Site Suitability Review of the NW Solid Waste Landfill

by
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and
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Prepared by the
North Dakota State Water Commission
and the
North Dakota Geological Survey

ND Landfill Site Investigation No. 35

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OF THE
NORTHWEST SOLID WASTE MANAGEMENT LANDFILL

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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, and additional studies may be necessary to meet the requirements of the NDSDHCL for continued operation of solid-waste landfills. The NW Solid Waste Management landfill is one of the landfills being evaluated.

Location of the NW Solid Waste Management Landfill

The NW Solid Waste Management landfill is located about one mile south of the City of Noonan in Township 162 North, Range 95 West, NW 1/4 Section 10. The NW Solid Waste Management landfill encompasses approximately 80 acres (Fig. 1).

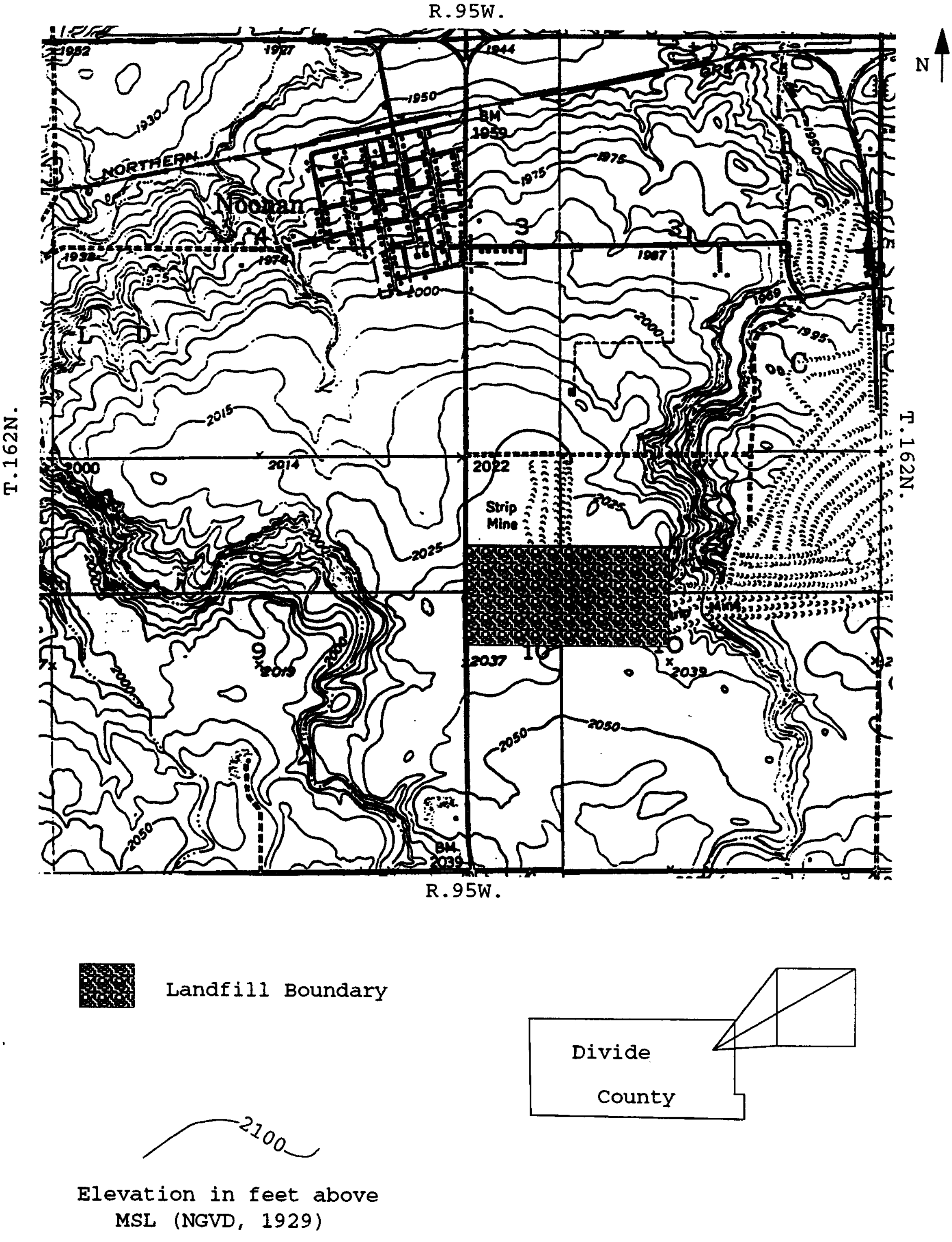

Figure 1. Location of the Northwest Solid Waste Management Council landfill in the S 1/2, NW 1/4, section 10, T.162N., R.95W.

Previous Site Investigations

A preliminary work plan was drafted by Water Supply, Inc. in March, 1991 for the purpose of a hydrogeologic investigation at the NW Solid Waste landfill. This investigation was never completed. The Mining and Mineral Resources Research Institute (MMRRI) installed monitoring wells in the vicinity of the NW Solid Waste Management landfill in 1982. A study was completed by the North Dakota Geological Survey and was included in a final report titled "Development of a Hydrogeological and Hydrochemical Data Base for Abandoned Lands" dated October, 1983 and February, 1986. This study indicated that the Noonan lignite bed was saturated in the unmined area west of the landfill. Logs of two of the monitoring wells from this study were used in the SWC/NDGS investigation and are included in Appendix C.

Methods of Investigation

The NW Solid Waste Management 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 NW Solid Waste Management landfill was based on the site's geology and depth to ground water, as determined by the preliminary evaluation. A forward rotary drill rig was used at the NW Solid Waste Management landfill because the sediments were consolidated and because the depth to the water table was expected to be greater than 70 feet. The lithologic descriptions were determined from the drill cuttings.

Monitoring Well Construction and Development

Three test holes were drilled at the NW Solid Waste Management landfill, and monitoring wells were installed in all of them. Two existing monitoring wells were also used for this investigation. The number of wells installed at the NW Solid Waste Management 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. All wells are located within boundaries of the landfill. Site locations were selected to avoid drilling through the buried refuse.

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

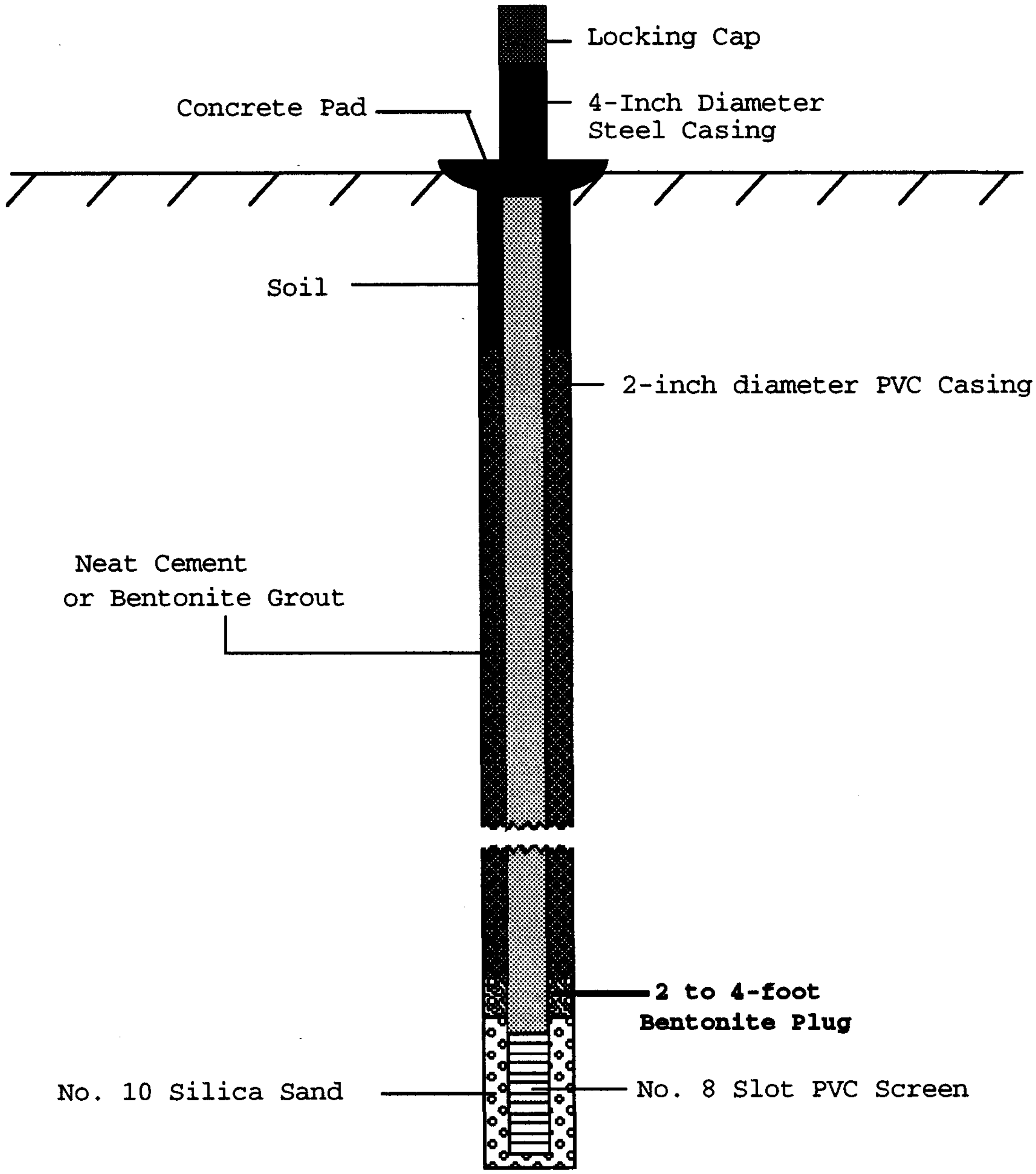

Figure 2. Construction design used for monitoring wells installed at the Northwest Solid Waste Management Council landfill.

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 0.008 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. A two to three-foot bentonite plug was placed above the sand pack using one-half inch diameter bentonite pellets. High-solids bentonite grout and/or neat cement was placed above the bentonite plug to seal the annulus to approximately five feet below land surface. The remaining 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*,

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

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 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 made 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 162-095-10BDA would be located in the NE1/4, SE1/4, NW1/4, Section 10, Township 162 North, Range 95 West. Consecutive numbers are added following the three letters if more than one well is located in a 10-acre tract, e.g. 162-095-10BDA1 and 162-095-10BDA2.

GEOLOGY

The Northwest solid waste landfill is situated near the base of the Missouri escarpment, a steep slope which rises about 300 feet from north to south. The area is covered with a thin layer of glacial sediments underlain by clay, silt, sand, sandstone, and lignite of the Sentinel Butte Formation.

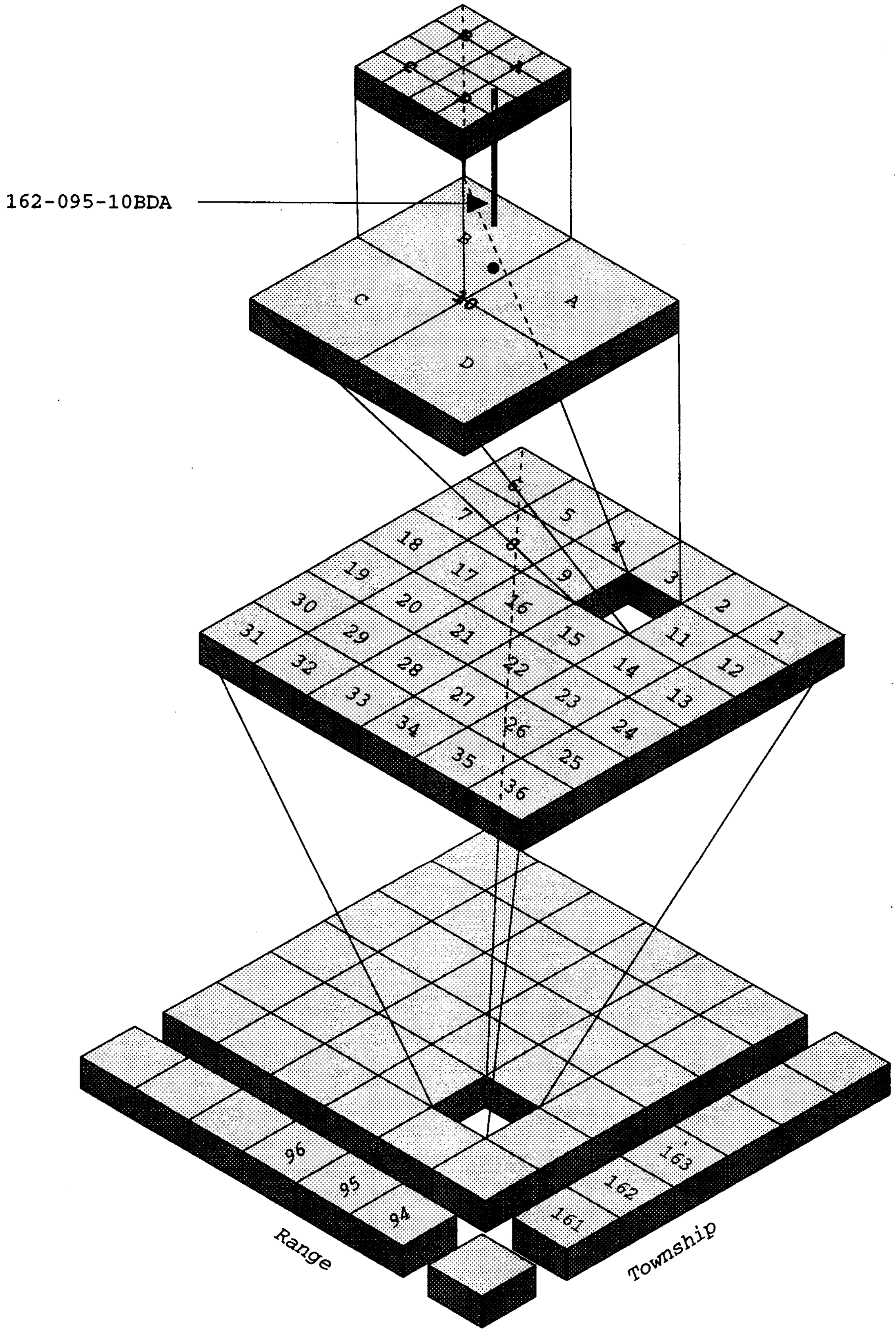

Figure 3. Location-numbering system.

The landfill is located in the Baukol-Noonan lignite strip mine that operated in the area between 1929 and 1962 (Groenewold, et al, 1986). This mine occupied several sections, including the north part of section 10, where the landfill is located (Fig. 4). Two small underground mines also operated in the area. One of these is located just north of the landfill in section 10; the other is located west of the landfill in section 9 (Groenewold, et al, 1986).

Test holes 162-095-09ADD1 and ADD2 (NDGS-NOO 18 and NOO 19) are located west of the landfill outside of the mined area. These holes were drilled by the North Dakota Geological Survey in 1982. The lithologic logs reported silt, sand, and gravel in the upper 18 feet. The presence of gravel indicates that this interval is glacial outwash. The materials from 18 feet on down appear to be bedrock (Fig. 5, lithologic logs in Appendix C).

Test hole 162-095-10BCD encountered 14 feet of fill at the surface underlain by bedrock. The main lignite (the Noonan bed) is 15 feet higher at 10BCD than in the test holes to the west (Fig. 5). Test holes 162-095-10BDA and BDD are located on the spoil piles within the strip mine. The spoil material from these test holes consists of variable amounts of silt, sand, and clay.

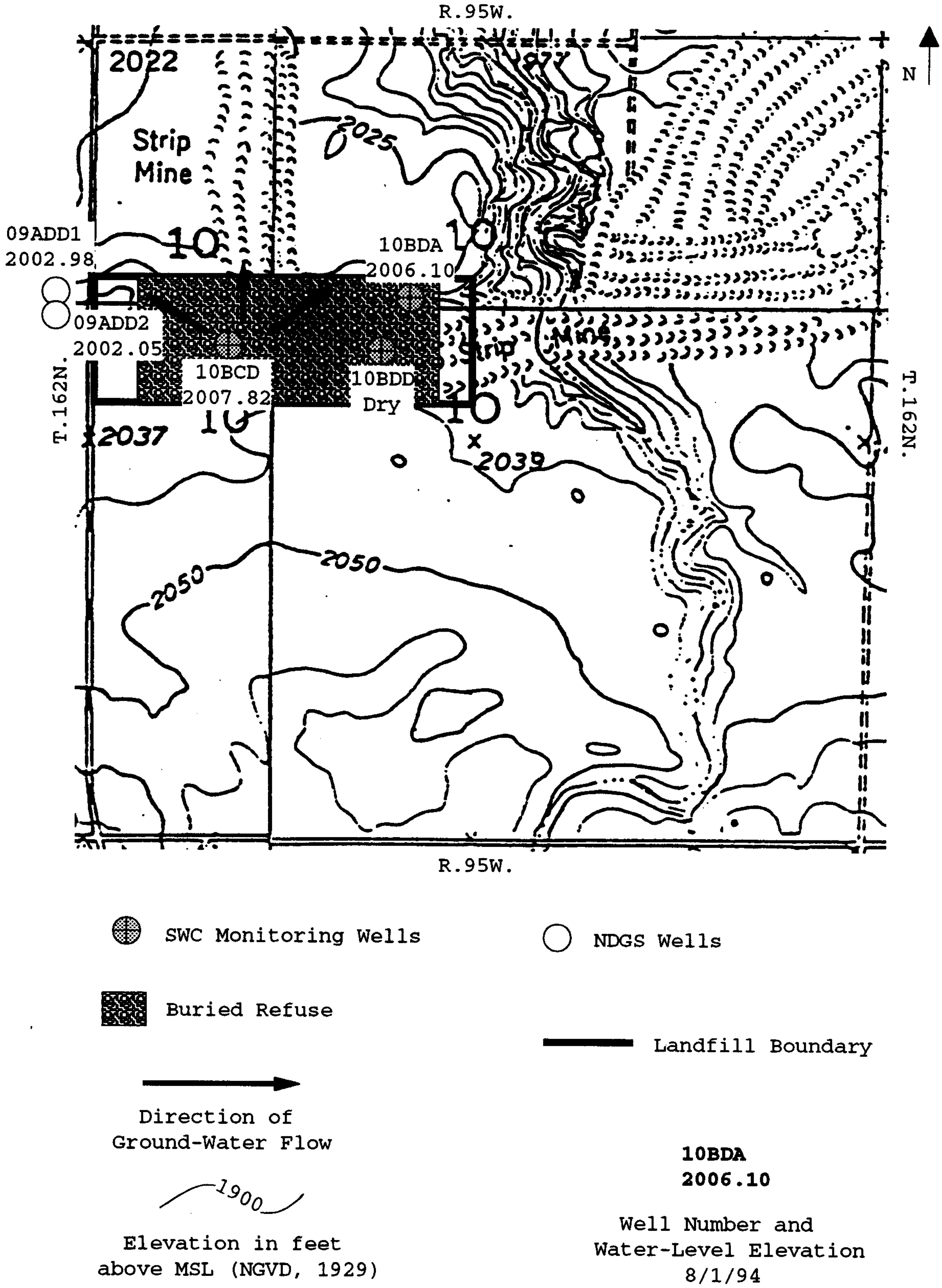

Figure 4. Location of monitoring wells and the direction of ground-water flow.

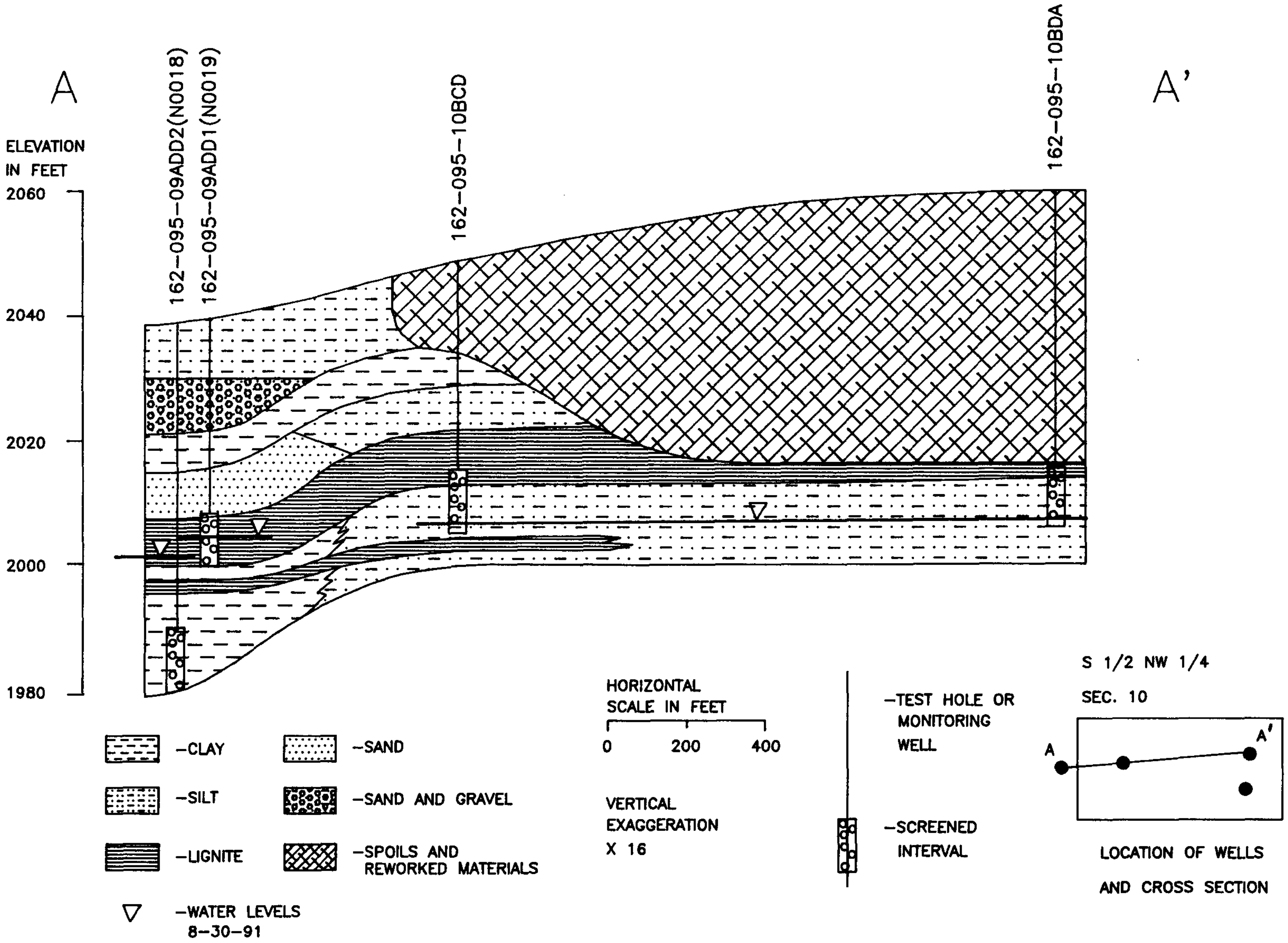

Figure 5. Geohydrologic section A–A' in the Northwest Solid Waste landfill.

HYDROLOGY

Surface-Water Hydrology

Numerous small ponds are located in depressions created by the mine spoils. Most of these ponds appear to be semi-permanent wetlands which are recharged mainly by precipitation. The small wetlands may be susceptible to contaminant migration by surface runoff within the landfill area. A larger wetland is located along the south edge of the landfill in the final cut of the Baukol-Noonan mine and should not be affected by contaminant migration from the landfill.

Regional Ground-Water Hydrology

Regional aquifers in the area of the NW Solid Waste landfill are located in the Bullion Creek and Sentinel Butte Formations or in glacial deposits. Aquifers within the Bullion Creek and Sentinel Butte Formations are located in zones of lignite and fine-grained, unconsolidated sandstone. These aquifers are located a few feet to about 400 feet below land surface (Armstrong, 1967). The city of Noonan obtains its water supply from the Bullion Creek aquifer with wells screened from 360 to 390 feet below land surface. Aquifers located in fractured lignite zones tend to be higher yielding. Recharge to these aquifers is by precipitation.

The direction of the regional ground-water flow is toward the Yellowstone aquifer (Armstrong, 1967).

Glacial aquifers are located within the ancient Yellowstone and Missouri River valleys (Armstrong, 1967). The Yellowstone River valley is located about 10 miles west of the landfill. This aquifer should not be affected by contaminant migration due to its distance up-gradient from the landfill (Armstrong, 1967). Water in the Yellowstone aquifer appears to flow south and north from a ground-water divide near Bright Water Lake (Armstrong, 1967).

The Wildrose aquifer is located about 15 miles southwest of the landfill. This aquifer occurs in collapsed outwash material consisting of fine sand to medium gravel with a thickness from 1 to 29 feet. This aquifer should not be affected by contaminant migration because of its distance up-gradient from the landfill.

Undifferentiated glacial aquifers may be located throughout the region. These aquifers are generally recharged by infiltration of precipitation, sloughs, and adjacent glacial deposits. There are no known undifferentiated glacial aquifers within a two-mile radius of the landfill.

Local Ground-Water Hydrology

Figure 4 shows the location of five monitoring wells used in this study (Appendix C). Two existing wells installed by the NDGS in 1982 along the west side of the landfill (09ADD1 and 09ADD2) were also used for this study. One well was screened in the Noonan lignite bed and one well is located in a layer of unconsolidated sandstone about 20 feet below the Noonan lignite bed. The three SWC/NDGS wells were screened at about the same depth as the Noonan lignite bed. The lignite has been removed from the landfill area except for a small area around well 162-095-10BCD. An abandoned oil well (no log) is located at this site.

Four water-level measurements were taken over an eight-week period (Appendix D). Monitoring well 162-095-10BDD was dry and monitoring wells 10BCD and 10BDA had only a trace of water during this investigation. Water-level measurements indicate that the direction of the local ground-water flow is to the north-northwest beneath the landfill (Fig. 4). The direction of the regional ground-water flow was determined by previous studies to be east-northeast.

Water Quality

Chemical analyses of water samples are shown in Appendix E. Mobilization of major ions and trace elements from the mine tailings may effectively mask input of major ions and trace elements from the landfill. Monitoring wells 10BCD and 10BDA did not have enough water to collect water samples for chemical analyses. Wells 09ADD1 and 09ADD2 detected concentrations of sodium (2,200 mg/L and 2,900 mg/L respectively) and sulfate (4,300 mg/L and 4,100 mg/L respectively) which are above the SMCL set by the Environmental Protection Agency. Bicarbonate concentrations measured in these wells also exceeded recommended levels. The source of these concentrations was not determined. The Sentinel Butte and Bullion Creek aquifers are characterized as a sodium-bicarbonate type water with varying concentrations of sulfate (Armstrong, 1967).

The water sample from well 09ADD1 indicated an iron concentration of 96 mg/L that exceeds the SMCL of 0.3 mg/L. Well 09ADD2 also detected an iron concentration of 1.2 mg/L that exceeded the SMCL. Based on previous investigations of lignite aquifers, the elevated iron concentrations may be derived from the lignite.

The trace element analyses indicated elevated concentrations of lead (21 µg/L), arsenic 27 µg/L), and strontium (3,900 µg/L) in well 09ADD1. These concentrations are below the MCL concentrations (Appendix A) and may be typical of ground water associated with the lignite aquifer in the study area.

The VOC analysis, from well 10BCD is shown in Appendix F. The VOC analyses detected the compounds chloroform (1.27 µg/L), bromodichloromethane (0.93 µg/L), chlorodibromomethane

(0.86 µg/L), toluene (0.64 µg/L), and tetrahydrofuran (75.7 µg/L). Chloroform, bromodichloromethane, chlorodibromomethane, and toluene are not associated with monitoring well construction. It is inconclusive as to whether the source of this VOC compound is the result of laboratory contamination† or migration from the landfill.

CONCLUSIONS

The Northwest Solid Waste landfill is situated near the base of the Missouri Escarpment. The region is covered with a thin layer of glacial sediments underlain by clay, silt, sand, sandstone, and lignite of the Sentinel Butte Formation. The landfill is located in the Baukol-Noonan lignite strip mine that operated between 1929 and 1962. Two small underground mines are also located near the landfill property. Monitoring wells 10BDA and 10BDD are located in the spoil area of the mine. The spoil material consists of variable amounts of silt, sand, and clay.

The surface hydrology at the Northwest Solid Waste landfill consists of numerous wetlands situated in depressions created by the spoil piles that are located throughout the landfill area. A large wetland is present to the south of the landfill in a final cut of the Baukol-Noonan

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† Beginning in September, 1994 the NDSDHCL changed their analytical procedures that lowered detection limits for VOC concentrations by one to two orders of magnitude.

lignite mine. These wetlands appear to be recharged by precipitation and surface runoff.

The uppermost aquifers beneath the landfill occur in the Bullion Creek and Sentinel Butte Formations. The depth of these aquifers ranges from a few feet to about 400 feet. The aquifer lithology consists of lignite and unconsolidated sand. The City of Noonan obtains its water supply from the Bullion Creek aquifer at a depth of 360 to 390 feet.

Mobilization of major ions and trace elements from the mine spoils may effectively mask input of major ions and trace elements from the landfill. Monitoring wells 10BCD and 10BDA did not have enough water to collect water samples for chemical analyses. Monitoring wells 09ADD1 and 09ADD2 detected anomalously high concentrations of sodium and sulfate that exceeded their SMCL.

The trace element analyses indicated elevated concentrations of lead, arsenic and strontium in well 09ADD1. These concentrations are below their MCL's but higher than the other wells in this study. These concentrations may be typical of ground water associated with the lignite aquifer in the study area.

The VOC analyses detected the compounds chloroform, bromodichloromethane, chlorodibromomethane, toluene, and tetrahydrofuran. It is inconclusive as to whether the source of this VOC compound is the result of laboratory contamination or migration from the landfill.

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Hem, J.D., 1989, Study and interpretation of the chemical characteristics of natural water: United States Geological Survey, Water-Supply Paper 2254, 263 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. Screw 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

162-095-10BCD
NDSWC

Date Completed:	5/9/94	Purpose:	Observation Well
L.S. Elevation (ft):	2048.52	Well Type:	2" PVC
Depth Drilled (ft):	48	Aquifer:	Bullion Creek
Screened Interval (ft):	32-42	Source:	
		Owner:	NW Consolidated Council

Lithologic Log

Unit	Description	Depth (ft)
CLAY	silty, fill.	0-3
CLAY	stiff, moderate yellowish brown, 10YR5/4.	3-9
SILT	fill, refuse.	9-14
CLAY	stiff, medium gray, N5, Bullion Creek Formation.	14-20
SILT	sandy, dark yellowish brown, 10YR4/2.	20-26
LIGNITE		26-35
SILT	very fine sand, medium gray, N5.	35-45
LIGNITE		45-46
SILT	medium gray, N5.	46-48

162-095-10BDA
NDSWC

Date Completed:	5/10/94	Purpose:	Observation Well
L.S. Elevation (ft):	2060.84	Well Type:	2" PVC
Depth Drilled (ft):	60	Aquifer:	Bullion Creek
Screened Interval (ft):	46-56	Source:	
		Owner:	NW SOLID WASTE COUNCIL

Lithologic Log

Unit	Description	Depth (ft)
CLAY	moderate yellowish brown, 10YR5/4, fill.	0-4
LIGNITE		4-5
CLAY	moderate yellowish brown, 10YR5/4.	5-16
CLAY	silty, moderate yellowish brown, 10YR5/4.	16-24
SAND	fine grained, clayey, silty, dark yellowish brown, 10YR4/2.	24-33
SILT	sandy, dark yellowish brown, 10YR4/2, Bullion Creek Formation.	33-44
LIGNITE		44-48
SILT	sandy, clayey, medium gray, N5.	48-60

162-095-10BDD

NDSWC

Date Completed:	5/9/94	Purpose:	Observation Well
L.S. Elevation (ft):	2060.68	Well Type:	2" PVC
Depth Drilled (ft):	60	Aquifer:	Bullion Creek
Screened Interval (ft):	45-55	Source:	
		Owner:	NW Solid Waste Council

Lithologic Log

Unit	Description	Depth (ft)
CLAY	with silt and lignite, fill.	0-8
CLAY	stiff, medium gray, N5.	8-13
SILT	clayey, moderate yellowish brown, 10YR5/4.	13-18
SILT	sandy, dark yellowish brown, 10YR4/2.	18-25
SAND	fine grained, clayey, medium gray, N5.	25-29
LIGNITE		29-30
SILT	with fine grained sand, medium gray, N5, Bullion Creek Formation.	30-48
LIGNITE		48-51
SILT	medium gray, N5.	51-60

NDGS Drill Log

Hole Number:	Noo 18	Date Drilled:	10/04/82
Location:	162-95-9 AD	Geologist:	Craig R. Schmit
Total Depth:	60' (18.3 m)	Driller:	Moe Drilling Inc.
Surface Elevation:	2039.67' (621.69 m)	Comments:	

Depth	Description
0-5'	Silt with some fine sand, clayey, tan, dry and very friable
5-10'	Silt to fine sand, clayey with occasional very high clay content, generally tan but gray where clay concentrated, Fe-oxide staining with local concentrations, friable where clay content low
10-18'	Sand, generally medium but some fine and coarse, clayey with local clay concentrations and some fine gravel, brown
18-20'	Clay, silty, gray to brownish-gray, massive, some Fe-oxide staining
20-25'	85% clay, slightly to moderately silty, gray to mainly brownish-gray, massive 10% sand, fine, clayey, brown, some Fe-oxide staining 5% clay, very slightly silty, orange
25-33'	Sand, fine, silty to clayey, tan to brown, very friable
33-40'	Lignite with clay parting from 36-36.5' (driller picked lignite from 33-39 or 39.5' with parting as noted)
40-42'	Clay, very slightly silty, gray to dark gray, massive
42-42.25'	Lignite and or carbonaceous shale (driller's pick)
42.25-50'	Clay, very slightly silty, gray to dark gray, massive
50-54'	Clay, silty, dark gray to mainly gray, massive
54-55'	Silt, very clayey, gray, quite friable
55-60'	Clay, some silty, to clayey silt, mainly gray with some dark gray, massive

NDGS Drill Log

Hole Number:	Noo 19	Date Drilled:	10/04/82
Location:	162-95-9 AD	Geologist:	Craig R. Schmit
Total Depth:	60' (18.3 m)	Driller:	Moe Drilling Inc.
Surface Elevation:	2039.67' (621.69 m)	Comments:	

Depth	Description
0-5'	Silt with some fine sand, clayey, tan, dry and very friable
5-10'	Silt to fine sand, clayey with occasional very high clay content, generally tan but gray where clay concentrated, Fe-oxide staining with local concentrations, friable where clay content low
10-18'	Sand, generally medium but some fine and coarse, clayey with local clay concentrations and some fine gravel, brown
18-20'	Clay, silty, gray to brownish-gray, massive, some Fe-oxide staining
20-25'	85% clay, slightly to moderately silty, gray to mainly brownish-gray, massive 10% sand, fine, clayey, brown, some Fe-oxide staining 5% clay, very slightly silty, orange
25-33'	Sand, fine, silty to clayey, tan to brown, very friable
33-40'	Lignite with clay parting from 36-36.5' (driller picked lignite from 33-39 or 39.5' with parting as noted)

APPENDIX D

WATER-LEVEL TABLES

Northwest Solid Waste Landfill Water Levels
6/20/94 to 8/30/94

162-095-09ADD1 — MP Elev (msl,ft)=2040.26
Bullion Creek Aquifer — SI (ft.)=0-0

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/20/94	37.36	2002.90	08/17/94	37.31	2002.95
07/18/94	37.25	2003.01	08/30/94	37.35	2002.91
08/01/94	37.28	2002.98			

162-095-09ADD2 — MP Elev (msl,ft)=2040.13
Bullion Creek Aquifer — SI (ft.)=0-0

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/20/94	38.45	2001.68	08/17/94	38.11	2002.02
07/18/94	38.04	2002.09	08/30/94	38.17	2001.96
08/01/94	38.08	2002.05			

162-095-10BCD — MP Elev (msl,ft)=2050.41
Bullion Creek Aquifer — SI (ft.)=33-43

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/20/94	0.00	2050.41	08/17/94	42.82	2007.59
07/18/94	42.40	2008.01	08/30/94	43.01	2007.40
08/01/94	42.59	2007.82			

162-095-10BDA — MP Elev (msl,ft)=2062.9
Bullion Creek Aquifer — SI (ft.)=47-57

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/20/94	0.00	2062.90	08/17/94	56.99	2005.91
07/18/94	56.64	2006.26	08/30/94	57.21	2005.69
08/01/94	56.80	2006.10			

162-095-10BDD — MP Elev (msl,ft)=2062.59
Bullion Creek Aquifer — SI (ft.)=45-55

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/20/94	0.00	2062.59	08/17/94	0.00	2062.59
07/18/94	0.00	2062.59	08/30/94	0.00	2062.59
08/01/94	0.00	2062.59			

APPENDIX E

MAJOR ION AND TRACE-ELEMENT CONCENTRATIONS

NW Solid Waste Management Landfill Water Quality
Major Ions

Location	Screened Interval (ft)	Date Sampled	SiO_2	Fe	Mn	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	NO_3	B	TDS	Hardness as $CaCO_3$	NCH	% Na	SAR	Spec Cond (µmho)	Temp (∞C)	pH
			(milligrams per liter)																					
162-095-09ADD1	0-0	06/20/94	71	96	4.1	190	70	2200	18	1370	0	4300	15	0.2	2	1.3	7640	760	0	85	35	10100	10	6.86
162-095-09ADD2	0-0	06/20/94	18	1.2	0.92	65	40	2900	16	2920	0	4100	68	0.5	9.1	0.18	8660	330	0	95	69	12700	27	7.21

Trace Element Analyses

Location	Date Sampled	Selenium	Lead	Cadmium	Mercury	Arsenic	Molybdenum	Strontium
		(micrograms per liter)						
162-095-09ADD1	6/20/94	0	0	0	0.1	0	2	2100
162-095-09ADD2	8/01/94	0	12	2	0.1	69	0	3600

APPENDIX F

VOLATILE ORGANIC COMPOUNDS
FOR WELL 162-095-10BCD

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	<0.5
Vinyl Chloride	<0.5
Carbon Tetrachloride	<0.5
1,2-Dichlorethane	<0.5
Trichloroethylene	<0.5
1,1-Dichloroethylene	<0.5
1,1,1-Trichloroethane	<0.5
para-Dichlorobenzene	<0.5
Acetone	<50
2-Butanone (MEK)	<50
2-Hexanone	<50
4-Methyl-2-pentanone	<50
Chloroform	1.27*
Bromodichloromethane	0.93*
Chlorodibromomethane	0.86*
Bromoform	<0.5
trans1,2-Dichloroethylene	<0.5
Chlorobenzene	<0.5
m-Dichlorobenzene	<0.5
Dichloromethane	<0.5
cis-1,2-Dichloroethylene	<0.5
o-Dichlorobenzene	<0.5
Dibromomethane	<0.5
1,1-Dichloropropene	<0.5
Tetrachlorethylene	<0.5
Toluene	0.64*
Xylene(s)	<0.5
1,1-Dichloroethane	<0.5
1,2-Dichloropropane	<0.5
1,1,2,2-Tetrachloroethane	<0.5
Ethyl Benzene	<0.5
1,3-Dichloropropane	<0.5
Styrene	<0.5
Chloromethane	<0.5
Bromomethane	<0.5
1,2,3-Trichloropropane	<0.5
1,1,1,2-Tetrachloroethane	<0.5
Chloroethane	<0.5
1,1,2-Trichloroethane	<0.5

* Constituent Detection

VOC Constituents cont.

2,2-Dichloropropane	<0.5
o-Chloroluene	<0.5
p-Chlorotoluene	<0.5
Bromobenzene	<0.5
1,3-Dichloropropene	<0.5
1,2,4-Trimethylbenzene	<0.5
1,2,4-Trichlorobenzene	<0.5
1,2,3-Trichlorobenzene	<0.5
n-Propylbenzene	<0.5
n-Butylbenzene	<0.5
Naphthalene	<0.5
Hexachlorobutadiene	<0.5
1,3,5-Trimethylbenzene	<0.5
p-Isopropyltoluene	<0.5
Isopropylbenzene	<0.5
Tert-butylbenzene	<0.5
Sec-butylbenzene	<0.5
Fluorotrichloromethane	<0.5
Dichlorodifluoromethane	<5
Bromochloromethane	<0.5
Allylchloride	<5
2,3-Dichloro-1-propane	<5
Tetrahydrofuran	75.7*
Pentachloroethane	<5
Trichlorotrifluoroethane	<5
Carbondisufide	<5
Ether	<5
trans-1,3-Dichloropropene	<0.5

* Constituent Detection