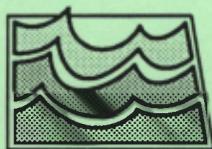


Site Suitability Review of the Dunseith Landfill (Joe Murphy)

by
Jeffrey Olson
North Dakota State Water Commission
and
Phillip L. Greer
North Dakota Geological Survey



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

ND Landfill Site Investigation No. 28

SITE SUITABILITY REVIEW
OF THE
DUNSEITH LANDFILL
(Joe Murphy)

By Jeffrey M. Olson, North Dakota State Water Commission,
and Phillip L. Greer, North Dakota Geological Survey

North Dakota Landfill Site Investigation 28

Prepared by the NORTH DAKOTA STATE WATER COMMISSION
and the NORTH DAKOTA GEOLOGICAL SURVEY

Bismarck, North Dakota
1994

TABLE OF CONTENTS

	Page
INTRODUCTION	1
Purpose	1
Location of the Dunseith Landfill	1
Previous Site Investigations	3
Methods of Investigation	3
Test Drilling Procedure	3
Monitoring Well Construction and Development ...	3
Collecting and Analyzing Water Samples	6
Water-Level Measurements	8
Well-abandonment procedure	8
Location-Numbering System	10
GEOLOGY	10
Regional Geology	10
Local Geology	12
HYDROLOGY	15
Surface Water Hydrology	15
Regional Ground-Water Hydrology	16
Local Ground-Water Hydrology	17
Water Quality	18
CONCLUSIONS	19
REFERENCES	21
APPENDIX A Water Quality Standards and Maximum Contaminant Levels	22
APPENDIX B Sampling Procedure for Volatile Organic Compounds	24

TABLE OF CONTENTS (cont.)

	Page
APPENDIX C Lithologic Logs of Wells and Test Holes.....	26
APPENDIX D Water Level Tables.....	32
APPENDIX E Major Ion and Trace Element Concentrations.....	34
APPENDIX F Volatile Organic Compounds for Well 162-073-04CBA.....	36
APPENDIX G Volatile Organic Compounds for Well 162-073-04CBBD.....	39

LIST OF FIGURES

	Page
Figure 1. Location of the Dunseith landfill in the SW quarter of section 4, T162N, R73W.....	2
Figure 2. Well construction design used for monitoring wells installed at the Dunseith landfill.....	5
Figure 3. Well abandonment procedures.....	9
Figure 4. Location-numbering system for the Dunseith landfill.....	11
Figure 5. Location of monitoring wells and test holes at the Dunseith landfill.....	13
Figure 6. Hydrogeologic-section A-A' in the Dunseith landfill.....	14

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 (NDS DHCL) 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 NDS DHCL for continued operation of solid waste landfills. The Dunseith solid waste landfill is one of the landfills being evaluated.

Location of the Dunseith Landfill

The Dunseith solid waste landfill is located five miles west and five miles north of the City of Dunseith in Township 162 North, Range 73 West, SW 1/4 Section 4 (Fig. 1). The landfill site encompasses approximately 10 acres.

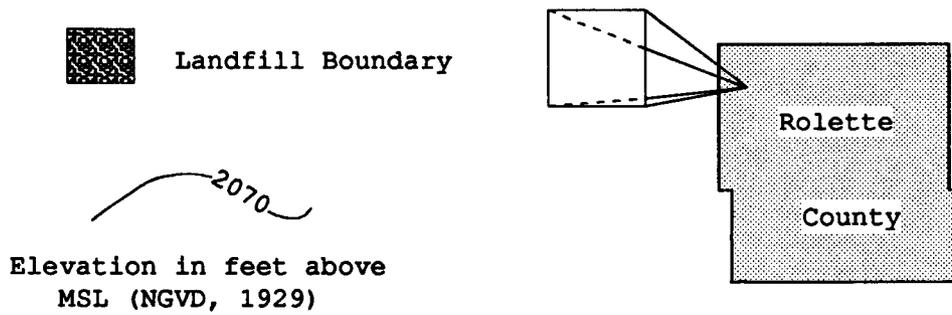
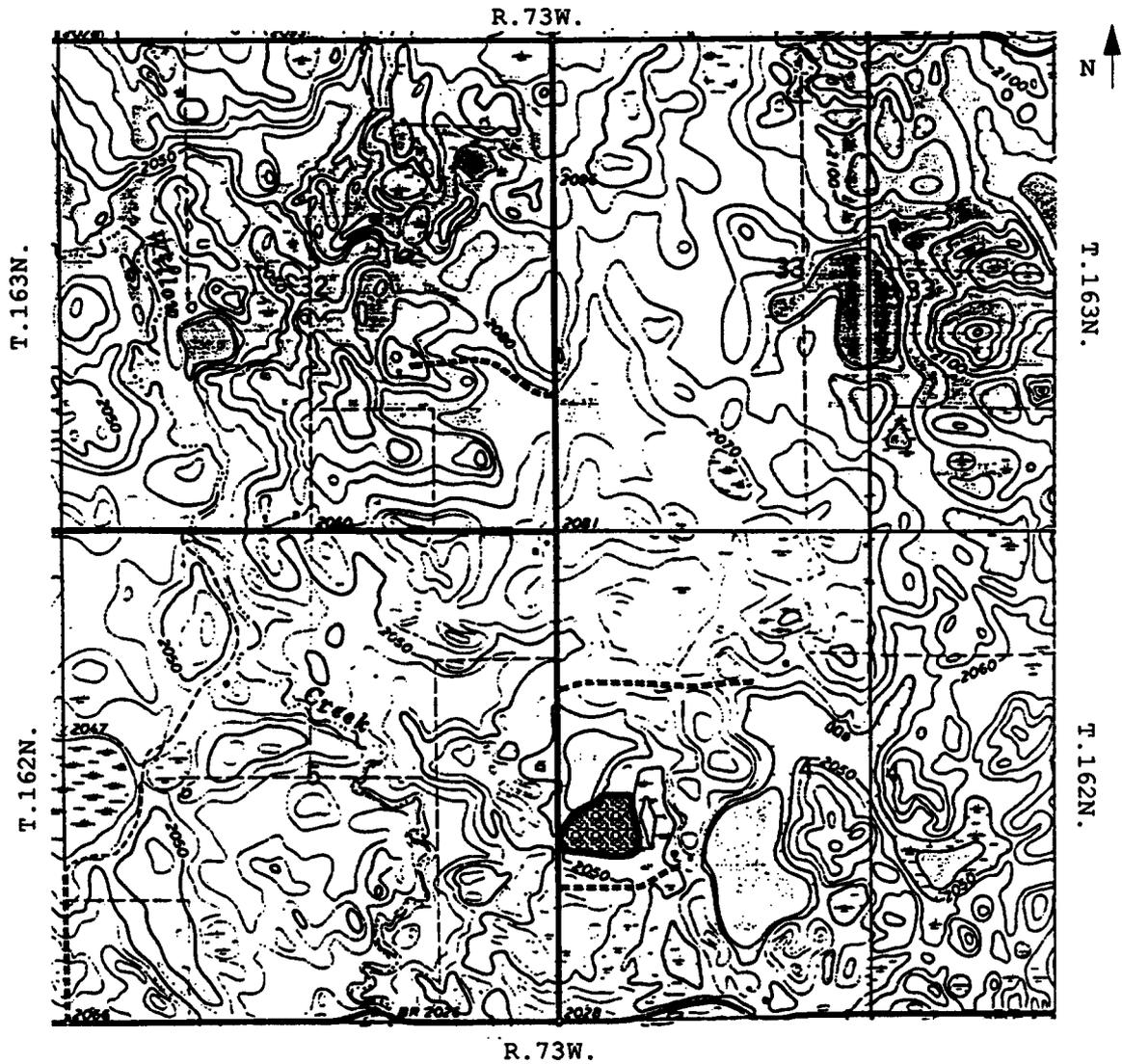


Figure 1. Location of the Dunseith landfill in the SW 1/4, section 4, T.162N., R.73W.

Previous Site Investigations

No previous hydrogeologic investigations are available from the Dunseith landfill.

Methods of Investigation

The Dunseith 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. Well abandonment procedures were followed for non-permanent monitoring wells.

Test-Drilling Procedure

The drilling method at the Dunseith landfill was based on the site's geology and depth to ground water, as determined by the preliminary evaluation. A hollow-stem auger was used at the Dunseith landfill because the sediments were poorly consolidated and because the depth to the water table was expected to be less than 70 feet. The lithologic descriptions were determined from the drill cuttings.

Monitoring Well Construction and Development

Five test holes were drilled at the Dunseith landfill, and monitoring wells were installed in four of the test

holes. The number of wells installed at the Dunseith 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 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 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

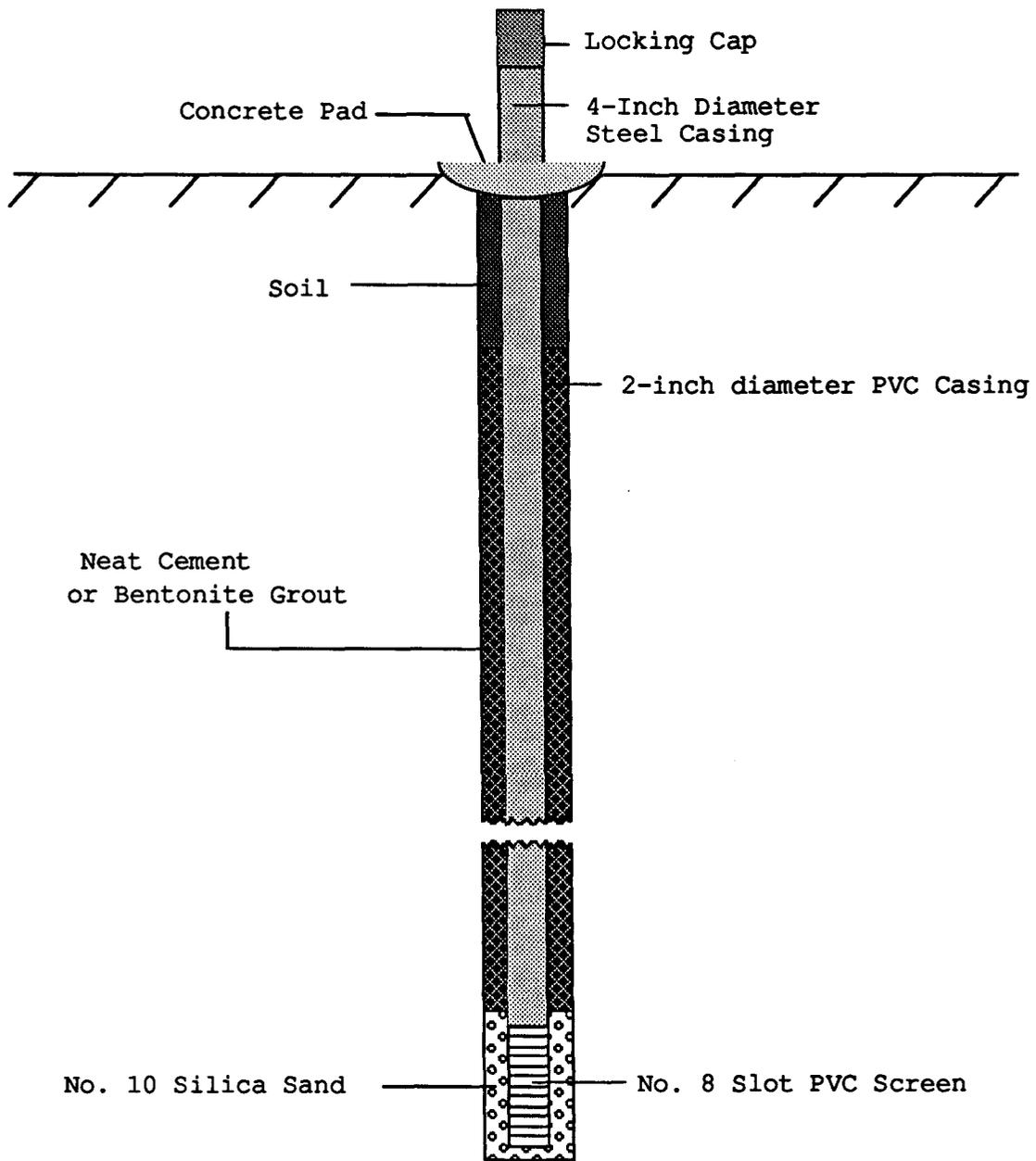


Figure 2. Construction design used for monitoring wells installed at the Dunseith landfill.

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, field 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 Water Commission (NDSWC) Laboratory and VOC analyses were performed by the NDS DHCL.

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

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.

Well-Abandonment Procedure

The test holes and monitoring wells that were not permanent were abandoned according to NDS DHCL and Board of Water Well Contractors regulations (North Dakota Department of Health, 1986). The soil around the well was dug to a depth of approximately three to four feet below land surface (Fig. 3) to prevent disturbance of the sealed wells. The screened interval of the well was plugged with bentonite chips to a height of approximately one foot above the top of the screen and the remaining well casing was filled with neat cement. The upper three to four feet was then filled with cuttings and the disturbed area was blended into the surrounding land surface. Test holes were plugged with high-solids bentonite grout and/or neat cement to a depth approximately five feet below land surface. The upper five feet of the test hole was filled with soil cuttings.

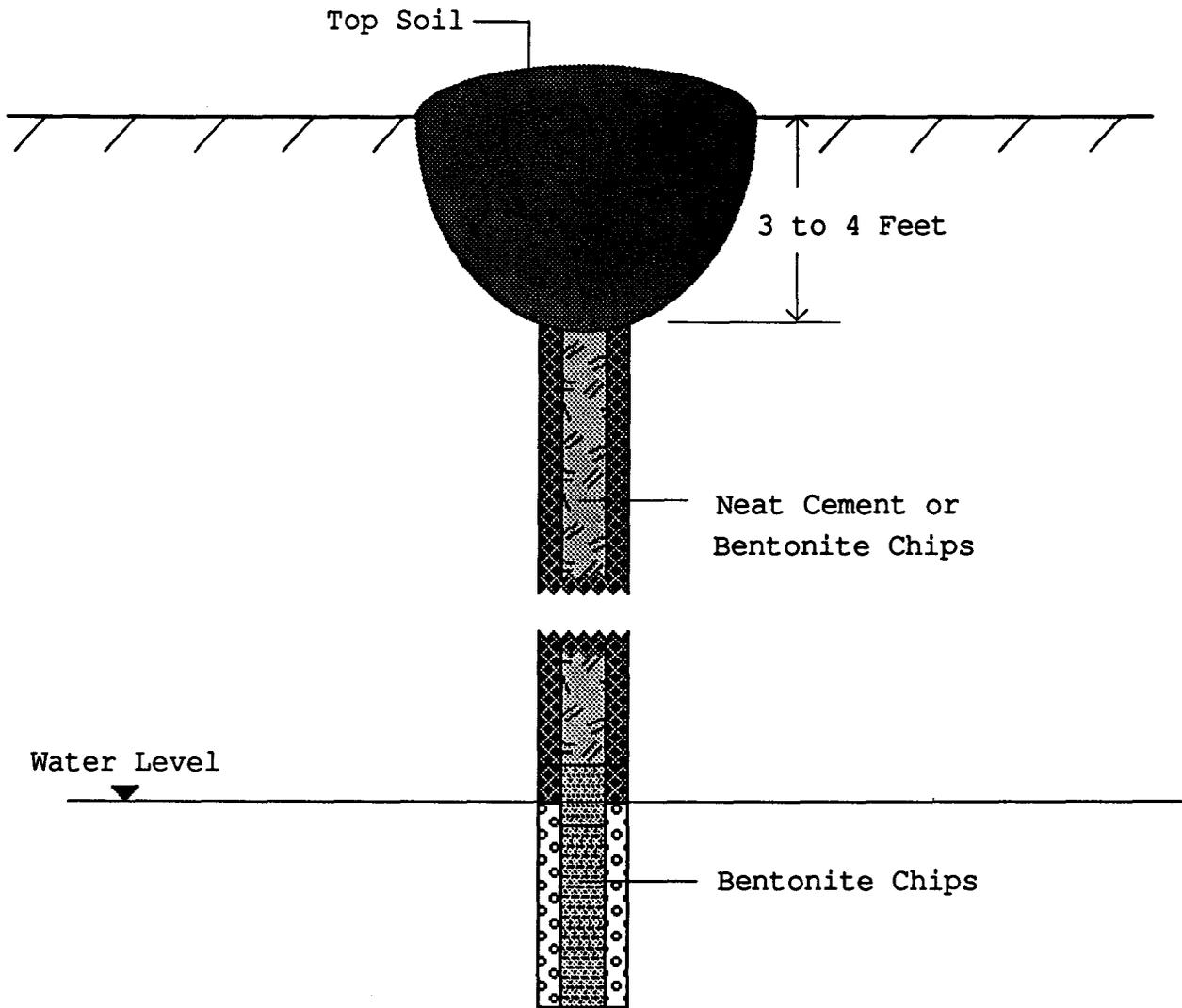


Figure 3. Monitoring well abandonment procedures.

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. 4). 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 162-073-04CBA would be located in the NE1/4, NW1/4, SW1/4, Section 4, Township 162 North, Range 73 West. Consecutive numbers are added following the three letters if more than one well is located in a 10-acre tract, e.g. 162-073-04CBA1 and 162-073-04CBA2.

GEOLOGY

Regional Geology

The Dunseith landfill is located within the Turtle Mountains. The present topography of the Turtle Mountains originated when a previously existing plateau was overridden by glaciers. Compression and shearing within the glaciers brought large amounts of material to the surface of the ice.

162-073-04CBA

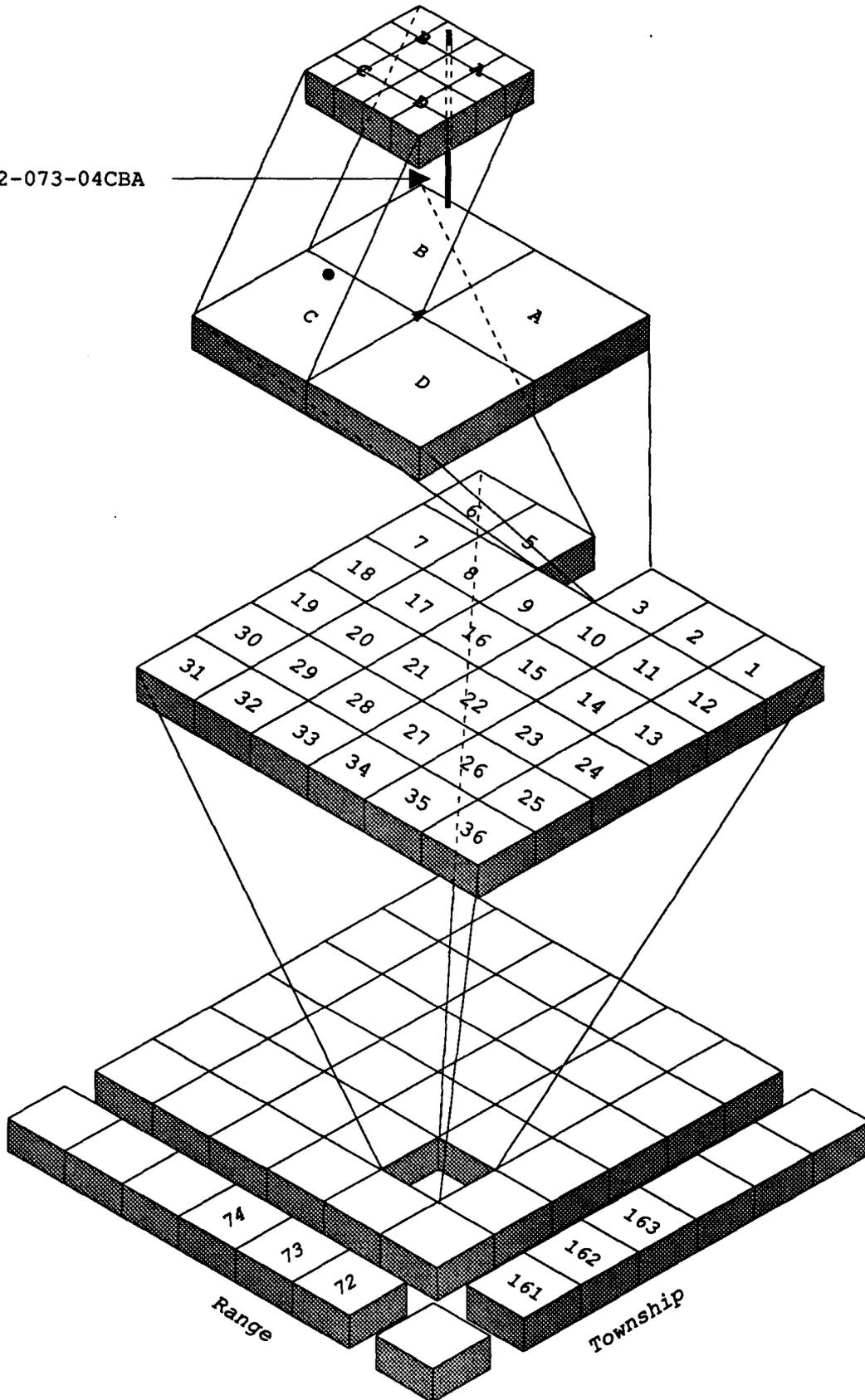


Figure 4. Location-numbering system for the Dunseith landfill.

This supraglacial sediment insulated the ice below. Ice-walled lakes developed on top of the supraglacial sediment. When the ice eventually melted the supraglacial sediment was redeposited by mudflows (Deal, 1971; Bluemle, 1991).

The Turtle Mountains stand about 400 feet above the surrounding plain. The collapsed supraglacial sediments have produced a hummocky topography with significant local relief and numerous closed depressions. The geologic materials at or near the surface consist of glacial till, lake sediments, and outwash.

Local Geology

The Dunseith landfill is located on a small, conical hill (Fig. 5). Four test holes for this study were drilled around the base of the hill, and one test hole was drilled on top of the hill. The test hole drilled on top of the hill (162-073-04CBBD) penetrated 4 feet of till followed by 31 feet of sand and 7 more feet of till (Fig. 6). Based on shape and lithology, the hill is probably a kame with a thin layer of till draped over the surface.

On the east side of the hill test hole 162-073-04CBA encountered 5 feet of sand near the surface underlain by 4 feet of till. This hole bottomed in medium to coarse sand at a depth of 20 feet (Fig. 6). The remaining three test holes encountered till with a few intervals of clay (lithologic

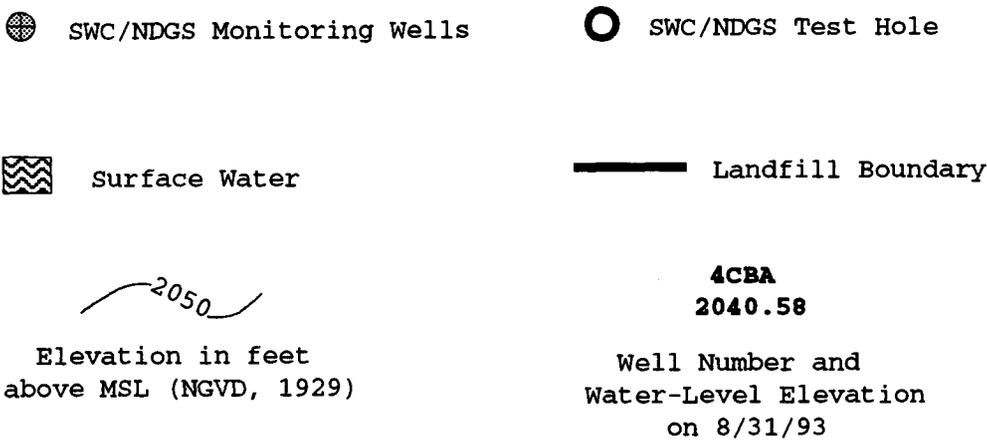
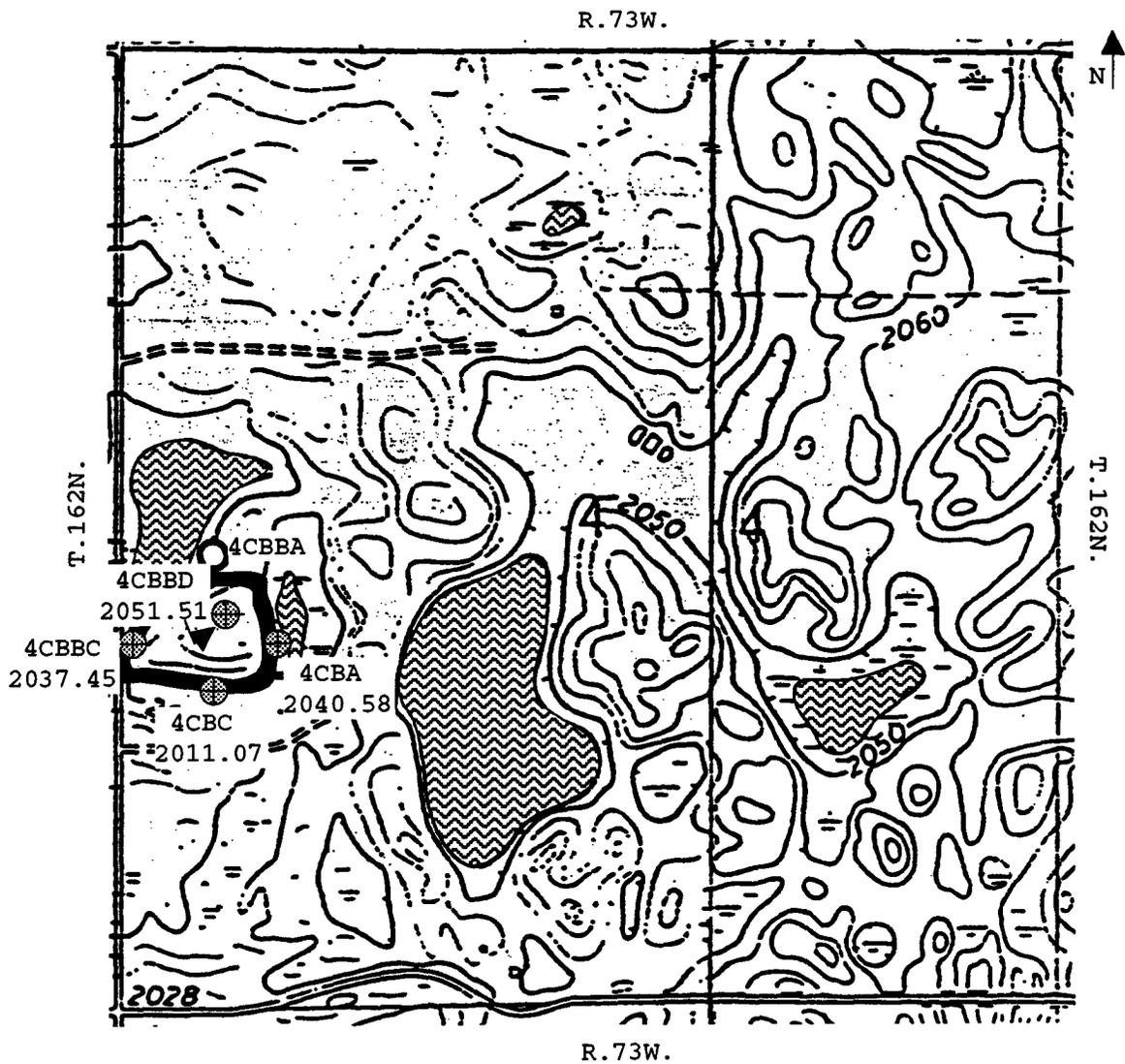


Figure 5. Location of monitoring wells and test holes at the Dunseith landfill.

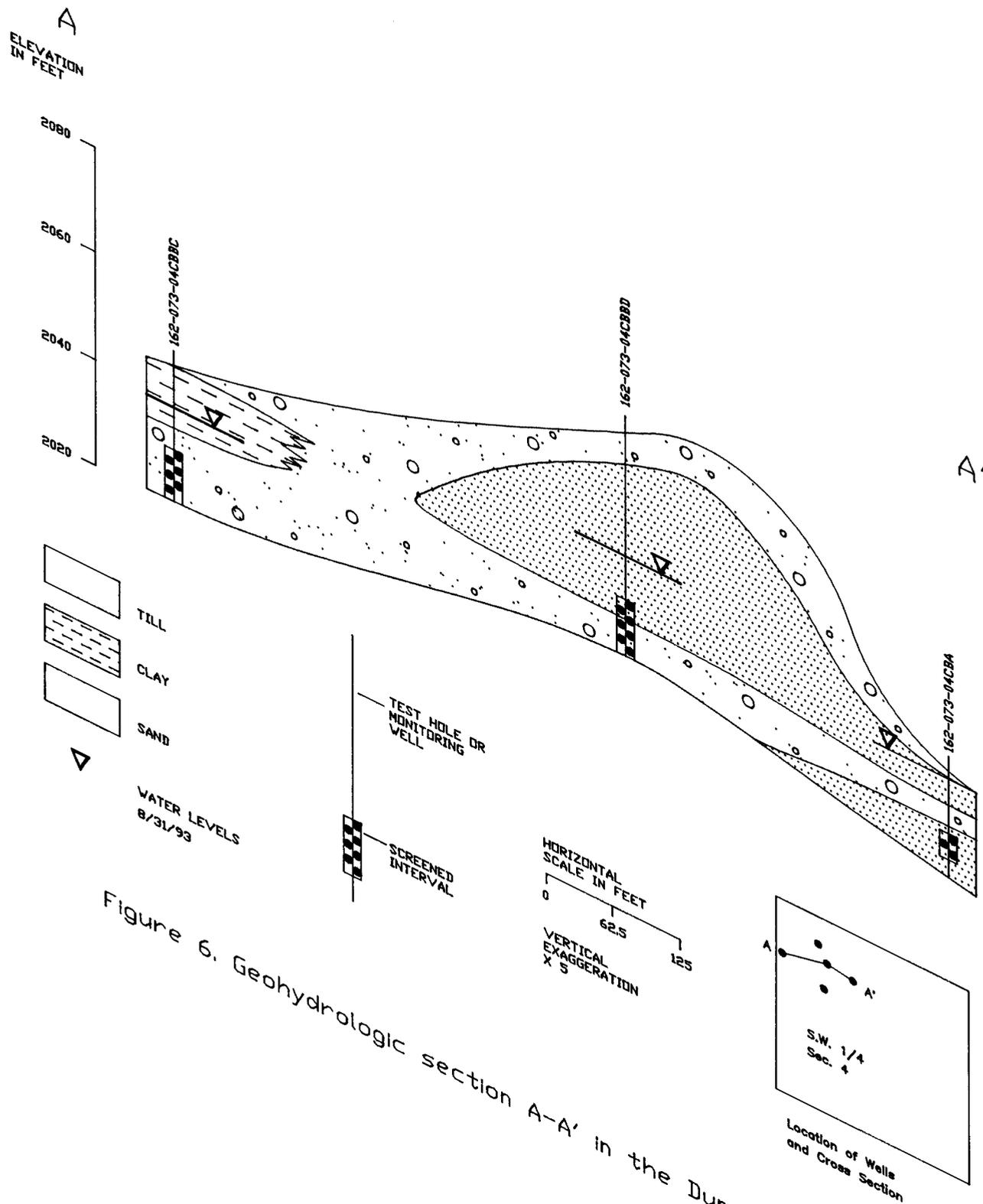


Figure 6. Geohydrologic section A-A' in the Dunseith Landfill.

logs in Appendix C). The till at this location is very clay-rich, with little sand and a trace of gravel.

HYDROLOGY

Surface-Water Hydrology

The Dunseith landfill is located in an area of collapsed glacial sediments with a hummocky topography (Fig. 1). Several wetlands and depressions are located near the boundaries of the landfill. Water samples were not collected from any of the surface waters.

Wetlands near the Dunseith landfill are both seasonal and semi-permanent. Seasonal wetlands contain water during certain periods of the year while semi-permanent wetlands contain water throughout most of the year. Wetlands act as discharge areas for the ground water during periods of low precipitation and collection basins for surface-water runoff.

A temporary wetland is located below the eastern slope of the disposal area. This wetland may be susceptible to contaminant migration from surface runoff and lateral groundwater flow from the disposal area. A semi-permanent wetland is located at the base of the northwestern slope of the disposal area. This wetland also may be susceptible to contaminant migration from surface runoff and lateral groundwater flow from the disposal area.

Willow Lake is located about 2.5 miles north of the landfill. Willow Lake should not be susceptible to contaminant migration because of its up-gradient location from the landfill.

Willow Creek is located about one-quarter mile west of the landfill. This creek flows south from Willow Lake and discharges into the Souris River. Willow Creek should not be susceptible to subsurface contaminant migration from the landfill the occurrence of low hydraulic conductivity till between the landfill and Willow Creek.

Regional Ground-Water Hydrology

Regional aquifers consist of both glacial and bedrock lithologies. There are no major glacial aquifers within a two-mile radius of the Dunseith landfill.

Undifferentiated sand and gravel aquifers are found throughout the region and commonly are a source for domestic and stock supplies. These aquifers are not extensive and as a result are characterized by limited recharge. The undifferentiated aquifers generally are characterized by a mixed cation-bicarbonate-sulfate type water (Randich and Kuzniar, 1984).

The Hell Creek Formation directly underlies the glacial till in the area of the landfill and is comprised of discontinuous sandstone beds that vary in thickness and area (Randich and Kuzniar, 1984). This aquifer is characterized

by a sodium-sulfate type water. The City of Dunseith obtains its municipal water supply from the Hell Creek aquifer.

The Fox Hills aquifer is the most extensive bedrock aquifer in the area of the landfill and is comprised of sandstone with an average thickness of about 25 feet (Randich and Kuzniar, 1984). Recharge to the Fox Hills aquifer is by precipitation and lateral flow from adjacent aquifers. Discharge is by pumping or flowing wells, seeps, and lateral flow into streams, and adjacent aquifers (Randich and Kuzniar, 1984). The regional flow of the Fox Hills aquifer is toward the Souris River valley. This aquifer is characterized by a sodium-mixed anion type water (Randich and Kuzniar, 1984). Both the Hell Creek and the Fox Hills aquifers should not be susceptible to contaminant migration from the landfill.

Local Ground-Water Hydrology

Four monitoring wells were installed at the Dunseith landfill (Fig. 5). The well screens were placed in the uppermost undifferentiated glacial aquifer. Four water-level measurements were taken over a seven-week period. Well 162-073-04CBBB is located at the top of the hill near the refuse cells. This well is screened in a glacial sand deposit that is about 31 feet thick (Fig. 6). This sand may be hydraulically connected to the sand at well 04CBA which is located at the base of the eastern slope next to a seasonal

wetland (Fig. 5). The local ground-water flow direction was indeterminate using available data. Given that the water table is a subdued replica of the land surface topography, local ground-water flow probably radiates outward from the small conical hill where the landfill is located.

Water Quality

Chemical analyses of water samples are shown in Appendix E. Well 04CBA, located at the base of the eastern slope of the buried refuse, indicated elevated concentrations of iron (5.4 mg/L), magnesium (440 mg/L), sulfate (2,100 mg/L), and total dissolved solids (3,630 mg/L). These concentrations exceed the SMCL and recommended concentrations set by the EPA (Appendix A). These concentrations also exceed the concentrations measured from the other wells in this study.

A selenium concentration of 130 $\mu\text{g/L}$ was detected in well 04CBBC. This is 13 times higher than the MCL of 10 $\mu\text{g/L}$. A molybdenum concentration of 104 $\mu\text{g/L}$, also detected in well 04CBBC, exceeded the MCL of 100 $\mu\text{g/L}$. This well is located at the base of the western slope of the buried refuse. These concentrations exceed the concentrations measured from other wells in this area. The source of these trace elements may be due to contaminant migration from the buried refuse.

Results of the VOC analyses, from wells 04CBA and 04CBBD, are shown in Appendices F and G. The results from

well 04CBA detected three VOC compounds. They are chloroform (32.2 µg/L), bromodichloromethane (7.28 µg/L), and chlorodibromomethane (3.71 µg/L). These compounds are man-made and are associated with numerous manufacturing processes. Because these compounds are not associated with well construction leachate migration from the landfill is considered a plausible source.

CONCLUSIONS

The Dunseith landfill is located on a small, conical hill within the Turtle Mountains. The geologic materials at or near the surface consist of till, lake sediments, and outwash.

The lithology and shape of the hill that is used for refuse disposal appears to be a typical kame with a thin layer of till over the surface. The sand deposit of the hill appears to extend to the wetland at the base of the eastern slope of the hill.

Wetlands are located throughout the area of the Dunseith landfill. A temporary wetland located at the base of the eastern slope of the landfill may be susceptible to contaminant migration from surface-water runoff and lateral ground-water flow. A semi-permanent wetland located at the base of the northwestern slope of the landfill also may be

susceptible to contaminant migration by surface runoff and lateral ground-water flow.

The major aquifers in the region of the Dunseith landfill consist of undifferentiated glacial aquifers and bedrock aquifers. The Fox Hills and Hell Creek aquifers should not be susceptible to contaminant migration from the landfill. Local undifferentiated glacial aquifers may be susceptible to contaminant migration from the landfill.

Well 04CBA detected increased concentrations of iron, sulfate, magnesium, and total dissolved solids that exceed the EPA's SMCL and recommended concentration limits. Well 04BBC detected selenium and molybdenum concentrations that exceeded their MCL's. The source of these elevated concentrations may be due to contaminant migration from the landfill.

A VOC analysis from well 04CBA, detected chloroform, bromodichloromethane, and chlorodibromomethane. These compounds are man-made and are associated with numerous manufacturing processes. Because these compounds are not associated with well construction leachate migration from the landfill is considered a plausible source.

REFERENCES

- Bluemle, J.P., 1991, The face of North Dakota, revised edition: North Dakota Geological Survey, Educational Series 21, 177 p.
- Deal, D.E., 1971, Geology of Rolette County, North Dakota: North Dakota Geological Survey, Bulletin 58, 89 p.
- Hem, J.D., 1989, Study and interpretation of the chemical characteristics of natural water: United States Geological Survey, Water-Supply Paper 2254, 263 p.
- North Dakota Department of Health, 1986, Water well construction and water well pump installation: Article 33-18 of the North Dakota Administrative Code, 42 p.
- Randich, P.G., and Kuzniar, R.L., 1984, Ground-water resources of Bottineau and Rolette Counties, North Dakota: North Dakota Geological Survey, Bulletin 78, North Dakota State Water Commission, County Ground-Water Studies 35, Part III, 41 p.

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	-----

<u>Constituent</u>	<u>MCL (µg/L)</u>
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).

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

	<u>Recommended Concentration Limits (mg/L)</u>
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

162-073-04CBA

NDSWC

Date Completed:	7/13/93	Purpose:	Observation Well
L.S. Elevation (ft):	2041.83	Well Type:	2" PVC
Depth Drilled (ft):	17	Aquifer:	UND
Screened Interval (ft):	12-17	Source:	
		Owner:	Joe Murphy

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	Clayey, trace gravel, dark yellowish brown 10YR4/2 (till).	2-7
CLAY	Sandy, trace gravel, dark yellowish brown 10YR4/2 (till).	7-11
SAND	Medium to coarse, moderate yellowish brown 10YR5/4.	11-17

162-073-04CBBA

NDSWC

Date Completed:	7/14/93	Purpose:	Observation Well
L.S. Elevation (ft):	2047.84	Well Type:	0" None
Depth Drilled (ft):	65	Aquifer:	UND
Screened Interval (ft):	0-0	Source:	
		Owner:	Joe Murphy

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Dark yellowish brown 10YR4/2.	1-4
CLAY	Gravelly, trace sand, moderate yellowish brown 10YR5/4 (till).	4-11
CLAY	Trace gravel, moderate yellowish brown 10YR 5/4 (till).	11-32
CLAY	Trace sand and gravel, olive gray 5Y4/1 (till).	32-48
CLAY	Trace gravel, olive gray 5Y4/1 (till).---DRY HOLE.	48-65

162-073-04CEBC

NDSWC

Date Completed: 7/14/93
 L.S. Elevation (ft): 2045.99
 Depth Drilled (ft): 25
 Screened Interval (ft): 15-25

Purpose:
 Well Type:
 Aquifer:
 Source:
 Owner:

Observation Well
 2" PVC
 UND
 Joe Murphy

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	Olive black 5Y2/1.	2-8
CLAY	Pale yellowish brown 10YR6/2.	8-12
CLAY	Trace sand, moderate yellowish brown 10YR 5/4.	12-14
CLAY	Silty, few small pebbles, moderate yellowish brown 10YR5/4 (till).	14-20
CLAY	Silty, few small pebbles, medium dark gray ~4 (till).	20-25

162-073-04CBED

NDSWC

Date Completed:	7/14/93	Purpose:	Observation Well
L.S. Elevation (ft):	2075.41	Well Type:	2" PVC
Depth Drilled (ft):	42	Aquifer:	UND
Screened Interval (ft):	32-42	Source:	
		Owner:	Joe Murphy

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Sandy, trace gravel, moderate yellowish brown 10YR5/4 (till).	1-4
SAND	Fine grained, clayey, trace gravel, moderate yellowish brown 10YR5/4 (till).	4-23
SAND	Fine grained, pale yellowish brown 10YR6/2.	23-28
SAND	Fine to medium grained, clayey, trace gravel, moderate yellowish brown 10YR5/4.	28-35
CLAY	Sandy, trace gravel, moderate yellowish brown 10YR5/4 (till).	35-39
CLAY	Trace sand and gravel, olive gray 5Y4/1 (till).	39-42

162-073-04CBC

NDSWC

Date Completed:	7/13/93	Purpose:	Observation Well
L.S. Elevation (ft):	2044.81	Well Type:	2" PVC
Depth Drilled (ft):	50	Aquifer:	UND
Screened Interval (ft):	40-50	Source:	
		Owner:	Joe Murphy

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Trace sand and gravel, pale yellowish brown (till).	1-4
CLAY	Trace sand and gravel, moderate yellowish brown with orange mottling (till).	4-16
CLAY	Silty, trace sand and gravel, olive gray 5Y4/1	16-21
CLAY	Silty, olive gray 5Y4/1.	21-27
CLAY	Trace sand and pebbles, olive gray 5Y4/1 (till).	27-33
CLAY	Rare pebbles, olive gray 5Y4/1.	33-50

APPENDIX D

WATER-LEVEL TABLES

Dunseith Water Levels
7/28/93 to 9/16/93

162-073-04CBA
UND Aquifer

LS Elev (msl, ft)=2041.83
SI (ft.)=12-17

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/28/93	0.22	2041.61	08/31/93	1.25	2040.58
08/19/93	1.90	2039.93	09/16/93	1.85	2039.98

162-073-04CBC
UND Aquifer

LS Elev (msl, ft)=2045.99
SI (ft.)=15-25

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/28/93	6.51	2039.48	08/31/93	8.54	2037.45
08/19/93	8.70	2037.29	09/16/93	8.52	2037.47

162-073-04CBD
UND Aquifer

LS Elev (msl, ft)=2075.41
SI (ft.)=32-42

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/28/93	25.62	2049.79	08/31/93	23.90	2051.51
08/19/93	24.30	2051.11	09/16/93	23.93	2051.48

162-073-04CBC
UND Aquifer

LS Elev (msl, ft)=2044.81
SI (ft.)=40-50

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/28/93	19.61	2025.20	08/31/93	33.74	2011.07
08/19/93	36.11	2008.70	09/16/93	31.36	2013.45

APPENDIX E

MAJOR ION AND TRACE-ELEMENT
CONCENTRATIONS

Dunseith Landfill Water Quality Major Ions

Location	Screened Interval (ft)	Date Sampled	(milligrams per liter)																Spec					
			SiO ₂	Fe	Mn	Ca	Mg	Na	K	HCO ₃	CO ₃	SO ₄	Cl	F	NO ₃	B	TDS	Hardness as CaCO ₃	as NCH	% Na	SAR	Cond (µmho)	Temp (°C)	pH
162-073-04CBA	12-17	07/28/93	21	5.4	1.3	310	440	170	22	1050	0	2100	39	0.4	5.2	0.37	3630	2600	1700	12	1.5	3850	14	7.1
162-073-04CBBC	15-25	07/28/93	23	0.08	1.3	150	69	27	45	655	0	250	6.2	0.6	14	0.18	909	660	120	8	0.5	1300	13	7.67
162-073-04CBBD	32-42	07/28/93	24	0.04	0.08	93	54	56	19	360	0	290	9.3	0.5	3.7	0.21	727	450	160	20	1.2	1041	12	8.36
162-073-04CBC	40-50	07/28/93	16	0.06	0.5	140	48	140	14	278	0	620	39	0.5	4.7	0.31	1160	550	320	35	2.6		12	7.55

Trace Element Analyses

Location	Date Sampled	Selenium	Lead	Cadmium	Mercury	Arsenic	Molybdenum	Strontium
		(micrograms per liter)						
162-073-04CBA	7/28/93	5	0	0	0.1	5	8	1500
162-073-04CBBC	7/28/93	130	0	0	0	8	104	680
162-073-04CBBD	7/28/93	4	0	0	0	2	32	650
162-073-04CBC	7/28/93	1	0	0	0	0	16	890

APPENDIX F

VOLATILE ORGANIC COMPOUNDS
FOR WELL 162-073-04CBA

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-Dichloroethane	<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	32.20*
Bromodichloromethane	7.28*
Chlorodibromomethane	3.71*
Bromoform	<5
trans-1,2-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
Carbondisulfide	<5
Ether	<5

* Constituent Detection

APPENDIX G

VOLATILE ORGANIC COMPOUNDS
FOR WELL 162-073-04CBB

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-Dichloroethane	<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
trans-1,2-Dichloroethylene	<2
Chlorobenzene	<2
m-Dichlorobenzene	<5
Dichloromethane	<5
cis-1,2-Dichloroethylene	<2
o-Dichlorobenzene	<2
Dibromomethane	<5
1,1-Dichloropropene	<5
Tetrachloroethylene	<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
Fluorotrchloromethane	<5
Dichlorodifluoromethane	<5
Bromochloromethane	<5
Allylchloride	<5
2,3-Dichloro-1-propane	<5
Tetrahydrofuran	<50
Pentachloroethane	<5
Trichlorotrofluoroethane	<5
Carbondisulfide	<5
Ether	<5

* Constituent Detection