

Site Suitability Review of the Valley Landfill Association

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. 42

SITE SUITABILITY REVIEW
OF THE
VALLEY LANDFILL ASSOCIATION LANDFILL

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North Dakota Landfill Site Investigation 42

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

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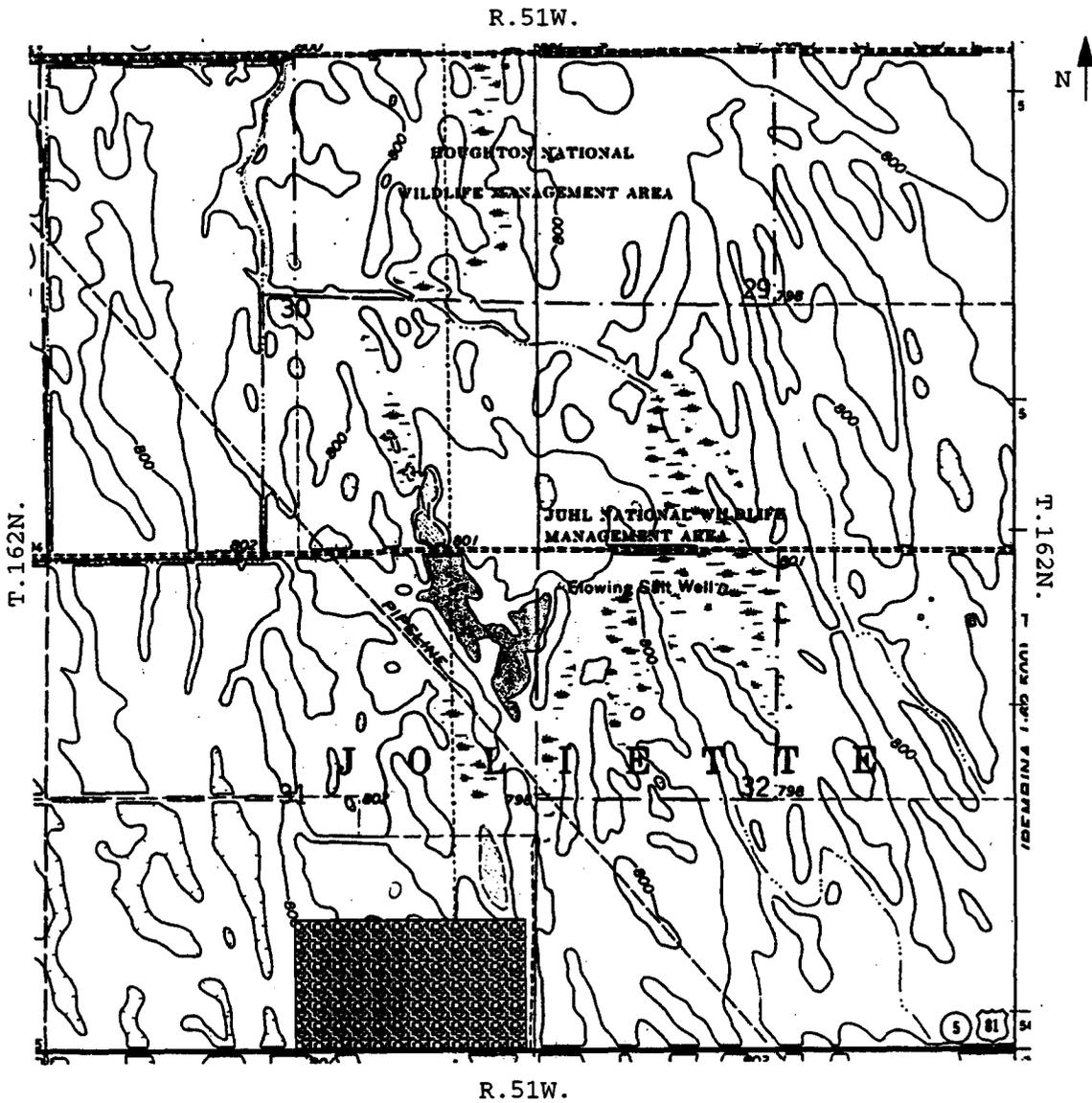
INTRODUCTION

Purpose

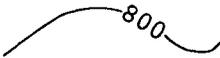
The North Dakota State Engineer and the North Dakota State Geologist were instructed by the 52nd State Legislative Assembly to conduct site-suitability reviews of the solid waste landfills in the state of North Dakota. These reviews are to be completed by July 1, 1995 (North Dakota Century Code 23-29-07.7). 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 (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 Valley Landfill Association solid-waste landfill is one of the landfills being evaluated.

Location of the Valley Landfill Association Landfill

The Valley solid-waste landfill is located eight miles east of the City of Hamilton in the S 1/2, SE 1/4, Section 31, Township 162 North, Range 51 West (Fig. 1). The landfill property encompasses 80 acres of which approximately 25 acres have been used.



 Landfill Boundary



Elevation in feet above
MSL (NGVD, 1929)

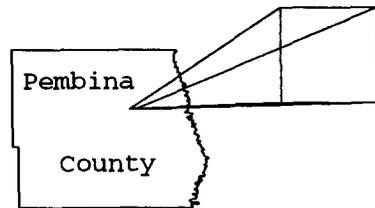


Figure 1. Location of the Valley Landfill Association in the S 1/2, SE 1/4, Section 31, T.162N., R.51W.

Previous Site Investigations

In 1987 Twin City Testing Corporation drilled twelve test borings on the property and completed four of the borings as monitoring wells. The monitoring wells were placed around the active area of the landfill. One of the wells, located at the northeast corner of the landfill, has been destroyed.

Methods of Investigation

The Valley landfill 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 was based on the site's geology and depth to ground water, as determined by the preliminary site evaluation. A hollow-stem auger was used at the Valley landfill. The lithologic descriptions were determined from the drill cuttings. The water used with the rig was obtained from municipal water supplies.

Monitoring Well Construction and Development

Two additional test holes with monitoring wells were completed at the Valley landfill to supplement the wells already in place. The wells were placed near the active area of the landfill. The drill rig could not reach the north end of the landfill because of mud and standing water in this area. The depth and intake interval of each well was selected to monitor the water level at the top of the uppermost aquifer.

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. A two to three-foot bentonite plug was placed above the sand pack using medium-size bentonite chips. 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

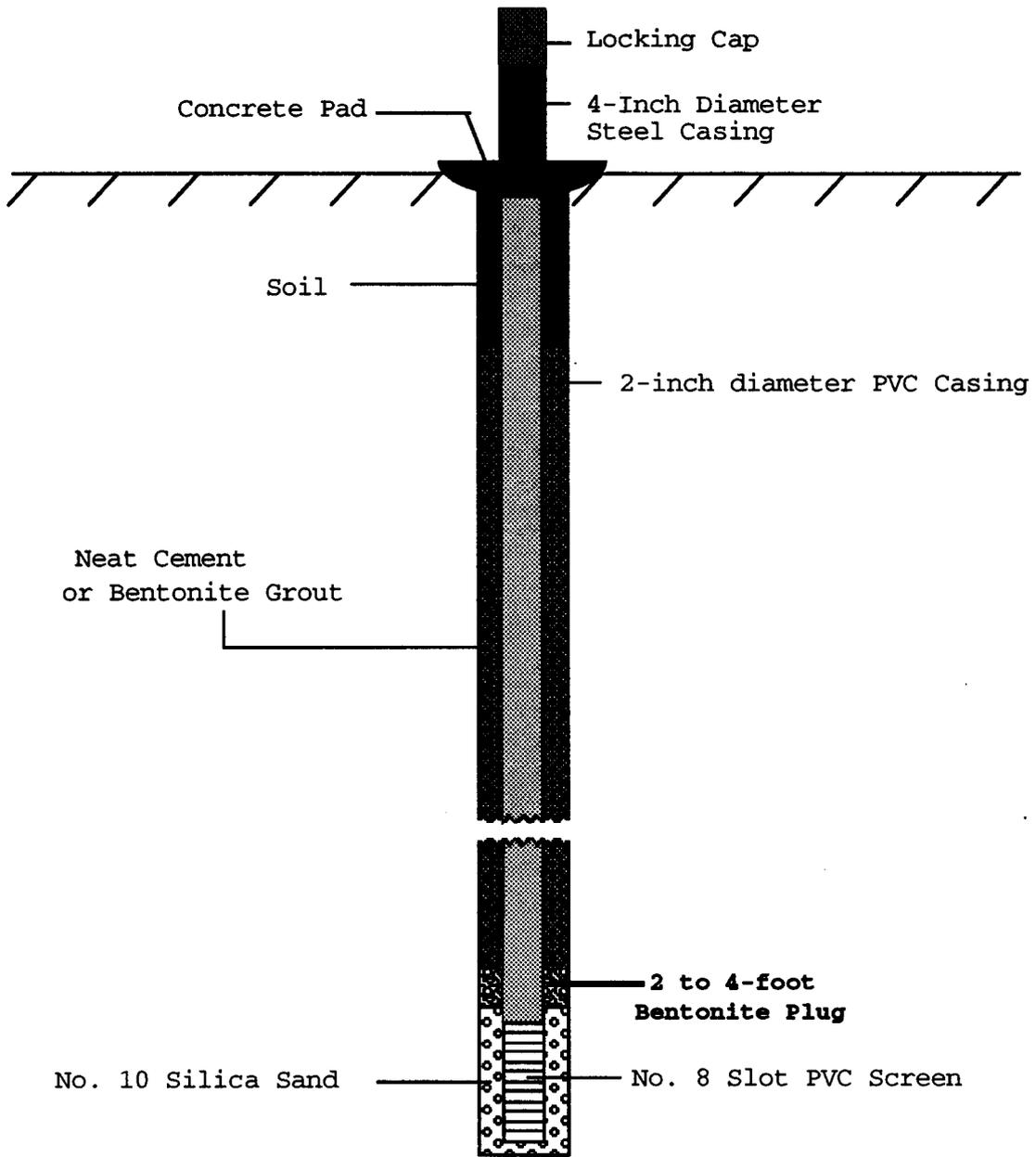


Figure 2. Construction design used for monitoring wells installed at the Valley Landfill Association landfill.

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

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

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

Collecting and Analyzing Water Samples

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

Water samples were collected using a bladder pump constructed of stainless steel with a teflon bladder. A teflon bailer was used in monitoring wells with limited

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

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

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

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

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

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

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 162-051-31DCD would be located in the SE1/4, SW1/4, SE1/4, Section 31, Township 162 North, Range 51 West. Consecutive numbers are added following the three letters if more than one well is

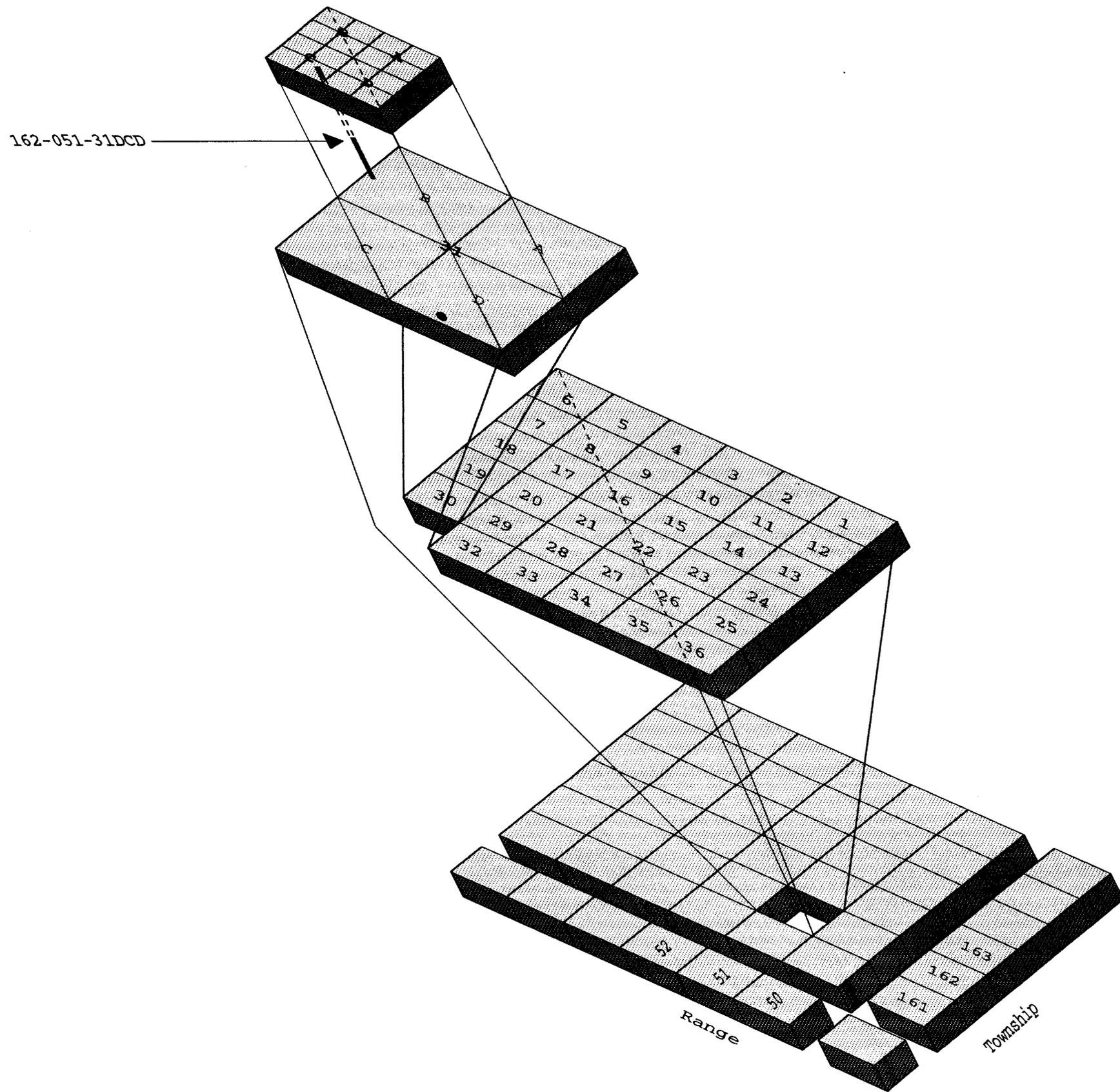


Figure 3. Location-numbering system.

located in a 10-acre tract, e.g. 162-051-31DCD1 and 162-051-31DCD2.

GEOLOGY

The Valley landfill lies within the Red River Valley physiographic region, a broad plain that was formerly the basin of glacial Lake Agassiz. The landfill is located in a flat area which slopes gradually to the east (Fig. 1). The near-surface geologic materials in the area of the landfill consist of offshore lake sediment, mainly clay and silt. Soils in the area are very saline due to the discharge of saline ground water from underlying Paleozoic carbonates (Arndt, 1975).

The two test holes drilled at the landfill for this study encountered mostly silty clay. Test hole 162-051-31DCCD also included a 3-foot-thick layer of silt and test hole 162-051-31DDB included a 4-foot-thick layer of silt with clay and very fine sand (Fig. 4, lithologic logs in Appendix C). Lithologic logs from test holes drilled by Twin City Testing (1987) likewise reported clay with layers and lenses of silt.

A test hole drilled two miles east of the landfill illustrates the deeper subsurface stratigraphy of the area. Test hole 162-051-34CCC was drilled by the North Dakota State Water Commission in 1969. This hole penetrated lacustrine

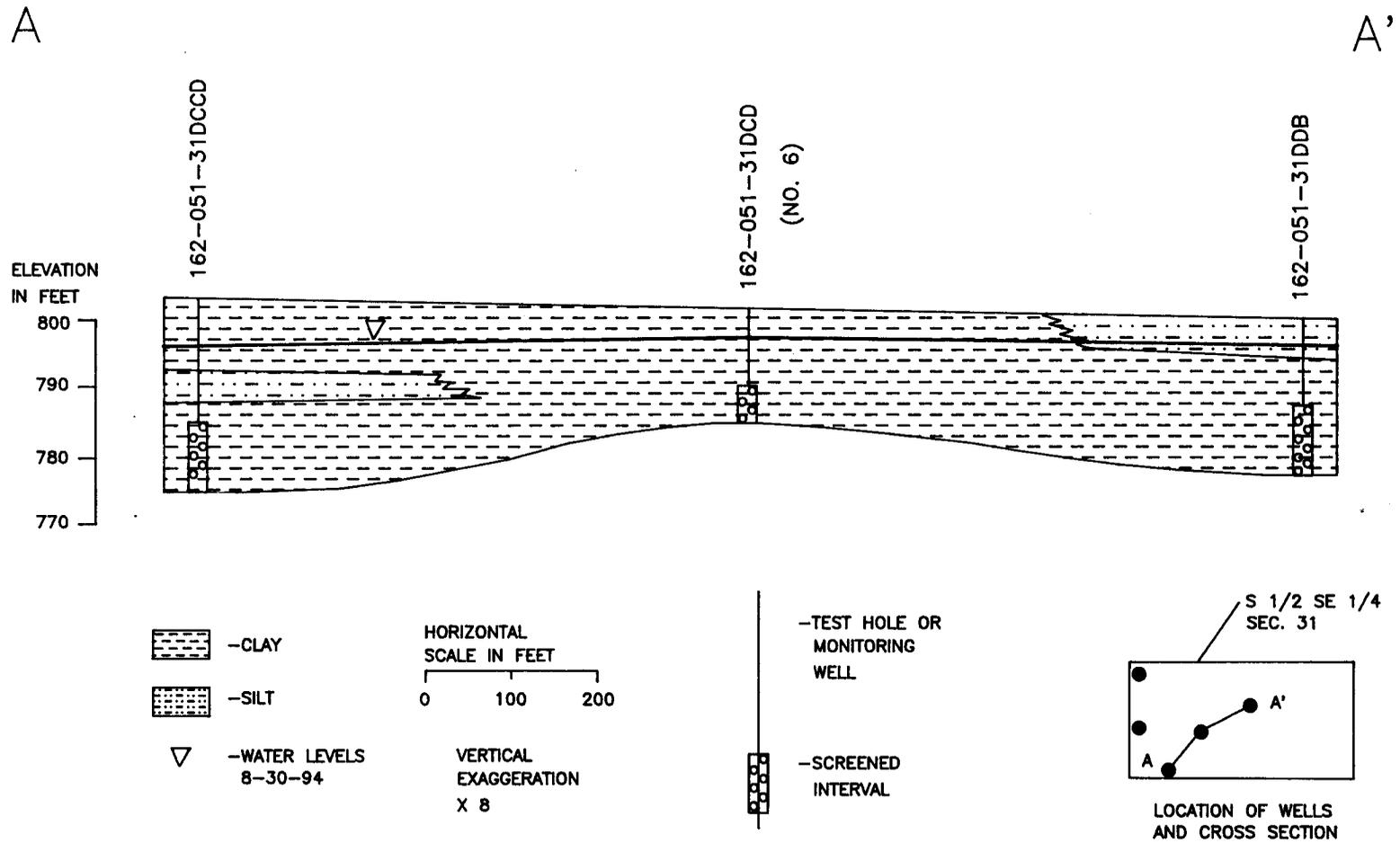


Figure 4. Geohydrologic section A-A' in the Valley landfill.

clay and silt from the surface to a depth of 144 feet, followed by gravel from 144 feet to 173 feet. The test hole encountered till from 173 feet to 218 feet. Ordovician limestone of the Red River Formation was encountered at a depth of 218 feet (Hutchinson, 1973).

HYDROLOGY

Surface-Water Hydrology

The Juhl National Wildlife Management area is located adjacent to the north boundary of the Valley landfill. The Pembina Prairie National Wildlife Management area is located about one-half mile south of the landfill. These wildlife areas should not be affected by the landfill because they are located upgradient from the landfill.

Small depressions are located throughout the area of the landfill creating potential wetlands. These wetlands appear to hold water throughout much of the year because surface runoff is minor, infiltration rates are low, and the water table is shallow. These wetlands may be susceptible to contaminant migration if they are within the boundaries of the landfill.

Regional Ground-Water Hydrology

The regional ground-water hydrology consists of glacial aquifers and bedrock aquifers. Bedrock aquifers, probably within the Red River Formation, have an upward flow gradient that may influence the regional ground-water chemistry and create a shallow ground water system near the landfill (Hutchinson, 1977). The Red River Formation aquifer is characterized as a sodium-chloride brine type of water (Hutchinson, 1977). This aquifer should not be affected by contaminant migration due to its depth and upward hydraulic gradient.

The Hamilton glacial aquifer is located about 4.5 miles west of the Valley landfill. The Hamilton aquifer is characterized by a sodium-chloride type water. The chemistry of this aquifer may be influenced by upward water movement from bedrock aquifers. Although the exact boundaries of the Hamilton aquifer have not been well delineated, this aquifer probably is not connected hydraulically to the landfill. As a result, this aquifer should not be affected by contaminant migration from the landfill.

Undifferentiated glacial aquifers are present in isolated sand and gravel deposits. These aquifers are limited in areal extent and contain small amounts of water. The ground-water chemistry in these aquifers is variable. It

is not known if any undifferentiated aquifers are present near the Valley landfill.

Local Ground-Water Hydrology

Two test holes were drilled at the Valley landfill with monitoring wells constructed in both of them. Three existing monitoring wells from Twin City Testing (1987) were also used to determine the occurrence and movement of ground water in this study (Fig. 5).

The local ground water in the area of the Valley landfill is influenced by upward movement of ground water from the Red River Formation. This upward movement probably contributes to the maintenance of a shallow water table.

Four water-level measurements were taken over an eight-week period (Appendix D). Water-level elevations at the landfill are about 797 feet above sea level. The direction of ground-water flow beneath the landfill appears to be south-southeast (Fig. 5). This direction of ground-water flow may be influenced by the occurrence of a road ditch along the southern boundary of the landfill and by ground-water mounding beneath the landfill. Locally, ground-water flow surrounding the landfill appears to be to the east toward the Red River. The rate of ground-water flow probably is slow due to the low hydraulic conductivity of the lacustrine clays.

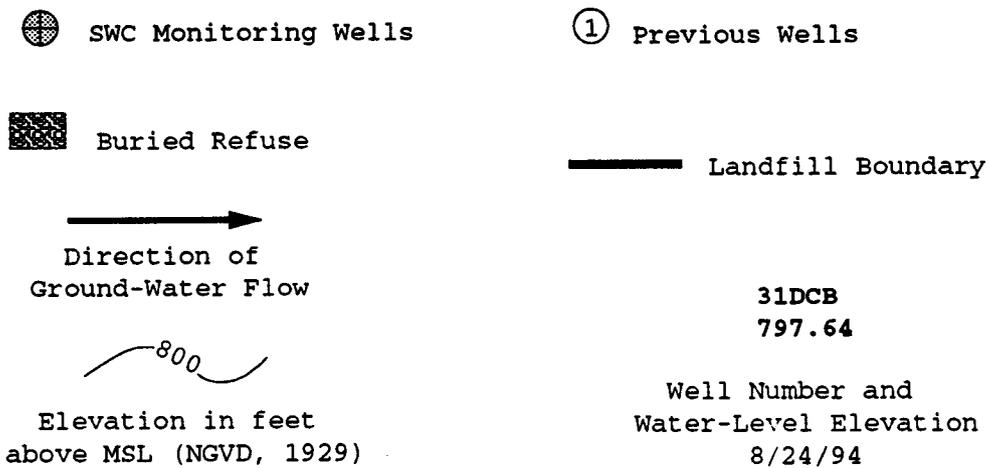
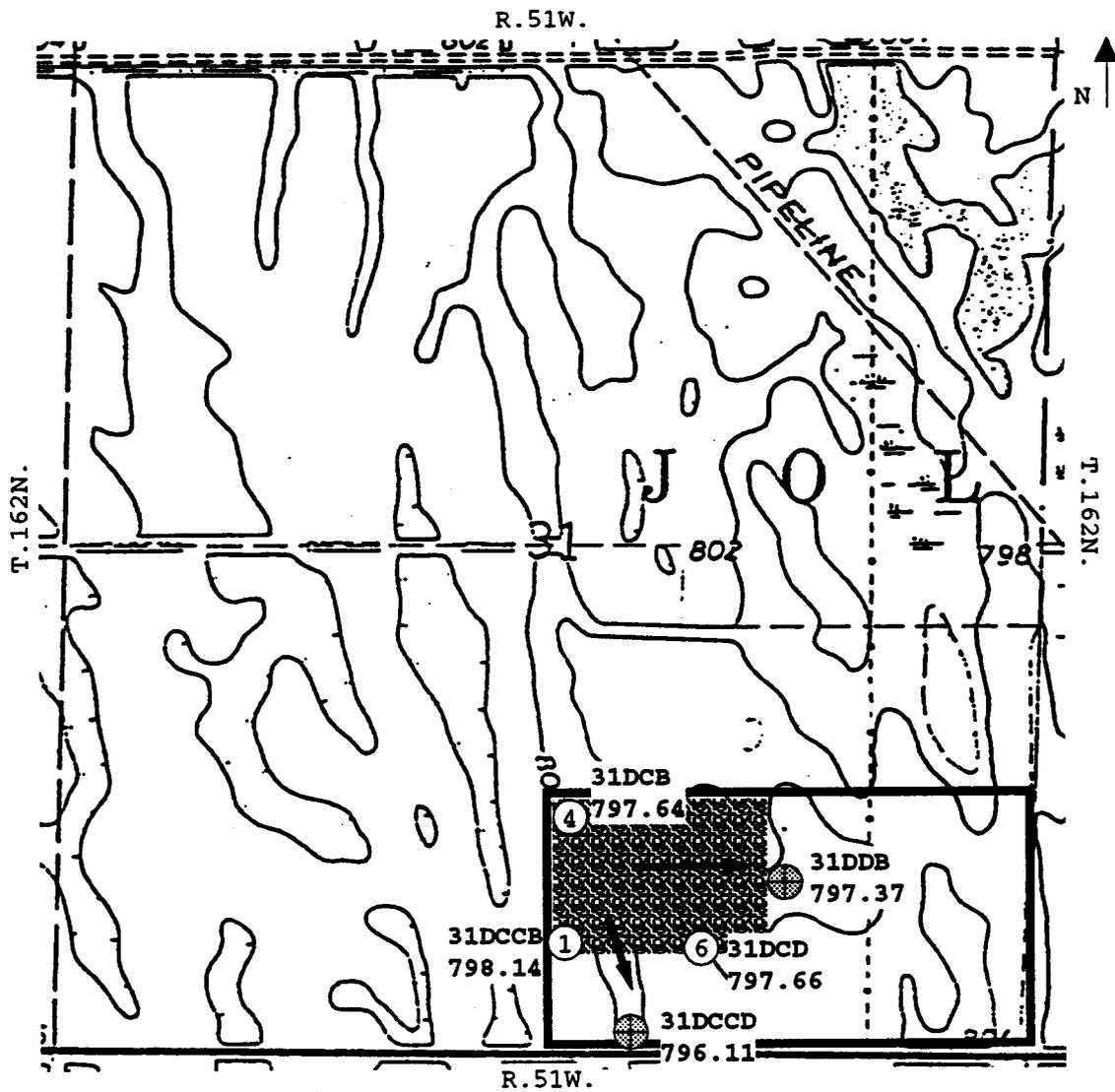


Figure 5. Location of monitoring wells and the direction of ground-water flow.

Water Quality

Chemical analyses of water samples are shown in Appendix E. Water in the up-gradient wells is characterized by a calcium-bicarbonate type, while the down-gradient wells are characterized by a calcium-chloride type. Anomalously high chloride concentrations were detected in all but one monitoring well (Fig. 6). Well 31DCCD detected a chloride concentration of 19,000 mg/L, well 31DDB detected 9,800 mg/L, well 31DCD detected 3,500 mg/L, and well 31DCCB detected 310 mg/L. These concentrations greatly exceed the SMCL of 250 mg/L set by the Environmental Protection Agency (EPA). Part of the chloride concentration at well 31DCCD may be attributed to road salt applied during the winter months. Some of the chloride concentration in the monitoring wells may be attributed to upward ground-water flow from bedrock aquifers. Well 31DCB is located up-gradient of the buried refuse and appears to have the lowest chloride concentration (170 mg/L). This may indicate that the buried refuse is contributing to the high chloride concentrations of the other wells.

Anomalously high sodium concentrations were detected in three water samples (Fig. 7). Well 31DCCD detected a sodium concentration of 1,600 mg/L, well 31DDB detected 1,600 mg/L, and well 31DCD detected 630 mg/L. These concentrations exceed the SMCL of 250 mg/L set by the EPA. Upward ground-water flow from bedrock aquifers may be contributing a

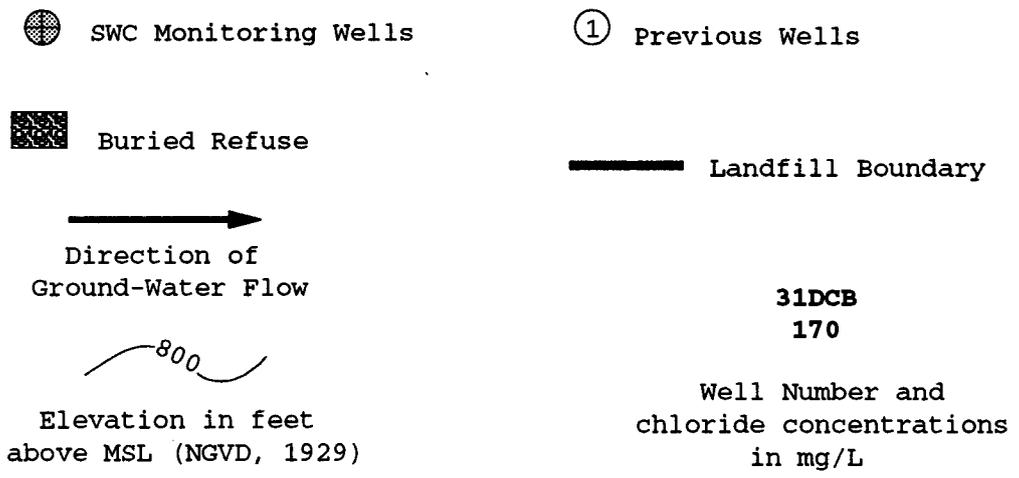
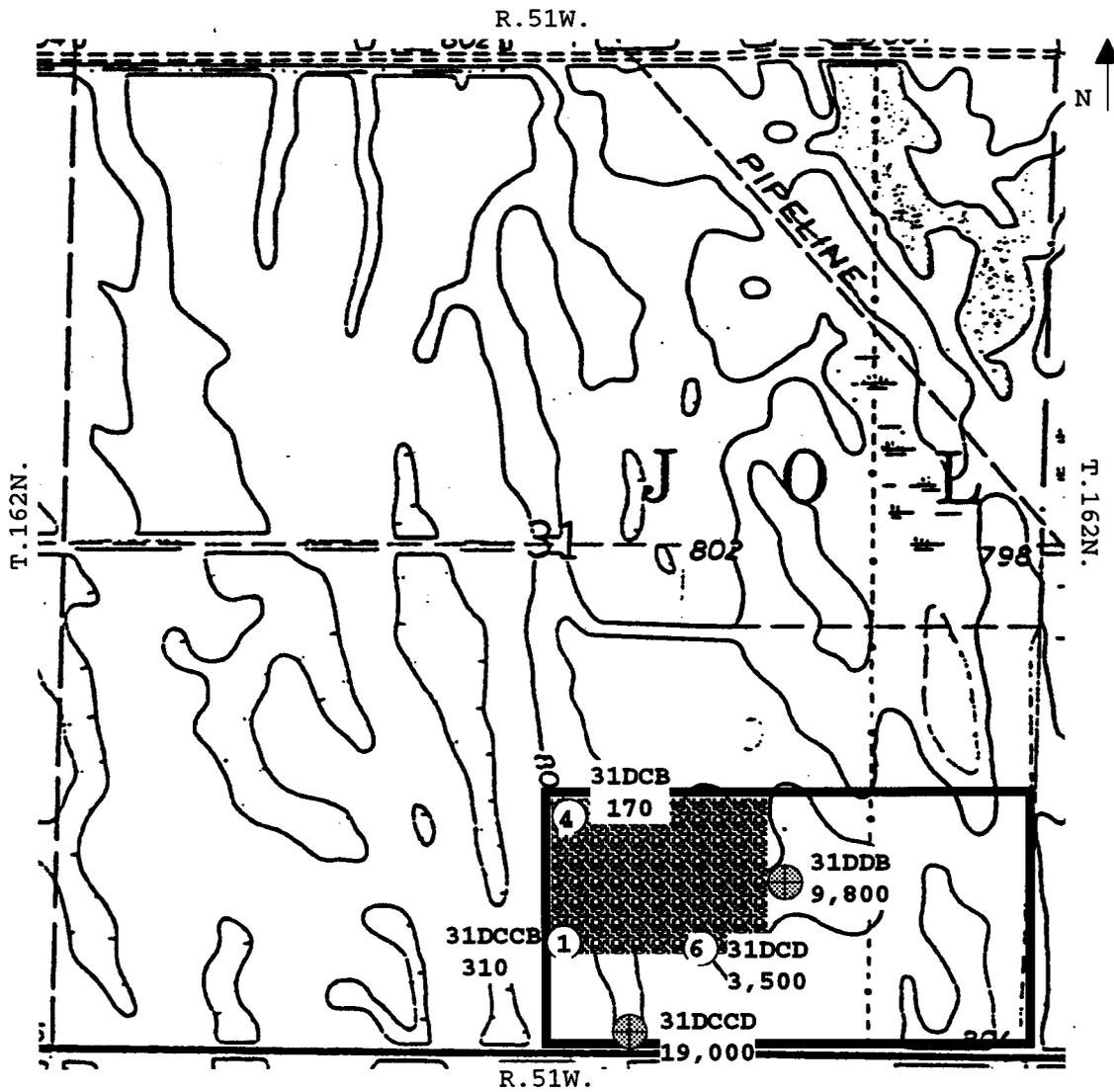


Figure 6. Location of monitoring wells and chloride concentrations.

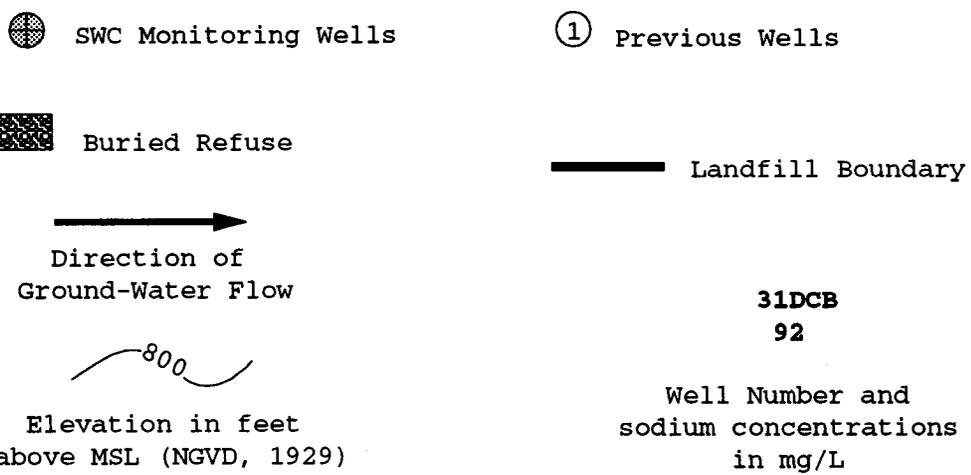
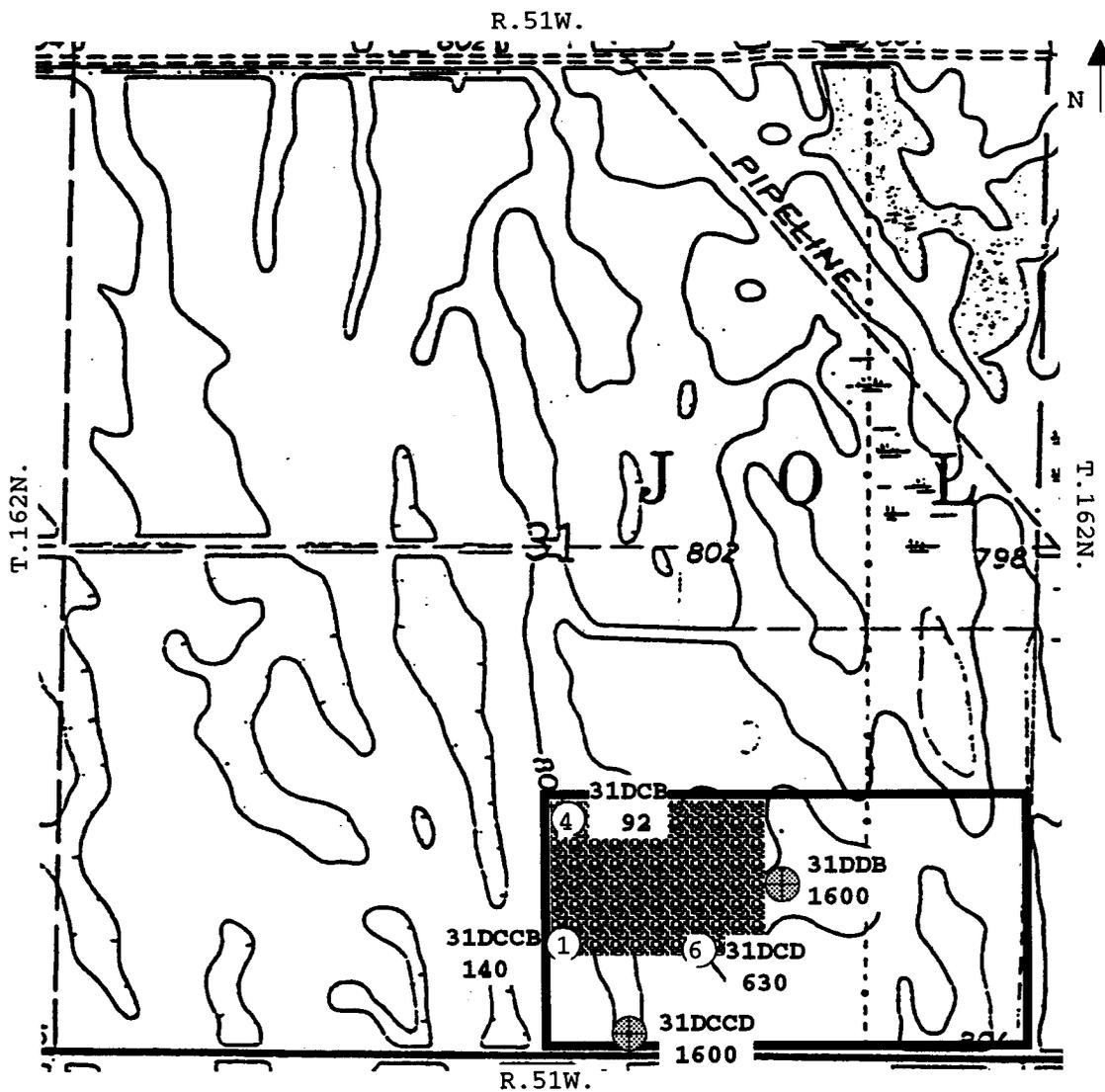


Figure 7. Location of monitoring wells and sodium concentrations.

portion of the sodium at these wells. Part of the sodium concentration in well 31DCCD may also be attributed to road salt.

Monitoring wells 31DCD and 31DDB indicated iron concentrations of 14 mg/L and 0.44 mg/L, respectively, that exceed the SMCL of 0.3 mg/L. These concentrations may be partially attributed to leachate migration from the landfill as they are located adjacent to the buried refuse.

A nitrate concentration of 74 mg/L was detected in well 31DCCD, that exceeded the SMCL of 45 mg/L. The source of the nitrate concentration was not determined, but may indicate contaminant migration from the landfill.

The trace element analyses detected a selenium concentration of 70 $\mu\text{g/L}$ in well 31DCCD, this exceeds the MCL of 10 $\mu\text{g/L}$. This concentration is not typical for ground water in this area and may indicate contaminant migration from the landfill.

The results of the VOC analysis, from well 162-051-31DCD, are shown in Appendix F. The VOC analyses detected VOC concentrations of acetone (2,350 $\mu\text{g/L}$), 2-butanone (MEK, 1420 $\mu\text{g/L}$), 4-methyl-2-pentanone (56 $\mu\text{g/L}$), dichloromethane (32.2 $\mu\text{g/L}$), toluene (4.23 $\mu\text{g/L}$), xylene (7.53 $\mu\text{g/L}$), 1,1-dichloroethane (5.17 $\mu\text{g/L}$), ethylbenzene (1.6 $\mu\text{g/L}$), chloromethane (1.98 $\mu\text{g/L}$), chloroethane (0.97 $\mu\text{g/L}$), fluorotrichloromethane (0.87 $\mu\text{g/L}$), dichlorodifluoromethane (41.1 $\mu\text{g/L}$) and ether (23 $\mu\text{g/L}$). Although concentrations of acetone, 2-butanone, toluene, and dichloromethane may be

attributed to laboratory contamination[†], the concentrations detected in well 31DCD exceed the contamination potential of the laboratory. Therefore, the VOC concentrations may indicate contaminant migration from the landfill.

CONCLUSIONS

The Valley landfill is located in a very low-relief area surrounded by small depressions and wetlands. The stratigraphy of the area consists of more than 100 feet of lake deposits underlain by glacial till and outwash. The Ordovician Red River Formation occurs at a depth of about 200 feet. Test holes drilled at the landfill encountered clay and silty clay with a few layers and lenses of silt.

Glacial sand and gravel deposits comprise the main aquifers in the area. The water quality in the glacial aquifers is adversely affected by upward flow of saline water from the Red River Formation. The upward flow gradient also influences the chemistry of the shallow ground water within the lake sediments.

The upward movement of water, minor surface runoff, and low infiltration rates contribute to the maintenance of a shallow water table beneath the landfill. Depths to ground water ranged from 4 to 8 feet. The water-level measurements indicate a direction of ground-water flow to the south-

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

southeast. The direction of ground-water flow may be affected by the road ditch along the southern boundary and by ground-water mounding beneath the landfill.

Chemical analyses of water samples detected very high chloride and sodium concentrations in the down-gradient wells (31DDB, 31DCD, and 31DCCD). These chemicals may be derived from a combination of sources, including road salt in the case of well 31DCCD and upward flow of ground water from the Ordovician bedrock. The fact that the concentrations in these wells are much higher than in the upgradient well 31DCB suggests that part of the chloride and sodium probably originated from the landfill. An anomalously high nitrate concentration that exceeded the MCL was detected in well 31DCCD. This concentration may indicate contaminant migration from the landfill. Two of the downgradient wells also detected elevated concentrations of iron.

Trace element analyses detected a selenium concentration in well 31DCCD that was seven times higher than the MCL. This concentration is not typical for ground water in this area and may indicate contaminant migration from the landfill.

The VOC analysis, from well 31DCD, detected acetone, 2-butanone, 4-methyl-2-pentanone, toluene, xylene, dichloromethane, dichloroethane, ether, ethylbenzene, chloromethane, chloroethane, fluorotrichloromethane, and dichlorodifluoromethane. Although concentrations of some of these compounds may be attributed to laboratory influence,

the concentrations detected in well 31DCD exceed the contamination potential of the laboratory. Therefore, the VOC concentrations may indicate contaminant migration from the landfill.

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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	-----

<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

162-051-31DCCD

NDSWC

Date Completed: 6/8/94
L.S. Elevation (ft): 802.63
Depth Drilled (ft): 27
Screened Interval (ft): 17-27

Purpose:
Well Type:
Aquifer:
Source:
Owner:

Observation Well
2" PVC
Undefined
VALLEY LANDFILL

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	SILTY, YELLOWISH-BROWN	2-7
CLAY	SILTY, YELLOWISH-BROWN WITH ORANGE AND LIGHT GRAY MOTTLING	7-12
SILT	CLAYEY, YELLOWISH-BROWN, MOIST	12-15
CLAY	SILTY, OLIVE-GRAY TOTAL DEPTH 27 FEET.	15-27

162-051-31DDB

NDSWC

Date Completed: 6/8/94
L.S. Elevation (ft): 800.36
Depth Drilled (ft): 22
Screened Interval (ft): 12-22

Purpose:
Well Type:
Aquifer:
Source:
Owner:

Observation Well
2" PVC
Undefined
VALLEY LANDFILL

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SILT	CLAYEY, YELLOWISH-BROWN, TRACE VERY FINE SAND	2-6
CLAY	SILTY, YELLOWISH-BROWN WITH ORANGE MOTTLING	6-12
CLAY	SILTY, OLIVE-GRAY TOTAL DEPTH 22 FEET.	12-22

LOG OF TEST BORING

JOB NO. 5200-87-0217

VERTICAL SCALE 1" = 4'

BORING NO. 1

PROJECT SANITARY LANDFILL - PEMBINA, NORTH DAKOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL ↓ SURFACE ELEVATION _____	GEOLOGIC ORIGIN	N	WL	SAMPLE		LABORATORY TESTS				
					NO	TYPE	W	D	LL PL	Ou	
5	FILL, mostly LEAN CLAY, dark brown and black, pieces of paper	FILL	9		1	SB					
			6	▼	2	SB					
19	MEDIUM FAT CLAY, brown, medium to soft to rather stiff, lenses and layers of silt (CL-CH)	LAKE AGASSIZ DEPOSIT	5		3	SB	37			49 23	
			3		4	SB					
			4		5	SB					
			8		6	SB					
			11		7	SB					
23	MEDIUM FAT CLAY, gray, rather stiff, lenses and layers of silt (CL-CH)		9		8	SB					
30	FAT CLAY, gray, soft (CH)		3		9	SB					
	-CONTINUED ON NEXT PAGE-										

LOG OF TEST BORING

 JOB NO 5200-87-0217

 VERTICAL SCALE 1" = 4'

 BORING NO 1-continued

 PROJECT SANITARY LANDFILL - PEMBINA, NORTH DAKOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE		LABORATORY TESTS			
					NO	TYPE	W	D	LL PL	Qu
30	FAT CLAY - continued	LAKE AGASSIZ DEPOSIT CONTINUED	3		10	SB				
			3		11	SB				
			3		12	SB				
			3		13	SB				
51	END OF BORING		3		14	SB				

WATER LEVEL MEASUREMENTS

 START 5-13-87 COMPLETE 5-13-87

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD	REMARKS
5-13	7:45	6'	4½'	4½'	10	3'	3½" HSA 0-9'	@ 10:00
5-13	10:45	51'	9'	45½'	10	5'	J.W. 9'-49½'	
5-13	11:18	51'	None	49½'	10	4'		
5-13	8:30	51'	None	49½'	10	3'		

 CREW CHIEF Jacobson

LOG OF TEST BORING

 JOB NO 5200-87-0217

 VERTICAL SCALE 1" = 4'

 BORING NO 4

 PROJECT SANITARY LANDFILL - PEMBINA, NORTH DAKOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE		LABORATORY TESTS				
					NO	TYPE	W	D	LL PL	Qu	
	↙ SURFACE ELEVATION _____										
14	TOPSOIL, LEAN CLAY, black (OL)	TOPSOIL				1	FA				
	MEDIUM FAT CLAY, brown, lenses and layers of silt (CL-CH)	LAKE AGASSIZ DEPOSIT				2	FA				
				▼		3	FA				
						4	FA				
						5	FA				
						6	FA				
15	END OF BORING										

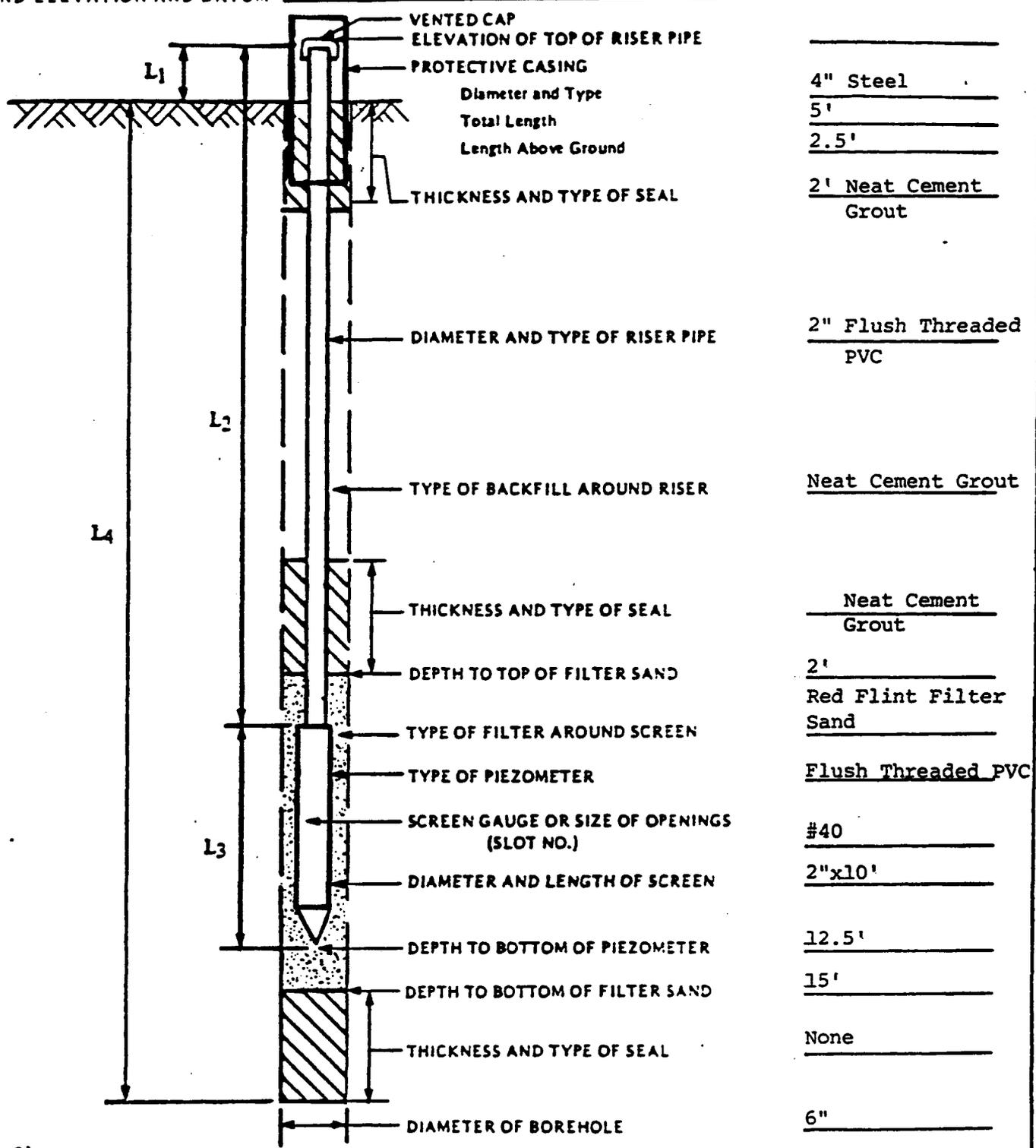
WATER LEVEL MEASUREMENTS

 START 5-14-87 COMPLETE 5-14-87

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL	METHOD	TIME
5-14	11:45	15'	None	15'	10	6'	6"FA 0-15'	@ 12:15
					10			
					10			
					10			

 CREW CHIEF Jacobson

GROUND ELEVATION AND DATUM



- 4" Steel
- 5'
- 2.5'
- 2' Neat Cement Grout
- 2" Flush Threaded PVC
- Neat Cement Grout
- Neat Cement Grout
- 2'
- Red Flint Filter Sand
- Flush Threaded PVC
- #40
- 2"x10'
- 12.5'
- 15'
- None
- 6"

L₁ = 2½ FT
 L₂ = 5 FT
 L₃ = 10 FT
 L₄ = 15 FT

PIEZOMETER WATER LEVEL MEASUREMENTS			
DATE	TIME	BAILED DEPTHS	WATER LEVEL
5-14	12:15		6.3'
5-14	6:30		6.2'

INSTALLATION COMPLETED:
 Date 5-14-87 Time 12:15

LOG OF TEST BORING

JOB NO 5200-87-0217 VERTICAL SCALE 1" = 4' BORING NO 6
 PROJECT SANITARY LANDFILL - PEMBINA, NORTH DAKOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE		LABORATORY TESTS				
					NO	TYPE	W	D	LL P.L.	Ou	
	↙ SURFACE ELEVATION _____										
2	FILL OR TOPSOIL, LEAN CLAY, dark brown	FILL OR TOPSOIL				1	FA				
	MEDIUM FAT CLAY, brown mottled, lenses and layers of silt (CL-CH)	LAKE AGASSIZ DEPOSIT				2	FA				
						3	FA				
						4	FA				
					▼	5	FA				
						6	FA				
15	END OF BORING										

WATER LEVEL MEASUREMENTS

START 5-14-87 COMPLETE 5-14-87

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
5-14	3:30	15'	None	15'	10	10'
					10	
					10	
					10	

METHOD 6"FA 0-15' @ 3:30

CREW CHIEF Jacobson

APPENDIX D

WATER-LEVEL TABLES

Valley Landfill Water Levels
7/26/94 to 9/8/94

162-051-31DCB MP Elev (msl,ft)=803.86
Undefined Aquifer SI (ft.)=2.5-12.5

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/26/94	5.02	798.84	08/24/94	6.22	797.64
08/11/94	5.74	798.12	09/08/94	6.26	797.60

162-051-31DCCB MP Elev (msl,ft)=804.9
Undefined Aquifer SI (ft.)=3-13

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/26/94	4.87	800.03	08/24/94	6.76	798.14
08/11/94	6.35	798.55	09/08/94	6.93	797.97

162-051-31DCCD MP Elev (msl,ft)=804.09
Undefined Aquifer SI (ft.)=17-27

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/26/94	5.41	798.68	08/24/94	7.98	796.11
08/11/94	7.20	796.89	09/08/94	7.71	796.38

162-051-31DCD MP Elev (msl,ft)=802.34
Undefined Aquifer SI (ft.)=3-13

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/26/94	Not taken		08/24/94	4.68	797.66
08/11/94	4.23	798.11	09/08/94	4.48	797.86

162-051-31DDB MP Elev (msl,ft)=801.92
Undefined Aquifer SI (ft.)=12-22

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/26/94	3.04	798.88	08/24/94	4.55	797.37
08/11/94	4.14	797.78	09/08/94	3.98	797.94

APPENDIX E

MAJOR ION AND TRACE-ELEMENT
CONCENTRATIONS

Valley Landfill Water Quality Major Ions

Location	Screened Interval (ft)	Date Sampled	(milligrams per liter)															TDS	Hardness as CaCO ₃	as NCH	% 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									
162-051-31DCB	2.5-12.5	07/21/94	11	0.07	0.24	300	170	92	19	889	0	640	170	0.2	4	0.42	1840	1400	720	12	1.1	3160	14		
162-051-31DCCB	3-13	07/21/94	9.8	0.07	0.48	250	160	140	44	579	0	790	310	0.1	13	1.1	2000	1300	810	19	1.7	3240	15		
162-051-31DCCD	17-27	07/21/94	16	0.31	8.6	2100	5600	1600	19	315	0	3000	19000	0.1	74	0.16	31600	28000	28000	11	4.2	51900	15		
162-051-31DCD	3-13	07/21/94	51	14	10	930	750	630	27	1690	0	1100	3500	0	0	0.38	8700	5400	4000	20	3.7	13100	13		
162-051-31DDB	12-22	07/20/94	18	0.44	1.8	2100	1700	1600	24	281	0	1700	9800	0.2	6.2	0.17	17100	12000	12000	22	6.4	31500	11		

Trace Element Analyses

Location	Date Sampled	Selenium	Lead	Cadmium	Mercury	Arsenic	Molybdenum	Strontium
		(micrograms per liter)						
162-051-31DCB	07/21/94	2	0	1	0.1	2	7	890
162-051-31DCCB	07/21/94	3	0	1	0	1	2	760
162-051-31DCCD	07/21/94	70	0	1	0.4	21	4	4200
162-051-31DCD	07/21/94	0	0	0	0.1	7	9	4100
162-051-31DDB	07/21/94	23	0	0	0.3	7	8	8000

APPENDIX F

VOLATILE ORGANIC COMPOUNDS
FOR WELL 162-051-31DCD

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-Dichloroethane	<0.5
Trichloroethylene	<0.5
1,1-Dichloroethylene	<0.5
1,1,1-Trichloroethane	<0.5
para-Dichlorobenzene	<0.5
Acetone	2350.00*
2-Butanone (MEK)	1420.00*
2-Hexanone	<50
4-Methyl-2-pentanone	56.00*
Chloroform	<0.5
Bromodichloromethane	<0.5
Chlorodibromomethane	<0.5
Bromoform	<0.5
trans1,2-Dichloroethylene	<0.5
Chlorobenzene	<0.5
m-Dichlorobenzene	<0.5
Dichloromethane	32.20*
cis-1,2-Dichloroethylene	<0.5
o-Dichlorobenzene	<0.5
Dibromomethane	<0.5
1,1-Dichloropropene	<0.5
Tetrachlorethylene	<0.5
Toluene	4.23*
Xylene (s)	7.53*
1,1-Dichloroethane	5.17*
1,2-Dichloropropane	<0.5
1,1,2,2-Tetrachloroethane	<0.5
Ethyl Benzene	1.60*
1,3-Dichloropropane	<0.5
Styrene	<0.5
Chloromethane	1.98*
Bromomethane	<0.5
1,2,3-Trichloropropane	<0.5
1,1,1,2-Tetrachloroethane	<0.5
Chloroethane	0.97*
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	0.87*
Dichlorodifluoromethane	41.10*
Bromochloromethane	<0.5
Allylchloride	<5
2,3-Dichloro-1-propane	<5
Tetrahydrofuran	<50
Pentachloroethane	<5
Trichlorotrifluoroethane	<5
Carbondisulfide	<5
Ether	23.00*
trans-1,3-Dichloropropene	<0.5

* Constituent Detection