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TERRAIN ANALYSIS AND HYDROGEOLOGICAL STUDY
PROPOSED RESIDENTIAL DEVELOPMENT
PART OF LOTS 3 AND 4, CONCESSION 4, TOWNSHIP OF OSGOODE
CITY OF OTTAWA, ONTARIO

Prepared for

Sunset Lakes Development Corporation

Report No. G8105-04

May 23, 2002

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

1.1 Terms of Reference

As requested by Mr. Matthew Nesrallah, of Sunset Lakes Development Corporation, this firm was commissioned to conduct a Terrain Analysis and Hydrogeological Study for those lands identified as Part of Lots 3 and 4, Concession 4, in the Township of Osgoode, City of Ottawa, Ontario.

1.2 Background

This firm has been integrally involved with the residential development in this area over the past two years. In particular, a previous hydrogeological study was conducted on three parcels of land surrounding this site, which were reported under our Report No. G7643-01.

In addition to our studies, similar studies have been conducted on the adjacent subdivision lands, as described in reporting by Jacques, Whitford Environment Limited (JWEL), Project No. 30086, and by Water and Earth Science Associates (WESA), as described in a report, dated June 4, 1987. These reports have been reviewed as part of this study.

The purpose of this study has been to specifically determine the hydrogeological conditions under the site of 59 residential lots as shown on Drawing No. G8105-03, as they relate to water supply and private sewage disposal. Specifically, the intent of this report is to determine whether or not a potable water supply exists under the site, and to determine if the proposed residential development will have an acceptable and minimum impact on groundwater resources of the site and the neighbouring properties.

2.0 METHOD OF STUDY

2.1 Terrain Analysis

A preliminary field investigation was conducted by Morey Houle Chevrier Limited, and the factual data was provided to us to incorporate into our study. In addition, an additional twelve (12) test holes were put down by this firm to supplement and verify the previous investigation. The field investigation was initiated on March 13, 2001. The additional test holes were put down using hand auger methods, to provide for a thorough delineation of the stratigraphic profile across the property. The soil profiles in each test pit were recorded by a technologist from this firm.

Test pit locations were selected by John D. Paterson and Associates personnel. The soil profiles observed in the test pits, including the depth to the groundwater table, were recorded in detail in the field. The subsurface conditions observed at the test pit locations are shown on their respective Test Hole Location Plans, in Appendix 4,

pit locations are shown on their respective Test Hole
and on the Soil Profile and Test Data sheets, in Appendix 1 of this report.

Representative samples of the soils were recovered from the test pits. All samples were classified texturally in the field and sealed in proper containers for further perusal in our laboratory. The depths at which the auger samples were recovered from the test holes are shown as "G" on the Soil Profile and Test Data sheets.

2.2 Test Wells

Two (2) test wells (TW 1 and TW 2) were drilled by Air Rock Drilling of Jasper, Ontario, and the drilling and grouting operations were supervised by this firm. An existing well was also used as part of this study (NTW 1),with that well being drilled in 1994, as part of a previous geotechnical study. In situ pump testing was carried out on each test well, and water samples from the wells were also preserved for chemical analyses.

- Test well TW 1 was completed on February 7, 2001. A six-hour pump test, with recovery measurements was conducted on TW 1 on February 14, 2001.

- Test well TW 2 was completed on February 8, 2001. A six-hour pump test, with recovery measurements was conducted on TW 2 on February 15, 2001.

- Test well NTW 1 was completed in 1994. A six-hour pump test, with recovery measurements was conducted on TW 3 on February 16, 2001.

measurements was conducted on

In addition to the field testing component of this study, published MOE Water Well Records were reviewed to assess the general aquifer characteristics of the area. The specific details and results of the testing program are discussed in more detail later in this report.

2.3 Laboratory Testing

Three samples of the representative in situ soils were selected for grain size analyses in our laboratory. The results of the testing are provided on the Grain Size Distribution sheets in Appendix 3.

Based on the results of this testing (sample grading), the soils are estimated to have the following percolation rates:

- Sand from AH 3 and AH 12: T = 6 to 8 min/cm.
- Sandy silt from AH 1: T = 20 to 40 min/cm.

Two (2) water samples were recovered from each of the three (3) test wells during the pump testing program at 3 hours of pumping and 6 hours of pumping, respectively, and were preserved for chemical analyses. The analyses were conducted by Accutest Laboratories, of Nepean, Ontario. The groundwater test results are presented in Appendix 3, and are discussed under Section 4.3.

All soil samples will be stored in our laboratory for a period of three months after issuance of this report. They will then be discarded unless we are directed otherwise.

3.0 GEOLOGY

The following sections describe the regional and site-specific geology of the study area(s).

3.1 Bedrock Geology

3.1 Bedrock Geology

Published mapping shows the study area is underlain by dolomite and limestone of the Oxford Formation, of Ordovician Period. Dolomite and sandstone of the March Formation, followed by sandstone of the Nepean Formation, underlie the Oxford Formation within the bounds of the study area.

The primary sources of water supply are expected to consist of the upper fractured zone of the dolomite/limestone of the Oxford Formations and the deeper March sandstone.

3.2 Surficial Geology

The surficial geology of each of the parcels was mapped by putting down a series of test pits. The test hole locations and profiles are presented graphically on Drawing No. G8105-3, and the details of the soil profile at each test pit location are provided on the Soil Profile and Test Data sheets in Appendix 1.

In general, the surficial soil conditions consist primarily of intermittent strata of sand, sandy silt and sand-gravel materials, as is typical of the regional subsurface conditions in the area. Based on the findings of others, a silty clay layer is known to underlay portions of the site at depth. Reference should be made to the Soil Profile and Test Data sheets in Appendix 1 for the details of the Soil Profile at each test hole location.

At the time of the fieldwork, the groundwater levels were measured and are recorded as shown on the Soil Profile and Test Data sheets. It is expected that the seasonal high groundwater levels could be somewhat higher. Stormwater management practices will tend have a stabilizing effect on the long-term groundwater levels.

4.0 PHYSICAL HYDROGEOLOGY

The following sections describe the results of the regional and local hydrogeological analysis conducted in this study.

analysis conducted in this study.

4.1 Regional Hydrogeology

The available MOE Water Well records were reviewed within the vicinity of the sites. The primary sources of water supply consist of the upper fractured zone of the dolomite/limestone of the Oxford Formations and the deeper March sandstone. Well yields are generally considered to be quite high in the area, and no indication of any quantitative or qualitative problems were noted in our review. There have been some problems with turbidity (based on laboratory test values) in the area, but these are generally addressed by the proper development of the well. It should also be noted that in situ turbidity measurements at the well head produce more accurate data, and are generally lower than laboratory values, due to the formation of precipitates that can occur after sampling.

4.2 Test Wells

Two test wells were drilled, on the subject site, by Air Rock Well Drilling of Jasper, Ontario. The wells were drilled using a rotary drill. In addition, an existing, previously drilled well was pump tested for purposes of this study. A copy of the drillers Well Record for each of the test wells has been provided in Appendix 2.

The details of the well construction for each of the test wells (from the Well Records) are summarized in Table 1, below. In each of the wells drilled as part of this study, steel casing was installed and grouted to depths of 13.4 m and 16.2 m. Township of Osgoode Well Construction Requirements require a minimum casing length of 12.2 metres where the overburden thickness is less than 3 metres, and a minimum casing length of 6.1 metres or 1.5 metres into bedrock, whichever is greater, where the overburden thickness is at least 3 metres.

Each test well was pumped at constant rates, varying from 5 to 17 IGPM for a period of 6 hours. No appreciable drawdown was observed in TW 2 or NTW1, during pumping, and a maximum drawdown of 5.2 metres occurred in TW 1 after 6 hours. In situ turbidity testing was conducted at the well head using a field turbidimeter. When the pump was stopped, the water level returned to the near static level almost immediately in each of the test wells.

TABLE 1

SUMMARY OF WELL CHARACTERISTICS

ITEM	TW 1	TW 2	NTW 1
Depth of Overburden (m)	10.7	13.41	2.4
Depth of Well (m)	73.2	24.4	55.8
Depth of Casing (m)	13.4	16.2	6.7
Depth to Aquifers (m)	27.1 72.2	21.0 22.3	24.1
Static Water Level (m)	4.84	2.83	7.65
Estimated Yield (IPGM)	5	45	50

4.3 Aquifer Analysis

The following sections discuss the results of the physical and bacteriological and chemical analysis completed on the aquifer.

Physical Analysis

A six hour constant discharge aquifer test was completed on each of the test wells. During pumping, drawdown measurements were recorded, and our observations in this regard are summarized in Appendix 2. Subsequent to the completion of pumping, the recovery was recorded and determined to be essentially immediate.

The drawdown data obtained during each of the pump tests was analysed using the Cooper and Jacob Drawdown method (using Aquifer Test software). The results of those analyses are provided in Appendix 2 and in Table 2 below. The results yielded transmissivities in the range of 3.17×10^{-3} m^2/min to 1.11×10^{-1} m^2/min, which demonstrate that the aquifer produces an abundant water supply, more than capable of servicing single family homes. Water samples were taken at the halfway point and the completion of the pump test, and were subsequently submitted to Accutest Laboratories for chemical testing.

TABLE 2
AQUIFER TEST RESULTS

ITEM	TW 1	TW 2	NTW 1
Pumping Rate (IGPM)	10.7	13.41	2.4
Depth of Well (m)	73.2	24.4	55.8
Static Water Level (m)	4.8	2.8	7.6
Available Drawdown (m)	68.4	21.6	48.2
Maximum Drawdown (m)	5.55	0.44	0.55
% Available Drawdown	8.1	2.0	1.1
Storativity	1.02×10^{-3}	1.78×10^{-1}	2.02×10^{-1}
Transmissivity (m^2/min)	3.17×10^{-3}	1.11×10^{-1}	3.83×10^{-2}

Groundwater Geochemistry

Water samples were taken at the three hour and six hour mark of each of the aquifer tests (pump tests). The samples were submitted to Accutest Laboratories Limited for bacteriological and chemical analyses. The laboratory reports are found in Appendix 3, and are summarized below. The analytical results are summarized in Tables 3 and 4, below, and compared to the MOE limits and targets.

The water quality in the test wells is generally satisfactory, and all health-related parameters are met. In the samples from TW 1 and NTW 1,high **sodium** levels were delineated. However, these elevated levels are below the ODW objective of 200 mg/L and only require that the Medical Officer of Health be notified, since the concentration of sodium is above 20 mg/L.

The groundwater in this area is considered to be **hard.** The **TDS** for the samples taken from NTW 1 are above the ODWO (MOE Ontario Drinking Water Objective) of 500 mg/L, which is also where the water is hardest. These are aesthetic parameters

500 mg/L, which is also where the water is hardest. These are aesthetic and not health-related. The ODWO (MOE Ontario Drinking Water Objective) of 0.3 mg/L for **iron** was exceeded in the first samples from TW 1 and TW 2, but the wells cleared up by the end of the pump tests and the second samples were below the ODWO. A commercial water softener will likely remove the hardness as well as some iron from the water.

Elevated **turbidity** levels were encountered in the laboratory samples from the test wells. As a matter of routine, the turbidity was measured for each sample in the field using a portable field turbidimeter. All of the field turbidity results were within acceptable limits by the end of the pump tests.

TABLE 3
SUMMARY OF HEALTH RELATED PARAMETERS

PARAMETER	TW 1 3 hrs.	TW 1 6 hrs.	TW 2 3 hrs.	TW 2 6 hrs.	NTW 3 3 hrs.	NTW 3 6 hrs.	MOEE Water Quality Objective
Sodium	21	27	7	7	121	129	**20 (200)**
Fluoride	0.42	0.49	0.13	0.11	0.32	0.29	**2.4**
Ammonia	0.19	0.19	0.04	0.05	0.34	0.26	**-**
Nitrite	ND	ND	ND	ND	ND	ND	**1**
Nitrate	ND	ND	ND	ND	ND	ND	**10**
Turbidity (NTU) Laboratory	90.0	2.8	2.8	1.5	0.4	0.3	**1**

Field	70.8	0.51	.080	0.28	0.62	0.20	
Total Coliform	0	0	0	0	3	2	5
Faecal Coliform	0	0	0	0	0	0	<2
Faecal Streptococcus	1	0	0	0	0	0	0

Note: ***All parameters are in mg/L unless otherwise indicated.***
Bacteria counts are in counts per 100 mL.
ND means below method detection limit.
At sodium concentrations in excess of 20 mg/L, notification of the Medical Officer of Health should be notified as it pertains to people on sodium-reduced diets.

TABLE 4
SUMMARY OF AESTHETIC RELATED PARAMETERS

PARAMETER	TW 1 Parc. 3 3 hrs.	TW 1 Parc. 3 6 hrs.	TW 2 Parc. 2 3 hrs.	TW 2 Parc. 2 6 hrs.	TW 3 Parc. 1 3 hrs.	TW 3 Parc. 1 6 hrs.	MOEE Water Quality Objective
Conductivity (µmhos/cm)	373	395	433	428	1240	1340	
Colour (TCU)	4	<2	<2	2	3	3	**5**
Hardness	153	144	211	217	371	390	**80 - 100**
Alkalinity	180	185	186	186	311	336	**500**
Total Dissolved Solids	212	216	252	268	728	796	**500**
pH	7.61	7.59	7.69	7.85	7.68	7.83	**6.5 to 8.5**

Chloride	9	12	13	12	206	135	**250**
Sulphate	21	19	9	36	97	101	**500**
Calcium	30	28	53	54	76	82	
Magnesium	19	18	19	20	44	45	
Potassium	6	6	2	2	7	7	
TKN	0.24	0.20	0.09	0.09	0.43	0.47	
Total Organic Carbon	1.1	0.5	0.4	0.6	1.3	1.8	**5**
Iron	1.04	0.11	0.32	0.25	0.01	0.03	**0.3**
Manganese	0.03	0.02	0.01	0.01	0.03	0.04	**0.05**
Hydrogen Sulphide	0.10	ND	ND	ND	0.05	0.03	**0.08**
Phenols	ND	ND	ND	ND	ND	ND	**0.002**
Tannin & Lignin	0.5	0.1	0.1	0.1	ND	ND	**-**

Note: All parameters are in mg/L unless otherwise indicated

5.0 DEVELOPMENT RECOMMENDATIONS

The following sections outline the recommendations for development which have been formulated from the data collected in this investigation.

5.1 Site Development

Based on the results of our investigation, this site is considered to be suitable for the development of the 59 lots as described in the introduction of this report. The on-site sewage disposal can be handled with in-ground or partially-raised Class 4 septic systems, as per Part 8 of the Ontario Building Code, and an adequate water supply can be obtained with private wells.

5.2 Lot Development Plans

One objective of the hydrogeological study is to enhance development and minimize

One objective of the hydrogeological study is to enhance development and the effects of sewage systems on the surrounding environment. This is achieved through prevention of accumulation of surface water, by ensuring proper construction of water supply and sewage systems, and by coordinating the overall positioning of the services to maximize separations. A minimum separation of 15 m (18 m for fully-raised systems) is required between a well and sewage system, whether they are servicing a single lot, or are on neighbouring lots.

Drawing No. G8105-04 shows the proposed lot development plan for the site. The purpose of this drawing is to show that a typical home and services will fit onto the proposed lot, and can meet all pertinent regulations without causing environmental constraints. The house shown in this drawing covers a plan area of 120 m^2 , assuming a two-storey 240 m^2 (2600 ft^2) home, with a garage of 50 m^2, and is serviced by a sewage system with the capacity of 3000 L/day. In actuality, the daily sewage flows will likely be significantly lower than this figure.

It is not the intent of the drawing to restrict placement of the home on each lot. While the position of the home may change, the relative position of the home, sewage system and well should be maintained. In all cases, the separation criteria for the immediate and neighbouring lots should be followed.

The required separation distance from a leaching bed to surface water is 15 metres. In the case of the ponds, houses will be located closer to the pond than the sewage systems, so separation distances will not be an issue.

5.3. Nitrate Impact Assessment

The tile beds which will serve the proposed subdivisions have the potential of increasing the nitrate levels in the underlying aquifers (which are now at "non-detected" levels). The potential for contamination of the aquifer can be reduced by ensuring that the tile beds are correctly sized and positioned on the proposed lots.

In our analysis, consideration has been given to the planned use of the western

In our analysis, consideration has been given portion of the site as an amenities area, which includes a network of trails and lakes. Although the typical lot size is of the order of 0.4 hectares, the overall land-use density is actually of the order of 0.82 hectares per lot, with the incorporation of the amenities area in the overall site development.

Typically, runoff coefficients of the order of 0.2 exist for developments of this nature; however, it is our understanding that al of the runoff will be directed towards the lakes that exist on the property. Also, with the green-space areas that exist on this site, the overall runoff would actually be reduced significantly, to approximately 0.15.

It is our understanding that as part of the proposed development, the runoff from precipitation will remain on site, with stormwater management being provided by the series of lakes. This would mean that all of the runoff would be available for infiltration. In our analysis, we have taken a conservative approach in assuming that only 50% of the runoff reaches the lakes. As such, the combined runoff and evoraporation / evapotranspiration should not exceed 550 mm per year, leaving a surplus water for infiltration of approximately 360 mm per year. This would equate to an infiltration coefficient of 0.4 for this site (compared to a figure of 0.5, which would be applicable if full reliance on site contained runoff is made).

A Mass Balance Model has been used to determine the cumulative nitrate impact using recharge from infiltration only. With the permeable soils and the presence of the series of lakes, groundwater flushing will occur, which will lead to further dilution of the nitrates, however, this is not accounted for in our analysis.

Based on the results of our analysis, the proposed development will result in a long term nitrate concentration of 3.4 mg/l, which is below the Ontario Drinking Water Objectives.

5.4 Sewage System Design

Sewage systems must be designed according to Part 8 of the Ontario Building Code. The regulations state that 0.9 m of suitable soil above an unacceptable layer (bedrock) and 0.9 m of suitable soil above the high water table are required below absorption trenches.

A large 4 bedroom luxury residence may produce up to 3000 L/day of sewage effluent, although generally, design sewage flows will be less than 2500 L/day. In-ground or raised leaching beds can be used in this subdivision. Raised beds will require a 15 metre long and 0.3 metre thick imported fill mantle, however the in situ soils will suffice as a mantle for partially raised beds.

An imported soil with a percolation time (T) of between 6 and 8 min/cm will be required for raised tile bed and mantle construction. A tile length of 120 metres (i.e. - 8 runs of 15 metres) is required for the design sewage flow of 3000 L/day. The Lot Development Plans illustrate the size of such tile beds. The sewage system should be placed down slope from any nearby wells, where possible.

5.5 Well Design

Drilled wells, completed in the bedrock aquifer, should be used for the water supply in this development. The wells should be drilled by a licensed well driller experienced in the study area. A minimum well yield of 3 IGPM is recommended for an average residence.

A rotary drill has been proven to provide satisfactory water supply results in the test wells. Drilling should continue down into the bedrock so that the casing is seated firmly into the bedrock. The space between the casing and hole should be cement grouted using a method recommended by the MOE (Appendix 4). Township of Osgoode Well Construction Requirements require a minimum casing length of 12.2 metres where the overburden thickness is less than 3 metres, and a minimum casing length of 6.1 metres or 1.5 metres into bedrock, whichever is greater, where the overburden thickness is at least 3 metres.

After allowing the cement to set (24 hours for quick-set cement, 72 hours for regular cement), drilling should continue at a 150 mm diameter until the necessary water yield is intercepted. The well should be developed by surging or pumping until the water is clear.

The well should be completed with a submersible pump, pitless adaptor and well cap. The casing should project for approximately 0.30 m above the final lot grade. The grading around the well casing should be slightly elevated to direct surface runoff away from the well.

6.0 CONCLUSIONS

A terrain analysis and hydrogeological investigation were completed on a property identified as Part of Lots 3 and 4, Concession 4, in the Township of Osgoode, Village of Greely, Ontario. The current proposed development calls for 59 residential lots with a typical lot size of 0.4 hectares, and an average land use per lot of 0.82 hectares per lot, when green-space and lake areas are considered.

The terrain consists of one or the other of silty sands or of more permeable sand and sand-gravel within this phase of the subdivision. Sewage systems with either partially raised or in-ground leaching beds are suitable for this development.

The water supply was confirmed with the drilling of two test wells and the testing of a third existing well. The yields obtained have more than the required capacities to provide a water supply for a typical residences. Hardness was elevated in all of the test wells. These aesthetic problems can be reduced noticeably if the water supply is treated with a water softener.

In summary, this site is suitable for development as a residential subdivision at the proposed density. The hydrogeological recommendations of this report, if followed, will ensure that the development takes place in an effective manner, with a minimal impact on the environment.

JOHN D. PATERSON AND ASSOCIATES LIMITED

JOHN D. PATERSON AND ASSOCIATES LIM

Stephen J Walker

Stephen J. Walker, P.Eng.

Report Distribution:

- Sunset Lakes Development Corp. - Mr. Matthew Nesrallah (8 copies)
- John D. Paterson and Associates Limited (1 copy)

APPENDIX 1

Soil Profile and Test Data Sheets

JOHN D. PATERSON & ASSOCIATES LTD.
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SOIL PROFILE & TEST DATA

Hydrogeological Study and Terrain Analysis
Sunset Lakes Subdivision, Old Prescott Road
Ottawa (Greely), Ontario

DATUM

REMARKS

BORINGS BY Hand Auger

DATE 13 MAR 01

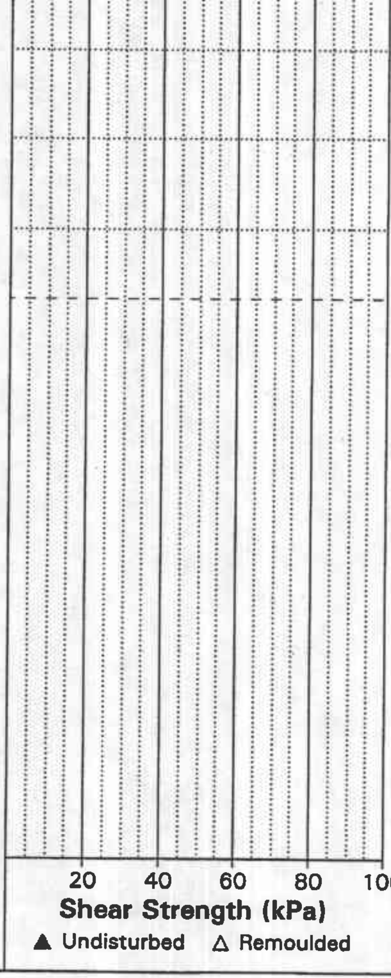
FILE NO. G8105

HOLE NO. AH 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
GROUND SURFACE						0			
Dark brown sandy **TOPSOIL**		G	1						
0.30									
Yellowish brown **SILTY SAND**, trace gravel		G	2						
0.71									
Brown **SAND**, some gravel						1			

		G	3
Brownish grey **SILTY FINE SAND**	1.50	G	4
End of Auger Hole	1.75		

(Open hole WL @ 1.5m depth)



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SOIL PROFILE & TEST DATA

Hydrogeological Study and Terrain Analysis
Sunset Lakes Subdivision, Old Prescott Road
Ottawa (Greely), Ontario

DATUM

REMARKS

BORINGS BY Hand Auger

DATE 13 MAR 01

FILE NO. G8105

HOLE NO. AH 2

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD				
GROUND SURFACE						0			
Black sandy TOPSOIL 0.10	■	G	5						
Yellowish brown SAND, some silt 0.36		G	6						
Light brown SAND 0.99		G	7						
						1			∇

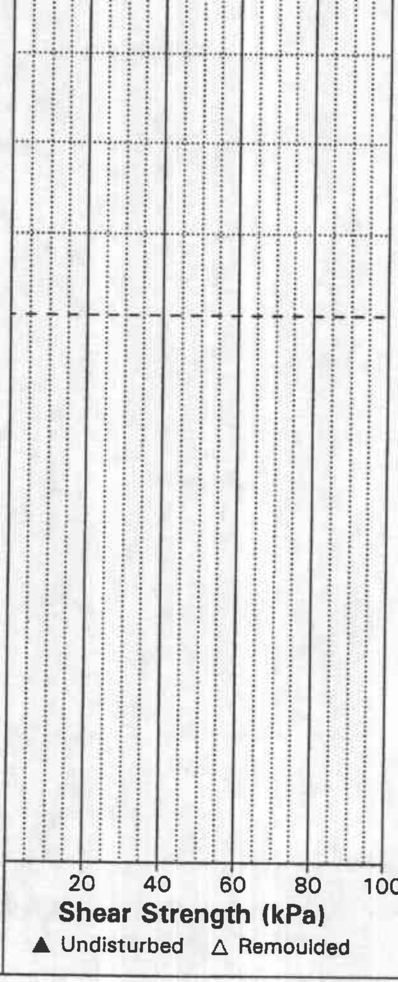
Brown SAND

G 8

1.78

End of Auger Hole

(Open hole WL @ 1.0m depth)



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SOIL PROFILE & TEST DATA

Hydrogeological Study and Terrain Analysis
Sunset Lakes Subdivision, Old Prescott Road
Ottawa (Greely), Ontario

DATUM

REMARKS

BORINGS BY Hand Auger

DATE 13 MAR 01

FILE NO. G8105

HOLE NO. AH 3

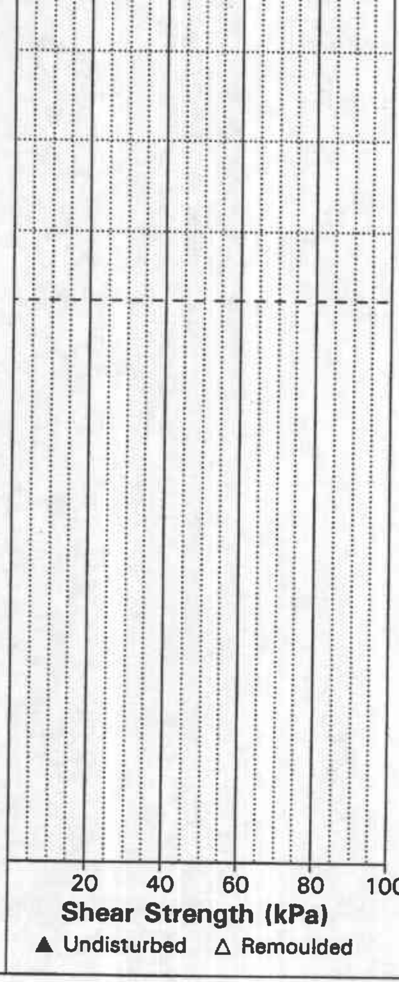
SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
GROUND SURFACE						0			
Dark brown sandy **TOPSOIL**									
0.28									
Brown **SAND**		G	9						
0.76									
Light brown **SAND**									
1.04						1			∇

Brown SAND

1.75

End of Auger Hole

(Open hole WL 1.0m depth)



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SOIL PROFILE & TEST DATA

Hydrogeological Study and Terrain Analysis
Sunset Lakes Subdivision, Old Prescott Road
Ottawa (Greely), Ontario

DATUM

REMARKS

BORINGS BY Hand Auger

DATE 14 MAR 01

FILE NO. G8105

HOLE NO. AH 4

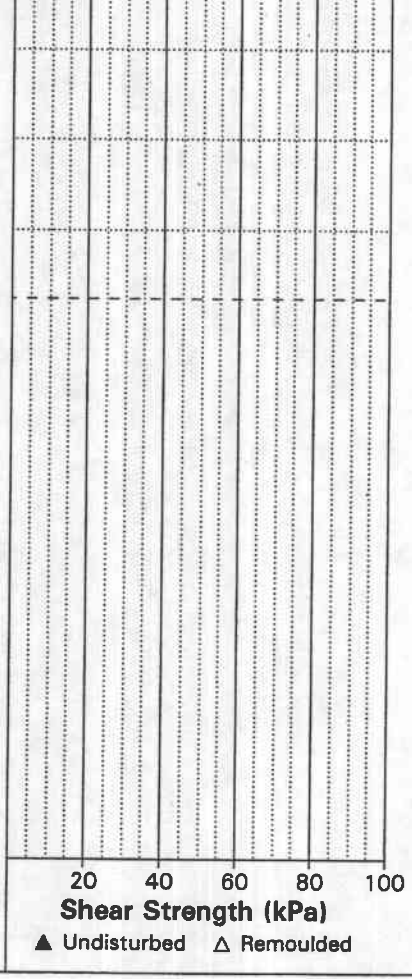
SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
GROUND SURFACE						0			
Dark brown sandy TOPSOIL, some gravel 0.28									
Light brown SAND, some gravel 0.68		G	10						
						1			

Brown SAND, some gravel

G 11

1.75

End of Auger Hole



Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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Sunset Lakes Subdivision, Old Prescott Road
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DATUM

REMARKS

BORINGS BY Hand Auger

DATE 14 MAR 01

FILE NO. G8105

HOLE NO. AH 5

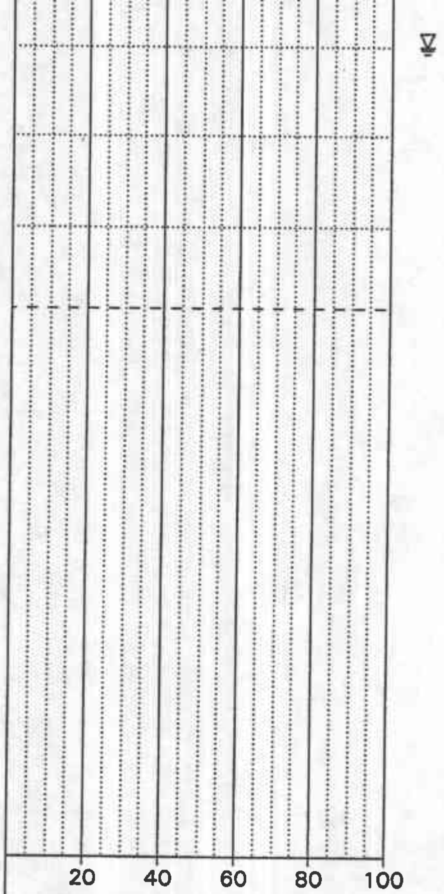
SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
GROUND SURFACE						0			
Black sandy TOPSOIL 0.28		G	12						
Yellowish brown SILTY SAND, some gravel 0.48		G	13						
Light brown SAND, some gravel 0.79									
						1			

Brown SAND, some gravel

1.78

End of Auger Hole

(Open hole WL @ 1.2m depth)



Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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SOIL PROFILE & TEST DATA

Hydrogeological Study and Terrain Analysis
Sunset Lakes Subdivision, Old Prescott Road
Ottawa (Greely), Ontario

DATUM

REMARKS

BORINGS BY Hand Auger

DATE 14 MAR 01

FILE NO. G8105

HOLE NO. AH 6

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
GROUND SURFACE						0			
Black sandy TOPSOIL									
0.38									
Brown SAND, some silt		G	15						
0.63									
Light brown SAND		G	16						
0.89									
						1			
Grey SILTY FINE SAND									

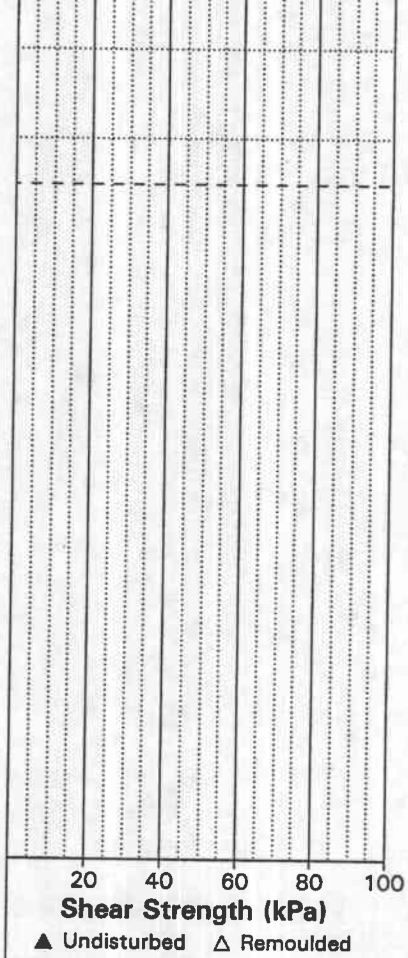
Grey SILTY FINE SAND G 17

1.37

Brown SAND

1.50

End of Auger Hole



Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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BORINGS BY Hand Auger

DATE 14 MAR 01

FILE NO. G8105

HOLE NO. AH 7

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD				
GROUND SURFACE						0			
Black sandy TOPSOIL 0.28	■								
Light brown SAND 1.07	⠿					1			
Grey fine SANDY SILT 1.14									

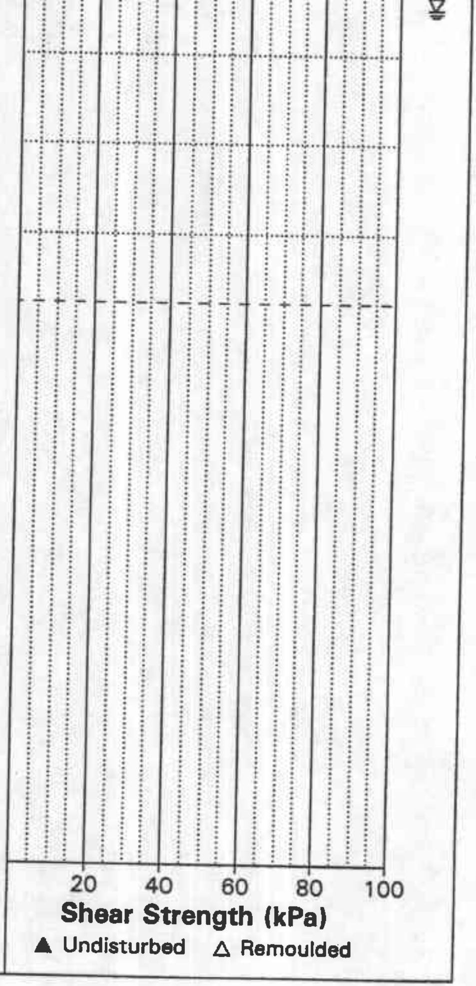
1.14

Brown SAND

1.75

End of Auger Hole

(Open hole WL @ 1.1m depth)



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DATUM

REMARKS

BORINGS BY Hand Auger

DATE 14 MAR 01

FILE NO. G8105

HOLE NO. AH 8

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
GROUND SURFACE						0			
Black sandy TOPSOIL 0.20									
Light brown SAND 0.74									
						1			

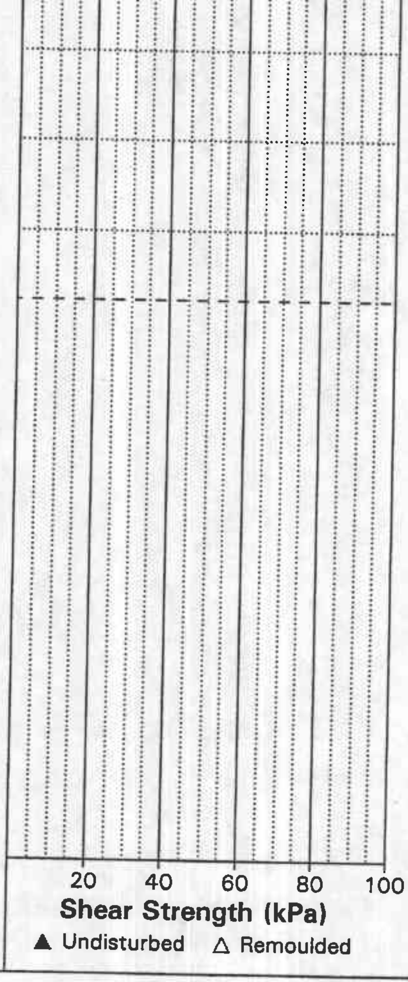
Brown SAND

G 14

1.75

End of Auger Hole

(Open hole WL @ 1.4m depth)



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REMARKS

BORINGS BY Hand Auger

DATE 15 MAR 01

FILE NO. G8105

HOLE NO. AH 9

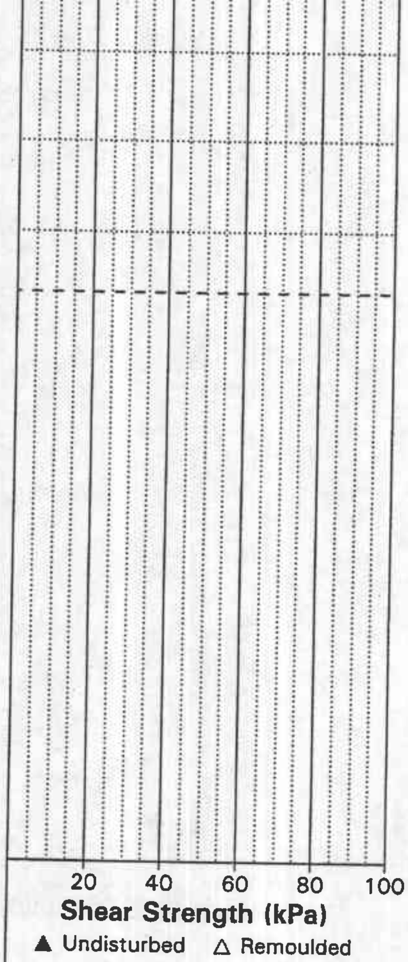
SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
GROUND SURFACE						0			
Dark brown sandy **TOPSOIL** 0.36									
Yellowish brown SAND, some silt 0.45									
Light brown SAND 0.76									
Brown SAND						1			

1.50

Brown SAND, some gravel

1.73

End of Auger Hole



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DATUM

REMARKS

BORINGS BY Hand Auger

DATE 15 MAR 01

FILE NO. G8105

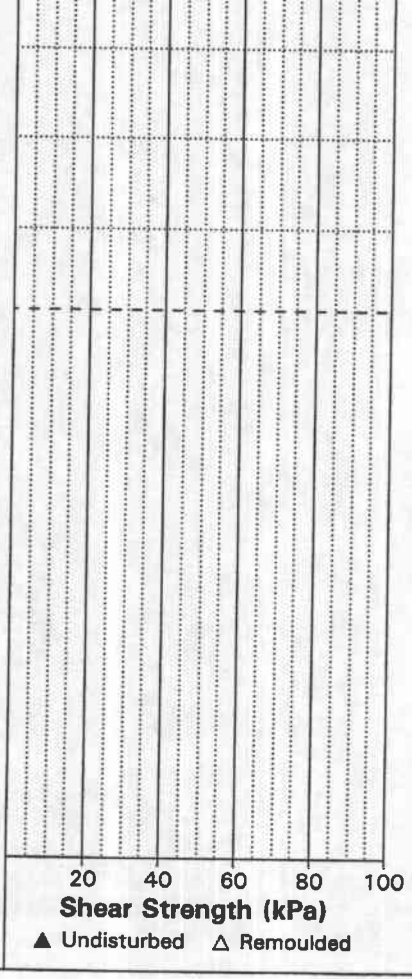
HOLE NO. AH10

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	PIEZOMETER CONSTRUCTION
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD			20 40 60 80	
GROUND SURFACE						0			
Black sandy TOPSOIL 0.25									
Light brown SAND, some silt 0.76									
						1			

Brown SAND

1.78

End of Auger Hole



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SOIL PROFILE & TEST DATA

Hydrogeological Study and Terrain Analysis
Sunset Lakes Subdivision, Old Prescott Road
Ottawa (Greely), Ontario

DATUM

REMARKS

BORINGS BY Hand Auger

DATE 15 MAR 01

FILE NO. G8105

HOLE NO. AH11

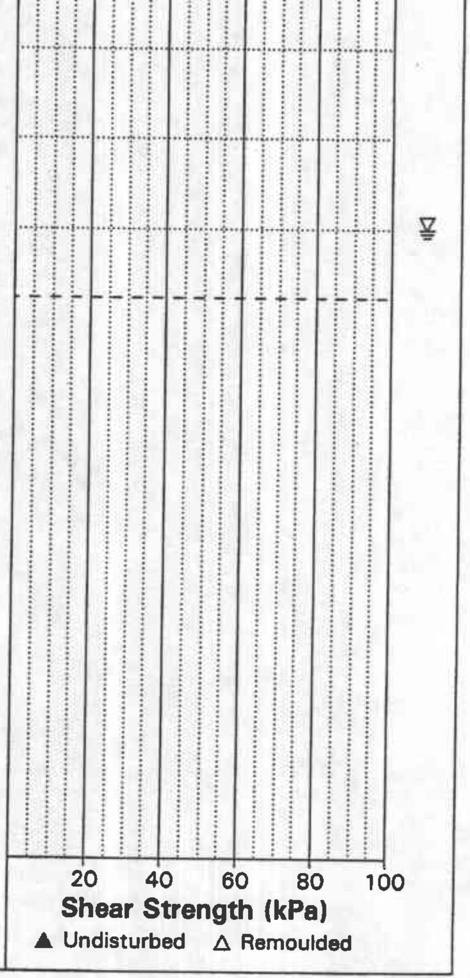
SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
GROUND SURFACE						0			
Black sandy TOPSOIL 0.13	■								
Light brown SAND, some silt 0.74	░								
	░					1			

Brown SAND

1.75

End of Auger Hole

(Open hole WL @ 1.6m depth)



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SOIL PROFILE & TEST DATA

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Sunset Lakes Subdivision, Old Prescott Road
Ottawa (Greely), Ontario

DATUM

REMARKS

BORINGS BY Hand Auger

DATE 15 MAR 01

FILE NO. G8105

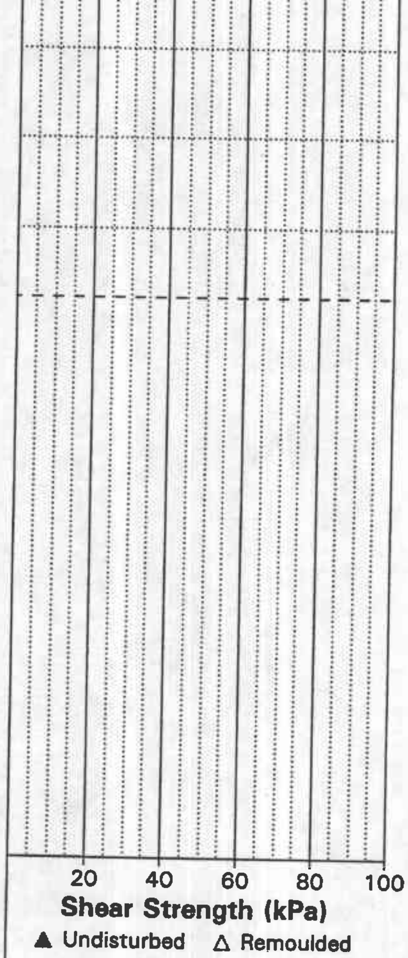
HOLE NO. AH12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	PIEZOMETER CONSTRUCTION
GROUND SURFACE						0		20 40 60 80	
Black sandy TOPSOIL 0.15									
Light brown SAND, some silt 0.48		G	18						
Brown SAND						1			

1.75

End of Auger Hole

(Open hole WL @ 1.5m depth)



SYMBOLS AND TERMS

SOIL DESCRIPTION

Behavioural properties, such as structure and strength, take precedence over particle gradation in describing soils. Terminology describing soil structure are as follows:

Desiccated	-	having visible signs of weathering by oxidation of clay minerals, shrinkage cracks, etc.
Fissured	-	having cracks, and hence a blocky structure.
Varved	-	composed of regular alternating layers of silt and clay.
Stratified	-	composed of alternating layers of different soil types, e.g. silt and sand or silt and clay.
Well-Graded	-	having wide range in grain sizes and substantial amounts of all intermediate particle sizes (see Grain Size Distribution).
Uniformly-Graded	-	predominantly of one grain size (see Grain Size Distribution).

The standard terminology to describe the strength of cohesionless soils is the relative density, usually inferred from the results of the Standard Penetration Test (SPT) 'N' value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm.

Relative Density	'N' Value	Relative Density %
Very Loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard termmology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by in situ or laboratory vane tests, penetrometer tests, unconfined compression tests, or occasionally by Standard Penetration Tests.

Consistency	Undrained Shear Strength (kPa)	'N' Value
Very Soft	<12	<2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

Cohesive soils can also classified according to their "sensitivity". The sensitivity is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil.

Terminology used for describing soil strata based upon texture, or the proportion of individual particle sizes present is provided on the Textural Soil Classification Chart at the end of this information package.

ROCK DESCRIPTION

The structural description of the bedrock mass is based on the Rock Quality Designation (RQD).

The RQD classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be a result of closely-spaced discontinuities (resulting from shearing, jointing, faulting, or weathering) in the rock mass and are not counted. RQD is ideally determined from NXL size core. However, it can be used on smaller core sizes, such as BX, if the bulk of the fractures caused by drilling stresses (called "mechanical breaks") are easily distinguishable from the normal in-situ fractures.

RQD %	ROCK QUALITY
90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

SAMPLE TYPES

SS - Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT))

TW - Thin wall tube or Shelby tube

PS - Piston sample

AU - Auger sample or bulk sample

WS - Wash sample

RC - Rock core sample (Core bit size AXT, BXL, etc.) Rock core samples are obtained with the use of standard diamond drilling bits

SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

MC% - Natural moisture content or water content of sample, %
LL - Liquid limit, % (water content above which soil behaves as a liquid)
PL - Plastic limit, % (water content above which soil behaves plastically)
PI - Plasticity index, % (difference between LL and PL)

Dxx - Grain size at which xx% of the soil, by weight, is of finer grain sizes
These grain size descriptions are not used below 0.075 mm grain size
D10 - Grain size at which 10% of the soil is finer (effective grain size)
D60 - Grain size at which 60% of the soil is finer

Cc - Concavity coefficient = $(D30)^2 / (D10 \times D60)$
Cu - Uniformity coefficient = $D60 / D10$

Cc and Cu are used to assess the grading of sands and gravels:
Well-graded gravels have: $1 < Cc < 3$ and $Cu > 4$
Well-graded sands have: $1 < Cc < 3$ and $Cu > 6$
Sand and gravels not meeting the above requirements are poorly-graded or uniformly-graded.
Cc and Cu are not applicable for the description of soils with more than 10% silt and clay (more than 10% finer than 0.075 mm or the #200 sieve)

CONSOLIDATION TEST

p'_o - Present effective overburden pressure at sample depth
p'_c - Preconsolidation pressure of (maximum past pressure on) sample
Ccr - Recompression index (in effect at pressures below p'_c)
Cc - Compression index (in effect at pressures above p'_c)

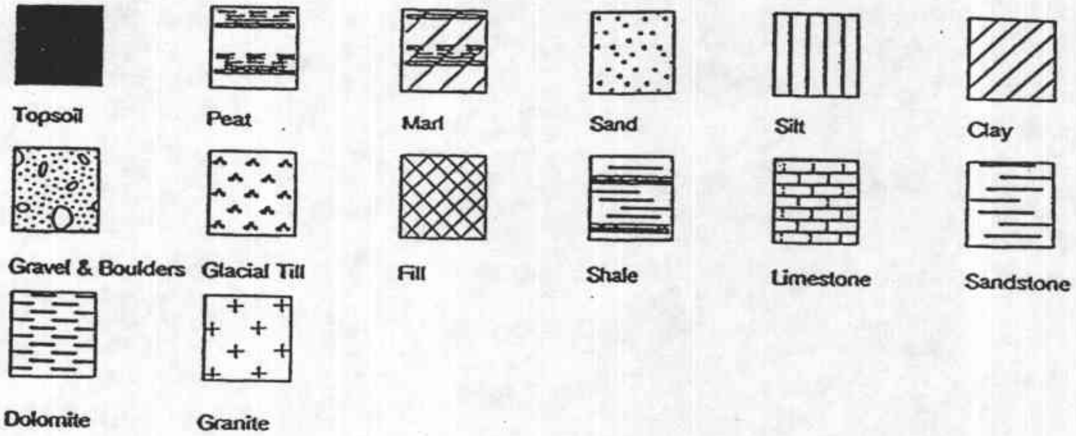
OC Ratio Overconsolidation ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

PERMEABILITY TEST

k - Coefficient of permeability or hydraulic conductivity is a measure of the ability of water to flow through the sample. The value of k is measured at a specified unit weight for (remoulded) cohesionless soil samples, because its value will vary with the unit weight or density of the sample during the test.

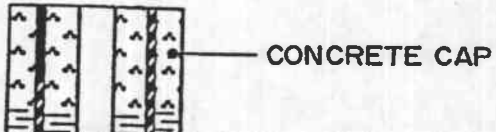
SYMBOLS AND TERMS (continued)

STRATA PLOT

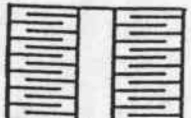


MONITORING WELL AND PIEZOMETER CONSTRUCTION

Monitoring Well Construction



Piezometer Construction



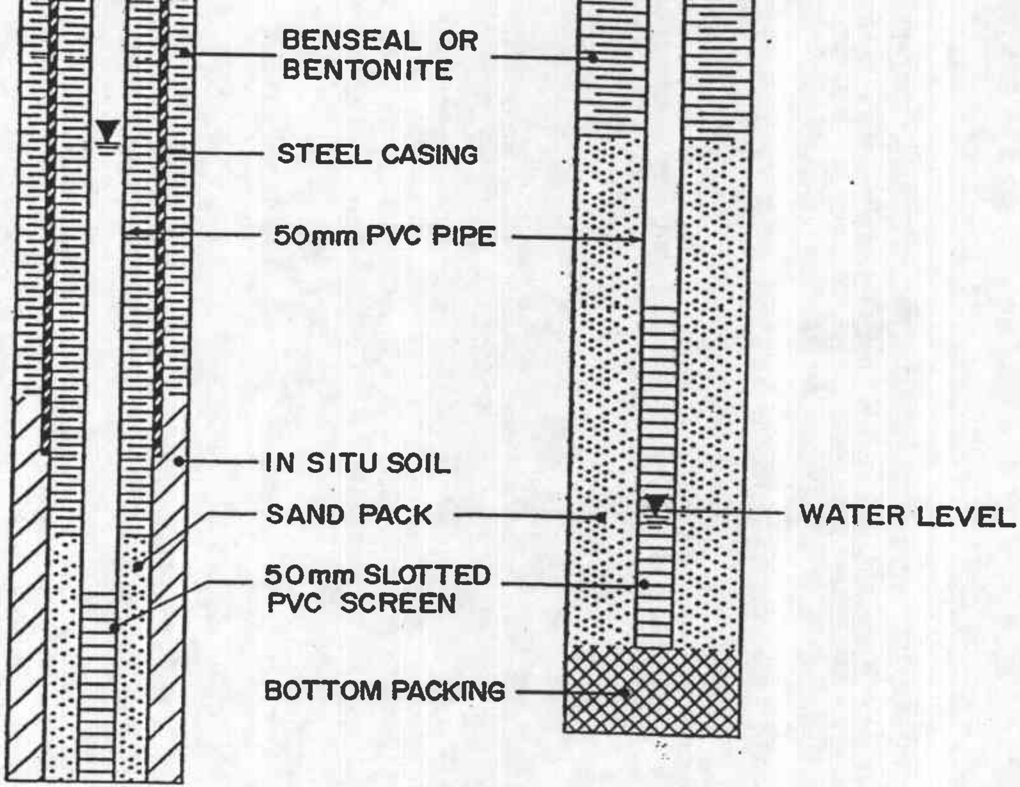

BENSEAL OR BENTONITE
STEEL CASING
50mm PVC PIPE
IN SITU SOIL
SAND PACK
WATER LEVEL
50mm SLOTTED PVC SCREEN
BOTTOM PACKING

TABLE 1
RECORD OF TEST PITS
TERRAIN EVALUATION
SUNSET LAKES DEVELOPMENT CORPORATION
GREELY, ONTARIO

TEST PIT NUMBER	DEPTH (metres)	DESCRIPTION
TP 1	0.00-0.18	Dark brown TOPSOIL
	0.18-0.71	Brown fine to medium SAND, trace silt.
	0.71-1.83	Light grey medium SAND.
	1.83	End of test pit, sides of test pit caving.
	Groundwater at 1.35 metres below ground surface on October 3, 2000.	
TP 2	0.00-0.20	Dark brown TOPSOIL
	0.20-0.64	Brown fine to medium SAND, trace silt.
	0.64-2.44	Light grey medium SAND.
	2.44	End of test pit, sides of

	2.44	End of test pit, sides of test pit caving.

Groundwater at 1.30 metres below ground surface on October 3, 2000.

TP 3	0.00-0.18	Dark brown TOPSOIL
	0.18-0.64	Brown fine to medium SAND, trace silt.
	0.64-2.13	Light grey medium SAND.
	2.13-2.59	Grey SILTY CLAY.
	2.59	End of test pit, sides of test pit caving.

Groundwater at 1.27 metres below ground surface on October 3, 2000.

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TABLE 1
RECORD OF TEST PITS
TERRAIN EVALUATION
SUNSET LAKES DEVELOPMENT CORPORATION
GREELY, ONTARIO

TP 4	0.00-0.23	Dark brown TOPSOIL
	0.23-0.56	Brown fine to medium SAND, trace silt.
	0.56-1.52	Light grey medium SAND (See Figure 3 for grain size distribution analyses).
	1.52-2.13	Grey SILTY CLAY.
	2.13	End of test pit, sides of test pit caving.
	Groundwater at 0.79 metres below ground surface on October 3, 2000.	
TP 5	0.00-0.30	Dark brown TOPSOIL
	0.30-1.63	Light grey medium SAND.
	1.63-2.13	Grey SILTY CLAY.

	2.13	End of test pit, sides of test pit caving.

Groundwater at 0.81 metres below ground surface on October 3, 2000.

TP 6	0.00-0.23	Dark brown TOPSOIL
	0.23-0.41	Brown fine to medium SAND, trace silt.
	0.41-1.52	Grey medium SAND.
	1.52-2.13	Grey SILTY CLAY.
	2.13	End of test pit, sides of test pit caving.

Groundwater at 0.89 metres below ground surface on October 3, 2000.

TP 7	0.00-0.20	Dark brown TOPSOIL.
	0.20-1.52	Light grey medium SAND.
	1.52-2.13	Grey SILTY CLAY.
	2.13	End of test pit, sides of test pit caving.

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TABLE 1
RECORD OF TEST PITS
TERRAIN EVALUATION
SUNSET LAKES DEVELOPMENT CORPORATION
GREELY, ONTARIO

TP 8	0.00-0.15	Dark brown TOPSOIL.
	0.15-0.23	Brown medium SAND, trace silt.
	0.23-1.52	Light grey medium SAND, trace shells.
	1.52-2.13	Grey SILTY CLAY.
	2.13	End of test pit sides of test pit caving.
	Groundwater at 0.53 metres below ground surface on October 3, 2000.	
TP 9	0.00-0.18	Dark brown TOPSOIL.
	0.18-0.38	Brown fine to medium SAND, trace silt.
	0.38-1.52	Light grey medium SAND.
	1.52-2.13	Grey SILTY CLAY

	2.13	End of test pit sides of test pit caving.

Groundwater at 0.74 metres below ground surface on October 3, 2000.

TP 10	0.00-0.28	Dark brown TOPSOIL.
	0.28-0.79	Brown fine to medium SAND, trace silt.
	0.79-1.83	Grey medium SAND, trace shells.
	1.83-2.13	Grey SILTY CLAY.
	2.13	End of test pit, sides of test pit caving.

Groundwater at 1.12 metres below ground surface on October 3, 2000.

Morey Houle Chevrier Engineering Ltd.

TABLE 1
RECORD OF TEST PITS
TERRAIN EVALUATION
SUNSET LAKES DEVELOPMENT CORPORATION
GREELY, ONTARIO

TP 11	0.00-0.25	Dark brown TOPSOIL.
	0.25-0.86	Brown fine to medium SAND, trace silt.
	0.86-1.52	Grey medium SAND.
	1.52-1.83	Grey SILTY CLAY.
	1.83	End of test pit sides of test pit caving.
	Groundwater at 1.19 metres below ground surface on October 3, 2000.	
TP 12	0.00-0.20	Dark brown TOPSOIL.
	0.20-0.58	Brown fine to medium SAND, trace silt.
	0.58-1.22	Grey brown fine to coarse SAND (See Figure 4 for grain size distribution analyses).
	1.04-2.13	Grey SILTY CLAY

	[illegible]	Grey SILTY CLAY.
	2.13	End of test pit sides of test pit caving.

Groundwater at 1.14 metres below ground surface on October 3, 2000.

TP 13	0.00-0.41	Dark brown TOPSOIL, cobbles, and boulders.
	0.41-0.61	Grey brown fine to medium SAND, trace silt.
	0.61-1.07	Grey brown medium SAND.
	1.07-1.83	Grey SILTY CLAY.
	1.83	End of test pit, sides of test pit caving.

Groundwater at 0.94 metres below ground surface on October 3, 2000.

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TABLE 1
RECORD OF TEST PITS
TERRAIN EVALUATION
SUNSET LAKES DEVELOPMENT CORPORATION
GREELY, ONTARIO

TP 14	0.00-0.30	Dark brown TOPSOIL.
	0.30-0.86	Grey brown SILTY SAND and SANDY SILT.
	0.86-1.52	Grey SILTY CLAY.
	1.52	End of test pit sides of test pit caving.
	Water inflow at 0.81 metres below ground surface on October 3, 2000.	
TP 15	0.00-0.48	Dark brown TOPSOIL/PEAT.
	0.48-0.74	Brown fine to medium SAND, trace silt.
	0.74-0.91	Grey SANDY SILT.
	0.91-1.73	Grey SILTY CLAY.
	1.73	End of test pit sides of test pit caving

pit sides of test pit caving.

Groundwater at 1.30 metres below ground surface on October 4, 2000.

TP 16	0.00-0.23	Dark brown TOPSOIL/PEAT.
	0.23-0.76	Brown fine to medium SAND, trace silt.
	0.76-1.83	Grey SILTY CLAY.
	1.83	End of test pit sides of test pit caving.
TP 17	0.00-0.23	Dark brown TOPSOIL/PEAT.
	0.23-0.89	Brown fine to medium SAND, trace silt.
	0.89-1.98	Grey SILTY CLAY.
	1.98	End of test pit sides of test pit caving.

Water inflow at 0.86 metres below ground surface on October 4, 2000.

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TABLE 1
RECORD OF TEST PITS
TERRAIN EVALUATION
SUNSET LAKES DEVELOPMENT CORPORATION
GREELY, ONTARIO

TP 18	0.00-0.23	Dark brown TOPSOIL/PEAT.
	0.23-0.76	Grey fine to medium SAND, trace silt.
	0.76-1.52	Grey SILTY CLAY.
	1.52	End of test pit sides of test pit caving.
	Water inflow at 0.76 metres below ground surface on October 4, 2000.	
TP 19	0.00-0.33	Dark brown TOPSOIL with roots.
	0.33-1.12	Grey fine to medium SAND, trace silt.
	1.12-2.13	Grey SILTY CLAY.
	2.13	End of test pit sides of test pit caving.
	Water inflow at 1.09 metres below ground surface on October 4, 2000.	

TP 20	0.00-0.20	Dark brown TOPSOIL/PEAT.
	0.20-1.02	Grey fine to medium SAND, trace silt.
	1.02-1.14	Grey medium SAND, trace silt.
	1.14-1.83	Grey SILTY CLAY.
	1.83	End of test pit sides of test pit caving.
	Groundwater at 1.57 metres below ground surface on October 4, 2000.	
TP 21	0.00-0.69	PEAT
	0.69-0.99	Grey medium SAND, trace silt.
	0.99-1.91	Grey SILTY CLAY.
	1.91	End of test pit sides of test pit caving.
	Water inflow at 0.99 metres below ground surface on October 4, 2000.	

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TABLE 1
RECORD OF TEST PITS
TERRAIN EVALUATION
SUNSET LAKES DEVELOPMENT CORPORATION
GREELY, ONTARIO

TP 22	0.00-0.18	PEAT
	0.18-0.64	Brown fine to medium SAND, trace silt.
	0.64-1.52	Grey medium SAND.
	1.52-2.13	Grey SILTY CLAY.
	2.13	End of test pit sides of test pit caving.
	Groundwater at 0.86 metres below ground surface on October 4, 2000.	
TP 23	0.00-0.20	PEAT
	0.20-0.64	Brown fine to medium SAND, trace silt.
	0.64-1.32	Grey medium SAND.
	1.32-1.83	Grey SILTY CLAY.

	1.83	End of test pit sides of test pit caving.
	Groundwater at 0.64 metres below ground surface on October 4, 2000.	
TP 24	0.00-1.07	PEAT
	1.07-1.52	Grey SILTY CLAY.
	1.52	End of test pit sides of test pit caving.
	Test pit dry on October 4, 2000.	
TP 25	0.00-0.23	Dark brown TOPSOIL.
	0.23-1.02	Brown fine to medium SAND, trace silt.
	1.02-2.13	Grey fine to medium SAND, trace silt.
	2.13-2.29	Grey SILTY CLAY.
	2.29	End of test pit, sides of test pit caving.
	Groundwater at 0.64 metres below ground surface on October 4, 2000.	

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TABLE 1
RECORD OF TEST PITS
TERRAIN EVALUATION
SUNSET LAKES DEVELOPMENT CORPORATION
GREELY, ONTARIO

TP 26	0.00-0.23	Dark brown TOPSOIL.
	0.23-0.97	Brown fine to medium SAND, trace silt.
	0.97-1.47	SILTY SAND, trace shells, some cobbles, boulders
	1.47	Practical refusal, end of test pit.
	Test pit dry on October 4, 2000.	
TP 27	0.00-0.25	Dark brown TOPSOIL.
	0.25-0.79	Brown fine to medium SAND, trace silt and shells.
	0.79-2.13	Grey fine to medium SAND, trace silt, trace shells.
	2.13	End of test pit, sides of test pit caving

		End of test pit, sides of test pit caving.
TP 28	0.00-0.30	Dark brown TOPSOIL.
	0.30-0.69	Brown fine to medium SAND, trace silt.
	0.69-2.13	Grey medium SAND, trace silt.
	2.13	End of test pit, sides of test pit caving.
	Water inflow at 1.68 metres below ground surface on October 4, 2000.	
TP 29	0.00-0.25	Dark brown TOPSOIL.
	0.25-0.81	Brown fine to medium SAND, trace silt.
	0.81-1.27	Grey medium SAND, trace silt.
	1.27-2.13	Grey SILTY CLAY.
	2.13	End of test pit, sides of test pit caving.
	Water inflow at 1.17 metres below ground surface on October 5, 2000.	

Morey Houle Chevrier Engineering Ltd.

TABLE 1
RECORD OF TEST PITS
TERRAIN EVALUATION
SUNSET LAKES DEVELOPMENT CORPORATION
GREELY, ONTARIO

TP 30	0.00-0.28	Dark brown TOPSOIL.
	0.28-2.13	Grey brown fine to medium SAND, trace silt.
	2.13	End of test pit, sides of test pit caving.
TP 31	0.00-0.20	Dark brown TOPSOIL.
	0.20-0.69	Brown fine to medium SAND, trace silt.
	0.69-2.44	Grey medium SAND.
	2.44	End of test pit, sides of test pit caving.
	Groundwater at 1.22 metres below ground surface on October 5, 2000.	
TP 32	0.00-0.23	Dark brown TOPSOIL.

	0.23-0.89	Brown fine to medium SAND, trace silt.
	0.89-2.13	Grey medium SAND, trace shells.
	2.13	End of test pit, sides of test pit caving.

Groundwater at 1.14 metres below ground surface on October 5, 2000.

TP 33	0.00-0.25	Dark brown TOPSOIL.
	0.25-0.71	Brown fine to medium SAND, trace silt.
	0.71-2.13	Grey medium SAND.
	2.13	End of test pit, sides of test pit caving.

TABLE 1
RECORD OF TEST PITS
TERRAIN EVALUATION
SUNSET LAKES DEVELOPMENT CORPORATION
GREELY, ONTARIO

TP 34	0.00-0.28	Dark brown TOPSOIL.
	0.28-0.99	Brown fine to medium SAND, trace silt.
	0.99-2.13	Grey coarse SAND, some gravel.
	2.13	End of test pit, sides of test pit caving.
	Groundwater at 1.37 metres below ground surface on October 6, 2000.	
TP 35	0.00-0.36	Dark brown topsoil, FILL.
	0.36-0.58	Dark brown TOPSOIL.
	0.58-0.79	Brown fine to medium SAND, trace silt.
	0.79-2.13	Grey brown medium SAND, trace silt, trace gravel.
	2.13-2.29	Grey SILTY CLAY

	2.29	End of test pit, sides of test pit caving.

Water inflow at 1.73 metres below ground surface on October 6, 2000.

TP 36	0.00-0.20	Dark brown TOPSOIL.
	0.20-0.84	Brown fine to medium SAND, trace silt.
	0.84-2.13	Grey medium SAND, trace shells, trace gravel.
	2.13	End of test pit, sides of test pit caving.

Water inflow at 1.12 metres below ground surface on October 6, 2000.

Morey Houle Chevrier Engineering Ltd.

TABLE 1
RECORD OF TEST PITS
TERRAIN EVALUATION
SUNSET LAKES DEVELOPMENT CORPORATION
GREELY, ONTARIO

TP 37	0.00-0.25	Dark brown TOPSOIL.
	0.25-0.46	Brown fine to medium SAND, trace silt.
	0.46-2.13	Grey SILTY CLAY.
	2.13	End of test pit, sides of test pit caving.
	Water inflow at 1.35 metres below ground surface on October 6, 2000.	
TP 38	0.00-0.56	Cobbles, FILL.
	0.56-0.79	Dark brown TOPSOIL.
	0.79-2.13	Grey SANDY SILT.
	2.13	End of test pit, sides of test pit caving.
	Test pit dry on October 6, 2000.	

TP 39	0.00-0.30	Dark brown TOPSOIL.
	0.30-1.17	Brown medium SAND, trace gravel, trace cobbles.
	1.17-2.13	Grey SANDY SILT.
	2.13	End of test pit, sides of test pit caving.

Test pit dry on October 6, 2000.

Morey Houle Chevrier Engineering Ltd.

APPENDIX 2

Aquifer Test Data

Ontario Ministry of the Environment

The Ontario Water Resources Act

WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

County or District OttawaCarleton	Township/Borough/City/Town/Village Osgoode	Con block tract survey, etc. 4	Lot Part of 3+4
Owner's surname First Name Sweet lakes,	Address Greely, Ont		Date completed 07 day 02 month 01 year

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth - feet From	Depth - feet To
	Sand	bowlders		0	35
grey	limestone			35	142
grey	Sandstone			142	240

WATER RECORD

Water found at - feet	Kind of water
89	☑ Fresh ☐ Salt ☐ Sulphur ☐ ~~Minerals~~ ☑ Gas NO

CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth - feet From	Depth - feet To
	☒ Steel ☐ Galvanized			

SCREEN	Sizes of opening (Slot No.)	Diameter inches	Length feet
	Material and type		Depth at top of screen

237	☑ Fresh ☐ Salty	☐ Sulphur ☐ Minerals ☐ Gas [illegible]
	☐ Fresh ☒ Salty	☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty	☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty	☐ Sulphur ☐ Minerals ☐ Gas

6¼	☐ Concrete ☐ Open hole ☐ Plastic	188	0	44
8¾	☐ Steel ☐ Galvanized ☐ Concrete ☑ Open hole ☐ Plastic		0	42
6	☐ Steel ☐ Galvanized ☐ Concrete ☑ Open hole ☐ Plastic		42	240

PLUGGING & SEALING RECORD

☑ Annular space ☐ Abandonment

Depth set at - feet		Material and type (Cement grout, bentonite, etc.)
From	To	
2	44	~~Cement Grout~~
		Bentonite

PUMPING TEST

Pumping test method ☑ Pump ☐ Bailer

Pumping rate 5 GPM

Duration of pumping 1 Hours ____ Mins

Static level 35 feet

Water level end of pumping 220 feet

Water levels during ☐ Pumping ☑ Recovery

15 minutes	30 minutes	45 minutes	60 minutes
160 feet	101 feet	41 feet	35 feet

If flowing give rate ____ GPM

Pump intake set at ____ feet

Water at end of test ☐ Clear ☑ Cloudy

Recommended pump type ☐ Shallow ☑ Deep

Recommended pump setting 220 feet

Recommended pump rate 5 GPM

FINAL STATUS OF WELL

☑ Water supply
☐ Observation well
☐ Test hole
☐ Recharge well
☐ Abandoned, insufficient supply
☐ Abandoned, poor quality
☐ Abandoned (Other)
☐ Dewatering
☐ Unfinished
☐ Replacement well

WATER USE

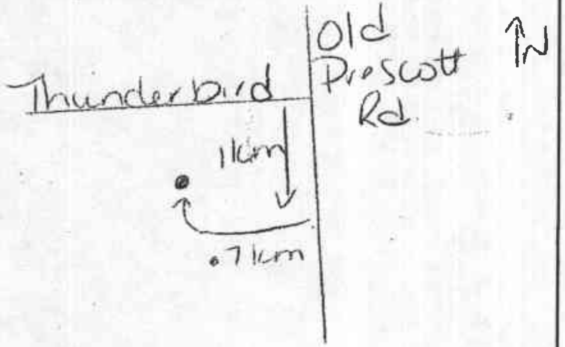
☑ Domestic
☐ Stock
☐ Irrigation
☐ Industrial
☐ Commercial
☐ Municipal
☐ Public supply
☐ Cooling & air conditioning
☐ Not use
☐ Other ____

METHOD OF CONSTRUCTION

☐ Cable tool
☐ Rotary (conventional)
☐ Rotary (reverse)
☐ Rotary (air)
☑ Air percussion
☐ Boring
☐ Diamond
☐ Jetting
☐ Driving
☐ Digging
☐ Other ____

LOCATION OF WELL

In diagram below show distances of well from road and lot line. Indicate north by arrow.



229481

Name of Well Contractor: Air Rock Drilling Ltd

Well Contractor's Licence No. 1119

Address: RR#2 Jasper, Ont

Name of Well Technician: Shannon Purcell

Well Technician's Licence No. T2122

Signature of Technician/Contractor

Submission date day mo yr

MINISTRY USE ONLY

3 - OWNER'S COPY

0506 (07/00) Front Form 9

Ontario **Ministry of the Environment**

The Ontario Water Resources Act

WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

Pawl Dz

County or District: Ottawa Carleton
Township/Borough/City/Town/Village: Osgoode
Con block tract survey, etc.: 4
Lot: 3&4
Owner's surname: Sunset Lakes
First Name:
Address: Greely, Ont
Date completed: 08 day 02 month 01 year

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth - feet	
				From	To
	sand	boulders		0	44
grey	limestone			44	80

WATER RECORD

Water found at - feet	Kind of water
69	☒ Fresh ☐ Sulphur ☐ Salty ☒ Minerals ☐ Gas

CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth - feet	
			From	To
	☒ Steel ☐ Galvanized			

SCREEN

Sizes of opening (Slot No.)
Diameter inches
Length feet
Material and type
Depth at top of screen

73	☒ Fresh ☐ Salty (S D)	☐ Sulphur ☐ Minerals ☒ Gas
	☐ Fresh ☐ Salty	☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty	☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty	☐ Sulphur ☐ Minerals ☐ Gas

6 1/4	☐ Concrete ☐ Open hole ☐ Plastic	188	0	53
0 3/4	☐ Steel ☐ Galvanized ☐ Concrete ☒ Open hole ☐ Plastic		0	51
6	☐ Steel ☐ Galvanized ☐ Concrete ☒ Open hole ☐ Plastic		51	80

PLUGGING & SEALING RECORD

☒ Annular space ☐ Abandonment

Depth set at - feet		Material and type (Cement grout, bentonite, etc.)
From	To	
2	53	~~Cement grout~~ Bentonite

PUMPING TEST

Pumping test method ☒ Pump ☐ Bailer

Pumping rate 45 GPM

Duration of pumping 1 Hours ____ Mins

Static level	Water level end of pumping	Water levels during ☐ Pumping ☒ Recovery			
		15 minutes	30 minutes	45 minutes	60 minutes
12 feet	70 feet	12 feet	12 feet	12 feet	12 feet

If flowing give rate ____ GPM

Pump intake set at ____ feet

Water at end of test ☐ Clear ☒ Cloudy

Recommended pump type ☐ Shallow ☒ Deep

Recommended pump setting 70 feet

Recommended pump rate 12 GPM

FINAL STATUS OF WELL

☒ Water supply
☐ Observation well
☐ Test hole
☐ Recharge well
☐ Abandoned, insufficient supply
☐ Abandoned, poor quality
☐ Abandoned (Other)
☐ Dewatering
☐ Unfinished
☐ Replacement well

WATER USE

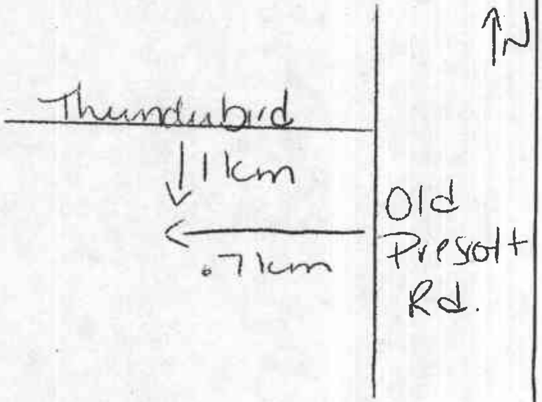
☒ Domestic
☐ Stock
☐ Irrigation
☐ Industrial
☐ Commercial
☐ Municipal
☐ Public supply
☐ Cooling & air conditioning
☐ Not use
☐ Other ________

METHOD OF CONSTRUCTION

☐ Cable tool
☐ Rotary (conventional)
☐ Rotary (reverse)
☐ Rotary (air)
☒ Air percussion
☐ Boring
☐ Diamond
☐ Jetting
☐ Driving
☐ Digging
☐ Other ________

LOCATION OF WELL

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Sunset Lakes Test #2. 229482

Name of Well Contractor: Air Rock Drilling Co Ltd

Well Contractor's Licence No. 1119

Address: RR#2 Jasper Ont

Name of Well Technician: Shannon Purcell

Well Technician's Licence No. T2122

Signature of Technician/Contractor

Submission date day mo yr

MINISTRY USE ONLY

3 OWNER'S COPY

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John D. Paterson & Associates Ltd.
1-28 Concourse Gate
Nepean, Ontario
K2E 7T7

Pumping test analysis
Time-Drawdown-method after
COOPER & JACOB
Confined aquifer

Date: 21.06.2001

Page 1

Project: Sunset Lakes Subdivision

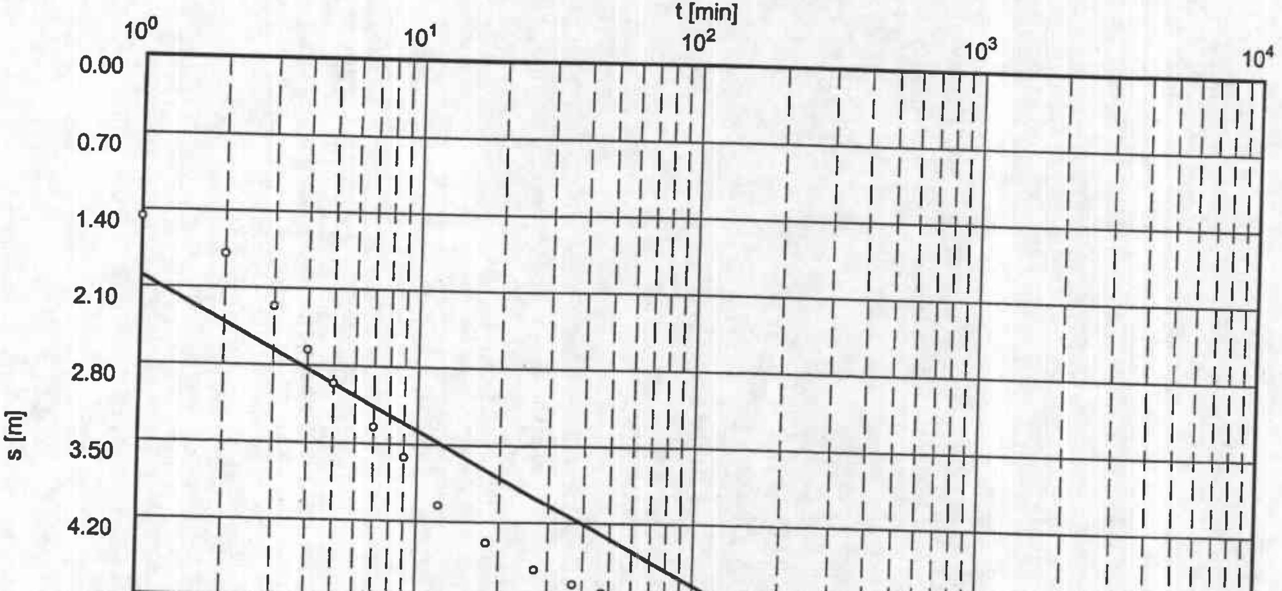
Evaluated by: SJW

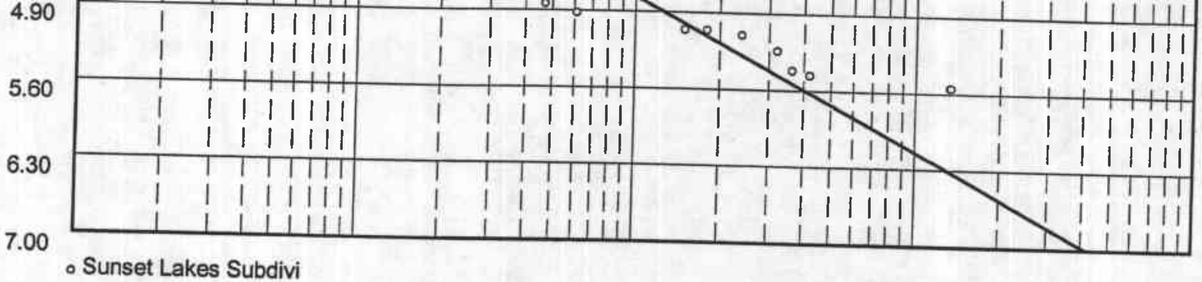
Pumping Test No. 1

Test conducted on: 14.02.2001

TW 1

Discharge 0.40 l/s





Transmissivity [m²/min]: 3.17×10^{-3}

Storativity: 1.02×10^{-3}

John D. Paterson & Associates Ltd.
1-28 Concourse Gate
Nepean, Ontario
K2E 7T7

Pumping test analysis
Time-Drawdown-method after
COOPER & JACOB
Confined aquifer

Date: 21.06.2001 | Page 2
Project: Sunset Lakes Subdivision
Evaluated by: SJW

Pumping Test No. 1

Test conducted on: 14.02.2001

TW 1

Sunset Lakes Subdivision - TW1

Discharge 0.40 l/s

Distance from the pumping well 0.500 m

Static water level: 4.840 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]	
1	1.00	6.300	1.460	
2	2.00	6.630	1.790	
3	3.00	7.110	2.270	
4	4.00	7.500	2.660	
5	5.00	7.800	2.960	
6	7.00	8.190	3.350	
7	9.00	8.460	3.620	
8	12.00	8.890	4.050	
9	18.00	9.230	4.390	
10	27.00	9.470	4.630	
11	37.00	9.600	4.760	
12	47.00	9.680	4.840	
13	61.00	9.760	4.920	
14	150.00	9.900	5.060	
15	180.00	9.900	5.060	
16	240.00	9.940	5.100	
17	322.00	10.080	5.240	
18	364.00	10.260	5.420	
19	420.00	10.300		

[illegible]	[illegible]	10.300	5.460	
20	1327.00	10.390	5.550	
21	1337.00	10.390	5.550	

John D. Paterson & Associates Ltd.
1-28 Concourse Gate
Nepean, Ontario
K2E 7T7

Pumping test analysis
Time-Drawdown-method after
COOPER & JACOB
Confined aquifer

Date: 21.06.2001
Page 3

Project: Sunset Lakes Subdivision

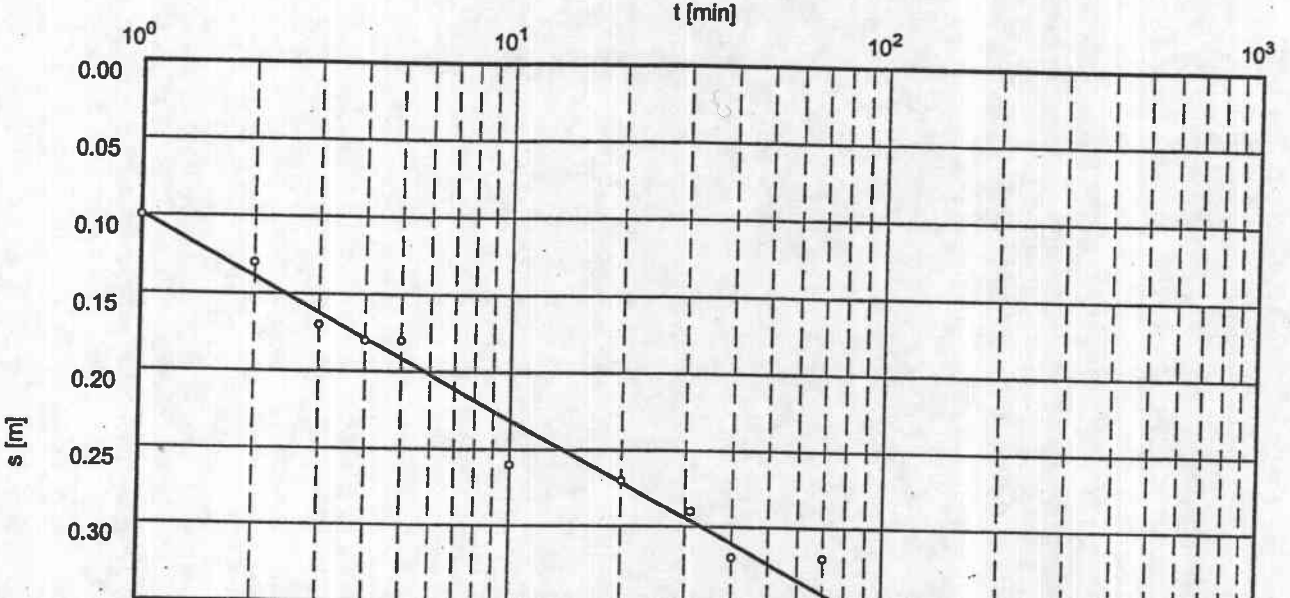
Evaluated by: SJW

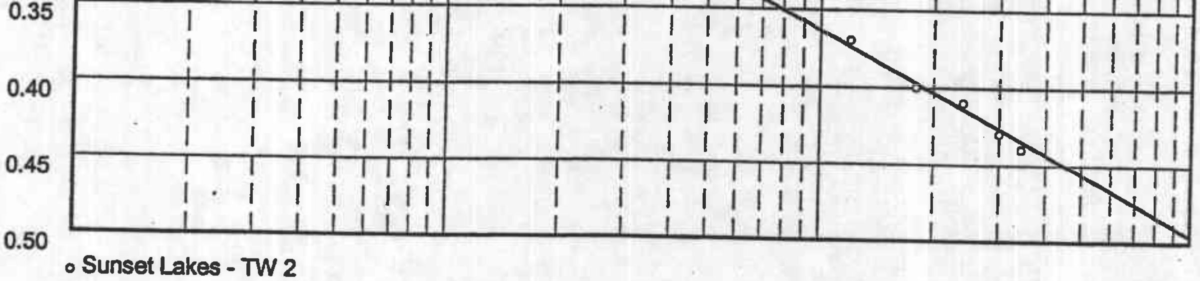
Pumping Test No. 2

Test conducted on: 15.02.2001

TW-2

Discharge 1.34 l/s





Transmissivity [m^2/min]: 1.11×10^{-1}

Storativity: 1.78×10^{-1}

John D. Paterson & Associates Ltd.
1-28 Concourse Gate
Nepean, Ontario
K2E 7T7

Pumping test analysis
Time-Drawdown-method after
COOPER & JACOB
Confined aquifer

Date: 21.06.2001 | Page 4

Project: Sunset Lakes Subdivision

Evaluated by: SJW

Pumping Test No. 2

Test conducted on: 15.02.2001

TW-2

Sunset Lakes - TW 2

Discharge 1.34 l/s

Distance from the pumping well 0.500 m

Static water level: 2.830 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]	
1	1.00	2.930	0.100	
2	2.00	2.960	0.130	
3	3.00	3.000	0.170	
4	4.00	3.010	0.180	
5	5.00	3.010	0.180	
6	10.00	3.090	0.260	
7	20.00	3.100	0.270	
8	31.00	3.120	0.290	
9	40.00	3.150	0.320	
10	70.00	3.150	0.320	
11	120.00	3.200	0.370	
12	180.00	3.230	0.400	
13	240.00	3.240	0.410	
14	300.00	3.260	0.430	
15	345.00	3.270	0.440	
16	346.00	3.270	0.440	
17	347.00	3.170	0.340	
18	348.00	3.140	0.310	
19	349.00	3.120	[illegible]	

	[illegible]	3.120	0.290	
20	350.00	3.100	0.270	

John D. Paterson & Associates Ltd.
1-28 Concourse Gate
Nepean, Ontario
K2E 7T7

Pumping test analysis
Time-Drawdown-method after
COOPER & JACOB
Confined aquifer

Date: 21.06.2001

Project: Sunset Lakes Subdivision

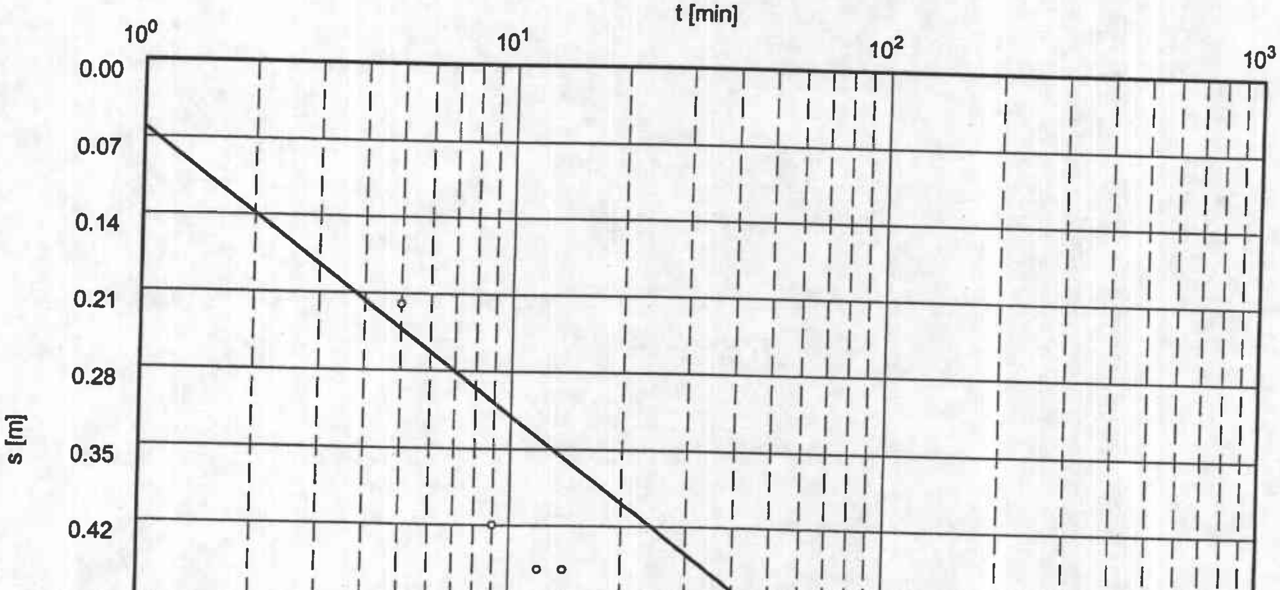
Evaluated by: SJW

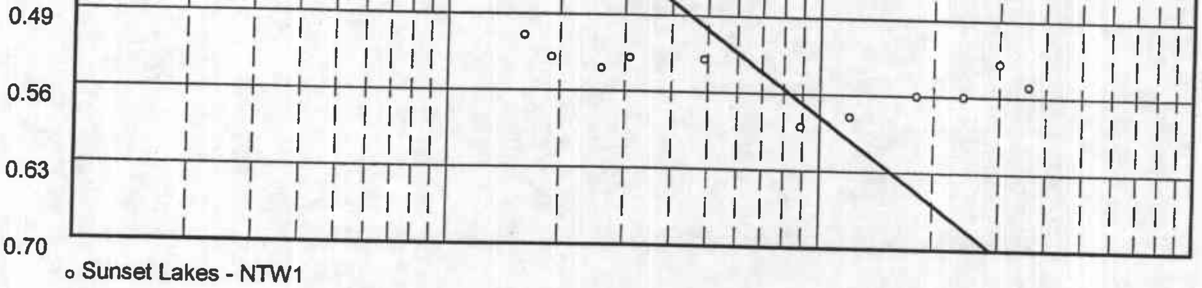
Pumping Test No. 3

Test conducted on: 16.02.2001

TW 3

Discharge 0.91 l/s





Transmissivity [m²/min]: 3.83 x 10^{-2}

Storativity: 2.02 x 10^{-1}

John D. Paterson & Associates Ltd.
1-28 Concourse Gate
Nepean, Ontario
K2E 7T7

Pumping test analysis
Time-Drawdown-method after
COOPER & JACOB
Confined aquifer

Date: 21.06.2001
Page 6
Project: Sunset Lakes Subdivision
Evaluated by: SJW

Pumping Test No. 3
Test conducted on: 16.02.2001
TW 3
Sunset Lakes - NTW1
Discharge 0.91 l/s
Distance from the pumping well 0.500 m
Static water level: 7.650 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]	
1	1.00	7.610	-0.040	
2	2.00	7.640	-0.010	
3	5.00	7.870	0.220	
4	9.00	8.070	0.420	
5	12.00	8.110	0.460	
6	14.00	8.110	0.460	
7	16.00	8.160	0.510	
8	19.00	8.180	0.530	
9	26.00	8.190	0.540	
10	31.00	8.180	0.530	
11	49.00	8.180	0.530	
12	89.00	8.240	0.590	
13	120.00	8.230	0.580	
14	180.00	8.210	0.560	
15	240.00	8.210	0.560	
16	300.00	8.180	0.530	
17	360.00	8.200	0.550	
18	361.00	7.770	0.120	
19	362.00	7.740	[illegible]	

	362.00	7.740	0.090	
20	363.00	7.710	0.060	
21	364.00	7.600	-0.050	

NITRATE IMPACT ASSESSMENT

PROJECT : Sunset Lakes Subdivision, Township of Osgoode
PROJECT NO.: G8105
CLIENT : Sunset Lakes Development Corporation

DATA ENTRY

Septic Effluent

Concentration of Effluent (Cs) = 40 mg/L
Daily Sewage Flow (Qs)= 207 m3

Groundwater Flow Calculation

Background Nitrate Concentration (Qg) = 0 mg/L
Hydraulic Conductivity (k) = 0 m/s
Horizontal Gradient (i) = 0
Length (L) = 0 m
Aquifer Thickness (t) = 0 m
Groundwater Flow (Qg) = 0.00 m3/day

Infiltration Calculation

Nitrate Concentration in Precipitation (Ci) = 0 mg/L
Precipitation per Year (R) = 0.911 m/yr
Infiltration Coefficient (C) =

Infiltration Coefficient (C) = 0.4

Infiltration Area (A) = 639020 m2

Infiltration Flow Entering the System (Qi) = 637.97 m3/day

Simple Mass Balance Model (Minnesota Pollution Control Agency, 1984)

Co = (QbCb+QsCs+QiCi)/(Qb+Qs+Qi) = Cumulative Nitrate Concentration

where:

Qb = flow entering the system across the upgradient area = 0.00 m3

Cb = background nitrate concentration = 0 mg/L

Qs = flow entering the system from the septic drainfield = 207 m3

Cs = concentration of nitrates in the septic effluent = 40 mg/L

Qi = flow entering the system from infiltration = 637.97 m3

Ci = Concentration of nitrates in the infiltrate = 0 mg/L

Therefore:

Co = 9.8 mg/L

NITRATE IMPACT ASSESSMENT

PROJECT : Sunset Lakes Subdivision, Township of Osgoode
PROJECT NO.: G8105
CLIENT : Sunset Lakes Development Corporation

DATA ENTRY

Septic Effluent

Concentration of Effluent (Cs) = 40 mg/L
Daily Sewage Flow (Qs)= 207 m3

Groundwater Flow Calculation

Background Nitrate Concentration (Qg) = 0 mg/L
Hydraulic Conductivity (k) = 0 m/s
Horizontal Gradient (i) = 0
Length (L) = 0 m
Aquifer Thickness (t) = 0 m
Groundwater Flow (Qg) = 0.00 m3/day

Infiltration Calculation

Nitrate Concentration in Precipitation (Ci) = 0 mg/L
Precipitation per Year (R) = 0.911 m/yr

Infiltration Coefficient (C) = 0.4
Infiltration Area (A) = 639020 m2
Infiltration Flow Entering the System (Qi) = 637.97 m3/day

Simple Mass Balance Model (Minnesota Pollution Control Agency, 1984)

Co = (QbCb+QsCs+QiCi)/(Qb+Qs+Qi) = Cumulative Nitrate Concentration

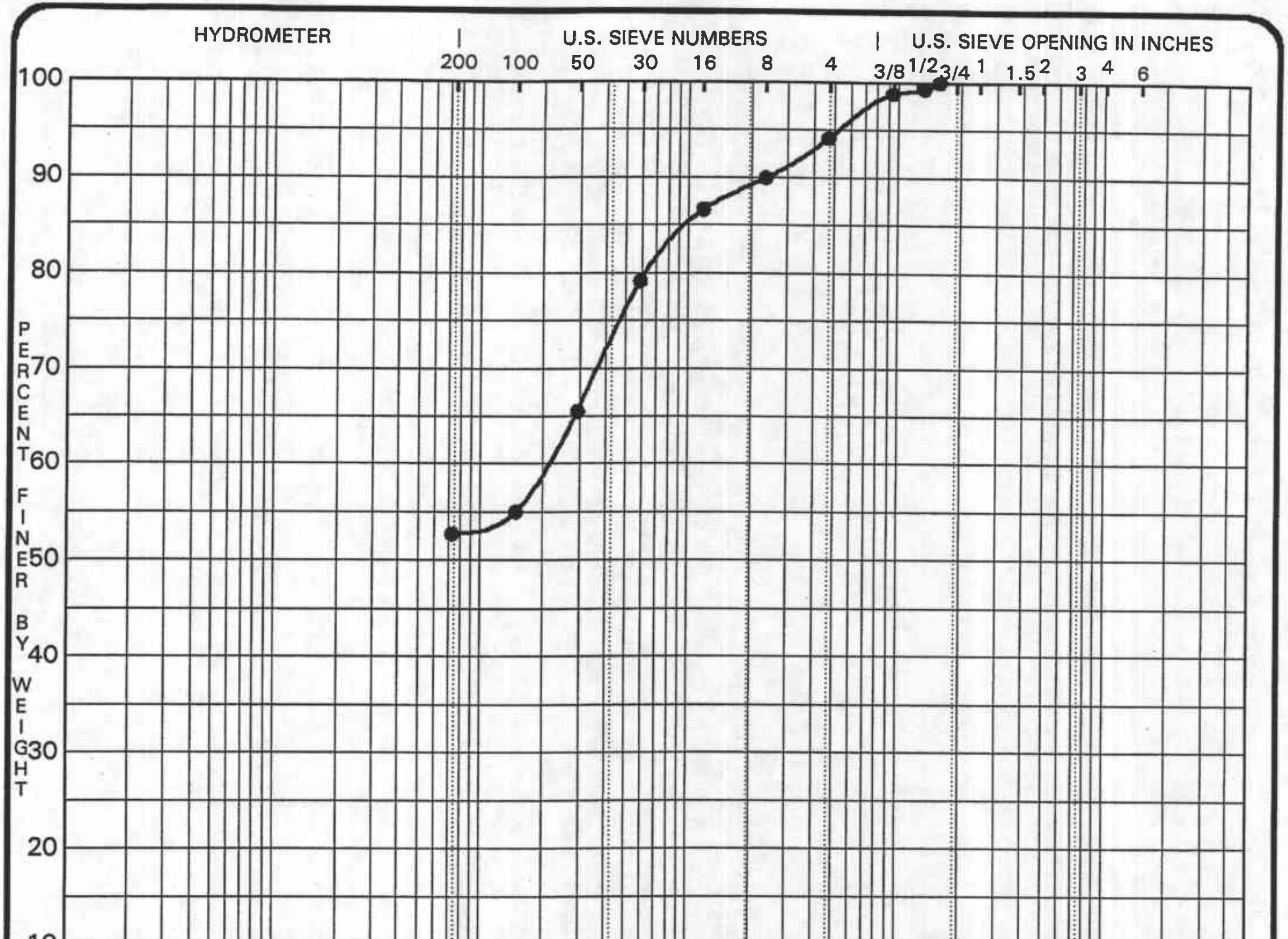
where:
Qb = flow entering the system across the upgradient area = 0.00 m3
Cb = background nitrate concentration = 0 mg/L
Qs = flow entering the system from the septic drainfield = 207 m3
Cs = concentration of nitrates in the septic effluent = 40 mg/L
Qi = flow entering the system from infiltration = 637.97 m3
Ci = Concentration of nitrates in the infiltrate = 0 mg/L

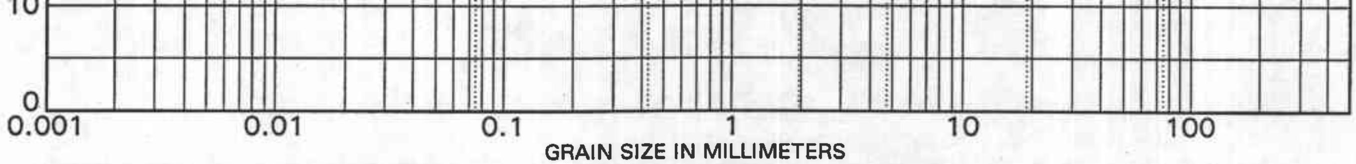
Therefore:

Co = 9.8 mg/L

APPENDIX 3

Laboratory Test Data


HYDROMETER
U.S. SIEVE NUMBERS
U.S. SIEVE OPENING IN INCHES
200
100
50
30
16
8
4
3/8
1/2
3/4
1
1.5
2
3
4
6
100
90
80
70
60
50
40
30
20
PERCENT FINER BY WEIGHT



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
● AH 1	G 2	SILTY SAND/SANDY SILT (Est. T = 20 to 40 min/cm)						

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● AH 1	G 2	15.63	0.20			5.8	41.4	52.8	

CLIENT **Sunset Lakes Development Corp.**

PROJECT **Hydrogeological Study and Terrain Analysis - Sunset Lakes Subdivision, Old Prescott Road**

FILE NO. **G8105**

DATE **13 MAR 01**

GRAIN SIZE DISTRIBUTION

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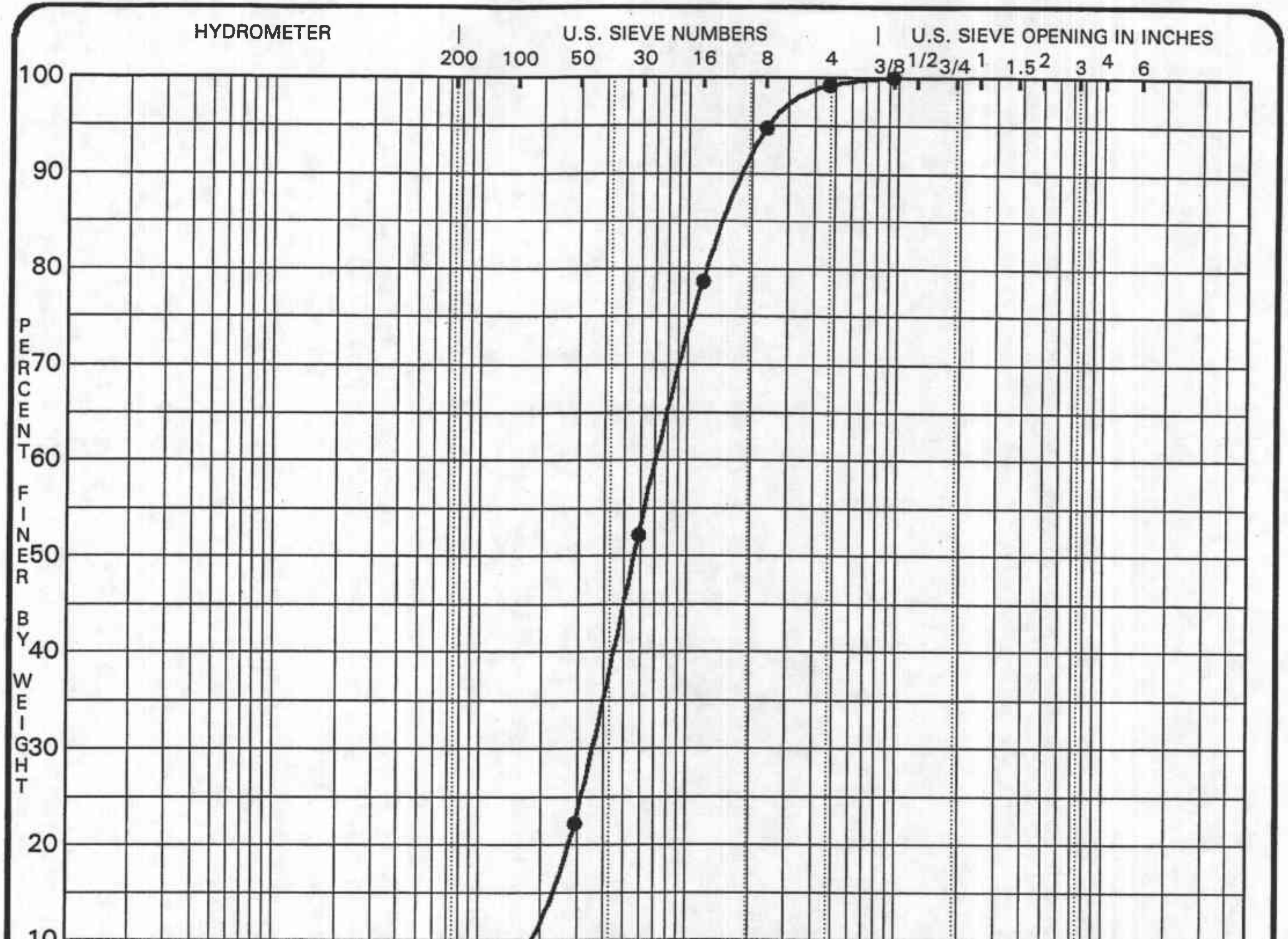
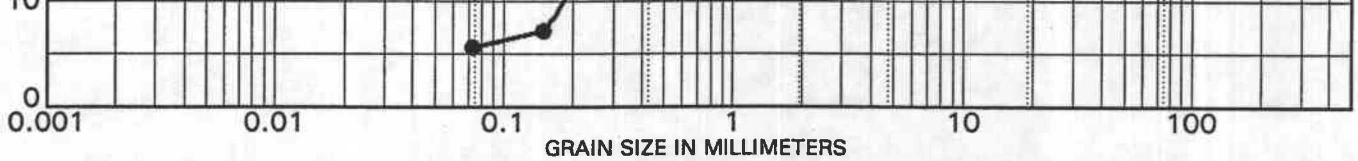

HYDROMETER
U.S. SIEVE NUMBERS
U.S. SIEVE OPENING IN INCHES
200
100
50
30
16
8
4
3/8
1/2
3/4
1
1.5
2
3
4
6
100
90
80
70
60
50
40
30
20
10
PERCENT FINER BY WEIGHT



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● AH 3 G 9	**SAND (Est. T = 6 to 8 min/cm)**						

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● AH 3 G 9	9.38	0.72	0.351	0.1681	0.8	93.5	5.8	

CLIENT **Sunset Lakes Development Corp.**
FILE NO. **G8105**
PROJECT **Hydrogeological Study and Terrain Analysis -**
Sunset Lakes Subdivision, Old Prescott Road
DATE **13 MAR 01**

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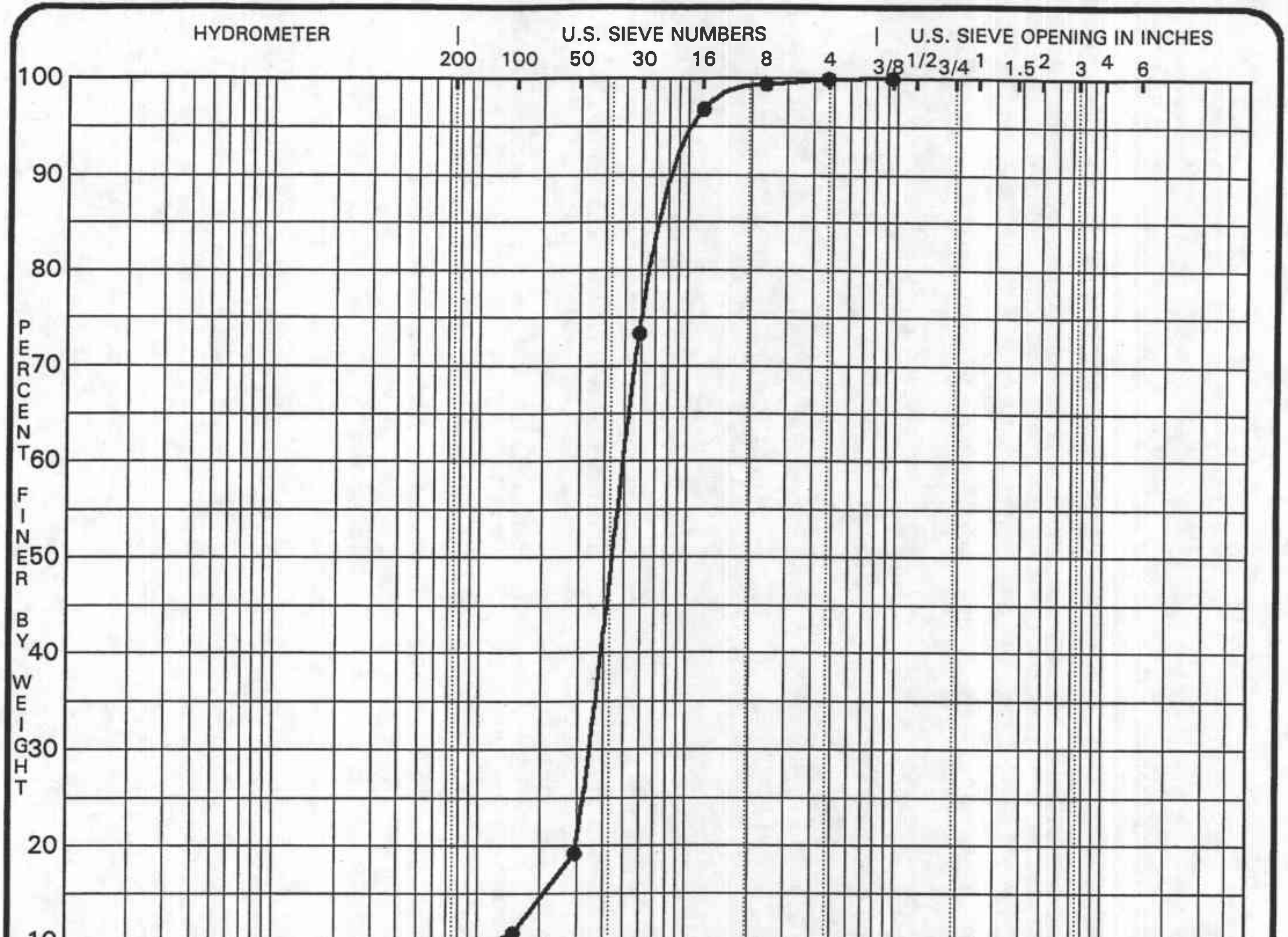
HYDROMETER
U.S. SIEVE NUMBERS
U.S. SIEVE OPENING IN INCHES
200
100
50
30
16
8
4
3/8
1/2
3/4
1
1.5
2
3
4
6
100
90
80
70
60
50
40
30
20
10
PERCENT FINER BY WEIGHT

SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	AH12	G 18	SAND (Est. T = 6 to 8 min/cm)						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	AH12	G 18	9.38	0.49	0.336	0.1218	0.1	91.9	8.0	

CLIENT **Sunset Lakes Development Corp.**

PROJECT **Hydrogeological Study and Terrain Analysis -**
Sunset Lakes Subdivision, Old Prescott Road

FILE NO. **G8105**

DATE **15 MAR 01**

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ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSIS

Client: **J.D. Paterson & Associates**

ATT: Al Van Schie

Report Number: 2101441
Date: 2001-02-23
Date Submitted: 2001-02-16
Date Collected: 2001-02-15
Project: G8105

P.O. Number:
Matrix: Water

PARAMETER	**UNITS**	**MDL**	112123	112124			
			TW2-WS#3	TW2-WS#4			
Alkalinity as CaCO3	mg/L	5	186	186			
Ca	mg/L	2	53	54			
Cl	mg/L	1	13	12			
Conductivity	uS/cm	5	433	428			
Colour	TCU	2	<2	2			
DOC	mg/L	0.3	0.4	0.6			
Escherichia Coli	ct/100mL		0	0			
F	mg/L	0.10	0.13	0.11			
Faecal Coliforms	ct/100mL		0	0			
Faecal Streptococcus	ct/100mL		0	0			
Fe	mg/L	0.01	0.32	0.25			
H2S	mg/L	0.01	<0.01				
Hardness as CaCO3	mg/L	1	211	217			

Ion Balance		0.01	1.07	0.98			
Mg	mg/L	1	19	20			
Mn	mg/L	0.01	0.01	0.01			
N-NH3	mg/L	0.02	0.04	0.05			
N-NO2	mg/L	0.10	<0.10	<0.10			
N-NO3	mg/L	0.10	<0.10	<0.10			
pH			7.69	7.85			
Phenols	mg/L	0.001	<0.001	<0.001			
K	mg/L	1	2	2			
Na	mg/L	2	7	7			
Heterotrophic Plate Count	ct/1mL		0	0			
SO4	mg/L	1	9	36			
Tannin & Lignin	mg/L	0.1	0.1	0.1			
Total Coliforms	ct/100mL		0	0			
TDS	mg/L	2	252	268			
Total Kjeldahl Nitrogen	mg/L	0.05	0.09	0.09			
Turbidity	NTU	0.1	2.8	1.5			

MDL = Method Detection Limit INC = Incomplete

Comment:

APPROVAL:

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSIS

Client: J.D. Paterson & Associates

ATT: Al Van Schie

Report Number:	2101377
Date:	2001-02-22
Date Submitted:	2001-02-15
Date Collected:	2001-02-14
Project:	G8101
P.O. Number:	
Matrix:	Water

PARAMETER	UNITS	MDL	111853	111854			
			TW1-WS#1	TW1-WS#2			
Alkalinity as CaCO3	mg/L	5	180	185			
Ca	mg/L	2	30	28			
Cl	mg/L	1	9	12			
Conductivity	uS/cm	5	373	395			
Colour	TCU	2	4	<2			
DOC	mg/L	0.3	1.1	0.5			
Escherichia Coli	ct/100mL		0	0			
F	mg/L	0.10	0.42	0.49			
Faecal Coliforms	ct/100mL		0	0			
Faecal Streptococcus	ct/100mL		1	0			
Fe	mg/L	0.01	1.04	0.11			
H2S	mg/L	0.01	0.10	<0.01			
Hardness as CaCO3	mg/L	1	153	144			

Ion Balance		0.01	0.96	0.95			
Mg	mg/L	1	19	18			
Mn	mg/L	0.01	0.03	0.02			
N-NH3	mg/L	0.02	0.19	0.19			
N-NO2	mg/L	0.10	<0.10	<0.10			
N-NO3	mg/L	0.10	<0.10	<0.10			
pH			7.61	7.59			
Phenols	mg/L	0.001	<0.001	<0.001			
K	mg/L	1	6	6			
Na	mg/L	2	21	27			
Heterotrophic Plate Count	ct/1mL		3	0			
SO4	mg/L	1	21	19			
Tannin & Lignin	mg/L	0.1	0.5	0.1			
Total Coliforms	ct/100mL		0	0			
TDS	mg/L	2	212	216			
Total Kjeldahl Nitrogen	mg/L	0.05	0.24	0.20			
Turbidity	NTU	0.1	90.0	2.8			

MDL = Method Detection Limit INC = Incomplete

Comment:

APPROVAL:

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSIS

Client: J.D. Paterson & Associates

ATT: Al Van Schie

Report Number:	2101443
Date:	2001-02-26
Date Submitted:	2001-02-16
Date Collected:	2001-02-16
Project:	G8105
P.O. Number:	
Matrix:	Water

PARAMETER	UNITS	MDL	112126 NTW1-WS5	112127 NTW1-WS6			
Alkalinity as CaCO3	mg/L	5	311	336			
Ca	mg/L	2	76	82			
Cl	mg/L	1	206	138			
Conductivity	uS/cm	5	1240	1340			
Colour	TCU	2	3	3			
DOC	mg/L	0.3	1.3	1.8			
Escherichia Coli	ct/100mL		0	0			
F	mg/L	0.10	0.32	0.29			
Faecal Coliforms	ct/100mL		0	0			
Faecal Streptococcus	ct/100mL		0	0			
Fe	mg/L	0.01	0.01	0.03			
H2S	mg/L	0.01	0.05	0.03			
Hardness as CaCO3	mg/L	1	371	390			

Ion Balance		0.01	0.92	1.07			
Mg	mg/L	1	44	45			
Mn	mg/L	0.01	0.03	0.04			
N-NH3	mg/L	0.02	0.34	0.26			
N-NO2	mg/L	0.10	<0.10	<0.10			
N-NO3	mg/L	0.10	<0.10	<0.10			
pH			7.68	7.83			
Phenols	mg/L	0.001	<0.001	<0.001			
K	mg/L	1	7	7			
Na	mg/L	2	121	129			
Heterotrophic Plate Count	ct/1mL		22	7			
SO4	mg/L	1	97	101			
Tannin & Lignin	mg/L	0.1	<0.1	<0.1			
Total Coliforms	ct/100mL		3	2			
TDS	mg/L	2	728	796			
Total Kjeldahl Nitrogen	mg/L	0.05	0.43	0.47			
Turbidity	NTU	0.1	0.4	0.3			

MDL = Method Detection Limit INC = Incomplete

Comment:

APPROVAL:

APPENDIX 4

Drawing and Specifications

1. Well Design
   MOE Well Construction Fact Sheet

2. **Test Hole Location Plan**

3. **Lot Development Plan**

Ontario

Green Facts

June
2000

Environment topics at a glance

Important facts about water well construction

Anyone engaged in the business of constructing water wells must be licenced by the province and be in possession of a valid contractor's licence.

The licence requires that the contractor be insured against liability claims, employ only licensed well technicians, and comply with all requirements of the Act and regulation.

A well technician's licence, issued by the province, is required for anyone working on well construction. The class of licence depends on the type of equipment the well technician operates (e.g. Class 1 - drilling, Class 2 - digging and boring and Class 3 - special). All persons installing pumps in wells must be provincially licenced Class 4 well technicians.

For your protection, you should ask to see the

Environment giving the well's location, and details about construction.

The well contractor is responsible for all work and costs associated with the prevention of any uncontrolled flow from a well and/or the abandonment of a flowing well in accordance with the regulation, unless a written contract with the owner expressly releases the well contractor from responsibility for costs. In any case, completion of the work by the well contractor is mandatory.

Here are some of the other construction requirements:

- A well must be at least 15 metres from any source of pollution if the casing is watertight to a depth of at least six metres. It must be at least 30 metres away if the casing is not

If you are planning to have a water well bored, drilled or dug on your property, there are some important facts you should know. Ontario has a

Ontario has a regulation under the Ontario Water Resources Act *that sets out requirements for water wells. It requires that all well contractors and well technicians in the province be licenced, and it sets minimum construction standards.*

licence of your well contractor and well technician before work begins.

Construction requirements

There are a number of detailed requirements pertaining to well construction in the regulation. They cover such things as casing, grouting and sealing, and testing of the well.

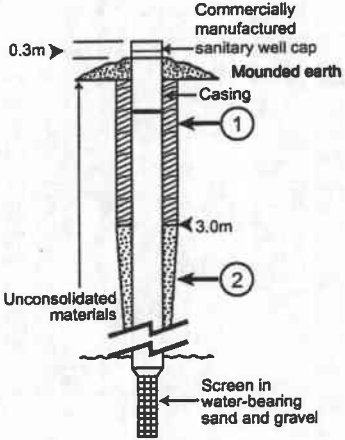
Some of these requirements relate directly to the consumer. For example, the contractor must notify the well owner if the well is not in a sand-free state. The well contractor must provide the owner with a one-litre sample of well water for visual examination, and measure the well depth in the presence of the owner.

The well contractor is required to pump test a new well for at least one hour and to measure and record on a Water Well Record the rate at which water is withdrawn from the well and the water levels in the well during pumping or recovery after pumping. The contractor will estimate and report the yield of the well and recommend a pump setting.

Within two weeks of completion of the well, the well contractor must deliver to the owner a copy of the Water Well Record, which is the official document filed with the Ministry of the

at least 30 metres away if the casing is not watertight to a depth less than six metres.

- A well must be constructed so that surface drainage will not pond in the vicinity of the well.
- During construction, steps must be taken to protect the well against the entry of surface water and foreign material.
- A new well must be chlorinated to a minimum residual concentration of 250 milligrams of chlorine per litre of water. This concentration must be maintained for a minimum of 12 hours.
- A well must be constructed in such a way that there is no break-out of flowing water from around the well bore or an adjacent property. A device is required on the well casing to permit stoppage or regulation of flow from the well casing.
- All casing materials must be new and the top of the casing must be a minimum of 30 cm above the ground surface or floor of a wellpit. Casing in a drilled well must be a minimum of six metres in length unless the only useful aquifer of water-bearing zone is shallower.



TYPE 1
Drilled well in unconsolidated materials

Well contamination

One of the common causes of well contamination is failure to seal properly the annular space (see figure 1) which is the space between the well casing and the hole in the ground.

There are a variety of materials that can be used for sealing this space, such as cement grout, concrete, or bentonite. You should ask your contractor how he intends to seal the well and what is the best material for your local conditions.

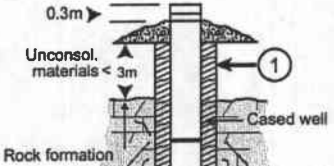
The pump connection also requires special care to ensure that it is watertight if the connection is made through the casing below the ground surface. The method of connecting may vary from a commercially manufactured pitless adaptor (drilled well) to the use of durable sealing materials (bored/dug well). Grouting material in the excavated annulus should extend half a metre into the trench excavation. Where a pump connection is made through the top of a watertight casing in a drilled well, a commercial sanitary well seal is required.

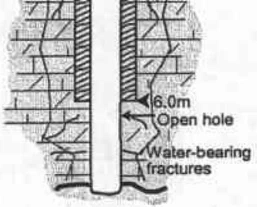
Most properly sealed wells require ventilation to allow air into the well casing for proper operation of the well and pump. The regulation specifies standards for the vent pipe.

It is important to ensure that wells which emit natural gas are vented to the outside of buildings to avoid the risk of explosion and fire.

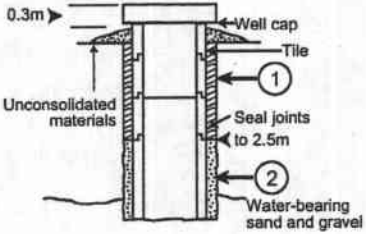
Maintenance

Once the well is constructed, it is the well-owner's responsibility to maintain it in a manner that will prevent the entry of surface water or other foreign





TYPE 2
Drilled well completed in rock
with < 3m unconsolidated materials



TYPE 3
Bored or dug well
>2.5m deep

FIGURE 1

Construction requirements for some typical well types

①= Formation seal in annular space

②= Formation stabilizer in annual space

materials that are likely to contaminate the well and the aquifer.

Abandoning a well

The regulation also covers procedures for abandoning a well. New wells must be sealed if they are dry, and older wells if they are not going to be used anymore. Wells that produce unpotable salty, sulphurous or mineralized water must be abandoned.

Wells may also have to be abandoned on the order of the Ministry of the Environment if it is determined that natural gas poses a potential hazard or if the well construction standards have not been followed.

Abandoned wells are required to be plugged with concrete or other suitable materials. In special cases, such as in deep or flowing wells, an experienced well contractor should be retained.

Additional information sources

There are some additional ministry references you may wish to read.

You may obtain a copy of the Regulation 903 itself. The Ministry of the Environment also has fact sheets entitled *Protection of Water Quality in Drilled Wells, Bored and Dug Wells* and *Recommended Methods for Plugging Abandoned Water Wells.*

For further information about wells contact your nearest Ministry of the Environment office as listed in the blue pages of your telephone directory. Or call the ministry's public information centre at 1-800-565-4923.

In Toronto call 416-325-4000. The ministry's Web site is at www.ene.gov.on.ca.

Ministry of the Environment

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Ontario

Green facts

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2000

Environment topics at a glance

The protection of water quality in drilled wells

People who rely on drilled wells for their water can help preserve their water quality by maintaining or upgrading their drilled wells.

Improper well construction, and the failure to carry out routine preventive maintenance on drilled wells, may result in the contamination of a well supply and the creation of a hazard to both health and safety.

Section 20 of Regulation 903 under the Ontario Water Resources Act states that "The well owner shall maintain the well at all times after the completion date in a manner sufficient to prevent the entry into the well of surface water or other foreign materials."

The following information will help people who rely on drilled wells for their water supply preserve the water quality by maintaining or upgrading their drilled wells. Although upgrading work can be done by the owner,

diameter. These are subsequently lined with steel casing or plastic. Problems due to surface contamination occur when the sealing on the outside or top of the casing is not watertight. This also applies to well pits.

Proper sealing is usually easier to achieve and maintain in drilled wells because of the small diameters and the liner materials involved. However, other damage such as subsidence or corrosion can occur, allowing surface waters to enter the well.

Indicators that sealing is inadequate and surface contamination is gaining access to the well include:

- presence of coliform bacteria in counts exceeding recommended limits set by employing a competent well contractor is advised.

Well regulations

Ontario Regulation 903 provides for the licensing of water well contractors and well technicians by the Ministry of the Environment. This regulation prescribes the minimum construction standards that all well contractors, including private homeowners, must adhere to. The diagrams illustrate the minimum sealing requirements for drilled wells in different geological formations and well pits.

Factors contributing to the deterioration of well water quality

A poorly maintained or constructed well can result in the bacterial and/or chemical contamination of its water. The most common cause of contamination is foreign materials and surface waters in the immediate vicinity having direct access to the well.

In Ontario drilled wells are constructed using a variety of drilling machines that produce holes of 15 centimetres or more in

health authorities

- changes in the quality of the water, such as turbidity, colour, taste and odour, especially after a rainstorm or snow melt
- rapid or large changes in the well water level, especially after a rainstorm or snow melt
- cascading or seeping water and/or staining along the casing in a well pit
- presence of biological material, such as animals or roots, in a well pit
- unsealed or parted joints or cracks in the casing wall or cover of a well pit
- settlement of soils around the well casing(s) and well pit, to or below land surface level
- absence of sanitary well seal or watertight cover set at an appropriate height above land surface level
- changes in the chemical quality of the well water detected through laboratory analysis.

Green facts

Preventive maintenance measures

The homeowner should be aware of the measures that can be taken for the care and maintenance of a well to help it provide good quality water.

1) Well location

To safeguard a well supply, do not do anything near the well that might result in contamination. Do not store, use or dispose of refuse, manure, petroleum, salt, pesticides or any other potential contaminant in the vicinity of the well. When mixing pesticides, the water supply line from the pressure system should be equipped with a backflow device.

2) Well construction

The sanitary well seal (well pit) or the well cap must be securely in place and watertight. If the well cap is damaged or cracked, replace it immediately so that contaminants will not have direct access to the well pit.

The sanitary well seal or well cap must be a minimum of 30 centimetres above land surface level. The well casing should not be cut off and buried. … should be raised to at least 30 centimetres above ground level and regraded so that it slopes away from the well.

The connection at the well casing for pump and electrical lines must be watertight and properly sealed. If not, the casing may have to be excavated and the seal replaced. Use a commercially manufactured pitless adaptor for a good watertight seal through the side of the well casing, or a commercially manufactured sanitary well seal installed on top of the well casing.

Keep the well pit free of groundwater seepage and surface water, either through adequate drainage or the installation of an automatic pump. Well pits are not recommended where the high water table is less then 0.5 metres below the floor of the pit.

All wells that have been repaired should be chlorinated and tested for potability immediately after the work has been completed.

All abandoned wells must be sealed in accordance with Ontario Regulation 903.

Additional information sources

cut off and buried.

The well vent pipes should be shielded and screened to prevent the entry of foreign matter. The vent pipe in a well pit must extend to within 15 centimetres or less of the well cap.

If any unsealed openings are found in the wall or along the joints of cement-tile casing in a well pit, make them watertight with an appropriate durable sealing material. Applying this from the outside of the casing is preferable.

Any space outside the casing(s) should have been filled with a suitable sealant, such as Portland cement grout, concrete, bentonite, equivalent commercial slurry or clay slurry or well cuttings. This will prevent surface water runoff or shallow groundwater seeping directly into the well around the casing. Where settlement of the sealant has occurred, the circular space around the well casing should be excavated and backfilled with one of the sealants listed above.

If the general land surface around the well is depressed or susceptible to flooding, it

Additional information sources

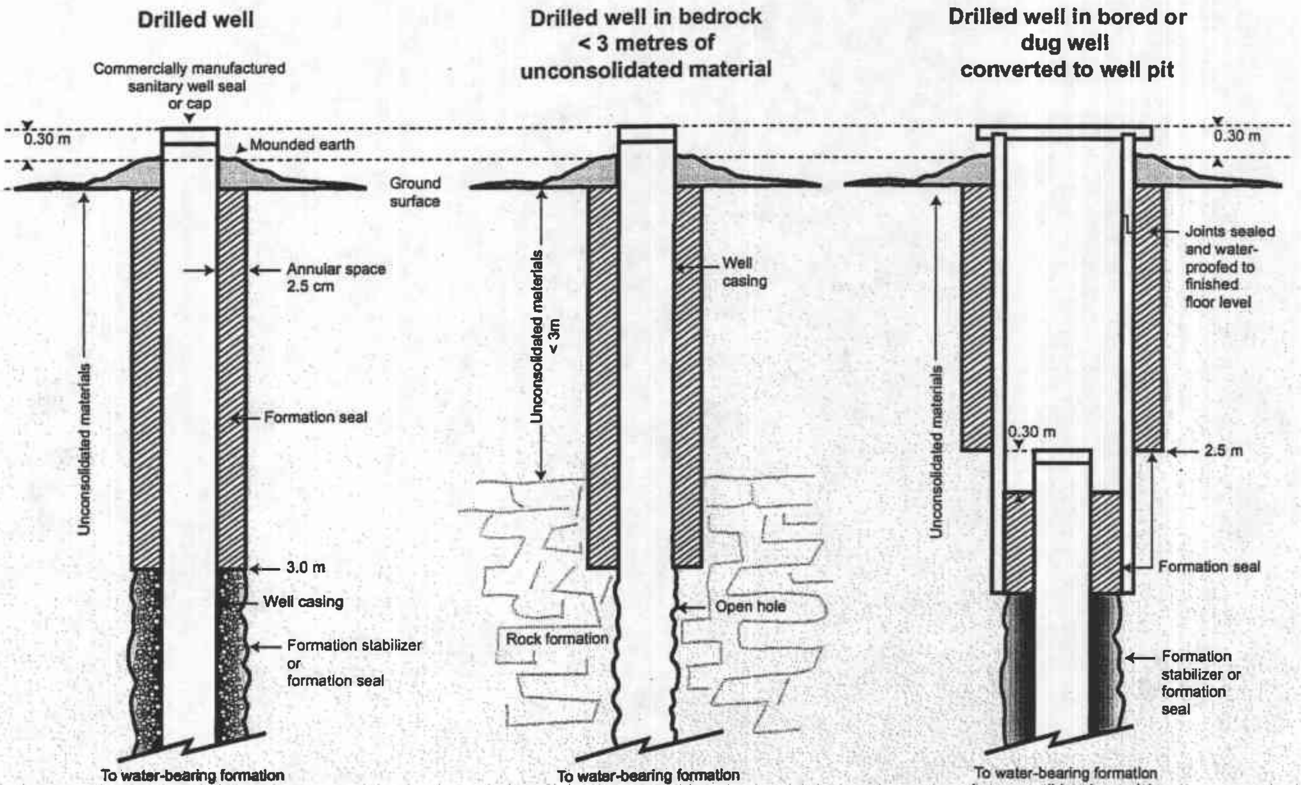
There are some additional publications you may wish to read. You can obtain a copy of the *Regulation 903* itself. The Ministry of the Environment also has factsheets titled:

- *The protection of water quality in bored and dug wells*
- *Important facts about well construction*
- *Recommended methods of plugging abandoned water wells.*

For further information about wells contact your nearest Ministry of the Environment office as listed in the blue pages of your telephone directory.
Or call the ministry's public information centre at 1-800-565-4923.
In Toronto call 416-325-4000.
The ministry's Web site is at www.ene.gov.on.ca.

Green facts

Drilled wells and their sealing requirements



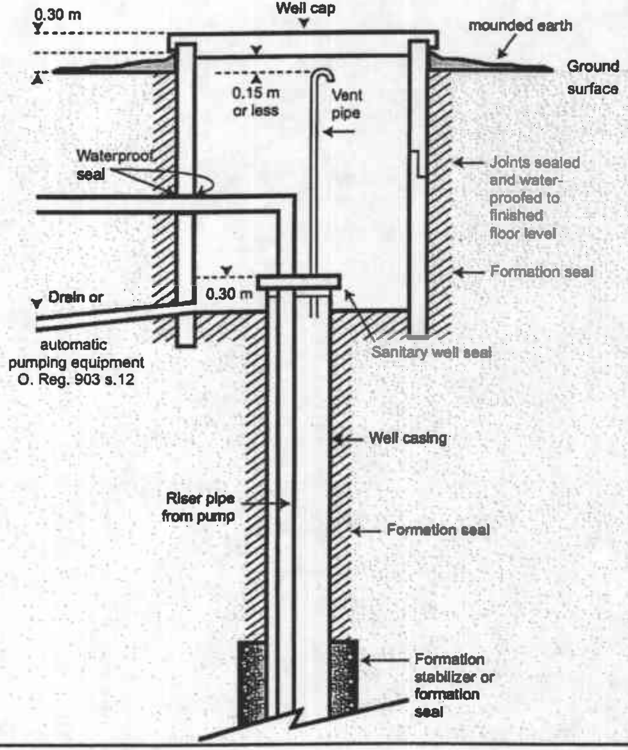
Drilled well

Drilled well in bedrock < 3 metres of unconsolidated material

Drilled well in bored or dug well converted to well pit

in unconsolidated materials or rock	in rock	in unconsolidated materials or rock

Well pit construction



▨ **Formation seal**

Can be composed of portland cement grout, concrete, bentonite, equivalent commercial slurry or clay slurry. For details on selection and placement, see O. Reg. 903 s.14

▩ **Formation stabilizer**

Can be composed of clean washed sand or gravel, clean overburden materials or cuttings.

NOTE:
all dimensions are minimum construction standards