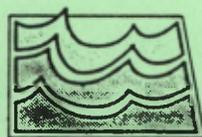


Site Suitability Review of the Gahner Sanitation Landfill

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. 13

SITE SUITABILITY REVIEW
OF THE
GAHNER LANDFILL

By Jeffrey M. Olson, North Dakota State Water Commission,
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North Dakota Landfill Site Investigation 13

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

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 Gahner Sanitation solid waste landfill is one of the landfills being evaluated.

Location of the Gahner Landfill

The Gahner municipal solid waste landfill is located one and a half miles east and a half mile south of the City of Kulm in Township 133 North, Range 66 West, NE 1/4 Section 36 (Fig. 1). The landfill site encompasses approximately 10 acres, most of which has been used.

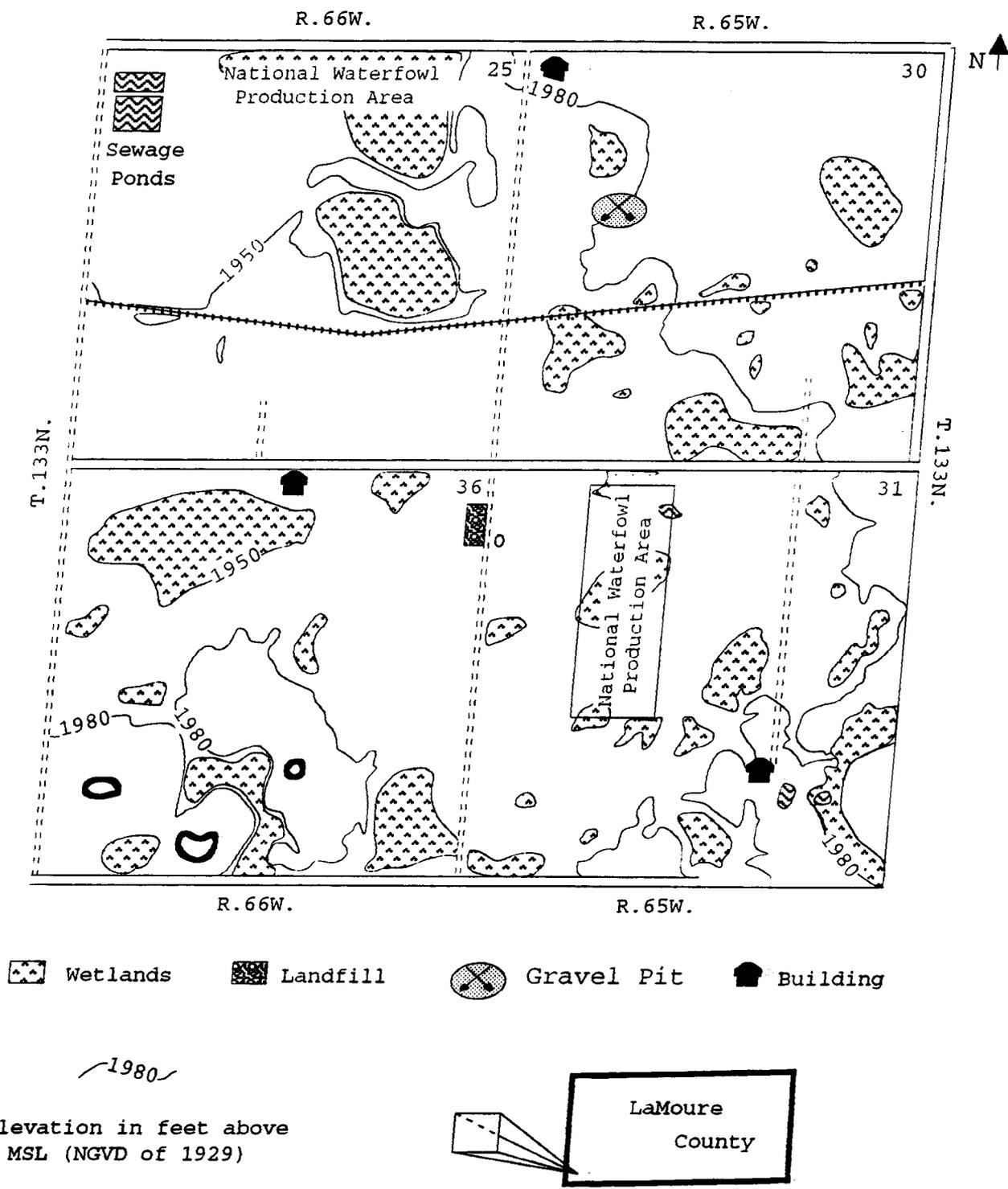


Figure 1. Location of the Gahner landfill in the NE 1/4 of section 36, T133N, R66W.

Previous Site Investigations

No previous geological or hydrological investigations have been completed at the Gahner landfill.

Methods of Investigation

The Gahner 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 Gahner 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 Gahner landfill because the sediments were poorly consolidated and because the depth to the water table was expected to be less than 70 feet. The lithologic descriptions were determined from the drill cuttings.

Monitoring Well Construction and Development

Five test holes were drilled at the Gahner landfill, and monitoring wells were installed in all of the test holes.

The number of wells installed at the Gahner 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 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 NDSDHCL and the North Dakota Board of Water Well Contractors (North Dakota Department of Health, 1986). The wells were constructed using a 2-inch diameter, SDR21, polyvinyl chloride (PVC) well casing and a PVC screen, either 5 or 10 feet long, with a slot-opening size of 0.012 or 0.013 inches. The screen was fastened to the casing with stainless steel screws (no solvent weld cement was used). After the casing and screen were installed into the drill hole, the annulus around the screen was filled with No. 10 (grain-size diameter) silica sand to a height of two feet above the top of the screen. High-solids bentonite grout and/or neat cement was placed above the silica sand to seal the annulus to approximately five feet below land surface. The remaining annulus was filled with drill cuttings. The permanent wells were secured with a protective steel casing and a locking cover protected by a two-foot-square concrete pad.

All monitoring wells were developed using a stainless steel bladder pump or a teflon bailer. Any drilling fluid

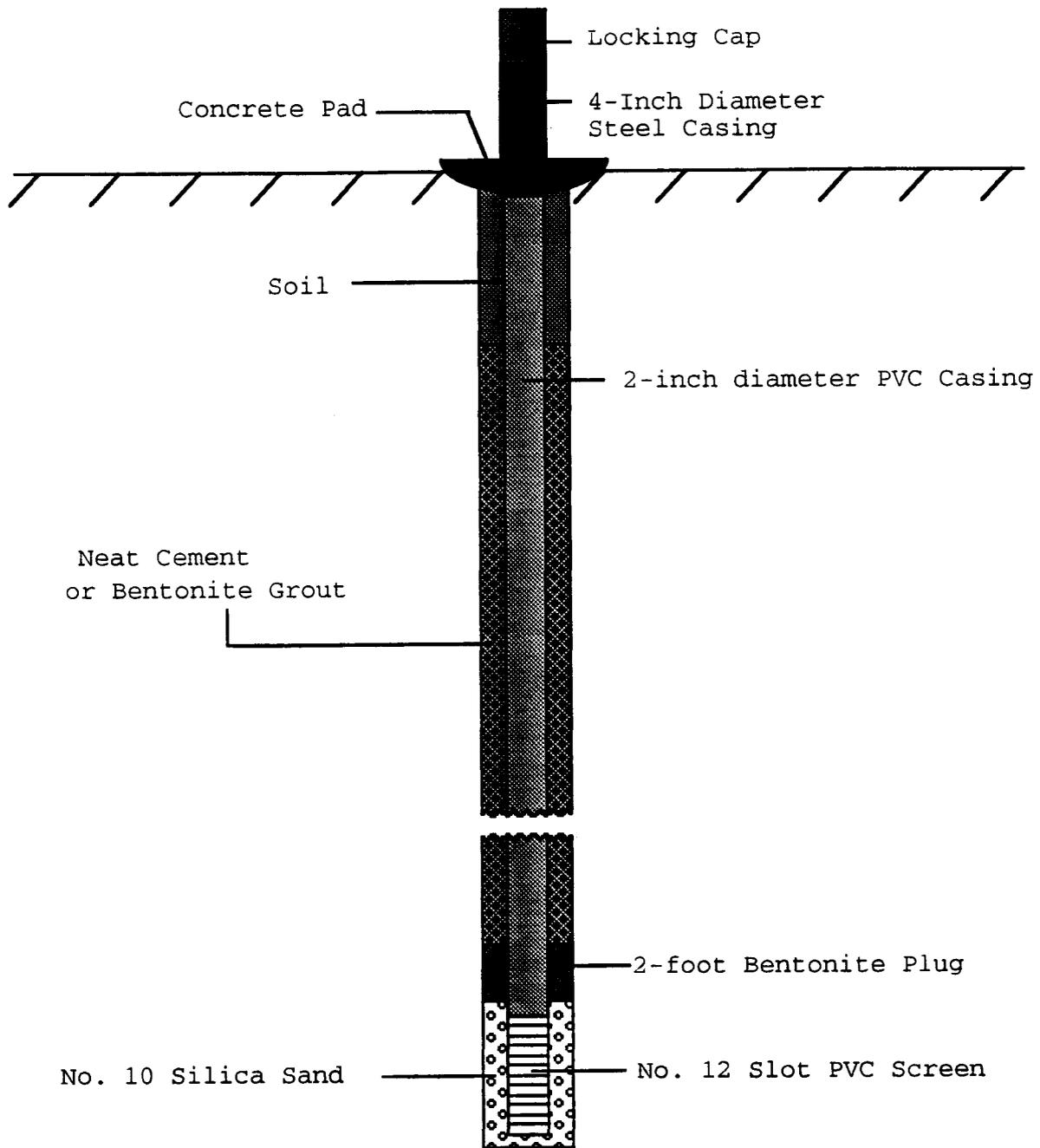


Figure 2. Construction design used for monitoring wells installed at the Gahner landfill.

and fine materials present near the well were removed to insure movement of formation water through the screen.

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

Collecting and Analyzing Water Samples

Water-quality analyses were used to determine if leachate is migrating from the landfill into the underlying ground-water system. Selected field parameters, major ions, and trace elements were measured for each water sample. These field parameters and analytes are listed in Appendix A with their Maximum Contaminant Levels (MCL). MCLs are enforceable drinking water standards 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 NDSDHCL.

Water-Level Measurements

Water-level measurements were made 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.

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

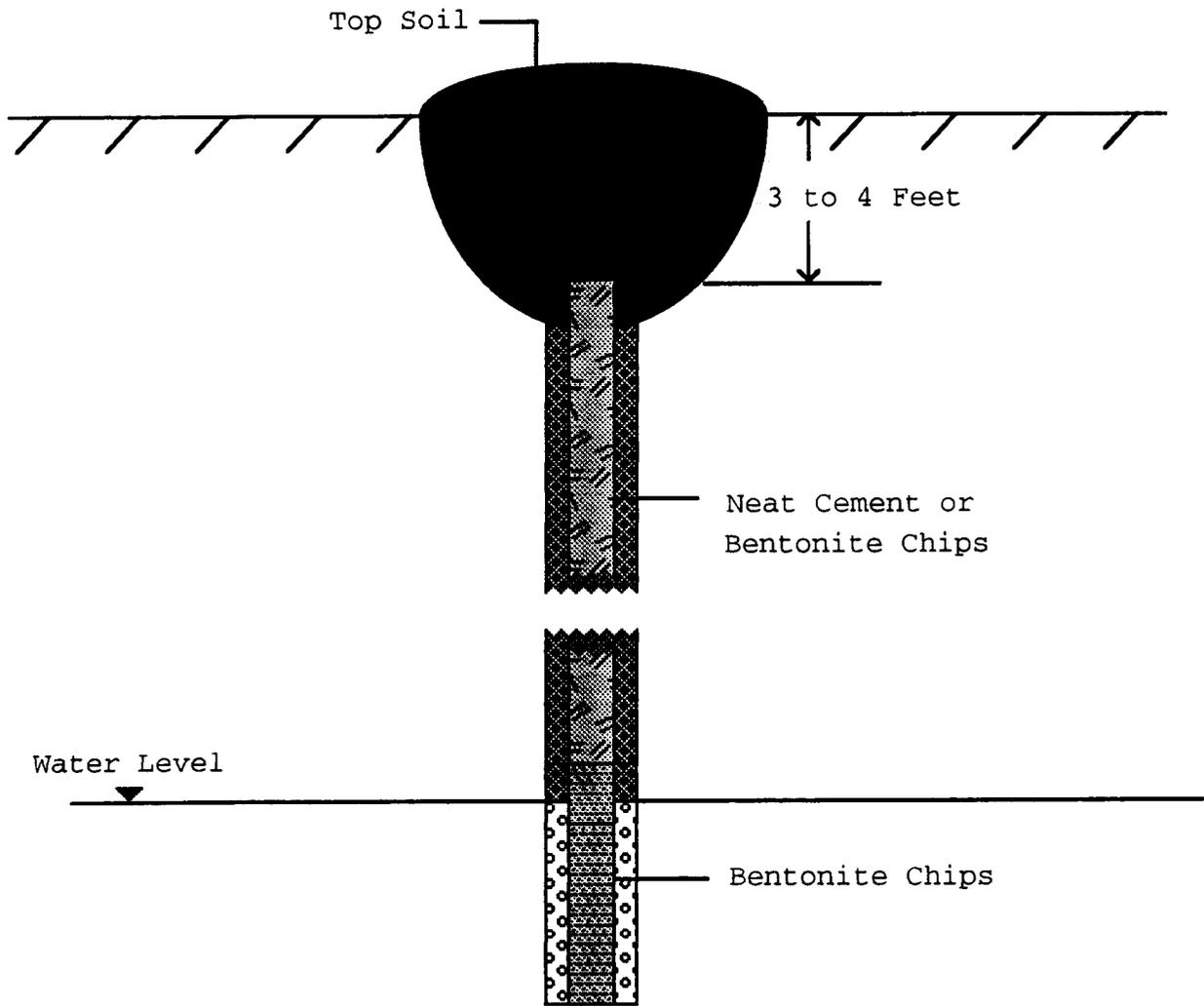


Figure 3. Monitoring well abandonment procedure.

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 133-066-36ADA would be located in the NE1/4, SE1/4, NE1/4, Section 36, Township 133 North, Range 66 West. Consecutive numbers are added following the three letters if more than one well is located in a 10-acre tract, e.g. 133-066-36ADA1 and 133-066-36ADA2.

GEOLOGY

The Gahner landfill is located in an area with a hummocky topography and poorly integrated drainage (Fig. 5). The geologic materials in the region include Pleistocene glacial sediments, glacial meltwater sediments, and Holocene pond and slough sediments. The Pleistocene and Holocene deposits range from 300 to 500 feet thick and are underlain by the Cretaceous Pierre Formation (Bluemle, 1979).

Test holes drilled in the present study encountered predominantly till consisting of clay and sandy clay with a trace of gravel. The till is yellowish brown near the surface and olive gray below a depth of about 15 to 20 feet.

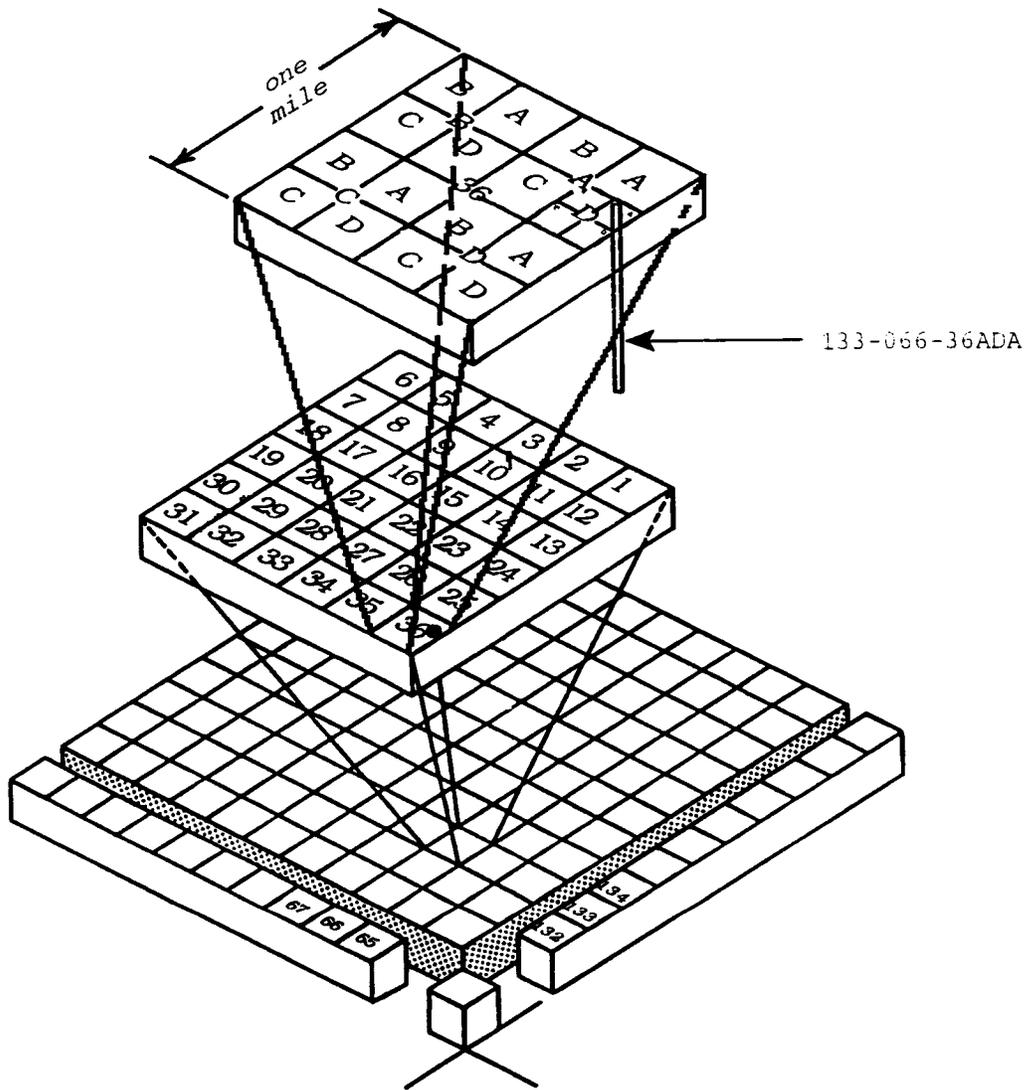


Figure 3. Location-numbering system for the Gahner landfill.

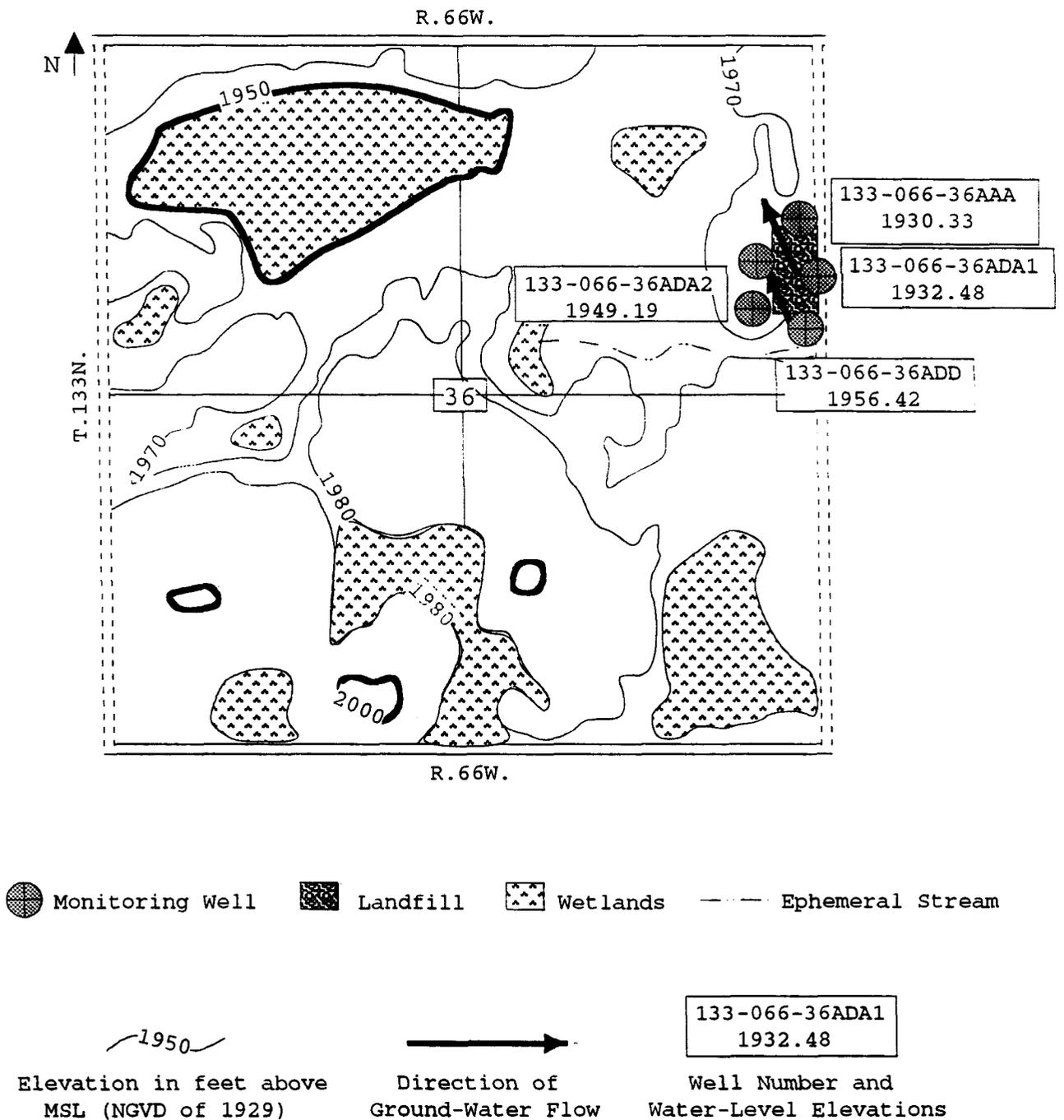


Figure 5. Location of monitoring wells and the direction of ground-water flow in the till aquifer.

A layer of fine- to coarse-grained sand, observed in test hole 133-66-36AAD, was not present in the other four test holes (Fig. 6, lithologic logs in Appendix C).

HYDROLOGY

Surface-Water Hydrology

The Gahner landfill is located in an area surrounded by numerous wetland depressions. The surface drainage system in the region is nonintegrated. There are two wetlands located within a quarter-mile of the landfill boundary and numerous wetlands are located within a half mile radius of the landfill. It is not known if there is a hydraulic connection between these wetlands.

Two National Waterfowl Production Areas are located in the vicinity of the landfill. One production area is located less than a quarter-mile to the east of the landfill. The second production area is located about a half-mile north of the landfill. It is possible that these wetlands may be susceptible to leachate migration from the landfill.

Regional Ground-Water Hydrology

Both bedrock and glacial aquifers comprise the regional ground-water flow system. Bedrock aquifers are located within the Dakota Group and Pierre Formation. The Dakota

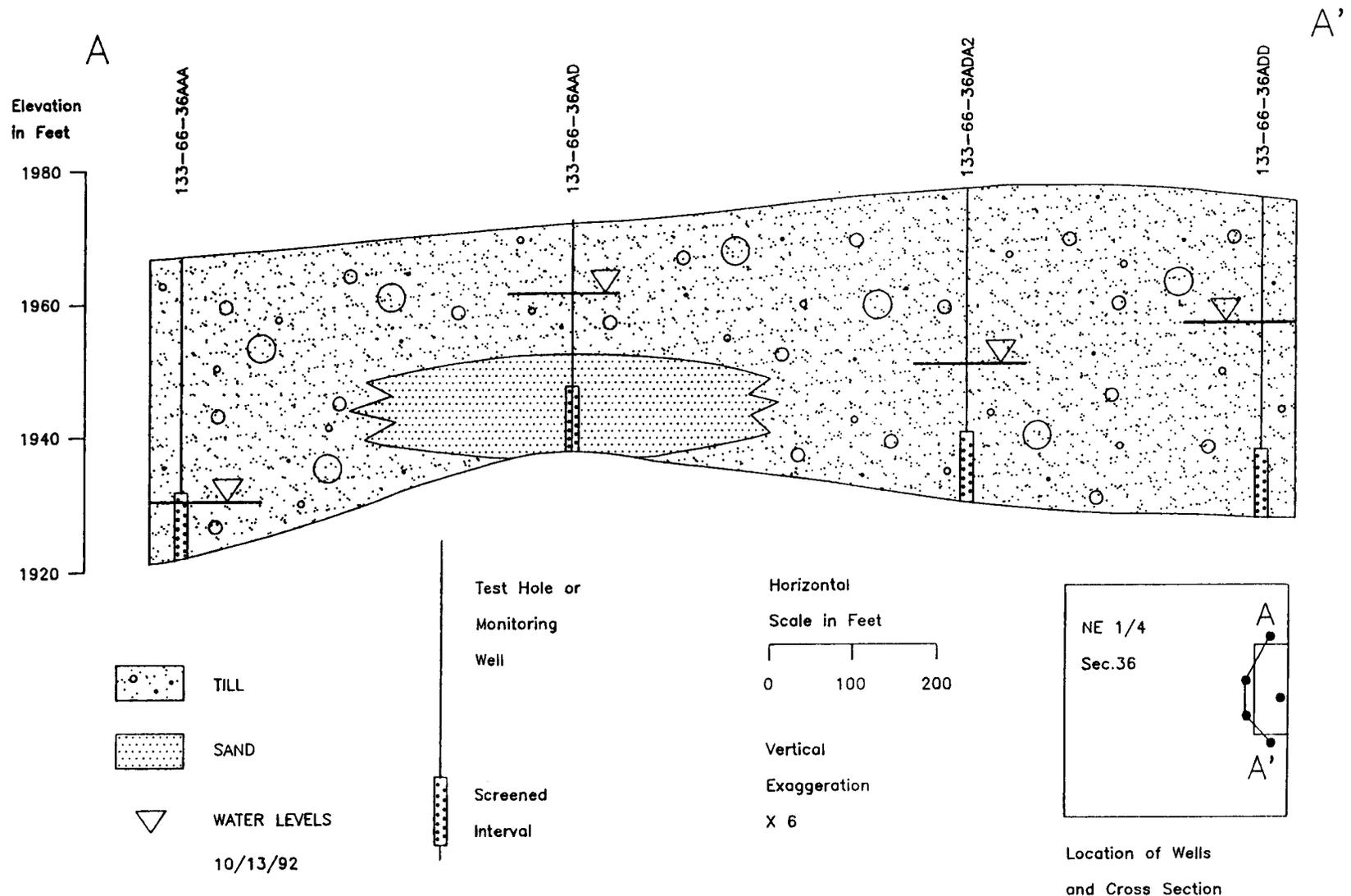


Figure 6. Geohydrologic section A – A' in the Gahner landfill

Group consists of the Lakota-Fall River and Newcastle Formations (Armstrong, 1980). These aquifers are located at a depth of 2,000 feet or greater and are generally characterized by a sodium-sulfate to a sodium-chloride type water. (Armstrong, 1980). Water from these aquifers is used locally for domestic and stock use and some public supplies.

The Pierre Formation, a fractured shale, directly underlies the glacial deposits. The Pierre aquifer is characterized by a sodium-sulfate to a sodium-chloride type water. Local wells screened in the Pierre aquifer are generally used for stock or domestic purposes.

The Edgeley aquifer, a major aquifer of glaciofluvial origin, is located 10 to 15 miles northeast of the landfill. The Edgeley aquifer is characterized by a calcium-magnesium-bicarbonate type water. Due to the distance and direction from the landfill, this aquifer should not be affected by leachate migration from the landfill.

Other aquifers of glaciofluvial origin consist of undifferentiated sand and gravel aquifers found throughout the region. Areas most likely to contain these undifferentiated aquifers are elongated surface depressions or areas where several wetlands occur in a chain (Armstrong, 1980). Recharge to these aquifers is by precipitation, lateral movement from adjacent sediments, and areas of surface water runoff and accumulation. Sodium, calcium, sulfate and bicarbonate are the dominant ions in water associated with these undifferentiated aquifers.

Local Ground-Water Hydrology

Five test holes were drilled at the Gahner landfill and monitoring wells were installed in each of them. The well screens were placed near the top of the upper-most aquifer beneath the landfill. Five water-level measurements were taken over a seven to eight week period (Appendix D). Four of the five wells were screened within till and one (133-066-36AAD) was screened within a glaciofluvial sand (Fig. 6). Based on the water-level measurements, the sand aquifer is confined. The higher water level in the sand aquifer compared to the surrounding till aquifer (Fig. 6), indicates the sand aquifer derives additional water from another source that is not hydraulically connected to the till aquifer. This suggests that the sand may have significant areal extent or the sand may be thicker and extend closer to land surface where surface recharge is greater. The direction of ground-water flow in the sand aquifer was not determined. The direction of ground-water flow in the till aquifer appears to be to the north-northwest (Fig. 5).

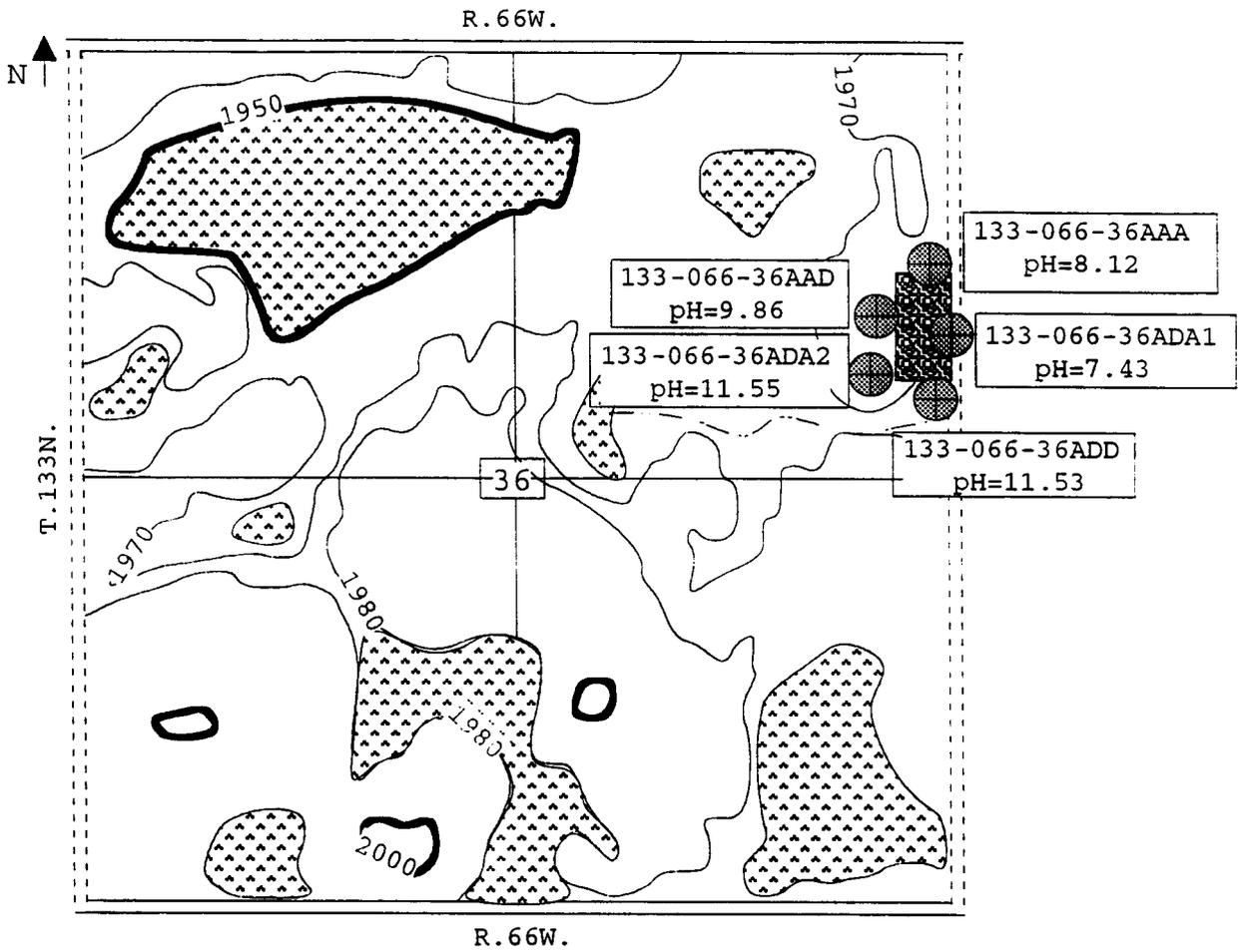
Water Quality

Samples for water quality analyses were collected from all five monitoring wells on September 3, 1992 and on October 22, 1992. Chemical analyses of the water samples are shown

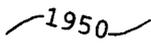
in Appendix E. The water analyses indicated high pH readings in three of the five wells. Natural pH levels for this area range from 7.0 to 8.5 (Armstrong, 1980). Four pH readings were taken from each well over a period of seven to eight weeks to evaluate temporal pH variations. These pH measurements are shown in Appendix F. The source of these high pH levels was not determined. The stability or increase from the initial pH reading in wells 133-066-36ADA2 and 133-066-36ADD (Fig. 7) indicate that the pH may be influenced by landfill activity and/or a slight influence from well construction.

Well 133-066-36AAD is screened in a sand lens that appears to extend beneath the landfill. The high pH measured in this well may be due to leachate migration from the landfill. The decreasing pH levels in wells 133-066-36ADA1 and 133-066-36AAA, appear to have been influenced by well construction.

The chemical analyses also indicated high concentrations of sulfate in all the wells which may be the result of dissolution of gypsum and/or oxidation of organic sulfur in the till or upward movement of sulfate enriched water from the underlying Pierre Formation. High sulfate concentrations are typical for ground water in this area. Three wells indicated elevated concentrations of total dissolved solids (TDS) and may reflect long residence times associated with small hydraulic conductivity till deposits. Trace element



 Monitoring Well
  Landfill
  Wetlands
 - - - Ephemeral Stream

 1950
 Elevation in feet above MSL (NGVD of 1929)

 →
 Direction of Ground-Water Flow

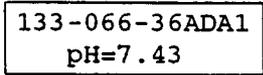
 133-066-36ADA1
 pH=7.43
 Well Number and pH levels

Figure 7. PH measurements on 10/22/92 at the Gahner landfill.

analyses did not indicate any elevated concentrations in either sampling period.

The results of VOC analyses, from wells 133-066-36AAD and 133-066-36ADD, are shown in Appendix G and H. These analyses did not detect any VOC compounds in either well.

CONCLUSIONS

The Gahner landfill is located in an area of hummocky topography and poorly integrated drainage. The geologic material in the area of the landfill consists of a predominantly clay till with interbedded sand lenses.

Water levels were measured in a glaciofluvial sand aquifer and in till. Water-level measurements indicated that the sand aquifer is confined. The direction of ground-water flow in this aquifer was not determined. Ground water in the till appears to flow to the north-northwest.

Water-quality analyses indicated pH levels higher than would be expected in three of the five monitoring wells. The pH levels were measured over a period of seven to eight weeks to evaluate temporal variability. The elevated pH's in three of the wells may be partially influenced by leachate migration from the landfill. The glaciofluvial sand aquifer also appears to be susceptible to contamination by leachate migration from the landfill.

High concentrations of sulfate and total dissolved solids were detected. These concentrations appear to be typical for ground-water chemistry in this area.

Trace element analyses did not indicate elevated concentrations. No VOC's were detected in wells 133-066-36AAD and 133-066-36ADD.

REFERENCES

- Armstrong, C.A., 1980, Ground-water resources of Dickey and LaMoure Counties, North Dakota: North Dakota Geological Survey, Bulletin 70, North Dakota State Water Commission, County Ground-Water Studies 28, Part III, 61 p.
- Bluemle, J.P., 1979, Geology of Dickey and LaMoure Counties, North Dakota: North Dakota Geological Survey, Bulletin 70, North Dakota State Water Commission, County Ground Water-Studies 28, Part I, 72 p.
- Hem, J.D., 1989, Study and interpretation of the chemical characteristics of natural water: United States Geological Survey, Water-Supply Paper 2254, 263 p.
- North Dakota Department of Health, 1986, Water well construction and water well pump installation: Article 33-18 of the North Dakota Administrative Code, 42 p.

APPENDIX A

WATER QUALITY STANDARDS
AND
MAXIMUM CONTAMINANT LEVELS

**Water Quality Standards
and
Maximum Contaminant Levels**

Field Parameters	MCL/SMCL (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

133-066-36ADD

NDSWC

Date Completed: 8/20/92 Well Type: P2
 Depth Drilled (ft): 48 Source of Data:
 Screened Interval (ft): 38-48 Principal Aquifer : Undefined
 Casing size (in) & Type: L.S. Elevation (ft) 1973.74

Unit	Description	Lithologic Log	Depth (ft)
TOPSOIL			0-2
CLAY	Sandy with a trace of gravel, pale yellow-brown 10Yr6/2.		2-7
CLAY	Sandy with a trace of pebbles, moderate yellow-brown 10YR5/4 with moderate red-brown 10YR4/6 mottles.		7-15
CLAY	Trace of sand and pebbles, moderate yellow-brown 10YR5/4.		15-20
CLAY	Trace of sand and pebbles, olive gray 5Y4/1.		20-48

133-066-36ADA2

NDSWC

Date Completed:	8/21/92	Well Type:	P2
Depth Drilled (ft):	48	Source of Data:	
Screened Interval (ft):	38-48	Principal Aquifer :	Undefined
Casing size (in) & Type:		L.S. Elevation (ft)	1975.71

Lithologic Log			
Unit	Description		Depth (ft)
TOPSOIL			0-2
CLAY	Sandy with a trace of pebbles, dark yellow-brown 10YR4/2.		2-10
CLAY	Trace of sand and pebbles, dark yellow-brown 10YR4/2.		10-15
CLAY	Sandy with a trace of pebbles, dark yellow-brown 10YR4/2.		15-19
CLAY	Trace of sand and pebbles, olive gray 5Y4/1.		19-22
CLAY	Trace of sand and pebbles, dark yellow-brown 10YR4/2.		22-34
CLAY	Trace of sand and pebbles, olive gray 5Y4/1.		34-48

133-066-36ADA1

NDSWC

Date Completed:	8/20/92	Well Type:	P2
Depth Drilled (ft):	50	Source of Data:	
Screened Interval (ft):	40-50	Principal Aquifer :	Undefined
Casing size (in) & Type:		L.S. Elevation (ft)	1973.21

Lithologic Log		
Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Trace of sand, gray-brown 5YR3/2.	1-12
CLAY	Trace of sand and gravel, olive gray 5Y4/1.	12-21
CLAY	Trace of sand, olive gray 5Y4/1.	21-40
CLAY	Trace of sand, olive gray, 5Y4/1. moist.	40-50

133-066-36AAD

NDSWC

Date Completed:	8/21/92	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)	1971.58

Lithologic Log			
Unit	Description	Lithologic Log	Depth (ft)
TOPSOIL			0-1
CLAY	Trace of sand and pebbles, pale yellow-brown 10YR6/2 with very pale orange 10YR8/2 mottles.		1-9
CLAY	Trace of pebbles, pale yellow-brown 10YR4/1.		9-19
CLAY	Trace of pebbles, olive gray 5Y4/1.		19-24
SAND	Fine to coarse grain, clayey with a trace of pebbles, olive gray 5Y4/1.		24-35

133-066-36AAA

NDSWC

Date Completed: 8/21/92 Well Type: P2
Depth Drilled (ft): 45 Source of Data:
Screened Interval (ft): 35-45 Principal Aquifer : Undefined
Casing size (in) & Type: L.S. Elevation (ft) 1967.25

Lithologic Log		
Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	Trace of sand and pebbles, trace of lignite fragments, moderate yellow-brown 10YR5/4 with few moderate red-brown 10R4/6 mottles.	2-9
CLAY	Trace of sand and pebbles, moderate yellow-brown, 10YR5/4.	9-15
CLAY	Sandy with a trace of pebbles, olive gray 5Y4/1.	15-45

APPENDIX D

WATER-LEVEL TABLES

Gahner Water Levels
8/31/92 to 10/22/92

133-066-36AAA

LS Elev (msl,ft)=1967.25
SI (ft.)=35-45

Undefined Aquifer

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/31/92	9.38	1957.87	10/13/92	36.92	1930.33
09/03/92	39.33	1927.92	10/22/92	36.67	1930.58
09/14/92	40.41	1926.84			

133-066-36AAD

LS Elev (msl,ft)=1971.58
SI (ft.)=35-35

Undefined Aquifer

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/31/92	10.09	1961.49	10/13/92	11.80	1959.78
09/03/92	10.16	1961.42	10/22/92	11.73	1960.85
09/14/92	10.34	1961.24			

133-066-36ADA1

LS Elev (msl,ft)=1973.21
SI (ft.)=40-50

Undefined Aquifer

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/31/92	5.32	1967.89	10/13/92	40.73	1932.48
09/03/92	42.03	1931.18	10/22/92	40.70	1932.51
09/14/92	43.36	1929.85			

133-066-36ADA2

LS Elev (msl,ft)=1975.71
SI (ft.)=38-48

Undefined Aquifer

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/31/92	1.61	1974.10	10/13/92	26.52	1949.19
09/03/92	42.24	1933.47	10/22/92	24.73	1950.98
09/14/92	40.11	1935.60			

133-066-36ADD

LS Elev (msl,ft)=1973.74
SI (ft.)=38-48

Undefined Aquifer

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/31/92	15.06	1958.68	10/13/92	17.32	1956.42
09/03/92	16.82	1956.92	10/22/92	14.86	1958.88
09/14/92	15.81	1957.93			

APPENDIX E

MAJOR ION AND TRACE-ELEMENT
CONCENTRATIONS

Gahner 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									
133-066-36AAA	35-45	09/14/92	27	0.01	0	37	2	140	16	76	16	300	33	0.9	4	0.38	613	100	12	72	6.1	883	8	9.75	
133-066-36AAA	35-45	10/22/92	23	0.02	0.01	43	8	170	16	214	14	340	15	0.5	4.3	0.49	739	140	0	70	6.2	1038	10	8.12	
133-066-36AAD	25-35	09/03/92	19	0.02	0.02	55	16	180	35	156	0	570	13	0.4	5.3	0.28	961	200	75	61	5.2	1390	8	8.8	
133-066-36AAD	25-35	10/22/92	20	0.01	0	53	16	180	30	49	22	590	8.1	0.2	0.2	0.19	944	200	120	62	5.5	1330	10	9.86	
133-066-36ADA1	40-50	09/03/92	25	0.02	0.01	51	11	230	13	78	0	610	21	0.7	5.7	0.36	1010	170	110	73	7.7	1395	12	9.19	
133-066-36ADA1	40-50	10/22/92	18	0.02	0.72	100	0.8	270	15	261	0	760	19	0.4	6.2	0.46	1350	360	150	61	6.2	1831	8	7.43	
133-066-36ADA2	39-48	09/03/92	15	0.04	0.01	210	0	170	22	0	0	540	10	0.3	1.2	0.08	1070	520	220	40	3.2	2830	10	11.89	
133-066-36ADA2	38-48	10/22/92	7.2	0.04	0	220	0	280	120	0	0	930	11	0.2	0.4	0.12	1670	550	260	46	5.2	3180	9	11.55	
133-066-36ADD	38-48	09/03/92	4.5	0.05	0.01	230	0	180	23	0	0	400	24	0.4	4.2	0.21	1040	570	54	39	3.3	3400	11	12.01	
133-066-36ADD	38-48	10/22/92	16	0.03	0.01	140	0	260	20	0	0	500	37	0.2	0.4	0.34	1060	350	85	60	6	2520	8	11.53	

Gahner Water Quality
Trace Element Analyses

Location	Date Sampled	Selenium	Lead	Cadmium	Mercury	Arsenic	Molybdenum	Strontium
		(micrograms per liter)						
133-066-36AAA	09/14/92	0	0	0	0	20	24	390
133-066-36AAA	10/22/92	7	0	0	0.1	12	43	510
133-066-36AAD	09/03/92	1	0	0	0	4	0	800
133-066-36AAD	10/22/92	2	0	0	0	4	16	770
133-066-36ADA1	09/03/92	3	0	0	0	7	16	450
133-066-36ADA1	10/22/92	5	0	0	0.1	5	27	950
133-066-36ADA2	09/03/92	0	0	0	0	3	0	1100
133-066-36ADA2	10/22/92	2	0	0	0.1	4	18	2600
133-066-36ADD	09/03/92	1	0	0	0	3	5	1400
133-066-36ADD	10/22/92	2	0	0	0.1	7	20	880

APPENDIX F

PH MEASUREMENTS FROM 9/3/92 TO 10/22/92

<u>Well Number</u>	<u>Date Taken</u>	<u>pH Reading</u>
133-066-36AAA	9/3/92	11.17
	9/14/92	9.75
	10/13/92	9.25
	10/22/92	8.12
133-066-36AAD	9/3/92	8.80
	9/14/92	*
	10/13/92	9.69
	10/22/92	9.86
133-066-36ADA1	9/3/92	8.55
	9/14/92	9.19
	10/13/92	8.34
	10/22/92	7.43
133-066-36ADA2	9/3/92	11.89
	9/14/92	11.02
	10/13/92	12.07
	10/22/92	11.55
133-066-36ADD	9/3/92	12.01
	9/14/92	12.04
	10/13/92	11.68
	10/22/92	11.53

* Reading not taken

APPENDIX G

VOLATILE ORGANIC COMPOUNDS
FOR WELL 133-066-36AAD

Volatile Organic Compounds
and
Minimum Concentrations

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

Constituent	Chemical Analysis $\mu\text{g/L}$
Benzene	<2
Vinyl Chloride	<1
Carbon Tetrachloride	<2
1,2-Dichlorethane	<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	<50
Pentachloroethane	<5
Trichlorotrofluoroethane	<5
Carbondisulfide	<5
Ether	<5

* Constituent Detection

APPENDIX H

VOLATILE ORGANIC COMPOUNDS
FOR WELL 133-066-36ADD

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	<50
Pentachloroethane	<5
Trichlorotrofluoroethane	<5
Carbondisulfide	<5
Ether	<5

* Constituent Detection