Site Suitability Review of the Fargo Landfill

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

ND Landfill Site Investigation No. 47

1861

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OF THE
FARGO LANDFILL

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Bismarck, North Dakota
1995

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INTRODUCTION

Purpose

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

Location of the Fargo Landfill

The Fargo landfill is located in Township 139 N., Range 49 W., northeast quarter of section 4 (Fig. 1). The landfill area encompasses about 160 acres.

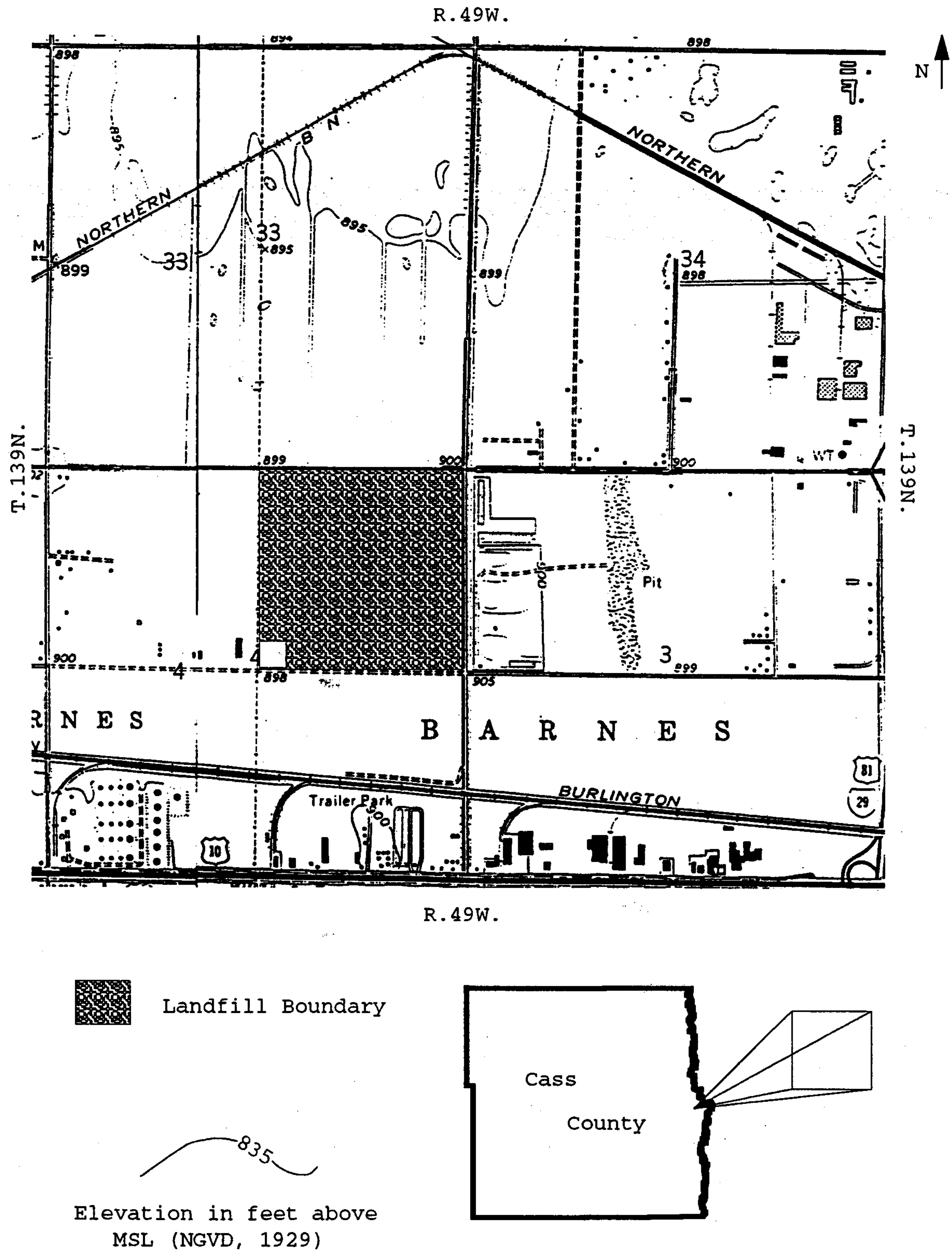

Figure 1. Location of the Fargo landfill in the NE 1/4, Section 4, T.139N., R.49W.

Previous Site Investigations

A hydrogeological investigation was completed by Donohue Engineering in January, 1990. Donohue concluded that the landfill site is underlain by a minimum of 60 feet of relatively impermeable clay. The surficial clay ranges in thickness from 9 to 10 feet and is underlain by a layer of silty sand ranging in thickness from 0.5 to 15.5 feet (two-foot thickness beneath the landfill). The silty sand is underlain by a layer of clay with a minimum thickness of 30 feet. This clay layer directly overlies the West Fargo aquifer. The direction of ground-water flow in the silty sand layer is to the northeast and discharge is into the Red River of the North. The present landfill is characterized by a water-table depression caused by the clay cut-off wall surrounding the site. The report also concluded that the local water quality has been impacted immediately beneath and adjacent to the fill areas, and that the contamination has not spread beyond the landfill boundaries.

Methods of Investigation

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

Test-Drilling Procedure

The drilling method at the Fargo landfill was based on the site's geology and depth to ground water, as determined by the preliminary evaluation. A forward rotary drill rig was used at the Fargo landfill. The lithologic descriptions were determined from the drill cuttings.

Monitoring Well Construction and Development

Five test holes were drilled at the Fargo landfill, and monitoring wells were installed in all of them. The number of wells installed at the Fargo landfill was based on the geologic and topographic characteristics of the site. The depth and intake interval of each well was selected to monitor the water level at the top of the uppermost aquifer. The wells were located within the boundaries of the landfill.

Wells were constructed following a standard design (Fig. 2) intended to comply with the construction regulations of the NDSDHCL and the North Dakota Board of Water Well Contractors (North Dakota Department of Health, 1986). The wells were constructed using a 2-inch diameter, SDR21, polyvinyl chloride (PVC) well casing and a PVC screen, either 5 or 10 feet long, with a slot-opening size of 0.012 or 0.013 inches. The screen was fastened to the casing with stainless steel screws (no solvent weld cement was used). After the casing and screen were installed into the drill hole, the

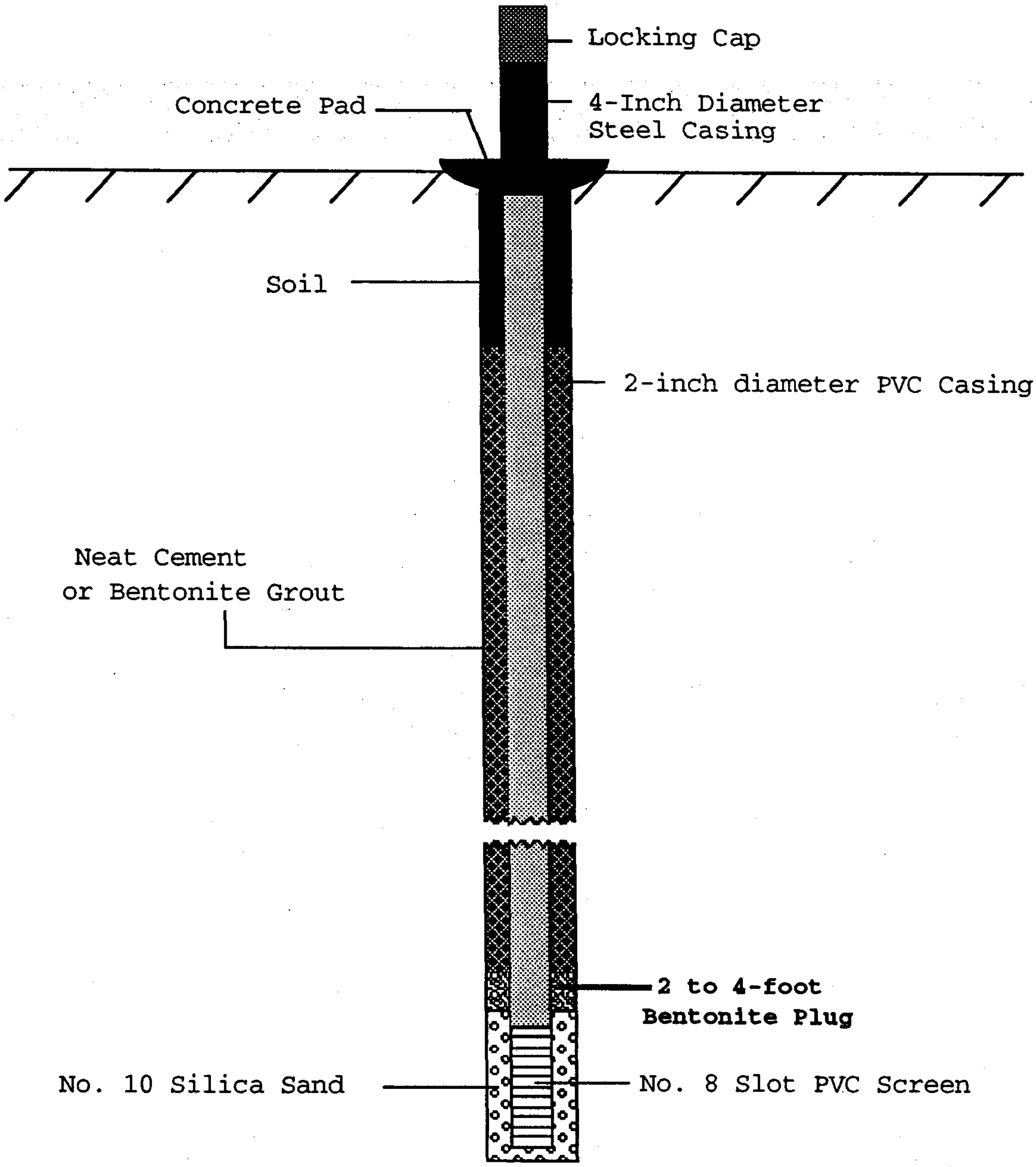

Figure 2. Construction design used for monitoring wells installed at the Fargo landfill.

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 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

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

B. Each sample was collected with a plastic throw-away bailer and kept chilled. These samples were analyzed within the permitted 14-day holding period. The standard water-quality analyses were performed at the North Dakota State Water Commission (NDSWC) Laboratory and VOC analyses were performed by the NDSDHCL.

Water-Level Measurements

Water-level measurements were taken at least three times at a minimum of two-week intervals. The measurements were 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 139-049-04ACD

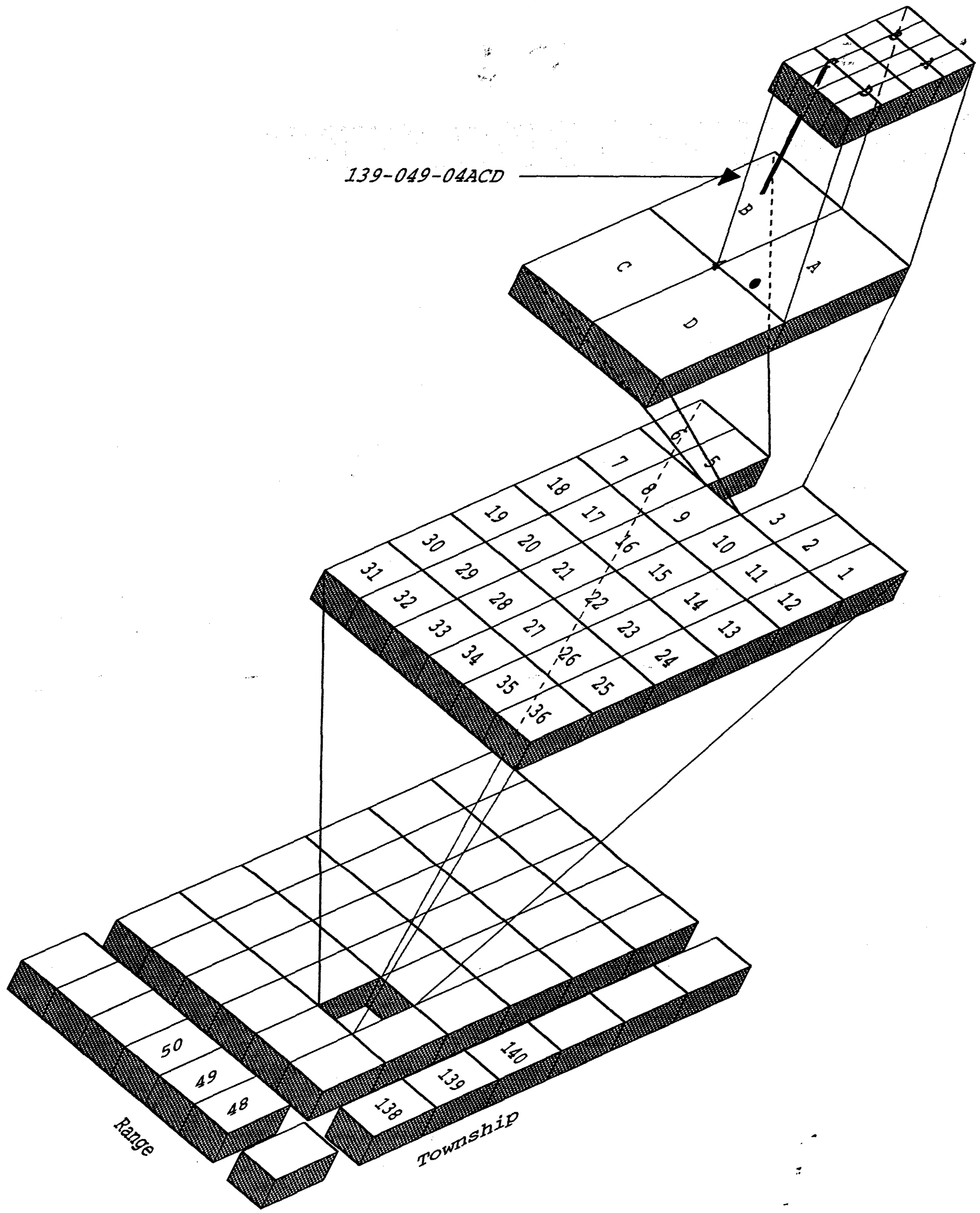


Figure 3. Location-numbering system at the Fargo landfill.

would be located in the SE1/4, SW1/4, NE1/4, Section 4, Township 139 North, Range 49 West. Consecutive numbers are added following the three letters if more than one well is located in a 10-acre tract, e.g. 139-049-04ACD1 and 139-049-04ACD2.

GEOLOGY

The Fargo landfill lies within the Red River Valley physiographic region, a broad plain that was formerly the basin of glacial Lake Agassiz. The landfill occupies an area of very low relief. Surface drainage is toward the north and northeast with eventual discharge into the Red River. A drainage ditch on the east side of the landfill flows northward. A clay slurry wall has been constructed around the perimeter of the landfill (Fig. 4) to lower the water table beneath the landfill and impede movement of ground water from the landfill area.

Surficial lithologies in the area consist primarily of offshore lake deposits. Alluvium, with a maximum known thickness of 15 feet, also occurs along the Sheyenne and Red Rivers. The West Fargo ridge terminates about a mile southwest of the landfill. This ridge is 5 to 10 feet high and is composed of silt, sand, and gravel. The ridge is believed to have been deposited by a stream flowing across the lake bed (Klausing, 1968a).

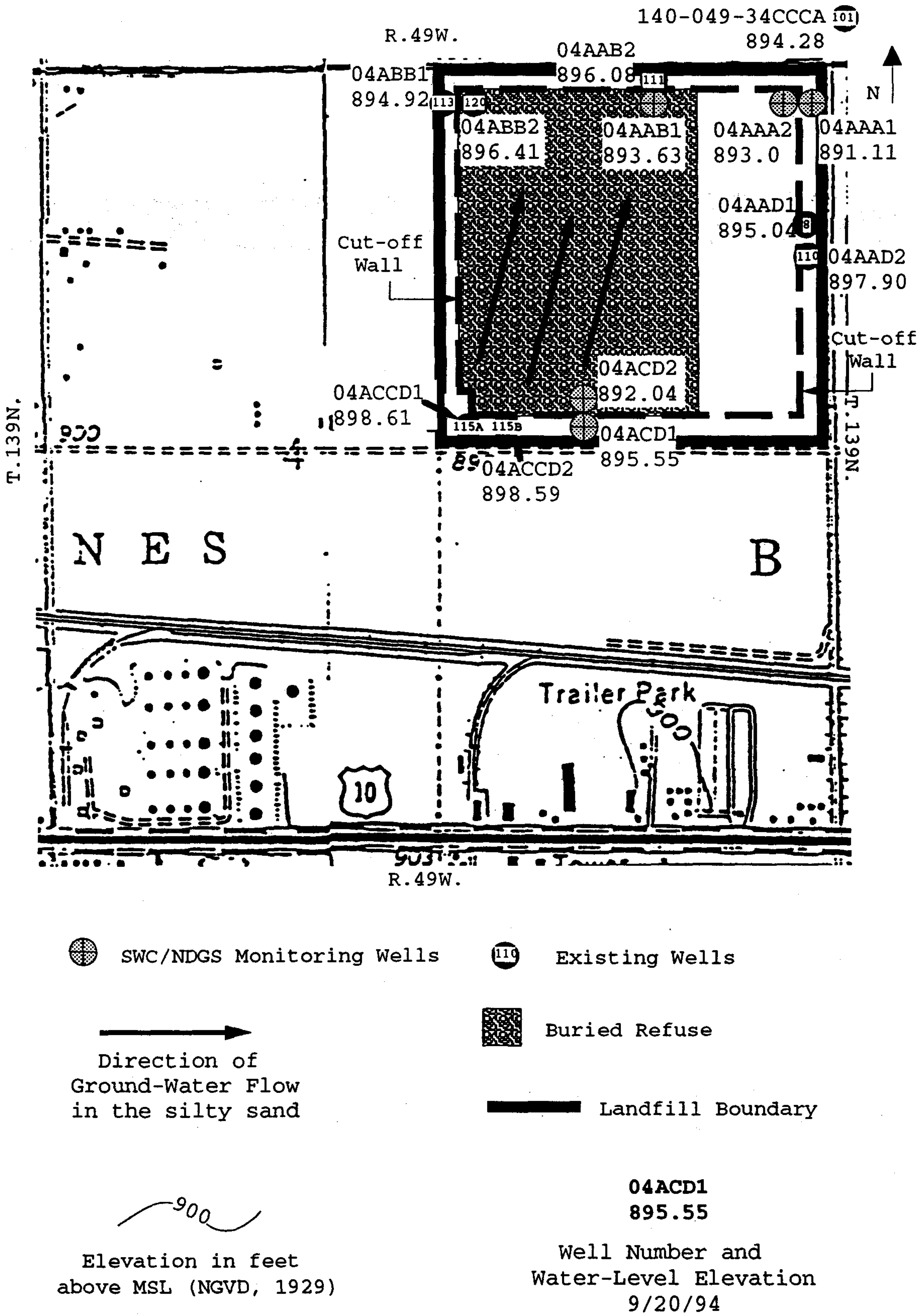


Figure 4. Location of monitoring wells and the direction of ground-water flow.

A deep test hole drilled adjacent to the landfill by the State Water Commission in 1982 penetrated 86 feet of lake deposits (NDSWC test hole 139-49-03BBB). These deposits consisted mainly of clay. The lake deposits were underlain by glacial till from 86 to 133 feet and by gravel from 133 to 189 feet. Cretaceous shale was encountered from a depth of 189 to 200 feet.

The thick gravel layer is part of the West Fargo aquifer. This aquifer appears to be a north-south trending, buried channel deposit. The fill materials in the channel consist of fine to coarse sand and gravel with lenses of clay and silt (Klausing, 1968b).

Test holes drilled for the present study encountered clay materials at the landfill except for a thin layer of fine-grained, silty sand occurring at depths between 10 to 20 feet. The sand was present in all test holes except for 139-049-04AAA2 (Figs. 5, 6, and 7, lithologic logs in Appendix C). Test holes drilled earlier by Twin City Testing (1989, 1982) and Midwest Testing (1979) also encountered the sand layer at most locations. The sand generally ranges from 1 to 3 feet thick beneath the present landfill.

The sand is thicker beneath the old Fargo landfill to the east, with a maximum thickness of 15 feet in test hole B103 (Twin City Testing, 1989). Cross sections drawn by Donohue across the new and old landfill sites show that the upper surface of the sand is relatively uniform in elevation. The base of the sand occurs at lower elevations toward the

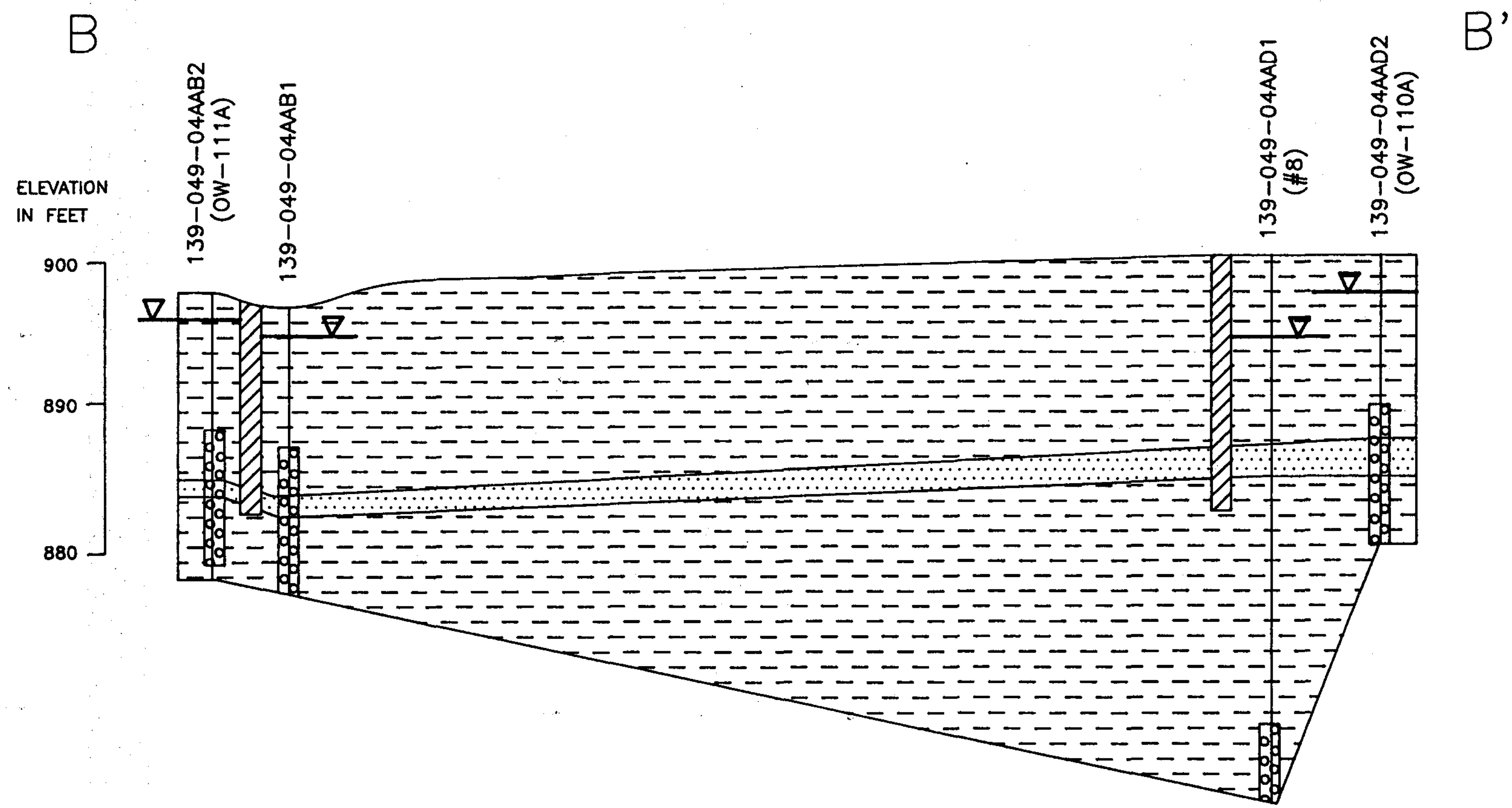


Figure 6. Geohydrologic section B–B' in the Fargo landfill.

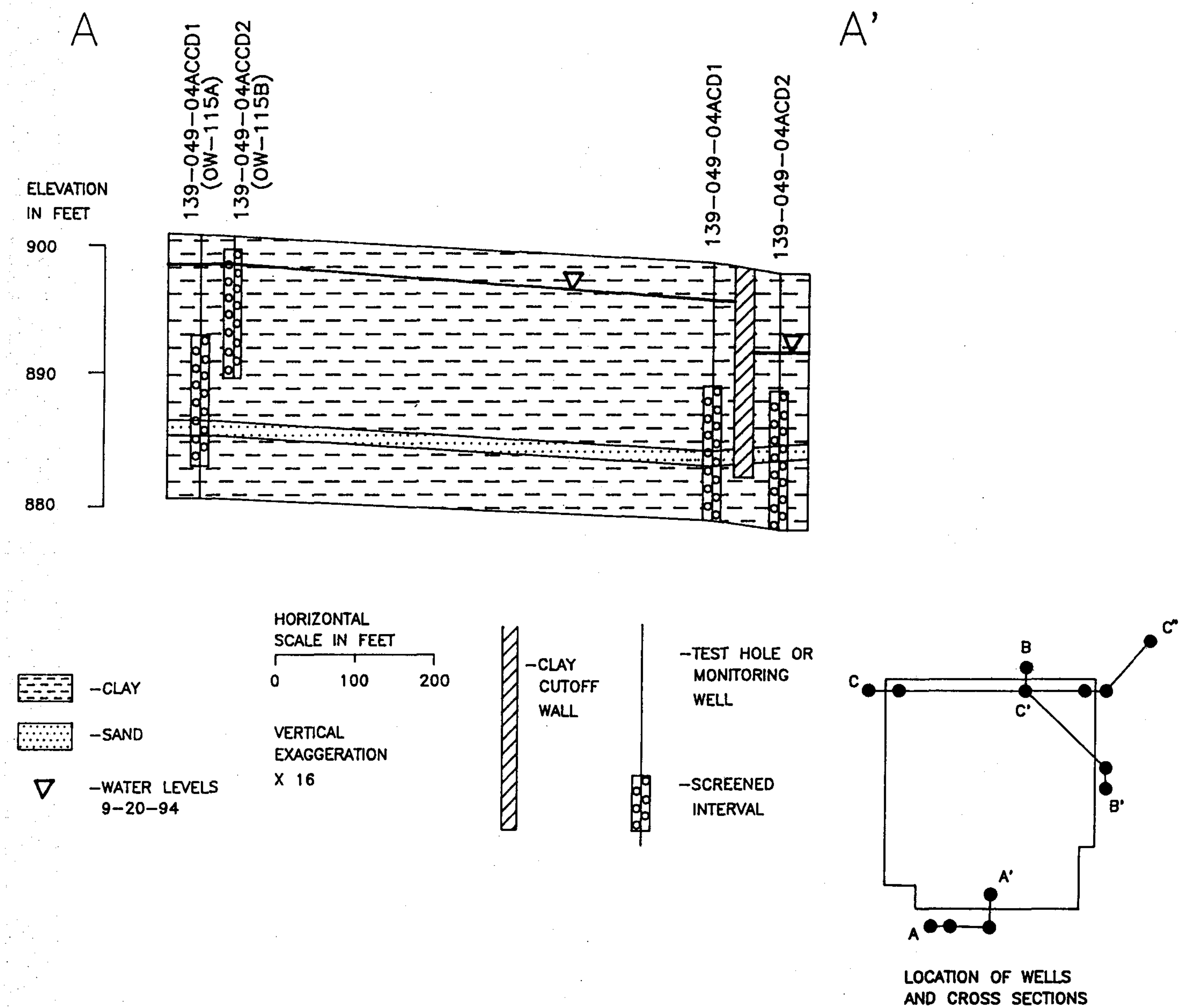


Figure 5. Geohydrologic section A–A' in the Fargo landfill.

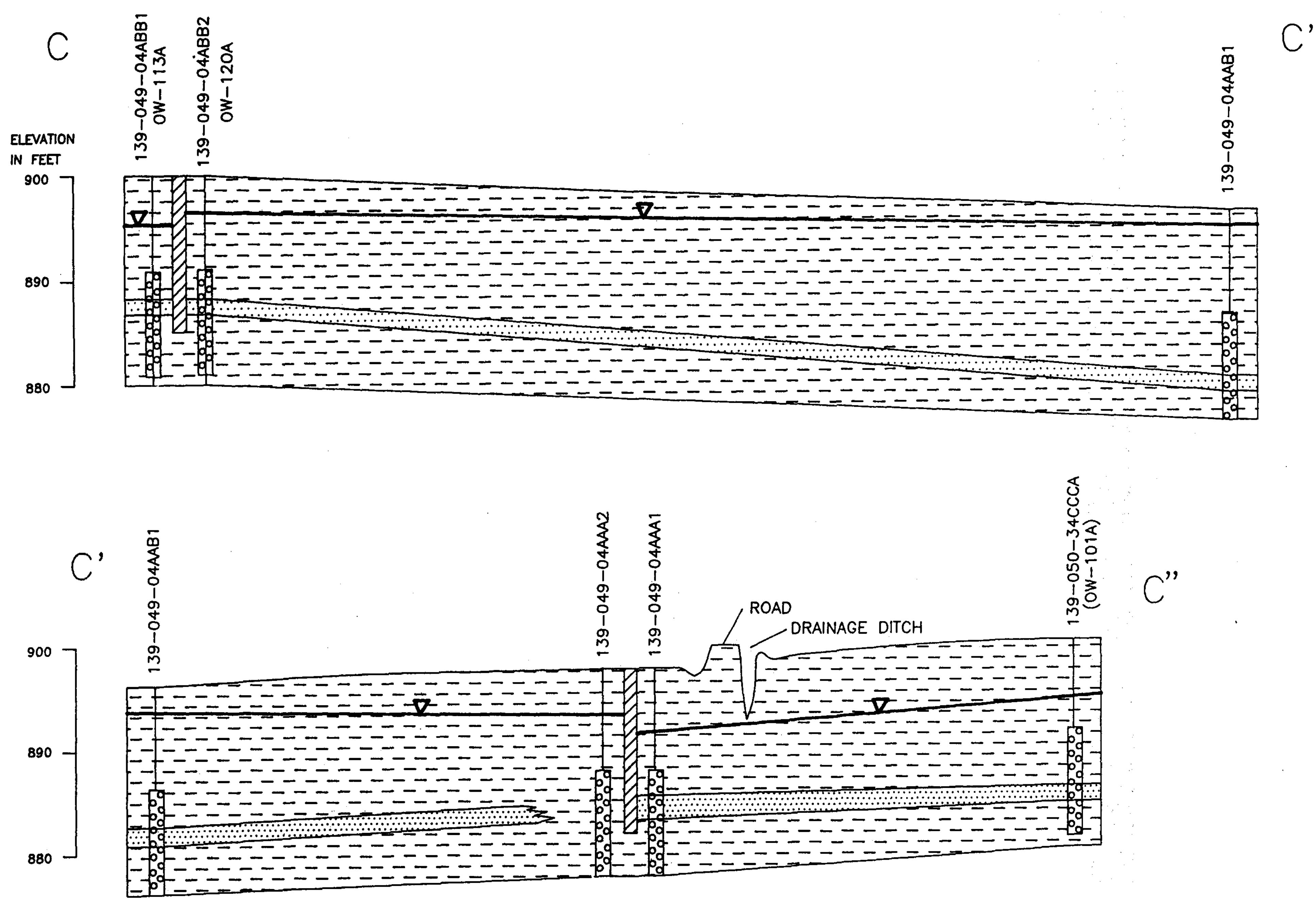


Figure 7. Geohydrologic section C–C' and C'–C" in the Fargo landfill.

east as the sand thickens (Donohue, 1990, Plates 7, 8, 9, and 10). The sand appears to have no direct hydraulic connection to the West Fargo aquifer.

HYDROLOGY

Surface-Water Hydrology

The nearest body of surface water is the Red River of the North, located about four miles east of the landfill. Due to its distance from the landfill, the Red River should not be susceptible to contaminant migration.

Regional Ground-Water Hydrology

The Dakota aquifer, the only bedrock aquifer in the area surrounding the Fargo landfill, is located about 200 to 300 feet below land surface (Klausing, 1968). The Dakota aquifer is characterized by a sodium-sulfate to sodium-chloride type water. The Dakota aquifer is confined with till and/or lacustrine material overlying the aquifer (Klausing, 1968). The Dakota aquifer should not be affected by contaminant migration from the landfill because of its depth and the overlying till and/or lacustrine clay aquitards.

The glacial aquifers in the area of the Fargo landfill are the West Fargo and Fargo aquifers. The Fargo landfill is located directly above the West Fargo aquifer. The West

Fargo aquifer ranges in depth from 100 to 130 feet below land surface (Klausing, 1968). The West Fargo aquifer is confined. The confining units consist of overlying till and lacustrine clay and the underlying bedrock shale. Recharge to the West Fargo aquifer is by precipitation and lateral ground-water flow from undifferentiated sand and gravel aquifers and the Dakota aquifer. Discharge from the West Fargo aquifer is by pumping. The City of West Fargo obtains its municipal water supply from this aquifer. A large ground-water "sink" has been established by the pumping of the city well and two industrial wells (Ripley, personal communication). The direction of ground-water flow in the West Fargo aquifer, beneath the landfill, is toward these wells. The West Fargo aquifer is characterized by a sodium-bicarbonate to a sodium-chloride type water (Klausing, 1968). The West Fargo aquifer should not be affected by contaminant migration from the landfill because of the occurrence of thick, overlying till and lacustrine clay aquitards.

The Fargo aquifer is located about 1.5 miles east of the landfill. The depth of the Fargo aquifer ranges from 100 to 130 feet (Klausing, 1968). The Fargo aquifer is confined. Confining units consist of overlying till and lacustrine clay and underlying crystalline bedrock. The Fargo and West Fargo aquifers are poorly connected hydraulically. Recharge to the Fargo aquifer is by precipitation and lateral flow from undifferentiated sand and gravel aquifers and the Dakota aquifer. Discharge from the Fargo aquifer is by pumping.

The Fargo aquifer is characterized by a sodium-bicarbonate type water (Klausing, 1968). The Fargo aquifer should not be susceptible to contaminant migration from the landfill because of the occurrence of thick, overlying till and lacustrine clay aquitards.

Undifferentiated glacial aquifers may be distributed throughout the area of the Fargo landfill. These aquifers usually are not very extensive and as a result ground-water storage is limited (Klausing, 1968). The 2-to 3-foot thick sand that occurs from 10 to 20 feet beneath the landfill is an undifferentiated aquifer.

Local Ground-Water Hydrology

Five test holes were drilled at the Fargo landfill with monitoring wells installed in all of them (Fig. 4). Eight existing monitoring wells were also used for this investigation (MW-115A, MW-115B, MW-110, MW-8, MW-111, MW-113, MW-120, AND MW-101). All of the monitoring wells are screened in a hydrologic unit consisting of a fine-grained silty sand. This unit is located at a depth of 10 to 20 feet and underlies lacustrine clay. Donohue (1989) measured vertical hydraulic conductivities of the lacustrine clay at the base of the refuse cells ranging from 1.5×10^{-8} cm/sec to 5.8×10^{-8} cm/sec. The horizontal hydraulic conductivities of the silty sand aquifer ranged from 9.0×10^{-5} cm/sec to 6.9×10^{-3} cm/sec (Donohue, 1989). Using Darcy's Law, Donohue

(1989) determined the rate of ground-water flow in the silty sand aquifer to be 7 feet per year. The direction of ground-water flow in this aquifer is northeast. The lateral extent of this aquifer is known to extend beneath Interstate 29 about 1.5 miles northeast of the landfill.

A bentonite slurry wall was installed around the perimeter of the landfill to lower the water level below the base of the refuse cells (Donohue, 1989). The slurry wall is about nine feet wide and extends to the base of the silty sand hydrologic unit. The purpose of the slurry wall is to prevent the migration of contaminants from the buried refuse (Donohue, 1989). Four of the monitoring wells are located inside the slurry wall that borders the landfill on all four sides and nine monitoring wells are located outside the slurry wall (Fig. 4).

Water Quality

Chemical analyses of water samples are shown in Appendix E. Due to mechanical failure in the pH meter, field pH measurements were not obtained at this site. The major ion analyses indicated anomalously high chloride concentrations in five of the wells (Fig. 8). The concentrations in these five wells ranged from 250 mg/L to 700 mg/L. These

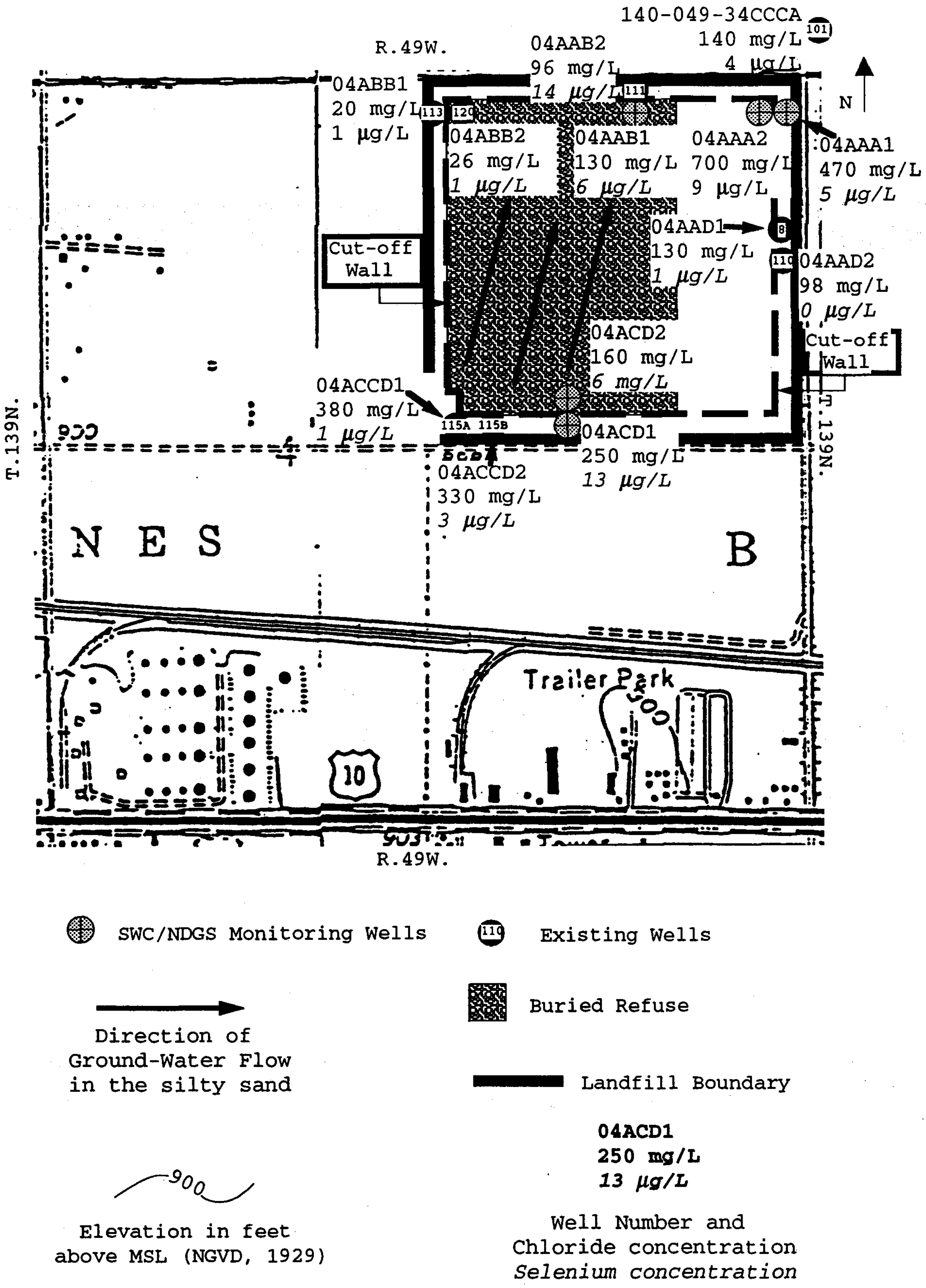


Figure 8. Location of monitoring wells with chloride and selenium concentrations.

concentrations are at or exceed the SMCL of 250 mg/L. The source of the chloride was not determined but the variability of the sodium and chloride may be indicative of contaminant migration from the landfill.

Elevated concentrations of sulfate, sodium, and total dissolved solids that exceeded the SMCL and recommended limits were also present in numerous wells (Appendix E). The source of these concentrations was not determined.

Well 139-049-04AAA1 detected an iron concentration of 0.43 mg/L which exceeds the SMCL of 0.3 mg/L. The source of the iron was not determined.

The trace element analyses detected selenium concentrations in wells 04AAA2 (9 μg/L), 04AAB2 (14 μg/L), and 04ACD1 (13 μg/L) that exceed or approach the MCL of 10 μg/L (Fig. 8). These concentrations appear to be higher than would be expected in ground water in this area and may be indicative of contaminant migration from the landfill.

The results of the VOC analyses from wells 04AAB1 and 04AAB2 are shown in Appendices F and G. Both analyses detected a concentration of dichloromethane (3.04 μg/L and 1.9 μg/L respectively). It is inconclusive whether the source of this VOC compound is the result of laboratory contamination[†] or migration from the landfill.

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

CONCLUSIONS

The Fargo landfill is located in a flat, low-lying area which slopes very gradually to the northeast. This area lies within the Red River Valley physiographic region which consisted of glacial Lake Agassiz. Surficial deposits consist mainly of offshore lake deposits. Previous investigations near the landfill penetrated 86 feet of lake deposits that consist mainly of clay. The lake deposits are underlain by glacial till from 86 to 133 feet and by gravel from 133 to 189 feet. Cretaceous shale was encountered from 189 to 200 feet below land surface.

The layer of gravel is part of the West Fargo aquifer. This aquifer appears to be a north-south trending buried channel consisting of coarse sand and gravel with lenses of clay and silt. The West Fargo aquifer is confined. The confining units consist of overlying till and lacustrine clay and the underlying bedrock shale. The Fargo landfill is located directly above the West Fargo aquifer. The West Fargo aquifer should not be affected by contaminant migration from the landfill because of the overlying till and lacustrine clay aquitards.

The Fargo aquifer is located about 1.5 miles east of the landfill at a depth ranging from 100 to 130 feet. The Fargo aquifer is confined. Confining units consist of overlying till and lacustrine clay and the underlying crystalline bedrock. The Fargo and West Fargo aquifers are poorly connected hydrologically. The Fargo aquifer should not be susceptible to contaminant migration from the landfill because of the occurrence of thick, overlying till and lacustrine clay aquitards.

An undifferentiated aquifer exists beneath the Fargo landfill. This aquifer consists of fine-grained silty sand located at a depth of 10 to 20 feet. The direction of ground-water flow in this aquifer is to the northeast and is known to extend beneath Interstate 29 about 1.5 miles northeast of the landfill.

A bentonite slurry wall was installed around the perimeter of the landfill extending downward to the base of the silty-sand aquifer. The purpose of the slurry wall is to lower the water level beneath the landfill and to prevent migration of contaminants from the buried refuse.

Chemical analyses of water samples indicated anomalously high chloride concentrations in five monitoring wells. These concentrations ranged from 250 to 700 mg/L which approach or exceed the SMCL of 250 mg/L. Elevated concentrations of sulfate, sodium, and total dissolved solids that exceeded the SMCL and recommended limits were also detected in numerous wells. The source of the chloride and other major ions were not determined but the variability of the sodium and chloride may be indicative of contaminant migration from the landfill.

An iron concentration of 0.43 mg/L was detected in well 04AAA1 that exceeds the SMCL of 0.3 mg/L. The source of the iron was not determined.

Trace element analyses detected selenium concentrations in wells 04AAA2, 04AAB2, and 04ACD1 that exceeded or approached the MCL of 10 μg/L. These concentrations appear to be higher than would be expected for ground water in this area and may be indicative of contaminant migration from the landfill.

The results of the VOC analyses in wells 04AAB1 and AAB2 detected a concentration of dichloromethane. It is inconclusive whether the source of this VOC compound is the result of laboratory contamination or migration from the landfill.

REFERENCES

Donohue and Associates, Inc., 1989, Detailed site design report new Fargo landfill: Donohue Project No. 42310, 1 volume.

Donohue and Associates, Inc., 1990, Supplemental hydrologic investigation for City of Fargo sanitary landfill sites: Donohue Project No. 42310.203, 2 volumes.

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

Klausing, R.L., 1968a, Geology and ground water resources of Cass County, North Dakota, Part I, Geology: North Dakota Geological Survey, Bulletin 47, North Dakota State Water Commission, County Ground Water Studies 8, 39 p.

Klausing, R.L., 1968b, Geology and ground water resources of Cass County, North Dakota, Part III, Hydrology: North Dakota Geological Survey, Bulletin 47, North Dakota State Water Commission, County Ground Water Studies 8, 77 p.

Midwest Testing Laboratory, 1979, Logs of test borings at the Fargo landfill.

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.

Twin City Testing, 1989, Logs of test borings at the Fargo landfill.

Twin City Testing, 1982, Logs of test borings at the Fargo landfill.

APPENDIX A

WATER QUALITY STANDARDS
AND
CONTAMINANT LEVELS

Water Quality Standards and Contaminant Levels

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

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

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

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

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

APPENDIX B

SAMPLING PROCEDURE FOR VOLATILE ORGANIC COMPOUNDS

SAMPLING PROCEDURE FOR 40ML AMBER BOTTLES

Sample Collection for Volatile Organic Compounds

by
North Dakota Department of Health
and Consolidated Laboratories

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

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

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

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

convex meniscus

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

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

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

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

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

APPENDIX C

LITHOLOGIC LOGS
OF WELLS AND TEST HOLES

139-049-04AAA1

NDSWC

Date Completed:	7/28/94	Purpose:	Observation Well
L.S. Elevation (ft):	897.3	Well Type:	2" PVC
Depth Drilled (ft):	20	Aquifer:	Undefined
Screened Interval (ft):	10-20	Source:	
		Owner:	Fargo

Lithologic Log

Unit	Description	Depth (ft)
Topsoil		0-1
Clay	Stiff, medium gray.	1-3
Clay	Yellowish-brown.	3-12
Sand	Fine grained, silty, yellowish-brown.	12-14
Clay	Silty, medium gray.	14-20

139-049-04AAA2

NDSWC

Date Completed:	7/28/94	Purpose:	Observation Well
L.S. Elevation (ft):	897.03	Well Type:	2" PVC
Depth Drilled (ft):	20	Aquifer:	Undefined
Screened Interval (ft):	10-20	Source:	
		Owner:	Fargo

Lithologic Log

Unit	Description	Depth (ft)
Topsoil		0-1
Clay	Gray.	1-2
Clay	Yellowish-brown.	2-11
Clay	Silty, yellowish-brown.	11-17
Clay	Gray.	17-20

139-049-04AAB
NDSWC

Date Completed:	7/28/94	Purpose:	Observation Well
L.S. Elevation (ft):	895.87	Well Type:	2" PVC
Depth Drilled (ft):	20	Aquifer:	Undefined
Screened Interval (ft):	10-20	Source:	
		Owner:	Fargo

Lithologic Log

Unit	Description	Depth (ft)
Topsoil		0-1
Clay	Dark gray.	1-3
Clay	Yellowish-brown.	3-11
Clay	Silty, dark reddish-orange.	11-13
Sand	Fine grained, silty.	13-14
Clay	Gray.	14-20

139-049-04ACD1

NDSWC

Date Completed:	7/28/94	Purpose:	Observation Well
L.S. Elevation (ft):	899.25	Well Type:	2" PVC
Depth Drilled (ft):	20	Aquifer:	Undefined
Screened Interval (ft):	10-20	Source:	
		Owner:	Fargo

Lithologic Log

Unit	Description	Depth (ft)
Topsoil		0-1
Clay	Gray.	1-5
Clay	Yellowish-brown.	5-15
Sand	Fine grained, silty.	15-16
Clay	Gray	16-20

139-049-04ACD2

NDSWC

Date Completed:	7/28/94	Purpose:	Observation Well
L.S. Elevation (ft):	898.24	Well Type:	2" PVC
Depth Drilled (ft):	20	Aquifer:	Undefined
Screened Interval (ft):	10-20	Source:	
		Owner:	Fargo

Lithologic Log

Unit	Description	Depth (ft)
Topsoil		0-1
Clay	Gray.	1-5
Clay	Yellowish-brown.	5-13
Sand	Fine grained, silty.	13-14
Clay	Gray.	14-20

LOG OF TEST BORING

JOB NO 53-1456 VERTICAL SCALE 1" = 5' BORING NO 8

PROJECT OBSERVATION WELL INSTALLATION, FARGO LANDFILL, FARGO, ND

SURFACE ELEVATION 97.7'

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	FILL, mostly FAT CLAY, brown, black and gray mixed, frozen to 1½'	FILL			1	FA				
			8		2	SB				
4	FAT CLAY, brown mottled, rather stiff (CH)	LAKE AGASSIZ DEPOSITS	9		3	SB				
6½	FAT CLAY, brown and gray mottled, rather stiff to medium, lenses and layers of silt (CH)		9		4	SB				
			5		5	SB				
			6		6	SB				
14	SILTY SAND, fine grained, grayish brown, wet, medium dense (SP-SM)	COARSE ALLUVIUM	10		7	SB				
16	FAT CLAY, gray, medium to soft (CH)	LAKE AGASSIZ DEPOSITS								
			5		8	SB				
			3		9	SB				
			3		10	SB				
			4		11	SB				
36	END OF BORING									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
12-29	11:00	16'	14½'	16'	to	14.5'
12-29	11:45	36'	34½'	36'	to	None
					to	
					to	

START 12-29-82 COMPLETE 12-29-82

METHOD 3¼" HSA 0-34½' @ 11:40

CREW CHIEF Miller

LOG OF TEST BORING

O. 5300 89-302 VERTICAL SCALE 1" = 5' BORING NO. 101

CT FARGO LANDFILL, FARGO, NORTH DAKOTA

DESCRIPTION OF MATERIAL (SURFACE ELEVATION 899.6')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	W	D	L.L./P.L.	Qu
FILL, A MIXTURE OF ORGANIC CLAY *	FILL	6		1	SB				
TOPSOIL, ORGANIC CLAY, black, rather stiff (OH)	TOPSOIL	13		2	SB	23			
FAT CLAY, brown and gray mottled, medium, laminations of silt (CH)	LAKE AGASSIZ DEPOSIT	7		3	SB				
		7		4	SB				
		5		5	SB	40		86/27	MA**
		5		6	SB				
SANDY SILT, brown and gray, moist, loose (ML)	FINE ALLUVIUM	8		7	SB				** MA
FAT CLAY, gray mottled, medium (CH)	LAKE AGASSIZ DEPOSIT			8	3T	41	77	103/33	K** MA**

END OF BORING

* AND SAND, black and brown

** See test results in Appendix E.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
-3	8:55	16'	15'	15'	to	None
					to	
					to	
					to	

START 7-3-89 COMPLETE 7-3-89

METHOD 6¼" HSA 0-18' 9:05

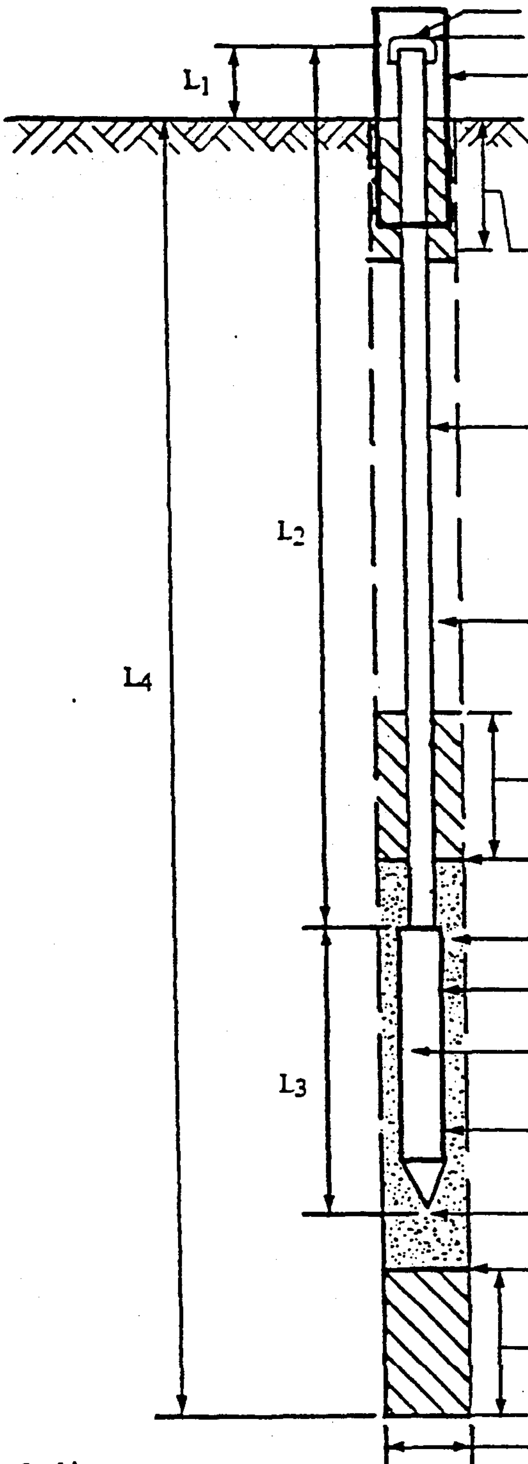
CREW CHIEF Miller

twin city testing

INSTALLATION OF PIEZOMETER

JOB NO. 53-1456 PIEZOMETER NO. 8

GROUND ELEVATION AND DATUM 97.7'



VENTED CAP	
ELEVATION OF TOP OF RISER PIPE	101.1'
PROTECTIVE CASING	
Diameter and Type	4" Steel
Total Length	5'
Length Above Ground	3.6'
THICKNESS AND TYPE OF SEAL	Grout
DIAMETER AND TYPE OF RISER PIPE	2" PVC
TYPE OF BACKFILL AROUND RISER	Grout
THICKNESS AND TYPE OF SEAL	Grout
DEPTH TO TOP OF FILTER SAND	28'
TYPE OF FILTER AROUND SCREEN	Filter Sand
TYPE OF PIEZOMETER	PVC
SCREEN GAUGE OR SIZE OF OPENINGS (SLOT NO.)	10 Slot
DIAMETER AND LENGTH OF SCREEN	2" x 5'
DEPTH TO BOTTOM OF PIEZOMETER	35'
DEPTH TO BOTTOM OF FILTER SAND	35'
THICKNESS AND TYPE OF SEAL	N/A
DIAMETER OF BOREHOLE	6"

L_1= 3.4' FT

L_2= 33.4' FT

L_3= 5' FT

L_4= 35' FT

INSTALLATION COMPLETED:
Date 12-30-82 Time 3:30

PIEZOMETER WATER LEVEL MEASUREMENTS

DATE	TIME	BAILED DEPTHS	WATER LEVEL
12-30-82	3:00		35'
1-3-83	9:00		19.2'

twin city testing

LOG OF TEST BORING

O. 5300 89-302 VERTICAL SCALE 1" = 5' BORING NO. 110

CT FARGO LANDFILL, FARGO, NORTH DAKOTA

DESCRIPTION OF MATERIAL SURFACE ELEVATION 900.9'	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	W	D	L.L. / P.L.	Qu
FILL, A MIXTURE OF ORGANIC CLAY AND FAT CLAY, black and gray	FILL	7		1	SB				
FAT CLAY, gray, rather stiff (CH)	LAKE AGASSIZ DEPOSITS	12		2	SB				
FAT CLAY, gray and brown mottled, laminations of silt, medium to soft (CH)		7		3	SB				
		7		4	SB				
		4		5	SB				
			▼						
SILTY SAND, fine grained, brown, waterbearing, medium dense (SM)	COARSE ALLUVIUM	11		6	SB				
FAT CLAY, gray mottled, soft to medium (CH)	LAKE AGASSIZ DEPOSIT	4		7	SB				
		5		8	SB				
END OF BORING									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
7	9:30	15'	13'	13'	to	12½'
					to	
					to	
					to	

START 6-27-89 COMPLETE 6-27-89

METHOD 6¼" HSA 0-18½' @ 10:05

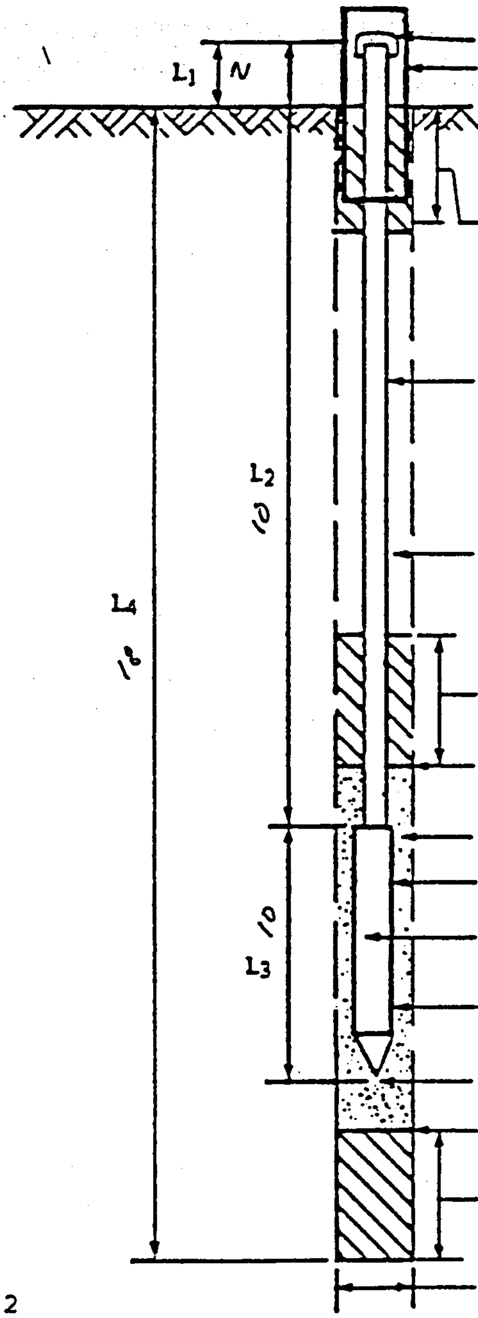
CREW CHIEF Miller

twin city testing

INSTALLATION OF MONITORING WELL

JOB NO. 5300 89-302 MONITORING WELL NO. OW-101A

GROUND SURFACE ELEVATION 899.6' TOP OF RISER PIPE ELEVATION (with cap removed) 901.60'



VENTED CAP	
PROTECTIVE CASING	
Diameter and Type	4" Steel
Total Length	5.3'
Length Above Ground	2.2'
THICKNESS AND TYPE OF SEAL	2.7' Cement Grout
DIAMETER AND TYPE OF RISER PIPE	2" Flush Threaded PVC
TYPE OF BACKFILL AROUND RISER	Neat Cement Grout
THICKNESS AND TYPE OF SEAL	2.1' Bentonite
DEPTH TO TOP OF FILTER SAND	6'
TYPE OF FILTER AROUND SCREEN	35-45mm Filter Sand
TYPE OF MONITORING WELL	PVC
SCREEN GAUGE OR SIZE OF OPENINGS (SLOT NO.)	#10
DIAMETER AND LENGTH OF SCREEN	2"x10'
DEPTH TO BOTTOM OF MONITORING WELL	18'
DEPTH TO BOTTOM OF FILTER SAND	18'
THICKNESS AND TYPE OF SEAL	Natural Soil
DIAMETER OF BOREHOLE	10"

L_1= 2 FT

L_2= 10 FT

L_3= 10 FT

L_4= 18 FT

INSTALLATION COMPLETED:
Date 7-5-89 Time 9:03

MONITORING WELL WATER LEVEL MEASUREMENTS

DATE	TIME	BAILED DEPTHS	WATER LEVEL *
7-24	3:30	---	9.35'

(1) DEPTH BELOW TOP OF RISER PIPE

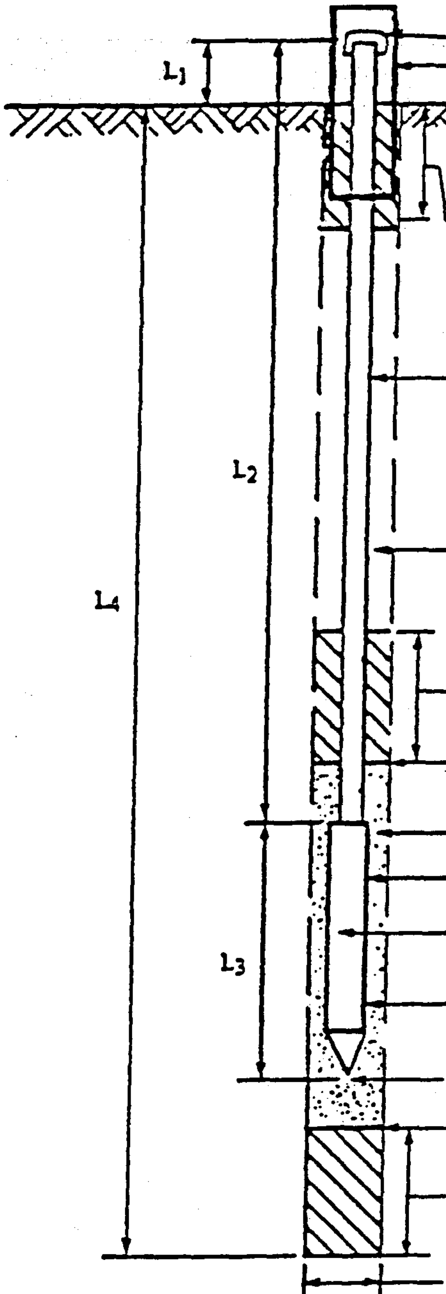
twin city testing corporation

SE-29 (83-8)

INSTALLATION OF MONITORING WELL

JOB NO. 5300 89-302 MONITORING WELL NO. OW-110A

GROUND SURFACE ELEVATION 900.9' TOP OF RISER PIPE ELEVATION (with cap removed) 902.99'



- VENTED CAP
- PROTECTIVE CASING
  - Diameter and Type: 4" Steel
  - Total Length: 5.3'
  - Length Above Ground: 2.2'
- THICKNESS AND TYPE OF SEAL: 2' Neat Cement, 1' Bentonite
- DIAMETER AND TYPE OF RISER PIPE: 2" Flush Threaded PVC
- TYPE OF BACKFILL AROUND RISER: Neat Cement Grout
- THICKNESS AND TYPE OF SEAL: 2' Bentonite
- DEPTH TO TOP OF FILTER SAND: 6.9'
- TYPE OF FILTER AROUND SCREEN: #20 Filter Sand
- TYPE OF MONITORING WELL: PVC
- SCREEN GAUGE OR SIZE OF OPENINGS (SLOT NO.): #10 Slot
- DIAMETER AND LENGTH OF SCREEN: 2" x 10'
- DEPTH TO BOTTOM OF MONITORING WELL: 19.8'
- DEPTH TO BOTTOM OF FILTER SAND: 19.8'
- THICKNESS AND TYPE OF SEAL: Natural Soil
- DIAMETER OF BOREHOLE: 10"

L_1 = 2.1 FT

L_2 = 11.9 FT

L_3 = 10 FT

L_4 = 19.8 FT

INSTALLATION COMPLETED:
Date 6-27-89 Time 12:15

MONITORING WELL WATER LEVEL MEASUREMENTS			
DATE	TIME	BAILED DEPTHS	WATER LEVEL *
7-21	9:30	---	11.82'

(1) DEPTH BELOW TOP OF RISER PIPE

twin city testing corporation

SE-29 (83-8)

LOG OF TEST BORING

JOB NO. 5300 89-302 VERTICAL SCALE 1" = 5' BORING NO. 111

PROJECT FARGO LANDFILL, FARGO, NORTH DAKOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 899.9'	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	W	D	L.L./P.L.	Qu
	FILL, A MIXTURE OF ORGANIC CLAY AND FAT CLAY, black and gray	FILL	5		1	SB				
3½			7		2	SB				
	FAT CLAY, brown and gray mottled, medium to soft, laminations of silt, a few calcite crystals (CH)	LAKE AGASSIZ DEPOSIT	6		3	SB				
			5		4	SB				
			3		5	SB				
13½			3		6	SB				
	SILTY SAND, fine grained, gray *	COARSE ALLUVIUM								
14½	FAT CLAY, gray mottled, medium (CH)	LAKE AGASSIZ DEPOSIT	6		7	SB				
17	FAT CLAY, gray, medium (CH)									
20			6		8	SB				
	END OF BORING									
	* waterbearing (SM)									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
6-28	8:45	16'	14½'	14½'	to	None
					to	
					to	
					to	

START 6-28-89 COMPLETE 6-28-89

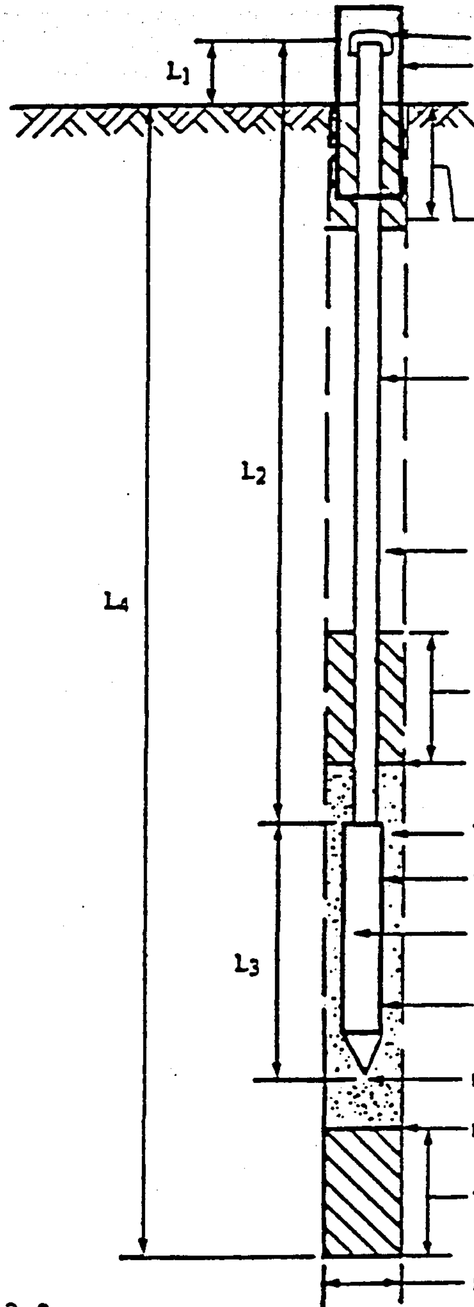
METHOD 6¼" HSA 0-19' @ 9:07

CREW CHIEF Miller

INSTALLATION OF MONITORING WELL

JOB NO. 5300 89-302 MONITORING WELL NO. OW-111A

GROUND SURFACE ELEVATION 899.9' TOP OF RISER PIPE ELEVATION (with cap removed) 902.15'



- VENTED CAP
- PROTECTIVE CASING
  - Diameter and Type: 4" Steel
  - Total Length: 5.3'
  - Length Above Ground: 2.2
- THICKNESS AND TYPE OF SEAL: 2' Neat Cement 1' Bentonite
- DIAMETER AND TYPE OF RISER PIPE: 2" Flush Threaded PVC
- TYPE OF BACKFILL AROUND RISER: Neat Cement Grout
- THICKNESS AND TYPE OF SEAL: 2' Bentonite
- DEPTH TO TOP OF FILTER SAND: 7.1'
- TYPE OF FILTER AROUND SCREEN: 45-55 mm Filter Sand
- TYPE OF MONITORING WELL: PVC
- SCREEN GAUGE OR SIZE OF OPENINGS (SLOT NO.): #10 Slot
- DIAMETER AND LENGTH OF SCREEN: 2" x 10'
- DEPTH TO BOTTOM OF MONITORING WELL: 19'
- DEPTH TO BOTTOM OF FILTER SAND: 19'
- THICKNESS AND TYPE OF SEAL: Natural Soil
- DIAMETER OF BOREHOLE: 10"

L_1= 2.2 FT

L_2= 11.2 FT

L_3= 10 FT

L_4= 19 FT

INSTALLATION COMPLETED:
Date 6-28-89 Time 11:15

MONITORING WELL WATER LEVEL MEASUREMENTS

DATE	TIME	BAILED DEPTHS	WATER LEVEL *
7-17	3:20	---	10.33'

(1) DEPTH BELOW TOP OF RISER PIPE

twin city testing corporation

SE-29 (83-8)

LOG OF TEST BORING

JOB NO. 5300 89-302 VERTICAL SCALE 1" = 5' BORING NO. 113

PROJECT FARGO LANDFILL, FARGO, NORTH DAKOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 899.9'	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LABORATORY TESTS W	D	L.L. / P.L.	Qu
	FILL, A MIXTURE OF ORGANIC CLAY AND FAT CLAY, black and gray	FILL	4		1	SB				
6	FAT CLAY, brown and gray mottled, soft, laminations of silt (CH)	LAKE AGASSIZ DEPOSIT	2		2	SB				
			4	▼	3	SB				
12	SILTY SAND, fine grained, brown. *	**	10		4	SB				*** MA
12½	FAT CLAY, gray mottled, rather stiff to medium, a 2" layer of sand at 13½-14' (CH)	LAKE AGASSIZ DEPOSIT	5		5	SB				
17	FAT CLAY, gray, soft (CH)		2		6	SB				
20	END OF BORING									

* medium dense (SM)

** COARSE ALLUVIUM

*** See test results in Appendix E.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
6-28	12:11	15'	13'	13'	to	12'
					to	
					to	
					to	

START 6-28-89 COMPLETE 6-28-89

METHOD 6¼" HSA 0-18½' @ 12:37

CREW CHIEF Miller

LOG OF TEST BORING

JOB NO. 5300 89-302 VERTICAL SCALE 1" = 5' BORING NO. 115

PROJECT FARGO LANDFILL, FARGO, NORTH DAKOTA

DESCRIPTION OF MATERIAL (SURFACE ELEVATION 901.2')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LAB W	LAB D	LAB LL/PL	LAB Qu
TOPSOIL, ORGANIC CLAY, black, medium (OH)	TOPSOIL	8		1	SB				
FAT CLAY, dark gray, medium (CH)	LAKE AGASSIZ DEPOSIT	7		2	SB				
FAT CLAY, gray and brown mottled, ranges from soft to medium, laminations of silt (CH)		6		3	SB				
		6		4	SB				
		2		5	SB				
		6		6	SB				
SILTY SAND, fine grained, brown *	COARSE ALLUVIUM								
FAT CLAY, brownish gray, medium (CH)	LAKE AGASSIZ DEPOSIT	6	▼	7	SB				MA**
FAT CLAY, gray (CH)				8	3T				

END OF BORING

* waterbearing (SM)

** See test results in Appendix E.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
29	11:05	20'	18'	18'	to	16½'
					to	
					to	
					to	

START 6-29-89 COMPLETE 6-29-89

METHOD 6¼" HSA 0-18' @ 11:00

CREW CHIEF Kopp

twin city testing

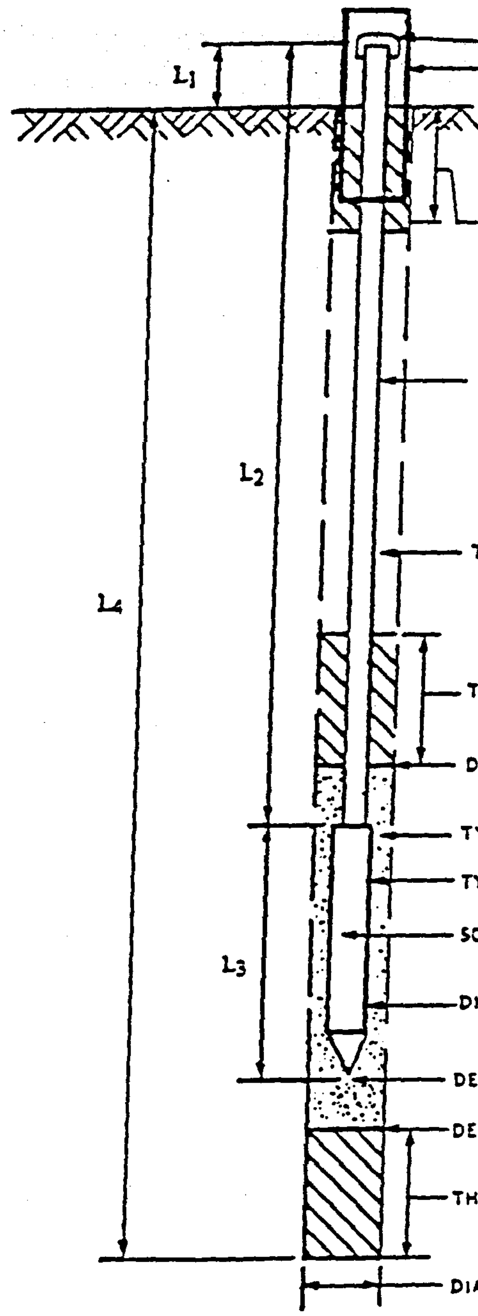
INSTALLATION OF MONITORING WELL

JOB NO. 5300 89-302

MONITORING WELL NO. OW-113A

GROUND SURFACE ELEVATION 899.9'

TOP OF RISER PIPE ELEVATION (with cap removed) 901.96'



VENTED CAP

PROTECTIVE CASING
- Diameter and Type: 4" Steel
- Total Length: 5.3'
- Length Above Ground: 2'

THICKNESS AND TYPE OF SEAL: 2' Cement, 1' Bentonite

DIAMETER AND TYPE OF RISER PIPE: 2" Flush Threaded PVC

TYPE OF BACKFILL AROUND RISER: Neat Cement Grout

THICKNESS AND TYPE OF SEAL: 2' Bentonite

DEPTH TO TOP OF FILTER SAND: 7'

TYPE OF FILTER AROUND SCREEN: 35-45 mm Filter Sand

TYPE OF MONITORING WELL: PVC

SCREEN GAUGE OR SIZE OF OPENINGS (SLOT NO.): #10 Slot

DIAMETER AND LENGTH OF SCREEN: 2" x 10'

DEPTH TO BOTTOM OF MONITORING WELL: 19'

DEPTH TO BOTTOM OF FILTER SAND: 19'

THICKNESS AND TYPE OF SEAL: Natural Soil

DIAMETER OF BOREHOLE: 10"

L_1 = 2 FT

L_2 = 11 FT

L_3 = 10 FT

L_4 = 19 FT

INSTALLATION COMPLETED:
Date 6-28-89 Time 2:47

MONITORING WELL WATER LEVEL MEASUREMENTS			
DATE	TIME	BAILED DEPTHS	WATER LEVEL *
7-17	11:00	---	9.27'

(1) DEPTH BELOW TOP OF RISER PIPE

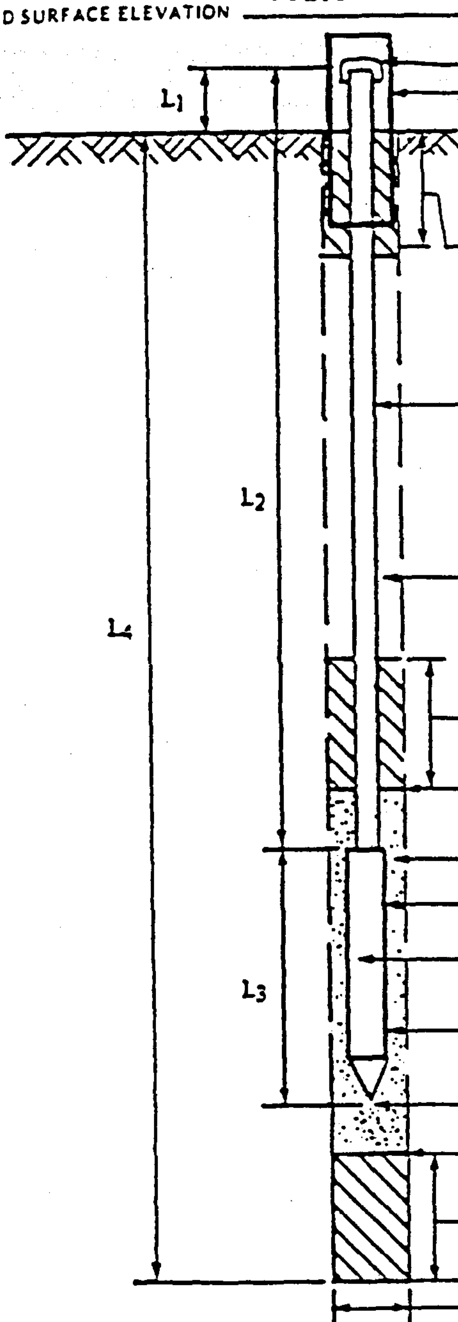
twin city testing corporation

SE-29 (83-8)

INSTALLATION OF MONITORING WELL

JOB NO. 5300 89-302 MONITORING WELL NO. OW-115B

GROUND SURFACE ELEVATION 901.5' TOP OF RISER PIPE ELEVATION (with cap removed) 903.42'



- VENTED CAP
- PROTECTIVE CASING
  - Diameter and Type: 4" Steel
  - Total Length: 5.3'
  - Length Above Ground: 2.1'
- THICKNESS AND TYPE OF SEAL: 2' Neat Cement 1' Bentonite
- DIAMETER AND TYPE OF RISER PIPE: 2" Flush Threaded PVC
- TYPE OF BACKFILL AROUND RISER: Neat Cement Grout
- THICKNESS AND TYPE OF SEAL: 1.7' Bentonite
- DEPTH TO TOP OF FILTER SAND: 4.7'
- TYPE OF FILTER AROUND SCREEN: 35-45 mm Filter Sand
- TYPE OF MONITORING WELL: PVC
- SCREEN GAUGE OR SIZE OF OPENINGS (SLOT NO.): #10 Slot
- DIAMETER AND LENGTH OF SCREEN: 2" x 10' (5')
- DEPTH TO BOTTOM OF MONITORING WELL: 11'
- DEPTH TO BOTTOM OF FILTER SAND: 11'
- THICKNESS AND TYPE OF SEAL: Natural Soil
- DIAMETER OF BOREHOLE: 6"

L_1 = 2.1 FT

L_2 = 3.1 FT

L_3 = 10 FT

L_4 = 11 FT

INSTALLATION COMPLETED:
Date 7-11-89 Time 10:00

MONITORING WELL WATER LEVEL MEASUREMENTS

DATE	TIME	BAILED DEPTHS	WATER LEVEL *
7-21	3:00	---	8.90'

(1) DEPTH BELOW TOP OF RISER PIPE

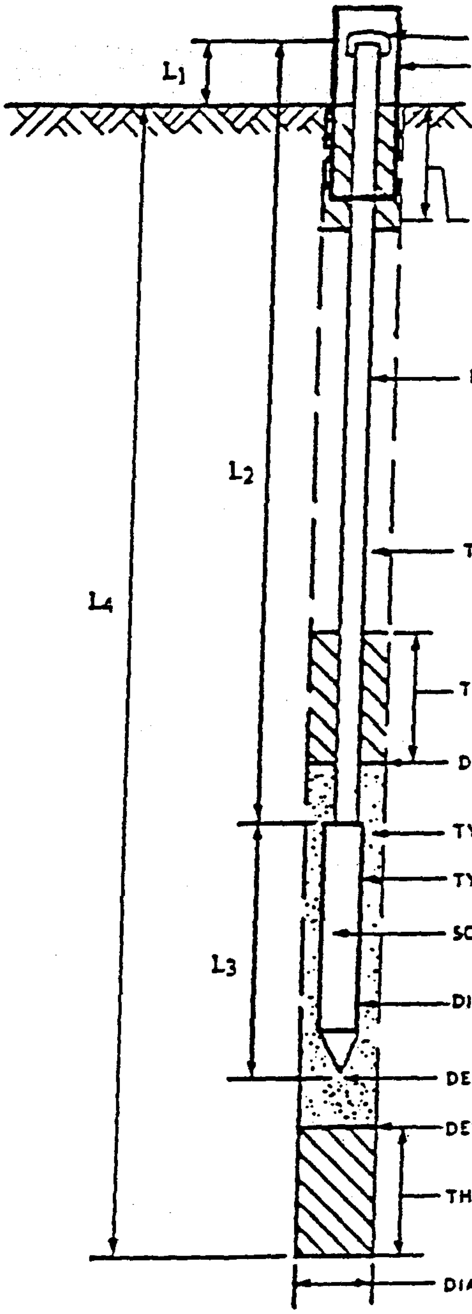
twin city testing corporation

SE-29 (83-B)

INSTALLATION OF MONITORING WELL

JOB NO. 5300 89-302 MONITORING WELL NO. OW-115A

GROUND SURFACE ELEVATION 901.2' TOP OF RISER PIPE ELEVATION (with cap removed) 903.27'



VENTED CAP	
PROTECTIVE CASING	
Diameter and Type	4" Steel
Total Length	5.3'
Length Above Ground	2'
THICKNESS AND TYPE OF SEAL	2' Cement 1' Bentonite
DIAMETER AND TYPE OF RISER PIPE	2" Flush Threaded PVC
TYPE OF BACKFILL AROUND RISER	Neat Cement Grout
THICKNESS AND TYPE OF SEAL	2' Bentonite
DEPTH TO TOP OF FILTER SAND	6.1'
TYPE OF FILTER AROUND SCREEN	45-55 mm Filter Sand
TYPE OF MONITORING WELL	PVC
SCREEN GAUGE OR SIZE OF OPENINGS (SLOT NO.)	#10 Slot
DIAMETER AND LENGTH OF SCREEN	2" x 10'
DEPTH TO BOTTOM OF MONITORING WELL	18'
DEPTH TO BOTTOM OF FILTER SAND	18'
THICKNESS AND TYPE OF SEAL	Natural Soil
DIAMETER OF BOREHOLE	10"

L_1 = 2 FT

L_2 = 10 FT

L_3 = 10 FT

L_4 = 18 FT

INSTALLATION COMPLETED:
Date 6-29-89 Time 1:00

MONITORING WELL WATER LEVEL MEASUREMENTS

DATE	TIME	BAILED DEPTHS	WATER LEVEL *
7-11	2:00	---	7.09'

(1) DEPTH BELOW TOP OF RISER PIPE

twin city testing corporation

SE-29 (83-8)

LOG OF TEST BORING

5300 89-302 VERTICAL SCALE 1" = 5' BORING NO. 120

FARGO LANDFILL, FARGO, ND

DESCRIPTION OF MATERIAL SURFACE ELEVATION 899.0'	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LABORATORY TESTS W	D	L.L./P.L.	Qu
No Samples Collected									
END OF BORING									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
					to	
					to	
					to	
					to	

START 7-11-89 COMPLETE 7-11-89

METHOD 6¼" HSA 0-19' @ 10:15

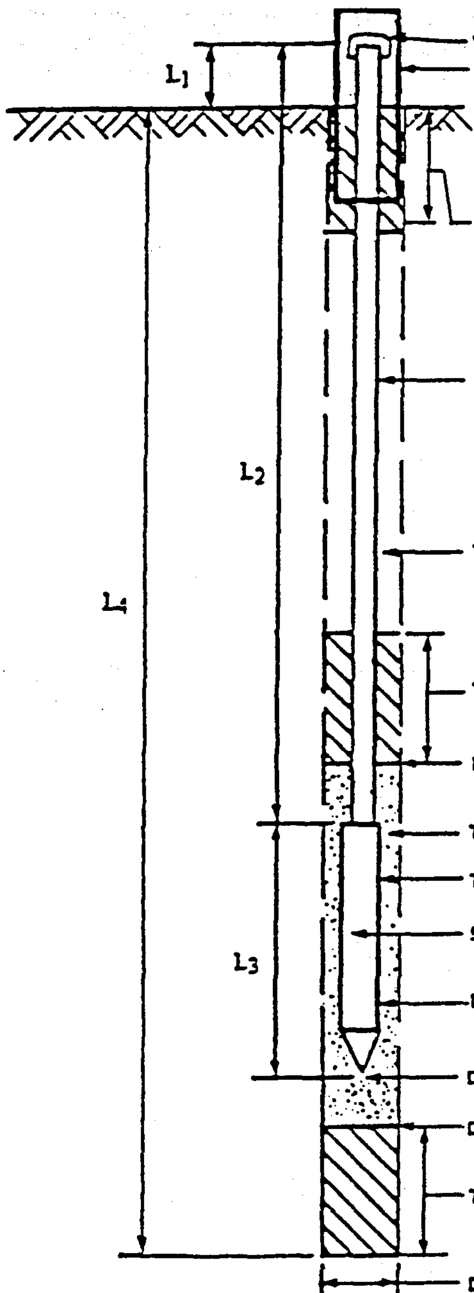
CREW CHIEF Miller

twin city testing

INSTALLATION OF MONITORING WELL

JOB NO. 5300 89-302   MONITORING WELL NO. OW-120A

GROUND SURFACE ELEVATION 899.0'   TOP OF RISER PIPE ELEVATION (with cap removed) 900.96'



- VENTED CAP
- PROTECTIVE CASING
  - Diameter and Type: 4" Steel
  - Total Length: 5.3'
  - Length Above Ground: 2'
- THICKNESS AND TYPE OF SEAL: 3' Neat Cement, 1' Bentonite
- DIAMETER AND TYPE OF RISER PIPE: 2" Flush Threaded PVC
- TYPE OF BACKFILL AROUND RISER: Neat Cement Grout
- THICKNESS AND TYPE OF SEAL: 2' Bentonite
- DEPTH TO TOP OF FILTER SAND: 7'
- TYPE OF FILTER AROUND SCREEN: 35-45 mm Filter Sand
- TYPE OF MONITORING WELL: PVC
- SCREEN GAUGE OR SIZE OF OPENINGS (SLOT NO.): #10 Slot
- DIAMETER AND LENGTH OF SCREEN: 2" x 10'
- DEPTH TO BOTTOM OF MONITORING WELL: 19'
- DEPTH TO BOTTOM OF FILTER SAND: 19'
- THICKNESS AND TYPE OF SEAL: Natural Soil
- DIAMETER OF BOREHOLE: 10"

L_1 = 1.9 FT

L_2 = 10.9 FT

L_3 = 10 FT

19

L_4 = ______ FT

INSTALLATION COMPLETED:
Date 7-11-89 Time 11:50

MONITORING WELL WATER LEVEL MEASUREMENTS			
DATE	TIME	BAILED DEPTHS	WATER LEVEL *
7-17	1:50	---	9.51'

(1) DEPTH BELOW TOP OF RISER PIPE

twin city testing corporation

SE-29 (83-8)

APPENDIX D

WATER-LEVEL TABLES

Fargo Water Levels
8/11/94 to 10/06/94

139-049-04AAA1 MP Elev (msl,ft)=899.19
Undefined Aquifer SI (ft.)=10-20

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/94	6.40	892.79	09/20/94	8.08	891.11
09/09/94	7.52	891.67	10/06/94	8.14	891.05

139-049-04AAA2 MP Elev (msl,ft)=898.73
Undefined Aquifer SI (ft.)=10-20

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/94	6.24	892.49	09/20/94	5.73	893.00
09/09/94	5.85	892.88	10/06/94	5.53	893.20

139-049-04AAB1 MP Elev (msl,ft)=897.86
Undefined Aquifer SI (ft.)=10-20

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/94	4.18	893.68	09/20/94	4.23	893.63
09/09/94	4.24	893.62	10/06/94	3.48	894.38

139-049-04AAB2 MP Elev (msl,ft)=902.15
Undefined Aquifer SI (ft.)=9-19

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/94	5.84	896.31	09/20/94	6.07	896.08
09/09/94	5.92	896.23	10/06/94	5.15	897.00

139-049-04AAD1 MP Elev (msl,ft)=901.09
Undefined Aquifer SI (ft.)=30-35

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/94	5.83	895.26	09/20/94	6.05	895.04
09/09/94	6.55	894.54	10/06/94	5.79	895.30

139-049-04AAD2 MP Elev (msl,ft)=902.99
Undefined Aquifer SI (ft.)=9.8-19.8

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/94	4.98	898.01	09/20/94	5.09	897.90
09/09/94	5.63	897.36	10/06/94	4.71	898.28

139-049-04ABB1 MP Elev (msl,ft)=899.16
Undefined Aquifer SI (ft.)=0-0

	Depth to	WL Elev		Depth to	WL Elev

Date	Water (ft)	(msl, ft)	Date	Water (ft)	(msl, ft)
08/11/94	3.60	895.56	09/20/94	4.24	894.92
09/09/94	5.16	894.00	10/06/94	3.68	895.48

139-049-04ABB2 MP Elev (msl,ft)=900.96

Undefined Aquifer SI (ft.)=9-19

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/94	2.64	898.32	09/20/94	4.55	896.41
09/09/94	4.99	895.97	10/06/94	4.59	896.37

139-049-04ACCD1 MP Elev (msl,ft)=903.27

Undefined Aquifer SI (ft.)=8-18

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/94	4.58	898.69	09/20/94	4.66	898.61
09/09/94	5.31	897.96	10/06/94	4.16	899.11

139-049-04ACCD2 MP Elev (msl,ft)=903.42

Undefined Aquifer SI (ft.)=8-18

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/94	4.91	898.51	09/20/94	4.83	898.59
09/09/94	5.42	898.00	10/06/94	4.29	899.13

139-049-04ACD1 MP Elev (msl,ft)=901.28

Undefined Aquifer SI (ft.)=10-20

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/94	5.47	895.81	09/20/94	5.73	895.55
09/09/94	6.22	895.06	10/06/94	5.44	895.84

139-049-04ACD2 MP Elev (msl,ft)=899.79

Undefined Aquifer SI (ft.)=10-20

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/94	6.08	893.71	09/20/94	7.75	892.04
09/09/94	8.02	891.77	10/06/94	7.43	892.36

140-049-34CCCA MP Elev (msl,ft)=901.6

Undefined Aquifer SI (ft.)=8-18

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/94	7.05	894.55	09/20/94	7.32	894.28
09/09/94	7.37	894.23	10/06/94	7.46	894.14

APPENDIX E

MAJOR ION AND TRACE-ELEMENT
CONCENTRATIONS

Fargo Landfill Water Quality
Major Ion Analyses

Location	Screened Interval (ft)	Date Sampled	SiO_2	Fe	Mn	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	NO_3	B	TDS	Hardness $CaCO_3$	as NCH	% Na	SAR	Spec Cond (μmho)	Temp (∞C)	pH
			(milligrams per liter)																					
139-049-04AAA1	10-20	08/04/94	25	0.43	4.1	350	520	1300	12	609	0	4500	470	0.4	1.2	0.33	7480	3000	2500	48	10	10200	11	
139-049-04AAA2	10-20	08/09/94	24	0.16	0.08	430	1300	2500	14	778	0	10000	700	0.4	1.4	0.33	15400	6400	5800	46	14	20800	12	
139-049-04AAB1	10-20	08/04/94	24	0.25	5.5	450	630	1500	13	732	0	6100	130	0.3	2.6	0.26	9220	3700	3100	47	11	11470	11	
139-049-04AAB2	9-19	08/04/94	23	0.11	0.17	420	1000	2000	12	735	0	8400	96	0.2	2.2	0.19	12300	5200	4600	46	12	15100	11	
139-049-04AAD1	30-35	08/04/94	42	0.03	0.07	190	96	200	8.1	779	0	510	130	0.1	3.3	0.48	1560	870	230	33	2.9	2760	11	
139-049-04AAD2	9.8-19.8	08/04/94	24	0.09	0.03	150	110	290	5	747	0	680	98	0.5	7.6	0.25	1730	830	220	43	4.4	2880	11	
139-049-04ABB1	10-20	08/04/94	24	0.03	0.06	140	72	68	3.6	482	0	480	20	0.6	0.5	0.18	1050	650	250	19	1.2	2400	13	
139-049-04ABB2	9-19	08/04/94	24	0.06	0.04	270	150	100	4.8	473	0	1000	26	0.4	0.7	0.22	1810	1300	900	14	1.2	3240	11	
139-049-04ACCD1	8-18	08/04/94	26	0.06	0.02	370	250	130	3.2	585	0	1100	380	0.5	4.6	0.29	2550	2000	1500	13	1.3	4410	11	
139-049-04ACCD2	8-18	08/04/94	23	0.09	0.03	350	150	240	2	479	0	1100	330	0.4	5.2	0.26	2440	1500	1100	26	2.7	4260	11	
139-049-04ACD1	10-20	08/04/94	27	0.09	0.53	390	600	1000	11	657	0	4700	250	0.3	28	0.31	7330	3400	2900	39	7.5	8510	11	
139-049-04ACD2	10-20	08/05/94	24	0.06	0.82	390	390	500	8	623	0	2900	160	0.4	4.6	0.31	4690	2600	2100	30	4.3	5710	11	
140-049-34CCCA	8-18	08/04/94	26	0.06	0.08	460	270	290	6.1	529	0	2200	140	0.3	14	0.09	3670	2300	1800	22	2.6	4450	11	

Trace Element Analyses

Location	Date Sampled	Selenium	Lead	Cadmium	Mercury	Arsenic	Molybdenum	Strontium
		(micrograms per liter)						
139-049-04AAA1	08/04/94	5	0	3	0.1	0	1	600
139-049-04AAA2	08/04/94	9	2	1	0	0	17	3800
139-049-04AAB1	08/04/94	6	1	3	0.1	0	2	740
139-049-04AAB2	08/04/94	14	0	1	0	1	0	4200
139-049-04AAD1	08/04/94	1	0	1	0	0	0	1000
139-049-04AAD2	08/04/94	0	0	1	0	0	0	710
139-049-04ABB1	08/04/94	1	0	0	0.1	0	0	280
139-049-04ABB2	08/04/94	1	0	1	0.1	2	0	500
139-049-04ACCD1	08/04/94	1	0	1	0.1	2	1	690
139-049-04ACCD2	08/04/94	3	0	1	0.1	1	3	490
139-049-04ACD1	08/04/94	13	1	2	0	1	6	3000
139-049-04ACD2	08/04/94	6	0	1	0	1	7	2000
140-049-34CCCA	08/04/94	4	0	1	0	0	8	1300

APPENDIX F

VOLATILE ORGANIC COMPOUNDS
FOR WELL 139-049-04AAB1

Volatile Organic Compounds
and
Minimum Concentrations

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

Constituent	Chemical Analysis µg/L
Benzene	<0.5
Vinyl Chloride	<0.5
Carbon Tetrachloride	<0.5
1,2-Dichlorethane	<0.5
Trichloroethylene	<0.5
1,1-Dichloroethylene	<0.5
1,1,1-Trichloroethane	<0.5
para-Dichlorobenzene	<0.5
Acetone	<50
2-Butanone (MEK)	<50
2-Hexanone	<50
4-Methyl-2-pentanone	<50
Chloroform	<0.5
Bromodichloromethane	<0.5
Chlorodibromomethane	<0.5
Bromoform	<0.5
trans1,2-Dichloroethylene	<0.5
Chlorobenzene	<0.5
m-Dichlorobenzene	<0.5
Dichloromethane	3.04*
cis-1,2-Dichloroethylene	<0.5
o-Dichlorobenzene	<0.5
Dibromomethane	<0.5
1,1-Dichloropropene	<0.5
Tetrachlorethylene	<0.5
Toluene	<0.5
Xylene(s)	<0.5
1,1-Dichloroethane	<0.5
1,2-Dichloropropane	<0.5
1,1,2,2-Tetrachloroethane	<0.5
Ethyl Benzene	<0.5
1,3-Dichloropropane	<0.5
Styrene	<0.5
Chloromethane	<0.5
Bromomethane	<0.5
1,2,3-Trichloropropane	<0.5
1,1,1,2-Tetrachloroethane	<0.5
Chloroethane	<0.5
1,1,2-Trichloroethane	<0.5

* Constituent Detection

VOC Constituents cont.

2,2-Dichloropropane	<0.5
o-Chloroluene	<0.5
p-Chlorotoluene	<0.5
Bromobenzene	<0.5
1,3-Dichloropropene	<0.5
1,2,4-Trimethylbenzene	<0.5
1,2,4-Trichlorobenzene	<0.5
1,2,3-Trichlorobenzene	<0.5
n-Propylbenzene	<0.5
n-Butylbenzene	<0.5
Naphthalene	<0.5
Hexachlorobutadiene	<0.5
1,3,5-Trimethylbenzene	<0.5
p-Isopropyltoluene	<0.5
Isopropylbenzene	<0.5
Tert-butylbenzene	<0.5
Sec-butylbenzene	<0.5
Fluorotrichloromethane	<0.5
Dichlorodifluoromethane	<5
Bromochloromethane	<0.5
Allylchloride	<5
2,3-Dichloro-1-propane	<5
Tetrahydrofuran	<50
Pentachloroethane	<5
Trichlorotrifluoroethane	<5
Carbondisufide	<5
Ether	<5
trans-1,3-Dichloropropene	<0.5

* Constituent Detection

APPENDIX G

VOLATILE ORGANIC COMPOUNDS
FOR WELL 139-049-04AAB2

Volatile Organic Compounds
and
Minimum Concentrations

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

Constituent	Chemical Analysis µg/L
Benzene	<0.5
Vinyl Chloride	<0.5
Carbon Tetrachloride	<0.5
1,2-Dichlorethane	<0.5
Trichloroethylene	<0.5
1,1-Dichloroethylene	<0.5
1,1,1-Trichloroethane	<0.5
para-Dichlorobenzene	<0.5
Acetone	<50
2-Butanone (MEK)	<50
2-Hexanone	<50
4-Methyl-2-pentanone	<50
Chloroform	<0.5
Bromodichloromethane	<0.5
Chlorodibromomethane	<0.5
Bromoform	<0.5
trans1,2-Dichloroethylene	<0.5
Chlorobenzene	<0.5
m-Dichlorobenzene	<0.5
Dichloromethane	1.90*
cis-1,2-Dichloroethylene	<0.5
o-Dichlorobenzene	<0.5
Dibromomethane	<0.5
1,1-Dichloropropene	<0.5
Tetrachlorethylene	<0.5
Toluene	<0.5
Xylene(s)	<0.5
1,1-Dichloroethane	<0.5
1,2-Dichloropropane	<0.5
1,1,2,2-Tetrachloroethane	<0.5
Ethyl Benzene	<0.5
1,3-Dichloropropane	<0.5
Styrene	<0.5
Chloromethane	<0.5
Bromomethane	<0.5
1,2,3-Trichloropropane	<0.5
1,1,1,2-Tetrachloroethane	<0.5
Chloroethane	<0.5
1,1,2-Trichloroethane	<0.5

* Constituent Detection

VOC Constituents cont.

2,2-Dichloropropane	<0.5
o-Chloroluene	<0.5
p-Chlorotoluene	<0.5
Bromobenzene	<0.5
1,3-Dichloropropene	<0.5
1,2,4-Trimethylbenzene	<0.5
1,2,4-Trichlorobenzene	<0.5
1,2,3-Trichlorobenzene	<0.5
n-Propylbenzene	<0.5
n-Butylbenzene	<0.5
Naphthalene	<0.5
Hexachlorobutadiene	<0.5
1,3,5-Trimethylbenzene	<0.5
p-Isopropyltoluene	<0.5
Isopropylbenzene	<0.5
Tert-butylbenzene	<0.5
Sec-butylbenzene	<0.5
Fluorotrichloromethane	<0.5
Dichlorodifluoromethane	<5
Bromochloromethane	<0.5
Allylchloride	<5
2,3-Dichloro-1-propane	<5
Tetrahydrofuran	<50
Pentachloroethane	<5
Trichlorotrifluoroethane	<5
Carbondisufide	<5
Ether	<5
trans-1,3-Dichloropropene	<0.5

* Constituent Detection