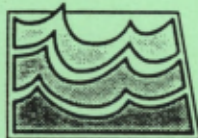


Site Suitability Review of the Nelson County Landfill

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



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

ND Landfill Site Investigation No. 10

SITE SUITABILITY REVIEW
OF THE
NELSON COUNTY LANDFILL

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

North Dakota Landfill Site Investigation 10

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

Bismarck, North Dakota
1993

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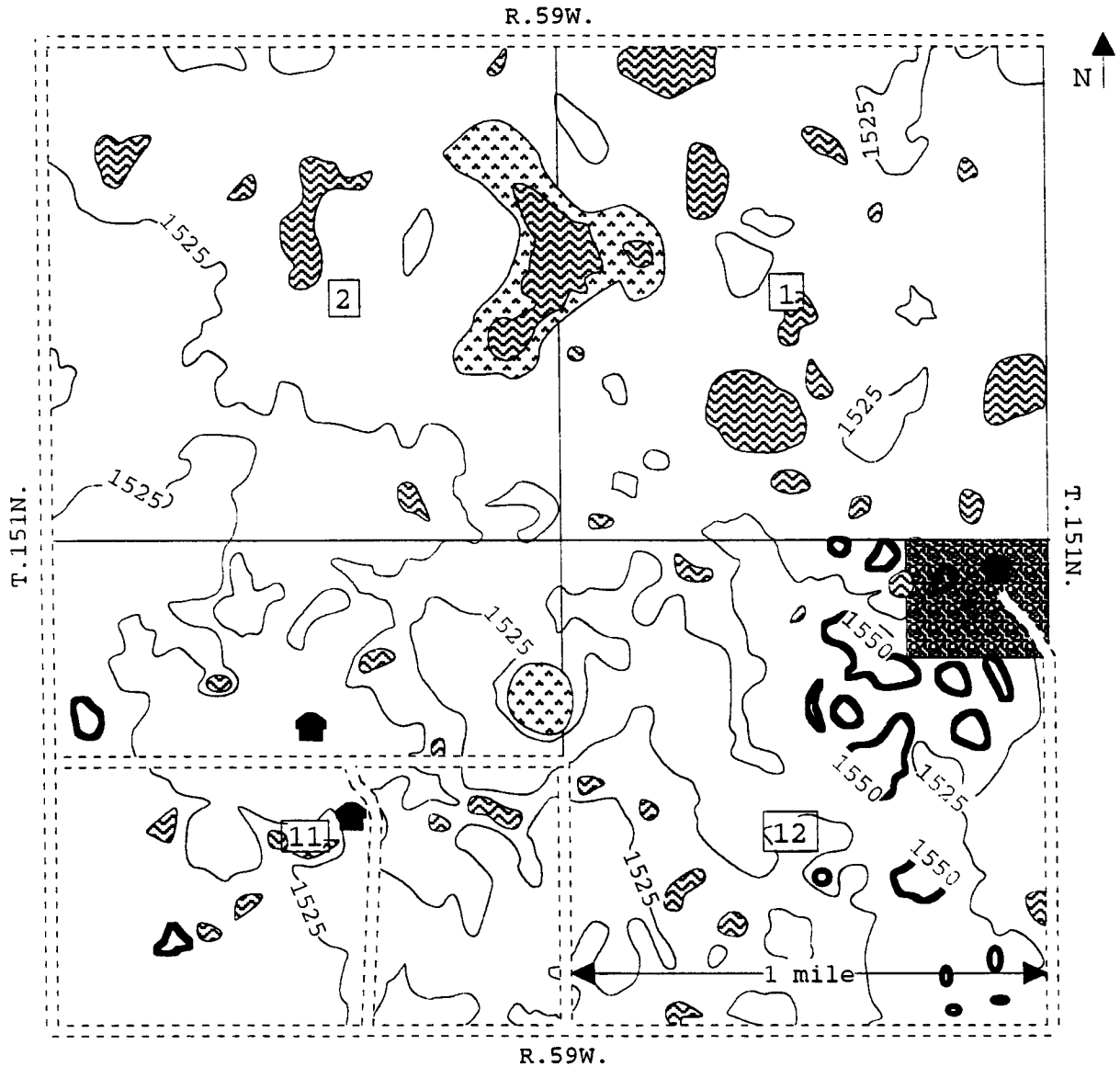
INTRODUCTION

Purpose

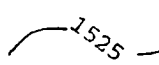
The North Dakota State Engineer and the North Dakota State Geologist were instructed by the 52nd State Legislative Assembly to conduct site-suitability reviews of the municipal landfills in the state of North Dakota. These reviews are to be completed by July 1, 1995 (North Dakota Century Code 23-29-07.7). 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. Additional studies may be necessary to meet the requirements of the NDS DHCL for continued operation of municipal solid waste landfills. The Nelson County solid waste landfill is one of the landfills being evaluated.

Location of the Nelson County Landfill

The Nelson County solid waste landfill is located ten miles north of the City of McVille in Township 151 North, Range 59 West, NE 1/4 Section 12 (Fig. 1). The landfill site encompasses approximately 160 acres of which 20 acres has been used.



Landfill
 Surface Water
 Wetland
 Building


 Elevation in feet above
 MSL (NGVD of 1929)

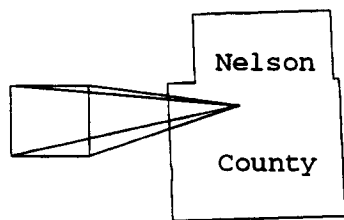


Figure 1. Location of the Nelson County landfill in the NE 1/4 of section 12, T.151N., R.59W.

Previous Site Investigations

The North Dakota Geological Survey drilled four test holes at the site in 1973. A report (Kehew, 1977) described the geologic materials as being primarily till, with lenses and pockets of stratified sand and silt.

Methods of Investigation

The Nelson County study was accomplished by means of: 1) test drilling; 2) construction and development of 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 Nelson County 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 Nelson County 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 monitoring wells installed at the Nelson County landfill, and one additional test hole was drilled to bedrock. The number of wells 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 near the active area of the landfill.

Wells were constructed following a standard design (Fig. 2) intended to comply with the construction regulations of the NDS DHCL 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

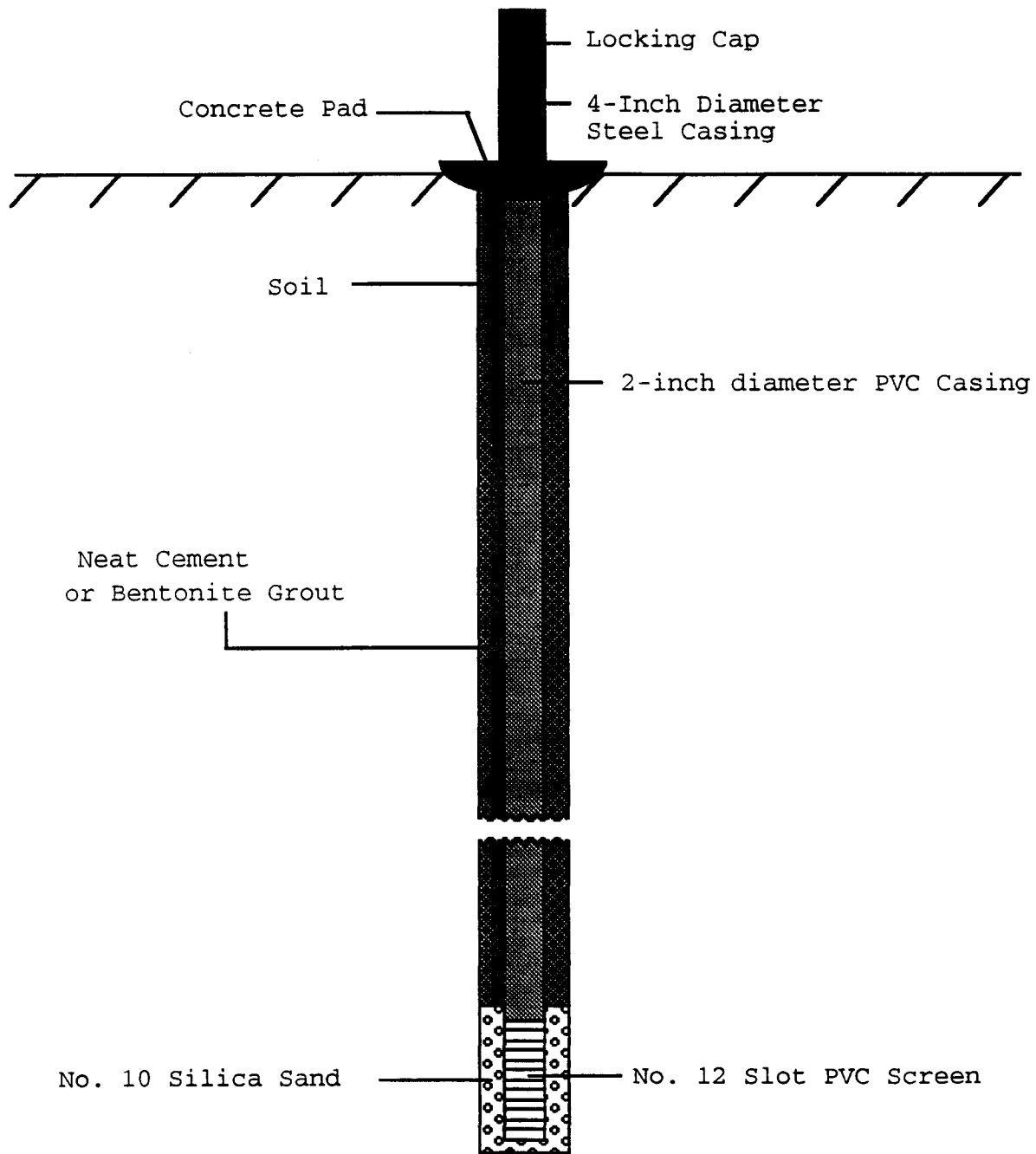


Figure 2. Construction design used for monitoring wells installed at the Nelson County landfill.

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

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.

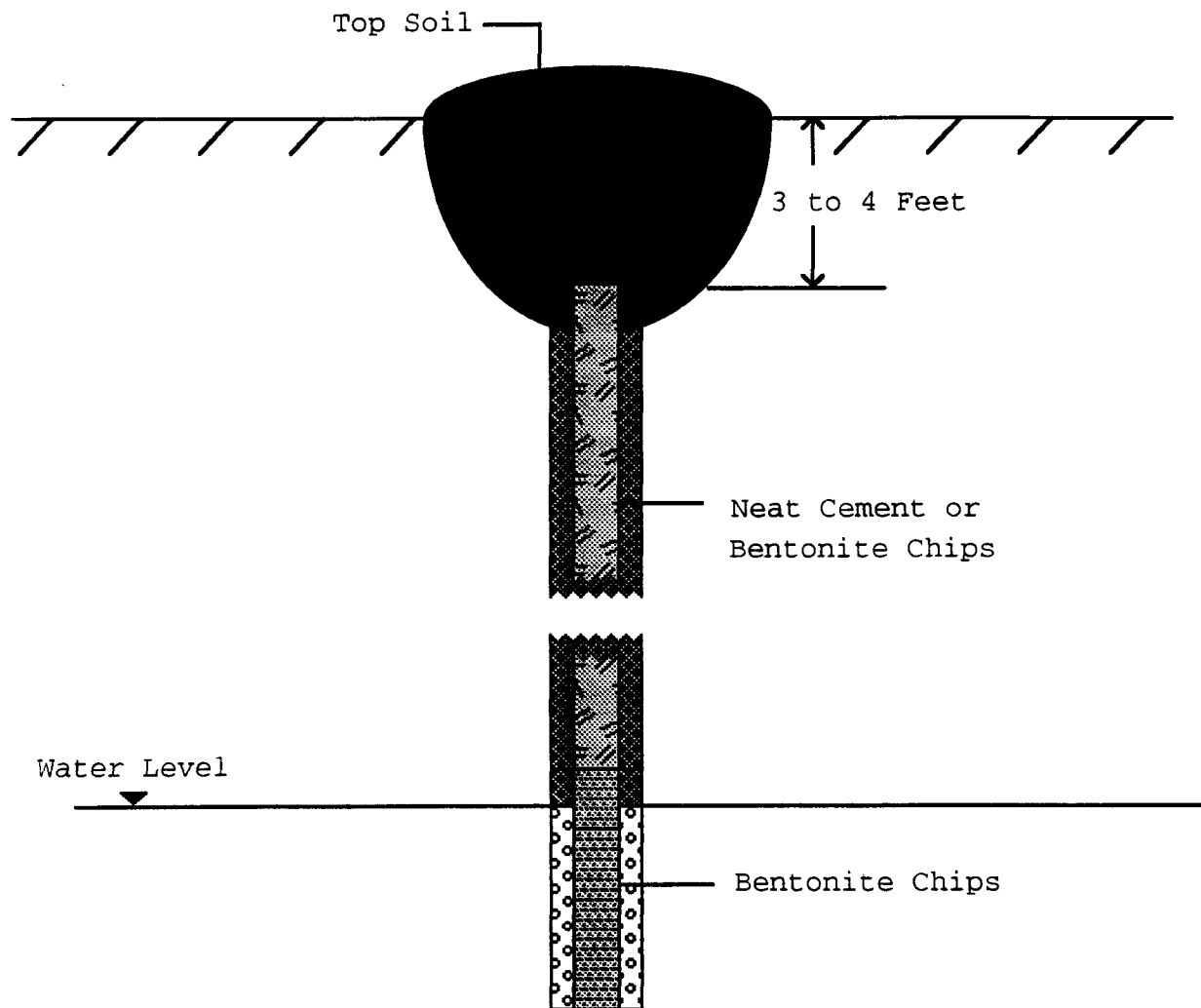


Figure 3. Monitoring well abandonment procedure.

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 151-059-12ADB would be located in the NW1/4, SW1/4, NE1/4 Section 12, Township 151 North, Range 59 West. Consecutive numbers are added following the three letters if more than one well is located in a 10-acre tract, e.g. 151-059-12ADB1 and 151-059-12ADB2.

GEOLOGY

The Nelson County landfill is located in an area of collapsed glacial sediments with a hummocky topography (Fig. 5). Numerous small hills and small, circular depressions are present at the site. Elevations range from 1510 to 1555 feet above NGVD of 1929.

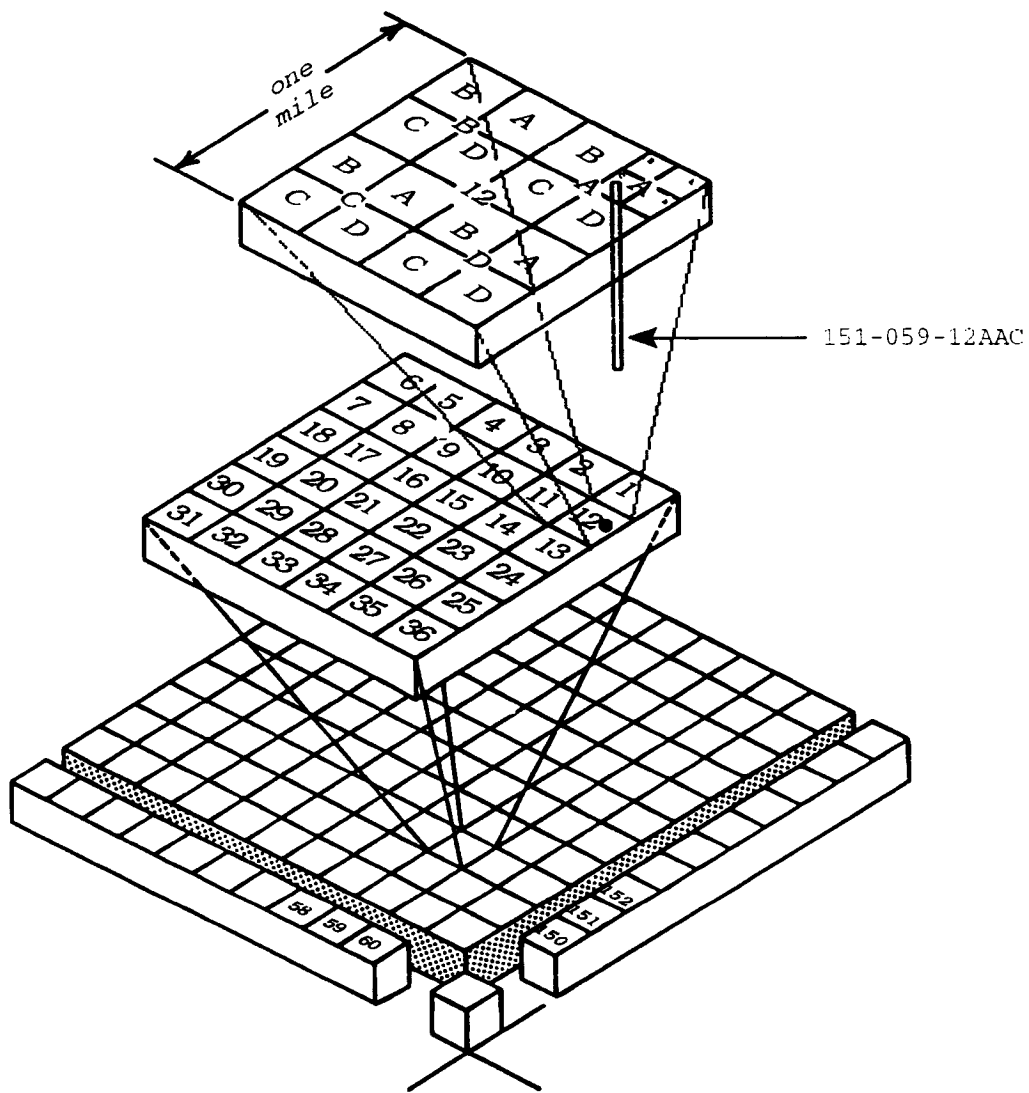


Figure 4. Location-numbering system for the Nelson County Sanitation landfill.

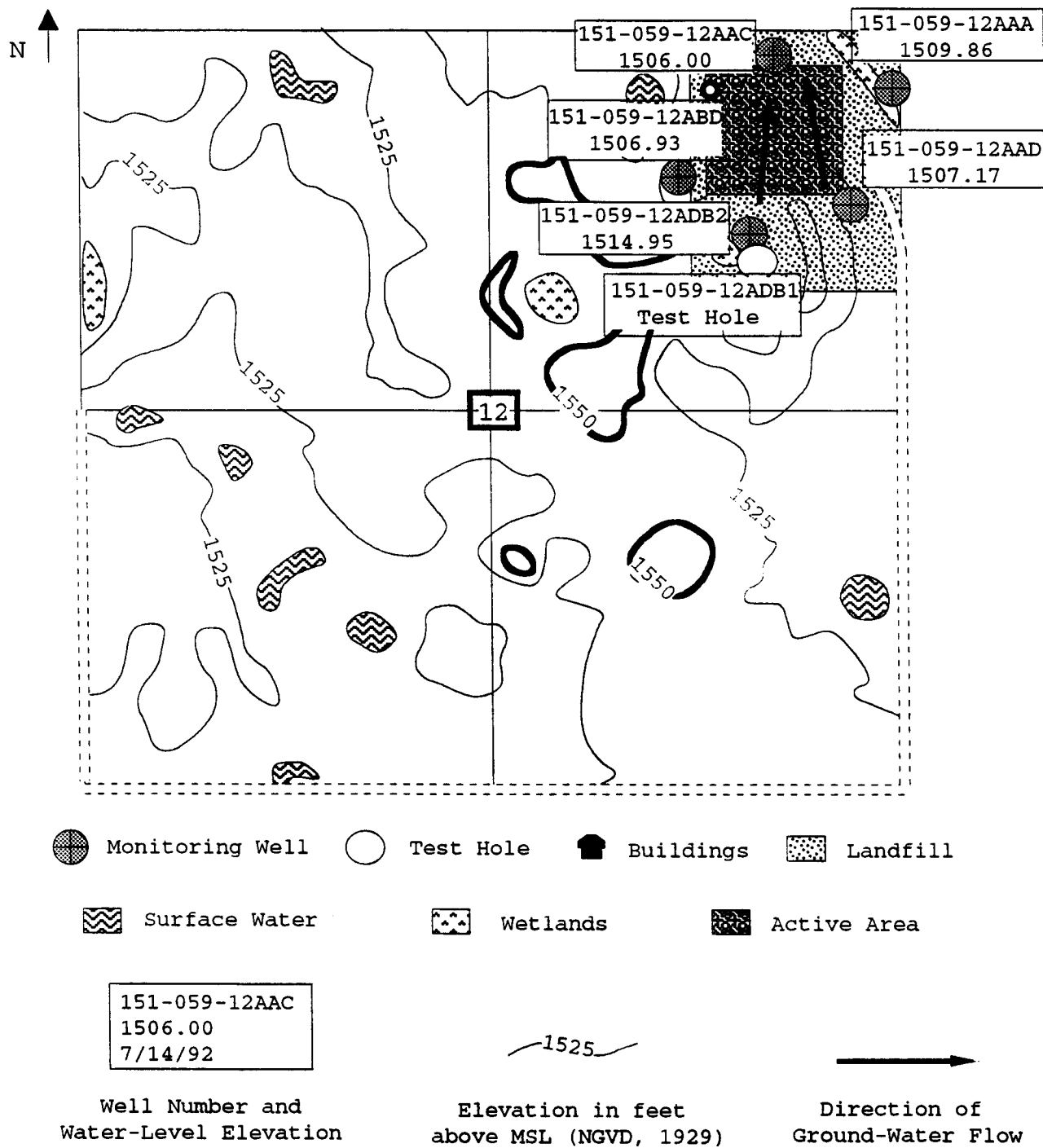


Figure 5. Location of monitoring wells and the direction of ground-water flow.

The near-surface materials in the area are included in the till facies of the Coleharbor Group (Bluemle, 1973). Drill cuttings from test holes in the present study indicate that the till is predominantly a silty, sandy clay with traces of gravel. (Lithologic logs are included in Appendix C). Intervals of stiff clay were encountered in two of the test holes (151-059-12AAA and 151-059-12AAD).

Three of the six test holes at the site intersected layers of fine-grained to coarse-grained sand (Fig. 6). The sand has a maximum thickness of 8 feet and appears to occupy discontinuous lenses or small channels. A layer of gravel, including cobbles and boulders, was encountered in one of the test holes (151-059-12AAC).

The uppermost bedrock unit beneath the site is the Cretaceous Pierre Formation. The Pierre Formation consists of light gray to dark gray shale, clay, and bentonite. The deepest test hole (151-059-12ADB1) penetrated the Pierre Formation at a depth of 64 feet.

HYDROLOGY

Surface-Water Hydrology

The Nelson County landfill is located in an area characterized by hummocky topography. Several wetlands and

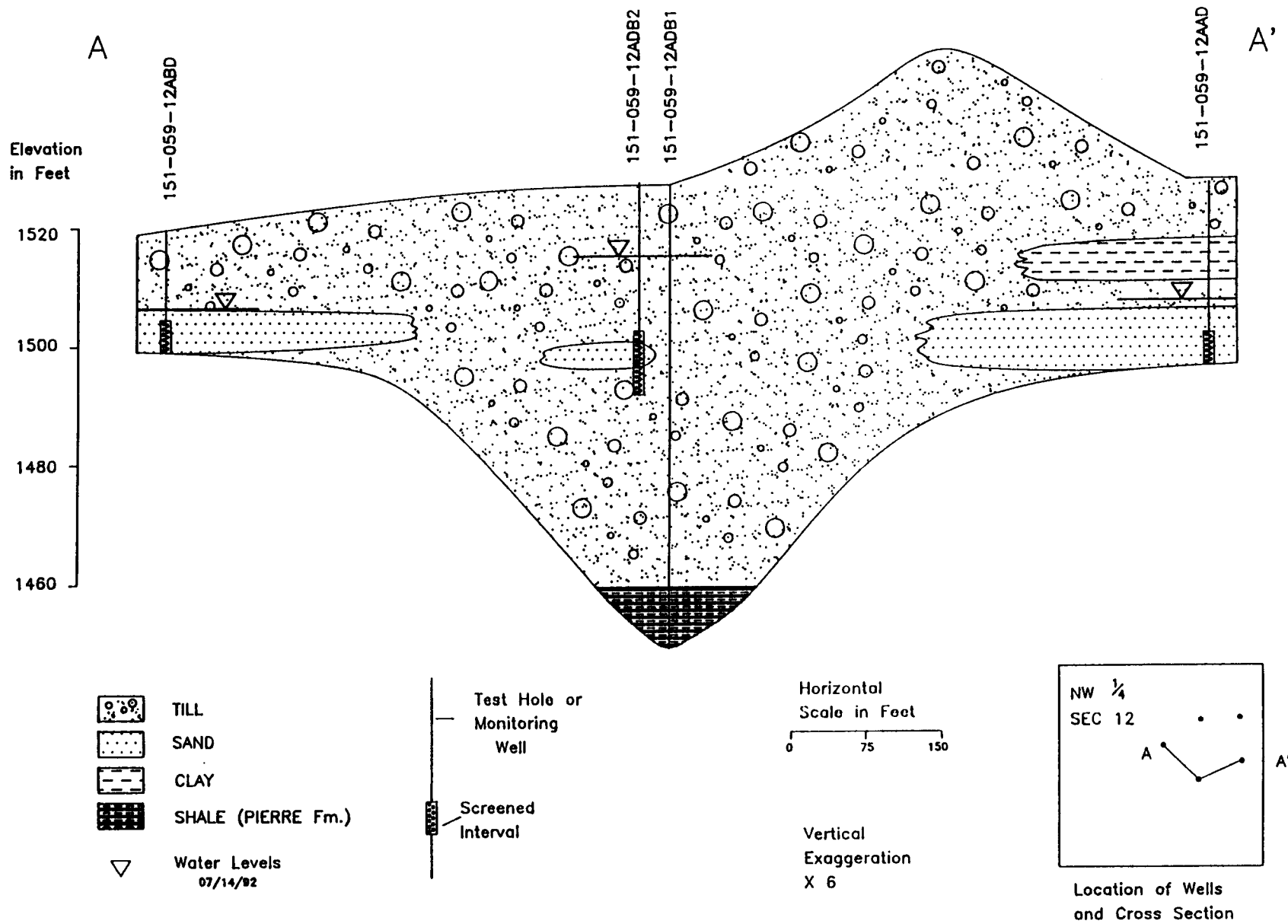


Figure 6. Geohydrologic section A-A' in the Nelson County landfill

depressions are situated along the boundaries of the landfill. Smaller seasonal wetlands are in the immediate area of the active area of the landfill. Water samples were not collected from any of the wetlands.

Wetlands near the Nelson County 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 recharge areas for the ground water during periods of high precipitation or runoff. Water that is not lost to evaporation infiltrates into the underlying aquifers. During periods of low precipitation these wetlands become local discharge areas for the ground-water flow system. As a result, contaminants may be introduced into these wetlands from lateral flow in the till and upward flow from the underlying sand aquifer.

Regional Ground-Water Hydrology

There are no major glacial aquifers within a two-mile radius of the Nelson County landfill. The McVille aquifer is located about ten miles west of the landfill. The McVille aquifer is characterized by a calcium-bicarbonate or a sodium-sulfate type water.

The bedrock aquifers are located within highly fractured regions of the Pierre Formation. Recharge to the Pierre aquifer is through the overlying glacial sediments. The

Pierre aquifer generally yields low quantities of water and is characterized by a sodium-bicarbonate-sulfate type water.

Local Ground-Water Hydrology

Six test holes were drilled at the Nelson County landfill with monitoring wells installed in five of the six (Fig. 5). The well screens were placed near the top of the till and sand layers beneath the landfill. Four water-level measurements were taken over a seven-week period (Appendix D).

The local ground-water flow system at the Nelson County landfill is complex in part because of the hummocky topography. The direction of ground-water flow in the glacial drift is toward the north-northwest (Fig. 5). Wells 151-059-12ABD and 151-059-12AAD are screened in a layer of sand at the same elevation and well 151-059-12AAC is screened in a gravelly clay (till).

Well 151-059-12AAA is located adjacent to a wetland east of the landfill and has a water level slightly higher than wells 151-059-12ABD, 151-059-12AAD, and 151-059-12AAC.

Well 151-059-12ADB2 is screened in a lower sand lens and has a higher water-level elevation as compared to wells 151-059-12ABD, 151-059-12AAD, and 151-059-12AAC (Fig. 5). A test hole (151-059-12ADB1), about fifteen feet south of the well, did not detect the sand layers. This suggests that the sand and gravel deposits are discontinuous lenses.

Water Quality

Chemical analyses of water samples are shown in Appendix E. Major ion analyses indicated high concentrations of sulfate, calcium, magnesium, bicarbonate and total dissolved solids in four of the five wells. Well 151-059-12ADB2 had a sulfate concentration of 3,300 mg/L which is about ten times higher than the MCL (250 mg/L). This well is located up-gradient of the landfill. Three other wells also indicated concentrations of sulfate greater than the MCL (Fig. 7).

The trace element analyses indicated concentrations of selenium above MCL (10 µg/L) in wells 151-059-12AAD (112 µg/L) and 151-059-12ADB2 (52 µg/L). Molybdenum concentrations above the MCL (100 µg/L) was detected in wells 151-059-12AAA (137 µg/L) and 151-059-12AAC (107µg/L). The Pierre shale may be the source of these trace elements (Tourtelot, 1962). Mobilization of major ions and trace elements from fragments of the Pierre Formation incorporated within the till may effectively mask input of major ions and trace elements from the landfill.

Water samples for VOC analysis were taken from well 151-059-12AAC north of the landfill. The analysis detected two VOC compounds which were ether (6 µg/L) and tetrahydrofuran

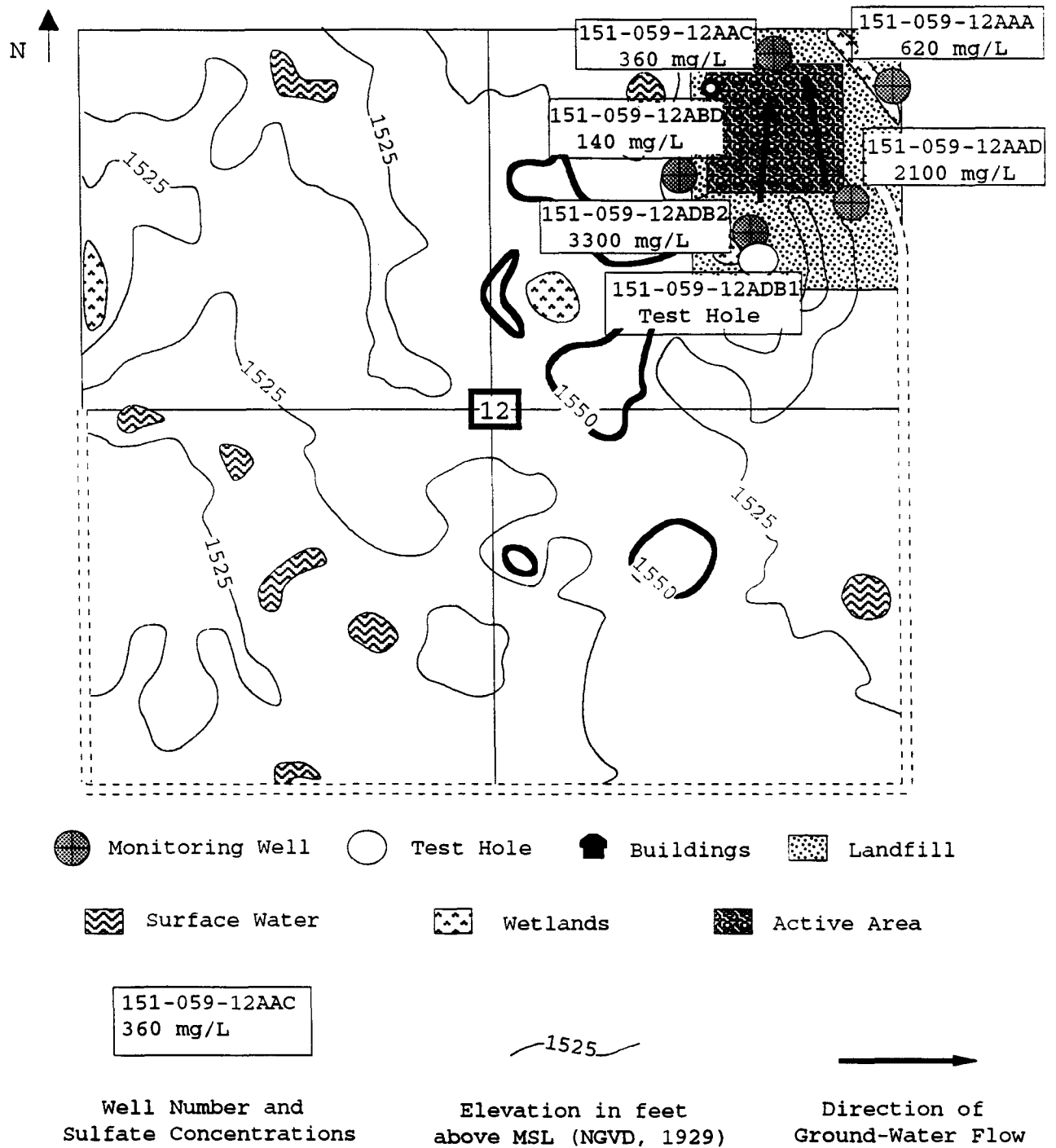


Figure 7. Sulfate concentrations at the Nelson County landfill.

(89 µg/L). These concentrations were slightly above the detection limits. Both compounds are man-made and are not found in natural ground waters. Ethers are used in cleaners, paint thinners, and varnishes. Tetrahydrofuran is a compound used in glues and liquid cements for fabricating packages and polyvinyl-chloride materials. The detection of these compounds may indicate leachate migration from the landfill.

CONCLUSIONS

The Nelson County landfill is located in an area of collapsed glacial sediments with a hummocky topography. Several small hills and small, circular depressions are present at the site. The small depressions adjacent to the landfill are generally seasonal wetlands. Several larger, semi-permanent wetlands occur within 1/2 mile of the landfill.

The near-surface materials consist of till with thin beds of sand and gravel. The sand and gravel deposits probably occur in discontinuous lenses or small channels. Bedrock shale of the Pierre Formation was encountered at a depth of 64 feet in the deepest test hole.

There are no major aquifers in the area which might be affected by the landfill. The nearest glacial aquifer is more than two miles away. Local domestic water supplies are

derived from sand lenses within the glacial sediments or from fractured zones in the Pierre Formation.

Within the landfill, ground water occurs in the till and sand lenses from 4 feet to 22 feet below land surface. The ground-water flow system is poorly defined because of the complex stratigraphy and irregular surface topography. Evaluation of water-level data suggests that the direction of ground-water flow in the glacial drift is to the north-northwest.

High concentrations of sulfate, calcium, magnesium, bicarbonate, and total dissolved solids were found in the monitoring wells adjacent to the landfill. Two of the wells tested high in selenium, and two different wells tested high in molybdenum. No consistent pattern is apparent when comparing up-gradient and down-gradient wells. The natural water quality of the region is probably quite variable, and as a result it is difficult to assess the impact of the landfill on water quality. The VOC analysis from well 151-059-12AAC detected ether and tetrahydrofuran compounds. These compounds are man-made and may suggest leachate migration from the landfill into the shallow ground water.

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- Kehew, A., 1977, Land disposal site inventory: North Dakota Geological Survey, unpublished report.
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APPENDIX A

WATER QUALITY STANDARDS
AND
MAXIMUM CONTAMINANT LEVELS

**Water Quality Standards
and
Maximum Contaminant Levels**

Field Parameters	MCL (mg/L)
appearance	color/odor
pH	6-8 (optimum)
specific conductance	-----
temperature	-----
water level	-----
Geochemical Parameters	
iron	>0.3
calcium	25-50
magnesium	25-50
manganese	>0.05
potassium	-----
total alkalinity	-----
bicarbonate	150-200
carbonate	150-200
chloride	250
fluoride	0.7-1.2
nitrate+nitrite (N)	10
sulfate	300-1000
sodium	20-170
total dissolved solids (TDS)	>1000
cation/anion balance	-----
hardness	>121 (hard to very hard)
Heavy Metals (µg/L)	
arsenic	50
cadmium	10
lead	50
molybdenum	100
mercury	2
selenium	10
strontium	*

* EPA has not set a MCL for strontium. The median concentration for most U.S. water supplies is 110 µg/L (Hem, 1989).

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

151-059-12AAA

NDSWC

Date Completed:	7/7/92	Well Type:	P2
Depth Drilled (ft):	15	Source of Data:	
Screened Interval (ft):	10-15	Principal Aquifer :	Undefined
Casing size (in) & Type:		L.S. Elevation (ft)	1511.46
Owner: Nelson County			

Unit	Description	Lithologic Log	Depth (ft)
TOPSOIL			0-2
TILL	CLAY, MOIST, DARK YELLOW-BROWN (10YR 4/2), (GLACIAL)		2-5
CLAY	DUSKY YELLOW (5Y 6/4)		5-8
CLAY	DARK YELLOW-ORANGE (10YR 6/6)		8-13
CLAY	GRAY-ORANGE (10YR 7/4)		13-15

151-059-12AAC

NDSWC

Date Completed: 7/8/92 Well Type: P2
 Depth Drilled (ft): 45 Source of Data:
 Screened Interval (ft): 38-43 Principal Aquifer : Undefined
 Casing size (in) & Type: L.S. Elevation (ft) 1528.19
 Owner: Nelson County

Unit	Description	Lithologic Log	Depth (ft)
TOPSOIL			0-1
SAND	WITH PEBBLES, COBBLES, AND BOULDERS, MODERATE YELLOWISH BROWN (10YR 5/4)		1-10
CLAY	SANDY, WITH PEBBLES AND COBBLES, MODERATE YELLOWISH BROWN (10YR 5/4) (TILL)		10-15
CLAY	GRAVELLY, MODERATE YELLOWISH BROWN (10YR 5/4) (TILL)		15-24
CLAY	TRACE SAND AND PEBBLES, DARK GRAY (N3) (TILL)		24-40
CLAY	TRACE SAND AND PEBBLES, OLIVE GRAY (5Y 4/1), HIT HARD ROCK AT 45' AND WERE UNABLE TO CONTINUE DRILLING		40-45

151-059-12AAD

NDSWC

Date Completed:	7/7/92	Well Type:	P2
Depth Drilled (ft):	30	Source of Data:	
Screened Interval (ft):	25-30	Principal Aquifer :	Undefined
Casing size (in) & Type:		L.S. Elevation (ft)	1527.35
Owner: Nelson County			

Unit	Description	Lithologic Log	Depth (ft)
TOPSOIL			0-2
CLAY	SANDY, GRAYISH ORANGE (10YR 7/4), DRY, (TILL)		2-10
CLAY	PALE YELLOW ORANGE (10YR 8/6)		10-12
CLAY	SILTY, DARK YELLOWISH ORANGE (10YR 6/6)		12-15
CLAY	STIFF, MODERATE YELLOWISH BROWN (10YR 5/4)		15-18
CLAY	SANDY, MOIST, DARK YELLOWISH ORANGE (10YR 6/6)		18-22
SAND	CLAYEY, DARK YELLOWISH ORANGE (10YR 6/6), MOIST		22-23
SAND	MEDIUM TO FINE-GRAINED, WET		23-30

151-059-12ABD

NDSWC

Date Completed: 7/8/92 Well Type: P2
Depth Drilled (ft): 19 Source of Data:
Screened Interval (ft): 14-19 Principal Aquifer : Undefined
Casing size (in) & Type: L.S. Elevation (ft) 1518.25
Owner: Nelson County

Unit	Description	Lithologic Log	Depth (ft)
TOPSOIL			0-1
CLAY	SANDY, PEBBLY, DARK YELLOWISH ORANGE (10YR 6/6), (TILL)		1-6
CLAY	SANDY, PEBBLY, MODERATE YELLOWISH-BROWN (10YR 5/4) (TILL)		6-11
SAND	FINE TO MEDIUM-GRAINED, SILTY, MODERATE YELLOWISH BROWN (10YR 5/4)		11-19

151-059-12ADB1

NDSWC

Date Completed: 7/7/92 Purpose: Test Hole
 Depth Drilled (ft): 74 Source of Data:
 L.S. Elevation (ft) 1527.19 Owner: Nelson County

Unit	Description	Lithologic Log	Depth (ft)
TOPSOIL			0-2
CLAY	SANDY, MODERATE YELLOWISH BROWN (10YR 5/4), (TILL)		2-5
CLAY	TRACE PEBBLES, MODERATE YELLOWISH BROWN (10YR 5/4) (TILL)		5-17
CLAY	TRACE PEBBLES, OLIVE GRAY (5Y 4/1) (TILL)		17-25
CLAY	TRACE SAND AND PEBBLES, OLIVE GRAY (5Y 4/1) (TILL)		25-64
SHALE	WELL CEMENTED, DARK GRAY (N3), (PIERRE FM), NO CUTTINGS AFTER 66', PROBABLY SHALE, STOPPED AT 74' BECAUSE OF HARD DRILLING		64-74

151-059-12ADB2

NDSWC

Date Completed:	7/8/92	Well Type:	P2
Depth Drilled (ft):	35	Source of Data:	
Screened Interval (ft):	25-35	Principal Aquifer :	Undefined
Casing size (in) & Type:		L.S. Elevation (ft)	1526.97
Owner:	Nelson County		

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	TRACE PEBBLES, MODERATE YELLOWISH BROWN (10YR 5/4), DRY, (TILL)	2-10
CLAY	TRACE PEBBLES, MODERATE YELLOWISH BROWN (10YR 5/4) (TILL)	10-16
CLAY	TRACE PEBBLES, OLIVE GRAY (5Y 4/1) (TILL)	16-27
SAND	COARSE-GRAINED, MODERATE YELLOWISH BROWN (10YR 5/4), WET	27-31
CLAY	SANDY, OLIVE GRAY (5Y 4/1) (TILL)	31-35

APPENDIX D

WATER-LEVEL TABLES

Nelson County Landfill Water Levels
7/14/92 to 9/1/92

151-059-12AAA LS Elev (msl,ft)=1511.46
Undefined Aquifer SI (ft.)=10-15

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/15/92	1.60	1509.86	08/11/92	3.29	1508.17
07/28/92	2.24	1509.22	09/01/92	4.28	1507.18

151-059-12AAC LS Elev (msl,ft)=1528.19
Undefined Aquifer SI (ft.)=38-43

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/14/92	22.19	1506.00	08/11/92	22.12	1506.07
07/28/92	22.10	1506.09	09/01/92	22.06	1506.13

151-059-12AAD LS Elev (msl,ft)=1527.35
Undefined Aquifer SI (ft.)=25-30

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/14/92	20.18	1507.17	08/11/92	20.59	1506.76
07/28/92	20.35	1507.00	09/01/92	20.91	1506.44

151-059-12ABD LS Elev (msl,ft)=1515.84
Undefined Aquifer SI (ft.)=14-19

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/14/92	8.91	1506.93	08/11/92	9.84	1506.00
07/28/92	9.84	1506.00	09/01/92	9.74	1506.10

151-059-12ADB2 LS Elev (msl,ft)=1526.97
Undefined Aquifer SI (ft.)=25-35

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/14/92	12.02	1514.95	08/11/92	12.27	1514.70
07/28/92	12.10	1514.87	09/01/92	12.51	1514.46

APPENDIX E

MAJOR ION AND TRACE-ELEMENT
CONCENTRATIONS

Nelson County Water Quality

Major Ions Analyses

Location	Screened Interval (ft)	Date Sampled	(milligrams per liter)																Hardness as CaCO ₃	% Na	SAR	Spec Cond (µmho)	Temp (°C)	pH
			SiO ₂	Fe	Mn	Ca	Mg	Na	K	HCO ₃	CO ₃	SO ₄	Cl	F	NO ₃	B	TDS							
151-059-12AAA	10-15	07/15/92	30	0.02	0.01	110	94	96	38	362	0	620	8.9	0.4	2.6	0.04	1180	660	360	23	1.6	8	8.08	
151-059-12AAC	38-43	07/14/92	23	0.1	0.14	110	47	50	20	179	0	360	48	0.2	0.2	0.08	747	470	320	18	1	17	8.24	
151-059-12AAD	25-30	07/14/92	26	0.06	0.05	400	290	140	14	377	0	2100	43	0.4	2.1	0.18	3200	2200	1900	12	1.3	15	7.98	
151-059-12ABD	14-19	07/14/92	28	0.07	0.02	100	33	6.5	4.2	324	0	140	4.1	0.2	0	0.04	476	390	120	3	0.1	13	7.75	
151-059-12ADB2	25-35	07/14/92	24	0.05	0.17	450	470	180	25	263	0	3300	50	0.6	2.8	0.11	4630	3100	2800	11	1.4	12	7.92	

Trace Element Analyses

Location	Date Sampled	(micrograms per liter)						
		Selenium	Lead	Cadmium	Mercury	Arsenic	Molybdenum	Strontium
151-059-12AAA	7/15/92	5	0	0	0	2	137	450
151-059-12AAC	7/14/92	2	0	0	0	1	107	700
151-059-12AAD	7/14/92	112	0	0	0	2	15	1400
151-059-12ABD	7/14/92	4	0	0	0	0	4	190
151-059-12ADB2	7/14/92	52	0	0	0	2	55	1600

APPENDIX F

VOLATILE ORGANIC COMPOUNDS
FOR WELL 151-059-12AAC

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
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	89*
Pentachloroethane	<5
Trichlorotrofluoroethane	<5
Carbondisulfide	<5
Ether	6*

* Constituent Detection