THOMSEN ASSOCIATES

FRONTIER CHEMICAL
HYDROGEOLOGIC INVESTIGATION

EMPIRE
SOILS INVESTIGATIONS INC.

FRONTIER CHEMICAL
HYDROGEOLOGIC INVESTIGATION

FOR
Frontier Chemical
Niagara Falls, New York

Job No. BD-84-142
February 1985

105 CORONA AVENUE, GROTON, NY 13073, 607-898-5881

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THOMSEN ASSOCIATES

FRONTIER CHEMICAL
HYDROGEOLOGIC INVESTIGATION

1.0 INTRODUCTION

1.1 Purpose and Scope

Empire Soils Investigations was retained by Frontier Chemical Waste Process, Inc. in November 1984 to install monitoring wells around their facility in Niagara Falls, New York and prepare a report describing hydrogeologic conditions encountered during the investigation. The purpose of this work was to comply with the requirements of the New York Department of Environmental Conservation for a ground water monitoring program at the facility. Specifically, the purpose of our work was to:

- Install wells around the site periphery to provide monitoring points at the property boundaries.
- Provide additional monitoring wells in the vicinity of the inactive sludge settler.
- Determine the direction of groundwater flow .

The scope of our work was limited to analyzing the data obtained from our field investigation and available information on general geology of the area. The field investigation included drilling and installing monitoring wells at nine locations, surveying the location and elevation of the wells and measuring water levels over a period of five weeks.

This report has been prepared for the exclusive use of Frontier Chemicals for specific application to groundwater monitoring at their facility in Niagara Falls, New York. No other warrenty, expressed or implied is made.

1.2. Site Location

Frontier Chemical Waste Process, Inc. is located in Niagara Falls, New York (see Figure 1). The property is bordered by Royal Avenue on the south and 46th Street on the east. The facility is approximately 3800 feet north of the Niagara River. The property is generally flat except for a swale along the western property boundary. The swale is found along the fence lines west of MW-17 and north of MW-15.

1.3 Methodology

Nine monitoring wells (MW-9 through MW-17) were installed around the periphery of the site and in the vicinity of the inactive sludge settler (Figure 2). The borings for the monitoring wells were advanced using a combination of hollow stem augers in the unconsolidated deposits and "NX" rock coring in bedrock. Soil samples were taken every five feet from the borings. The rock core was retrieved from each boring to investigate bedrock integrity. After coring bedrock, the borehole was enlarged to accommodate the monitoring well by reaming with a 3½ inch diameter roller bit.

Initially, all borings were advanced to a depth of 4.7 to 6.2 feet below the top of bedrock and wells installed with the bottom of the well screens placed between 3.4 and 5.8 feet below the top of rock. However, at the completion of drilling, 3 wells were found to be dry (MW-9, MW-11 and MW-13) and MW-12 had less than 1 foot of water, due to steep gradients along the southern and eastern property boundaries (see Section 2.2). These four wells (MW-9, MW-11, MW-12, and MW-13) were redrilled and new wells installed. The new wells were advanced to a depth of 15 to 17.7 feet below the top of limestone (see Appendix A for boring logs).

Wells were installed in all borings using 2 inch I. D. PVC pipe (threaded flush joints) for the well screen and riser pipe. The well screens have 0.01 inch slots. Clean silica sand was placed around the well screens. A bentonite pellet seal was placed above the sand and the remainder of the annular space filled with cement grout. A four-inch I. D. locking metal protector pipe was cemented over the PVC riser pipe. Well construction details for each well are shown on the hydrogeologic logs in Appendix A.

To minimize cross contamination between borings the drilling equipment was washed with clean water between borings. When suspected soil contamination was encountered in MW-15, the soil sampler was rinsed with acetone between samples and after completing the boring.

The locations and the elevations of the wells were surveyed by Empire Soils. After the wells were installed they were developed by bailing. Water levels in the wells were monitored over a five week period (see Table 1).

2.0 FINDINGS OF INVESTIGATION

2.1 Geology

The borings encountered between 11.0 and 18.2 feet of unconsolidated deposits overlying dolostone bedrock. The unconsolidated deposits consisted of between 0.6 and 7.5 feet of fill on top of silt and sand. Except at borings MW-10, MW-14, and MW-17, lacustrine silt, clay and sand deposits were encountered below the fill, with red brown glacial till consisting of silt and sand with some gravel found between the lacustrine deposits and bedrock. Only lacustrine silts and clays were encountered below the fill in borings MW-10 and MW-17. At boring MW-14 only glacial till was encountered below the fill.

Bedrock beneath the site is Lockport Dolomite of Upper Silurian age. (Richard and Fisher, 1970). The dolostone encountered was gray, weathered, hard, thin bedded to bedded with occasional carbon partings and some solution cavities and voids.

2.2 Groundwater Flow

Water elevations in the wells were monitored over a five week period (see Table 1). Water table contours are shown on Figure 2. Water table contours are based on water levels measured on February 8, 1985. Ground water flow in the bedrock aquifer is from the northwest corner of the site toward the east and south (Royal Avenue and 46th Streets). Wells MW-14, MW-15 and MW-17 are upgradient of the facility. Wells MW-9, MW-11, MW-12 and MW-13 are downgradient of the facility. Well MW-10 is downgradient of the inactive sludge settler.

The horizontal gradient varies from 0.01 ft/ft south of MW-17 to 0.08 ft/ft in the vicinity of MW-11. The steeper horizontal gradients found along the eastern and southern property boundaries (46th Streets and Royal Avenue) are attributed to deep sewers beneath the streets. A sewer 50 feet deep is found beneath Royal Avenue probably causing the steep gradients along the southern property boundary, and another deep sewer along 46th Street probably accounts for the steep gradients along the eastern edge of the property.

Groundwater flow in bedrock is primarily through fractures and solution cavaties. Voids or solution cavaties were encountered at wells MW-11, MW-13, MW-14 and MW-15.

3.0 CONCLUSIONS

Groundwater flow in the dolostone bedrock beneath the site is from the northwestern property corner toward both 46th Street and Royal Avenue. Monitoring wells MW-14, MW-15, MW-17 are upgradient of the facility while monitoring wells MW-9, MW-11, MW-12 and MW-13 are downgradient of the facility. Monitoring well MW-10 is downgradient of the inactive sludge settler. Comparison of water quality between the upgradient wells (MW-14, MW-15 and MW-17) and downgradient wells (MW-9, MW-10, MW-11, MW-12 and MW-13) should provide an assessment of the impact of the facility on groundwater quality in the dolostone aquifer.

4.0 REFERENCES

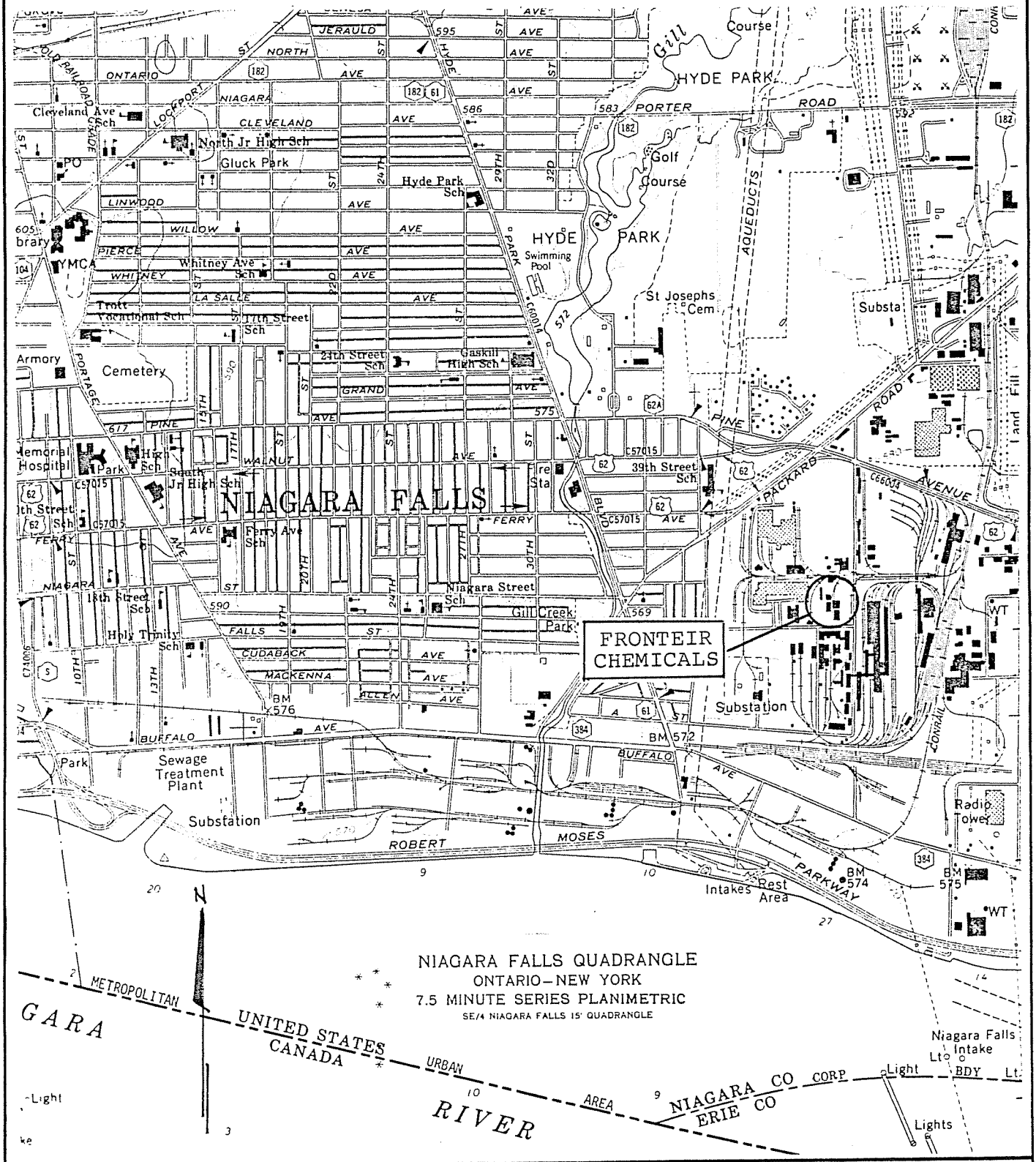
Rickard, L. V. and D. W. Fisher, 1970, "Geologic Map of New York, Niagara Sheet", New York State Museum and Science Service Map and Chart Series, No. 15.

Respectfully submitted,
EMPIRE-THOMSEN

Marjory Rinaldo-Lee

Marjory Rinaldo-Lee, C.P.G.S.

FIGURES



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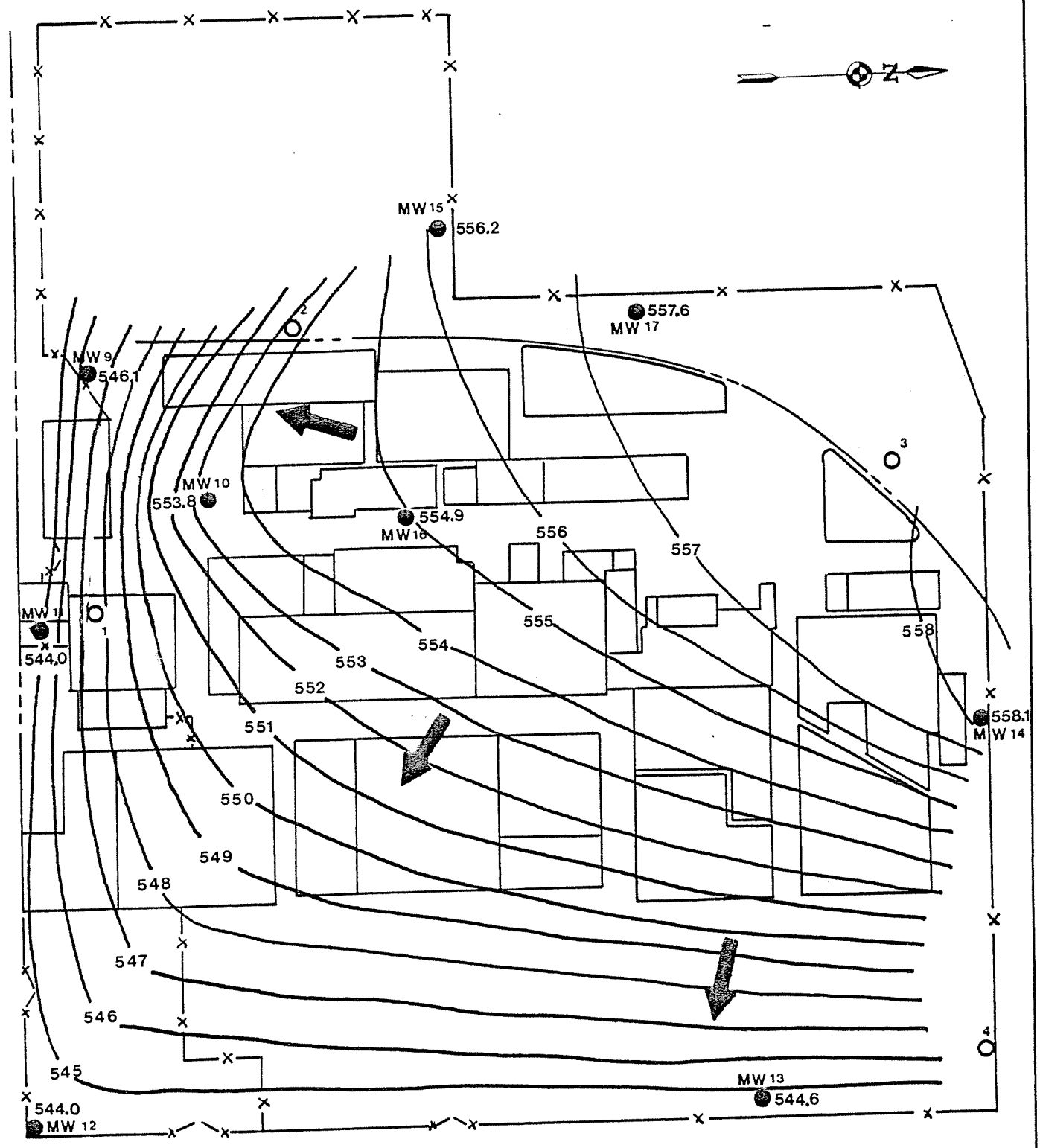
CONSULTING GEOTECHNICAL ENGINEERS & GEOLOGISTS

Groton ▪ Buffalo ▪ Rochester ▪ Syracuse ▪ Albany
New York ▪ Edison, New Jersey

SITE LOCATION PLAN

FRONTEIR CHEMICAL

DR. BY: --	SCALE: 1" = 2000'	PROJ. NO.: BD-84-142	
CK'D. BY:	DATE: Feb. 1985	DRWG. NO.: 1	



● MONITORING WELL

555 WATER TABLE CONTOUR

DIRECTION OF FLOW

NOTES: 1.) Water table contours based on water level measured on February 8, 1985.

2.) Base Map provided by Fronteir Chemicals.

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CONSULTING GEOTECHNICAL ENGINEERS & GEOLOGISTS

Groton ▪ Buffalo ▪ Rochester ▪ Syracuse ▪ Albany
New York ▪ Edison, New Jersey

MONITORING WELL LOCATIONS AND WATER TABLE MAP
Fronteir Chemicals

DR. BY: sc	SCALE: 1"≈100'	PROJ. NO.: BD-84-142	
CK'D. BY:	DATE: Feb. 1985	DRWG. NO.: 2	

TABLES

TABLE 1

Water Level Elevations

Well	Reference Point[1]	1-4-85[3]	1-11-85	1-15-85	1-29-85	1-31-85	2-1-85	2-8-85
MW-9[2]	573.9	dry	dry	dry	dry	dry	545.9	546.1
MW-10	575.7	554.4	554.0	554.2	554.0	554.1	554.1	553.8
MW-11[2]	573.7	550.65	dry	dry	dry	544.0	543.8	544.0
MW-12[2]	573.5	557.74	549.9	550.0	549.7	544.1[4]	543.8	544.0
MW-13[2]	574.0	dry	dry	dry	dry	dry	dry	544.6
MW-14	573.5	559.9	558.8	558.5	558.2	558.3	558.0	558.1
MW-15	572.4	556.8	557.0	557.0	556.4	556.5	556.2	556.2
MW-16	573.4	553.9	556.7	556.8	556.8	556.5	556.6	554.9
MW-17	573.0	558.2	557.9	557.9	557.6	557.6	557.6	557.6

[1]Reference Point is top of PVC

[2]Wells MW-9,MW-11,MW-12, and MW-13 were redrilled between Jan. 28, 1985 and Feb. 1, 1985

[3]Water levels were not stabilized on Jan. 4, 1985

[4]Well MW-12 was redrilled on Jan. 29, 1985

APPENDIX A

DEPTH	ELEVATION	SAMPLES	SAMPLE NO.	CHEM. SMPL	RECOVERY	N	SOIL or ROCK CLASSIFICATION	UNIFIED SOIL CLASSIF.	DENSITY (PCF)	WATER CONTENT (Percent)	PERMEABILITY (cm/sec)	MONITOR, PIEZOMETER CONSTRUCTION DETAILS						WATER PROBE READINGS				NOTES
																		Temp. (°C)	Cond. (µmho cm)	Eh (mV)	pH	
1	2	3	4	5	6	7	8	9	10	11	12	13	14					15	16	17	18	19

The figures in the Column 1 defines the scale of the Subsurface Log.

The associated elevation is shown in the second column.

The third column graphically shows the exact depth range from which a soil sample or rock core was recovered.

See Table I for a description of the symbols used to signify the various types of samples.

The Sample or Run No. is used for identification on sample containers and/or Laboratory Test Reports.

The Chemical Sample column graphically shows the depth range from which a sample was removed for chemical analysis.

The recovery column shows the recovery in inches for a soil sample. Rock core recovery is shown in percent.

N shows the number of blows required to drive a split spoon sampler into the soil. Unless otherwise stated, the results are for a "Standard Penetration Test", driving a two-inch diameter spoon 12 inches with a 140 pound hammer dropped 30 inches. RQD is the Rock Quality Designation for rock core. This equals the sum of the length of pieces greater than 4 inches divided by the length of the core run.

All recovered soil samples are reviewed in the laboratory. The visual descriptions are made on basis of the sample as recovered and in accordance with the Unified Classification System shown on Table VI. The Unified group symbol is shown in Column 9.

Guidelines for the terms used in descriptions are presented in Tables II and III. The description of the relative soil compactness or consistency is based upon the penetration records as defined in Table IV. The description of the soil mositure is based upon the condition of the sample as recovered. The moisture condition is described as dry, damp, moist or wet. Water used to advance the boring may have affected the in-situ moisture content of the sample. Special terms are used as required to describe materials in greater detail; several such terms are listed in Table V. When sampling gravelly soils with a standard two-inch diameter split spoon, the true percentage of gravel is often not recovered due to the relatively small sampler diameter. The presence of boulders and large gravel is sometimes, but not necessarily, detected by an evaluation of the casing and sampler blows or through the "action" of the drill rig as reported by the driller.

The results from nuclear field tests or laboratory tests for soil density and moisture are shown in Columns 11 and 12.

Soil or rock permeability, the testing method, and the depth range tested are shown in Column 12.

Column 13 is a graphic description of the monitor or piezometer installation. A Key to the description is presented on Table VII. Details of materials are noted in the NOTES column. The static water level (SWL) and date measured are noted in the adjacent column.

Columns 15 to 18 indicate the results of field tests at the depth tested. The date of the test is noted below the readings.

TABLE I

- Split Spoon Sample
- Shelby Tube Sample
- Auger or Pit Sample
- Rock Core

TABLE II

Identification of soil type is made on basis of an estimate of particle sizes, and in the case of fine grained soils also on basis of plasticity.

Soil Type	Soil Particle Size	
Boulder	>12"	
Cobble	3"-12"	
Gravel-Coarse	3"-3/4"	Coarse Grained
-Fine	#4-#10	(Granular)
Sand-Coarse	#10-#40	
-Medium	#40-#200	
-Fine		
Silt-Non Plastic (Granular)		
Clay-Plastic (Cohesive)	<#200	Fine Grained

TABLE III

The following terms are used in classifying soils consisting of mixtures of two or more soil types. The estimate is based on weight of total sample.

Term	Percent of Total Sample
and	35-50
some	20-35
little	10-20
trace	less than 10

(When sampling gravelly soils with a standard split spoon, the true percentage of gravel is often not recovered due to the relatively small sampler diameter.)

TABLE IV

The relative compactness or consistency is described in accordance with the following terms:

Granular Soils		Cohesive Soils	
Term	Blows per Foot, N	Term	Blows per Foot, N
Loose	<10	Very Soft	<2
Firm	11-30	Soft	3-5
Compact	31-50	Medium	6-15
Very Compact	>51	Stiff	16-25
		Hard	>25

(Large particles in the soils will often significantly influence the blows per foot recorded during the Penetration Test.)

TABLE V

Varved	Alternating layers, seams, and partings of soils.
Layer	Soil deposit more than 6" thick.
Seam	Soil deposit less than 6" thick.
Parting	Soil deposit less than 1/8" thick.
Uniform	All grains are of about the same diameter

TABLE VI

UNIFIED SOIL CLASSIFICATION

Major Division		Group Symbol	Soil Description
Coarse-grained (over 50% by weight coarser than No. 200 sieve)	Gravelly soils (over half of coarse fraction larger than No. 4)	GW	Well-graded gravels, sandy gravels. Little or no fines.
		GP	Gap-graded or uniform gravel, sandy gravels. Little or no fines.
		GM	Silty gravels, silty sandy gravels.
		GC	Clayey gravels, clayey sandy gravels.
	Sandy soils (over half of coarse fraction finer than No. 4	SW	Well-graded sand, gravelly sands. Little or no fines.
		SP	Gap-graded or uniform sands, gravelly sands. Little or no fines.
		SM	Silty sands, silty gravelly sands.
		SC	Clayey sands, clayey gravelly sands.
Fine-grained (over 50% by weight finer than No. 200 sieve)	Low compressibility (liquid limit less than 50)	ML	Silts, very fine sands, silty or clayey fine sands, rock floor.
		CL	Low plasticity clays, sandy or silty clays.
		OL	Low plasticity organic silts and clays.
	High compressibility (liquid limit more than 50)	MH	Micaceous or diatomaceous silts.
		CH	Highly plastic clays and sandy clays.
		OH	Organic silts and highly plastic clays.
Organic Soils			

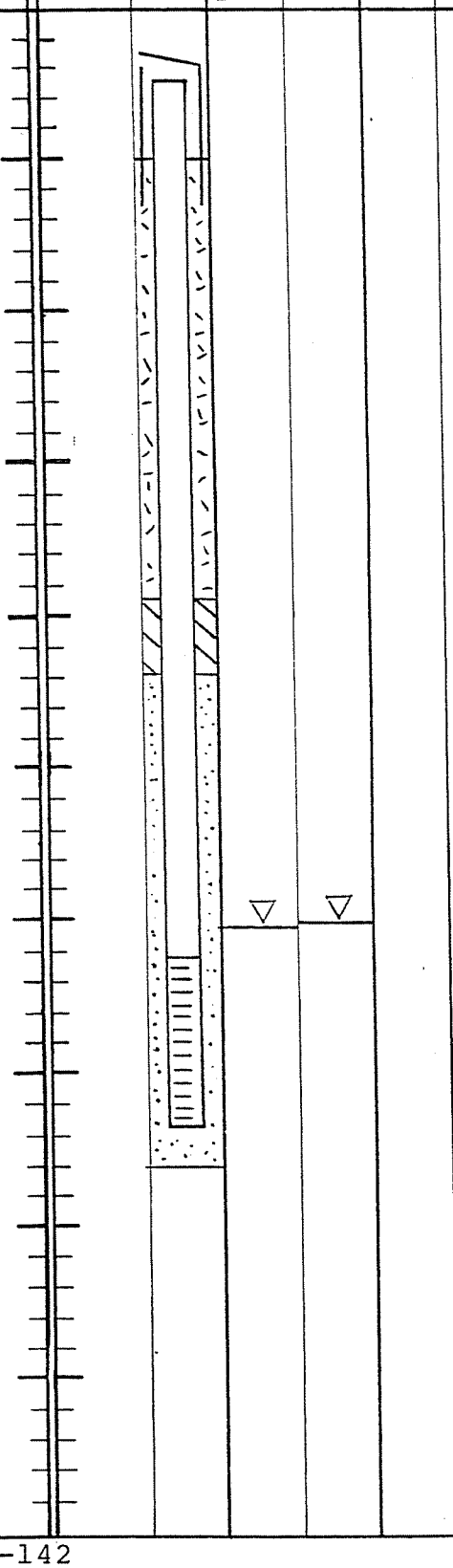
TABLE VII

- Curb Box
- Riser
- Well Screen
- Point Piezometer
- Sand Pack
- Bentonite Seal
- Concrete Seal
- Granular Fill

KEY TO HYDROGEOLOGIC LOG

DEPTH	ELEVATION	SAMPLES	SAMPLE NO.	CHEM. SMPL	RECOVERY (Inches)	N	SOIL or ROCK CLASSIFICATION	UNIFIED SOIL CLASSIF.	DENSITY (PCF)	WATER CONTENT (Percent)	PERMEABILITY (cm/sec)
0	571.8		1			7	TOPSOIL				
			2			6	Gray-Green SILT, trace clay, trace sand, trace brick (FILL) (Moist-Loose) becomes wet, firm, contains occasional fine Sand partings and seams 8.5'				
5			3			12					
			4			12					
			5			17					
10			6			15	Red-Brown Silty CLAY (Moist-Stiff) 10.5'				
							Red-Brown Clayey SILT and fine-coarse SAND, little fine gravel (Wet-Medium) 16.7'				
15			7			105					
			8			-					
			1A		92.0	0.8	Gray Dolostone ROCK, Hard, sound bedded, minor pitting, occasional carbon partings				
20			1B		100	0.8					
25			2B		95.0	0.2	Contains Red Sandstone pebbles				
30			3B		100	100	Occasional mineral precipitates				
							Boring Terminated @ 33.0'				
35											

MONITOR/PIEZOMETER CONSTRUCTION DETAILS



WATER PROBE READINGS			
Temp. (°C)	Cond. (µmho/cm)	Eh (mV)	pH

NOTES

WELL CONSTRUCTION
Well Screen: 2" ID PVC 0.01" machine slots
Riser Pipe: 2" ID PVC, threaded flush joint

PROTECTIVE CASING
4" ID locking steel pipe

REFERENCE ELEVATION:
573.9 (Top of PVC)

ROCK CORING
Run #1A 16.7'-21.7'
Run #1B 16.7'-26.7'
Run #2B 26.7' 28.7'
Run #3B 28.7'-33.0'
Roller bit from 16.7'-33.0'

NOTES
1. Boring drilled to 21.7' on 12-17-84 and well installed with bottom of well at 20.1'. Rock cored from 16.7'-21.7' (Run #1A). Free standing water at 5.7' before coring.
2. Boring redrilled deeper on 1-31-85 and new well installed. Original well dry before redrilling. Rock cored from 16.7' to 33.0' (Runs #1B,2B,3B).

NOTE: See key and explanation to log.

RUN NO.	RECOVERY (Percent)	RQD

Surface Elevation 571.8
Date Started 1-30-85
Date Completed 1-31-85
Number of Installations in Boring 1
Method of installation Hollow Stem Auger
NX Core and 3½" Roller Bit

Project No. BD-84-142
Project Title Frontier Chemicals
Location Niagara Falls, NY

Classified By A.K. & O.W. Checked MR-L

HYDROGEOLOGIC LOG

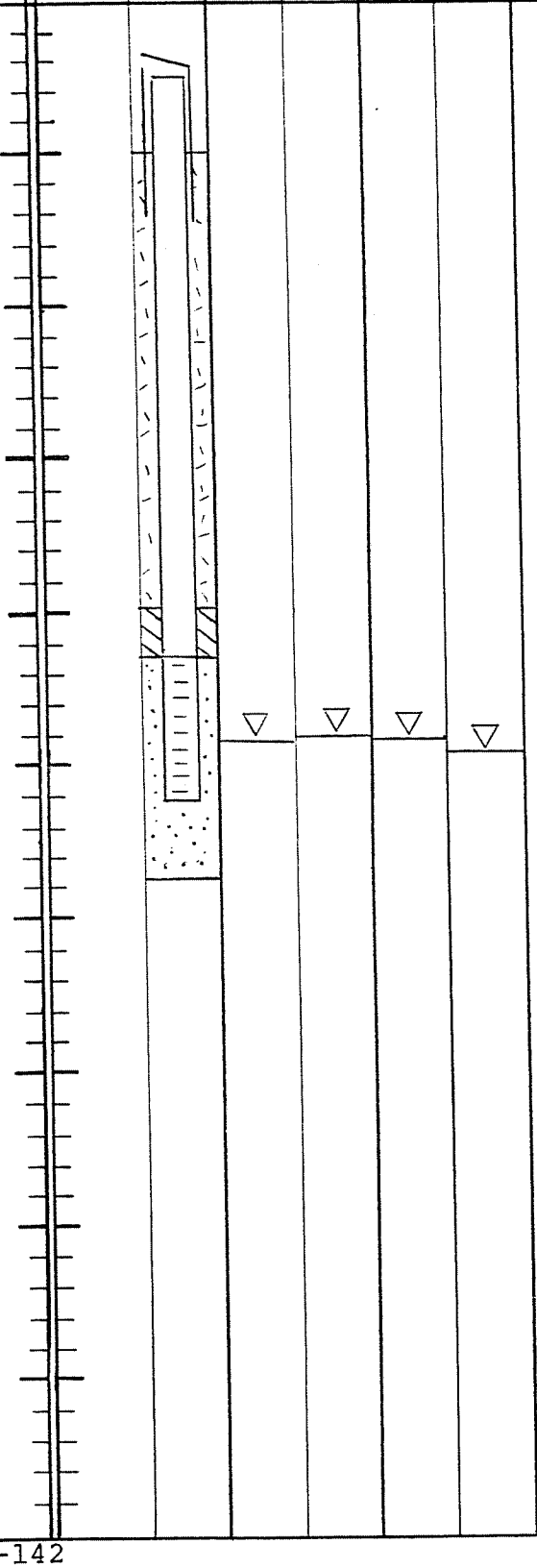
THOMSEN ASSOCIATES

MONITOR NO. MW-9

Sheet 1 of 1

DEPTH	ELEVATION	SAMPLES	SAMPLE NO.	CHEM. SMPL	RECOVERY (Inches)	N	SOIL or ROCK CLASSIFICATION	UNIFIED SOIL CLASSIF.	DENSITY (PCF)	WATER CONTENT (Percent)	PERMEABILITY (cm/sec)
0	573.3		1			-	Brown fine-coarse SAND, little silt, trace gravel, clay & brick fragments (FILL) (Moist) 3.5'±				
5			2			7	Green-Gray Clayey SILT, Some Cinders, contains trace white silt (Moist-Loose)				
10			3			8	becomes wet 13.5'±				
15			4			12	Red-Brown CLAY (Moist-Medium) 17.4'				
20			1		99.6	0.95	Light Gray DOLOSTONE, hard, sound, bedded				
25							Boring Terminated @ 23.6'				

MONITOR/PIEZOMETER CONSTRUCTION DETAILS



WATER PROBE READINGS

Temp. (°C)	Cond. (µmho/cm)	Eh (mV)	pH

NOTES

WELL CONSTRUCTION
Well Screen: 2" ID PVC, .0.01" machine slots
Riser Pipe: 2" ID PVC, threaded flush joint

PROTECTIVE CASING
4" ID locking steel pipe

REFERENCE ELEVATION:
575.67 (Top of PVC)

ROCK CORING
Run #1 17.6'-22.6'

Roller bit to 23.6'
Free standing water at 23.0' prior to coring
Chemical odor in sample #3
Free standing water at 8.3' after coring

NOTE:
See key and explanation to log.

RUN NO.	RECOVERY (Percent)	RQD

Surface Elevation 573.3
Date Started 12-17-84
Date Completed 12-18-84
Number of Installations in Boring 1
Method of installation Hollow Stem Auger, NX Core and 3½" Roller Bit

Project No. BD-84-142
Project Title Frontier Chemicals
Location Niagara Falls, NY

Classified By A.K.&O.W. Checked MR-L

HYDROGEOLOGIC LOG

THOMSEN ASSOCIATES

MONITOR NO. MW-10

Sheet 1 of 1

DEPTH	ELEVATION	SAMPLES	SAMPLE NO.	CHEM. SMPL	RECOVERY (Inches)	N	SOIL or ROCK CLASSIFICATION	UNIFIED SOIL CLASSIF.	DENSITY (PCF)	WATER CONTENT (Percent)	PERMEABILITY (cm/sec)
0	571.3										
			1			14	Brown fine-coarse SAND, Some Gravel, little clay, trace silt trace brick fragments (FILL) (Moist-Firm) 4.0'±				
5			2			22	Gray SILT, trace clay, trace gravel (Moist-Stiff) 8.5'±				
10			3			12	Red-Gray CLAY (Moist-Medium) becomes Orange-Red				
15			4			56	becomes compact-contains "and" fine-coarse gravel 17.0'.				
			1A		90.	0.62	Light Gray, stylolytic Dolostone ROCK, Hard, Sound, bedded, minor pitting contains occasional carbon partings Void @ 19.0'-19.3'				
20											
25			1B		99.	4 0.80					
30			2B		62.	0 0.52					
							Boring Terminated @ 33.0'				
35											

MONITOR/PIEZOMETER CONSTRUCTION DETAILS

Water Level 2-1 2-8

WATER PROBE READINGS

Temp. (°C)	Cond. (µmho/cm)	Eh (mV)	pH

NOTES

WELL CONSTRUCTION
Well Screen: 2" ID PVC, 0.01" machine slots
Riser Pipe: 2" ID PVC, threaded flush joint

PROTECTIVE CASING
4" ID locking steel pipe

REFERENCE ELEVATION:
573.7 (Top of PVC)

ROCK CORING
Run #1A 17.0'-22.0'
Run #1B 19.3'-28.0'
Run #2B 28.0'-33.0'

Roller bit from 16.9'-19.0' and 19.3'-33.0'

NOTES
1. Boring drilled to 22.0' on 12-27-84 well installed with bottom of well @ 22.0' Rock cored from 17.0' to 22.5' (Run #1A)
2. Boring redrilled deeper on 1-30-85 and new well installed. Original well dry before drilling. Rock cored from 19.3' to 33.0' (Runs #1B,2B)

NOTE: See key and explanation to log.

RUN NO.	RECOVERY (Percent)	RQD

Surface Elevation 571.3
Date Started 1-29-85
Date Completed 1-30-85
Number of Installations in Boring 1
Method of installation Hollow Stem Auger
NX Core and 3½" Roller Bit

Project No. BD-84-142
Project Title Frontier Chemicals
Location Niagara Falls, NY
Classified By A.K. & O.W. Checked MR-L

HYDROGEOLOGIC LOG

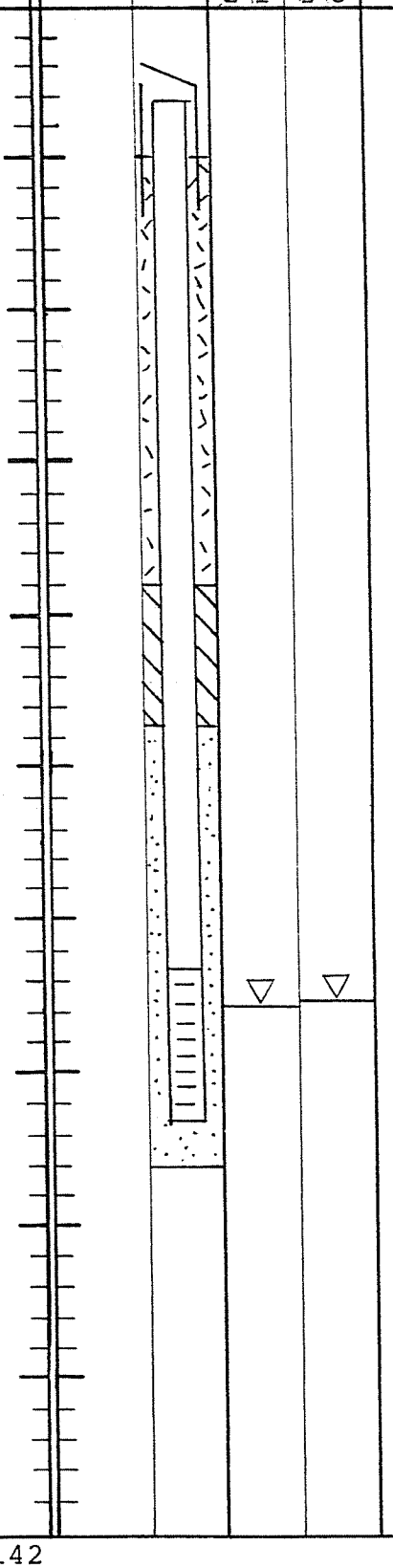
THOMSEN ASSOCIATES

MONITOR NO. MW-11

Sheet 1 of 1

DEPTH	ELEVATION	SAMPLES	SAMPLE NO.	CHEM. SMPL	RECOVERY (Inches)	N	SOIL or ROCK CLASSIFICATION	UNIFIED SOIL CLASSIF.	DENSITY (PCF)	WATER CONTENT (Percent)	PERMEABILITY (cm/sec)
0	571.6						ASPHALT CONCRETE 0.2'				
							CONCRETE 0.8'				
							CRUSHED STONE 2.0'				
5			1			12	Gray SILT, little fine sand, trace clay (FILL) (Moist-Firm) Becomes Greeen-gray 10.0'				
10			2			15	Red-Brown silty CLAY w/Silt lenses and partings (Moist-Medium) 12.5±				
15			3			21	Red-Brown SILT and fine-coarse SAND, Some fine-coarse Gravel, trace clay (Moist-Firm) 18.2'				
			4			--					
			1A		90.0	0.70	Gray Dolostone ROCK , Hard, sound, bedded to thin bedded, with occasional oblique fractures, sand seams at 23.0' to 23.6'; brown staining at 22.6', 22.8', 23.0'				
20			2A		100	0.71					
25			1B		89.8	0.83					
30											
35							Boring Terminated @ 33.0'				

MONITOR/PIEZOMETER CONSTRUCTION DETAILS



WATER PROBE READINGS			
Temp. (°C)	Cond. (µmho/cm)	Eh (mV)	pH

NOTES

WELL CONSTRUCTION
Well Screen: 2" ID PVC, 0.01" machine slots
Riser Pipe: 2" ID PVC, threaded flush-joint

PROTECTIVE CASING
4" ID locking steel pipe

REFERENCE ELEVATION:
573.5 (Top of PVC)

ROCK CORING
Run #1A 18.2'-21.2'
Run #2A 21.2'-24.0'
Run #1B 23.2'-33.0'

Roller bit from 23.2'-33.0'

NOTES
1. Boring drilled to 24.0' on-12-19-84 and well installed with bottom of well @ 23.2'. Rock cored from 18.2'-21.2' (Run #1A) and 21.2' to 24.0' (Run #2A). No free standing water before coring.
2. Boring redrilled deeper on 1-29-85 and new well installed. Water level in original well before redrilling at 21.9'. Rock cored from 23.2' to 33.0' (Run #1B).
3. Lost coring water @26.9'

NOTE:
See key and explanation to log.

RUN NO.	RECOVERY (Percent)	RQD

Surface Elevation 571.6
Date Started 12-19-84
Date Completed 12-19-84
Number of Installations in Boring 1
Method of installation Hollow Stem Auger
NX Core and 3½" Roller Bit

Project No. BD-84-142
Project Title Frontier Chemicals
Location Niagara Falls, NY
Classified By A.K. & O.W. Checked MR-L

HYDROGEOLOGIC LOG

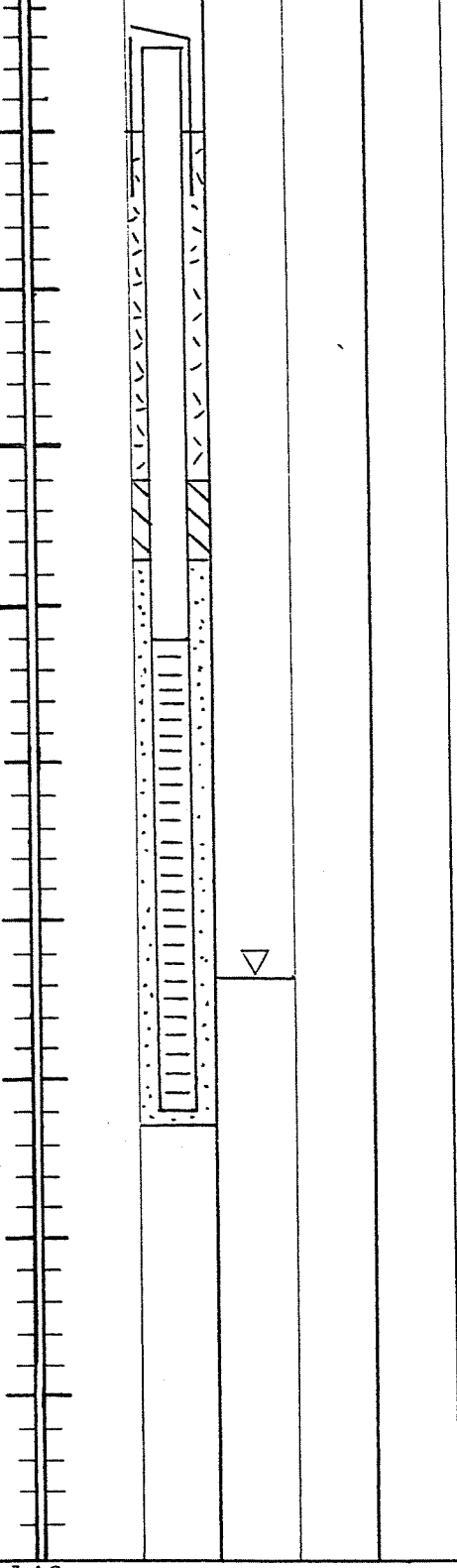
THOMSEN ASSOCIATES

MONITOR NO. MW-12

Sheet 1 of 1

DEPTH	ELEVATION	SAMPLES	SAMPLE NO.	CHEM. SMPL	RECOVERY (Inches)	N	SOIL or ROCK CLASSIFICATION	UNIFIED SOIL CLASSIF.	DENSITY (PCF)	WATER CONTENT (Percent)	PERMEABILITY (cm/sec)
0	571.3										
			1			6	Black fine-coarse SAND, Some Silt, little slag (FILL) (Moist-Loose) 3.5'±				
5			2			7	Brown-Tan SILT w/fine Sand seams trace clay (Moist-Medium) 8.0'±				
10			3			4	Gray Clayey SILT, Some fine Sand (Moist-Soft) 11.5'				
			4			-	Red-Brown Clayey SILT & fine-coarse Sand, Some fine-coarse Gravel (Wet-Loose) 13.6'				
15			1A		98.0	0.83	Gray Dolostone ROCK, Hard, sound thin bedded to bedded w/carbon partings Void @ 16.1'-16.2'				
			1B		97.1	0.86					
			2B		67.6	0.39					
20											
25			3B		95.2	0.91					
30							Boring Terminated @ 31.3'				
35											

MONITOR/PIEZOMETER CONSTRUCTION DETAILS



WATER PROBE READINGS			
Temp. (°C)	Cond. (µmho/cm)	Eh (mV)	pH

NOTES

WELL CONSTRUCTION
Well Screen: 2" ID PVC 0.01" machine slots
Riser Pipe: 2" ID PVC, threaded flush joint

PROTECTIVE CASING
4" ID locking steel pipe

REFERENCE ELEVATION:
574.0 (Top of PVC)

ROCK CORING
Run #1A 13.6'-18.6'
Run #1B 13.6'-17.1'
Run #2B 17.1'-20.8'
Run #3B 20.8'-31.3'

Roller bit from 13.6'-31.3'

NOTES
1. Boring drilled to 18.6' on 12-18-84 and well installed with bottom of well at 18.6'. Rock cored from 13.6'-18.6' (Run #1A). No free standing water prior to coring.
2. Boring redrilled deeper on 2-1-85 and new well installed. Original well dry before drilling. Rock cored from 13.6' to 31.3' (Runs #1B,2B,3B).

NOTE:
See key and explanation to log.

RUN NO.	RECOVERY (Percent)	RQD

Surface Elevation 571.3
Date Started 2-1-85
Date Completed 2-1-85
Number of Installations in Boring 1
Method of installation Hollow Stem Auger
NX Core and 3½" Roller Bit

Project No. BD-84-142
Project Title Frontier Chemicals
Location Niagara Falls, NY
Classified By A.K.&O.W. Checked MR-L

HYDROGEOLOGIC LOG

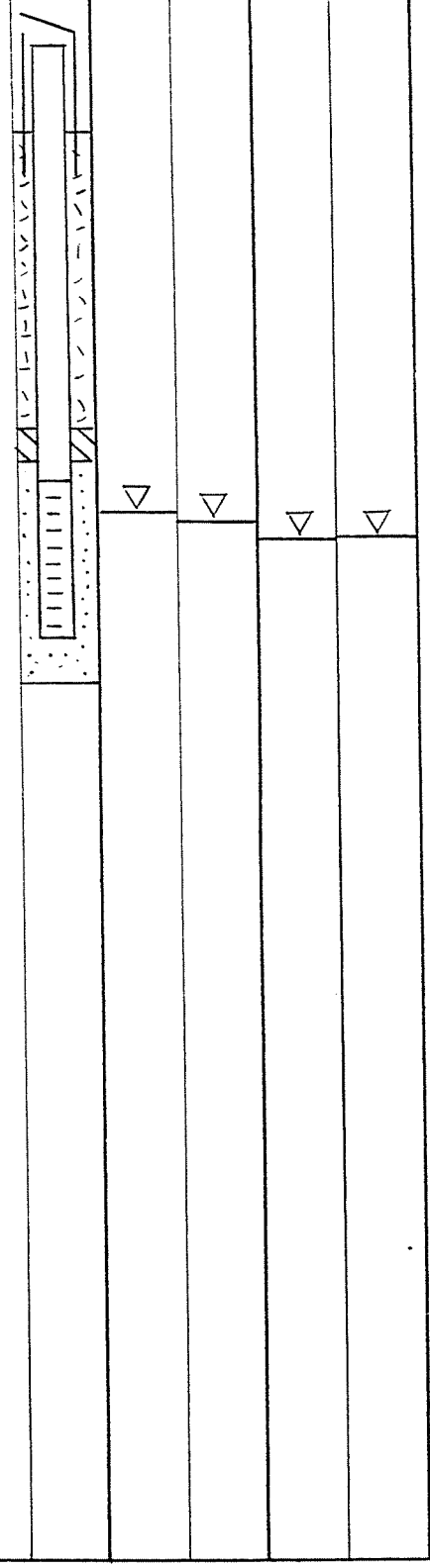
THOMSEN ASSOCIATES

MONITOR NO.
MW-13

Sheet 1 of 1

DEPTH	ELEVATION	SAMPLES	SAMPLE NO.	CHEM. SMPL	RECOVERY (inches)	N	SOIL or ROCK CLASSIFICATION	UNIFIED SOIL CLASSIF.	DENSITY (PCF)	WATER CONTENT (Percent)	PERMEABILITY (cm/sec)
0	570.8	/	1			15	Brown fine-coarse GRAVEL (FILL) (Wet-Firm) 2.5'±				
5		/	2			6	Brown SAND with Gravel and Clay, (Possible Fill) (Wet-Loose) 7.5'±				
10		/	3			-	Red-Brown Clayey SILT and fine-coarse SAND, Some fine-coarse Gravel (Wet-Firm) 11.3'				
15			1		100	0.74	Gray DOLOSTONE, Hard, Weathered, thin bedded-bedded, solution cavaties from 14.3'-15.0', occasional carbon partings				
			2		80	0.44					
20							Boring Terminated @ 17.3'				

MONITOR/PIEZOMETER CONSTRUCTION DETAILS



WATER PROBE READINGS			
Temp. (°C)	Cond. (µmho/cm)	Eh (mV)	pH

NOTES

WELL CONSTRUCTION
Well Screen: 2" ID PVC, 0.01" machine slots
Riser Pipe: 2" ID PVC, threaded flush joint

PROTECTIVE CASING
4" ID locking steel pipe

REFERENCE ELEVATION:
573.39 (Top of PVC)

ROCK CORING
Run #1 11.3'-14.8'
Run #2 14.8'-17.3'

Roller bit from 11.3-17.3'
No free standing water prior to coring.

NOTE: See key and explanation to log.

RUN NO.	RECOVERY (Percent)	RQD

Surface Elevation 570.8
Date Started 12-20-84
Date Completed 12-20-84
Number of Installations in Boring 1
Method of installation Hollow Stem Auger, NX Core and 3½" Roller Bit

Project No. BD-84-142
Project Title Frontier Chemicals
Location Niagara Falls, NY
Classified By A.K. & O.W. Checked MR-L

HYDROGEOLOGIC LOG

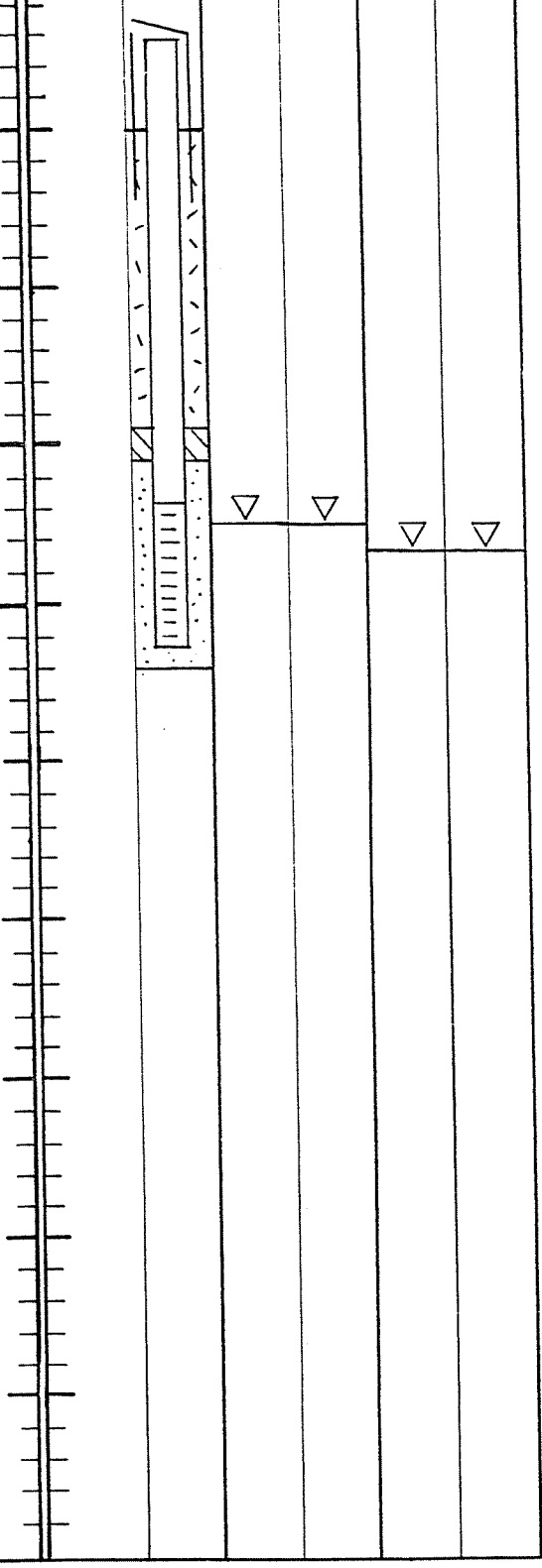
THOMSEN ASSOCIATES

MONITOR NO. MW-14

Sheet 1 of 1

DEPTH	ELEVATION	SAMPLES	SAMPLE NO.	CHEM. SMPL	RECOVERY (Inches)	N	SOIL or ROCK CLASSIFICATION	UNIFIED SOIL CLASSIF.	DENSITY (PCF)	WATER CONTENT (Percent)	PERMEABILITY (cm/sec)
0	569.5										
		/	1			3	SLAG, SILT, TOPSOIL (FILL) 0.6'				
							Tan-Brown SILT, little fine sand, trace clay (Moist-Loose)				
5		/	2			8	becomes Moist-wet, contains fine-medium Sand seams				
							— — — — — — — — 8.5'±				
10		/	3			-	Red-Brown Clayey SILT and fine-coarse SAND (Wet-Compact) 11.0'				
			1		91	1.4 0.57	Gray Dolostone ROCK with occasional carbon partings, hard, weathered, thin bedded to bedded				
15			2		100	0.84	Voids at 15.5' to 15.9'				
							Boring Terminated @ 17.0'				
20											

MONITOR/PIEZOMETER CONSTRUCTION DETAILS



WATER PROBE READINGS			
Temp. (°C)	Cond. (µmho/cm)	Eh (mV)	pH

NOTES

WELL CONSTRUCTION
Well Screen: 2" ID PVC, 0.01" machine slots
Riser Pipe: 2" ID PVC, threaded flush joint

PROTECTIVE CASING
4" ID locking steel pipe

REFERENCE ELEVATION
572.37 (Top of PVC)

ROCK CORING
Run #1 11.0'-14.5'
Run #2 14.5'-17.0'

Roller bit from 11.0-17.0'
No free standing water encountered prior to coring

Chemical odor to full depth during drilling, especially from 6.1 to 6.3 ft.
Soil sampler rinsed with acetone between samples and after drilling

NOTE:
See key and explanation to log.

RUN NO.	RECOVERY (Percent)	RQD

Surface Elevation 569.5
Date Started 12-18-84
Date Completed 12-18-84
Number of Installations in Boring 1
Method of installation Hollow Stem Auger, NX Core and 3½" Roller Bit

Project No. BD-84-142
Project Title Frontier Chemicals
Location Niagara Falls, NY

Classified By A.K.&O.W. Checked MR-L

HYDROGEOLOGIC LOG

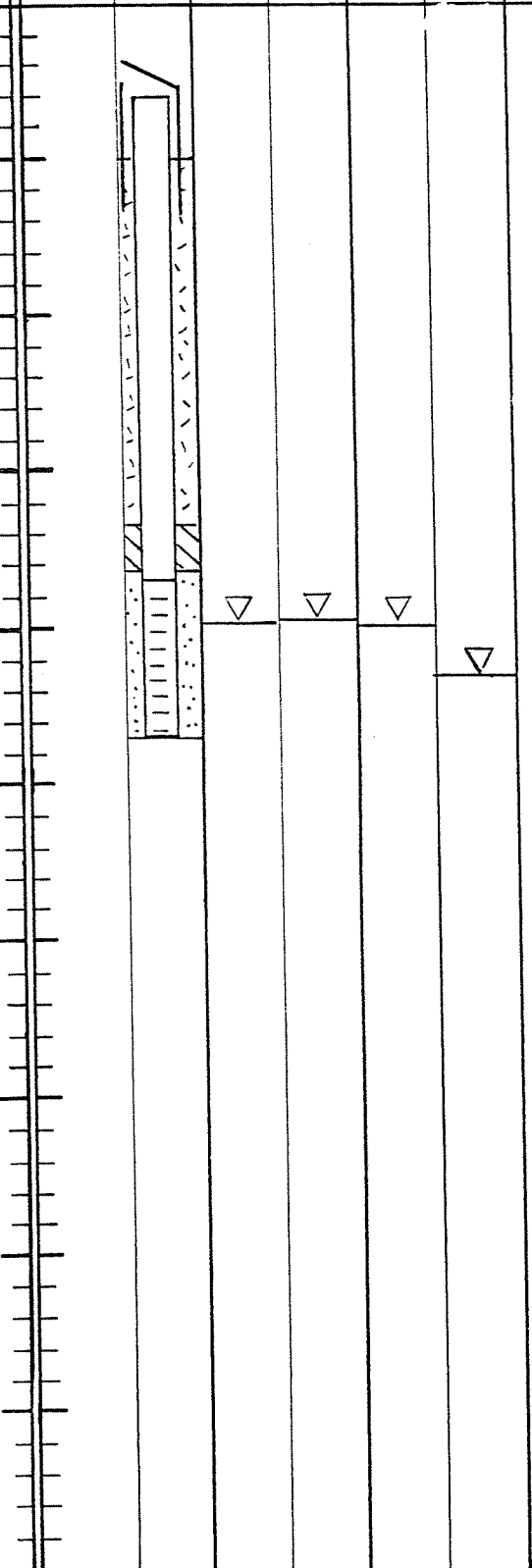
THOMSEN ASSOCIATES

MONITOR NO.
MW-15

Sheet 1 of 1

DEPTH	ELEVATION	SAMPLES	SAMPLE NO.	CHEM. SMPL	RECOVERY (Inches)	N	SOIL or ROCK CLASSIFICATION	UNIFIED SOIL CLASSIF.	DENSITY (PCF)	WATER CONTENT (Percent)	PERMEABILITY (cm/sec)
0	571.4										
			1				Black-Brown fine GRAVEL & SAND, trace silt				
			1			31	(Moist-Compact) 3.0'				
5			2			24	Gray SILT, trace clay				
						24	(Moist-Stiff) 10.0'				
10			3				Gray ROCK FRAGMENTS, trace silt (Moist-Very Compact) 13.1'				
							~~Red-Gray TILL & ROCK FRAGMENTS (Very Compact) 13.8'~~				
15			1		96	0.90	Light Gray DOLOSTONE, hard, sound, bedded				
							Boring Terminated @ 18.5'				
20											

MONITOR/PIEZOMETER CONSTRUCTION DETAILS



WATER PROBE READINGS			
Temp. (°C)	Cond. (µmho/cm)	Eh (mV)	pH

NOTES

WELL CONSTRUCTION
Well Screen: 2" ID PVC, 0.01" machine slots
Riser Pipe: 2" ID PVC, threaded flush joint

PROTECTIVE CASING
4" ID locking steel pipe

REFERENCE ELEVATION:
573.39 (Top of PVC)

ROCK CORING
Run #1 13.2'-18.2'

Roller bit to 18.5'

Free standing water encountered at 15.8' prior to coring

NOTE:
See key and explanation to log.

RUN NO.	RECOVERY (Percent)	RQD

Surface Elevation 571.4
Date Started 12-26-84
Date Completed 12-27-84
Number of Installations in Boring 1
Method of installation Hollow Stem Auger, NX Core and 3½" Roller Bit

Project No. BD-84-142
Project Title Frontier Chemicals
Location Niagara Falls, NY
Classified By A.K.&O.W. Checked MR-L

HYDROGEOLOGIC LOG

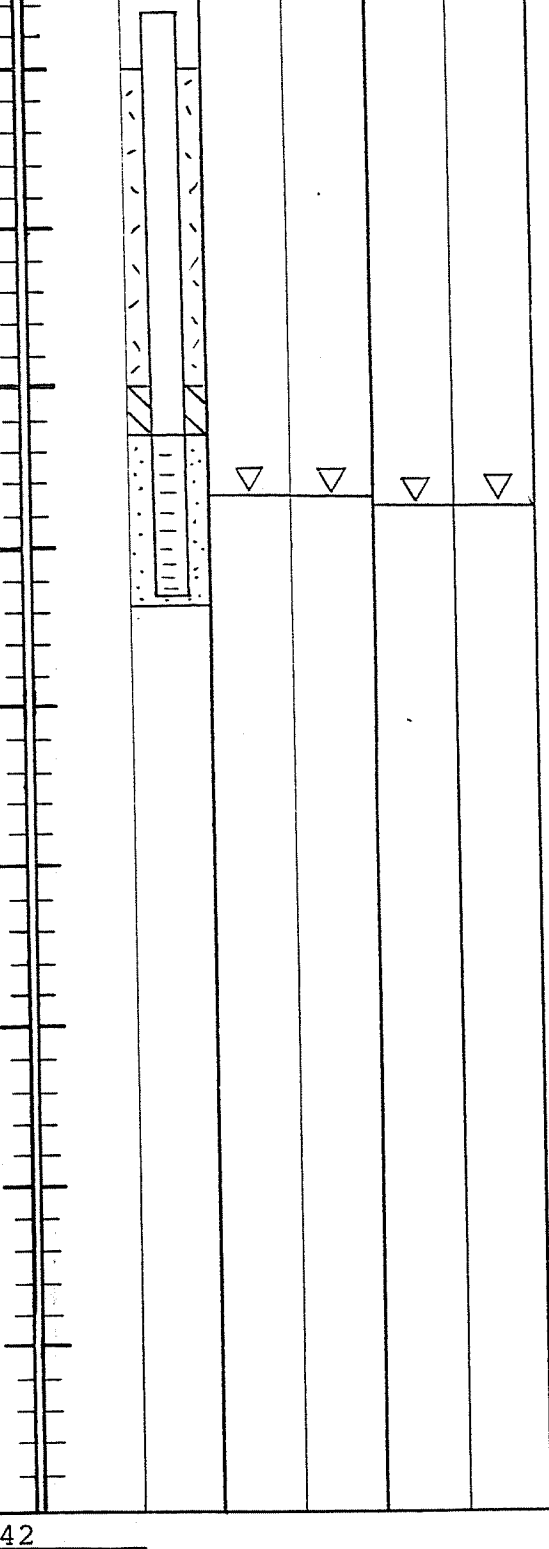
THOMSEN ASSOCIATES

MONITOR NO.
MW-16

Sheet 1 of 1

DEPTH	ELEVATION	SAMPLES	SAMPLE NO.	CHEM. SMPL	RECOVERY (Inches)	N	SOIL or ROCK CLASSIFICATION	UNIFIED SOIL CLASSIF.	DENSITY (PCF)	WATER CONTENT (Percent)	PERMEABILITY (cm/sec)
0	571.2		1			14	TOPSOIL 0.25'				
							White LIME (Wet-Medium) 4.0'				
5			2			20	Gray SILT with Some rust colored Silt (Moist-Stiff)				
							Becomes wet-contains Some Sand, trace fine gravel 10.0'				
10			3			20	Red-Brown CLAY (Moist-Stiff) 11.8'				
			1		100	0.81	DOLOSTONE, hard, sound, bedded, minor pitting, contains occasional carbon partings				
15							Boring Terminated @ 16.8'				
20											

MONITOR/PIEZOMETER CONSTRUCTION DETAILS



WATER PROBE READINGS			
Temp. (°C)	Cond. (µmho/cm)	Eh (mV)	pH

NOTES

WELL CONSTRUCTION
Well Screen: 2" ID PVC, 0.01" machine slots
Riser Pipe: 2" ID PVC, threaded flush joint

PROTECTIVE CASING
4" ID locking steel pipe

REFERENCE ELEVATION:
573.01 (Top of PVC)

ROCK CORING
Run #1 11.8'-16.8'

Roller bit to 16.8'
Free standing water encountered at 10' prior to coring

NOTE:
See key and explanation to log.

RUN NO. | RECOVERY (Percent) | RQD

Surface Elevation 571.2
Date Started 12-28-84
Date Completed 1-2-85
Number of Installations in Boring 1
Method of installation Hollow Stem Auger, NX Core and 3½" Roller Bit

Project No. BD-84-142
Project Title Frontier Chemicals
Location Niagara Falls, NY

Classified By A.K. & O.W. Checked MR-L

HYDROGEOLOGIC LOG

THOMSEN ASSOCIATES

MONITOR NO. MW-17

Sheet 1 of 1