Figure 3.5). The paleovalley was deeply eroded into bedrock and filled with more than 200 ft of alluvium overlain by Kansan till and loess. Erosional remnants of an early till occur on the valley wall at test holes 6-A-56 and 2-A-56. The deepest part of the paleovalley was cut into the Pennsylvanian Wabaunsee Group, the oldest bedrock formation encountered in the area. A silt unit at the base of the Pleistocene sequence, underlying either alluvium or early till, might be a remnant of late Nebraskan-age Fullerton loess that is preserved in the paleovalley.

3.2.2 Local Geology

As indicated in Section 3.1.3, local data include information and well logs from an area within 1 mi of the former CCC/USDA facility. Drillers' logs and test hole logs from irrigation wells, domestic wells, municipal test holes, and a municipal well, along with geologic logs from the Farmers Elevator Company Service Station LUST investigation, were examined for completeness and consistency. Log data that were consistent with the established regional stratigraphic section (Section 3.2.1) were incorporated into the local sections. The registration forms for municipal wells that include well depth are considered to be an indication of bedrock depth if the data are consistent with surrounding logs and the regional framework. Two local cross sections were constructed and interpreted by Argonne. Copies of the geologic and drillers' logs are in Appendix A, together with the well registration forms for former wells PWS 49-1, PWS 56-1, and PWS 65-1.

3.2.2.1 Cross Section D-D´

The location of geologic cross section D-D´ is shown in Figure 3.8. This section is oriented along a line from the former CCC/USDA site to contaminated municipal well PWS 64-1 and to a point north of Adams at irrigation well IW2. The driller's log of Wingate's domestic well, registration data for former municipal well PWS 49-1, the geologic log of monitoring well B-1 (Coranco 1997), and the drillers' logs for a municipal well test hole (for PWS 64-1) and irrigation well IW2 were used to construct the section (Figure 3.9).

Geologic section D-D´ shows that the depth to bedrock increases gradually from west to east in the village, but northeast of Adams the bedrock slopes steeply toward the center of the paleovalley. Uncertainties exist concerning the depth to bedrock near the former CCC/USDA site. These uncertainties reflect the driller's questionable interpretation of bedrock in the log of the Wingate well and the use of the registered well depth for PWS 49-1 as an estimate of the bedrock depth. Bedrock depth at the former CCC/USDA site, estimated from surrounding wells, is closer to the top of the "blue clay" (72 ft BGL) than to the limestone at 136 ft BGL. Therefore, the "blue clay" from 72-136 ft BGL in the Wingate driller's log might actually be weathered Permian shale. This uncertainty in interpretation is shown as a broken line in section D-D´ (Figure 3.9).

Thickening of the unconsolidated Pleistocene sediments in the paleovalley occurs entirely through the buildup of fluvial sand. At the former CCC/USDA site, Wingate's domestic

well intersected a 27-ft water-bearing sand layer at 45-72 ft BGL. From here, the sand layer thickens gradually to the east, reaching a thickness of 42 ft (at 24-66 ft BGL) near the edge of the paleovalley at contaminated former municipal well PWS 64-1. Within the paleovalley, the sand is 98 ft thick (at 24-122 ft BGL) at irrigation well IW2. The mantle of loess thins from 45 ft at the former CCC/USDA site to 24 ft in the paleovalley.

The Holocene-Pleistocene section is composed of fluvial deposits of sand overlain by silt-clay loess. In the paleovalley, the lithology described at irrigation well IW2 shows that the sand deposit consists of several fining-upward sequences that are characteristic of point bar (channel) deposits of a river system (Reading 1978). No tills were positively identified along the section. Lack of a confirmed till unit at Adams could be the result of poor differentiation of till from silt in the drillers' logs or the postglacial erosion of till along the major stream valleys.

The Pleistocene section rests directly and unconformably on Permian bedrock. The Nebraska CSD bedrock map shown in Figure 3.3 indicates that the uppermost bedrock at Adams is interbedded Permian limestone and shale of the Council Grove Group.

3.2.2.2 Cross Section E-E´

The location of southwest-to-northeast geologic cross section E-E´ is shown in Figure 3.8. The section begins at the former CCC/USDA site and is oriented in the direction of regional groundwater flow (see Section 3.3). The cross section (Figure 3.10) was constructed from drillers' logs for Wingate's domestic well, municipal well PWS 79-1, irrigation wells IW2 and IW3, and test holes TH1 and TH2.

Three wells (IW2, PWS 79-1, and Wingate's well) penetrate the entire Pleistocene section into Permian limestone, providing for good control on the bedrock surface in the southwest and central portions of cross section E-E´. In the northeast portion of the cross section, a deep irrigation well (IW3) provides information on the distribution and thickness of sands and gravels in the paleovalley. The bedrock surface in the northeast portion of the section was extrapolated (by Argonne) from wells IW2 and PWS 79-1. The two test holes, TH1 and TH2, are shallow and provide information only on the upper part of the Pleistocene section.

Geologic cross section E-E´ (Figure 3.10), as developed and interpreted by Argonne, shows unconsolidated Quaternary deposits resting unconformably on Permian bedrock. As

described in Section 3.2.2.1, the uppermost bedrock unit at Adams consists of interbedded limestone and shale of the Permian Council Grove Group. The cross section shows that Quaternary sediments gradually increase in thickness from southwest to northeast, toward a paleovalley in the bedrock surface. The unconsolidated section is composed of fluvial deposits of sand and gravel overlain by silty-clay loess. The Pleistocene fluvial sand deposits are laterally continuous and are present in all wells on the cross section. Within the paleovalley, a thick gravel layer directly underlies the fluvial sand. The gravel layer penetrated by well IW3 is more than 61 ft thick. Irrigation well IW3 shows that the gravel and sand deposits form a contiguous unit, with a thickness varying from 27 ft at the former CCC/USDA site to more than 113 ft in the paleovalley. Silty-clay loess and topsoil, ranging from 19 ft to 45 ft in thickness, overlie the sand and gravel throughout the area. No till was identified in the logs for borings included in cross section E-E´. Glacial and postglacial streams probably eroded all preexisting glacial tills near the former CCC/USDA site.

3.3 Hydrogeology and Hydrogeochemistry

3.3.1 Regional Hydrogeology and Hydrogeochemistry

Groundwater in the region of northeastern Gage County and western Johnson County is mainly produced from Quaternary sands and gravels. The availability and productivity of groundwater in the Quaternary sands and gravels ranges from scarce to abundant, depending on aquifer properties and the occurrence, lateral continuity, and thickness of the deposits, which vary widely throughout the region. The bedrock formations underlying the Quaternary section are not generally suitable for water supply purposes. Most of the Permian interbedded shales and limestones lack the permeability necessary to produce water in sufficient quantity.

The Quaternary sands and gravels in the region can be subdivided into the following two predominant aquifer types (Tanner and Steele 1991):

1. Shallow aquifers consisting of (a) shallow Holocene alluvium in valleys representing areally limited remnants of fluvial sand and gravel deposited in meandering streams and (b) discontinuous Pleistocene lenses of sand and gravel within glacial till. The shallow Holocene aquifers (1a) are generally unconfined to semiconfined and might be hydraulically connected to surface water, other shallow aquifers, or paleovalley alluvial aquifers. Shallow valley

aquifers generally yield 50-700 gpm. The discontinuous Pleistocene aquifers (1b) are usually confined to semiconfined, areally restricted, and relatively isolated. Wells within the discontinuous Pleistocene aquifers yield 10-100 gpm.

2. Paleovalley alluvial aquifers consisting of thick Pleistocene deposits of sand and gravel in bedrock valleys. The paleovalley alluvial aquifers are generally semiconfined to confined. Sand and gravel deposits in the bedrock valleys are relatively uniform and as much as 200 ft thick. Yields typically range from 500 to 1,000 gpm, reaching as much as 1,500 gpm in places (Tanner and Steele 1991). Major paleovalley aquifer locations in the vicinity of Adams are shown in Figure 3.1.

Recharge of the Quaternary aquifers occurs through infiltration of precipitation and irrigation water from the surface and through underflow of groundwater from the west. The regional water table of the Quaternary aquifer is a subdued reflection of the land surface. Groundwater generally flows toward stream valleys that are cut deep enough to permit groundwater discharge to the surface. Figure 3.11 shows the general configuration of the regional water table as constructed by CSD (1999). In northeast Gage County and western Johnson County, groundwater flows toward the Big Nemaha River in the northeastern part of the region, and toward the Big Blue River in the southwestern part.

Water quality and hydrogeochemical data (Tanner and Steele 1991) indicate that groundwater from the sand and gravel of the Quaternary aquifers in northeastern Gage County and western Johnson County is a calcium bicarbonate type. Moderately elevated nitrate concentrations (5-10 mg/L) were found in some 100- to 200-ft-deep wells in paleovalley areas, indicating that the paleovalley alluvial aquifer is contaminated with nitrate, probably because of the high intensity of agricultural activity in the area.

Available records show that since 1939 the village of Adams has constructed six municipal wells to produce groundwater for the community. Figure 3.2 shows the locations of the former and current municipal wells, as confirmed during Argonne's site visit in September 1999. In the past, the quality of the supply suffered because of high levels of nitrate and hardness that eventually required the installation in 1991 of an ion exchange system for water softening and nitrate removal.

3.3.2 Local Hydrogeology

The drillers' logs from irrigation wells, domestic wells, and test holes within 1 mi of the former CCC/USDA site indicate that the Quaternary alluvial deposits of sand and gravel are vertically continuous and saturated, forming one aquifer. The reported well productivity from this aquifer is 12 gpm for the Wingate domestic well at the former CCC/USDA site and 160 gpm for former municipal well PWS 49-1. As the aquifer thickens toward the paleovalley, well productivity increases to 800 gpm for municipal well PWS 79-1 and 1,500 gpm for irrigation wells farther north.

From the regional water table configuration (Figure 3.11), groundwater near Adams is expected to flow generally northeastward to the Middle Branch of Big Nemaha River. Within 1 mi of the former CCC/USDA site, depths to water measured at various times and locations have ranged from about 10 to 30 ft BGL. On the basis of the approximate ground surface elevations at these locations, water levels near Adams of 1,215-1,240 ft AMSL can be estimated. However, these estimates are not suitable for determining flow directions because they make no allowance for the possible effects of seasonal water level fluctuations. More precise water level data collected simultaneously from a number of wells will be required to establish the local water table configuration and unconfined hydraulic gradient. Using concurrent measurements, Coranco (1990) mapped the water table for a small area around the Farmers Elevator Company Service Station, east of the former CCC/USDA site. The resulting surface suggests both eastward and northeastward groundwater flow directions (Figure 3.12), possibly influenced by pumping of PWS 64-1. A revised water table constructed for the LUST site in May 1992 showed an easterly flow direction, possibly reflecting a reduction in pumping of PWS 64-1 after it was removed from the municipal supply network in May 1991 (Coranco 1992). The influence of municipal and irrigation well pumping on the water levels and flow directions at Adams has not been evaluated.

3.4 Preliminary Conceptual Model

Earlier parts of this section discussed the way data and information were critically reviewed and evaluated. First, the regional geology, hydrogeology, and hydrogeochemistry were evaluated and compared to the established and expected parameters for the area of northeastern Gage County and western Johnson County. Data that met the criteria for completeness and

consistency, as explained in Section 3.1, were selected for analysis and integration. Second, data on the local geology and hydrogeology were evaluated and integrated with the regional data set.

The resulting regional and local geologic-hydrogeologic framework was extrapolated to the CCC/USDA site, where no high-quality data are available. Thus, a preliminary conceptual model of the geology and hydrogeology for the CCC/USDA site was developed from selected preexisting data. With this approach, the predicted geology and hydrogeology should be the most likely and most reasonable interpretation of the site. During the Phase I QuickSite^{SM} investigation, the preliminary conceptual model for the site will be tested and revised.

3.4.1 Predicted Geology

The conceptual geologic model is reflected in cross sections D-D´ and E-E´ (Figures 3.9 and 3.10). Near the CCC/USDA site, unconsolidated Holocene and Pleistocene brown clay to silty clay loess 20-30 ft thick is predicted to overlie a laterally continuous fine- to medium-grained sand unit consisting of multiple fining-upward sequences. A thick gravel unit is expected beneath the sand deposit in the bedrock valley north of Adams. The anticipated thickness of the combined sand-gravel deposit is 27-42 ft near the former CCC/USDA site, increasing to more than 113 ft in the paleovalley.

The Pleistocene deposits of sand and gravel rest unconformably on the Council Grove Group, consisting of interbedded Permian shale and limestone (Figures 3.9 and 3.10). The expected depth to bedrock is about 72 ft BGL at the site and more than 141 ft BGL to the north of Adams.

3.4.2 Predicted Hydrogeology

A single aquifer hosted by the sand-gravel deposit is projected for the site. The aquifer may be unconfined to semiconfined, with a static water level at 10-30 ft BGL. The aquifer at the site is a fine- to medium-grained sand with an estimated hydraulic conductivity of 7-42 ft/d (Coranco 1991). The water-bearing unit is expected to increase in both thickness and hydraulic conductivity toward the north-northeast, corresponding to an increase in fluvial sand-gravel fill in the paleovalley.

The ambient water table is expected to be a subdued reflection of the land surface and to slope gently toward the Big Nemaha River. The groundwater flow direction is probably to the northeast at the former CCC/USDA site and possibly easterly near contaminated well PWS 64-1 on the east side of the village. The effect on groundwater flow of pumping of irrigation and

public supply wells is unknown. The Permian bedrock is not considered a potential source of groundwater near Adams.

3.5 Summary

This section documents the results of the initial critical review of the regional, local, and site-specific geologic, hydrogeologic, and hydrogeochemical data pertinent to the groundwater contamination at Adams, Nebraska. The objectives of this review were (1) to evaluate the quality of the pertinent geologic, hydrogeologic, and hydrogeochemical information that is available; (2) to establish a regional geologic and hydrogeologic framework as a basis for interpreting local geologic, hydrogeologic, and hydrogeochemical data from Adams; (3) to use these data to develop a preliminary conceptual model for the Adams site; and (4) to use the preliminary conceptual model as the basis for identifying critical issues and defining investigative objectives to be addressed in Phase I of the QuickSite^{SM} investigation.

Sufficient geologic, hydrogeologic, and hydrogeochemical data were available for construction of the regional framework. The data consist of geologic test hole logs, drillers' logs, well registration forms, and reports from a variety of sources. The data are considered reliable and are consistent with the established stratigraphy of northeastern Gage County and western Johnson County.

Data available on the local geology and hydrogeology at Adams consist of drillers' logs of variable quality and geologic logs from a LUST investigation. One driller's log of dubious quality is available for the former CCC/USDA site. Consequently, the well-established regional geologic and hydrogeologic framework was extrapolated and integrated with the local data to develop the best available conceptual model for the site.

The Adams site in Gage County is in the Southeastern Nebraska Glacial Drift topographic region. This region consists of rolling hills having series of ridges and valleys that were formed by glaciers and then modified by postglacial erosion and deposition. The area of northeastern Gage County and western Johnson County, including Adams, is drained by the Middle Branch of the Big Nemaha River, a tributary of the Big Nemaha River.

The region is covered by loamy topsoil, underlain by undifferentiated clayey silt loess. Below the loess are Kansan tills in the glacial drift hills and sand and gravel in the valleys where

the till was eroded. During the Nickerson and Cedar Bluff glacial retreats (Kansan age), thick alluvial sands and gravels were deposited in bedrock valleys and streambeds. The Pleistocene deposits unconformably overlie interbedded Permian limestones and shales. The Pleistocene sands and gravels form the primary regional aquifer, which has yields exceeding 500 gpm. The dominant direction of regional groundwater flow near Adams is toward the east-northeast.

Locally, the geology consists of several feet of loamy topsoil, underlain by 20-30 ft of clayey silt loess. Below the loess are Pleistocene fluvial deposits. The Pleistocene fluvial beds are fine- to medium-grained sands with a thickness of 27-42 ft near the former CCC/USDA site. Within the paleovalley north of Adams, the Pleistocene fluvial deposits increase in thickness to more than 113 ft and contain basal gravels. Throughout the area, the Pleistocene fluvial deposits are unconformably underlain by interbedded Permian shales and limestones of the Council Grove Group.

A single Holocene and Pleistocene sand-gravel aquifer is the major water source for the community and for irrigation near Adams. All wells near the site are pumping groundwater from this aquifer. The flow direction of the groundwater is probably from southwest to northeast, toward the Middle Branch of the Big Nemaha River.

The regional and local geologic and hydrogeologic framework formed the basis for development of the conceptual model for the site. In summary, the geologic sequence at the former CCC/USDA site consists of a few feet of topsoil underlain by 30 ft of clayey silt loess. Below the loess is 27-42 ft of fine- to medium-grained Holocene and Pleistocene sand. Underlying the sand is interbedded shale and limestone of the Permian Council Grove Group at 72 ft BGL, or possibly till from 72-136 ft BGL (“blue clay” in the Wingate driller’s log, which might be till or weathered Permian shale). The single Holocene-Pleistocene aquifer is probably unconfined at the site, and the static water level is expected at about 25-30 ft BGL. The groundwater flow direction at the site is probably from southwest to northeast, toward the Middle Branch of the Big Nemaha River.

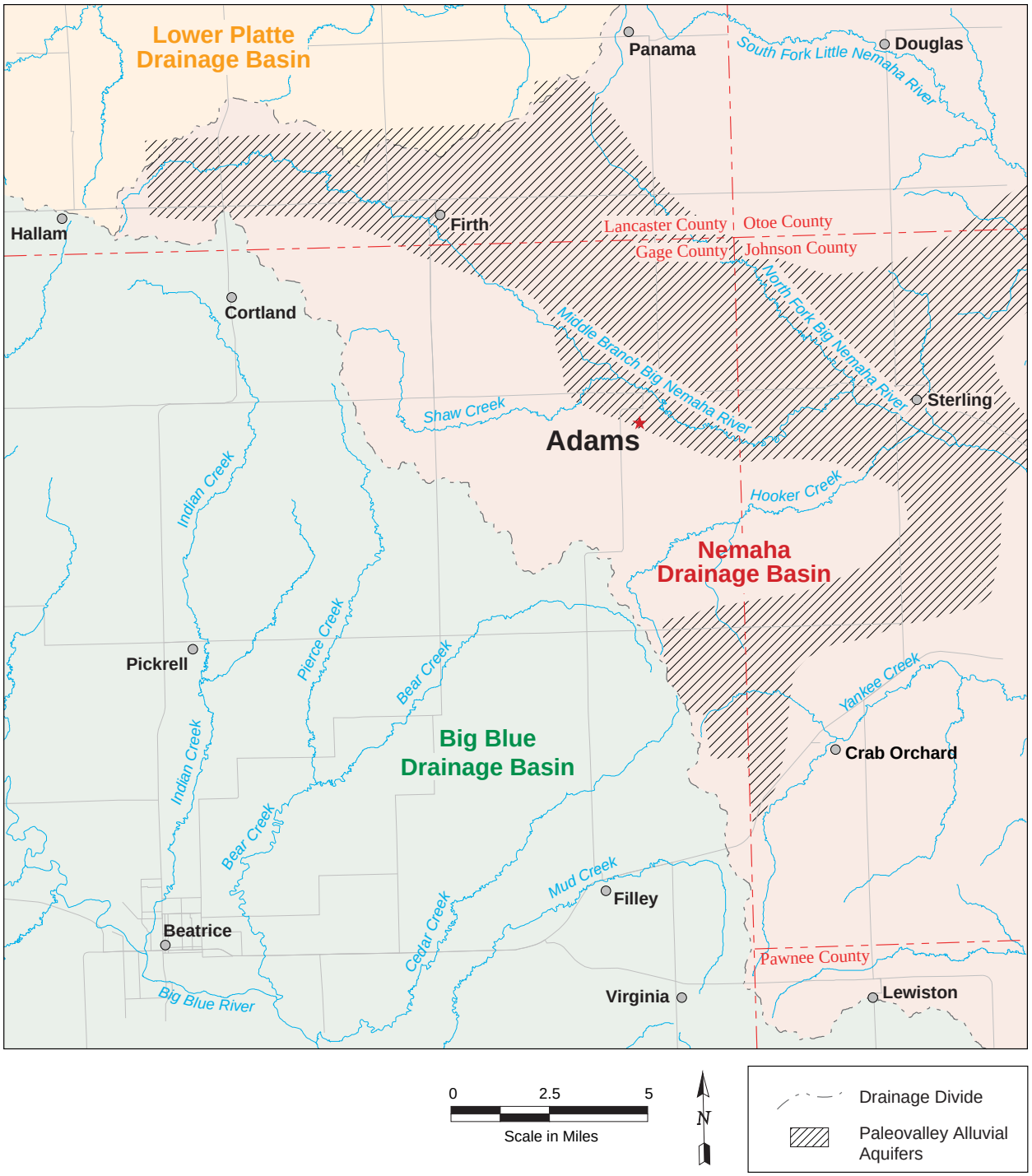

FIGURE 3.1 Map of Southeastern Nebraska, Showing Drainage Basins, Major Rivers and Streams, and Locations of Paleovalley Alluvial Aquifers (Source: CSD 1999)

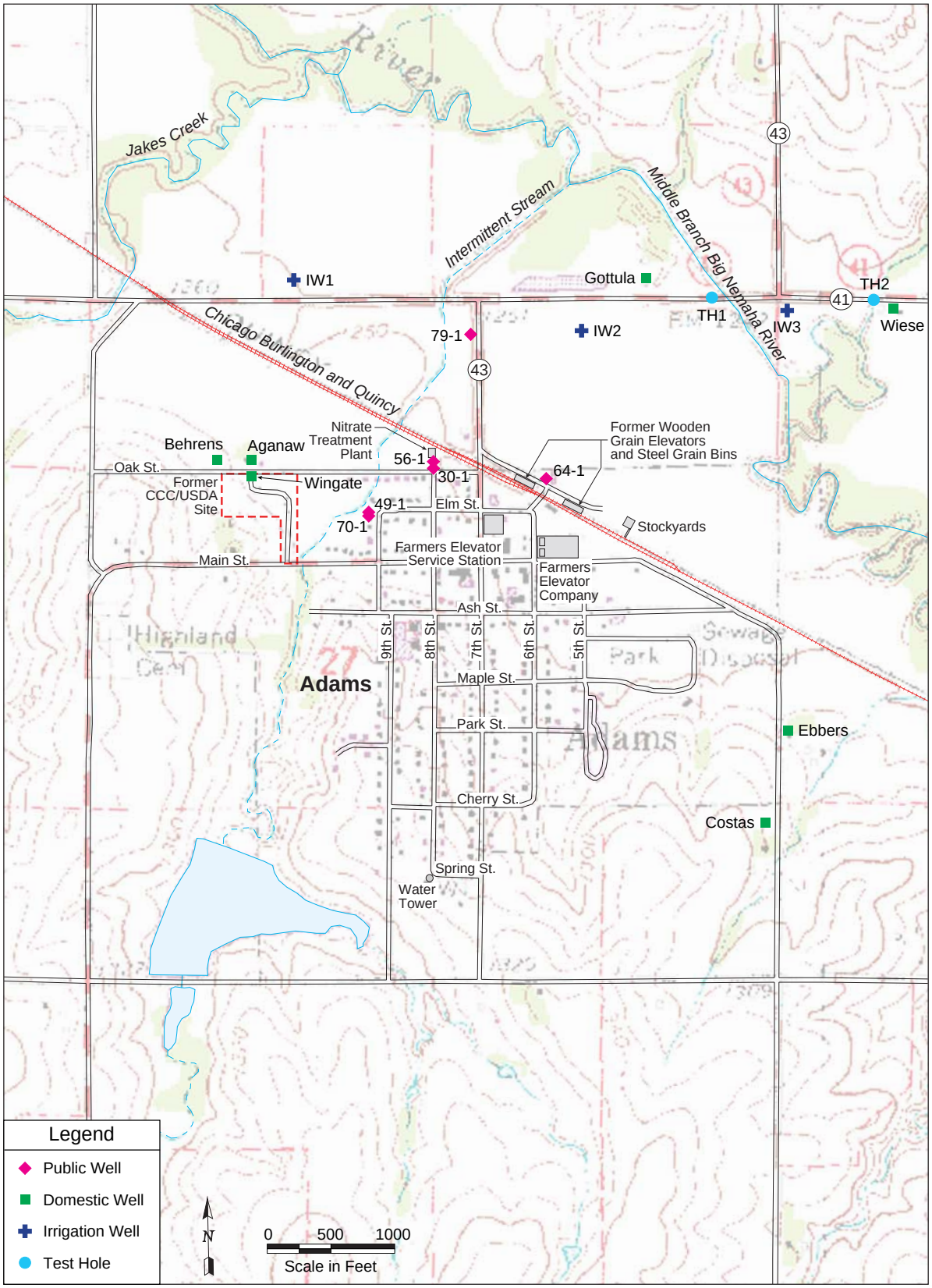

FIGURE 3.2 Map of Adams, Nebraska, Showing Topography and Locations of Public Supply Wells, Domestic Wells, Irrigation Wells, and Test Holes (Source: USGS 1965, 1993)

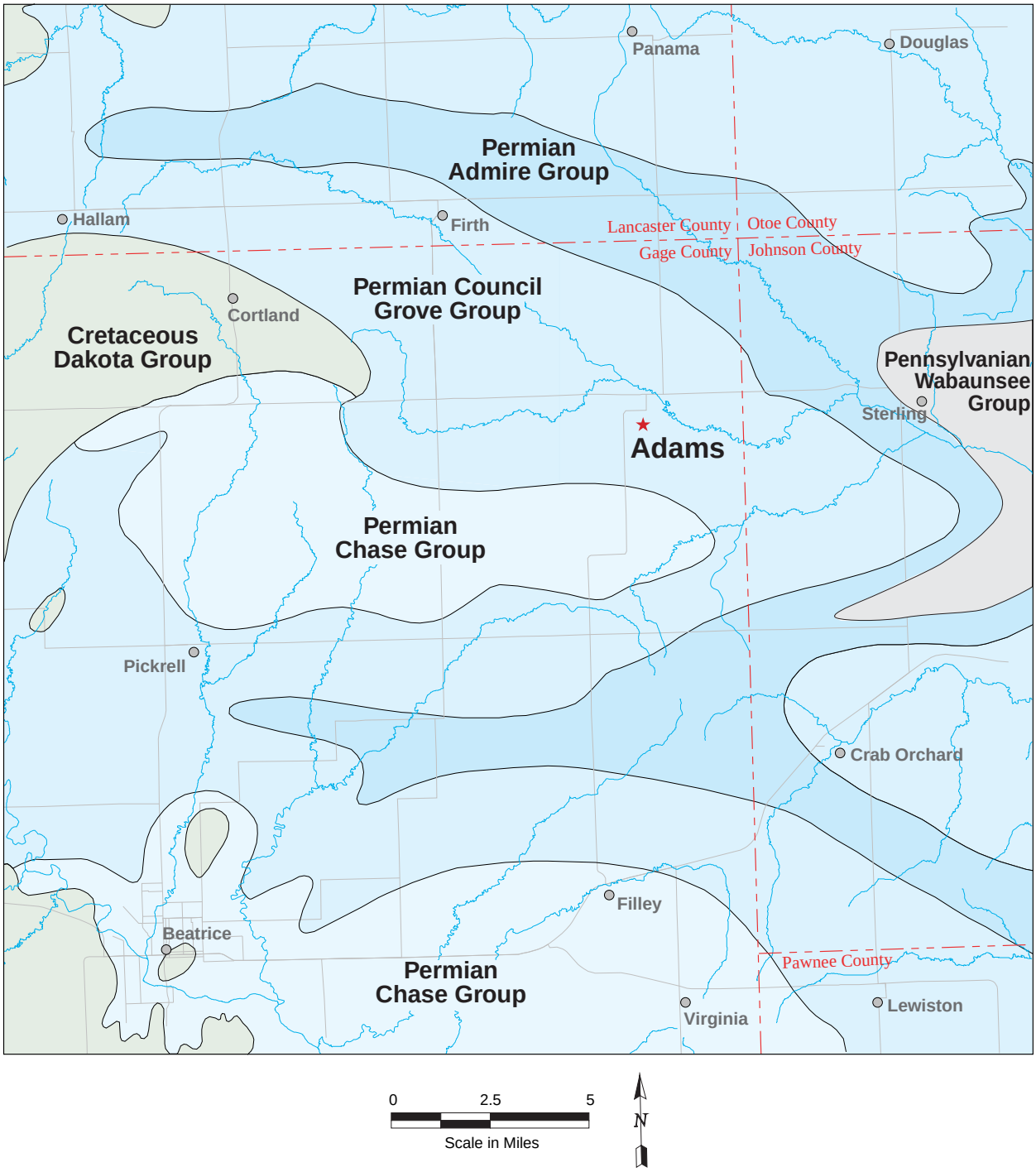

FIGURE 3.3 Map of Bedrock Formations in Northeastern Gage County and Western Johnson County, Nebraska (Source: CSD 1999; Burchett and Smith 1989b)

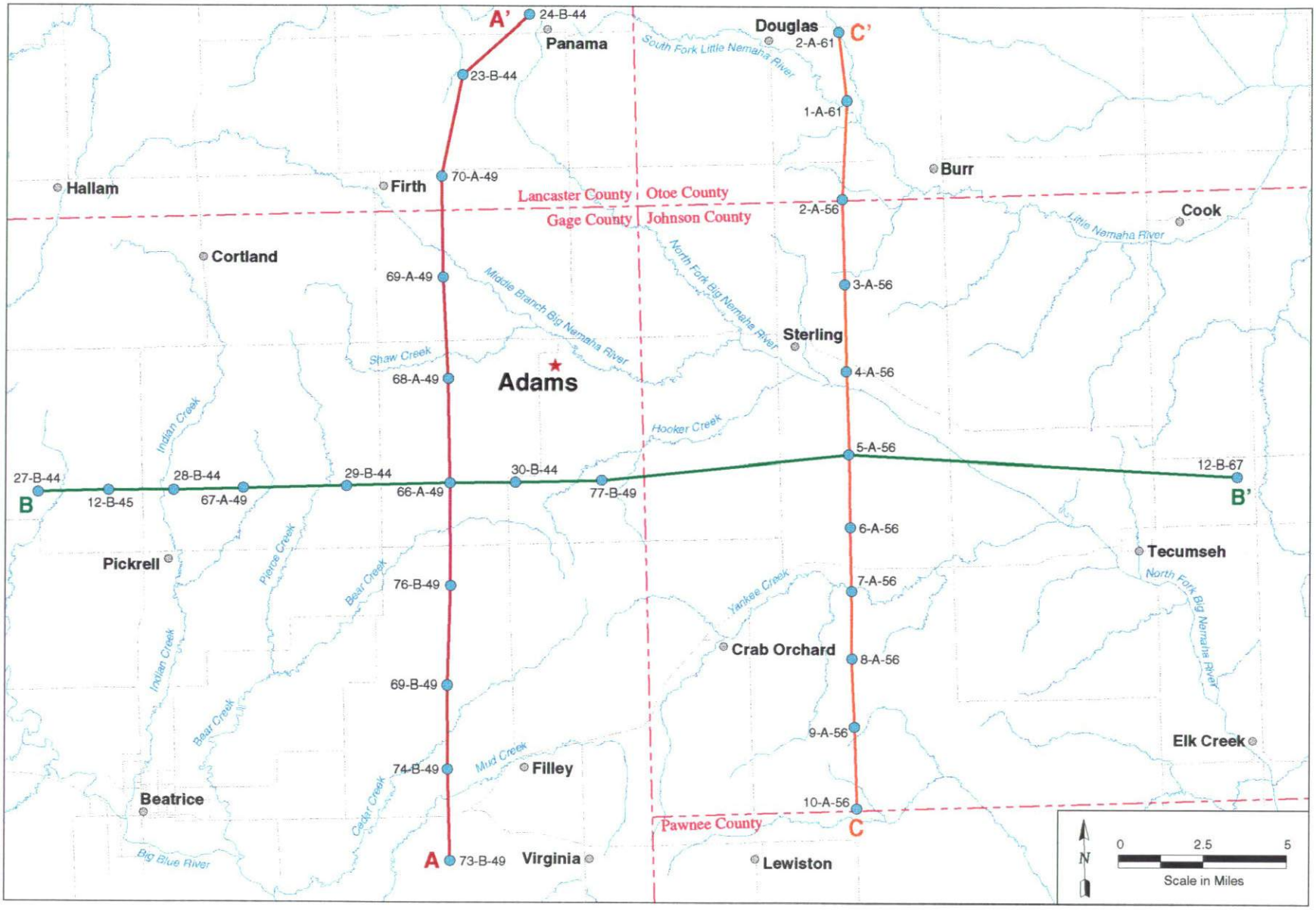

FIGURE 3.4 Map of Eastern Gage County and Western Johnson County, Nebraska, Showing the Locations of Nebraska Conservation and Survey Division Test Holes and Regional Cross Sections A-A´, B-B´, and C-C´

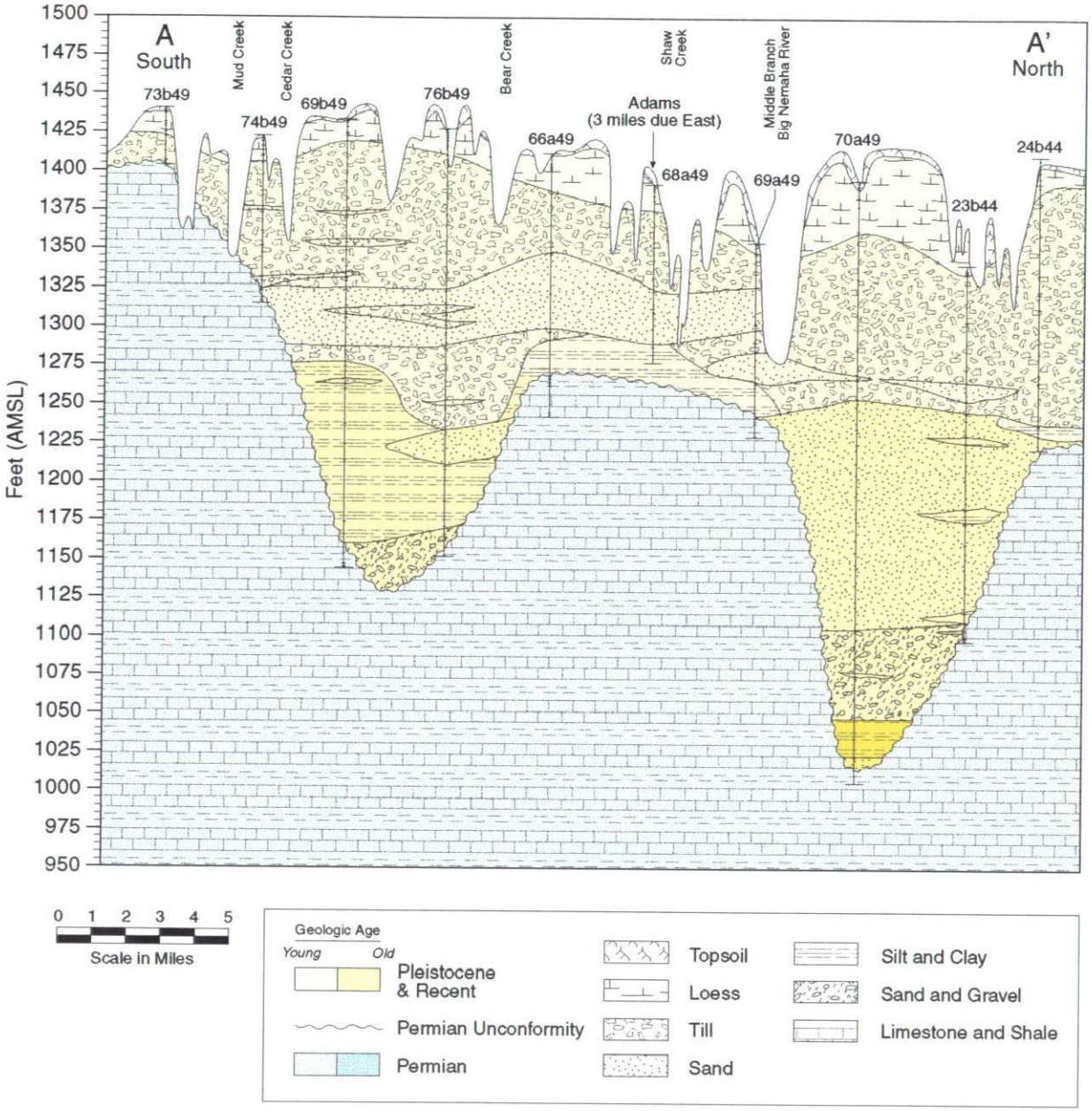

FIGURE 3.5 Interpretative South-to-North Geologic Cross Section A-A´, Gage and Lancaster Counties, Nebraska

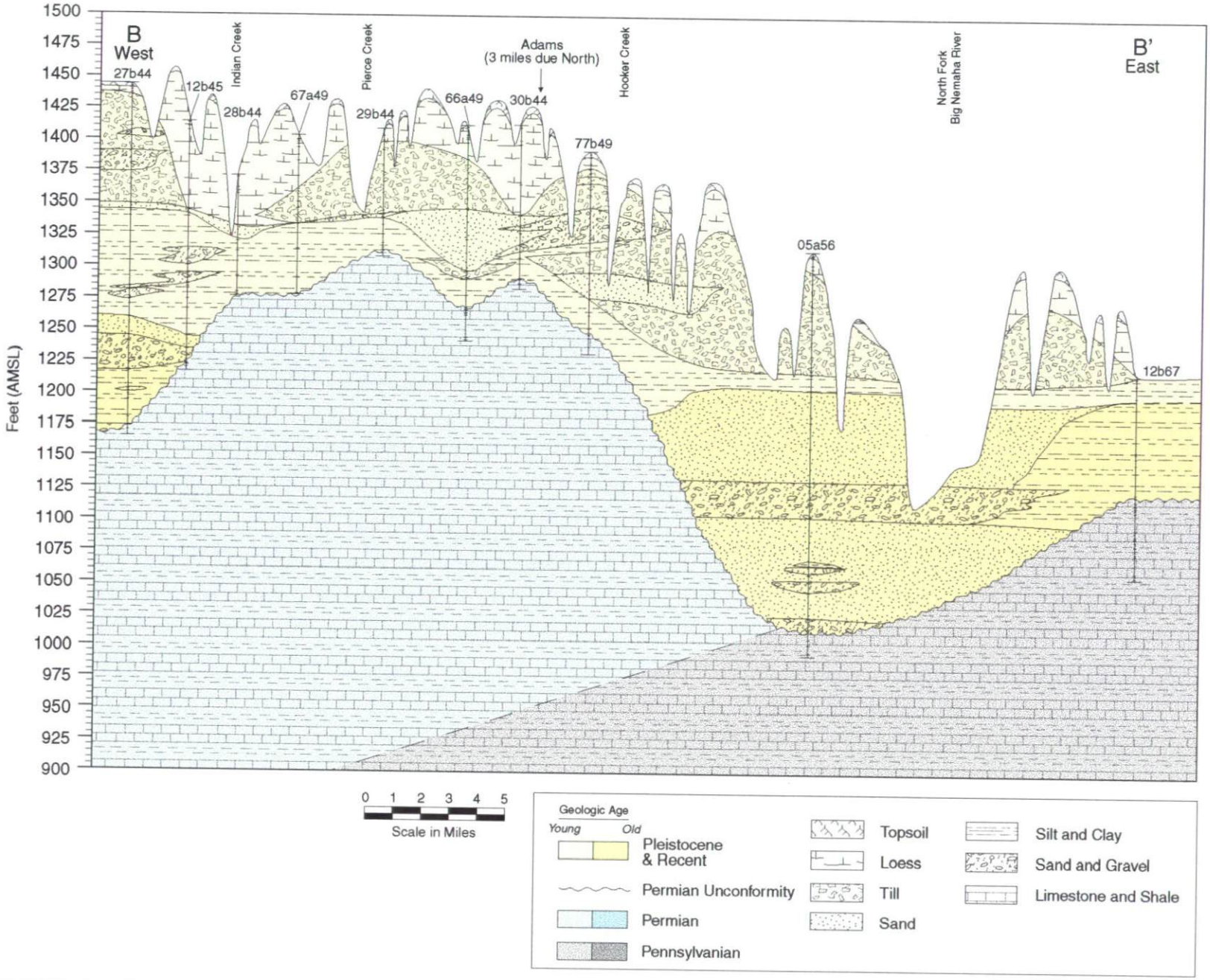

FIGURE 3.6 Interpretative West-to-East Geologic Cross Section B-B´, Gage and Johnson Counties, Nebraska

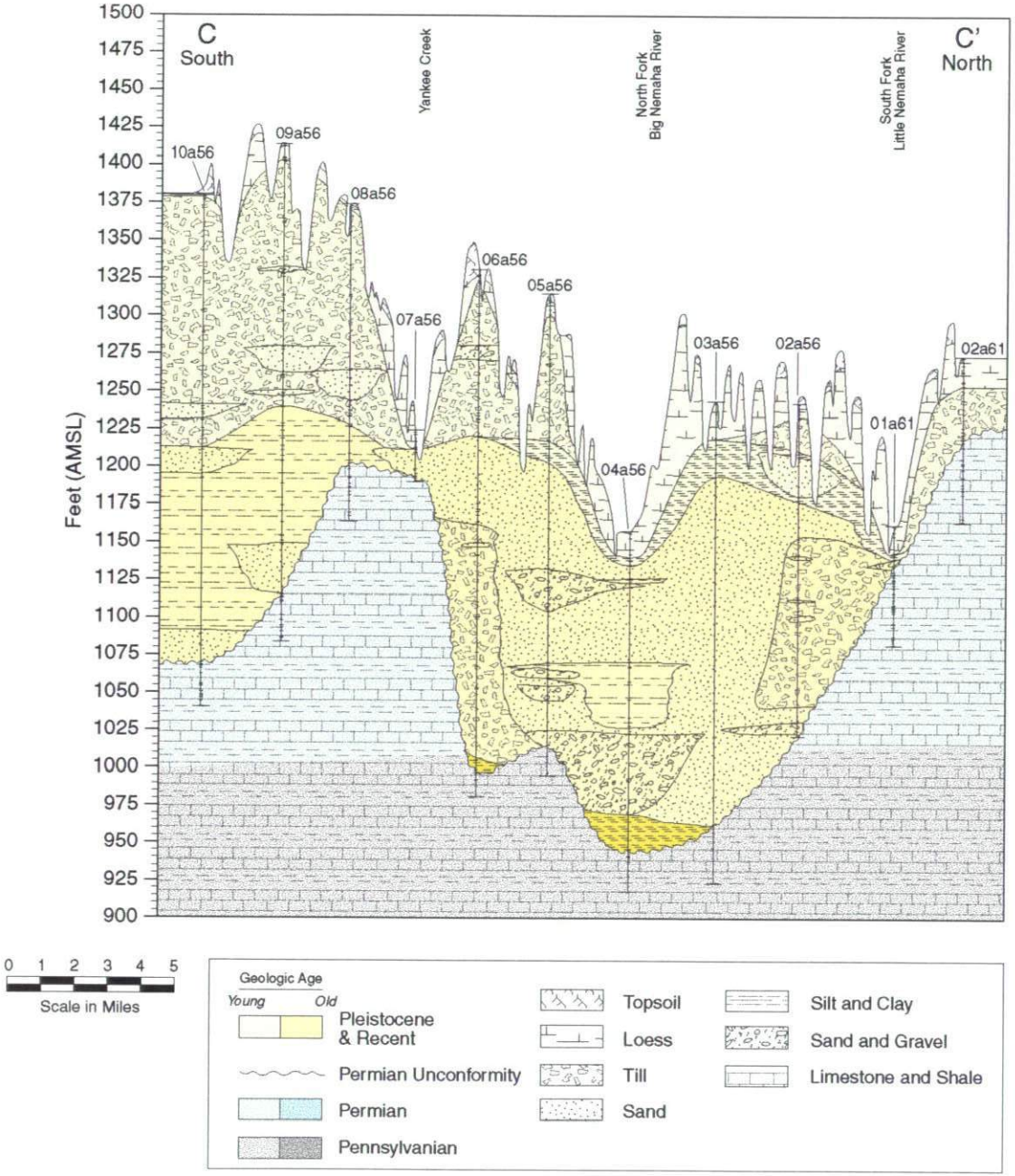

FIGURE 3.7 Interpretative South-to-North Geologic Cross Section C-C´, Johnson and Otoe Counties, Nebraska

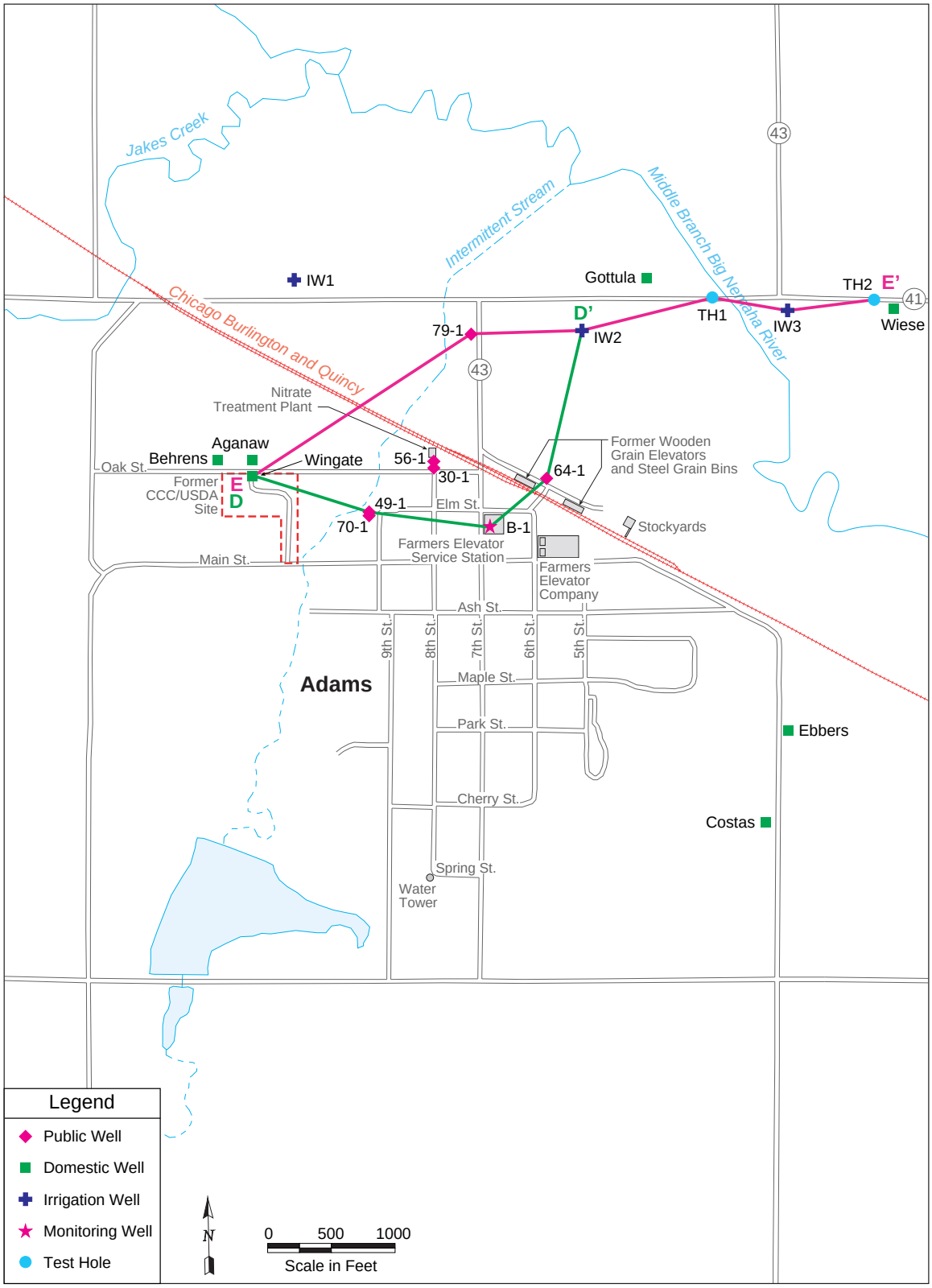

FIGURE 3.8 Map Showing Locations of Geologic Cross Sections D-D´ and E-E´, along with Locations of Irrigation Wells, Test Holes, Public Water Supply Wells, Domestic Wells, and Monitoring Well B-1 from the LUST Investigation at Adams, Nebraska (Source: Coranco 1990)

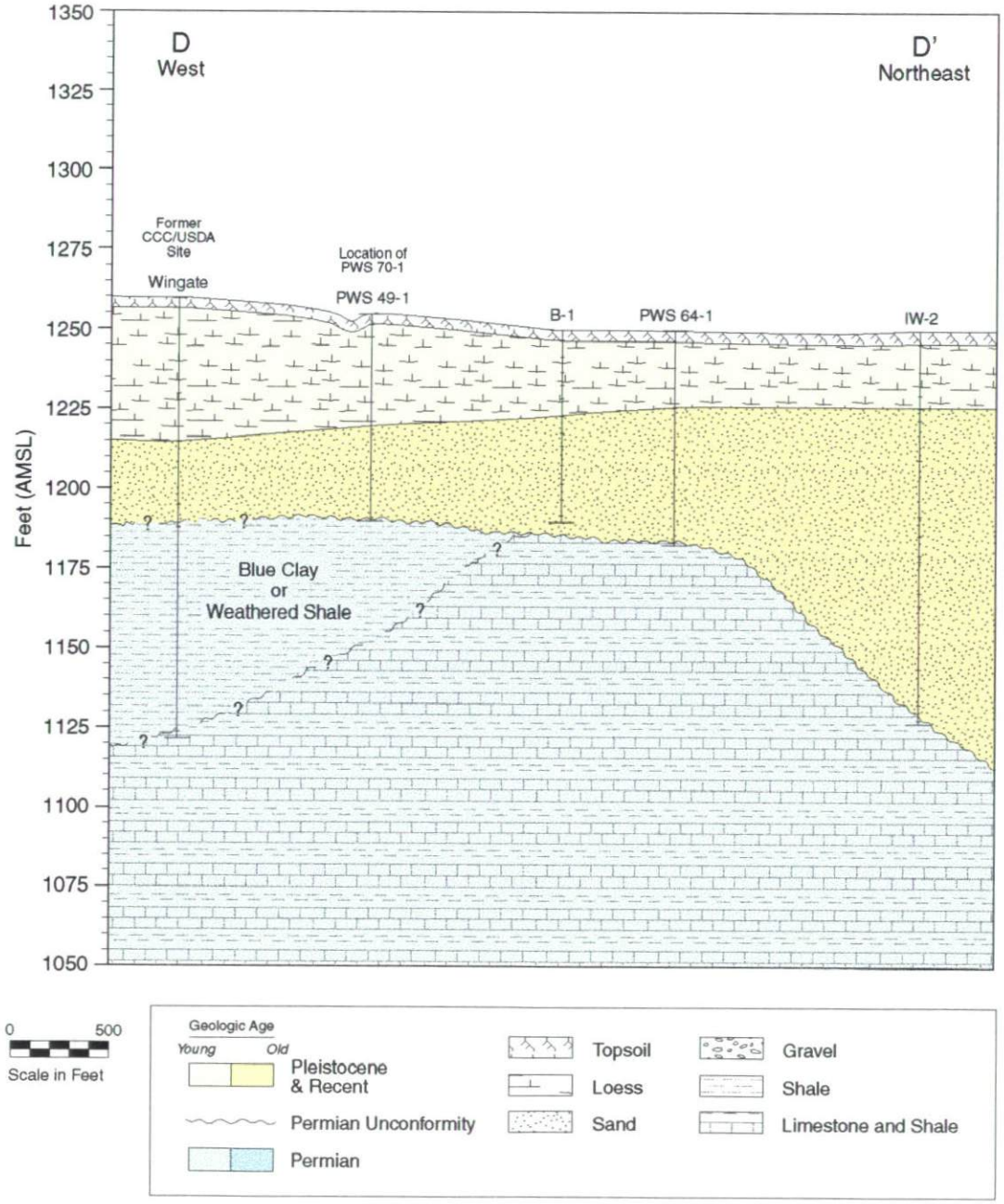

FIGURE 3.9 Interpretative Geologic Cross Section D-D′ from the Former CCC/USDA Site, through Contaminated Well PWS 64-1, and to the North of Adams, Nebraska

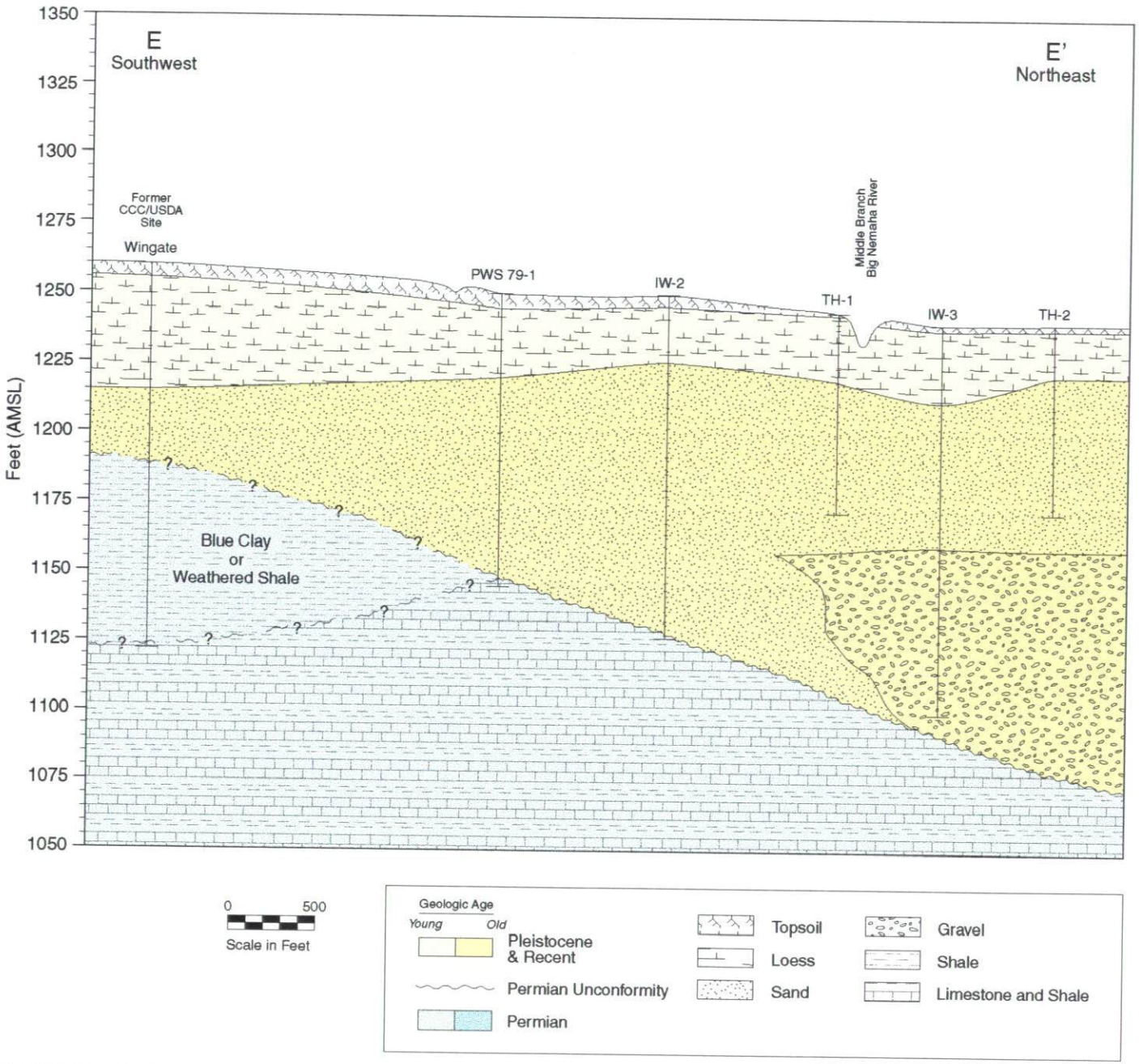

FIGURE 3.10 Interpretative Geologic Cross Section E-E´, Oriented in the Assumed Direction of Regional Groundwater Flow from the Former CCC/USDA Site, Adams, Nebraska

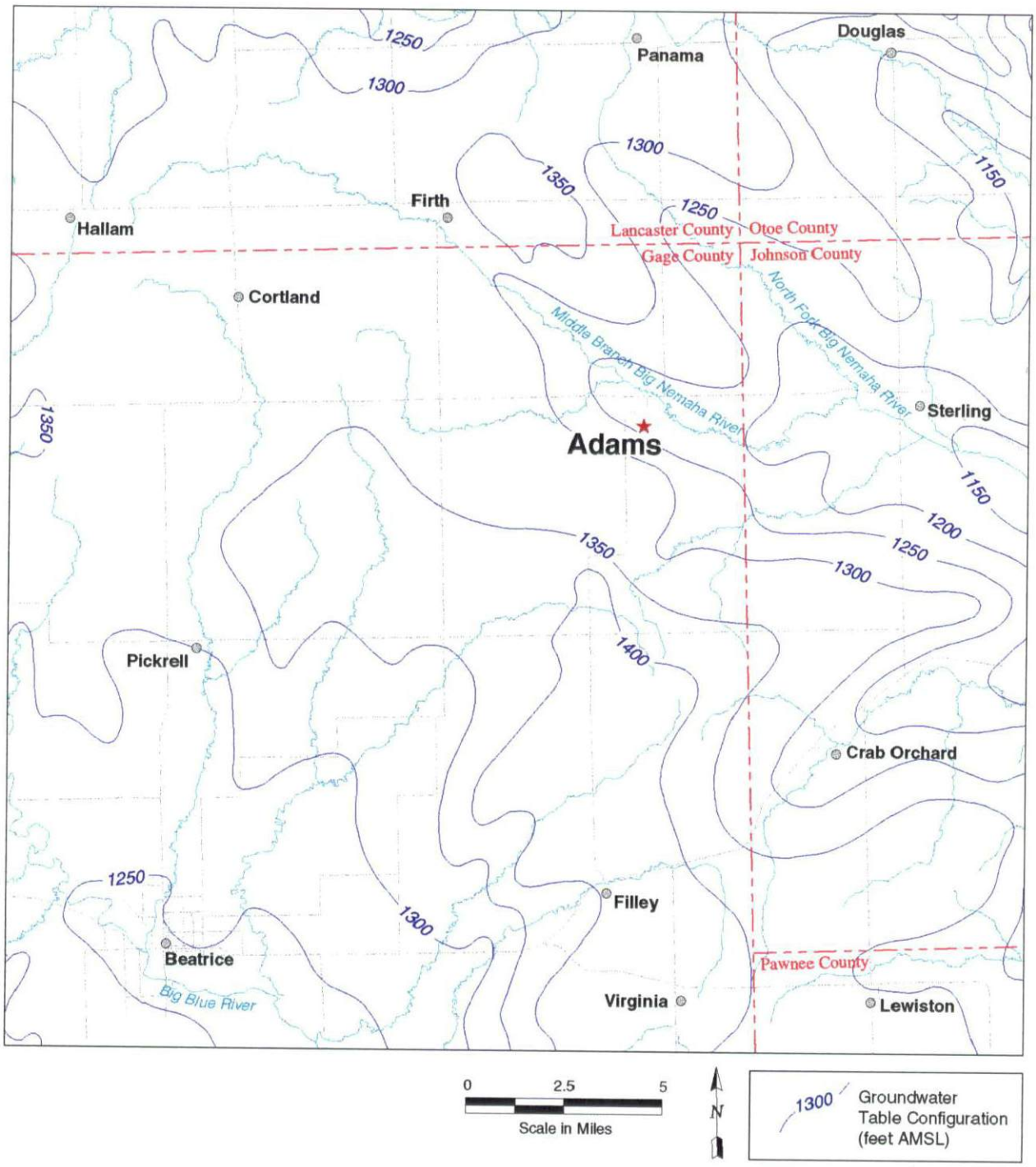

FIGURE 3.11 Map of Northeastern Gage County and Western Johnson County, Nebraska, Showing the Configuration of the Groundwater Table (Source: CSD 1999)

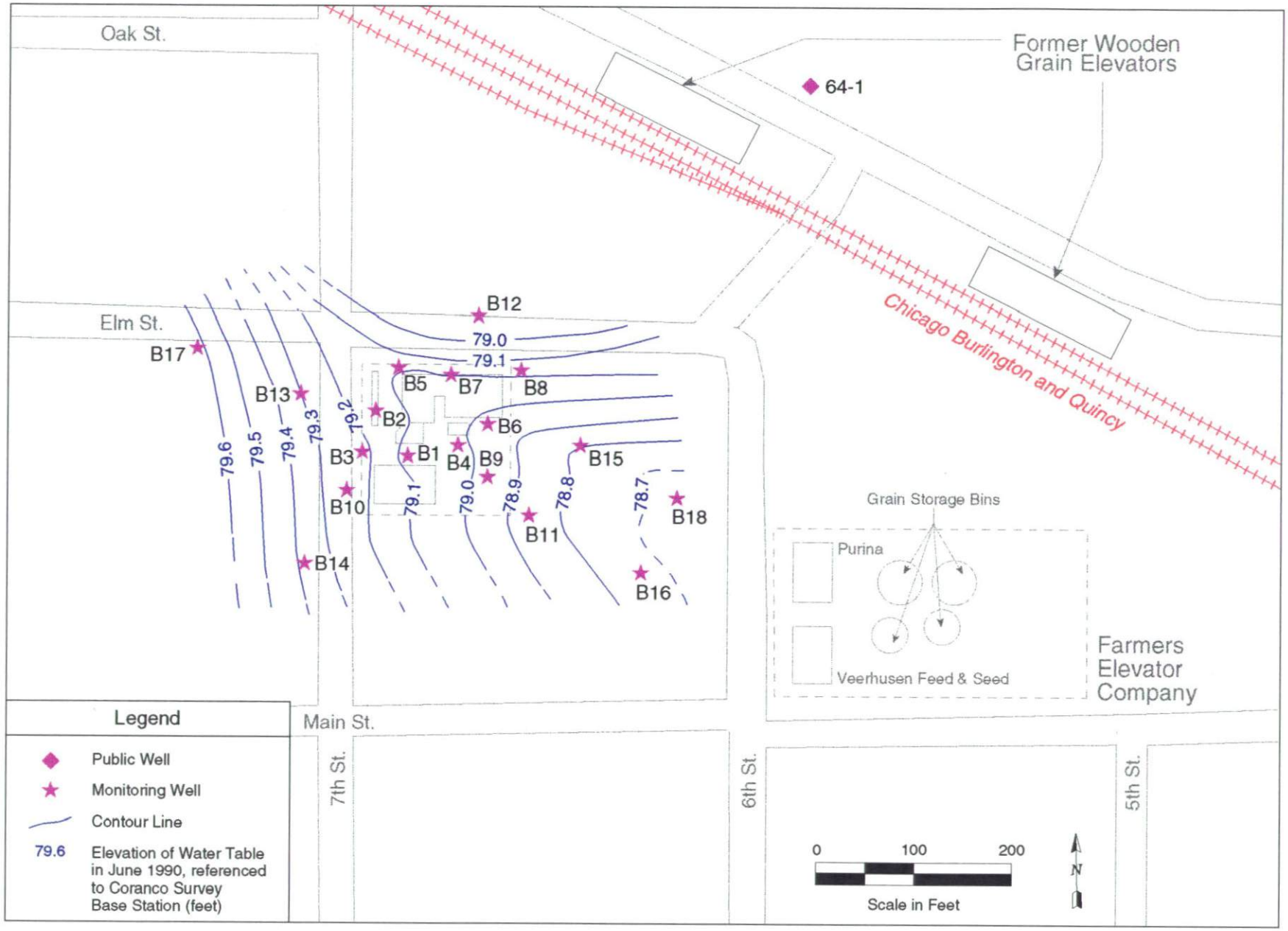

FIGURE 3.12 Map Showing the Configuration of the Local Water Table in the Area Surrounding the Farmers Elevator Company Service Station, Adams, Nebraska (Source: Coranco 1990)

4 Community Relations Plan

This community relations plan identifies issues of community concern regarding the Adams, Nebraska, groundwater contamination site and outlines community relations activities to be conducted in conjunction with the investigation. The CCC/USDA, which operated a grain storage facility in Adams, has assumed lead responsibility for all technical and community relations activities at the Adams site. Argonne will conduct these activities for the CCC/USDA. Officials from NHHS, the NDEQ, and the EPA Region VII office may also be involved in activities at the site.

To have an effective community relations effort, Argonne will need to work closely with Adams officials and community leaders, because community concern is likely to increase when the investigative field work begins and Argonne's presence becomes known throughout the village. In addition, as discussed in this community relations plan, information should be disseminated widely in the community and local area to ensure that all interested residents are adequately informed.

This community relations plan is divided into five sections:

1. Site description
2. Community background
3. Community relations objectives
4. Timing of community relations activities
5. Contact list of key officials

4.1 Site Description

Section 2 of this report contains a complete description of the site and its history.

4.2 Community Background

4.2.1 Community Profile

The village of Adams is located in Gage County, in southeastern Nebraska, about 27 mi northeast of the city of Beatrice and about 33 mi southeast of Lincoln. The village is located on State Highway 43, near the intersection of State Highways 41 and 43.

Adams, which has a population of about 472, is governed by a village chairperson and a village board. The village does not maintain a village office. In addition to public works and other responsibilities, the village board has authority to provide and maintain the public water supply system. The village has a utility superintendent who handles the routine operations and maintenance of the public water system.

Virtually all village residents are connected to the public water system, which provides the village with an adequate supply of drinking water. A few village residents have domestic wells that might be used for drinking. In May 1991, one of the village's three public water supply wells was taken off-line because of the detection of carbon tetrachloride at concentrations above the MCL. Carbon tetrachloride has also been detected occasionally over the past several years in one of the village's two active public water supply wells. However, the contaminant concentrations detected in this active well have been well within safe drinking water limits and have never exceeded the MCL.

The village's population has remained stable in recent years. Many Adams residents commute to jobs in nearby Beatrice and Lincoln. The land in the immediate vicinity of Adams is sparsely populated and is devoted to agricultural uses.

From a community relations perspective, an important feature of Adams is its relatively small size. Many area residents know one another, and, as a result, news travels fast. Village residents are likely to become aware of the presence of officials or contractors for the federal or state government. Area residents appreciate being informed of activities through credible sources such as their village board, *The Lincoln Journal Star*, and *The Beatrice Daily Sun*.

4.2.2 History of Community Involvement

Since 1990, residents have been aware of the presence of carbon tetrachloride in the Adams public water supply well. Community involvement regarding the carbon tetrachloride contamination was probably the highest when the contamination was discovered and in 1991, when the public water supply well with carbon tetrachloride concentrations that exceeded the MCL was taken off-line. In spite of the occasional detections of carbon tetrachloride in one of the village's two active public supply wells since that time, community involvement has been minimal, because the contaminant concentrations detected in the active well have been well within safe drinking water limits and have never exceeded the MCL.

In 1990, the village also had to contend with the detection of excessive nitrate levels in its public water supply system. The village addressed this problem by constructing a water treatment system in 1991. According to the village, this treatment system has effectively reduced nitrate concentrations in the public water supply system to levels that are within safe drinking water limits.

4.2.3 Key Community Concerns

Community concern regarding the carbon tetrachloride contamination in the public water supply has been moderate because only low levels have been detected occasionally over the past several years. Concern was considerably higher in 1990 and 1991, when excessive levels of both carbon tetrachloride and nitrates were present in the public water supply.

Once the investigation begins and the presence of Argonne officials and CCC/USDA contractors is known by Adams residents, concern and curiosity might increase significantly. In developing and implementing a community relations program for this site, it is important to anticipate the potential for more active public interest.

4.3 Community Relations Objectives

The Adams community relations plan has the following major objectives:

1. Explain the investigative plans of the CCC/USDA and provide general information about the program, to gain community acceptance.

2. Inform the local community of findings and developments.

3. Respond to citizens' inquiries about site activities and the presence of human health hazards, environmental hazards, or both.

4. Contact NHHS about any human health hazards identified.

5. Ensure that the public has appropriate opportunities for involvement in site-related decisions.

6. Determine, on the basis of community interviews, appropriate activities to ensure such public involvement.

7. Provide appropriate opportunities for the community to learn about the site.

4.4 Timing of Community Relations Activities

This section describes the numerous activities needed to meet the community relations objectives. Many of these activities need to take place before field work begins. Listed below are milestones and planned community relations activities.

4.4.1 Activities before Field Work Begins

The CCC/USDA and Argonne will provide for the conduct of the following community relations activities, to the extent practicable, before field work begins:

- A point of contact will be designated for Argonne. The individual will be Argonne's liaison with the community regarding implementation of the community relations plan.

- Upon obtaining approval from the CCC/USDA, Argonne will make initial contact with the officials of the village government to explain proposed activities and schedules.

- Argonne will make arrangements to conduct discussions (by telephone and in person) with interested residents and any other interested or affected parties, as

appropriate, to determine their concerns and information needs and to learn how and when citizens would like to be involved in the process. This activity can accomplish the following specific tasks:

- Develop a list of names, addresses and telephone numbers of local officials and interested citizens.

- Identify an information repository, with concurrence of village leaders.

- Identify wells near the site that could be used for sampling.

- Discuss access issues.

- Learn of any physical or legal constraints or barriers to investigative plans.

• Upon completion and approval of this site-specific *Work Plan* for the investigation, Argonne will request the assistance of local community leaders in arranging a meeting or meetings between appropriate CCC/USDA, Argonne, and community officials and interested citizens. State and EPA officials should also be invited. The purpose of the meeting(s) will be for CCC/USDA and Argonne to accomplish the following:

- Describe the site location and problem.

- Explain why action is required (legal, health, other issues).

- Explain what the CCC/USDA and Argonne hope to accomplish through the investigation.

- Describe this site-specific *Work Plan* and its schedule in detail, including staff, contractors, and equipment to be on the site.

- Introduce key staff members, including points of contact (telephone numbers and addresses).

- Present the CCC/USDA-Argonne communications plan to be followed during all phases of the investigation.

- Seek input and answer questions from the community regarding the investigation and the communications plan.

- Discuss any access issues/problems that may need to be addressed.

- Announce the location of the information repository.

• Argonne will make every effort to ensure that individuals living just outside the village boundaries receive information about the investigation.

• Argonne will establish an information repository and an administrative record file. The repository will be available for public inspection and copying and will include the following:

- The contact list of key officials (names, telephone numbers, and addresses of CCC/USDA and Argonne officials, other federal officials, state and local leaders, and interested groups and citizens).

- Copies of this site-specific *Work Plan*, the community relations plan, all applicable correspondence, fact sheets, results, guidance documents, and any other relevant information.

4.4.2 Activities during Field Work

The CCC/USDA and Argonne will provide for the conduct of the following community relations activities, to the extent practicable, during field work:

• Arrange for meetings with public officials and interested citizens when needed.

• Continue to update the information repository and the contact list.

- Prepare and distribute fact sheets or letters to inform the community of progress, significant milestones, or any changes in plans.

- Maintain telephone contact with state and local officials, as well as interested residents.

4.4.3 Activities upon Completion of the Investigation

The CCC/USDA and Argonne will provide for the conduct of the following community relations activities, to the extent practicable, upon completion of the investigation:

- Arrange for meetings with public officials and interested citizens to discuss findings, results, recommendations, and any future activities at the site.

- Prepare and distribute information outlining results and any future activities at site.

- Conduct information sessions with citizens and/or key community leaders.

4.5 Contact List of Key Officials

The contact list of key officials includes federal, state, and local officials and individuals living or working near the site.

4.5.1 Federal Elected Officials

Senator Chuck Hagel
Washington, D.C., Office
346 Senate Russell Office Building
Washington, DC 20510
(202) 224-4224
(402) 476-1400

Senator Chuck Hagel
State Office
Room 294, Federal Building
100 Centennial Mall North
Lincoln, NE 68508

Senator Bob Kerrey
Washington, D.C., Office
316 Senate Hart Office Building
Washington, DC 20510-2704
(202) 224-6551
(402) 437-5246

Senator Bob Kerrey
State Office
Room 294, Federal Building
100 Centennial Mall North
Lincoln, NE 68508

Congressman Doug Bereuter
Washington, D.C., Office
2348 Rayburn House Office Building
Washington, DC 20515-2703
(202) 225-4806
(402) 438-1598

Congressman Doug Bereuter
District Office
1045 K Street
P.O. Box 82887
Lincoln, NE 68501-2852

4.5.2 State Elected Officials

Governor Mike Johanns
State Capitol Building
P.O. Box 94848
Lincoln, NE 68509-4848
(402) 471-2244

State Senator Dennis Byars
District 30
State Capitol Building
Lincoln, NE 68509
(402) 471-2620

4.5.3 Adams Municipal Government Officials

Steve Robeson
Village Board Chairperson
Village of Adams
P.O. Box 41
Adams, NE 68301
(402) 988-5955 (Home)

Diane Rapp
Clerk and Treasurer
(402) 988-3165 (Home)

Dean Purde, Board Member
Jason Reimers, Board Member
Larry Agena, Board Member
Lloyd Goracke, Board Member
Darwin Buss, Utility Superintendent (402) 988-3435 (Office)
(402) 790-7832 (Pager)
(402) 988-4715 (Home)

4.5.4 Federal Officials

Robert Stephenson, Director
Conservation and Environmental Protection Division
Farm Service Agency
Commodity Credit Corporation
U.S. Department of Agriculture
Stop 0513, Room 4714-S
1400 Independence Avenue, SW
Washington, DC 20250-0513
(202) 720-5295

Michael Linsenbigler
Chief of Environmental Activities
Conservation and Environmental Protection Division
Farm Service Agency
Commodity Credit Corporation
U.S. Department of Agriculture
Stop 0513, Room 4719-S
1400 Independence Avenue, SW
Washington, DC 20250-0513
(202) 720-6303

Steve Gilmore
Conservation and Environmental Protection Division
Farm Service Agency
Commodity Credit Corporation
U.S. Department of Agriculture
Stop 0513, Room 4725-S
1400 Independence Avenue, SW
Washington, DC 20250-0513
(202) 720-5104

Victor Lyke
U.S. Environmental Protection Agency, Region VII
901 North Fifth Street
Mail Code SUPR/FFSE
Kansas City, KS 66101
(913) 551-7256

Jeff Field
Drinking Water Branch
U.S. Environmental Protection Agency, Region VII
901 North Fifth Street
Mail Code WWPD/DWGW
Kansas City, KS 66101
(913) 551-7548

4.5.5 State Officials

Howard Isaacs, Supervisor
Monitoring and Compliance Section
Nebraska Department of Health and Human Services
P.O. Box 95007
Lincoln, NE 68509
(402) 471-0930

Mary Yelken
Nebraska Department of Environmental Quality
Superfund
Suite 400, The Atrium
1200 N Street
Lincoln, NE 68509-8922
(402) 471-2181

4.5.6 Citizens and Other Interested Parties

No other citizens and interested parties have been identified.

4.5.7 Contact List for QuickSite^{SM} Investigation Team

The contact list of Argonne personnel responsible for activities at the Adams site is in Section 6, Table 6.1.

5 Phase I Technical Work Plan

This section describes the technical work plan that will guide the initial phase of the investigation. The planned program (Figure 5.1) is designed in accordance with the conceptual model of the geology and hydrogeology of the study area. This preliminary model, developed by critically reviewing existing data on the site and pertinent regional geologic and hydrogeologic data, is presented in Section 3 of this *Work Plan*. The principal goal of this initial phase of the investigation is to test this preliminary conceptual model and revise it as necessary. The revised conceptual model will then be used to design and guide the second phase of the investigation, which will focus primarily on delineating contamination at the site.

5.1 Technical Objectives for Phase I

The preliminary conceptual model of the geology and hydrogeology of the study area provides a guide for the initial phase of the investigation, but it is not considered the definitive model of the area. As investigative activities proceed during Phase I, the conceptual model will be updated continuously to reflect newly acquired data pertaining to the spatial distribution of the Quaternary sediments and their relationship to groundwater flow and possible contaminant migration. The updated model will guide subsequent investigative activities.

Groundwater sampling by the EPA (Curry 1999) has potentially identified carbon tetrachloride contamination in the shallow part of the aquifer at the former CCC/USDA site and at the existing Farmers Elevator Company grain storage facility (see Section 2). Quality control data were not provided in documentation of the sampling events, so no judgment can be made regarding the accuracy of these data. Historically, carbon tetrachloride has been detected in municipal supply well PWS 64-1 at levels above the MCL and in well PWS 70-1 at concentrations below the MCL. Once again, quality control data that would allow Argonne to validate these results are not available. Contaminated well PWS 70-1 is 500 ft east of the former CCC/USDA site, and well PWS 64-1 is 400 ft north of the Farmers Elevator Company grain storage facility (Figure 5.1). The conceptual understanding of the site developed in Section 3 suggests one pathway by which carbon tetrachloride might have migrated from the former CCC/USDA site to PWS 70-1 and two potential pathways from the site to PWS 64-1:

1. Movement of carbon tetrachloride downward at the former CCC/USDA site until the contaminant reached the Quaternary aquifer, followed by easterly

subhorizontal migration to municipal supply well PWS 70-1 (previously PWS 49-1). Potential variations of this pathway could result from southeastward flow from the northern part of the site (pathway 1a) or northeastward flow from the southern part of the site (pathway 1b). This pathway terminates at PWS 70-1 and does not act as a source for well PWS 64-1.

2. Movement of carbon tetrachloride downward at the former CCC/USDA site until the contaminant reached the Quaternary aquifer, followed by easterly subhorizontal migration through the location of well PWS 70-1 (PWS 49-1) and on to well PWS 64-1. Potential variations of this pathway could bypass well PWS 70-1 (PWS 49-1) to the north (pathway 2a), the south (pathway 2b), or both.

3. Movement of carbon tetrachloride downward at the former CCC/USDA site, followed by northeastward subhorizontal migration in the Quaternary aquifer passing to the north of the capture zone for PWS 70-1 (PWS 49-1), then easterly migration through the location of abandoned well PWS 56-1 to well PWS 64-1.

These potential pathways are shown schematically in Figures 5.2 and 5.3. Figure 5.2 is a west-to-east cross section (D-D´) running from the former CCC/USDA site and through the location of well PWS 70-1 to well PWS 64-1, showing potential pathways 1 and 2 and their variations. Figure 5.3 is a plan of the area showing all three potential pathways. During Phase I, addition data will be acquired to accomplish the following:

1. Identify the contaminant migration pathway(s) in the study area.

2. Characterize the geology and hydrogeology of the stratigraphic units that compose these pathways.

To achieve these goals, Phase I work will address the following technical objectives:

1. Characterize the Quaternary aquifer between the CCC/USDA site and the contaminated public supply wells.

2. Identify the migration pathway(s) responsible for contamination in wells PWS 64-1 and PWS 70-1.

3. Establish the direction(s) of groundwater flow in the Quaternary aquifer along the postulated migration pathways.

4. Evaluate the effects of pumping wells on groundwater flow along the postulated migration pathways.

Each of these technical objectives is discussed below in the context of the preliminary conceptual model of the site and the goals of Phase I. The investigative activities selected to achieve these technical objectives are described in Section 5.2. The procedures governing the proposed activities (such as core drilling, electronic cone penetrometer [ECPT] operations, sampling, and sample analysis) to achieve these objectives are described in the *Master Work Plan* (Argonne 1994).

The expanded geologic and hydrogeologic understanding of the site obtained by achieving the objectives of Phase I will provide the framework for designing and then guiding the second phase of this investigation. Phase II will focus primarily on delineating carbon tetrachloride contamination at potential source areas and within the hydrostratigraphic units that compose the migration pathways.

5.1.1 Characterize the Quaternary Aquifer between the CCC/USDA Site and the Contaminated Public Supply Wells

To understand the movement of groundwater and hence identify the contaminant migration pathways in the Quaternary section between the former CCC/USDA site and wells PWS 70-1 and PWS 64-1, it is necessary to characterize aquifer heterogeneity accurately. Groundwater contamination at the site could be associated with saturated loess at the top of the aquifer or with fine-grained sands within the alluvium. The carbon tetrachloride (up to 18 μg/L) detected in groundwater collected at 33-37 ft BGL at the former CCC/USDA site might have migrated from saturated loess above the permeable sands in the main part of the aquifer. The driller's log for the Wingate well has a gap at this depth, but loess is the unit most likely to be encountered there, on the basis of local stratigraphy. Significantly, repeated sampling of the Wingate well on the former CCC/USDA site has not revealed carbon tetrachloride (see Section 2). A possible explanation is that although carbon tetrachloride migration is retarded in

the saturated silt, the contaminant has migrated off-site in the permeable part of the aquifer in which the Wingate well is presumably screened (42-72 ft BGL).

Existing well control is inadequate to determine the detailed stratigraphy at the site. During Phase I, the preliminary conceptual model will be tested and refined by doing the following:

1. Obtaining detailed lithologic information from the critical part of the geologic section at the base of the loess and the top of the alluvial sand, where the gap in the log description conceals the stratigraphic relationships.

2. Evaluating the hydraulic characteristics of the geologic materials within the Quaternary aquifer at the site.

3. Obtaining data on the natural geochemistry of water in each of the aquifer zones as an aid in establishing lateral continuity and potential hydraulic separation.

4. Determining whether the Quaternary aquifer sands overlie “blue clay” (till) or weathered shale bedrock and whether this lower unit is a confining layer.

Details of the stratigraphy will be obtained from a continuously cored hollow-stem auger hole from surface to bedrock at the former CCC/USDA site, ECPT logs, and examination of ECPT split-spoon samples. Information on the hydraulic characteristic of the materials will be obtained by examination and physical testing of materials from the core and from selected split-spoon samples collected from representative lithologies by using the ECPT. Geochemical data for the various water-bearing units will be obtained by sampling with the ECPT and by sampling the LUST monitoring wells, the PWS wells, and accessible domestic wells pertinent to the objectives of the Phase I investigation.

5.1.2 Identify the Migration Pathway(s) Responsible for Contamination in Wells PWS 64-1 and PWS 70-1

To focus future investigative activities, Argonne must establish the potential migration pathway(s) from the former CCC/USDA site to wells PWS 70-1 and PWS 64-1. Existing

information on the lithology and carbon tetrachloride contamination suggests at least three potential migration pathways with possible variations (see Section 5.1). Confirming this working hypothesis will require the following:

1. Obtain data on the distribution (i.e., the presence or absence) of carbon tetrachloride, chloroform, and other VOCs along each of the postulated migration pathways.

2. Integrate the contaminant distribution data with information on hydrostratigraphic and geochemical characteristics of the water-bearing units to establish the migration pathway(s) responsible for contamination detected in wells PWS 70-1 and PWS 64-1.

Data on carbon tetrachloride and chloroform contamination in the water-bearing materials will be obtained through a combination of ECPT sampling and sampling of the existing monitoring wells and private wells in the study area.

5.1.3 Establish the Direction(s) of Groundwater Flow along the Migration Pathways

An understanding of the direction and magnitude of groundwater flow in the Quaternary aquifer is needed to guide future delineation of potential groundwater contamination and predict the movement of contaminants. No reliable water level data along the potential migration pathways exist. The possible presence of contamination in well PWS 70-1 suggests easterly movement of groundwater from the former CCC/USDA site to the well. Existing well control does not support detailed mapping of the direction of groundwater movement. Once the detailed hydrostratigraphy of the study area is established, water level observation wells (piezometers) must be installed to determine the direction and magnitude of groundwater movement. To guide the selection of piezometer locations, further ECPT testing might be conducted to determine the local stratigraphy and test for contamination of the aquifer. In addition, geophysical surveys will be conducted, if necessary, to map the relief on the bedrock surface and the distribution of the sand- and gravel-bearing units in the Pleistocene section across the area of investigation.

5.1.4 Evaluate the Effects of Public Supply Wells and Other Pumping Wells on Groundwater Flow along the Migration Pathways

The effects of pumping wells on the present and historical migration of carbon tetrachloride in the Quaternary aquifer are unknown. Under pathways 1, 1a, and 1b, a plume originating at the former CCC/USDA site and migrating generally easterly is assumed to explain the presence of traces of carbon tetrachloride in well PWS 70-1. However, carbon tetrachloride in well PWS 64-1 can be attributed to the former CCC/USDA site only by easterly groundwater flow, with the contamination passing directly through (pathway 2) or around (pathways 2a and 2b) the capture zone of well PWS 70-1 (PWS 49-1). If groundwater flow is to the northeast at the former CCC/USDA site, as postulated in the preliminary conceptual model, carbon tetrachloride could reach well PWS 64-1 only if the plume was deflected to the east (pathway 3). Pumping at well PWS 56-1 (replacement for PWS 30-1) and then well PWS 64-1 might have caused migration of the plume toward the east. If groundwater flow is to the northeast from the CCC/USDA site, the sporadic low levels of contamination found in well PWS 70-1 might be the result of partial capture of the edge of the plume as it passed to the north of the well. However, results from the recent ESI show that the aquifer might be free of contamination at both shallow and deep levels (Figure 2.3) immediately to the east of the contaminated northern part of the former CCC/USDA site (Section 2).

To fully understand whether and how groundwater contamination originating at the former CCC/USDA site could have reached contaminated well PWS 64-1, it will be necessary to reconstruct the pumping histories for the public supply wells from municipal records for the 1960s and later if such records are available. If the records exist, they will be combined with data on the aquifer characteristics acquired in Phase I to build a preliminary numerical model to simulate contaminant transport scenarios under various potential external stresses (such as historical pumping events). If the flow at the former CCC/USDA site is determined to be to the northeast and if modeling indicates that well PWS 56-1 did not influence the path of the plume, another source for the contamination at well PWS 64-1 must be sought. The only other identified source of carbon tetrachloride contamination is the Farmers Elevator Company, located south of well PWS 64-1 (Curry 1999). Pumping of well PWS 64-1 for extended periods in the past, or seasonal pumping of IW1 and IW2, might have induced northerly plume migration from the Farmers Elevator Company to the public supply well.

The influence of municipal and irrigation well pumping on the horizontal contaminant migration pathway will be evaluated by automated monitoring of water levels in the piezometers

and wells over an extended period, both before and during the irrigation season. The effect of municipal well pumping might also be evaluated by conducting pump tests at wells PWS 70-1 and PWS 64-1. These activities will probably require a prolonged period between the completion of the Phase I subsurface investigations and the beginning of Phase II.

5.2 Technical Program for Phase I

The investigative program outlined below is based on the conceptual understanding of the site outlined in Section 3 of this *Work Plan* and the objectives described in Section 5.1. The investigative tasks and locations discussed below are intended to test and refine specific aspects of the conceptual model. Locations were selected after consideration of potential accessibility. As new data are acquired during the field program, these tasks might be revised to reflect the improved conceptual understanding of the site. Modifications might include reduction in scope, elimination of specific activities judged to be unnecessary, or expansion of some portions of the investigative program to address specific questions raised by new data.

5.2.1 Drilling Program

Initially, one drilled borehole (SB01, Figure 5.1) is planned at the site (1) to confirm the stratigraphic sequence inferred from local and regional data, (2) to obtain detailed lithologic and hydrogeologic information on the aquifer, and (3) to calibrate the logging tools of Argonne's ECPT. The proposed location for the soil boring is on the former CCC/USDA site, where the EPA detected contamination in the shallow aquifer (Curry 1999). Borehole SB01 will be cored continuously with a hollow-stem auger through the Holocene and Pleistocene and to the top of bedrock. The depth to bedrock might be about 72 ft BGL if the "blue clay" described in the driller's log of the Wingate well is weathered Permian shale, or it might be as deep as 136 ft BGL if the "blue clay" is Pleistocene clay or till. Drilling will be conducted in accordance with procedures described in the *Master Work Plan* (Argonne 1994).

The core from SB01 will be logged in detail to (1) describe the lithologic sequence at the site, (2) evaluate the grain size distribution within the Quaternary aquifer, (3) determine whether the 64-ft-thick "blue clay" is impermeable Pleistocene till or weathered Permian shale, and (4) evaluate the hydraulic properties of the weathered shale, if it is present. Sediment samples will be collected for grain size analysis and to estimate hydraulic properties at different depths within the aquifer. If the "blue clay" is determined to be impermeable Pleistocene till, the

borehole will be drilled to the limestone bedrock. If the "blue clay" is determined to be weathered shale, the hole will be drilled to the limestone or to refusal. Samples might also be taken at selected intervals in the weathered shale, particularly if the shale is fractured, for chemical analysis for carbon tetrachloride.

5.2.2 Electronic Cone Penetrometer Program

Initially, an ECPT test hole will be attempted adjacent to borehole SB01 to determine whether the ECPT can penetrate the Quaternary sediments, identify the top of bedrock, collect groundwater samples, and install piezometers. The proposed location for the initial test hole (CP1) is adjacent to SB01 (Figure 5.1). The ECPT logs of tip stress, sleeve friction, and pore pressure will be compared to the stratigraphic records obtained from the core log of SB01. In addition, split-spoon samples will be collected with the ECPT to resolve discrepancies between the interpretations developed from the ECPT log and the lithologic log at the test hole location. If correlation between the ECPT log and the lithologic log is confirmed, the results at the test hole will be used to guide interpretation of subsequent ECPT penetrations to support mapping of the distribution of lithologies of interest. Multiple water samples will also be obtained at this location for geochemical and contaminant analyses. All ECPT activities will be conducted in accordance with procedures described in the *Master Work Plan* (Argonne 1994).

The need for and locations of any subsequent test holes will be determined in the field on the basis of findings from the initial test hole. However, the initial ECPT holes will follow the number sequence shown in Figure 5.1, working toward the east and northeast of the site. Any additional test holes will be placed on the basis of contaminant distribution. These holes will be used to collect groundwater samples for geochemical and contaminant analyses, to install piezometers for measurement of water levels, to refine the top-of-bedrock map, to identify variations in the distribution of sediment types within the unconsolidated cover, and to collect soil samples for analysis of physical properties.

Conventional drilling and well installation might prove necessary if the ECPT cannot penetrate the section of interest, the ECPT logs do not correlate well with the observed stratigraphy, or ECPT logging at subsequent locations indicates significant variations in local stratigraphy across the site.

5.2.3 Groundwater Sampling Program

A suite of groundwater samples will be collected to quantify groundwater chemistry and contaminant concentration within water-saturated units. The initial ECPT holes will follow the number sequence shown in Figure 5.1, working toward the east and northeast of the site. Groundwater sampling will be conducted in accordance with procedures described in the *Master Work Plan* (Argonne 1994). Analyses will be performed off-site with the EPA's Contract Laboratory Program methods. All samples will be analyzed for basic chemical properties and for possible carbon tetrachloride, chloroform, and other VOC contaminants. If necessary for further characterization of the aquifer, selected samples will be analyzed for oxygen, hydrogen, and tritium isotope values.

Groundwater samples will be collected with the ECPT at regular intervals from top to bottom of the Quaternary aquifer, in accord with procedures described in the *Master Work Plan* (Argonne 1994). Monitoring wells from previous investigations and accessible domestic or irrigation wells pertinent to the objectives of the Phase I investigation will also be sampled. Potential locations for the initial groundwater samples are shown on Figure 5.1.

Detailed analysis of variations in groundwater elemental and isotopic chemistries might prove critical in developing an understanding of the distribution of and the relative degree of hydraulic communication between potential zones of saturation within the Quaternary section. To develop a conceptual hydrogeologic model of the Adams aquifer system, these data will be integrated with (1) the detailed stratigraphy and information regarding depositional environments obtained from geologic cores and logs and (2) the results of monitoring of groundwater flow directions and levels. The conceptual model will be used to guide more focused activities during Phase II of the investigation, aimed at determining the distribution and probable migration pathways of carbon tetrachloride and chloroform in the groundwater and subsurface soils at the site.

5.2.4 Soil and Vegetation Sampling Program

If the results of hollow-stem auger coring and ECPT sampling indicate the presence of carbon tetrachloride or chloroform in groundwater, vegetation will be sampled at the former CCC/USDA site to obtain information on the potential distribution of these contaminants in subsurface soils and to guide the selection of locations for future soil borings. Near-surface soils

will also be sampled for carbon tetrachloride and chloroform to support risk analysis calculations for the surface soils.

The Adams site no longer contains the buildings and grain bins used by the CCC/USDA in 1950-1975. Figure 5.4 is an aerial photograph showing the locations of the buildings and steel bins at the site in 1965, when it was an active CCC/USDA facility. Targeted sampling will be conducted at and around the former locations of bins and buildings, as shown in Figure 5.4. Both soil and vegetation sampling will be performed, with the specific locations and sample types to be determined in the field on the basis of on-site conditions at time of sampling. Vegetation sampled might include leaf, stem, seed, root, and trunk samples; soil samples will be collected from each lithologic material within the first 6 ft BGL. In addition, samples will be collected from the SB01 soil boring cores at approximately 5-ft intervals, or as necessary to reflect lithologic variations within the sediments, to test for the presence of carbon tetrachloride and chloroform within the vadose zone at the former CCC/USDA site. The detailed procedures governing soil and vegetation sampling and analysis are in the *Master Work Plan* (Argonne 1994).

5.2.5 Water Level Monitoring Program

Depending on the results of pathway identification, the ECPT might be used to install temporary 1-in.-diameter polyvinyl chloride piezometers to measure water levels in the Quaternary aquifer at selected locations. Potential ECPT piezometer locations are shown in Figure 5.1. All piezometers will be installed in accordance with the procedures outlined in the *Master Work Plan* (Argonne 1994). Piezometers will be installed as needed to complete a network of observation wells to support mapping of the pattern of groundwater flow in the aquifer. Accessible LUST monitoring wells and former public water supply wells will be included in the observation network. Automated data loggers will be used to record water levels in the monitoring wells over extended periods if it is considered necessary to resolve seasonal or temporal pumping effects on local water levels.

As an adjunct to this program, a document search of the village water department records will be undertaken in an attempt to reconstruct the operational history of the public water supply wells. Information derived from this search will be incorporated with the results of the water level monitoring program to develop an understanding of past groundwater flow patterns.

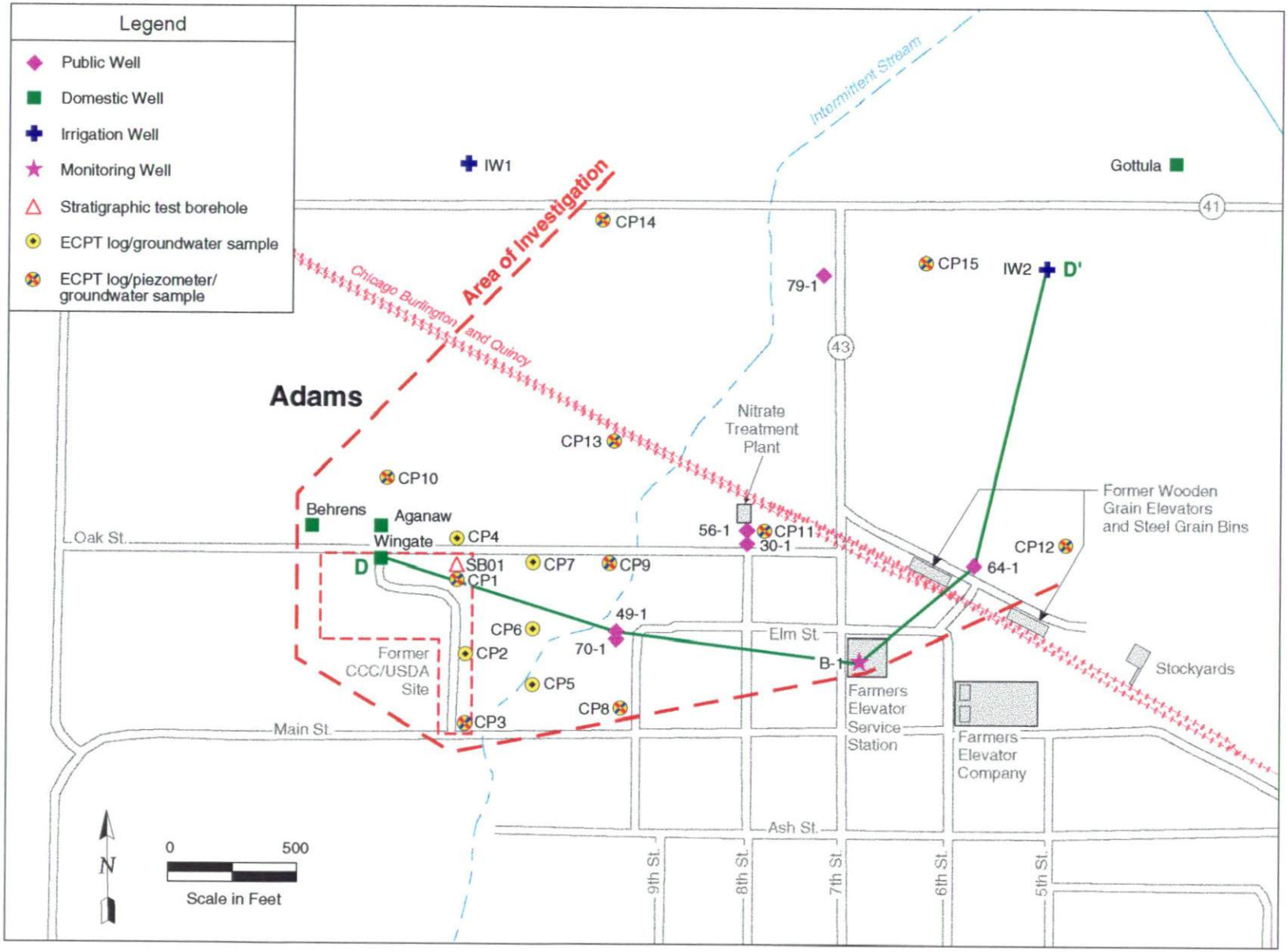

FIGURE 5.1 Map Showing the Area of Investigation and Approximate Locations of Planned Phase I Activities at Adams, Nebraska, and Vicinity

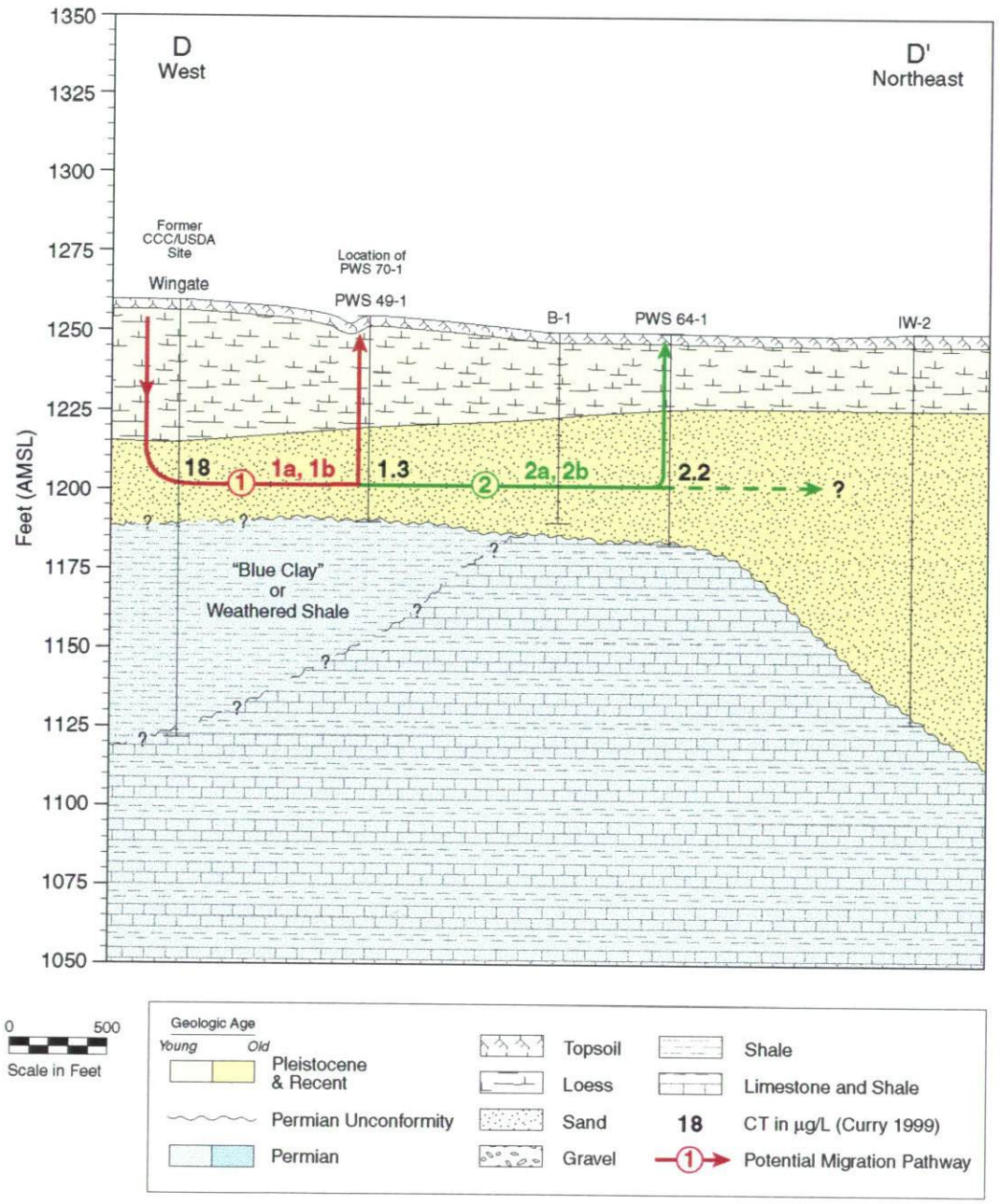

FIGURE 5.2 Interpretative West-to-East Geologic Cross Section D-D´, Adams, Nebraska, Showing Potential Pathways 1 and 2 for Migration of Carbon Tetrachloride from the Former CCC/USDA Site to Contaminated Wells PWS 70-1 and PWS 64-1

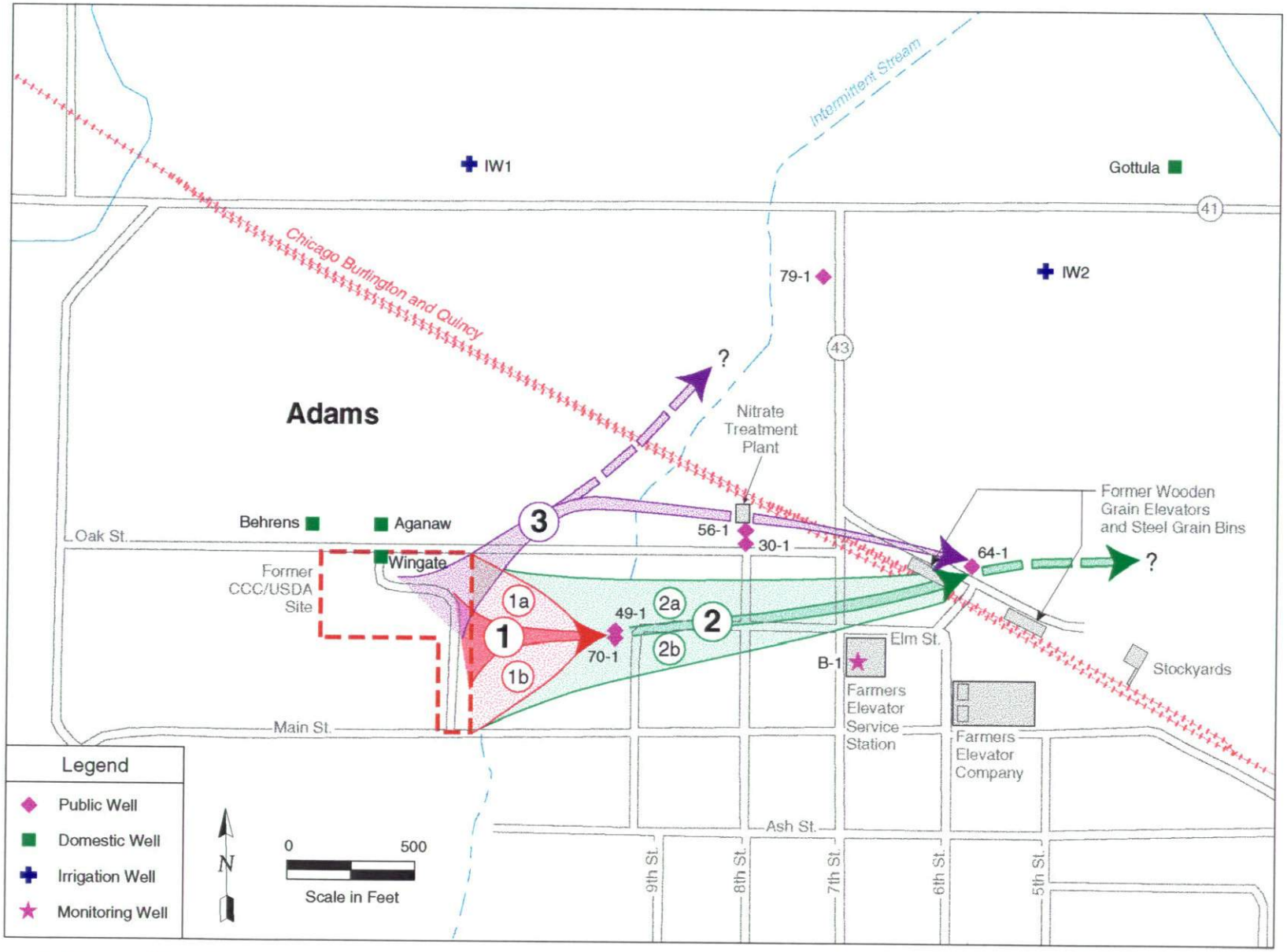

FIGURE 5.3 Map Showing Potential Pathways 1, 2, and 3 for Migration of Carbon Tetrachloride from the Former CCC/USDA Site to Contaminated Wells PWS 70-1 and PWS 64-1

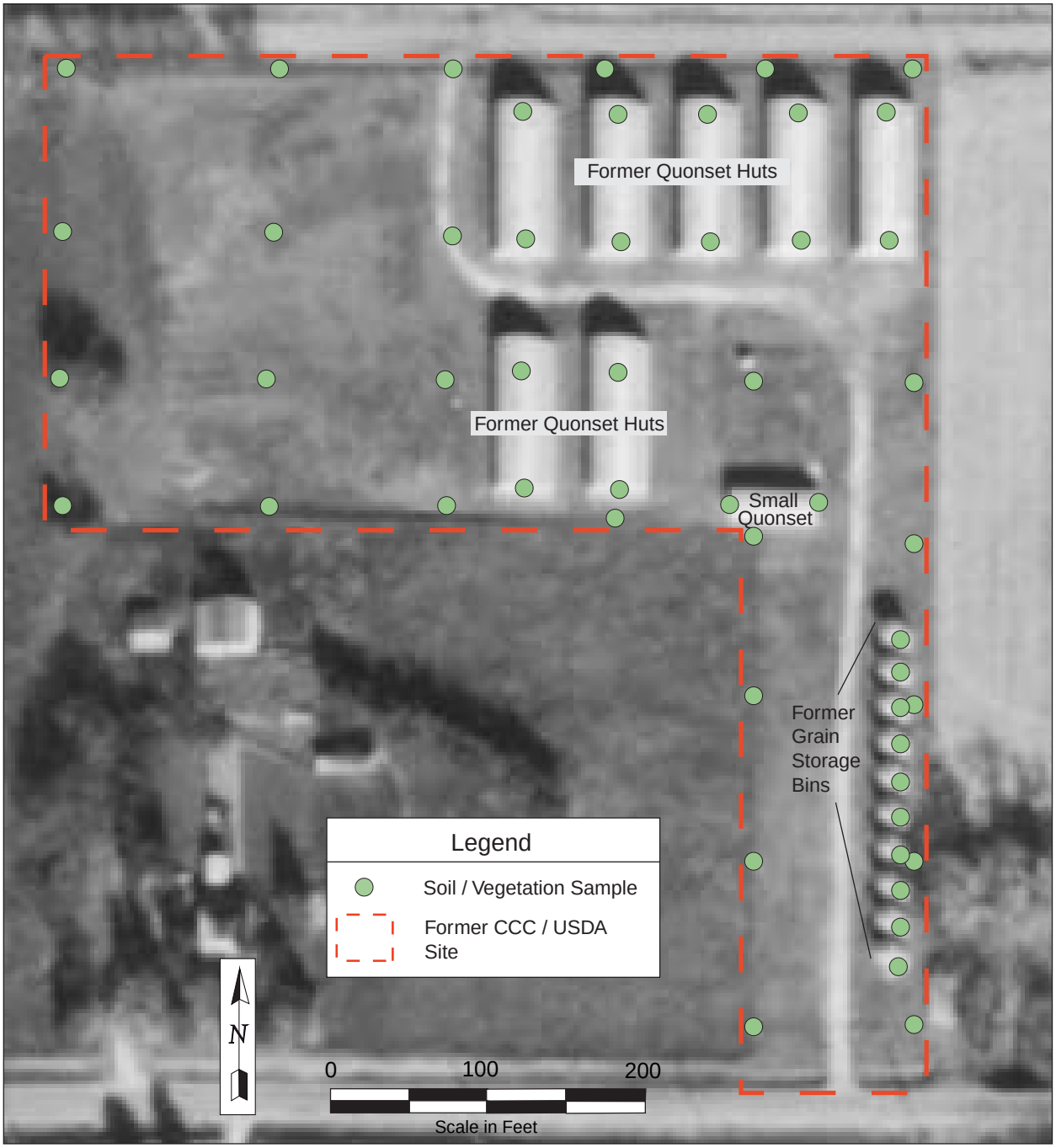

FIGURE 5.4 Aerial Photograph of the Former CCC/USDA Site near Adams, Nebraska, Showing the Locations of Former Buildings and Grain Storage Bins and Approximate Locations of Proposed Soil and Vegetation Samples (Photograph: USDA 1965)

6 Health and Safety Information for Adams, Nebraska

The general health and safety plan for the Adams site is in Section 3 of the *Master Work Plan* (Argonne 1994). The general plan addresses all anticipated safety issues for the investigation. Specific emergency information for use at the site is given below.

Adams has emergency 911 service. All emergency calls, including police, fire, and ambulance calls, will be directed for an appropriate response from this number. No emergency medical facilities exist at Adams. The nearest hospital with emergency medical facilities is in Beatrice, Nebraska. Driving directions to the hospital are in Figure 6.1. Additional emergency information is in Table 6.1. The Argonne project personnel responsible for activities at the site are listed in Table 6.2.

Directions from Adams to Beatrice Community Hospital and Health Center in Beatrice, Nebraska (1110 North Tenth Street)

1. From Adams, proceed about 0.2 mi north on State Rt. 43 to State Rt. 41.
2. Turn left onto State Rt. 41, and proceed west approximately 11 mi to U.S. Highway 77.
3. Turn left (south) onto U.S. Highway 77. Proceed south approximately 14 mi to Monroe Street in Beatrice, Nebraska.
4. Turn left onto Monroe Street, and proceed east to Tenth Street.
5. Turn right onto Tenth Street, and proceed two blocks to the hospital at 1110 North Tenth Street. The emergency room is on the southwest corner of the building.

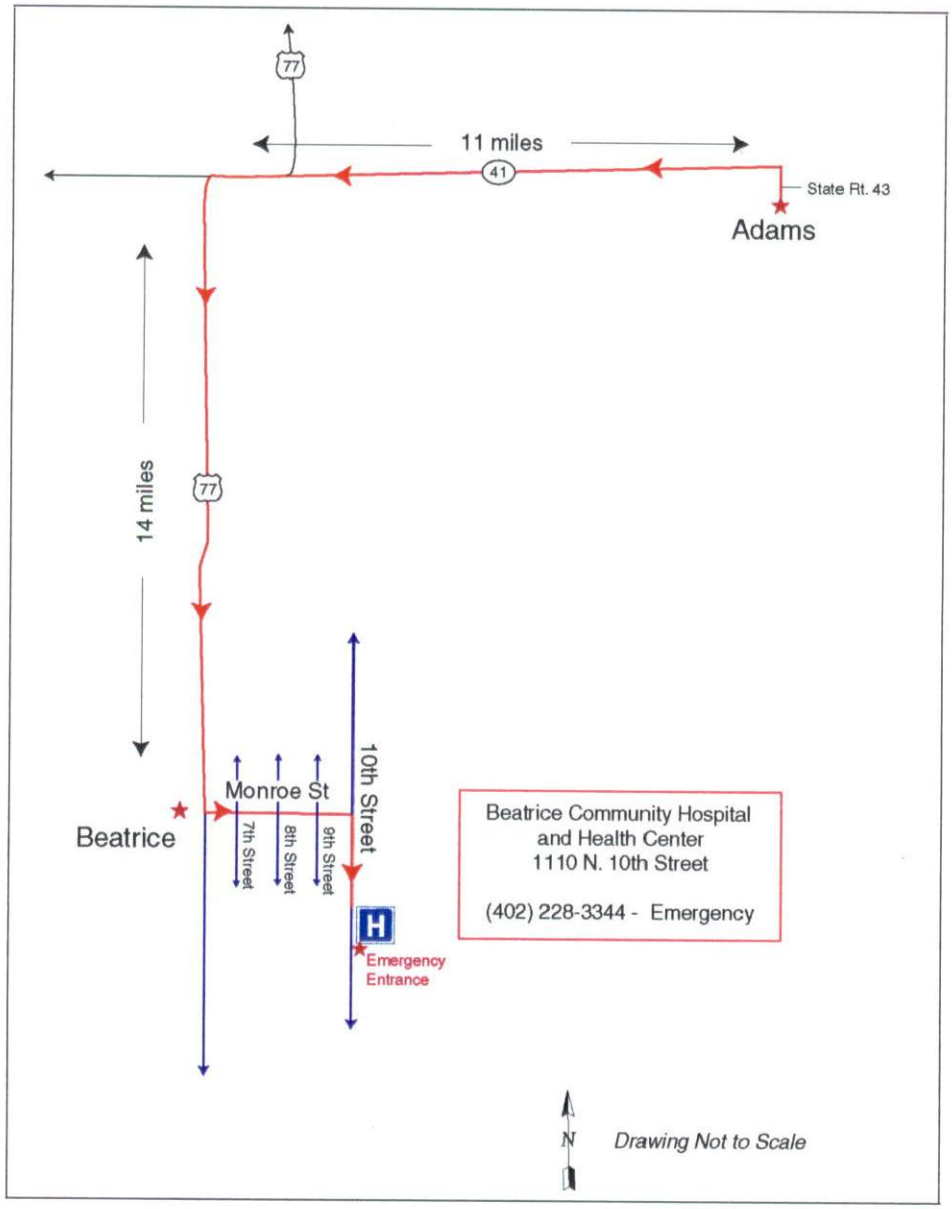

FIGURE 6.1 Map of a Portion of Gage County, Nebraska, Showing the Emergency Route from Adams to Beatrice Community Hospital and Health Center, Beatrice, Nebraska

TABLE 6.1 Emergency Information for the Adams, Nebraska, QuickSite[SM] Investigation[a]

Resource	Telephone Number	Name
At the Site		
Ambulance	911	-
Hospital	(402) 228-3344	Beatrice Community Hospital[b] 1110 North Tenth Street Beatrice, Nebraska
Fire	911	Adams Fire Department
Police	911	Adams Police Department
Industrial Hygiene	(630) 252-3310	Argonne-Industrial Hygiene
Safety	(630) 252-2885	ER Division[c] Safety Officer (Monte Brandner)
Environmental Concerns	(630) 252-4852	ER Division Regulatory Supervisor (Ron Kolpa)
Security	(630) 252-5731	Argonne-Operations Security
In the Local Area		
Ambulance	911	
Hospital	(402) 228-3344	Beatrice Community Hospital[b] 1110 North Tenth Street Beatrice, Nebraska
Fire	911	
Police	911 or (402) 323-5221	Gage County Sheriff Non-Emergency
Poison Control	(800) 955-9119	Omaha, Nebraska

[a] Post this table in the field operations base.

[b] The route from Adams to the hospital is shown in Figure 6.1.

[c] Environmental Research Division at Argonne.

TABLE 6.2 Information for the QuickSite^{SM} Investigation Team, Adams, Nebraska

Position	Name	Office Telephone	Field Address[a]	Field Telephone[a]
Program manager	J. Burton	(630) 252-8795	TBD	TBD
Project manager	T. Meyer	(630) 252-5781	TBD	TBD
Community relations coordinator	J. Hansen	(630) 252-4938 (202) 488-2453	TBD	TBD
Health and safety coordinator	W. Kickels	(630) 252-8594	TBD	TBD
Team members	J. Alvarado	(630) 252-5267	TBD	TBD
	R. Becker	(630) 252-7595	TBD	TBD
	C. Dennis	(630) 252-5999	TBD	TBD
	M. Krokosz	(630) 252-5027	TBD	TBD
	W. Kickels	(630) 252-8594	TBD	TBD
	L. LaFreniere	(630) 252-7969	TBD	TBD
	B. Nashold	(630) 252-7698	TBD	TBD
	R. Sedivy	(630) 252-1897	TBD	TBD
	K. Spokas	(630) 252-5463	TBD	TBD
	J. Taylor	(630) 252-5237	TBD	TBD
	E. Yan	(630) 252-6322	TBD	TBD
Subcontractors	Layne-Western, Inc., Omaha, Nebraska	(402) 359-2042		
	ASW Associates, Inc., Lincoln, Nebraska	(402) 432-3124		

[a] Locations and telephone numbers for team members are to be determined (TBD) before the field program begins.

7 References

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Appendix A:

Drilling Records for Adams, Nebraska, and Vicinity

03N 08E 07BCBC 73-B-49

Test Hole #73-B-49
(A3-8-7bc)
Gage County

Location: SW NW SW NW sec. 7, T. 3 N., R. 8 E., approximately 1,850 feet south and 19 feet east of northwest corner.
Ground elevation: 1,440.0 ft. (Wymore NE 7.5 min. quadrangle)
Depth to water: 31.0 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, dark brown to black.....	0.0	1.5
Clay, silty, dark brown.....	1.5	3.0
Silt, clayey, light brown.....	3.0	8.5
Silt, slightly clayey, soil-like, dark reddish brown,granular.....	8.5	10.0
Silt, light reddish brown.....	10.0	11.0
Silt, clayey to slightly sandy, reddish brown, contains very fine sand.....	11.0	15.0
Silt, clayey to sandy, reddish orange to Yellowish gray, contains very fine sand.....	15.0	18.0
Till: silt, sandy to clayey, slightly to Moderately calcareous, dark yellowish brown, iron stained,contains very fine to medium sand and calcareous fragments.....	18.0	27.5
Till: silt, clayey to sandy and gravelly, moderately calcareous, dark gray to reddish brown, iron stained, contains calcareous fragments.....	27.5	33.8
Permian System - Big Blue Series - Chase Group:		
Shale, yellow, silty, very calcareous.....	33.8	35.0
Limestone, yellow to pink.....	35.0	36.0
Shale, red, very calcareous.....	36.0	36.2
No sample, very hard.....	36.2	36.3

04N 08E 30BCCC 74-B-49

Test Hole #74-B-49
(A4-8-30bc)
Gage County

Location: SW SW NW sec. 30, T. 4 N., R. 8 E., approximately 2,340 feet south and 22 feet east of northwest corner.
Ground elevation: 1,423.0 ft. (Filley 7.5 min. quadrangle)
Depth to water: 50.5 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, black	0.0	1.0
Clay, silty, dark brown	1.0	3.5
Silt, light brown	3.5	7.0
Silt, very slightly clayey, soil-like, dark reddish brown, lighter below 10.0 ft	7.0	12.5
Clay, silty, light reddish brown	12.5	13.5
Till: silt, sandy to clayey, medium to dark yellowish brown	13.5	18.0
Till: silt, clayey to sandy and gravelly, very calcareous, light yellowish gray to dark yellowish brown, iron-stained, contains many calcareous fragments and pebbles	18.0	48.5
Sand, yellowish brown, texture grades from very fine to very coarse, contains many calcareous fragments	48.5	50.0
Till: silt, clayey to sandy and gravelly, very calcareous, gray to yellowish brown	50.0	61.5
Silt, very calcareous, grayish to reddish brown	61.5	71.0
Till: silt, sandy to clayey, very calcareous, gray to yellowish brown, contains very fine to coarse sand, dark bluish gray below 79.0 ft	71.0	92.0
Limestone, chalky, grayish white	92.0	93.8
Sand and gravel, consists of chert, flint and calcareous pebbles	93.8	100.0
Permian System - Big Blue Series - Chase Group:		
Shale, dark reddish brown to yellowish buff, very calcareous	100.0	105.8
Shale, grayish tan, silty, very calcareous	105.8	107.2
Shale, dark bluish gray, sandy, very calcareous, contains very fine to medium sand	107.2	107.9
Limestone, dark bluish gray, shaly	107.9	108.0

04N 08E 07CCCC 69-B-49

Test Hole #69-B-49
(A4-8-7cc)
Gage County

Location: SW corner sec. 7, T. 4 N., R. 8 E., approximately 92 feet north and 22 feet east of southwest corner.
Ground elevation: 1,434.0 ft. (Filley 7.5 min. quadrangle)
Depth to water: 15.3 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, dark brown to black	0.0	1.5
Clay, dark grayish brown	1.5	2.5
Clay, silty, dark gray, iron-stained	2.5	5.0
Silt, light green to dark brownish green, limonitic-stained, contains rootlets	5.0	9.0
Silt, soil-like, dark brown with reddish tint, iron-stained	9.0	10.0
Clay, silty, dark brown with reddish tint	10.0	11.0
Clay, dark brown to grayish green and pink, iron-stained	11.0	14.5
Till: clay, silty, to silt, clayey, sandy to gravelly, moderately calcareous, yellowish brown to grayish green, contains calcareous fragments, chalk and reworked shale fragments	14.5	61.5
Sand, yellowish brown, texture grades from very fine to coarse	61.5	64.0
Till: silt, sandy to slightly clayey, moderately calcareous, yellowish brown to grayish green, contains a few pebbles and calcareous fragments	64.0	80.0
Sand and gravel, yellowish brown, contains a few pebbles and sandstone fragments	80.0	85.0
Till: silt, sandy to clayey, slightly calcareous, dark yellowish brown, contains very fine to coarse sand	85.0	95.0
Till: silt, sandy to slightly clayey, slightly calcareous, dark bluish gray, contains very fine to coarse sand, contains few orange chalk fragments	95.0	102.0
Sand, yellowish brown, texture grades from very fine to very coarse, iron-stained	102.0	103.0
Till: silt, sandy to slightly clayey, slightly calcareous, dark bluish gray, contains very fine to coarse sand	103.0	105.0
Sand and gravel, dark yellowish brown, contains layers of bluish gray silt	105.0	110.0

Sand and some gravel, grayish brown to yellow, texture grades from very fine sand to medium gravel..	110.0	124.5
Till: clay, silty, slightly calcareous, dark bluish gray.....	124.5	128.5
Sand, yellowish brown, texture grades from very fine to medium sand, contains a few yellow chalk fragments.....	128.5	150.0
Till: silt, sandy to clayey, dark bluish gray, contains very fine to fine sand.....	150.0	160.0
Silt, sandy, slightly calcareous, dark bluish gray, contains very fine to medium sand.....	160.0	171.0
Sand, bluish gray, texture grades from very fine to coarse.....	171.0	173.5
Silt, sandy, slightly to moderately calcareous, light bluish gray, contains very fine to medium sand.....	173.5	196.5
Silt, very slightly clayey, slightly calcareous, medium bluish gray.....	196.5	210.0
Silt, slightly calcareous, light bluish gray.....	210.0	220.0
Silt, sandy, slightly calcareous, light bluish gray, contains very fine to medium sand.....	220.0	260.0
Silt, sandy to slightly clayey, slightly calcareous, light bluish gray, contains very fine to fine sand	260.0	280.0
Permian System - Big Blue Series - Chase Group:		
Silt, grayish white, chalky.....	280.0	286.8
Limestone, grayish white.....	286.8	287.1
Silt, grayish white, chalky.....	287.1	288.8
Limestone, grayish white with pink tint.....	288.8	289.0
Silt, grayish white, chalky.....	289.0	290.0

05N 07E 36AAAA 76-B-49

Test Hole #76-B-49
(A5-7-36aa)
Gage County

Location: NE NE NE NE sec. 36, T. 5 N., R. 7 E., approximately 7 feet south and 158 feet west of northeast corner.
Ground elevation: 1,428.0 ft. (Filley 7.5 min. quadrangle)
Depth to water: 40.6 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil and road fill: silt, clayey, black.....	0.0	0.5
Silt, clayey, dark brown.....	0.5	3.0
Silt, grayish tan to brown with some iron stain, contains calcareous rootlets.....	3.0	4.5
Clay, silty, grayish tan with some iron stain.....	4.5	6.0
Silt, slightly clayey, soil-like, dark reddish brown, granular, contains calcareous nodules.....	6.0	8.0
Clay, silty, reddish brown.....	8.0	11.5
Silt, sandy to slightly clayey, gray, contains very fine to medium sand.....	11.5	17.5
Sand, yellowish brown, texture grades from very fine to coarse, iron-stained.....	17.5	18.0
Till: silt, sandy to clayey, moderately calcareous, light to dark yellowish brown with iron stain, contains very fine to coarse sand with some gravel and few pebbles, contains a few calcareous nodules	18.0	95.5
Sand, yellowish brown, texture grades from very fine to coarse, contains a few calcareous fragments....	95.5	97.0
Till: silt, sandy, moderately calcareous, dark yellowish brown, contains very fine to coarse sand, iron-stained.....	97.0	99.0
Till: silt, slightly sandy, slightly calcareous, gray, contains very fine to fine sand.....	99.0	104.5
Sand, yellowish brown, texture grades from very fine to fine.....	104.5	115.5
Silt, moderately calcareous, light brown with some iron stain.....	115.5	118.5
Silt, clayey to sandy, moderately calcareous, light bluish gray, contains very fine to medium sand and some peat.....	118.5	120.0
Silt, slightly calcareous, dark brown to black.....	120.0	121.0
Sand, light bluish gray, texture grades from very fine to fine.....	121.0	127.0
Silt, very sandy, moderately calcareous, light bluish gray, contains very fine to medium sand....	127.0	132.0

Sand, light bluish gray, texture grades from very fine to coarse sand, contains many calcareous and dark blue clay fragments.....	132.0	142.5
Till: silt, sandy to clayey, slightly to moderately calcareous, dark bluish gray, contains very fine to coarse sand and many calcareous fragments.....	142.5	180.0
Sand, bluish gray, texture grades from very fine to very coarse.....	180.0	181.5
Till: silt, sandy to clayey, slightly calcareous, dark bluish gray, contains very fine to coarse sand.....	181.5	198.0
Sand, light bluish gray, texture grades from very fine to coarse, contains some sandy silt below 203.5 ft.....	198.0	220.0
Silt, sandy, slightly calcareous, dark bluish gray, contains very fine to medium sand.....	220.0	240.0
Clay, slightly sandy, slightly calcareous, dark bluish gray, contains very fine to fine sand, black from 247.0 to 250.0 ft.....	240.0	257.0
Silt, sandy, in part slightly calcareous, dark brown to dark grayish tan, contains very fine to medium sand.....	257.0	262.0
Sand and some gravel, light bluish gray, texture grades from very fine sand to fine gravel.....	262.0	275.5
Permian System - Big Blue Series - Council Grove Group:		
Limestone to chalk, grayish white to white.....	275.5	276.0
Limestone, grayish pink.....	276.0	276.1

05N 08E 07CCCC 66-A-49

Test Hole #66-A-49
(A5-8-7cc)
Gage County

Location: SW corner sec. 7, T. 5 N., R. 8 E., approximately 92 feet north and 10 feet east of southwest corner.
Ground elevation: 1,412.0 ft. (Adams 7.5 min. quadrangle)
Depth to water: 40.5 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, dark brown to brown.....	0.0	1.5
Silt, clayey, dark to medium brown.....	1.5	7.0
Silt, dark brown, soil-like.....	7.0	9.0
Clay, silty, dark reddish brown, granular.....	9.0	10.5
Clay, slightly silty to sandy, grayish white, contains very fine to fine sand, very fine to coarse sand and pinkish tan below 20.0 ft.....	10.5	26.5
Till: silt, clayey to sandy and gravelly, light yellowish brown, contains calcareous nodules and iron-stained below 30.0 ft.....	26.5	65.0
Sand, dark brown, texture grades from very fine to medium with some coarse.....	65.0	90.0
Sand, grayish tan with some iron stain, texture grades from very fine to very coarse, contains a few calcareous fragments.....	90.0	115.0
Till: silt, sandy, moderately calcareous, medium bluish gray, contains very fine to very coarse sand.....	115.0	120.0
Silt, sandy, moderately calcareous, grayish white, contains very fine to fine sand, light tan with pinkish tint below 130.0 ft.....	120.0	143.0
Sand and gravel, composed principally of reworked chert, jasper and limestone fragments.....	143.0	144.0
Permian System - Big Blue Series - Chase Group:		
Shale, light yellowish brown, sandy, very calcareous, contains very fine to fine sand.....	144.0	145.0
Limestone, dark grayish blue.....	145.0	145.5
Shale, light green to yellowish brown, very calcareous.....	145.5	147.0
Limestone, pinkish gray.....	147.0	148.2
Shale, light green, very calcareous.....	148.2	149.5
Shale, light reddish brown, slightly sandy, very calcareous, contains very fine sand, dark red from 157.0 to 160.0 ft., dark gray below 160.0 ft.....	149.5	167.0
Shale, light gray to grayish white to green, very calcareous.....	167.0	169.0
Limestone, grayish white.....	169.0	170.0

06N 07E 25DDDD 68-A-49

Test Hole #68-A-49
(A6-7-25dd)
Gage County

Location: SE SE SE SE sec. 25, T. 6 N., R. 7 E., approximately 151 feet north and 21 feet west of southeast corner.
Ground elevation: 1,392.0 ft. (Adams 7.5 min. quadrangle)
Depth to water: 18.5 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, dark brown to black.....	0.0	1.5
Clay, dark brown with slight reddish tint.....	1.5	2.5
Clay, medium brown.....	2.5	4.0
Silt, slightly clayey, light brown.....	4.0	7.5
Silt, medium reddish brown.....	7.5	10.0
Silt, very slightly clayey, dark yellowish brown....	10.0	16.5
Till: silt, clayey to sandy and gravelly, moderately calcareous, grayish tan to light yellowish brown, limonitic-stained, contains calcareous nodules, dark grayish blue below 44.0 ft.....	16.5	68.5
Sand, dark yellowish brown, texture grades from very fine to very coarse.....	68.5	79.5
Till: silt, very sandy, moderately calcareous, dark bluish gray, contains very fine to medium sand....	79.5	82.0
Sand, grayish brown to tan, texture grades from very fine to medium, slightly coarser texture below 102.0 ft.....	82.0	104.5
Silt, sandy, moderately calcareous, dark gray, contains very fine to medium sand.....	104.5	115.1

06N 07E 12DDDC 69-A-49

Test Hole #69-A-49
(A6-7-12dd)
Gage County

Location: SE SE SE sec. 12, T. 6 N., R. 7 E., approximately 20 feet north and 392 feet west of southeast corner.
Ground elevation: 1,355.0 ft. (Adams 7.5 min. quadrangle)
Depth to water: 49.6 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, dark brown to black.....	0.0	1.0
Clay, silty, dark brown.....	1.0	3.0
Silt, sandy, dark red, contains very fine to coarse sand, granular.....	3.0	7.0
Till: silt, clayey to sandy and gravelly, slightly to moderately calcareous, yellowish brown, contains a few calcareous fragments.....	7.0	28.5
Sand, light yellowish brown, texture grades from very fine to fine, contains some medium to very coarse sand below 51.5 ft.....	28.5	52.5
Silt, sandy, light yellowish brown, contains very fine to fine sand.....	52.5	53.5
Sand, dark brown, texture grades from very fine to medium.....	53.5	56.5
Till: silt, clayey to sandy, moderately calcareous, grayish tan, contains very fine to coarse sand, dark bluish gray below 59.0 ft.....	56.5	70.5
Sand, grayish tan, texture grades from very fine to medium.....	70.5	91.0
Silt, sandy, moderately calcareous, light tan to grayish blue, contains very fine sand.....	91.0	113.5
Permian System - Big Blue Series - Council Grove Group:		
Shale, light yellowish gray, very calcareous.....	113.5	115.1
Limestone, pinkish gray.....	115.1	117.0
Shale, dark brown, silty, very calcareous.....	117.0	125.2
Limestone, pinkish gray.....	125.2	125.8

07N 08E 31BBBB 70-A-49

Test Hole #70-A-49
(A7-8-31bb)
Lancaster County

Location: NW NW NW sec. 31, T. 7 N., R. 8 E., approximately 305 feet south and 11 feet east of the northwest corner.
Ground elevation: 1,395.0 ft. (t). (Firth 7.5 min. quadrangle)
Depth to water: 11.8 ft. (11-29-49).

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Road fill	0.0	1.5
Soil, silt, black; granular	1.5	3.5
Soil, silt, clayey, dark brown; granular	3.5	4.0
Clay, silty, grayish brown	4.0	5.0
Silt, slightly clayey, slightly calcareous, grayish brown with greenish tint; contains some iron stain	5.0	10.5
Silt, moderately clayey, dark brown with reddish tint; granular	10.5	16.0
Silt, clayey, slightly sandy, medium gray; sand is very fine to medium; light gray below 20 ft; slightly calcareous from 20 to 25 ft; moderately calcareous below 25 ft; contains some iron stain below 30 ft	16.0	32.5
Till, clay, sandy to gravelly, calcareous, gray to yellow brown; at 43.5 ft. contains a sandy lens; light yellowish brown below 47 ft	32.5	63.0
Till, clay, sandy to gravelly, calcareous, dark bluish gray; contains a sand lens from 91.5 to 92 ft; light bluish gray below 110 ft	63.0	126.5
Sand, very fine to coarse; contains calcareous fragments	126.5	128.0
Till, clay, sandy to gravelly, calcareous, light bluish gray	128.0	140.0
Sand, very fine to very coarse; contains some light gray, interbedded sandy silt layers; contains some fine gravel below 150 ft	140.0	160.0
Sand, very fine to fine	160.0	170.0
Sand, very fine to medium; sand is very fine to very coarse below 190 ft; contains a trace of fine gravel below 230 ft; contains a silty clay layer from 248 to 249 ft	170.0	250.0
Sand, very fine to very coarse with some fine gravel	250.0	290.0
Sand and gravel, very fine sand to fine gravel (60 percent gravel)	290.0	319.5

Silt, slightly clayey, very sandy, light brown; sand is very fine.....	319.5	320.5
Sand and gravel, very fine sand to medium gravel (40 percent gravel).....	320.5	347.0
Silt, slightly clayey, sandy, light brown; sand is very fine to fine.....	347.0	372.5
Sand, very fine to coarse with some limy fragments..	362.5	380.0
Permian System - Big Blue Series - Admire Group:		
Limestone and shale, interbedded, light gray.....	380.0	389.0

07N 08E 18AAAB 23-B-44

Test Hole #23-B-44
(A7-8-18aa)
Lancaster County

Location: NE NE NE sec. 18, T. 7 N., R. 8 E., approximately 5 feet south and 396 feet west of the northeast corner.
Ground elevation: 1,341.0 ft. (t). (Firth 7.5 min. quadrangle)
Depth to water: 13.2 ft. (8-16-44).

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil	0.0	3.5
Clay, silty, in part till-like, light yellow brown	3.5	5.0
Till, clay, sandy to gravelly, calcareous, light gray	5.0	36.5
Till, clay, sandy to gravelly, calcareous, bluish gray; contains much gravel from 50 to 65 ft; very sandy to gravelly below 65 ft	36.5	75.0
Sand, very fine to coarse	75.0	87.5
Till, clay, sandy to gravelly, calcareous, bluish gray	87.5	95.0
Sand and gravel, fine sane to fine gravel; heterogeneous (70 percent gravel)	95.0	100.0
Sand, very fine to coarse with some very coarse; heterogeneous	100.0	110.0
Silt, slightly clayey, calcareous, micaceous, greenish gray; contains some limy pebbles	110.0	115.0
Sand, fine to coarse; sand is fine to medium with a little coarse below 120 ft	115.0	157.5
Silt, moderately clayey, calcareous, micaceous, light bluish gray; slightly darker below 160 ft	157.5	167.0
Sand, very fine to medium; contains about 15 percent gravel from 169 to 175 ft	167.0	180.0
Sand, very fine to fine with a little medium; sand is very fine to medium below 215 ft	180.0	224.5
Silt, moderately clayey, calcareous, greenish gray	224.5	230.5
Sand and gravel, coarse sand to fine gravel; heterogeneous	230.5	235.0
Silt, moderately clayey, calcareous, light gray; contains bryozoa and crinoid stem fragments	235.0	240.0
Permian System - Big Blue Series - Admire Group:		
Limestone, pink	240.0	240.7
Shale, black; carbonaceous	240.7	242.4
Limestone, light gray	242.4	243.0

07N 08E 04ADAA 24-B-44

Test Hole #24-B-44
(A7-8-4ad)
Lancaster County

Location: NE SE NE sec. 4, T. 7 N., R. 8 E., approximately 1,600 feet south and 7 feet west of the southeast corner.
Ground elevation: 1,411.0 ft. (a). (Firth 7.5 min. quadrangle)
Depth to water: 12.0 ft. (8-21-44).

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil	0.0	2.0
Silt, moderately clayey, brown; contains some iron stain	2.0	5.0
Silt, moderately clayey, light brown to gray; contains some iron stain and limy nodules	5.0	10.0
Silt, slightly clayey, pale brown; contains iron stain	10.0	14.0
Silt, moderately clayey, light gray	14.0	20.0
Till, clay, sandy to gravelly, calcareous, light gray	20.0	27.5
Till, clay, sandy to gravelly, calcareous, pale yellow; slightly darker color below 35.5 ft	27.5	45.0
Till, clay, sandy to gravelly, calcareous, light gray; contains much gravel below 70 ft	45.0	76.0
Till, clay, sandy to gravelly, calcareous, light gray to brownish yellow; pale yellow with some light gray below 85 ft	76.0	88.0
Till, clay, sandy to gravelly, calcareous, dark gray with some olive gray	88.0	97.5
Silt, slightly clayey, sandy, calcareous, light brownish gray; sand is very fine to fine	97.5	140.0
Silt, slightly clayey, sandy, brownish gray; sand is very fine to fine	140.0	145.0
Till, clay, sandy to gravelly, calcareous, brownish gray with some bluish gray	145.0	172.5
Silt, moderately clayey, calcareous, bluish gray	172.5	173.5
Silt, moderately clayey, sandy, calcareous, light olive gray; sand is very fine to fine with some medium to coarse	173.5	180.0
Sand, fine to coarse	180.0	188.5
Permian System - Big Blue Series - Council Grove Group:		
Limestone, pink and light gray	188.5	189.0

05N 05E 12DDDC 27-B-44

Test Hole #27-B-44
(A5-5-12dd)
Gage County

Location: SE SE SE sec. 12, T. 5 N., R. 5 E., approximately 5 feet north and 350 feet west of southeast corner.
Ground elevation: 1,444.0 ft. (Claytonia 7.5 min. quadrangle)
Depth to water: 20.4 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, black	0.0	2.5
Silt, gray to tan	2.5	5.0
Clay, silty, reddish brown	5.0	7.5
Till: clay, silty, calcareous, brownish gray to yellowish gray, iron-stained below 20.0 ft	7.5	38.0
Gravel	38.0	42.0
Till: clay, silty, gray, iron-stained	42.0	53.5
Sand and gravel, contains a few limonite fragments	53.5	70.0
Till: clay, silty, in part calcareous, gray, limonitic-stained	70.0	95.5
Sandstone and silt, gray, contains a few limestone chips	95.5	100.0
Clay, pinkish gray to yellow, contains some pebbly material	100.0	105.0
Silt, gray, limonitic-stained, contains some pebbly material	105.0	160.5
Sand and gravel, texture grades from medium sand to coarse gravel	160.5	163.0
Till: clay, silty, calcareous, bluish gray, contains a few pebbles	163.0	171.0
Silt, carbonaceous, dark gray to black	171.0	175.0
Clay, silty, light bluish gray, slightly calcareous below 180.0 ft	175.0	185.0
Sand, silty, grayish pink, fine texture, grayish brown and slightly calcareous below 190.0 ft	185.0	200.0
Sand and gravel, feldspathic, texture grades from coarse sand to medium gravel	200.0	227.5
Silt, in part calcareous, tan to dark gray	227.5	242.0
Sand, coarse texture	242.0	244.0
Silt, light gray to green	244.0	246.0
Silt, sandy, slightly calcareous, dark gray	246.0	250.0
Silt, dark gray to black	250.0	264.5
Silt, moderately calcareous, light brownish gray	264.5	270.5
Gravel, consists of reworked limestone, shale and sandstone fragments	270.5	273.5
Permian System - Big Blue Series - Council Grove Group:		
Siliceous material, white	273.5	278.5

05N 06E 08DDDD 12-B-45

Test Hole #12-B-45
(A5-6-8dd)
Gage County

Location: SE corner sec. 8, T. 5 N., R. 6 E., approximately 76 feet north and 7 feet west of southeast corner.
Ground elevation: 1,414.0 ft. (Claytonia 7.5 min. quadrangle)
Depth to water: 74.1 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, dark brown	0.0	1.0
Silt, medium brownish gray	1.0	4.0
Clay, silty, light to medium brownish gray	4.0	7.0
Clay, silty to sandy, light gray to medium brown	7.0	70.0
Sand and gravel, brownish gray, texture grades from fine sand to medium gravel, contains some coarse gravel and pebbles	70.0	72.5
Clay, silty to sandy, gray to brown	72.5	100.0
Sand and gravel, brownish gray, texture grades from medium sand to medium gravel, contains many brown ironstone fragments below 110.0 ft	100.0	114.0
Silt, sandy, light gray to brown	114.0	120.0
Sand and gravel, brownish gray, texture grades from medium sand to medium gravel	120.0	128.0
Silt, sandy, medium gray	128.0	130.0
Silt, light gray to green, light gray to brown below 135.0 ft	130.0	140.0
Silt, sandy, light brownish gray, contains fine sand	140.0	169.5
Sand, brownish gray, texture grades from fine to medium	169.5	180.0
Sand and gravel, brownish gray, texture grades from fine sand to medium gravel with some coarse gravel	180.0	191.0
Permian System - Big Blue Series - Council Grove Group:		
Shale, yellow, silty	191.0	192.0
Shale, greenish yellow	192.0	194.0
Limestone, gray to brownish gray	194.0	197.0

05N 06E 15AABA 28-B-44

Test Hole #28-B-44
(A5-6-15aa)
Gage County

Location: NE NW NE NE sec. 15, T. 5 N., R. 6 E., approximately 8 feet south and 750 feet west of north east corner.
Ground elevation: 1,372.0 ft. (Pickrell 7.5 min. quadrangle)
Depth to water: 38.3 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, black	0.0	2.0
Silt, tan	2.0	10.0
Soil: silt, dark reddish brown	10.0	15.0
Silt, light reddish brown to gray	15.0	40.0
Sand, silty, gray, fine texture	40.0	52.0
Silt, bluish green	52.0	60.0
Clay, silty, reddish brown, contains a few hard calcareous zones	60.0	80.0
Silt, pinkish tan, contains calcareous zones	80.0	92.0
Gravel	92.0	94.5
Permian System - Big Blue Series - Chase Group:		
Limestone, light gray, iron-stained at top	94.5	95.5

05N 07E 07CDCC 67-A-49

Test Hole #67-A-49
(A5-7-7cd)
Gage County

Location: SW SE SW sec. 7, T. 5 N., R. 7 E., approximately 12 feet north and 1,667 feet east of southwest corner.
Ground elevation: 1,404.0 ft. (Pickrell 7.5 min. quadrangle)
Depth to water: unknown

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil and road fill: silt, dark brown to black.....	0.0	3.0
Soil: silt, clayey, dark brown to black.....	3.0	4.0
Clay, silty, grayish brown to brown.....	4.0	5.0
Clay, silty to slightly sandy, light gray, contains very fine sand, iron-stained.....	5.0	7.0
Silt, clayey, soil-like, dark brown with reddish tint.....	7.0	9.5
Clay, silty, pinkish tan.....	9.5	20.0
Silt, slightly sandy, pinkish tan, contains very fine to medium sand with some coarse sand.....	20.0	43.0
Till: silt, clayey to sandy, slightly calcareous, grayish yellow to brown with iron stain, contains very fine to very coarse sand, contains calcareous nodules.....	43.0	53.0
Sand, dark yellowish brown, texture grades from very fine to very coarse sand, contains a few calcareous nodules.....	53.0	57.5
Till: clay, silty to sandy, dark bluish gray, contains very fine to coarse sand, moderately calcareous below 60.0 ft.....	57.5	70.0
Silt, slightly to very calcareous, light gray to grayish tan.....	70.0	90.0
Silt, sandy moderately to very calcareous, light gray to light grayish tan, contains a few limestone fragments.....	90.0	113.0
Silt, slightly clayey, slightly calcareous, dark gray.....	113.0	125.0
Permian System - Big Blue Series - Chase Group:		
Limestone, grayish white, cherty.....	125.0	126.0

05N 07E 10CCCC 29-B-44

Test Hole #29-B-44
(A5-7-10cc)
Gage County

Location: SW corner sec. 10, T. 5 N., R. 7 E., approximately 81 feet north and 6 feet east of southwest corner.
Ground elevation: 1,409.0 ft. (Pickrell 7.5 min. quadrangle)
Depth to water: 51.0 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, dark brown to black	0.0	1.0
Clay, silty, tan	1.0	5.0
Clay, silty, reddish brown	5.0	8.5
Till: clay, silty, calcareous, yellowish gray, contains calcareous pebbles, sand, gravel and limonitic material	8.5	66.5
Gravel, contains shell fragments and reworked material	66.5	70.0
Silt, light gray, contains a limonitic zone at 70.0 ft	70.0	75.0
Silt and fine sand, interbedded, light gray, texture grades from fine to medium sand	75.0	90.0
Clay, silty, green to light gray	90.0	93.5
Clay, silty, calcareous, bluish gray	93.5	95.0
Gravel	95.0	95.5
Permian System - Big Blue Series - Chase Group:		
Shale, dark red to gray	95.5	100.5

05N 08E 07CCCC 66-A-49

Test Hole #66-A-49
(A5-8-7cc)
Gage County

Location: SW corner sec. 7, T. 5 N., R. 8 E., approximately 92 feet north and 10 feet east of southwest corner.
Ground elevation: 1,412.0 ft. (Adams 7.5 min. quadrangle)
Depth to water: 40.5 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, dark brown to brown.....	0.0	1.5
Silt, clayey, dark to medium brown.....	1.5	7.0
Silt, dark brown, soil-like.....	7.0	9.0
Clay, silty, dark reddish brown, granular.....	9.0	10.5
Clay, slightly silty to sandy, grayish white, contains very fine to fine sand, very fine to coarse sand and pinkish tan below 20.0 ft.....	10.5	26.5
Till: silt, clayey to sandy and gravelly, light yellowish brown, contains calcareous nodules and iron-stained below 30.0 ft.....	26.5	65.0
Sand, dark brown, texture grades from very fine to medium with some coarse.....	65.0	90.0
Sand, grayish tan with some iron stain, texture grades from very fine to very coarse, contains a few calcareous fragments.....	90.0	115.0
Till: silt, sandy, moderately calcareous, medium bluish gray, contains very fine to very coarse sand.....	115.0	120.0
Silt, sandy, moderately calcareous, grayish white, contains very fine to fine sand, light tan with pinkish tint below 130.0 ft.....	120.0	143.0
Sand and gravel, composed principally of reworked chert, jasper and limestone fragments.....	143.0	144.0
Permian System - Big Blue Series - Chase Group:		
Shale, light yellowish brown, sandy, very calcareous, contains very fine to fine sand.....	144.0	145.0
Limestone, dark grayish blue.....	145.0	145.5
Shale, light green to yellowish brown, very calcareous.....	145.5	147.0
Limestone, pinkish gray.....	147.0	148.2
Shale, light green, very calcareous.....	148.2	149.5
Shale, light reddish brown, slightly sandy, very calcareous, contains very fine sand, dark red from 157.0 to 160.0 ft., dark gray below 160.0 ft.....	149.5	167.0
Shale, light gray to grayish white to green, very calcareous.....	167.0	169.0
Limestone, grayish white.....	169.0	170.0

05N 08E 16BBAA 30-B-44

Test Hole #30-B-44
(A5-8-16bb)
Gage County

Location: Center north line NW sec. 16, T. 5 N., R. 8 E., approximately 15 feet south and 1,320 feet east of northwest corner.
Ground elevation: 1,413.0 ft. (Adams 7.5 min. quadrangle)
Depth to water: 10.2 ft.

	Depth, in feet	
	From	To
Quaternary System, undifferentiated:		
Soil: silt, black	0.0	2.5
Clay, silty, tannish gray	2.5	12.0
Clay, silty, reddish brown	12.0	15.0
Clay, silty, gray	15.0	47.0
Clay, silty, greenish gray to reddish brown, limonitic-stain	47.0	71.0
Sand, grayish brown, texture grades from fine to medium	71.0	80.0
Sand and gravel, brownish gray	80.0	85.0
Sand, fine texture, limonitic-stained	85.0	95.0
Sand and gravel, contains silty clay layers	95.0	100.0
Clay, moderately calcareous, green to gray	100.0	105.0
Clay, silty, light bluish gray	105.0	121.5
Permian System - Big Blue Series - Chase Group:		
Shale, pink to light greenish gray	121.5	125.0
Siliceous material, white	125.0	129.0

05N 08E 11DDCC 77-B-49

Test Hole #77-B-49
(A5-8-11dd)
Gage County

Location: Center south line SE sec. 11, T. 5 N., R. 8 E., approximately 15 feet north and 1,320 feet west of southeast corner.
Ground elevation: 1,393.0 ft. (Sterling 7.5 min. quadrangle)
Depth to water: 67.5 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, black to dark brown	0.0	2.5
Silt, clayey, light brown	2.5	5.0
Silt, grayish brown, black below 9.0 ft	5.0	10.0
Silt, sandy, light reddish brown, contains very fine to medium sand	10.0	14.0
Till: silt, sandy to clayey, grayish yellow to yellowish brown, with iron stain, contains very fine to coarse sand and calcareous nodules	14.0	18.0
Sand, yellowish brown, texture grades from very fine to medium	18.0	26.0
Till: silt, sandy to clayey, moderately calcareous, grayish yellow to light yellowish brown with some iron stain, contains calcareous nodules	26.0	45.0
Sand and some gravel, dark yellowish brown, texture grades from very fine sand to fine gravel, slightly finer texture below 60.0 ft	45.0	72.0
Silt, slightly sandy, moderately calcareous, yellowish brown, contains very fine sand	72.0	80.5
Till: silt, sandy to clayey, moderately calcareous, dark grayish blue, contains very fine to coarse sand	80.5	96.0
Sand, tan to light brown, texture grades from very fine to medium, contains many blue gray clay fragments	96.0	116.0
Silt, medium grayish tan, light bluish gray below 120.0 ft., slightly calcareous below 125.0 ft	116.0	130.0
Silt, slightly sandy, light bluish gray to tan, contains very fine sand	130.0	140.0
Silt, dark bluish gray to tan	140.0	145.2
Permian System - Big Blue Series - Chase Group:		
Limestone, light yellow	145.2	145.5
Shale, dark red to brown red, very calcareous, light green below 158.0 ft	145.5	160.0

05N 10E 07BCCB 05-A-56

Test Hole #5-A-56
(A5-10-7bc)
Johnson County

Location: SW SW NW sec. 7, T. 5 N., R. 10 E., approximately 2,240 feet south and 23 feet east of northwest corner.
Ground elevation: 1,315.0 ft. (St. Mary 7.5 min. quadrangle)
Depth to water: 153.0 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, moderately clayey, slightly sandy, dark brownish gray, contains very fine to medium sand..	0.0	2.5
Silt, very clayey, medium yellowish gray.....	2.5	3.5
Clay, silty, medium yellowish gray.....	3.5	5.0
Silt, very clayey, light yellowish gray, contains some mottled yellowish brown from 10.0 to 10.5 ft.	5.0	10.5
Silt, moderately clayey, medium brown, very clayey and medium brownish gray below 11.0 ft., slightly sandy to pebbly below 13.0 ft.....	10.5	13.8
Till: silt, very clayey, slightly sandy to pebbly, light yellowish gray with some mottled yellowish brown and light gray, moderately calcareous, contains limy nodules from 16.0 to 20.5 ft., slightly calcareous below 20.5 ft., medium yellowish gray from 28.0 to 30.0 ft., brownish yellow below 39.0 ft., very sandy to pebbly from 42.0 to 42.5 ft....	13.8	42.8
Sand and gravel, texture grades from fine sand to medium gravel with a trace of coarse gravel, contains some thin till layers.....	42.8	46.5
Till, interbedded, light yellowish brown and gravel with some sand, slightly calcareous, texture grades from fine sand to coarse gravel.....	46.5	48.0
Till: silt, very clayey, moderately sandy to slightly pebble, slightly calcareous, medium brownish yellow, contains very fine silty sand from 60.0 to 65.0 ft., slightly sandy to pebbly below 78.0 ft., mottled with medium olive gray to medium gray from 79.0 to 85.0 ft., medium gray from 83.5 to 92.0 ft., light yellowish gray below 92.5 ft.....	48.0	94.5
Silt, moderately clayey, moderately calcareous, light brownish yellow, moderately sandy below 95.0 ft., contains coarse silt and very fine sand.....	94.5	97.0

Silt, slightly clayey, very sandy, moderately calcareous, light yellowish gray, contains very fine sand.....	97.0	110.0
Sand, texture of sand grades from very fine to fine with a trace of medium, in part slightly silty....	110.0	135.0
Sand, quartz with some green and pink silicates, texture grades from very fine to very coarse with a trace of gravel, slightly finer below 145.0 ft..	135.0	155.0
Sand, texture of sand grades from very fine to medium with some coarse.....	155.0	182.0
Sand and gravel, texture grades from coarse sand to medium gravel, (about 20 percent gravel).....	182.0	185.0
Gravel and sand, texture grades from coarse sand to medium gravel, (about 70 percent gravel).....	185.0	190.0
Sand and gravel, texture grades from coarse sand to medium gravel with a trace of fine to medium sand, contains some limestone fragments.....	190.0	195.0
Sand and gravel, texture grades from fine sand to fine gravel, contains thin silt layers from 197.2 to 197.4 ft.....	195.0	210.0
Sand, texture of sand grades from very fine to coarse, contains a trace of coarse sand from 210.0 to 220.0 ft., slightly finer from 220.0 to 230.0 ft.....	210.0	244.5
Silt, moderately clayey, slightly sandy, slightly calcareous, light gray, contains very fine sand, slightly clayey and moderately sandy below 246.5 ft., dark brownish gray below 246.5 ft.....	244.5	249.0
Sand and gravel, texture grades from medium sand to medium gravel, much coarse to very coarse sand....	249.0	254.9
Silt, slightly clayey, slightly sandy, light to medium gray.....	254.9	255.6
Sand, texture grades from medium to very coarse sand with about 5 percent fine gravel, contains much coarse to very coarse sand.....	255.6	260.0
Sand and gravel, quartz with pink, green and gray silicates, texture grades from medium sand to medium gravel with much very coarse sand.....	260.0	270.0
Sand, texture grades from very fine to coarse sand, contains a trace of very coarse sand from 270.0 to 280.0 ft., finer below 280.0 ft.....	270.0	290.0
Sand and gravel, texture grades from fine sand to fine gravel, contains much coarse to very coarse sand.....	290.0	299.7

Pennsylvanian System - Virgil Series - Wabaunsee Group:

Limestone, light gray, in part shaly, very shaly from 303.2 to 304.8 ft. and from 306.2 to 306.5 ft.....	299.7	307.2
Shale, light gray, dark reddish brown from 309.4 to 310.1 ft., light gray with brown tint from 310.1 to 311.0 ft.....	307.2	311.0
Shale, medium reddish brown, contains hard limy layer from 312.0 to 312.3 ft. and at 313.5 ft., medium brown with reddish tint from 316.3 to 317.0 ft., slightly calcareous from 316.3 to 317.0 ft., medium brownish gray with reddish tint below 317.0 ft., moderately calcareous below 317.0 ft.....	311.0	317.8
Limestone, light gray, slightly shaly below 318.7 ft.....	317.8	320.0

05N 11E 13AABB 12-B-67

Test Hole #12-B-67
Johnson County

Location: C NL NW NE NE sec. 13, T. 5 N., R. 11 E., approximately 8 feet south of north section line and 1,004 feet west of east section line.
Ground elevation: 1,219.0 ft. (Tecumseh NW 7.5 min. quadrangle)
Depth to water: 7.32 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Road fill	0.0	0.7
Clay, slightly silty, light yellowish brown	0.7	1.5
Clay, moderately silty, slightly sandy, slightly to moderately gravelly, reddish yellow	1.5	7.0
Clay, moderately silty, slightly sandy, iron and manganese stained, contains lime nodules, yellow	7.0	16.9
Clay, moderately to very silty, slightly sandy, (very fine to fine sand), light gray	16.9	59.6
Clay, slightly silty, contains very fine to coarse sand and small gravel, olive gray and light gray	59.6	61.0
Silt, moderately clayey, contains very fine to coarse sand and some gravel, light gray	61.0	64.3
Clay, moderately silty, contains very fine to coarse sand, gray to olive gray	64.3	70.0
Clay, moderately silty, contains very fine to coarse sand, very dark grayish brown	70.0	85.0
Clay, moderately silty, contains very fine to coarse sand, dark olive gray	85.0	93.5
Pennsylvanian System - Virgil Series - Wabaunsee Group:		
Tarkio Formation:		
Limestone, light yellowish brown, very finely crystalline, contains fusulinids	93.5	96.0
Limestone, pale yellow, very finely crystalline	96.0	98.5
Willard Formation:		
Sandstone, pale yellow, very fine-grained, very finely micaceous	98.5	99.5
Shale, pale red mottled with yellow, sandy, micaceous	99.5	101.5
Shale, pale olive, very finely micaceous, very sandy	101.5	102.0
Shale, pale red, sandy, very finely micaceous	102.0	103.5
Shale, light yellowish brown mottled with red, very finely micaceous	103.5	104.0
Shale, light greenish gray, very finely micaceous	104.0	105.0
Shale, pale olive, very finely micaceous	105.0	105.5

Shale, light greenish gray, very finely micaceous...	105.5	107.5
Shale, light gray, very finely micaceous.....	107.5	108.0
Shale, light to medium gray, non-calcareous, contains pyrite.....	108.0	121.5
Shale, light to medium gray, moderately calcareous..	121.5	122.1
Emporia Formation:		
Elmont - Harveyville - Reading Members:		
Limestone, brownish gray, very finely crystalline, contains crinoids and brachiopods.....	122.1	123.7
Shale, light gray.....	123.7	126.5
Shale, light greenish gray with interbedded very thin limestone seams.....	126.5	127.2
Limestone, medium gray, very finely crystalline with interbedded light greenish gray shale seams.....	127.2	128.0
Shale, light gray, very calcareous.....	128.0	128.5
Limestone, light brown, very finely crystalline, contains crinoids.....	128.5	130.4
Limestone, medium gray, very finely crystalline, contains crinoids with interbedded light gray shale.....	130.4	131.0
Auburn Formation:		
Shale, light gray with interbedded very thin medium gray limestone seams.....	131.0	134.2
Shale, light greenish gray, very finely micaceous...	134.2	135.0
Shale, dark reddish brown, very finely micaceous....	135.0	138.3
Sandstone, light gray, very finely micaceous and interbedded with pale red shale.....	138.3	140.4
Shale, light gray, very finely micaceous.....	140.4	141.9
Shale, light to medium gray.....	141.9	155.7
Shale, light to medium gray with interbedded medium gray limestone, contains brachiopods and glauconites.....	155.7	156.8
Wakarusa Formation:		
Limestone, medium gray, very finely crystalline, contains crinoids and brachiopods with some shale.	156.8	159.5
Limestone, medium gray, very finely crystalline, contains a trace of black shale.....	4159.5	160.5

04N 09E 36DDAD 10-A-56

Test Hole #10-A-56
(A36dd)
Johnson County

Location: SE NE SE SE sec. 36, T. 4 N., R. 9 E., approximately 704 feet north and 7 feet west of southeast corner.
Ground elevation: 1,381.0 ft. (Vesta 7.5 min. quadrangle)
Depth to water: 43.25 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, very clayey, medium brown.....	0.0	2.0
Clay, silty, medium brown, contains some fine to coarse sand and a few limy nodules.....	2.0	4.0
Till: clay, silty, slightly sandy to pebbly, light yellowish gray, some brownish yellow and light gray from 5.0 to 13.2 ft., contains limy nodules from 7.0 to 10.0 ft. and from 13.2 to 15.0 ft., moderately calcareous below 7.0 ft., contains fine to coarse embedded gravel from 10.0 to 31.5 ft., moderately sandy from 13.2 to 31.5 ft., light brownish yellow from 17.0 to 21.5 ft. and from 31.5 to 45.0 ft. with some light gray and yellowish gray, light yellowish brown with light gray and light yellowish gray from 57.2 to 65.0 ft., moderately sandy below 57.2 ft., medium yellowish gray with some light to dark gray below 72.9 ft..	4.0	77.5
Till: clay, silty, moderately sandy to pebbly, moderately calcareous, medium yellowish gray with some dark gray and light olive gray from 77.5 to 78.8 ft., medium gray with some light yellowish gray from 78.8 to 81.5 ft. and from 83.0 to 84.5 ft., medium yellowish brown from 81.5 to 83.0 ft. and from 84.5 to 86.7 ft., thin limy layer at 90.1 ft.....	77.5	91.8
Till: clay, silty, slightly sandy to pebbly, moderately calcareous, medium gray, contains some limy nodules and a trace of aragonite from 91.8 to 95.0 ft., brown tint from 105.0 to 110.0 ft., contains gravelly layer from 113.8 to 114.0 ft., medium olive gray from 138.9 to 139.0 ft.....	91.8	141.3
Sand, very silty, moderately calcareous, texture grades from coarse silt to very fine sand with some fine to coarse sand and fine gravel.....	141.3	143.1
Sand, slightly calcareous, texture grades from very fine to medium with some coarse sand.....	143.1	145.0
Sand, slightly calcareous, quartz with dark silicates and limestones, texture grades from medium to coarse with some very coarse sand, well sorted.	145.0	150.3
Silt, moderately clayey, slightly sandy, slightly calcareous, light gray, contains small limy nodules below 153.5 ft.....	150.3	155.0

Silt, moderately clayey, and silt, slightly sandy, interbedded, slightly calcareous, light gray, contains very fine sand with thin, slightly consolidated sand layers from 155.0 to 158.5 ft.....	155.0	161.0
Till: silt, moderately clayey, slightly sandy, slightly calcareous, medium gray, thin sandy silt and clay layers below 164.5 ft.....	161.0	170.0
Sand, slightly silty, brownish gray, and silty, moderately clayey, interbedded, slightly sandy, light gray, slightly calcareous, texture of sand grades from very fine to fine with some medium, slightly coarser from 170.0 to 173.4 ft.....	170.0	188.1
Silt, moderately clayey, slightly calcareous, light gray, coarse textured silt, slightly sandy from 188.1 to 190.0 ft., contains a trace of very fine sand from 190.0 to 205.0 ft., slightly clayey from 210.0 to 220.0 ft., from 250.0 to 265.0 ft. and from 275.0 to 285.0 ft., thin hard silt layers below 230.0 ft.....	188.1	291.8
Sand, slightly silty, texture of sand grades from very fine to coarse.....	291.8	300.0
Sand, texture grades from medium to coarse with some very coarse and a trace of fine sand and fine gravel.....	300.0	311.5
Permian System - Big Blue Series - Council Grove Group:		
Foraker Formation:		
Hughes Creek Member:		
Shale, light greenish gray and pale yellow, contains quartz fragments.....	311.5	312.8
Shale, light gray with a trace of limestone.....	312.8	313.5
Shale, medium gray.....	313.5	315.0
Shale, medium gray with a trace of sandstone, contains medium yellow limestone, granular.....	315.0	319.0
Shale, medium gray, contains medium yellow limestone and crinoids.....	319.0	325.0
Americus Member:		
Limestone, light bluish gray, finely crystalline, contains a trace of pale yellow sandstone.....	325.0	326.0
Limestone, pale yellow.....	326.0	326.5
Hamlin Formation:		
Oaks Member:		
Shale, light greenish gray.....	326.5	330.0
Shale, light greenish gray with selemite.....	330.0	332.2
Shale, medium grayish green.....	332.2	333.8
Shale, light greenish gray.....	333.8	336.5
Shale, light greenish gray mottled with yellow and red, slightly sandy.....	336.5	340.0

04N 09E 24DAAA 09-A-56

Test Hole #9-A-56
(A4-9-24da)
Johnson County

Location: NE corner SE sec. 24, T. 4 N., R. 9 E., approximately 2,426 feet north and 9 feet west of southeast corner.
Ground elevation: 1,414.0 ft. (Vesta 7.5 min. quadrangle)
Depth to water: 31.8 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil and some road fill: silt, very clayey, dark brownish gray.....	0.0	1.5
Silt, moderately clayey, medium yellowish gray, very clayey from 2.0 to 4.0 ft., contains limy nodules, slightly clayey below 5.0 ft., light yellowish gray, brown tint below 7.0 ft.....	1.5	8.5
Silt, very clayey, light brown.....	8.5	9.5
Clay, silty, light brown.....	9.5	11.0
Till: clay, very silty, slightly sandy to pebbly, moderately calcareous, light yellowish gray with some brownish yellow, mottled dark brown from 20.0 to 28.0 ft. and below 33.0 ft.....	11.0	50.0
Till: silt, moderately clayey, slightly sandy, moderately calcareous, brownish yellow, contains very fine to fine sand with a trace of coarser grains, very sandy and gravelly below 51.0 ft.....	50.0	51.7
Sand and gravel, texture grades from medium sand to coarse gravel.....	51.7	53.0
Till: clay, silty, slightly sandy to pebbly, moderately calcareous, mottled light gray, light yellowish gray and brownish yellow, medium yellowish gray from 55.0 to 65.0 ft. and from 71.0 to 79.0 ft., medium gray and brownish gray from 80.0 to 82.5 ft., very sandy and gravelly from 82.5 to 82.7 ft. and from 83.3 to 83.5 ft.....	53.0	83.5
Sand and gravel, clayey and silty, moderately calcareous, 10 percent gravel.....	83.5	86.0
Till: clay, very silty, slightly sandy to pebbly, moderately calcareous, light and medium yellowish gray, slightly more gravel and in part brownish yellow below 87.5 ft.....	86.0	88.0
Till: clay, very silty, slightly sandy to pebbly, moderately calcareous, medium gray, slightly more sandy to pebbly from 91.0 to 99.0 ft., contains thin interbedded silt layers below 99.0 ft., clayey to fine sand, medium gray.....	88.0	100.0
Silt, moderately clayey, moderately calcareous, medium gray, contains some very fine sand.....	100.0	100.5
Till: clay, silty, slightly sandy to pebbly, moderately calcareous, medium brownish gray.....	100.5	110.5

Silt, slightly clayey, slightly sandy, moderately calcareous, medium brownish gray.....	110.5	111.0
Till: clay, silty, slightly sandy to pebbly, moderately calcareous, medium gray, slightly less sandy to pebbly from 115.0 to 120.0 ft.....	111.0	134.0
Sand, very silty, moderately calcareous, dark brown, texture of sand grades from very fine to fine.....	134.0	136.0
Sand, slightly calcareous, brownish gray, texture grades from very fine to medium with a trace of coarse sand, contains some yellowish brown sandy silt to 140.0 ft., contains some coarse sand and a trace of very coarse sand below 150.0 ft., limestone boulder at 152.7 ft.....	136.0	152.7
Silt, slightly clayey, slightly sandy, moderately calcareous.....	152.7	154.0
Till: silt, very clayey, slightly sandy, moderately calcareous, medium gray, contains much pyrite.....	154.0	155.0
Till: clay, silty, slightly sandy to pebbly, moderately calcareous, medium gray, moderately sandy below 162.0 ft.....	155.0	165.0
Sand, gravel, sandy silt, and silty sand, interbedded, moderately calcareous, medium gray.....	165.0	167.8
Till: silt, slightly clayey, slightly sandy, moderately calcareous, medium gray, moderately sandy below 174.0 ft., contains very fine sand.....	167.8	174.5
Silt, slightly clayey, slightly sandy, moderately calcareous, light gray, contains coarse to very coarse silt and very fine sand, moderately clayey below 181.5 ft., medium gray from 181.5 to 184.2 ft.....	174.5	185.0
Silt, moderately clayey, and clay, very silty, interbedded, moderately calcareous, light gray, contains a trace of very fine sand.....	185.0	190.0
Silt, very clayey, slightly sandy, moderately calcareous, light gray, contains very fine sand.....	190.0	195.0
Clay, very silty, and silt, very clayey, interbedded, in part moderately sandy, moderately calcareous, light gray, contains coarse textured silt and very fine sand.....	195.0	200.0
Silt, slightly clayey, slightly sandy, moderately calcareous, light gray, contains coarse textured silt and very fine sand.....	200.0	203.0
Clay, silty, moderately calcareous, light gray.....	203.0	206.5
Clay, silty, dark brownish gray, contains some very fine sand, medium brownish gray below 208.0 ft....	206.5	210.0
Silt, slightly clayey, slightly sandy, light gray, contains very fine sand, light brownish gray from 214.0 to 218.5 ft., slightly calcareous below 214.0 ft., moderately clayey below 218.0 ft., contains white limy areas and small limy nodules, contains slightly more sand below 223.5 ft., contains some fine sand.....	210.0	225.0

Silt, slightly clayey, moderately sandy, slightly calcareous, light gray, contains very fine and some fine sand, contains small limy nodules, light brownish gray from 230.0 to 235.5 ft., light yellowish gray below 235.5 ft., contains thin hard limy layer from 234.7 to 234.8 ft.....	225.0	240.0
Silt, moderately clayey, slightly sandy, light brown, contains very fine sand, less sandy and more clayey below 245.0 ft., contains hard limy layers at 244.0 ft. and at 245.2 ft.....	240.0	250.5
Clay, silty, slightly sandy, light pinkish gray, contains very fine sand, contains some interbedded coarser sand grains below 253.5 ft. and a trace of gravel below 254.5 ft., moderately sandy below 255.0 ft.....	250.5	260.0
Silt, slightly clayey, very sandy, light pinkish gray.....	260.0	263.0
Silt, slightly calcareous, texture grades from very fine to medium.....	263.0	265.0
Sand, quartz with some green and pink silicates, slightly calcareous, texture grades from fine to coarse with some very coarse sand, well sorted below 270.0 ft., contains very little fine to medium sand, contains some fine gravel below 270.0 ft., contains silt layer from 283.0 to 283.5 ft., moderately clayey, light gray, contains some chert pebbles and boulders below 295.0 ft.....	265.0	299.0
Chert, yellowish gray and brown.....	299.0	300.0
Permian System - Big Blue Series - Council Grove Group:		
Red Eagle Formation:		
Bennett Member:		
Shale, light tannish gray with selemite flakes.....	300.0	300.5
Shale, light gray.....	300.5	302.7
Glenrock Member:		
Limestone, light gray, finely crystalline.....	302.7	303.3
Johnson Formation:		
Shale, light greenish gray.....	303.3	312.0
Foraker Formation:		
Long Creek Member:		
Limestone, medium yellow, finely crystalline, vuggy with interbedded pale yellow shale.....	312.0	315.8
Hughes Creek Member:		
Shale, pale yellow.....	315.8	319.0
Shale, light gray with black carbonaceous streaks...	319.0	320.7
Shale, light gray.....	320.7	323.0
Shale, medium gray.....	323.0	327.0
Shale, medium gray with interbedded medium gray limestone, irregular crystalline, contains brachiopods.....	327.0	327.6
Shale, medium gray.....	327.6	330.0

04N 09E 12ADDD 08-A-56

Test Hole #8-A-56
(A4-9-12ad)
Johnson County

Location: SE corner NE sec. 12, T. 4 N., R. 9 E., approximately 2,619 feet south and 9 feet west of northeast corner.
Ground elevation: 1,374.0 ft. (Vesta 7.5 min. quadrangle)
Depth to water: 80.0 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil and road fill: silt, very clayey, dark brownish gray	0.0	1.0
Soil: clay, silty, slightly sandy, medium brownish gray	1.0	2.5
Till: clay, silty, slightly sandy to pebbly, moderately calcareous, light yellowish gray, contains white limy areas from 6.0 to 15.0 ft., light gray from 20.0 to 35.0 ft., brownish yellow below 45.0 ft	2.5	60.0
Till: clay, silty, slightly sandy to pebbly, moderately calcareous, light yellowish gray, brownish yellow and a little light gray from 60.0 to 72.0 ft., with some medium gray from 69.0 to 72.0 ft., medium brownish gray and medium gray from 72.0 to 75.0 ft., medium gray and in part brown tint from 75.0 to 102.0 ft., contains limestone grains from 99.0 to 99.5 ft., medium brownish gray below 102.0 ft., slightly sandy to gravelly below 105.0 ft.	60.0	110.0
Sand, slightly calcareous, quartz with dark silicates, texture grades from very fine to medium sand with a trace of coarse sand	110.0	115.0
Sand, slightly calcareous, texture grades from fine to coarse sand with 10 percent fine gravel	115.0	120.0
Sand, slightly calcareous, texture grades from fine to coarse with some very coarse sand, contains a trace of fine gravel below 125.0 ft	120.0	130.5
Till: clay, silty, slightly sandy to pebbly, moderately calcareous, medium gray	130.5	133.5
Silt, moderately clayey, slightly sandy, moderately calcareous, medium gray, contains very fine sand, light gray below 135.0 ft., contains a little interbedded silty clay below 135.0 ft	133.5	136.5
Till: clay, silty, slightly sandy to pebbly, moderately calcareous, medium gray	136.5	139.0
Silt, moderately clayey, moderately sandy, moderately calcareous, medium gray, texture grades from very fine to fine sand with a trace of coarser grains from 139.0 to 140.0 ft	139.0	140.4
Sand, moderately calcareous, texture grades from fine to coarse sand with some fine to medium gravel	140.4	141.0

Till: silt, very clayey, slightly sandy to pebbly, moderately calcareous, medium gray, lighter in color below 145.0 ft.....	141.0	147.0
Clay, silty, moderately calcareous, medium gray.....	147.0	147.5
Silt, moderately clayey, medium and dark brownish gray, light gray from 153.0 to 155.0 ft. and from 159.5 to 162.0 ft., slightly calcareous below 155.0 ft., contains a thin limy nodular layer from 155.9 to 156.0 ft.....	147.5	165.0
Silt, moderately clayey, slightly calcareous, light gray, contains a little sandy silt from 167.5 to 167.8 ft., some limy nodules below 170.0 ft., and a trace of embedded sand and gravel below 170.0 ft.....	165.0	171.5
Permian System - Big Blue Series - Council Grove Group:		
Eskridge Formation:		
Shale, clayey, slightly calcareous, brown mottled with some light gray, light greenish gray, and white, contains limy nodular layer from 172.5 to 172.8 ft., moderately calcareous from 174.0 to 175.0 ft.....	171.5	175.5
Shale, clayey, slightly calcareous, reddish brown, mottled with white and light gray from 176.0 to 177.7 ft., contains limy nodular layer from 177.4 to 177.6 ft., brown mottled with some light greenish gray below 179.0 ft.....	175.5	180.5
Grenola Formation:		
Neva - Salem Point Members:		
Limestone and shale, interbedded, limestone coarsely crystalline and in part nodular, shale, light greenish gray.....	180.5	181.7
Limestone, dense, light yellow to yellowish gray, light gray and fossiliferous below 184.0 ft.....	181.7	185.0
Limestone, shaly, light gray, contains some limy shale from 185.0 to 186.3 ft.....	185.0	187.5
Shale, silty clay, moderately calcareous, mottled and interbedded light yellowish gray, light gray and medium gray.....	187.5	190.5
Limestone, shaly, yellowish brown from 190.5 to 192.0 ft., light yellow to light yellowish gray below 192.0 ft., very porous and weathered.....	190.5	193.1
Shale, clayey, moderately calcareous, light yellowish gray.....	193.1	197.0
Shale, clayey, moderately calcareous, light yellowish gray, contains interbedded shaly limestone layers from 197.0 to 198.4 ft. and below 203.0 ft.	197.0	204.0
Burr Member:		
Limestone, light gray, shaly below 204.9 ft. with some thin shale layers.....	204.0	206.4
Limestone, light gray and medium gray, contains moderately calcareous dark gray shale layers from 206.4 to 206.6 ft. and from 207.7 to 207.9 ft.....	206.4	210.0

05N 09E 36ADDD 07-A-56

Test Hole #7-A-56
(A5-9-36ad)
Johnson County

Location: SE corner SE NE sec. 36, T. 5 N., R. 9 E., approximately 2,558 feet south and 6 feet west of northeast corner.
Ground elevation: 1,225.0 ft. (Vesta 7.5 min. quadrangle)
Depth to water: 25.2 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil and road fill: silt, moderately clayey, dark brownish gray.....	0.0	2.0
Clay, silty, medium yellowish gray.....	2.0	3.5
Silt, very clayey, light yellowish gray mottled with a little medium brownish gray and brownish yellow.	3.5	8.0
Silt, moderately clayey, light yellowish gray and light gray, contains a trace of sand from 9.7 to 10.0 ft., much mottled brownish yellow from 9.7 to 10.0 ft., slightly sandy from 10.0 to 11.5 ft., contains very fine to fine sand, light brownish gray with some brownish yellow, very clayey and light gray below 11.5 ft.....	8.0	11.7
Silt, slightly clayey, slightly sandy, medium yellowish gray, moderately sandy below 12.5 ft., contains very fine to fine sand.....	11.7	13.1
Sand, slightly silty, texture grades from very fine to coarse with a trace of very coarse sand, contains iron-cemented silt and sand nodules.....	13.1	15.5
Gravel and sand, texture grades from fine sand to coarse gravel, contains thin silt layers at 17.0 and 19.5 ft.....	15.5	26.4
Silt, very clayey, light yellowish gray from 26.4 to 27.0 ft., light brown below 27.0 ft., slightly calcareous from 28.0 to 30.0 ft., moderately calcareous below 30.0 ft.....	26.4	31.0
Permian System - Big Blue Series - Council Grove Group:		
Limestone, light gray and light brownish gray, shaly, and interbedded shale, very calcareous.....	31.0	32.1
Limestone, gray to white and light yellowish gray, very porous.....	32.1	34.6
Shale, very calcareous, white, contains interbedded limestone from 34.9 to 35.0 ft.....	34.6	35.0

05N 09E 24DAAD 06-A-56

Test Hole #6-A-56
(A5-9-24da)
Johnson County

Location: NE NE SE sec. 24, T. 5 N., R. 9 E., approximately 2,095 feet north and 7 feet west of southeast corner.
Ground elevation: 1,331.0 ft. (St. Mary 7.5 min. quadrangle)
Depth to water: 21.9 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, moderately clayey, dark brownish gray from 0.5 to 1.0 ft., medium brownish gray from 1.0 to 2.0 ft., light brown below 2.0 ft.....	0.0	3.2
Silt, moderately clayey, light brownish gray from 3.2 to 6.0 ft., medium yellowish gray from 6.0 to 7.5 ft.....	3.2	7.5
Till: wilt, very clayey, slightly sandy to pebbly, slightly calcareous below 10.0 ft., medium brown from 7.5 to 8.5 ft., light brown from 8.5 to 18.0 ft with some light gray and yellowish brown from 12.5 to 18.0 ft., contains limy nodules from 12.5 to 25.0 ft., light yellowish brown from 18.0 to 22.0 ft. with mottled olive gray from 23.5 to 25.0 ft., brown tint from 23.5 to 28.9 ft.....	7.5	29.2
Sand and gravel with some silty clay, light gray, texture grades from fine sand to coarse gravel....	29.2	30.1
Till: silt, very clayey, moderately sandy to pebbly, slightly calcareous, light brown with some yellowish brown from 30.1 to 32.0 ft., light gray with some yellowish brown from 32.0 to 37.0 ft., contains limy nodules from 32.0 to 35.0 ft. and from 40.0 to 45.5 ft., yellowish brown with some mottled olive gray from 37.0 to 47.0 ft., light yellowish gray with some mottled yellowish brown below 47.0 ft.....	30.1	49.7
Sand and some gravel, moderately calcareous, quartz with green and dark silicates and some silty limestones, interbedded with light yellowish brown and light gray till below 50.2 ft., slightly calcareous below 55.0 ft.....	49.7	59.5
Till: silt, clayey, sandy to gravelly, moderately calcareous, yellowish brown with some light gray from 59.5 to 61.2 ft., medium brownish gray to yellowish brown from 61.2 to 63.0 ft., medium brown from 63.0 to 64.2 ft, medium gray with a trace of light gray and dark brown from 64.2 to 66.1 ft., light gray with some medium brownish gray from 66.1 to 74.5 ft., contains limy nodules from 74.5 to 75.0 ft., medium brownish gray below 74.5 ft.....	59.5	95.0

Sand, slightly silty, slightly calcareous, light gray, texture of sand grades from very fine to fine, slightly consolidated.....	95.0	97.0
Silt, slightly clayey, slightly calcareous, light gray, contains thin sandstone layers.....	97.0	99.0
Sand, slightly calcareous, medium gray with brown tint, slightly consolidated.....	99.0	100.9
Till: silt, moderately clayey, slightly sandy to gravelly, slightly calcareous, medium brownish gray, moderately sandy below 106.0 ft., contains very fine to fine sand, yellowish brown and yellowish gray below 107.3 ft., very sandy below 108.4 ft.....	100.9	110.0
Sand, slightly calcareous, texture of sand grades from very fine to fine with some medium and a trace of coarse, texture of sand grades from very fine to medium with a trace of coarse below 140.0 ft.....	110.0	155.0
Sand, slightly calcareous, texture of sand grades from very fine to very coarse with some fine to medium gravel.....	155.0	158.5
Sand, very silty, slightly calcareous, light gray, texture of sand grades from very fine to fine.....	158.5	160.0
Silt, slightly clayey, slightly sandy, slightly calcareous, light brownish gray, contains coarse-grained silt, contains silty sand layer from 161.1 to 161.6 ft., light gray below 161.6 ft.....	160.0	162.4
Sand, very silty, slightly calcareous, texture of sand grades from very fine to fine with some medium and a trace of coarse.....	162.4	167.2
Silt, slightly clayey, moderately sandy, medium brownish gray, contains very fine to fine sand, moderately clayey from 170.0 to 172.0 ft., slightly calcareous from 170.0 to 175.5 ft., contains a trace of white limy areas from 172.0 to 173.5 ft., light brownish gray to light gray below 175.6 ft., contains white limy areas from 179.0 to 181.0 ft..	167.2	181.0
Sand, slightly silty, slightly calcareous, texture of sand grades from very fine to fine.....	181.0	183.7
Limestone boulder, light gray.....	183.7	184.0
Silt, slightly clayey, slightly sandy, very calcareous, light gray, contains very fine sand, contains limy nodules and white limy areas, contains fewer limy nodules below 185.0 ft., non-calcareous below 185.0 ft.....	184.0	189.2
Limestone boulder, light gray.....	189.2	189.5
Silt, moderately clayey, moderately sandy, slightly calcareous, light brownish gray, contains very fine sand, contains limy nodules from 190.0 to 190.5 ft., slightly clayey from 190.5 to 195.0 ft., non-calcareous from 190.5 to 195.0 ft, light gray below 195.0 ft.....	189.5	200.0

Silt, slightly clayey, moderately sandy, slightly calcareous, light gray, contains very fine sand, contains white limy areas from 204.0 to 208.0 ft. and from 210.0 to 210.5 ft., light yellowish gray from 204.5 to 208.0 ft., medium olive gray from 210.5 to 211.5 ft., slightly sandy from 210.5 to 215.0 ft. and below 217.0 ft., medium gray below 211.5 ft.....	200.0	220.1
Till: silt, very clayey, slightly sandy, slightly calcareous, medium gray, contains very fine to coarse sand, contains a trace of very fine sand from 225.5 to 227.2 ft., contains limestone grains and some reddish shale below 227.2 ft.....	220.1	230.0
Silt, slightly clayey, slightly calcareous, medium gray.....	230.0	231.5
Till: clay, very silty, slightly sandy, slightly calcareous, light gray, contains very fine to coarse sand grains and a grace of snail shells from 231.5 to 241.0 ft., slightly more sandy below 235.0 ft., contains very fine to coarse sand, medium gray below 235.0 ft., contains limy nodules below 235.0 ft., very sandy below 253.5 ft.....	231.5	253.7
Shale, reworked, calcareous, with some limy nodular zones, light gray, slightly blue tint from 255.0 to 257.3 ft., light olive gray from 257.3 to 259.5 ft. and from 261.5 to 262.5 ft., mottled with bluish tint and some light olive gray below 262.5 ft.....	253.7	263.5
Silt, sandy, moderately calcareous, light gray, contains coarse silt and very fine sand, slightly calcareous below 270.0 ft.....	263.5	277.1
Shale, reworked, medium brownish gray, nodular limestone layer from 277.1 to 277.5 ft.....	277.1	278.0
Till: clay, moderately silty, slightly calcareous, light gray, brown tint from 280.0 to 285.0 ft., medium brownish gray from 285.0 to 286.0 ft., slightly sandy to gravelly below 285.0 ft., contains some limy material and black shale fragments from 286.0 to 290.0 ft., chalky shale boulder at 299.0 ft., contains large limy nodules below 300.0 ft.....	278.0	325.5
Silt, moderately clayey, slightly sandy, moderately calcareous, medium gray, contains very fine to fine sand, contains small limy nodules below 333.5 ft.....	325.5	334.0
Pennsylvanian System - Virgil Series - Wabaunsee Group:		
Shale, clayey, slightly calcareous and medium gray with some olive gray from 334.0 to 334.5 ft., very calcareous and light gray below 334.5 ft. with thin, light gray limestone layers below 335.0 ft..	334.0	338.5

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Shale, clayey, slightly calcareous, reddish brown,
  very calcareous from 340.0 to 345.0 ft., mottled
  with a little light gray from 340.0 to 344.0 ft.,
  light yellowish gray from 344.0 to 346.5 ft.,
  moderately calcareous from 345.0 to 346.5 ft.,
  non-calcareous to slightly calcareous in part be-
  low 346.5 ft.....................................   338.5   350.0
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05N 10E 07BCCB 05-A-56

Test Hole #5-A-56
(A5-10-7bc)
Johnson County

Location: SW SW NW sec. 7, T. 5 N., R. 10 E., approximately 2,240 feet south and 23 feet east of northwest corner.
Ground elevation: 1,315.0 ft. (St. Mary 7.5 min. quadrangle)
Depth to water: 153.0 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Soil: silt, moderately clayey, slightly sandy, dark brownish gray, contains very fine to medium sand..	0.0	2.5
Silt, very clayey, medium yellowish gray.....	2.5	3.5
Clay, silty, medium yellowish gray.....	3.5	5.0
Silt, very clayey, light yellowish gray, contains some mottled yellowish brown from 10.0 to 10.5 ft.	5.0	10.5
Silt, moderately clayey, medium brown, very clayey and medium brownish gray below 11.0 ft., slightly sandy to pebbly below 13.0 ft.....	10.5	13.8
Till: silt, very clayey, slightly sandy to pebbly, light yellowish gray with some mottled yellowish brown and light gray, moderately calcareous, contains limy nodules from 16.0 to 20.5 ft., slightly calcareous below 20.5 ft., medium yellowish gray from 28.0 to 30.0 ft., brownish yellow below 39.0 ft., very sandy to pebbly from 42.0 to 42.5 ft....	13.8	42.8
Sand and gravel, texture grades from fine sand to medium gravel with a trace of coarse gravel, contains some thin till layers.....	42.8	46.5
Till, interbedded, light yellowish brown and gravel with some sand, slightly calcareous, texture grades from fine sand to coarse gravel.....	46.5	48.0
Till: silt, very clayey, moderately sandy to slightly pebble, slightly calcareous, medium brownish yellow, contains very fine silty sand from 60.0 to 65.0 ft., slightly sandy to pebbly below 78.0 ft., mottled with medium olive gray to medium gray from 79.0 to 85.0 ft., medium gray from 83.5 to 92.0 ft., light yellowish gray below 92.5 ft.....	48.0	94.5
Silt, moderately clayey, moderately calcareous, light brownish yellow, moderately sandy below 95.0 ft., contains coarse silt and very fine sand.....	94.5	97.0
Silt, slightly clayey, very sandy, moderately calcareous, light yellowish gray, contains very fine sand.....	97.0	110.0
Sand, texture of sand grades from very fine to fine with a trace of medium, in part slightly silty....	110.0	135.0
Sand, quartz with some green and pink silicates, texture grades from very fine to very coarse with a trace of gravel, slightly finer below 145.0 ft..	135.0	155.0

Sand, texture of sand grades from very fine to medium with some coarse.....	155.0	182.0
Sand and gravel, texture grades from coarse sand to medium gravel, (about 20 percent gravel).....	182.0	185.0
Gravel and sand, texture grades from coarse sand to medium gravel, (about 70 percent gravel).....	185.0	190.0
Sand and gravel, texture grades from coarse sand to medium gravel with a trace of fine to medium sand, contains some limestone fragments.....	190.0	195.0
Sand and gravel, texture grades from fine sand to fine gravel, contains thin silt layers from 197.2 to 197.4 ft.....	195.0	210.0
Sand, texture of sand grades from very fine to coarse, contains a trace of coarse sand from 210.0 to 220.0 ft., slightly finer from 220.0 to 230.0 ft.....	210.0	244.5
Silt, moderately clayey, slightly sandy, slightly calcareous, light gray, contains very fine sand, slightly clayey and moderately sandy below 246.5 ft., dark brownish gray below 246.5 ft.....	244.5	249.0
Sand and gravel, texture grades from medium sand to medium gravel, much coarse to very coarse sand....	249.0	254.9
Silt, slightly clayey, slightly sandy, light to medium gray.....	254.9	255.6
Sand, texture grades from medium to very coarse sand with about 5 percent fine gravel, contains much coarse to very coarse sand.....	255.6	260.0
Sand and gravel, quartz with pink, green and gray silicates, texture grades from medium sand to medium gravel with much very coarse sand.....	260.0	270.0
Sand, texture grades from very fine to coarse sand, contains a trace of very coarse sand from 270.0 to 280.0 ft., finer below 280.0 ft.....	270.0	290.0
Sand and gravel, texture grades from fine sand to fine gravel, contains much coarse to very coarse sand.....	290.0	299.7
Pennsylvanian System - Virgil Series - Wabaunsee Group:		
Limestone, light gray, in part shaly, very shaly from 303.2 to 304.8 ft. and from 306.2 to 306.5 ft.....	299.7	307.2
Shale, light gray, dark reddish brown from 309.4 to 310.1 ft., light gray with brown tint from 310.1 to 311.0 ft.....	307.2	311.0
Shale, medium reddish brown, contains hard limy layer from 312.0 to 312.3 ft. and at 313.5 ft., medium brown with reddish tint from 316.3 to 317.0 ft., slightly calcareous from 316.3 to 317.0 ft., medium brownish gray with reddish tint below 317.0 ft., moderately calcareous below 317.0 ft.....	311.0	317.8
Limestone, light gray, slightly shaly below 318.7 ft.....	317.8	320.0

06N 09E 25DDDD 04-A-56

Test Hole #4-A-56
(A6-9-25dd)
Johnson County

Location: SE corner sec. 25, T. 6 N., R. 9 E., approximately 64 feet north and 5 feet west of southeast corner.
Ground elevation: 1,158.0 ft. (St. Mary 7.5 min. quadrangle)
Depth to water: 18.4 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Road fill	0.0	1.5
Silt, moderately clayey, medium gray	1.5	5.0
Clay, silty, medium gray, medium brownish gray from 13.5 to 14.8 ft., light brownish gray below 14.8 ft	5.0	16.0
Silt, very clayey, medium gray, light gray below 19.5 ft	16.0	20.0
Silt, moderately clayey, light olive gray, contains a trace of sand from 20.0 to 22.0 ft., slightly sandy below 22.0 ft., contains very fine to fine sand	20.0	22.7
Sand, texture grades from very fine to coarse, contains a trace of fine to medium gravel below 25.0 ft., contains thin gray silt layers at 26.5 ft. and 27.5 ft	22.7	31.5
Silt, slightly clayey, medium gray, contains wood fragments	31.5	34.0
Gravel and sand, texture grades from medium sand to medium gravel, quartz with many dark silicates	34.0	35.0
Sand, texture grades from fine to very coarse, contains some fine gravel from 45.0 to 50.0 ft. and from 60.0 to 70.0 ft., slightly to moderately iron stained from 60.0 to 75.0 ft. and from 85.0 to 87.0 ft., quartz with some pink and light green silicates	35.0	87.0
Silt, very clayey, mottled light gray and light yellowish gray from 87.0 to 88.0 ft., medium gray below 88.0 ft., slightly calcareous below 88.0 ft., in part peaty from 89.0 to 90.0 ft	87.0	90.0
Clay, silty, slightly calcareous, light to medium gray	90.0	91.0
Silt, very clayey, slightly calcareous, light gray, moderately clayey below 94.0 ft., contains a little very fine sand below 94.0 ft	91.0	100.0
Silt, slightly clayey, slightly calcareous, light gray, in part sandy from 100.0 to 105.0 ft., granular textured from 102.0 to 103.0 ft., slightly sandy below 105.0 ft., contains very fine to fine sand	100.0	112.0

Clay, silty, slightly calcareous, interbedded with some thin clayey silt layers from 115.0 to 120.0 ft., contains some coarse textured silt.....	112.0	124.0
Silt, moderately clayey, slightly sandy, slightly calcareous, light gray, contains very fine to fine sand.....	124.0	127.0
Clay, silty, slightly calcareous, light gray.....	127.0	130.0
Sand, texture grades from very fine to medium, contains light gray clay layer from 132.4 to 132.6 ft. and light brown silt layer from 133.5 to 133.7 ft.....	130.0	135.0
Sand and gravel, texture grades from medium sand to fine gravel, contains 10 to 20 percent gravel from 135.0 to 145.0 ft., 30 to 50 percent gravel from 145.0 to 156.0 ft., and 5 to 10 percent gravel below 156.0 ft.....	135.0	188.6
Silt, moderately clayey, brownish yellow from 188.6 to 189.5 ft., light gray from 189.5 to 190.0 ft., medium gray below 190.0 ft., slightly calcareous below 190.0 ft., coarse silt below 190.0 ft., in part slightly sandy from 200.0 to 205.0 ft., contains a trace of medium to coarse sand from 205.0 to 207.0 ft., slightly sandy below 207.0 ft., contains limestone and sandstone fragments below 207.0 ft.....	188.6	212.8
Pennsylvanian System - Virgil Series - Wabaunsee Group:		
Shale, light gray, silty with interbedded siltstone to sandstone, non- to slightly calcareous.....	212.8	217.0
Siltstone, light gray, non- to slightly calcareous, contains very fine sand.....	217.0	220.0
Shale, light gray, clayey, silty, non- to slightly calcareous, contains thin siltstone to sandstone layers.....	220.0	230.0
Shale, light gray, clayey.....	230.0	240.0

06N 09E 13ADDD 03-A-56

Test Hole #3-A-56
(A6-9-13ad)
Johnson County

Location: SE corner NE sec. 13, T. 6 N., R. 9 E., approximately 2,581 feet south and 9 feet west of northeast corner.
Ground elevation: 1,244.0 ft. (St. Mary 7.5 min. quadrangle)
Depth to water: 107.0 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Clay, silty, medium brown.....	0.0	1.5
Silt, very clayey, light to medium yellowish gray, contains some limy nodules, moderately clayey below 3.5 ft.....	1.5	8.0
Silt, moderately clayey, medium reddish brown, contains a trace of very fine to medium sand from 10.0 to 20.0 ft., in part very sandy, contains some coarse sand below 20.0 ft., medium brown from 15.5 to 16.5 ft.....	8.0	23.3
Sand, slightly silty, texture grades from very fine to coarse with a little very coarse.....	23.3	23.7
Silt, slightly to moderately clayey, slightly sandy, medium to light brown, light pinkish gray from 25.2 to 28.0 ft., moderately to very clayey below 28.0 ft., contains very fine to medium sand with some coarse, contains a trace of gravel from 26.0 to 28.0 ft. and from 32.0 to 34.6 ft., contains a trace of sand from 28.0 to 32.0 ft.....	23.7	34.6
Sand, gravel, and boulders, clayey.....	34.6	35.0
Silt, slightly clayey, slightly sandy, very light brown to very light yellowish gray, contains very fine sand, coarse textured silt below 36.5 ft., principally very fine sand from 43.0 to 46.2 ft...	35.0	47.0
Sand, texture grades from very fine to fine with some medium sand, texture grades from very fine to medium from 50.0 to 60.0 ft., contains thin silt layers from 55.0 to 60.0 ft., slightly silty from 58.0 to 60.0 ft.....	47.0	90.0
Sand, texture grades from very fine to medium sand, contains thin sandy silt layers from 105.0 to 120.0 ft., contains some coarse sand below 120.0 ft.....	90.0	135.0
Sand, texture grades from fine to coarse, contains some very coarse sand from 135.0 to 140.0 ft. and below 150.0 ft., contains sandy silt layer from 139.0 to 139.7 ft.....	135.0	155.0
Sand, texture grades from medium to very coarse, contains some very fine sand and a trace of fine gravel, slightly finer textured below 170.0 ft....	155.0	175.0
Sand, texture grades from very fine to medium, contains some coarse sand to 185.0 ft.....	175.0	200.0

Sand, texture grades from fine to coarse, slightly coarser textured, contains some very coarse sand below 205.0 ft.....	200.0	210.0
Sand, texture grades from medium to very coarse, contains less medium sand and about 15 percent fine gravel below 215.0 ft., contains thin silty layers below 219.5 ft.....	210.0	222.5
Clay, silty, light gray.....	222.5	223.0
Sand, texture grades from fine to coarse with a little very coarse, slightly coarser textured below 235.0 ft., grades from fine to very coarse sand from 245.0 to 255.0 ft. and below 260.0 ft...	223.0	265.0
Sand, texture grades from medium to very coarse, contains a trace of fine gravel, contains a few limestone grains below 275.0 ft.....	265.0	281.2
Pennsylvanian System - Virgil Series - Wabaunsee Group:		
Shale, light gray, clayey.....	281.2	286.5
Shale, light gray, silty and sandy, interbedded with very fine-grained limestone, slightly calcareous..	286.5	297.0
Shale, medium gray, silty clay, contains some mica from 297.0 to 301.5 ft., light gray below 301.5 ft.....	297.0	320.0

07N 09E 36DDDA 02-A-56

Test Hole #2-A-56
(A7-9-36dd)
Otoe County

Location: NE corner SE SE SE sec 36, T. 7 N., R. 9 E., approximately 550 feet north and 6 feet west of southeast corner.
Ground elevation: 1,243.0 ft. (Burr 7.5 min. quadrangle)
Depth to water: 84.0 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Road fill	0.0	1.0
Silt, moderately clayey, slightly sandy, light brown and light brownish gray, contains very fine to fine sand, contains a trace of coarse sand to gravel below 5.0 ft., very sandy, light yellowish brown below 5.6 ft	1.0	7.0
Till: silt, very clayey, slightly sandy to pebbly, moderately calcareous, light and medium yellowish gray, some mottled light brown, dark brown and light gray	7.0	31.7
Coarse silt to very fine sand, interbedded, slightly calcareous	31.7	35.6
Limy nodular layer and clayey silt	35.6	37.0
Sand, quartz with green and some dark silicates, iron stained, texture grades from very fine to fine with some medium and a trace of coarse sand, texture grades from very fine to medium with a trace of coarse below 45.0 ft., contains thin clay layers at 52.0 and 53.0 ft	37.0	55.5
Silt, slightly clayey, slightly sandy, in part very sandy, light yellowish gray, contains very fine sand	55.5	62.0
Sand, texture grades from very fine to medium, fine to medium with some very fine and a little coarse sand from 70.0 to 75.0 ft., medium to very coarse with a trace of fine gravel from 75.0 to 85.0 ft., fine to very coarse below 85.0 ft., slightly iron stained from 75.0 to 77.0 ft. and from 80.0 to 85.0 ft	62.0	88.0
Sand and gravel, very iron stained, texture grades from coarse sand to fine gravel with a trace of medium gravel, contains many limestone grains	88.0	90.0
Sand, moderately iron stained, texture grades from fine to very coarse with a little fine to medium gravel	90.0	91.0
Till: silt, slightly clayey, moderately sandy, in part very sandy, moderately calcareous, yellowish gray, very clayey, slightly sandy below 94.5 ft., olive gray from 94.5 to 95.0 ft., medium gray below 95.0 ft	91.0	100.2
Sand and gravel, quartz with many limestone grains	100.2	100.8

Till: silt, very clayey, slightly sandy, moderately calcareous, medium gray, very sandy from 118.0 to 118.5 ft.....	100.8	128.5
Sand and gravel, quartz and dark silicates, many limestone grains, texture grades from medium sand to fine gravel, contains very sandy till layer from 129.5 to 129.8 ft.....	128.5	130.1
Till: silt, very clayey, slightly to moderately sandy, moderately calcareous, medium gray, contains quartzite boulder from 132.5 to 133.0 ft....	130.1	135.0
Till, very sandy and sand, interbedded, moderately calcareous, medium gray.....	135.0	138.0
Till: silt, very clayey, moderately sandy, moderately calcareous, medium gray.....	138.0	139.8
Sand, many limestone grains, texture grades from fine to very coarse sand with some fine gravel, contains very sandy till layer from 141.0 to 141.7 ft., and a boulder from 142.8 to 143.2 ft.....	139.8	143.2
Silt, moderately clayey, slightly sandy, light to medium gray, contains very fine sand, moderately sandy, slightly calcareous, contains very fine to fine sand below 156.0 ft.....	143.2	159.0
Silt, very clayey, slightly sandy, light to medium brownish gray, contains very fine sand, light to medium yellowish gray from 165.0 to 166.5 ft., medium brownish gray from 166.5 to 169.0 ft.....	159.0	173.0
Clay, silty, light to medium brownish gray.....	173.0	173.5
Silt, moderately clayey, in part very clayey, light to medium brownish gray, moderately sandy, contains very fine to fine with a trace of medium sand below 198.0 ft., contains a few small limy nodules from 175.0 to 180.0 ft. and from 184.0 to 188.5 ft. and below 190.0 ft., light to medium yellowish gray from 175.0 to 178.0 ft., slightly calcareous below 178.0 ft., light to medium gray from 190.0 to 197.0 ft., light gray below 197.0 ft., some white limy areas from 184.0 to 185.0 ft.	173.5	199.2
Sand, principally quartz with pink and green silicates, texture grades from very fine to coarse....	199.2	210.0
Sand and fine gravel, quartz with pink silicates, contains cemented sand and gravel or limestone boulder from 215.9 to 217.0 ft., non- to very calcareous.....	210.0	218.0
Permian System - Big Blue Series - Admire Group:		
Shale, clayey, slightly calcareous, yellowish brown, medium gray below 218.3 ft., contains thin shaly limestone layers, very light gray from 219.0 to 219.7 ft.....	218.0	221.0
Limestone, very calcareous, white, contains a trace of pyrite, dense.....	221.0	221.5

07N 10E 19BBAD 01-A-61

Test Hole #01-A-61
Otoe County

Location: NE NW NW sec. 19, T. 7 N., R. 10 E., approximately 440 feet south of north section line and 1,050 feet east of west section line.
Ground elevation: 1,162.2 ft. (Burr 7.5 min. quadrangle)
Depth to water: 8.08 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Road fill	0.0	0.5
Silt, slightly clayey, dark gray, below 3.5 ft. very dark grayish brown	0.5	4.5
Silt, moderately clayey, very dark brown, below 5.0 ft. very clayey, dark gray	4.5	7.5
Clay, silty, dark grayish brown, some iron stain, brown to yellowish brown below 8.3 ft	7.5	18.4
Silt, very sandy, moderately clayey, grayish brown, sand is very fine	18.4	20.2
Gravel, sandy, fine sand to coarse gravel	20.2	27.4
Permian System - Big Blue Series - Council Grove Group:		
Roca Formation:		
Shale, light grayish green, very slightly calcareous	27.4	31.3
Limestone, pale yellow, fine grained, soft	31.3	32.6
Shale, light greenish gray, very slightly calcareous	32.6	33.0
Shale, as above but sandy and very finely micaceous.	33.0	34.2
Shale, light reddish brown, very slightly calcareous	34.2	36.0
Shale, light gray mottled with light reddish brown	36.0	36.5
Limestone, pale yellow, fine grained, soft	36.5	37.4
Shale, light gray, slightly sandy, non-calcareous	37.4	38.3
Shale, light greenish gray, mottled with dark reddish brown	38.3	38.6
Red Eagle Formation:		
Howe Member:		
Limestone, light gray, very finely crystalline to dense, contains calcite stringers, some inter-bedded shale	38.6	40.0
Limestone, light brown, very finely crystalline to dense, vuggy, much interbedded light grayish green shale	40.0	41.8
Limestone, pale yellow, fine grained, soft and as above	41.8	45.0
Bennett Member:		
Shale, pale yellow, mottled with limonite color, moderately calcareous	45.0	48.8
Shale, medium gray, slightly calcareous	48.8	53.0
Shale, black, non-calcareous	53.0	53.1
Shale, light gray, moderately calcareous, pyrite	53.1	54.6
Shale, black, non-calcareous	54.6	55.0
Shale, dark gray, moderately calcareous	55.0	55.8

Glenrock Member:		
Limestone, light bluish gray, irregularly crystalline, contains fusulinids replaced with calcite...	55.8	56.8
Johnson Formation:		
Shale, light gray, slightly calcareous.....	56.8	58.1
Shale, light grayish green, moderately calcareous with some light gray, very fine grained sandstone.	58.1	65.0
Shale, medium gray, very slightly calcareous.....	65.0	65.5
Shale, light greenish gray, and as above.....	65.5	67.1
Foraker Formation:		
Long Creek Member:		
Limestone, white, fine grained to very finely crystalline, contains fossil fragments and much interbedded light greenish gray shale.....	67.1	73.8
Hughes Creek Member:		
Shale, light greenish gray with limestone as above..	73.8	75.0
Shale, medium gray, slightly calcareous.....	75.0	79.7
Shale, as above with limestone, dark gray, finely crystalline, contains pyrite, spines, fossil fragments and "algal looking material".....	79.7	80.0

07N 09E 01DDDD 02-A-61

Test Hole #02-A-61
Otoe County

Location: SE corner sec. 1, T. 7 N., R. 9 E., approximately 113 feet north of south section line and 17 feet west of east section line.
Ground elevation: 1,274.3 ft. (Burr 7.5 min. quadrangle)
Depth to water: 7.31 ft.

	Depth, in feet From	To
Quaternary System, undifferentiated:		
Clay, silty, light olive gray, some limy grains.....	0.0	0.5
Clay, silty, light brownish gray, below 2.5 ft., grayish brown.....	0.5	5.5
Silt, moderately clayey, dark brown, from 7.5 to 10.0 ft. very clayey, dark reddish brown.....	5.5	10.0
Clay, silty, slightly sandy, reddish brown, sand is very fine to fine, below 13.0 ft. brownish yellow, moderately sandy.....	10.0	16.7
Till: clay, silty, sandy to gravelly, light yellowish brown.....	16.7	17.5
Sand and gravel, fine sand to fine gravel, silty....	17.5	19.5
Till: clay, silty, sandy to gravelly, yellowish brown, some brown, some limy grains, below 35.5 ft. dark gray with greenish tint.....	19.5	47.0
Silt, moderately clayey, sandy, dark gray, sand is very fine, below 47.8 ft. very clayey, olive.....	47.0	49.5
Till: clay, silty, sandy, gravelly, moderately calcareous, dark gray, some limy grains.....	49.5	51.4
Permian System - Big Blue Series - Council Grove Group:		
Stearns Formation:		
Shale, pale yellow mottled with dark yellowish orange, slightly calcareous.....	51.4	53.1
Shale, pale yellow, clay to silt, hard, celestite...	53.1	55.0
Shale, light gray, slightly calcareous, hard with some limy material.....	55.0	57.0
Beattie Formation:		
Cottonwood Member:		
Limestone, light gray mottled with pale yellow, very finely crystalline to dense, and light gray, finely crystalline with fossil fragments.....	57.0	60.0
Limestone, pale yellowish gray, finely crystalline, vesicular, contains fusulinids and white chert....	60.0	68.0
Limestone, dark gray, finely crystalline, contains "algal looking material".....	68.0	70.8
Eskridge Formation:		
Shale, pale yellow, moderately calcareous.....	70.8	71.5
Shale, pale olive, moderately calcareous.....	71.5	75.0
Shale, light gray, moderately calcareous.....	75.0	80.0
Limestone, light brown, finely crystalline, contains fossil fragments.....	80.0	81.0
Shale, pink, moderately calcareous.....	81.0	85.0
Shale, pale olive gray, moderately calcareous.....	85.0	87.0

Limestone, medium gray, finely crystalline, contains fossil fragments, "black inclusions" and selenite.	87.0	88.7
Shale, light greenish gray, moderately calcareous...	88.7	92.0
Shale, dark reddish brown, slightly calcareous with seams of light greenish gray mottled with red from 92.0 to 93.5 ft., from 94.7 to 95.9 ft., from 97.5 to 98.5 ft., and from 101.5 to 101.7 ft.....	92.0	107.0
Shale, light greenish gray, slightly sandy, very finely micaceous, slightly calcareous.....	107.0	109.5
Grenola Formation:		
Neva Member:		
Limestone, light gray, stained red in part, very finely crystalline, with some light gray, finely crystalline, contains calcite and fossil fragments	109.5	110.0

Argonne National Laboratory

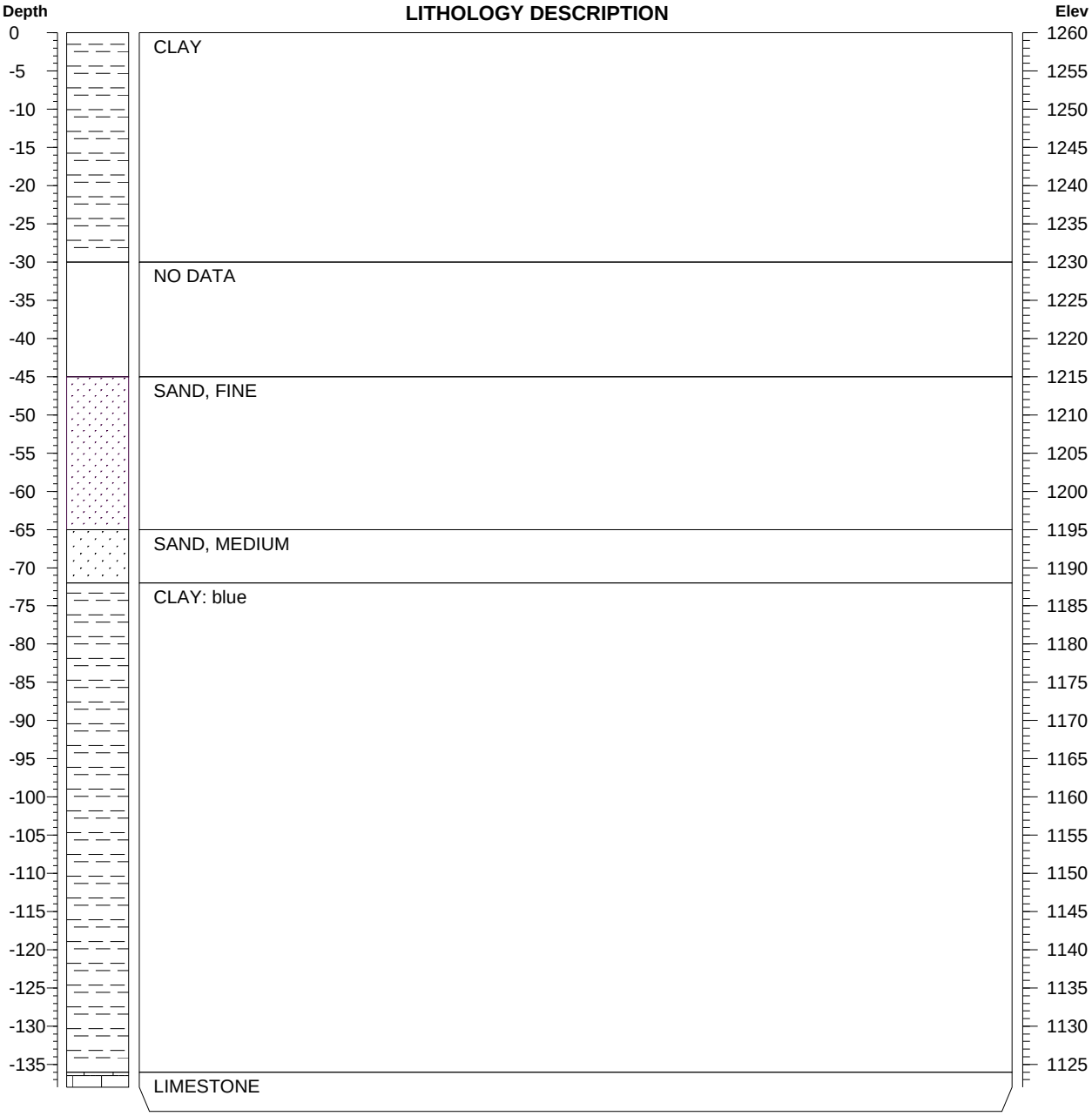
Well ID: **Wingate**

Project: **Adams, NE**
Location:

Elevation: N/A
Depth: 138 ft

Date: N/A
Plot Date: N/A

Rig: rig
Driller: name
Drilling Company: Waymore Well Drilling



Revised April 1967
M&I - 1

49-1
1

Registration No. G-29814 County of Gage Date Filed July 8, 1968

STATE OF NEBRASKA

MUNICIPAL OR INDUSTRIAL WELL REGISTRATION

I, Lawrence W. Fritz (Name of person signing registration) of Adams (Postoffice Address)

County of Gage State of Nebraska, do hereby certify:

1st. That the name of the owner of the municipal (or) industrial well registered herein is Adams whose postoffice address is Adams, Nebraska

2nd. That the well is located on the NE Quarter of the SW Quarter of Section 27, Township 6, Range 8 of the Sixth P. M., Gage County, and it is 300 feet from the north line and 300 feet from the east line of said tract, as accurately shown on the plat on page 2 hereof.

3rd. That the well was installed for the following purpose or purposes: Village Water supply

4th. That the capacity of said well under normal operating conditions is 160 gallons per minute.

5th. That the depth of the well is 65 feet, measured from the surface of the ground.

6th. That the inside diameter of the casing is 12 inches.

7th. That the static water level in the well is 26 feet below ground surface.

8th. That the depth to water under normal pumping condition is 40 (Pumping Level) feet below ground surface.

9th. That the diameter of the pump column is 6 inches. That the diameter of the Centrifugal (Give Number of bowls) bowl or bowls is inches.

10th. That the type and size of impeller is as follows: AK 5212

11th. That the well was completed on or about the day of, 19 48.

Gage County 6N 8E Sec. 27

Revised April 1967
M&I - 2

1

12th. That attached hereto are three copies of the log of the well certified to by the driller of the well.

13th. That the well was drilled by Layne-Western Company whose address is Omaha, Nebraska.

14th. That the relation which the subscriber to this affidavit bears to said registrant is that of Mayor (Owner or Agent) and that he is authorized to make this affidavit in behalf of the interest affected.

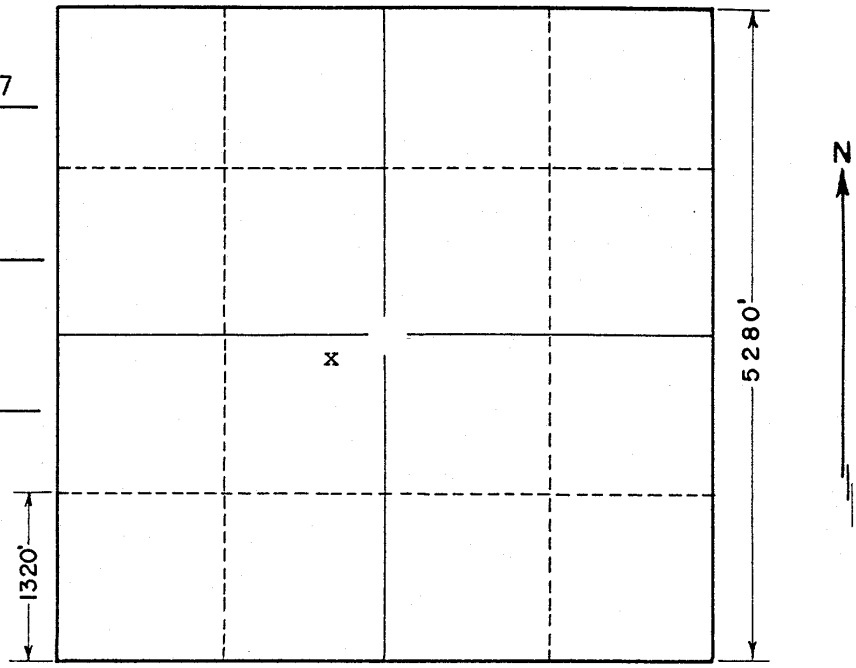
Lu Fr

This drawing represents one Section

Section No. 27

Township 6

Range 8



Each small subdivision is a 40 acre tract.

State of Nebraska

Department of Water Resources

This instrument was filed for record at 8:30 o'clock A M. on the 8th day of July, 1968.

Dan S. Jones Jr. ck
Director of Water Resources

PAGE 1 OF 2

EXPLORATION FOR: FARMER'S ELEVATOR COMPANY BORING NO.: B1-038-90Q
ADAMS, NEBRASKA

B-1

LOCATION:
NW 1/4, SW 1/4, NE 1/4, SEC. 27, T6N, R8E
DATE: 4-5-90
WEATHER: COOL & SUNNY
RECORDED BY: QAZI SALAHUDDIN
DRILL TYPE: 4" HOLLOW-STEM AUGER

SURFACE ELEV.: 99.9' Approx. Relative to Bench Mark
WATER LEVELS:
@ DRILLING: 72.9' Approx. Relative to Bench Mark
@ STATIC: 79.08' Relative to Bench Mark

SAMPLE NO.	SAMPLE TYPE	NO. OF BLOWS	DEPTH FEET	SOIL CHARACTERISTICS AND CLASSIFICATIONS	USCS	HNU (ppm)
				Silty clay, moderately-plastic, organic material (topsoil).		
1	SS	Driven	5	#1 Silty clay, brownish-gray, moderately-plastic, tubular holes.	CL	60
2	SS	Driven	10	#2 Silty, clay, brown with gray mottles, moderately-plastic, vertical root tubules.	CL	>350
3	SS	Driven	15	#3 Silty clay, brown with gray mottles, moderately-plastic, vertical root tubules.	CL	>350
4	SS	Driven	20	#4 Silty clay, yellowish-brown with green mottles, moderately-plastic with interbedded clayey fine sand (4-6" thick).	CL & SC	>350
5	SS	Driven	25	#5 Silty clay, brown with green mottles, moderately-plastic, mm wide vertical fractures, interbedded with 6-8" thick fine sand, little fines.	CL & SP	>350
6	SS	Driven	30	#6 Sand, with about 15% sub-rounded gravel, sub-angular, medium to coarse sand grains, little fines.	SW	50
7	SS	Driven	35	#7 Sand, with about 15% sub-rounded gravel, sub-angular, medium to coarse sand grains, little fines.	SW	50
8	SS	Driven	40	#8 Sand, with about 15% sub-rounded gravel, sub-angular, medium to coarse sand grains, little fines, with 3" thick gravel layer at bottom, well-graded.	SW & GW	40

NOTES: SS = SPLIT SPOON, * = FREE PRODUCT INFO.

REMARKS:

PAGE 2 OF 2

SOIL BORING RECORD CoRanCo, Inc. JOB NO. 90074

BORING NO.: B1-038-90Q (cont'd)

SAMPLE NO.	SAMPLE TYPE	NO. OF BLOWS	DEPTH FEET	SOIL CHARACTERISTICS AND CLASSIFICATIONS	USCS	HNU (ppm)
9	SS	45	42	#9 Sand, light gray, sub-angular, fine to medium grained, little fines, 8" thick gravel layer at top, gravel sub-rounded, well-graded.	SW & GW	20
10	SS	35	48	#10 Sand, light yellow, sub-angular, fine sand grained, little fines.	SP	3
11	SS	38	53	#11 Sand, light yellow, sub-angular, fine sand grained, little fines.	SP	1
12	SS	70	58	#12 Sand, yellowish-gray, sub-angular, fine to very fine sand grained, little fines.	SP	< 1

NOTE: SS = SPLIT SPOON, * = FREE PRODUCT INFO.

REMARKS:

64-1

WATER WELL DATA SHEET

LOCATION: Just N of center NE¼ Sec. 27-6N-8E DATE: July 28, 1964 COUNTY: Gage

OWNER: Village of Adams

DRILLER: Boyd Reed

STATIC WATER LEVEL 15' ELEVATION:

Test @ N edge of city limits just N of depot.

24 - 66 Sand

66 - Rock Boyd believes this limestone

Adams plans to drill a well at site of test.

T. 6 N., R. 8E, Sec. 27

BLUE VALLEY DRILLING

79-1

Gerald Strader
Blue Rapids, Kansas 66411
Phone 913-226-7353

Roger Strader
Pickrell, Nebraska 68422
Phone 402-673-4255

Well Completion Sheet

Name City of Adams Date 1--20-81

Address Adams, Nebr. Phone

Location

Location of well 1/4 N of Adams

Depth of finished well 105' 2"

Size of hole 24"

Method test pumped Deep well turbine

Static water level 20

259 GPM at 32' Ft. lift

380 GPM at 37' Ft. lift

526 GPM at 43' Ft. lift

710 GPM at 50' Ft. lift

818 GPM at 54' Ft. lift

Specific yield 24 Gal. per ft.

Method drilled Reverse Hyd.

Bottom cap 1 Type Stainless steel

Yards of gravel for gravel pack 10 Yds.

Well sealed Concrete grout top 20'

Number of test wells 2

Drilled by

Diameter of casing 10" ID

Gauge of perforations .035"

LOG OF WELL

Top	Bottom	
0	5	Top soil
5	30	Brown clay
30	50	Med. fine sand
50	60	Fine sand
60	102	Fine & Med.fine sand
102		Limestone

77' 7" Feet plain 10" steel Casing set 0 to 77' 7" & _____ to _____

_____ Feet perf. _____ Casing set _____ to _____ & _____ to _____

27' 7" Feet screen Stainless steel Casing set 77' 7" to 105'2" & _____ to _____

Legal description Johnson

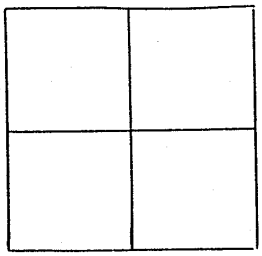
Normal operating conditions:

_____ GPM at _____ feet pumping level

Total head _____ Required HP _____

Driller

Purchaser



1 Square Mile

N

Revised December, 1975 — 1W2 DWR Form 602

DO NOT WRITE IN THIS SPACE

Registration No. G-69654 County Gage Date Filed 9/5/84 **3**

STATE OF NEBRASKA
DEPARTMENT OF WATER RESOURCES
WELL REGISTRATION

1. General information:
   A. Connected well
      Is this well connected to another well? ☐ Yes ☒ No
      If yes, give registration number of previously registered well_____
      (If new installation consists of a series of wells with one outlet, complete registration forms and driller's certificates for each and submit $7.50)
   B. Replacement well
      Is this well to replace a permanently abandoned well? ☐ Yes ☒ No
      If yes, give registration number of abandoned well_____
   C. Permit No._____(required only in a Ground Water Control Area)

Type of well to be registered: (Check One)
- ☒ IRRIGATION
- ☐ MUNICIPAL
- ☐ INDUSTRIAL
- ☐ Other_____

2. Name & address of well owner: Melvin Gottula
   506 - 9th
   Adams, Nebraska

   Zip Code 68301 Phone (402) 988-3015

3. Name & address of well driller: Blue Valley Drilling
   RFD.#1 Box 89A
   Pickrell, Nebraska

   Zip Code 68422 Phone: (402) 673-3465

4. Location & purpose of the well:
   A. 11 Nemaha Natural Resources District (Identify)
   B. NW ¼ of the NE ¼ of Section 27, Township 6N, Range 8 ☒ E ☐ W, (check one)
      Gage County.
   C. The well is 1,020 feet from the nearest municipal, irrigation, or industrial well. The nearest well is owned by ☐ you ☒ someone other than you. (check one)
   D. The well is intended to irrigate 80 acres of land, and it is intended to irrigate all or parts of the following land: NE¼ of Sec. 27--6N - 8E and SE¼ of 22-6-8
   OR
   E. The well shall be used for purposes of:_____.

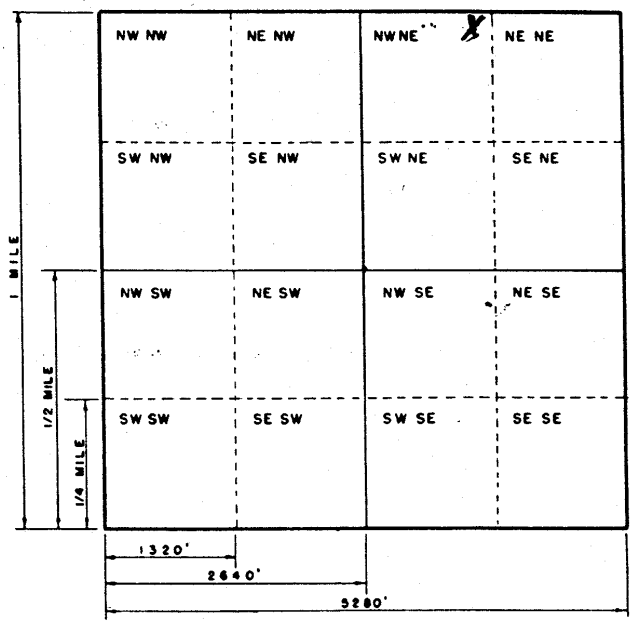
5. Well and pump specifications:
   A. Pumping rate under normal conditions: 1200 gallons per minute.
   B. Total well depth: 125 feet.
   C. Inside diameter of the casing: 16 inches.
   D. Static (non-pumping) water level in the well: 16 feet below ground surface.
   E. Depth of water under normal pumping conditions: 40 feet below ground surface.
   F. Pump column: Diameter 8 inches. Length 80 feet.
   G. The well was completed on or about Aug. 24, 19 84.

MORE ON BACK

GAGE CO. SEC. 27, T. 6N, R. 8E

MORE ON BACK

(With an "X" mark the location of the well)



This drawing represents one square mile (a section).
Each small subdivision is a 40-acre tract.

I certify that I am familiar with the information contained on this registration, and that to the best of my knowledge and belief such information is true, concise and accurate.

Melvin Sattler 8/28/84
Well Owner's Signature Date

Both a Well Registration and Driller's Certificate must be completed in triplicate and in full. An incomplete or defective form will be returned. A non-refundable $7.50 fee (payable to the Director of Water Resources) must accompany your submittal. No fee is required to register: (1) a permitted well within a Ground Water Control Area; (2) a well constructed to replace a previously registered well; or (3) a well connected in a series with another well previously registered. Forward to:

State of Nebraska
Department of Water Resources
301 Centennial Mall-South
P.O. Box 94676
Lincoln, Nebraska 68509

Revised April, 1976

3

Registration No. G-69654 County Gage Date Filed 9/5/84

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

Permit No. ..... (required only in a control area)

Name & Address of well driller: Blue Valley Drilling
RFD.#1 Boxx 89A
Pickrell, Nebraska 68422

Well Location:

Nemaha, Natural Resources District

NW Quarter of the NE Quarter of Section 27, Township 6N, Range 8E,

Gage County, and owned by Melvin Gottula

Drilling & construction specifications:

1. Date construction was begun: Aug. 23, 19 84
2. Date construction was completed: August 24, 19 84
3. Diameter of the drilled hole: 30 inches.
4. Was the hole electronically logged? ☐ Yes ☒ No.
5. How is drilled hole sealed (not sealed)? Gravel pack to top
6. Well casing & screen: 0--73' Transite (plain); 73'-125' Dbl.fine transite (perf, .093 (dbl.) slot
   (Give type of casing, lengths and vertical position of plain and slotted segments, slot or perforation size.)
7. Is the well artifically gravel stabilized? ☒ Yes ☐ No

Pumping test information:

1. Pumping rate: 1200 gallons per minute.
2. Depth to water before pumping: 16 feet.
3. Depth to water 40 feet after pumping 15 minutes.

DRILLING LOG ON BACK

DRILLING LOG ON BACK

DRILLING LOG

DEPTH IN FEET FROM	TO	MATERIAL DRILLED
0	4	Top soil
4	20	Brown clay
20	24	Sandy tan clay
24	28	Gravel to med. sand
28	40	Very fine sand
40	58	Fine to med. fine sand
58	64	Med. fine to med. sand
64	70	Fine to med. fine sand
70	72	Med. fine to med. sand
72	82	Fine to med. fine sand
82	86	Med. fine to med. sand
86	106	Med. fine to coarse sand
106	117	Fine to med. fine sand
117	122	Fine sand & clay
122	123	Limestone

Roger Shad
Well Driller's Signature

Aug 30 1984
Date

Argonne National Laboratory

Well ID: **TH 1**

Project: **Adams, NE**
Location:

Elevation: 1244.2 ft
Depth: 72 ft

Date: 4/8/54
Plot Date: 10/21/99

Rig: rig
Driller: name
Drilling Company: W.J. Wood

Depth	LITHOLOGY DESCRIPTION	Elev
0	TOPSOIL	
-5	CLAY, SILTY: medium dark brown	1240
	SILT, CLAYEY: dark brown	
-10	SILT, SANDY: medium dark brown	1235
	CLAY: very dark gray	
-15		1230
-20	SILT, SANDY: dark gray, very sandy	1225
-25	SAND: top 8' gray, med to coarse; middle portion - brown, medium; lower - fine, yellowish, iron-stained (after38'). Heavy rocks @25', 26-27'.	1220
-30		1215
-35		1210
-40		1205
-45		1200
-50		1195
-55		1190
-60		1185
-65		1180
-70		1175

Registration No. 33229 County of Dodge Date Filed August 28, 1964

1W3

STATE OF NEBRASKA
IRRIGATION WELL REGISTRATION

I, Richard Klein (Name of Person registering well) of Oscoola Nebr Box 523 (Postoffice Address)

County of ..... State of ....., being first duly sworn upon my oath say:

1st. That the name of the owner of the land upon which the irrigation well is located is same, of ..... Street, ... (City or Village) County of ..... State of .....

2nd. That the irrigation well is located on the NW Quarter of the NW Quarter of Section 26 Township 6, Range 8 of the Sixth P. M., Gage County, and is 25 feet from the north line and 1200 feet from the east line of said tract.

3rd. That the well was installed with the intention of irrigating all or parts of the following described land: 6.5 acres in NW/4 section 26 Township 6 range 8 and (Give Quarter, Section, Township and Range) 40 acres SW 1/4 of the SW/4 section 23 Township 6 range 8

Amounting in all to approximately 105 acres.

(If installation consists of a battery of wells with one outlet, give details on a sheet to be attached hereto.)

4th. That the capacity of said well under normal operating conditions is 1500 and over gallons per minute.

5th. That the depth of the well is 140 feet, measured from the surface of the ground.

6th. That the inside diameter of the casing is 24 inches.

7th. That the static water level in the well is 28 feet below ground surface.

8th. That the depth to water under normal pumping conditions is 48 (Pumping Level) feet below ground surface.

9th. That the diameter of the pump column is ~~10~~ 8" inches. That the diameter of the 2 (Give number of bowls) cylinder or bowls is 10" inches.

10th. That the type and size of impeller is as follows:

10" # 1004H

11th. That the well was completed on or about the 17 day of July, 1964.

26-6N-8E, Gage County

12th. That attached hereto are three copies of the log of the well certified to by the [illegible]

13th. That the relation which the subscriber to this affidavit bears to said registrant is that of

owner
(State whether owner, tenant or agent for land on which well is located)

and that he is authorized to make this affidavit in behalf of the interest affected.

x Richard Klein

STATE OF Nebraska
Lancaster County } ss.

I hereby certify that the foregoing was signed in my presence and sworn to before me this 28 day of Aug, 19 64

Notary Public

State of Nebraska
Department of Water Resources } ss.

This instrument was filed for record at 3:15 o'clock P.M., on the 28 day of August 19

Dan S. Lowe, Jr.
Director of Water Resources

Registration No. [illegible] County of Gage Date Filed August 28, 1964

STATE OF NEBRASKA
CERTIFICATE OF WELL DRILLER

I, Leo Laska (Name of Driller) of Duncan, Nebraska (Postoffice Address)

County of Platte State of Nebraska, do hereby certify that:

1. I am the driller of an irrigation well located on the N½ NW¼ Quarter, Section No. 26 Township 6 North, Range 8 E., owned by Richard R. Klein & Geraldine Klei husband & wife,

whose postoffice address is Osceola State of Nebraska

2. That the drilling was begun on the 16 day of July, 1964, and completed on the 17 day of July, 1964.

3. That the well is cased and screened in the following manner: 40 Feet Peforation (Give kind of casing, lengths and position of plain and screen casing, weight of metallic casing, etc.) 100 Feet plain concrete casing

4. That the diameter of drilled hole is 34 inches.

5. That Reverse Circulation type of drilling machinery was used.

6. That the drilled hole is/is not sealed, as follows: Screened plug at bottom

7. That the following is an accurate log of the depth, thickness and character of the different strata penetrated, and the location of water-bearing strata:

DEPTH IN FEET FROM	TO	MATERIAL DRILLED
0	28	Top-Soil
28	80	Sand
80	125	Fine Gravel
125	141	Coarse Gravel

Date Signed 8-26-64

Laska Drilling Company
Leo Laska
Driller

(If more space is required please use reverse side of this page.)

Argonne National Laboratory

Well ID: **TH 2**

Project: **Adams, NE**
Location:

Elevation: 1240.3 ft
Depth: 68 ft

Date: 4/6/54
Plot Date: 10/21/99

Rig: rig
Driller: name
Drilling Company: W.J. Wood

Depth	LITHOLOGY DESCRIPTION	Elev
0	SILT: dark gray	1240
-5	SILT: very dark brownish-gray	1235
-10		1230
-15	CLAY, SILTY: brown, red and yellowish; drilling harder	1225
-20	SAND, MEDIUM: gray to brown, medium	1220
-25		1215
-30	SAND, VERY FINE: clean	1210
-35	SAND, MEDIUM: yellowish, iron stained, clean	1205
-40		1200
-45		1195
-50		1190
-55		1185
-60		1180
-65		1175

Appendix B:

Chronological Listings of Previous Activities at the Adams Groundwater Site

Appendix B:

Chronological Listings of Previous Activities at the Adams Groundwater Site

B.1 Chronological Summary of Activities at Adams through the 1992 Preliminary Assessment

The chronological summary of prior groundwater sampling episodes, PA investigation activities, and pertinent historical information reported in the PA report is as follows:

- **June 19, 1974**. The NDH inspected village well PWS 70-1 and noted that adjacent public well PWS 49-1 was improperly abandoned (Burtrum 1974). Instructions for properly abandoning the well were provided to the village water system operator. A recommendation was made to verify that public wells PWS 56-1 and PWS 30-1 had been abandoned properly.

- **January 5, 1981**. The NDH was informed that improvements to the Adams water system were proceeding. Well PWS 79-1 had been drilled, and a distribution line into the village had been installed, although the well and line had not yet been linked. A list of all required tests before the village began to use the well and line was requested (Koler 1981).

- **July 25, 1983**. Sampling of the village's public water system by NDH showed no VOC contamination (Summers 1983).

- **May 21, 1984**. Burial of coal in Adams at a site assumed to be hydraulically downgradient from the village's municipal wells was approved by NDH, with the notation that leaching of contaminants from the buried coal might occur over time. The direction of regional groundwater flow was postulated to be northeast, toward the Middle Branch of the Big Nemaha River (Rowan and Atkinson 1984).

- **February 19, 1986**. The NDH inspected the Adams public water supply system. A check valve for well PWS 64-1 was noted as leaking (Wilson 1986).

- **February 5, 1990**. The NDH conducted routine sampling of the Adams public water supply wells. Carbon tetrachloride was detected in well PWS 64-1 at 12.9 μg/L. Wells PWS 70-1 and PWS 79-1 showed no contamination (Jacobs 1992). A vulnerability assessment of public wells PWS 64-1, PWS 70-1, and PWS 79-1 was conducted by Darryl Guest of NDH.

- **March 2, 1990**. Resampling of well PWS 64-1 confirmed the presence of carbon tetrachloride contamination at 13.1 μg/L (Jacobs 1992).

- **September 19, 1990**. The NDH informed the village of Adams that quarterly monitoring of wells PWS 70-1 and PWS 79-1 would be required for one year, with annual monitoring thereafter, because of the assessed vulnerability inherent in the wells' proximity (within 500 ft) to fuel storage (Peterson 1990).

- **October 9, 1990**. Carbon tetrachloride was detected in well PWS 70-1 at 0.4 μg/L. Contamination was not detected in well PWS 79-1 (Jacobs 1992).

- **December 17, 1990**. Sampling of wells PWS 70-1 and PWS 79-1 showed no VOC contamination (Jacobs 1992).

- **January 24, 1991**. The NDH informed the village of Adams that quarterly monitoring of well PWS 70-1 for eight regulated VOCs would be required because of the previous detection (on October 9) of carbon tetrachloride (Peterson 1991a).

- **January 25, 1991**. The NDH requested an assessment of domestic wells in the Adams area to determine the potential impact of the carbon tetrachloride contamination detected in public wells PWS 64-1 and PWS 70-1 (Peterson 1991b).

- **March 11, 1991**. Sampling of well PWS 70-1 showed no contamination (Jacobs 1992).

- **May 21, 1991**. An assessment of Adams domestic wells potentially at risk was conducted by Darryl Guest of the NDH (Guest 1991). Four domestic wells were identified in the Adams vicinity (at the Melvin Gottula, Eugene Wiese, Dennise Ebbers, and Glen Costas residences, shown in Figure 2.1).

- **May 23, 1991**. The NDH informed the NDEQ, on the basis of the NDH's May 21 assessment, that the NDH planned no further action in the absence of additional reports of carbon tetrachloride contamination (Pfeifer 1991a).

- **May 24, 1991**. The NDH contacted Adams resident Glen Oosting, recommending that he test his private well because carbon tetrachloride had been found in two of three public wells (Pfeifer 1991b).

- **August 17-18, 1991**. Jacobs Engineering conducted the PA site reconnaissance of Adams (Jacobs 1992).

- **September 3, 1991**. Sampling of well PWS 70-1 showed no contamination (Jacobs 1992).

- **May 22, 1992**. The NDEQ sent the CCC/USDA *Technical Action Plan* to the village of Adams, noting that the village was on the list of sites where the CCC/USDA planned to conduct a remedial investigation/feasibility study (RI/FS) (Peterson 1992).

- **September 29, 1992**. Jacobs completed its PA of the Adams groundwater contamination, concluding that the HRS score of 51.38 warranted further investigative activities to determine the source of carbon tetrachloride contamination in well PWS 64-1. Noting that the CCC/USDA planned to conduct an RI/FS, Jacobs recommended to the EPA Region VII that further work by the EPA be deferred to avoid duplication of effort (Aston 1992). Periodic sampling of the municipal water supply was recommended until completion of the RI/FS.

B.2 Chronological Summary of Focused Site Investigation Activities

A chronological summary of activities for the FSI is as follows:

- **April 14, 1993**. Carbon tetrachloride was detected in well PWS 70-1 at 0.3 μg/L. Contamination was not detected in well PWS 79-1 (NDEQ 1997).

- **December 9, 1994**. A public notice for a bid to conduct a soil gas survey at Adams was published in newspapers in general circulation in Lancaster County, Nebraska (Bowman 1994). Notices were also published on December 16 and December 23.

- **April 18, 1995**. Roy F. Weston, Inc., was granted a contract to conduct the soil gas survey at Adams (Weston 1995a).

- **May 16, 1995**. The NDEQ requested the village of Adams to grant access for a site investigation of the groundwater contamination (Johnson 1995).

- **July 27, 1995**. The *in situ* soil gas survey was conducted by Weston from July 27 to August 1 (NDEQ 1997).

- **September 14, 1995**. The NDEQ requested the NDH to sample two private water wells (at the Wingate residence and at the Behrens Excavating Company north of the former CCC/USDA site) found during the soil gas survey (Kelley 1995). Contamination was not detected (NDEQ 1997).

- **September 15, 1995**. The NDEQ completed its review of the draft version of Weston's soil gas report (Franklin 1995).

- **September 26, 1995**. Weston submitted revisions to its draft soil gas report to the NDEQ, addressing review comments received from the NDEQ (Weston 1995b). Two domestic wells (at the Wingate residence and at the Behrens Excavating Company north of the former CCC/USDA site) were sampled by NDH (NDEQ 1997).

- **October 6, 1995**. Weston submitted its final soil gas report to the NDEQ (Weston 1995c).

- **October 17, 1995**. The municipal water treatment plant was sampled for VOCs. None were detected (Topp 1999).

- **October 31, 1995**. The municipal water treatment plant was sampled for VOCs. 1,2-Dichloropropane was detected at 0.2 µg/L (Topp 1999).

- **January 23, 1996**. The municipal water treatment plant was sampled for VOCs. 1-2-Dichloropropane was detected at 0.2 µg/L (Topp 1999).

- **March 27, 1997**. The FSI report was sent from the NDEQ to the EPA Region VII (Schlenker 1997).

B.3 Monitoring of the Adams Public Water Supply

A chronological description of monitoring activities is as follows:

- **May 14, 1996**. The municipal water treatment plant effluent to the distribution system was sampled for VOCs. Carbon tetrachloride was detected at 0.8 µg/L. No other VOCs were detected (Topp 1999).

- **December 9, 1996**. The municipal water treatment plant was sampled for VOCs. Carbon tetrachloride was detected at 1.2 µg/L and chloroform at 0.3 µg/L (Topp 1999).

- **March 5, 1997**. Russell Topp, water utility supervisor of the Adams municipal water system, called the NDEQ to report on the status of the municipal water system (Topp 1997). Public well PWS 64-1 had been permanently disconnected from the water distribution system, although the well was still accessible through a side port. The valve and housing unit had previously been destroyed because of an electrical malfunction.

- **December 9, 1997**. The municipal water treatment plant was sampled for VOCs. Carbon tetrachloride was detected at 0.4 µg/L, chloroform at 0.2 µg/L, and bromodichloromethane at 0.3 µg/L (Topp 1999).

- **February 2, 1998**. Testing of the municipal water supply for trihalomethanes found chloroform at 0.2 µg/L.

- **February 9, 1999**. The municipal water treatment plant was sampled for VOCs. None were detected (Topp 1999).

- **April 12, 1999**. The municipal water treatment plant was sampled for VOCs. None were detected (Topp 1999).

- **June 14, 1999**. Carbon tetrachloride was detected at 2.2 µg/L in well PWS 64-1 and at 1.3 µg/L in well PWS 70-1 during sampling for the ESI (Topp 1999).

- **July 20, 1999**. The municipal water treatment plant was sampled for VOCs. None were detected (Topp 1999).

- **August 2, 1999**. The municipal water treatment plant was sampled for VOCs. Chlorodibromomethane and bromoform were both detected at 0.7 µg/L (Topp 1999).

B.4 Chronology of Farmers Elevator Company Service Station LUST Activities

A chronological summary of the LUST investigation activities is as follows:

- **October 1989**. Two diesel fuel underground storage tanks of 1,000-gal and 560-gal capacities and one gasoline tank of 1,000-gal capacity were removed from the Farmers Elevator Company Service Station. Soil samples collected 8-11 ft below the tanks yielded organic vapor analyzer readings of 75-150 ppm (parts per million) during tank removal (Coranco 1990). Much higher readings (> 1,000 ppm) were recorded along the product lines at a

depth of 3 ft BGL. The NDEQ was notified about the petroleum hydrocarbon contamination at the site.

- **April 1990**. Coranco, Inc., was contracted by Farmers Elevator Company to conduct an initial site assessment of the contamination, during which two monitoring wells were installed (Coranco 1990).

- **May 1990**. On May 7, approximately 1 ft of free product was observed in wells drilled at the site for the initial site assessment. Coranco (1990) was contracted to perform a detailed site assessment to delineate the free-product plume. Seventeen boreholes were drilled, with soil sampling conducted at 5-ft intervals. Monitoring wells were installed in all 17 boreholes. Groundwater was encountered at an average depth of 19 ft BGL. Well locations are shown in Figure 2.4.

- **June 1990**. Water levels were measured in the monitoring wells installed for the LUST detailed site assessment (Coranco 1990).

- **August 1990**. Coranco (1990) submitted its *Detailed Site Assessment* of the service station to the NDEQ.

- **May 1991**. Installation of a system for free-product recovery and soil vapor extraction began at the Farmers Elevator Company Service Station under direction of NDEQ LUST program (Coranco 1991).

- **July 1991**. Water levels in the monitoring wells installed for the UST detailed site assessment were measured (Coranco 1991).

- **July 1991**. A pump test was performed (Coranco 1991).

- **August 1991**. The pump test report was completed (Coranco 1991).

- **January 1992**. The remediation system at the Farmers Elevator Company Service Station began operation. Water levels were measured in the monitoring wells installed for the LUST detailed site assessment (Coranco 1992).

- **May 1992**. Water levels were measured in the monitoring wells installed for the LUST detailed site assessment (Coranco 1992).

- **June 1992**. The quarterly monitoring report for the service station remediation system was completed (Coranco 1992) for submission to the NDEQ.