Site Suitability Review of the Adams County Landfill

by
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and
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Prepared by the
North Dakota Geological Survey
and the
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ND Landfill Site Investigation No. 21

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INTRODUCTION

Purpose

The North Dakota State Engineer and the North Dakota State Geologist were instructed by the 52nd State Legislative Assembly to conduct site-suitability reviews of the solid waste landfills in the state of North Dakota. These reviews are to be completed by July 1, 1995 (North Dakota Century Code 23-29-07.7). The purpose of this program is to evaluate site suitability of each landfill for disposal of solid waste based on geologic and hydrologic characteristics. Reports will be provided to the North Dakota State Department of Health and Consolidated Laboratories (NDSDHCL) for use in site improvement, site remediation, or landfill closure. A one time ground-water sampling event was performed at each site thus, additional studies may be necessary to meet the requirements of the NDSDHCL for continued operation of solid-waste landfills. The Adams County municipal solid-waste landfill is one of the landfills being evaluated.

Location of the Adams County Landfill

The Adams County solid waste landfill is located about nine miles east of the city of Hettinger in an abandoned lignite mine (Fig. 1). The landfill site encompasses approximately 60 acres in Township 129 North, Range 94 West, NW 1/4, NE 1/4 Section 16.

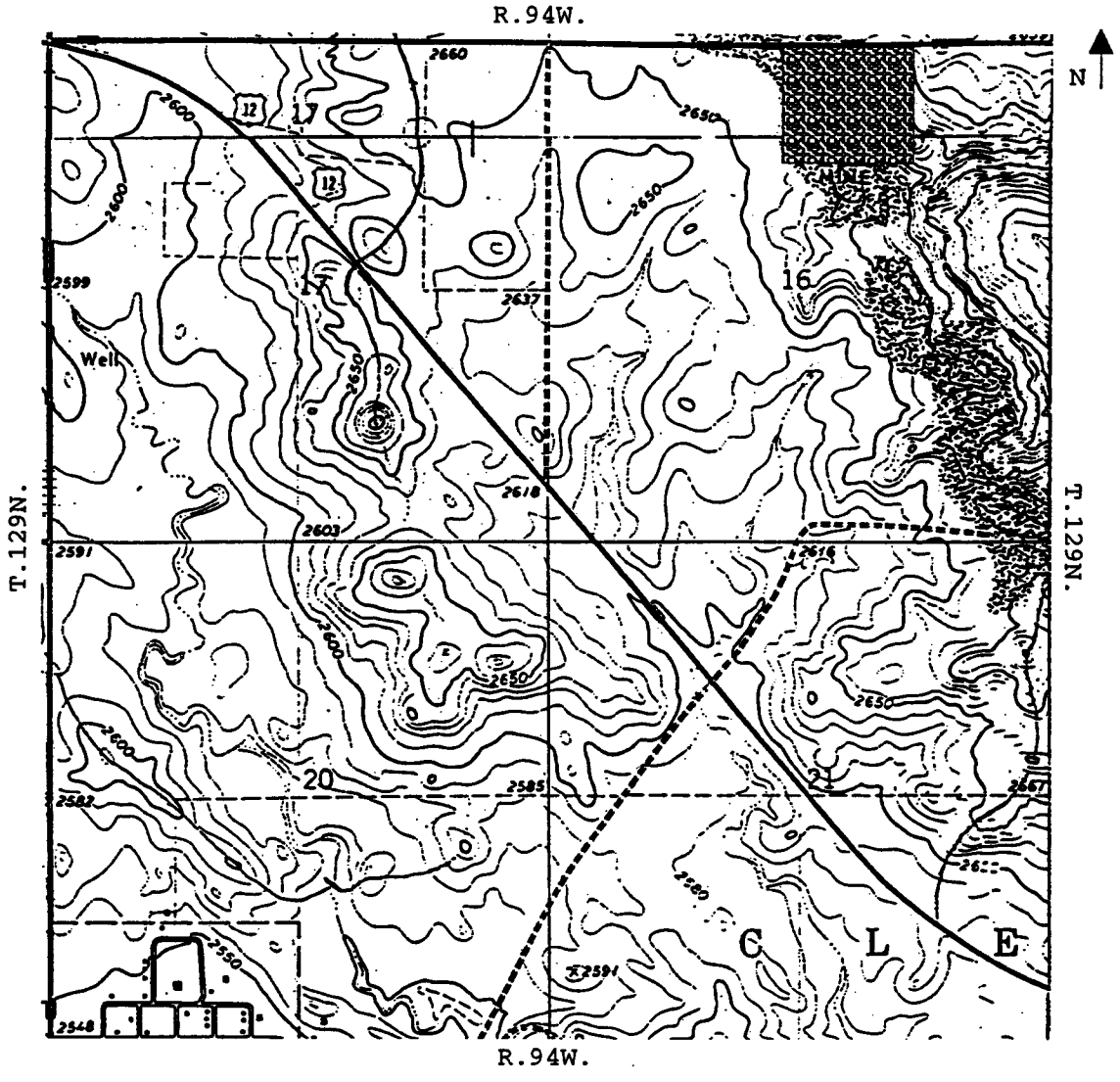


Figure 1. Location of the Adams County landfill in the NW 1/4 of the NE 1/4 of section 16, T.129N., R.94W.

Previous Site Investigations

Braun Intertec performed a hydrogeologic study of the Adams County landfill in 1990. This work included drilling four soil borings, installation of monitoring wells, sampling, and chemical analysis. The soil borings encountered clay, silt, sand, and lignite of the Bullion Creek Formation. Braun found the uppermost waterbearing unit to be a lignite bed about 30 to 50 feet below the surface.

Methods of Investigation

The Adams County study was accomplished by means of: 1) drilling test holes; 2) constructing and developing monitoring wells; 3) collecting and analyzing water samples; and 4) measuring water levels.

Test-Drilling Procedure

The drilling method at the Adams County landfill was based on the site's geology and depth to ground water, as determined by the preliminary site evaluation. A forward rotary rig was used at the Adams County landfill because of the presence of lignite at the site. The lithologic descriptions were determined from the drill cuttings. The water used with the rig was obtained from municipal water supplies.

Monitoring Well Construction and Development

Five test holes were drilled at the Adams County landfill, and monitoring wells were installed in all of them. Four existing monitoring wells installed by Braun Intertec were also used in this study. The number of wells installed at the Adams County landfill was based on the geologic and topographic characteristics of the site. The depth and intake interval of each well was selected to monitor the water level at the top of the uppermost aquifer. The wells were located within the boundaries of the landfill.

Wells were constructed following a standard design (Fig. 2) intended to comply with the construction regulations of the NDSDHCL and the North Dakota Board of Water Well Contractors (North Dakota Department of Health, 1986). The wells were constructed using a 2-inch diameter, SDR21, polyvinyl chloride (PVC) well casing and a PVC screen, either 5 or 10 feet long, with a slot-opening size of 0.012 or 0.013 inches. The screen was fastened to the casing with stainless steel screws (no solvent weld cement was used). After the casing and screen were installed into the drill hole, the annulus around the screen was filled with No. 10 (grain-size diameter) silica sand to a height of two feet above the top of the screen. High-solids bentonite grout and/or neat cement was placed above the silica sand to seal the annulus to approximately five feet below land surface. The remaining

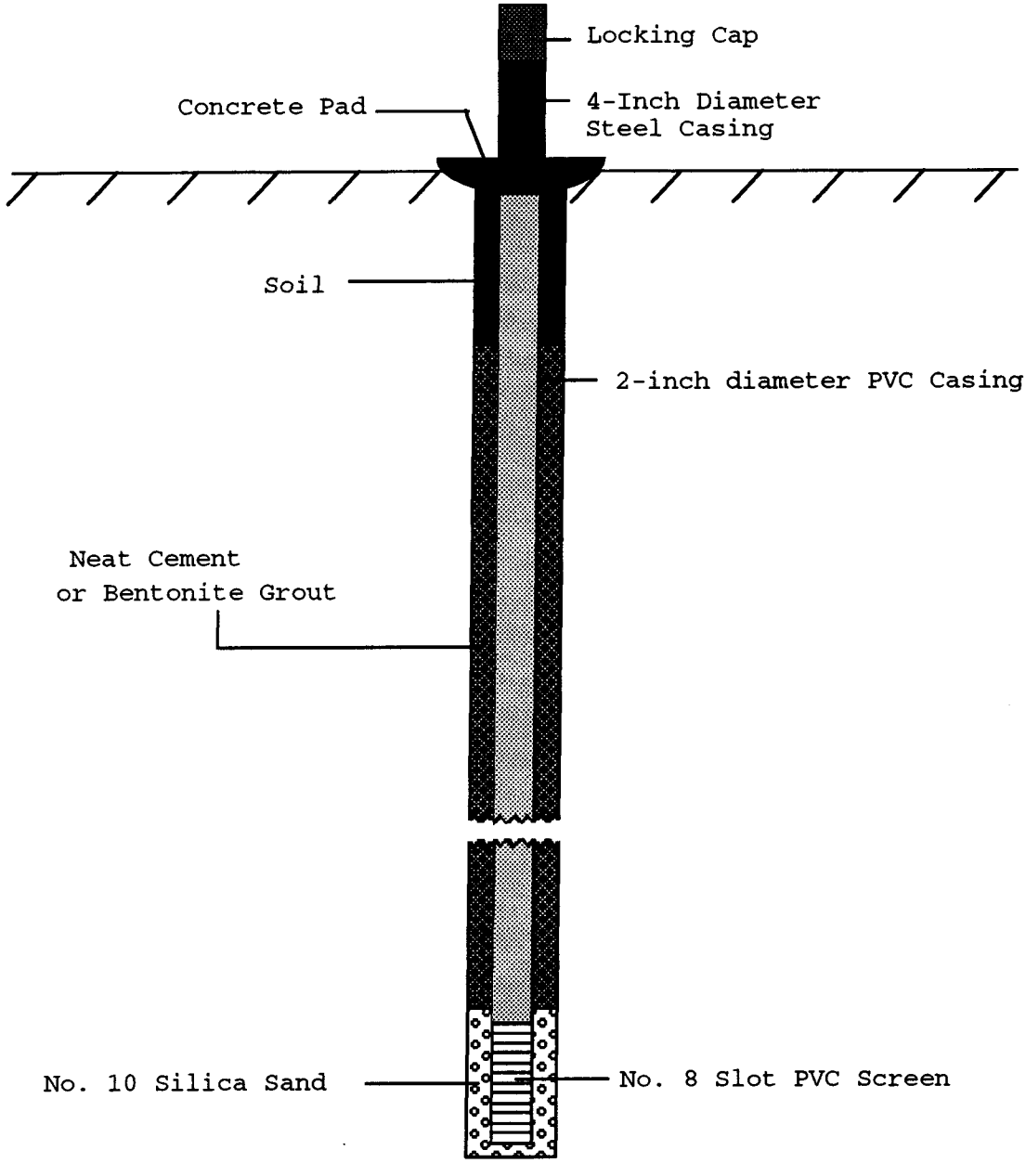


Figure 2. Construction design used for monitoring wells installed at the Adams County landfill.

annulus was filled with drill cuttings. The permanent wells were secured with a protective steel casing and a locking cover protected by a two-foot-square concrete pad.

All monitoring wells were developed using a stainless steel bladder pump or a teflon bailer. Any drilling fluid and fine materials present near the well were removed to insure movement of formation water through the screen.

The Mean Sea Level (MSL) elevation was established for each well by differential leveling to Third Order accuracy. The surveys established the MSL elevation at the top of the casing and the elevation of the land surface next to each well.

Collecting and Analyzing Water Samples

Water-quality analyses were used to determine if leachate is migrating from the landfill into the underlying ground-water system. Selected field parameters, major ions, and trace elements were measured for each water sample. These field parameters and analytes are listed in Appendix A with their Maximum Contaminant Levels (MCL). MCLs are enforceable drinking water standards that represent the maximum permissible level of a contaminant as stipulated by the U.S. Environmental Protection Agency (EPA).

Water samples were collected using a bladder pump constructed of stainless steel with a teflon bladder. A

teflon bailer was used in monitoring wells with limited transmitting capacity. Before sample collection, three to four well volumes were extracted to insure that unadulterated formation water was sampled. Four samples from each well were collected in high density polyethylene plastic bottles as follows:

1) Raw (500 ml)
2) Filtered (500 ml)
3) Filtered and acidified (500 ml)
4) Filtered and double acidified (500 ml)

The following parameters were determined for each sample. Specific conductance, pH, bicarbonate, and carbonate were analyzed using the raw sample. Sulfate, chloride, nitrate*, and dissolved solids were analyzed using the filtered sample. Calcium, magnesium, sodium, potassium, iron, and manganese were analyzed from the filtered, acidified sample. Cadmium, lead, arsenic, and mercury were analyzed using the filtered double-acidified samples.

One well was sampled for Volatile Organic Compounds (VOC) analysis. This sample was collected at a different time than the standard water-quality sample. The procedure used for collecting the VOC sample is described in Appendix B. Each sample was collected with a plastic throw-away bailer and kept chilled. These samples were analyzed within the permitted 14-day holding period. The standard water-quality analyses were performed at the North Dakota State

* No special preservative techniques were applied to nitrate samples and as a result reported nitrate concentrations may be lower than actual.

Water Commission (NDSWC) Laboratory and VOC analyses were performed by the NDSDHCL.

Water-Level Measurements

Water-level measurements were taken at least three times at a minimum of two-week intervals. The measurements were taken using a chalked-steel tape or an electronic (Solnist 10078) water-level indicator. These measurements were used to determine the shape and configuration of the water table.

Location-Numbering System

The system for denoting the location of a test hole or observation well is based on the federal system of rectangular surveys of public land. The first and second numbers indicate Township north and Range west of the 5th Principle Meridian and baseline (Fig. 3). The third number indicates the section. The letters A, B, C, and D designate, respectively, the northeast, northwest, southwest, and southeast quarter section (160-acre tract), quarter-quarter section (40-acre tract), and quarter-quarter-quarter section (10-acre tract). Therefore, a well denoted by 129-094-16ABD would be located in the SE1/4, NW1/4, NE1/4, Section 16, Township 129 North, Range 94 West. Consecutive numbers are added following the three letters if more than one well is

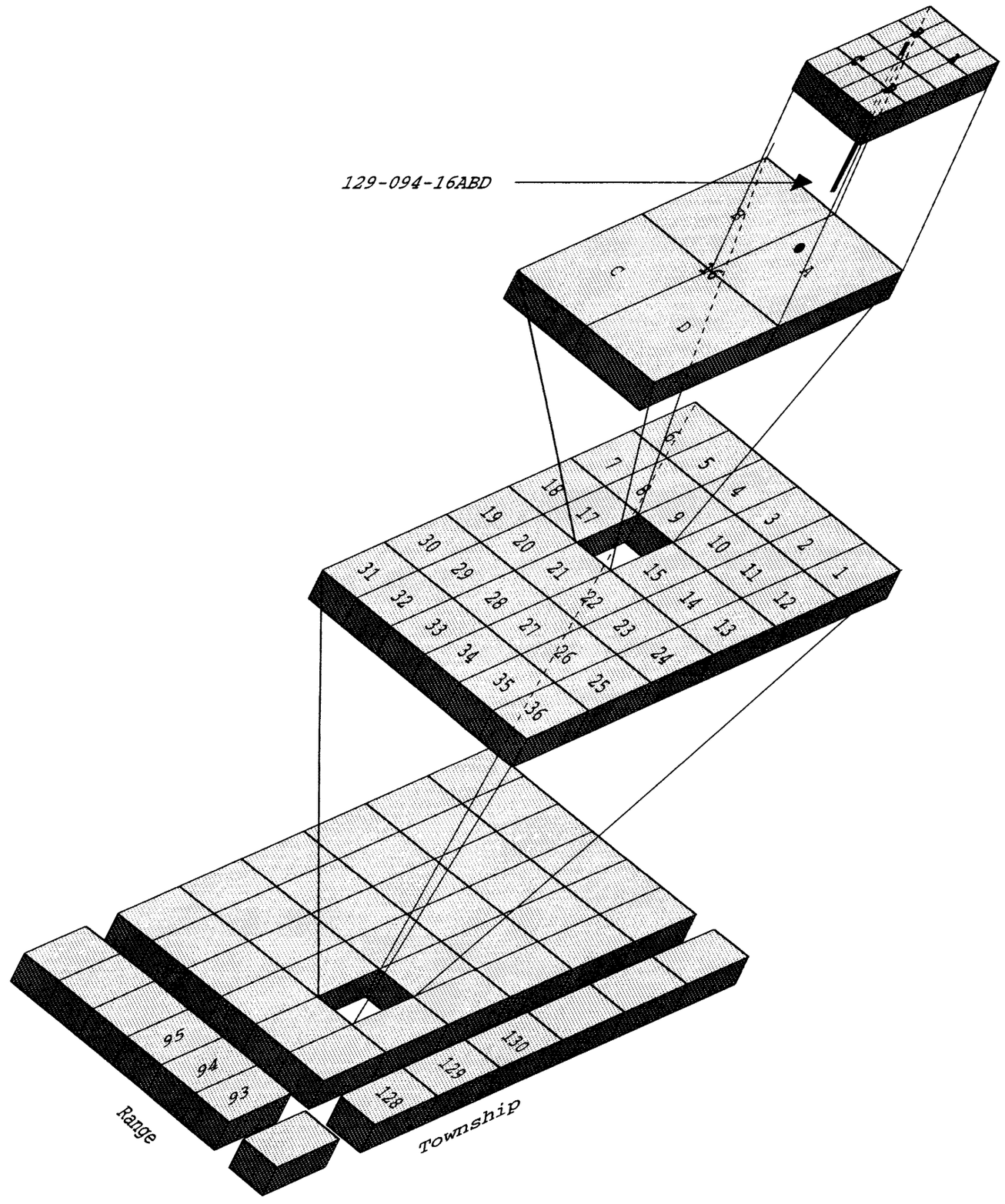


Figure 3. Location-numbering system at the Adams County landfill.

located in a 10-acre tract, e.g. 129-094-16ABD1 and 129-094-16ABD2.

GEOLOGY

The Adams County landfill is located on a northwest trending ridge. Elevations range from about 2,650 feet to 2,750 feet MSL (Fig. 4). Refuse at the landfill has been placed in a pit that remained after lignite mining operations. Abandoned underground mine tunnels also occur near the landfill.

The sediments at the landfill are part of to the Bullion Creek Formation (Carlson, 1979). The Bullion Creek Formation was deposited during the Paleocene Epoch in a deltaic environment. It is composed of clay, silt, sand, sandstone, lignite, and limestone. The Bullion Creek Formation is underlain by the Slope, Cannonball, Ludlow, Hell Creek, and Fox Hills Formations.

Geologic materials at the landfill are predominately clay with interbedded silt, sand, and lignite. A layer of fine-grained, silty sand occurs at the surface near the top of the ridge at the north end of the landfill (test hole 129-094-16ABA1, Fig. 5). The main lignite bed is 12 to 14 feet thick and lies 20 to 50 feet below the surface. The lignite has been mined out and replaced by fill material in test hole

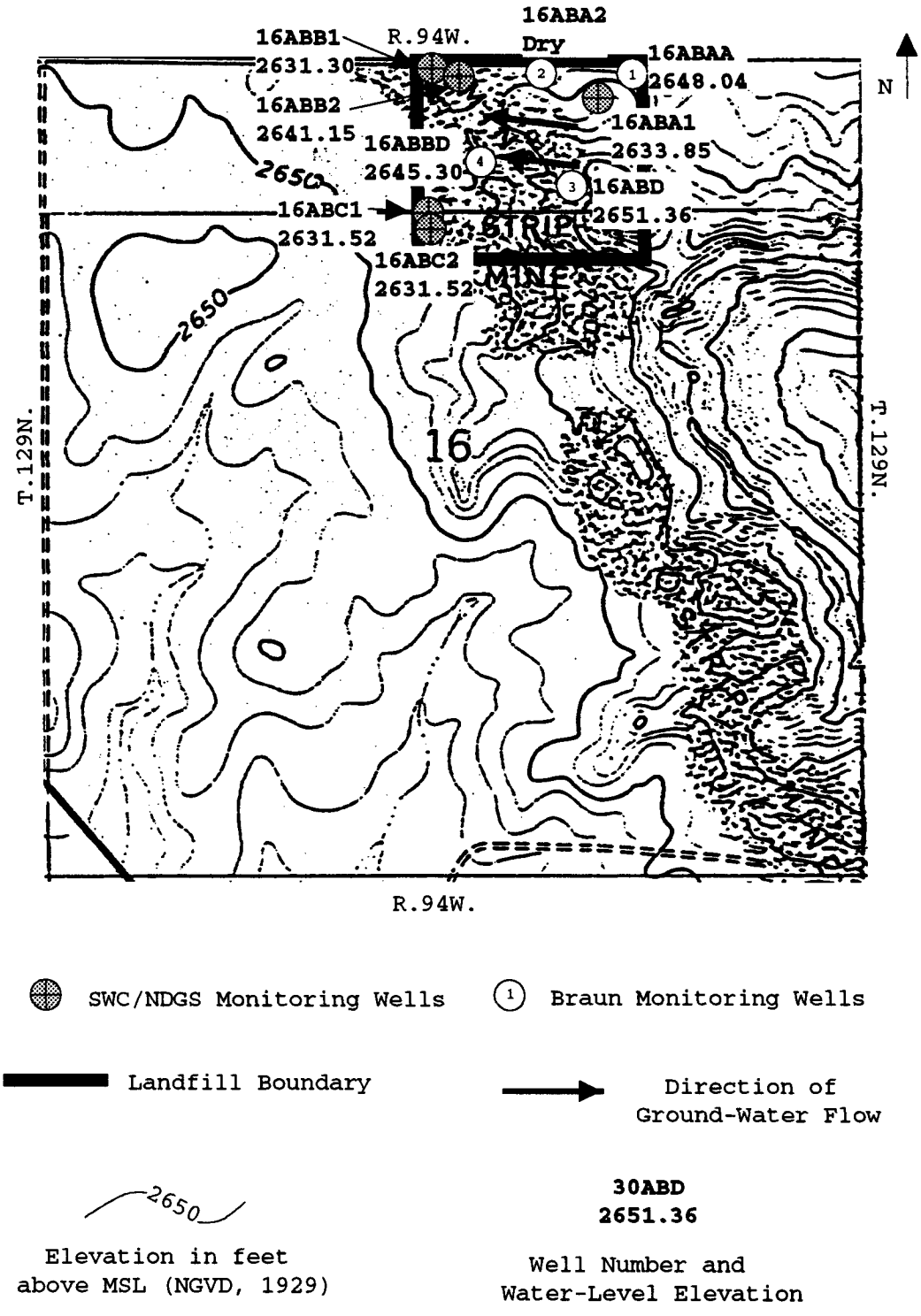


Figure 4. Location of monitoring wells and the direction of ground-water flow.

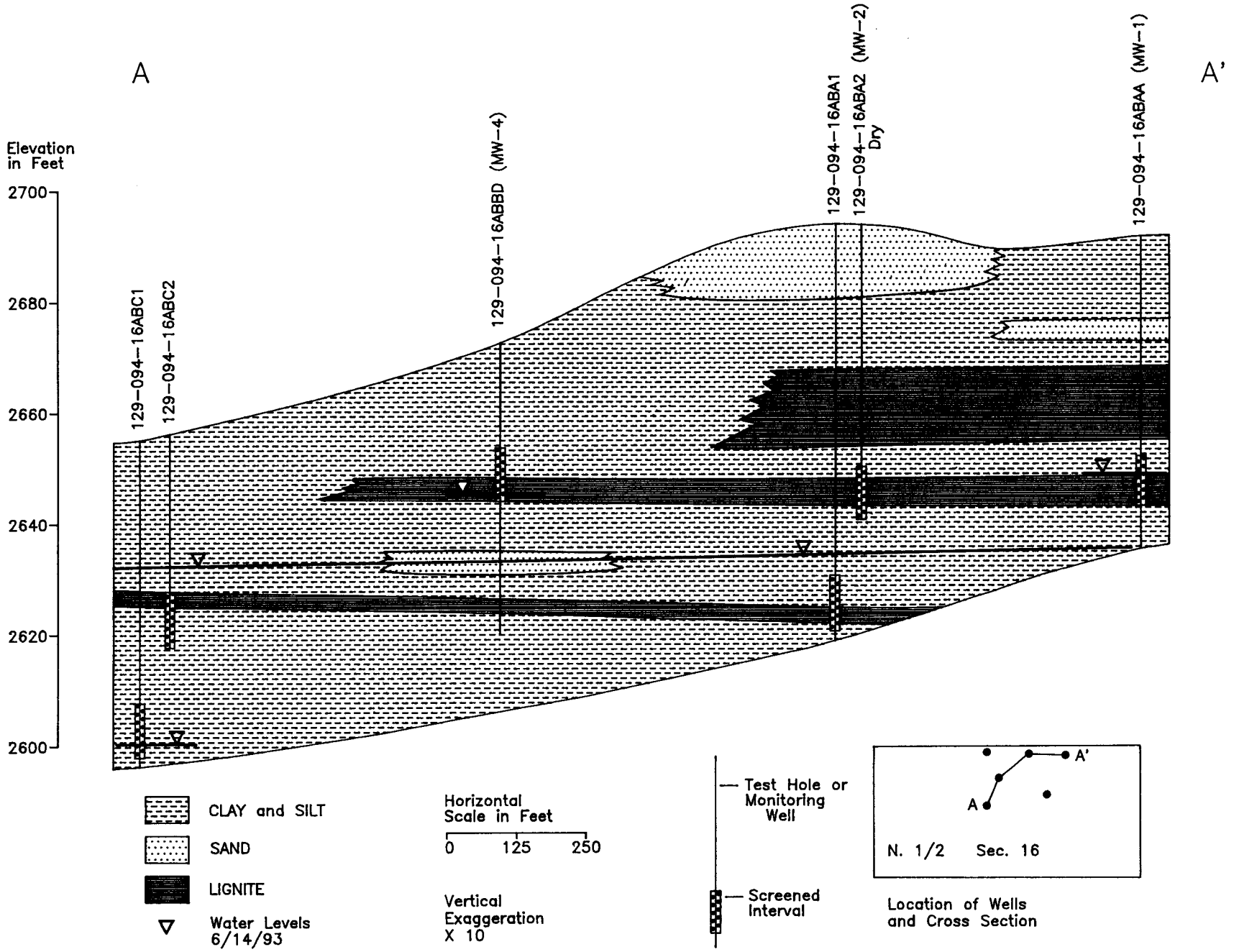


Figure 5. Geohydrologic section A–A' in the Adams County landfill.

129-094-16ABBD (Braun's MW-4, lithologic logs in Appendix C). Two more lignite beds occur below the main bed (Fig. 5).

HYDROLOGY

Surface-Water Hydrology

Surface water near the landfill consists of intermittent streams that appear to flow away in all directions from the landfill. The streams that originate within one-half mile of the active landfill area in section 16 may be most susceptible to contamination. The intermittent streams within section 16 flow to the south and discharge into Flat Creek which is located about 2 1/2 miles south of the landfill. No other surface waters are located within a three mile radius of the landfill.

Regional Ground-Water Hydrology

Regional aquifers occur in the Ludlow, Hell Creek, and Fox Hills Formations (Croft, 1978). Most of the wells in the region of the landfill appear to be screened in the Upper Ludlow aquifer. This aquifer can be encountered at an elevation of about 2,450 feet MSL (Braun, 1993) and is the uppermost aquifer in the area of the landfill. This aquifer is characterized by a sodium-sulfate type water.

The Middle Ludlow aquifer was created by interbedding of the Cannonball Formation into the Ludlow Formation. The depth of this aquifer ranges from 38 to 400 feet below land surface (Croft, 1978). This aquifer is characterized by a sodium-bicarbonate to a sodium-sulfate type water. This aquifer does not occur throughout Adams County. It is not known if this aquifer exists beneath the Adams County landfill.

The Lower Ludlow and Upper Hell Creek aquifer is located at a depth of about 490 feet below land surface near the study area (Croft, 1978). This aquifer is characterized by a sodium-bicarbonate to a sodium-sulfate type water. This aquifer should not be influenced by the landfill because of its depth and intervening aquitards.

The Fox Hills and Basal Hell Creek aquifer is located about 940 feet below land surface near the landfill (Croft, 1978). This aquifer is characterized by a sodium-bicarbonate type water. This aquifer should not be influenced by the landfill because of its depth and intervening aquitards.

Local Ground-Water Hydrology

The Adams County landfill is located in an old lignite strip mine. The site also contains numerous underground lignite mines. These underground mines may have a strong influence on the local direction of ground-water flow. The

uppermost lignite layer was dry at the time of drilling and well installation.

Two lignite aquifers were distinguished in the landfill study area (Fig. 5). The upper lignite aquifer was defined in wells 16ABAA, 16ABBD, and 16ABD. The lower lignite aquifer was defined from wells 16ABA1, 16ABC2, and 16ABB1. The two lignite aquifers are separated by about 22 feet of clay. The water level in the upper lignite aquifer is about 15 feet higher than that measured in the lower lignite aquifer. This indicates that the two lignite aquifers are not directly connected hydraulically in the study area. In both aquifers the local direction of ground-water flow is to the west.

Water Quality

Chemical analyses of water samples are shown in Appendix E. Well 16ABC1 did not have enough water to collect a sample. An anomalously low pH was measured in well 129-094-16ABBD (pH=4.38). The pH at well 16ABBD was measured three times over a period of ten weeks and ranged from 4.08 to 4.40. The surrounding monitoring wells indicated pH measurements ranging from 6.4 to 7.4. The source of this low pH is not known but may be due to leachate migration from the landfill. Well 16ABBD is located in the center of the landfill adjacent the buried refuse. This well also indicated an iron concentration (5.8 mg/L) that is 19 times

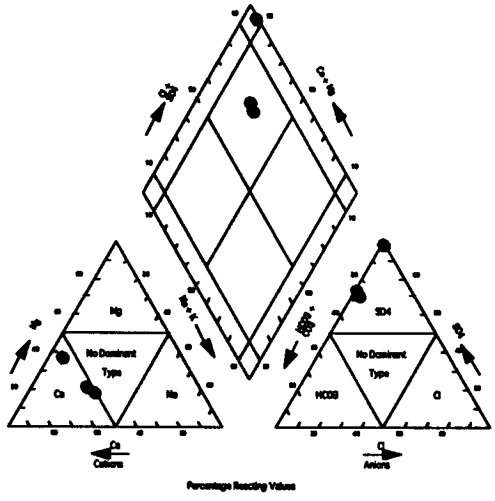
higher than the MCL (0.3 mg/L). Well 16ABD indicated an iron concentration of 20 mg/L. All major ion analyses indicated iron concentrations above the SMCL. The source of the elevated iron was not determined but may be related to lignite mining operations in the area.

Well 16ABB2 indicated a chloride concentration of 300 mg/L which is above the SMCL of 250 mg/L. This concentration is significantly higher than the concentrations from the other wells in the study area. The source of this concentration was not determined but chloride is a commonly used indicator of leachate migration.

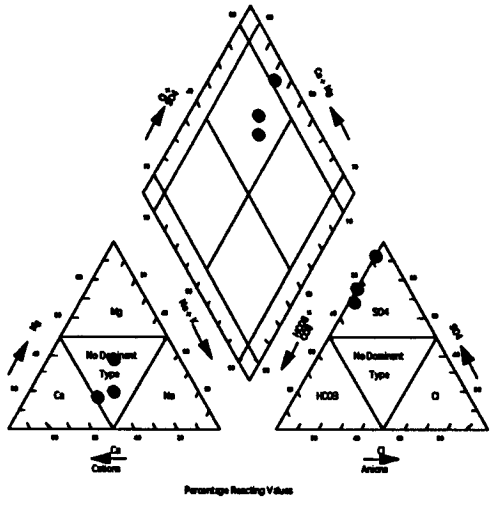
The upper lignite aquifer is characterized by a calcium-sulfate type water while the lower lignite aquifer is characterized by a calcium-sodium-sulfate type water (Fig. 6). This is typical for water in this area.

The trace element analyses indicated an elevated cadmium concentration (4 µg/L) in well 16ABBD which is below the MCL of 10 µg/L. The elevated cadmium concentration coupled with the elevated iron concentration and the low pH may be indicative of contamination migration from the landfill. No other trace element concentrations appear unusually large.

The results of the VOC analyses, from wells 16ABBD and 16ABD, are shown in Appendices F and G. The analyses did not detect any VOC compounds from either of the wells.



Upper Lignite Aquifer



Lower Lignite Aquifer

Figure 6. Piper diagram comparing the general ground-water chemistry of the upper lignite aquifer and the lower lignite aquifer

CONCLUSIONS

The Adams County landfill is located in an abandoned lignite pit in sediments of the Bullion Creek Formation. The geologic materials at the landfill are predominantly clay with interbedded silt, sand, and lignite. The main lignite bed is 12 to 14 feet thick and lies 20 to 50 feet below the surface. This lignite was dry at the time of the study. Two other lignite beds below the main bed were water bearing. Water levels indicate no direct hydraulic connection between these two lignite beds in the study area. Ground-water flow in both lignite beds is to the west.

An unusually low pH of 4.38 was measured in well 129-094-16ABBD. This well also had a very high iron concentration (5.8 mg/L) and an elevated cadmium concentration. The well is located in the center of the landfill next to the buried refuse and as a result may be affected by contaminant migration from the landfill. No VOC's were detected from wells 129-094-16ABBD and 16ABD.

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Braun Intertec, 1993, Preliminary site suitability of a proposed solid waste landfill, Adams County, North Dakota: Report to the Adams County Commission.

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Croft, M.G., 1978, Ground-water resources of Adams and Bowman counties, North Dakota: North Dakota Geological Survey, Bulletin 65, North Dakota State Water Commission, County Groundwater Studies 22, Part III, 54 p.

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APPENDIX A

WATER QUALITY STANDARDS
AND
CONTAMINANT LEVELS

Water Quality Standards and Contaminant Levels

Field Parameters	
appearance	color/odor
pH	6-9 (optimum)
specific conductance	-----
temperature	-----

Constituent	**MCL (µg/L)**
Arsenic	50
Cadmium	10
Lead	50
Molybdenum	100
Mercury	2
Selenium	10
Strontium	*

*EPA has not set an MCL for strontium. The median concentration for most U.S. water supplies is 100 µg/L (Hem, 1989).

	SMCL (mg/L)
Chloride	250
Iron	>0.3
Nitrate	50
Sodium	20-170
Sulfate	300-1000
Total Dissolved Solids	>1000

	Recommended Concentration Limits (mg/L)
Bicarbonate	150-200
Calcium	25-50
Carbonate	150-200
Magnesium	25-50
Hardness	>121 (hard to very hard)

APPENDIX B

SAMPLING PROCEDURE FOR VOLATILE ORGANIC COMPOUNDS

SAMPLING PROCEDURE FOR 40ML AMBER BOTTLES

Sample Collection for Volatile Organic Compounds

by
North Dakota Department of Health
and Consolidated Laboratories

1. Three samples must be collected in the 40ml bottles that are provided by the lab. One is the sample and the others are duplicates.

2. A blank will be sent along. Do Not open this blank and turn it in with the other three samples.

3. Adjust the flow so that no air bubbles pass through the sample as the bottle is being filled. No air should be trapped in the sample when the bottle is sealed. Make sure that you do not wash the ascorbic acid out of the bottle when taking the sample.

4. The meniscus of the water is the curved upper surface of the liquid. The meniscus should be convex (as shown) so that when the cover to the bottle is put on, no air bubbles will be allowed in the sample.

convex meniscus

5. Add the small vial of concentrated HCL to the bottle.

6. Scew the cover on with the white Teflon side down. Shake vigorously, turn the bottle upside down, and tap gently to check if air bubbles are in the sample.

7. If air bubbles are present, take the cover off the bottle and add more water. Continue this process until there are no air bubbles in the sample.

8. The sample must be iced after collection and delivered to the laboratory as soon as possible.

9. The 40 ml bottles contain ascorbic acid as a preservative and care must be taken not to wash it out of the bottles. The concentrated acid must be added after collection as an additional preservative.

APPENDIX C

LITHOLOGIC LOGS OF WELLS AND TEST HOLES

129-094-16ABA1
NDSWC

Date Completed:	5/5/93	Purpose:	Observation Well
L.S. Elevation (ft):	2693.15	Well Type:	2" PVC
Depth Drilled (ft):	75	Aquifer:	UND
Screened Interval (ft):	62-72	Source:	
		Owner:	ADAMS COUNTY

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	silty, clayey, fine grained, moderate yellowish-brown 10YR5/4	1-13
CLAY	stiff, light olive gray 5Y6/1	13-15
CLAY	silty, dark yellowish brown 10YR4/2	15-17
CLAY	stiff, dark yellowish brown 10YR4/2	17-20
CLAY	silty, dark yellowish brown 10YR4/2	20-26
CLAY	stiff, brownish gray 5YR4/1	26-28
LIGNITE		28-42
CLAY	silty, greenish gray 5GY6/1	42-47
LIGNITE		47-51
CLAY	silty, greenish gray 5GY6/1	51-65
SILT	greenish gray 5GY6/1	65-68
CLAY	brownish gray 5YR4/1	68-69

LIGNITE		69-71
CLAY	brownish gray 5YR4/1	71-75

129-094-16 ABA2
NDSWC

Date Completed:	3/14/90	Purpose:	Observation Well
L.S. Elevation (ft):	2691.2	Well Type:	2" PVC
Depth Drilled (ft):	88	Aquifer:	UND
Screened Interval (ft):	45-55	Source:	BRAUN INTERTEC #2
		Owner:	ADAMS COUNTY

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SILT	LIGHT GRAY WITH FINE-GRAIN SAND, REDDISH-YELLOW MOTTLES, DRY.	1-5.5
SANDSTONE	VERY FINE GRAIN, LIGHT BROWN, DRY.	5.5-6
SILT	LIGHT BROWN TO LIGHT GRAY, WITH REDDISH-YELLOW MOTTLES, MOIST.	6-8
SILTY-CLAY	GRAY WITH MINOR WHITE GYPSUM CRYSTALS AND FRACTURES, MOIST.	8-11
SILTY-CLAY	GRAY, SAME AS ABOVE BUT WITH WHITE GYPSUM CRYSTALS AND REDDISH-YELLOW STAINING ALONG FRACTURES, MOIST.	11-15.5
SILTY-CLAY	MEDIUM BROWN, WITH WHITE GYPSUM CRYSTALS.	15.5-21
SILTY-CLAY	MEDIUM BROWN WITH GYPSUM CRYSTALS, WITH ORGANIC LAMINAE INCREASING DOWNWARD.	21-24
LIGNITE	DRY.	24-35.5
CLAY	WITH SILT, GRAY, DRY.	35.5-35.7
LIGNITE		35.7-36.5

SILTY-CLAY	GRAY, DRY.	36.5-43
LIGNITE	DRY.	43-46
CLAY	GRAY, SILTY, DRY.	46-55.5
SAND	VERY FINE-GRAINED, POORLY GRADED, WITH SILT, GRAY, SOME ORGANIC LAMINAE BETWEEN 57 AND 57.4 FEET, MOIST.	55.5-58
CLAY	GRAY, SILTY DRY.	58-59
SAND	VERY FINE-GRAINED, POORLY GRADED, WITH SILT, GRAY, MOIST.	59-61
CLAY	GRAY, SILTY, DRY.	61-62
LIGNITE	DRY.	62-65.5
CLAY	GRAY, SILTY, GRADING TO DARKER GRAY TO 84 FT.	65.5-84
CLAY	GRAY, SILTY.	84-85.5
CLAY	SILTY, INTERBEDDED LIGHT AND DARK.	85.5-88

129-094-16ABAA
NDSWC

Date Completed:	3/16/90	Purpose:	Observation Well
L.S. Elevation (ft):	2691.06	Well Type:	2" PVC
Depth Drilled (ft):	58	Aquifer:	UND
Screened Interval (ft):	40.5-50.5	Source:	BRAUN INTERTEC #1
		Owner:	ADAMS COUNTY

Lithologic Log

Unit	Description	Depth (ft)
SILT	CLAYEY, BROWN, MOIST, TOPSOIL.	0-.5
SILT	WITH SOME MINOR FINE GRAINED SAND AND ROOTS, PALE YELLOW, DRY.	.5-2.5
SILT	CLAYEY, INTERBEDDED WITH YELLOW CLAYEY SILT, WITH WHITE GYPSUM CRYSTALS, GRAY, DRY.	2.5-17.2
SAND	SILTY, VERY FINE GRAINED, WITH MINOR SILT, GRAY, MOIST.	17.2-19.7
SILT	CLAYEY, INTERBEDDED WITH YELLOW CLAYEY SILT (SIMILAR TO ABOVE), SOME ORGANIC LAMINAE, GRAY, DRY.	19.7-23
LIGNITE	DRY.	23-37
CLAY	SILTY, GRAY, DRY.	37-42.5
LIGNITE	WET.	42.5-43.5
CLAY	SILTY, GRAY, WET, FRACTURE AT 43.7 FEET.	43.5-44.3
LIGNITE	WET	44.3-44.5
CLAY	SILTY, GRAY, WET, FRACTURE AT 44.5 FEET AND 44.6 FEET.	44.5-44.9
LIGNITE	WET.	44.9-50.2

CLAY	SILTY, GRAY, DRY.	50.2-58

129-094-16ABB1
NDSWC

Date Completed:	5/4/93	Purpose:	Observation Well
L.S. Elevation (ft):	2663.71	Well Type:	2" PVC
Depth Drilled (ft):	55	Aquifer:	UND
Screened Interval (ft):	48-53	Source:	
		Owner:	ADAMS COUNTY

Lithologic Log

Unit	Description	Depth (ft)
SOIL		0-2
CLAY	silty, trace sand, dark yellowish brown 10YR4/2	2-5
SILT	sandy, moderate yellowish brown 10YR5/4	5-8
LIGNITE		8-18
CLAY	silty, brownish gray 5YR4/1	18-22
SILT	light olive gray 5Y6/1	22-27
LIGNITE		27-30
CLAY	greenish gray 5GY6/1	30-38
CLAY	silty, greenish gray 5GY6/1	38-42
SANDSTONE	greenish gray 5GY6/1	42-43
CLAY	silty, greenish gray 5GY6/1	43-51
LIGNITE		51-53
CLAY	greenish gray 5GY6/1	53-55

129-094-16ABB2
NDSWC

Date Completed:	5/4/93	Purpose:	Observation Well
L.S. Elevation (ft):	2664.43	Well Type:	2" PVC
Depth Drilled (ft):	40	Aquifer:	UND
Screened Interval (ft):	28-38	Source:	
		Owner:	ADAMS COUNTY

Lithologic Log

Unit	Description	Depth (ft)
SOIL		0-2
CLAY	silty, moderate yellowish brown 10YR5/4	2-9
LIGNITE		9-20
CLAY	silty, yellowish gray 5Y8/1	20-23
SILT	trace fine sand, light olive gray 5Y6/1	23-28
LIGNITE		28-32
CLAY	silty, greenish gray 5GY6/1	32-40

129-094-16ABBD
NDSWC

Date Completed:	3/13/90	Purpose:	Observation Well
L.S. Elevation (ft):	2671.66	Well Type:	2" PVC
Depth Drilled (ft):	50.5	Aquifer:	UND
Screened Interval (ft):	17.5-27.5	Source:	BRAUN INTERTEC #4
		Owner:	ADAMS COUNTY

Lithologic Log

Unit	Description	Depth (ft)
SILT	LIGHT TO DARK BROWN, VEGETATION, ROOTS, MOIST.	0-2
SILT	DARK BROWN, WITH SOME ROOTS, DRY.	2-4
SILT	MEDIUM BROWN, MOIST.	4-6
SILT	LIGHT BROWN, DRY.	6-7
SILT	WITH MINOR CLAY FRACTURES, LINED WITH WHITE MINERALS, DRY.	7-9
SILT	CLAYEY, DARK BROWN, LESS FRACTURES THAN ABOVE, DRY.	9-15.5
SILT	CLAYEY, DARK BROWN WITH SOME LAMINAE OF ORGANIC MATERIAL, DRY.	15.5-19
PEAT	ORGANIC MATERIAL, WET.	19-20
CLAY	SILTY, GRAY, WITH SOME ORGANICS.	20-20.5
LIGNITE	WET	20.5-20.8
CLAY	SILTY, GRAY WITH SOME REDDISH STAINED FRACTURES, CONCENTRATED FRACUTRES AT 23 FEET, DRY.	20.8-25
LIGNITE	WET	25-26

CLAY	SILTY, BROWN, DRY.	26-26.5
LIGNITE	WET.	26.5-27.5
CLAY	SILTY, GRAY, DRY.	27.5-40.5
SAND	SILTY, POORLY GRADED, VERY FINE GRAINED.	40.5-42
CLAY	SILTY, GRAY, DRY.	42-44.5
SAND	SILTY, POORLY GRADED, VERY FINED GRAINED, WET.	44.5-46
CLAY	SILTY, DARK BROWN.	46-48
LIGNITE	DRY	48-49.5
CLAY	SILTY, DARK BROWN TO GRAY.	49.5-50.5

129-094-16ABC1
NDSWC

Date Completed:	5/4/93	Purpose:	Observation Well
L.S. Elevation (ft):	2655.98	Well Type:	2" PVC
Depth Drilled (ft):	60	Aquifer:	Undefined
Screened Interval (ft):	48-58	Source:	
		Owner:	ADAMS COUNTY

Lithologic Log

Unit	Description	Depth (ft)
SOIL		0-2
CLAY	trace sand and silt, dark yellowish brown 10YR4/2	2-9
CLAY	sandy, light olive gray 5Y6/1	9-11
CLAY	stiff, light olive gray 5Y6/1	11-16
CLAY	silty, light olive gray with dark yellowish orange mottles	16-27
CLAY	brownish gray 5YR4/1	27-29
ROCK		29-31
CLAY	stiff, brownish gray 5YR4/1	31-36
CLAY	stiff, greenish gray 5GY6/1	36-43
CLAY	silty, greenish gray 5GY6/1	43-46
CLAY	stiff, greenish gray 5GY6/1	46-60

129-094-16ABC2
NDSWC

Date Completed:	5/4/93	Purpose:	Observation Well
L.S. Elevation (ft):	2655.88	Well Type:	2" PVC
Depth Drilled (ft):	40	Aquifer:	UND
Screened Interval (ft):	28-38	Source:	
		Owner:	ADAMS COUNTY

Lithologic Log

Unit	Description	Depth (ft)
SOIL		0-1
CLAY	silty, trace sand, dark yellowish brown 10YR4/2	1-8
CLAY	stiff, light olive gray to dark yellowish orange	8-13
SILT	clayey, light olive gray 5Y6/1	13-16
CLAY	silty, light olive gray 5Y6/1	16-26
CLAY	stiff, light olive gray 5Y6/1	26-29
LIGNITE		29-31
CLAY	stiff, brownish gray 5YR4/1	31-36
CLAY	stiff, greenish gray 5GY6/1	36-40

129-094-16ABD
NDSWC

Date Completed:	3/15/90	Purpose:	Observation Well
L.S. Elevation (ft):	2694.67	Well Type:	2" PVC
Depth Drilled (ft):	65.5	Aquifer:	UND
Screened Interval (ft):	35-45	Source:	BRAUN INTERTEC #3
		Owner:	ADAMS COUNTY

Lithologic Log

Unit	Description	Depth (ft)
SILT	DARK BROWN, MOIST, TOPSOIL.	0-1
SAND	POORLY GRADED, BROWN, VERY FINE GRAINED, WITH ROOTS, DRY.	1-4.5
SILT	LIGHT YELLOW-BROWN, WITH SOME ROOTS, DRY. INTERBEDDED YELLOW-BROWN SILT AND DARK BROWN CLAY (MORE SILT THAN CLAY). LAYERS = 2-3 INCHES THICK.	4.5-21
LIGNITE	SILTY, MORE DARK BROWN, GRADATIONAL CONTACT LAYERS THAN YELLOW-BROWN LAYERS. LAYERS = 2-3 INCHES THICK, DRY.	21-25
LIGNITE	DRY.	25-37.5
CLAY	SILTY, GRAY, DRY.	37.5-37.7
LIGNITE	DRY.	37.7-38
CLAY	SILTY, GRAY, DRY.	38-40.8
LIGNITE	DRY.	40.8-41.8
CLAY	SILTY, GRAY, DRY.	41.8-42.4
LIGNITE	WET.	42.4-43.6

CLAY	SILTY, GRAY, DRY.	43.6-53
SAND	POORLY GRADED, VERY FINE GRAINED, GRAY, MOIST.	53-54.8
CLAY	SILTY, GRAY, DRY.	54.8-55.5
SAND	POORLY GRADED, VERY FINED GRAINED, GRAY, MOIST.	55.5-56.6
CLAY	SILTY, GRAY, DRY.	56.6-60
SAND	POORLY GRADED, VERY FINE GRAINED, GRAY, MOIST.	60-60.3
CLAY	SILTY, GRAY, DRY.	60.3-61.5
SILTSTONE/ CLAYSTONE	DARK BROWN, VERY HARD.	61.5-62.2
CLAY	SILTY, GRAY.	62.2-65.5
LIGNITE		65.5

APPENDIX D

WATER-LEVEL TABLES

Adams County Water Levels
05/26/93 to 7/02/93

129-094-16ABA2 LS Elev (msl,ft)=2692.51
UND Aquifer SI (ft.)=45-55

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
05/26/93	Dry		06/14/93	Dry	
06/03/93	Dry		07/02/93	Dry	

129-094-16ABA1 LS Elev (msl,ft)=2693.15
UND Aquifer SI (ft.)=62-72

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
05/26/93	55.96	2637.19	06/14/93	59.13	2634.02
06/03/93	58.55	2634.60	07/02/93	58.86	2634.29

129-094-16ABAA LS Elev (msl,ft)=2691.06
UND Aquifer SI (ft.)=40.5-50.5

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
05/26/93	42.90	2648.16	06/14/93	43.02	2648.04
06/03/93	42.97	2648.09	07/02/93	42.89	2648.17

129-094-16ABB1 LS Elev (msl,ft)=2663.71
UND Aquifer SI (ft.)=48-53

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
05/26/93	32.08	2631.63	06/14/93	32.41	2631.30
06/03/93	32.84	2630.87	07/02/93	32.10	2631.61

129-094-16ABB2 LS Elev (msl,ft)=2664.43
UND Aquifer SI (ft.)=28-38

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
05/26/93	22.97	2641.46	06/14/93	23.28	2641.15
06/03/93	23.14	2641.29	07/02/93	23.12	2641.31

129-094-16ABBD LS Elev (msl,ft)=2671.66
UND Aquifer SI (ft.)=17.5-27.5

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
05/26/93	26.35	2645.31	06/14/93	26.36	2645.30
06/04/93	26.54	2645.12	07/02/93	26.32	2645.34

129-094-16ABC1 LS Elev (msl,ft)=2655.98

Undefined Aquifer SI (ft.)=48-58

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
05/26/93	30.26	2625.72	06/14/93	55.69	2600.29
06/04/93	52.57	2603.41	07/02/93	55.96	2600.02

129-094-16ABC2 LS Elev (msl,ft)=2655.88

UND Aquifer SI (ft.)=28-38

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
05/26/93	24.16	2631.72	06/14/93	24.46	2631.42
06/04/93	24.37	2631.51	07/02/93	24.08	2631.80

129-094-16ABD LS Elev (msl,ft)=2694.67

UND Aquifer SI (ft.)=35-45

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
05/26/93	43.26	2651.41	06/14/93	43.31	2651.36
06/04/93	43.55	2651.12	07/02/93	42.45	2652.22

APPENDIX E

MAJOR ION AND TRACE-ELEMENT CONCENTRATIONS

Adams County Water Quality
Major Ion Analyses

Location	Screened Interval (ft)	Date Sampled	(milligrams per liter) SiO_2	Fe	Mn	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	NO_3	B	TDS	Hardness $CaCO_3$	as NCH	% Na	SAR	Spec Cond (µmho)	Temp (°C)	pH
129-094-16ABA1	62-72	06/02/93	9.5	0.1	0.89	390	92	310	30	658	0	1600	6.2	0.2	0.3	1.2	2760	1400	810	33	3.6	3180	16	7.63
129-094-16ABAA	40.5-50.5	06/02/93	9.7	1.1	1.6	440	110	250	28	706	0	1600	3	0.1	0.2	1.2	2790	1600	970	26	2.7	3170	15	7.15
129-094-16ABB1	48-53	06/02/93	11	1.9	1.2	410	130	460	27	920	0	1800	71	0.3	0.2	2	3370	1600	800	39	5	3800	14	7.36
129-094-16ABB2	28-38	06/02/93	14	0.07	4.2	530	230	250	17	682	0	2000	300	0.6	0.3	6.6	3690	2300	1700	19	2.3	3880	13	7.16
129-094-16ABBD	17.5-27.5	06/03/93	30	5.8	2.7	460	190	61	17	0	0	2000	22	0.3	0.1	3.2	2790	1900	1900	6	0.6	3100	12	4.35
129-094-16ABC2	28-38	06/03/93	9.9	1.8	0.5	450	370	570	21	245	0	3500	25	0.1	120	3.2	5190	2600	2400	32	4.9	5150	13	6.42
129-094-16ABD	35-45	06/02/93	11	20	4.2	410	100	280	22	700	0	1500	51	0.1	0.2	1.3	2740	1400	860	29	3.2	3170	13	6.58

Trace Element Analyses

Location	Date Sampled	Selenium	Lead	Cadmium	Mercury	Arsenic	Molybdenum	Strontium
		(micrograms per liter)						
129-094-16ABA1	6/02/93	0	0	0	0	0	1	8300
129-094-16ABAA	6/02/93	1	0	0	0	0	0	9100
129-094-16ABB1	6/02/93	0	0	0	0	0	2	8400
129-094-16ABB2	6/02/93	0	0	0	0	0	4	5700
129-094-16ABBD	6/03/93	0	0	4	0	0	1	7400
129-094-16ABC2	6/03/93	1	0	2	0	0	0	4400
129-094-16ABD	6/02/93	0	0	0	0	0	0	7200

APPENDIX F

VOLATILE ORGANIC COMPOUNDS FOR WELL 129-094-16ABD

Volatile Organic Compounds
and
Minimum Concentrations

Concentrations are based only on detection limits. Anything over the detection limit indicates possible contamination.

Constituent	Chemical Analysis µg/L
Benzene	<2
Vinyl Chloride	<1
Carbon Tetrachloride	<2
1,2-Dichlorethane	<2
Trichloroethylene	<2
1,1-Dichloroethylene	<2
1,1,1-Trichloroethane	<2
para-Dichlorobenzene	<2
Acetone	<50
2-Butanone (MEK)	<50
2-Hexanone	<50
4-Methyl-2-pentanone	<50
Chloroform	<5
Bromodichloromethane	<5
Chlorodibromomethane	<5
Bromoform	<5
trans1,2-Dichloroethylene	<2
Chlorobenzene	<2
m-Dichlorobenzene	<5
Dichloromethane	<5
cis-1,2-Dichloroethylene	<2
o-Dichlorobenzene	<2
Dibromomethane	<5
1,1-Dichloropropene	<5
Tetrachlorethylene	<2
Toluene	<2
Xylene(s)	<2
1,1-Dichloroethane	<5
1,2-Dichloropropane	<2
1,1,2,2-Tetrachloroethane	<5
Ethyl Benzene	<2
1,3-Dichloropropane	<5
Styrene	<2
Chloromethane	<5
Bromomethane	<5
1,2,3-Trichloropropane	<5
1,1,1,2-Tetrachloroethane	<5
Chloroethane	<5
1,1,2-Trichloroethane	<5

* Constituent Detection

VOC Constituents cont.

2,2-Dichloropropane	<5
o-Chloroluene	<5
p-Chlorotoluene	<5
Bromobenzene	<5
1,3-Dichloropropene	<5
1,2,4-Trimethylbenzene	<5
1,2,4-Trichlorobenzene	<5
1,2,3-Trichlorobenzene	<5
n-Propylbenzene	<5
n-Butylbenzene	<5
Naphthalene	<5
Hexachlorobutadiene	<5
1,3,5-Trimethylbenzene	<5
p-Isopropyltoluene	<5
Isopropylbenzene	<5
Tert-butylbenzene	<5
Sec-butylbenzene	<5
Fluorotrichloromethane	<5
Dichlorodifluoromethane	<5
Bromochloromethane	<5
Allylchloride	<5
2,3-Dichloro-1-propane	<5
Tetrahydrofuran	<50
Pentachloroethane	<5
Trichlorotrofluoroethane	<5
Carbondisufide	<5
Ether	<5

* Constituent Detection

APPENDIX G

VOLATILE ORGANIC COMPOUNDS FOR WELL 129-094-16ABBD

Volatile Organic Compounds
and
Minimum Concentrations

Concentrations are based only on detection limits. Anything over the detection limit indicates possible contamination.

Constituent	Chemical Analysis µg/L
Benzene	<2
Vinyl Chloride	<1
Carbon Tetrachloride	<2
1,2-Dichlorethane	<2
Trichloroethylene	<2
1,1-Dichloroethylene	<2
1,1,1-Trichloroethane	<2
para-Dichlorobenzene	<2
Acetone	<50
2-Butanone (MEK)	<50
2-Hexanone	<50
4-Methyl-2-pentanone	<50
Chloroform	<5
Bromodichloromethane	<5
Chlorodibromomethane	<5
Bromoform	<5
trans1,2-Dichloroethylene	<2
Chlorobenzene	<2
m-Dichlorobenzene	<5
Dichloromethane	<5
cis-1,2-Dichloroethylene	<2
o-Dichlorobenzene	<2
Dibromomethane	<5
1,1-Dichloropropene	<5
Tetrachlorethylene	<2
Toluene	<2
Xylene(s)	<2
1,1-Dichloroethane	<5
1,2-Dichloropropane	<2
1,1,2,2-Tetrachloroethane	<5
Ethyl Benzene	<2
1,3-Dichloropropane	<5
Styrene	<2
Chloromethane	<5
Bromomethane	<5
1,2,3-Trichloropropane	<5
1,1,1,2-Tetrachloroethane	<5
Chloroethane	<5
1,1,2-Trichloroethane	<5

* Constituent Detection

VOC Constituents cont.

2,2-Dichloropropane	<5
o-Chloroluene	<5
p-Chlorotoluene	<5
Bromobenzene	<5
1,3-Dichloropropene	<5
1,2,4-Trimethylbenzene	<5
1,2,4-Trichlorobenzene	<5
1,2,3-Trichlorobenzene	<5
n-Propylbenzene	<5
n-Butylbenzene	<5
Naphthalene	<5
Hexachlorobutadiene	<5
1,3,5-Trimethylbenzene	<5
p-Isopropyltoluene	<5
Isopropylbenzene	<5
Tert-butylbenzene	<5
Sec-butylbenzene	<5
Fluorotrichloromethane	<5
Dichlorodifluoromethane	<5
Bromochloromethane	<5
Allylchloride	<5
2,3-Dichloro-1-propane	<5
Tetrahydrofuran	<50
Pentachloroethane	<5
Trichlorotrofluoroethane	<5
Carbondisufide	<5
Ether	<5

* Constituent Detection