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Golder Associates

Final Report

REPORT ON

HYDROGEOLOGICAL EVALUATION FOR COMMUNAL WATER SUPPLY

PROVOST CARTAGE PROPERTY

VILLAGE OF WINCHESTER WATER SUPPLY STUDY

Submitted to:

J.L. Richards and Associates Limited
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Golder Associates

February 23, 1995

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J.L. Richards & Associates Limited
864 Lady Ellen Place
Ottawa, Ontario
K1Z 5M2

Attention: Mr. R.P. Cheek, P.Eng.

RE: HYDROGEOLOGICAL EVALUATION
COMMUNAL WATER SUPPLY
PROVOST CARTAGE PROPERTY
VILLAGE OF WINCHESTER WATER SUPPLY STUDY

Dear Sirs:

This submission presents our final hydrogeological report on the proposed communal water supply at the Provost Cartage property. The purpose of this water supply is to augment the existing water supply which serves the Village of Winchester. This final report incorporates, where appropriate, the comments received on the initial draft report from review agencies and the public resulting from the January 19, 1995 public information Open House. This report forms part of the Class Environmental Assessment documentation for this project.

Yours truly,

GOLDER ASSOCIATES LTD.
Environmental Division

K.A. Marentette, M.Sc.
Hydrogeologist

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Principal

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EXECUTIVE SUMMARY

This report provides a hydrogeological assessement of the potential of an overburden aquifer in the vicinity of the Provost Cartage property to satisfy the long term water supply requirements of the Village of Winchester. The present requirement is an additional 23 Litres per second (300 Igpm). The target for a groundwater supply of this magnitude is the Morewood esker at a location where it outcrops on the Provost Cartage property. The Provost Cartage property is located about 7 kilometres northeast of the Village of Winchester. The study included a two phase borehole drilling and monitoring well installation program; a test well construction program; and, a test well and aquifer pumping test program.

Based on a review of available geological data, the Morewood esker aquifer is interpreted to be about 600 to 1000 metres in width with the central gravel core indicated to be up to 150 metres wide. The saturated thickness of the aquifer is interpreted to be about 9 metres. The central part of the esker is unconfined whereas the east and west flanks are confined by (overlain by) a silty clay/clayey silt deposit.

A long term pumping test on a 30 centimetre diameter test well was conducted for a period of 30 days at a pumping rate of 2127 m^3/day (325 Igpm). The water quality testing conducted during the 30 day pumping test demonstrated that the groundwater quality meets Ontario Drinking Water Objectives.

The hydraulic response defined during the 30 day pumping test demonstrated a slowly expanding cone of influence. The area characterized by maximum drawdowns (based on November 4, 1994 water level data) in excess of 1 metre is limited to the zone within about 130 metres of the test well. The 20 year safe yield of the aquifer is estimated to range from 2252 to 2380 m^3/day (344 to 364 Igpm) based on empirical methods.

The maximum drawdowns during the 30 day pumping test in the closest domestic Lafleur and Groves wells were 0.36 and 1.02 metres, respectively. The maximum drawdowns in the Lafleur and Groves wells based on 365 days of continuous pumping at 2127 m^3/day (325 Igpm) with no aquifer recharge are estimated to be approximately 0.8 and 1.7 metres, respectively. These estimated drawdowns are not likely to impact on the water supply wells.

Based on data obtained during the pumping test, the point of zero drawdown was estimated to be located at a distance of about 3500 metres from the test well. As such, based on the large separation distances between the Provost Cartage property and the Embrun and Chesterville wells, it is concluded that the development of the communal water supply on the Provost Cartage property will not adversely impact the other municipal supply wells.

Based on the information collected during the water supply investigation, a proposed water resources protection strategy was prepared for the Morewood esker. The proposed water resources protection strategy comprises the delineation of a wellhead protection area (WHPA) in association with the development of a "Best Management Plan" (BMP) for activities associated with specific sub-areas within the WHPA. The primary components of the BMP include an inventory of potential contaminants and contaminant pathways within the WHPA; a groundwater monitoring; a public education program; a Water Resources Protection Committee; and, a compensation policy.

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1.0 INTRODUCTION

Golder Associates has been retained by J.L. Richards & Associates Limited for the Village of Winchester to assess the hydrogeological potential of an overburden aquifer in the vicinity of the Provost Cartage property, located about 7 kilometres northeast of the Village of Winchester (Figure 1). This assessment was carried out between June 1994 and December 1994 as a component of the ongoing Village of Winchester water supply study.

1.1 Background

The Village of Winchester and the Provost Cartage property are located in the Township of Winchester within Dundas County. The Village currently derives its water supply from four pumping wells completed in bedrock. Historically on average, these wells produce at a combined rate of about 23 Litres per second (300 Imperial gallons per minute). During an information session held on December 13, 1994, it was noted by Mr. D. Black of the Ontario Clean Water Agency (OCWA) that the wells are currently producing only about 180 Imperial gallons per minute (Igpm). Two other wells exist but are not normally utilized; one because of poor water quality and the other due to limited capacity. In 1984, the Ministry of Environment recommended that an additional 37.9 Litres per second (500 Igpm) be developed to meet future demand. The August 1992 Preliminary Findings report prepared by J.L. Richards & Associates Limited has concluded that the existing water supply needs to be augmented by an additional 23 Litres per second (300 Igpm) to satisfy the projected maximum day demand for a 20 year design period.

In an effort to identify potential groundwater supplies, Golder Associates was retained by J.L. Richards & Associates Limited to undertake a Phase I review of existing hydrogeological information (Golder Associates, 1989). As part of this review, two areas were identified which warranted additional investigation: one area in bedrock about 9 kilometres west of Winchester; the other area in the overburden about 6 kilometres east of Winchester.

In 1990, Phase II of the hydrogeological investigation commenced. This work focused on test drilling and pump testing in the two areas identified in Phase I. The results of this program are provided in Golder Associates (1990). In summary, the bedrock test well only produced about 4 Litres per second (50 Igpm) with elevated levels of chloride. Similarly, the overburden test well was only capable of supplying some 7.6 Litres per second (100 Igpm). However, water quality was determined to be suitable for a municipal supply and the pumping test results suggested that aquifer conditions improved to the north (i.e., in the direction of the D. St. Pierre and Provost Cartage gravel pits).

Following discussions in December 1991, permission was granted by Mr. D. St. Pierre, the owner of one of the gravel pits, to perform a pumping test from an existing 200 millimetre outside diameter well which was installed in the pit in 1988. There are reportedly no slots in the pipe; the well apparently consists of an open ended pipe completed to a depth of about 9 metres below grade. Although well efficiency would likely be low, the well was considered acceptable for a pumping test since additional observation wells were completed in the overburden aquifer as part of the pumping test program. The work program conducted at the St. Pierre Pit included a short term and longer term pumping test, borehole drilling and monitoring well installation program, and groundwater quality determination. The results of this investigation indicated that the water supply potential of the overburden aquifer was favourable for the development of a long term water supply for the Village of Winchester. Details pertaining to the investigation at the St. Pierre Pit are presented in Golder Associates (1992a).

In July 1992, ten boreholes were drilled in the area of the St. Pierre Pit to investigate the nature and quantity of the granular resources in this area. This investigation included borehole drilling, soil sampling, grain size distribution analyses, installation of monitoring wells, surveying of monitoring wells and ground surface elevations at all boreholes, measurement of groundwater levels, and a survey of ground surface spot elevations in the vicinity of the pit. Details pertaining to this study are provided in Golder Associates (1992b).

Although the results of the investigations on the St. Pierre property were favourable in terms of developing a communal water supply, an Option to Purchase a well site on the St. Pierre property could not be successfully negotiated. Consequently, discussions were initiated with Provost Cartage in an attempt to obtain an Option to Purchase on another property in the vicinity which is located within the same aquifer. The Provost Cartage property is located to the north and east of the St. Pierre property. An Option to Purchase a 2.6 hectare (6.5 acre) parcel of land was subsequently obtained.

1.2 Study Objectives

The overall objective of this study was to assess the potential of the aquifer underlying the Provost Cartage property to satisfy the long term water supply requirements of the Village of Winchester. As noted previously, the present goal is an additional 23 Litres per second (300 Igpm).

2.0 REGIONAL SETTING

2.1 Physiography and Soils

The area between the Village of Winchester and north of the Provost Cartage property includes several physiographic regions. Much of this area is an extensive clay plain characterized by flat to gently sloping topography and imperfect to poorly drained soils. The subsoil is a clay or silty clay loam which in many areas, particularly north of Winchester, requires artificial drainage in the form of open ditches and/or tile drains (Matthews and Richards, 1952).

The second largest physiographic division is the till plain north of Winchester and northeast of the Provost Cartage property. In this area the topography is undulating to slightly rolling. The subsoil varies from clay loam to sandy loam and the natural drainage is highly variable.

The most distinctive feature in the area however is the glaciofluvial outwash deposits that form the Morewood esker. The Morewood esker is an extensive north-south trending linear feature that is mappable from about 2 kilometres south of the Provost Cartage property to about 6 kilometres north (Figure 2). Local relief is generally less than 5 metres.

The Morewood esker consists of poorly to well sorted sand to gravel deposits. Natural drainage is good. The hydraulic characteristics of the materials comprising the esker indicate good groundwater supply potential as discussed in Section 2.3.

2.2 Geology

The general geology is briefly summarized below in terms of the bedrock and overburden units. More complete descriptions are provided in Wilson (1946) and Williams (1985).

2.2.1 Bedrock

Bedrock is encountered at depths ranging from 0 to about 20 metres below ground surface. It consists of a series of Lower to Middle Ordovician sedimentary rocks that dip eastward along a major synclinal structure (Wilson, 1946).

The oldest unit to outcrop in the area is the fine crystalline Oxford Formation. This unit is overlain by shales and sandstones of the Rockcliffe and St. Martin Formations. The Rockcliffe Formation is in turn overlain by the extensive Ottawa Formation. The Ottawa Formation consists of shale, sandstone, limestone and dolomite.

Bedrock outcrops are limited although several occur along escarpments north of Winchester and Morewood.

2.2.2 Overburden

The unconsolidated deposits overlying bedrock comprise an assortment of till, ice-contact stratified drift, and Champlain Sea marine clays, sands, and gravels (Geological Survey of Canada, 1982). These sediments are deposited over bedrock and are generally 0 to 20 metres thick.

As noted earlier, the north-south trending Morewood glaciofluvial complex is the prominent overburden feature between the Villages of Winchester and Morewood (Figure 2). One other large glaciofluvial complex occurs at Maple Ridge about 4 kilometres southeast of the Village of Winchester. The relationship or interconnection between this feature and the Morewood complex is uncertain; however, during the borehole investigation carried out as part of the Village of Winchester water supply study in 1990, coarse granular deposits were generally not found in the land area between these two identified complexes. Both complexes are currently utilized as municipal groundwater supplies.

2.3 Water Resources

Water resources in the area originate from both bedrock and overburden aquifers. A more complete discussion of the existing municipal wells in the Village of Winchester is provided in Golder Associates (1989). As noted, Winchester currently derives its water supply from four bedrock pumping wells that are producing, as of December 1994, a combined total of about 14 Litres per second (180 Igpm). In the past, and at present, some problems have been experienced with regard to diminished well yield and water quality including elevated chloride, hydrogen sulphide, and iron concentrations.

The Village of Chesterville is about 10 kilometres east of Winchester. Municipal water supplies are derived from three pumping wells. Two pumping wells are completed in a river connected gravel aquifer located in a bedrock depression west of the Village (Water and Earth Sciences Associates Ltd., 1988). The third well is completed in the glaciofluvial complex located about 5 kilometres west of the village at Maple Ridge (Figure 2). The aquifer is reportedly capable of delivering in excess of 23 Litres per second (300 Igpm) with minimal groundwater level decline (Water and Earth Science Associates Ltd., 1988). Water quality is acceptable. It is understood that the only water treatment required for this water supply is chlorination.

The Village of Embrun draws its groundwater supply from two high capacity wells completed in what may be a northern extension of the Morewood glaciofluvial complex (Figure 2) (Geo-Analysis Inc., 1990). The aquifer is capable of delivering in excess of 300 Igpm (Geo-Environ Limited, 1982; Geo-Analysis Inc., 1988), with the wells having been pump tested at up to 50 Litres per second (670 Igpm) with favourable results. It is proposed that these wells will serve both Embrun and Marionville in the future with a projected 20 to 25 year future combined population of 12,000 persons (Township of Russell, 1994). In terms of water quality, Lecompte Engineering Limited (1993) indicated that the Embrun well is to be provided with a treatment system to remove hydrogen sulphide, methane, iron, manganese, colour and turbidity.

The Village of Russell obtains it municipal groundwater supply from two wells located to the south of the Village. These wells are completed in bedrock and have been in service since 1989.

The Village of Morewood is currently serviced by individual private wells. It is understood that an application has been recently made to obtain funding to investigate the feasibility of a communal water supply for the Village.

3.0 INVESTIGATION PROCEDURES

3.1 Borehole Drilling and Monitoring Well Installation Program

The borehole drilling and monitoring well installation program was completed in two phases.

Phase I was conducted between May 20 and 27, 1994 during which time a total of six boreholes (identified as boreholes 94-1, 94-2, 94-3, 94-4, 94-5 and 94-6) were drilled. The objective of the Phase I program was to investigate the geological and hydrogeological conditions in the area of the Provost property with respect to the potential for development of a communal water supply. Phase II was conducted between September 19 and 22, 1994 during which time a total of six boreholes (identified as boreholes 94-7, 94-8, 94-9, 94-10, 94-11 and 94-12) were drilled. The objective of the Phase II program was to complete the installation of a network of monitoring wells adequate for monitoring the aquifer response during the long term pumping test. All boreholes were drilled using a CME-55 track mounted hollow stem auger/rotary drill rig supplied and operated by Marathon Drilling Co. Ltd. of Gloucester, Ontario under the full time supervision of a member of Golder Associates field technical staff.

The borehole locations are shown on Figure 3 along with the locations of other boreholes within the study area which were previously drilled by Golder Associates and Water and Earth Science Associates Ltd.

All boreholes were drilled using 200 millimetre diameter hollow stem augers. The boreholes were advanced to depths ranging from 8.1 metres (borehole 94-3) to 12.3 metres (borehole 94-11) below ground surface. All boreholes were terminated within the overburden. The overburden was generally sampled at 1.5 metre intervals of depth using a 50 millimetre diameter split spoon sampler in conjunction with performing the standard penetration test. Rotary drilling techniques were used during the drilling of borehole 94-6 because auger refusal was experienced on boulders and cobbles within the overburden at this location. The soil samples recovered from the boreholes during the drilling program were visually described in the field and returned to our laboratory in Ottawa for further examination and for laboratory analyses on selected samples. The grain size distribution curves are presented in Appendix B.

All boreholes (except boreholes 94-8 and 94-9) were completed with a single monitoring well installation. Boreholes 94-8 and 94-9 were completed with two monitoring well installations. The convention adopted in this report is that the deeper monitoring well at each borehole location is designated as monitoring well "A" and the shallower well at the same borehole location is referred to as monitoring well "B", where appropriate. No alphabetic designation is provided at borehole locations with only a single monitoring well installation.

The monitoring wells were installed in the boreholes to allow subsequent measurement of groundwater levels, groundwater sampling and in situ hydraulic testing. The monitoring wells consist of a 1.5 metre length of 38 or 50 millimetre diameter, schedule 40, #10 slot, PVC screen which extends to ground surface by means of a 38 or 50 millimetre diameter, schedule 40, flush threaded, PVC casing. Native material or a silica sand backfill (granular filter) was placed below, around and above the screened intervals in the monitoring wells. Bentonite seals were placed in the boreholes at specific intervals to isolate the screens over specific intervals of depth and/or to provide a surface seal. The monitoring wells in boreholes 94-6 through 94-12 were provided with steel protective casings.

The geodetic elevations of ground surface and top of the monitoring well casings (or other groundwater measurement datum) at each borehole location (including WESA16) as well as at the Lafleur, Misener and Groves drilled wells and the test well were surveyed by J.L. Richards & Associates Limited. The radial distance between the test well and the monitoring wells and drilled wells were also determined by J.L. Richards & Associates Limited. The data are provided in the following table:

Well Location	Ground Surface Elevation (metres)	Groundwater Measurement Datum		Radial Distance From Test Well (metres)
		Elevation (metres)	Description	
WESA16	78.50	78.50	TOC	1747.7
94-1	76.26	77.31	TOC	26.3
94-2	76.19	77.18	TOC	3.5
94-3	76.24	77.25	TOC	118.8
94-4	77.52	78.60	TOC	111.8

Well Location	Ground Surface Elevation (metres)	Groundwater Measurement Datum		Radial Distance From Test Well (metres)
		Elevation (metres)	Description	
94-5	76.23	77.16	TOC	182.5
94-6	82.79	83.55	TOC	709.1
94-7	80.56	80.47	TOC	67.8
94-8A	74.65	74.63	TOC	362.2
94-8B	74.65	74.64	TOC	362.2
94-9A	73.08	73.08	TOC	694.3
94-9B	73.08	73.08	TOC	694.3
94-10	76.59	76.77	TOC	648.6
94-11	82.62	82.52	TOC	875.4
94-12	79.58	79.51	TOC	1567.0
Groves Drilled Well	82.05	81.87	Top of Concrete Pad	122.2
Lafleur Drilled Well	80.68	80.69	Top of Plywood	678.0
Misener Drilled Well	76.50	77.19	TOC	1674.3
Test Well	76.00	76.68	TOC	-

NOTES: All elevations are geodetic
TOC - Top of Casing

Rising head tests were performed in monitoring wells in boreholes 94-1, 94-2, 94-3, 94-4, 94-5, 94-6, 94-7, 94-8 (deep monitor), 94-9, 94-10, 94-11 and 94-12 to obtain an indication of the horizontal hydraulic conductivity of the geological unit adjacent to the screened intervals. The results of the rising head tests are presented in Appendix C.

3.2 Test Well Construction Program

On completion of the Phase I borehole drilling and monitoring well installation program, a significant potential for development of a high capacity water supply on the Provost property had been defined. As a consequence, Olympic Drilling Co. Ltd. was contracted to construct a 30 centimetre diameter test well. The well is located near the southwest corner of the land comprising the Option to Purchase as shown on Figure 3.

To define the specific design requirements for the test well, such as well depth and screen length and slot sizes, data obtained from borehole 94-2 were utilized. The borehole log (Appendix A-III) and grain size distribution curves (Appendix B) provided the data necessary to design the test well.

The test well design includes 6 metres of nominal 30 centimetre diameter stainless steel well screen of variable slot size between 4 and 10 metres depth below ground surface. The variable screen slot size was required to optimize the well capacity based on observed formation grain size distributions. Steel casing, also 30 centimetres in diameter, extends from approximately 0.6 metres above ground surface to the top of the screen at a depth of 4.0 metres below ground surface. A 40 centimetre diameter casing was also installed to a depth of 10 metres to allow placement of the artificial gravel pack; this casing was subsequently pulled back to a depth of 6.1 metres as the gravel packed was installed. A 50 centimetre diameter casing was also installed during drilling to a depth of 4.6 metres to allow final grouting; this casing was removed once the grouting had been completed.

A schematic drawing of the test well is shown on Figure 4.

The test well was developed by air lifting and pumping with a vertical shaft turbine pump for a period of approximately 70 hours. The turbidity of the discharge water was less than 1 Nephelometric Turbidity Unit after the development period.

3.3 Test Well and Aquifer Pumping Test Program

3.3.1 Well Step Tests

Well and aquifer pumping test programs are required to define the hydraulic capabilities of the test well and aquifer. The hydraulic properties of the test well were defined by a series of step tests conducted on September 23, 1994. The step tests demonstrated a high capacity well with 3.94 metres of drawdown at pumping rates varying from an initial rate of 1364 Litres per minute (300 Igpm) to 2045 Litres per minute (450 Igpm). The step test pumping data are presented in Appendix E.

The step test data demonstrated that a long term aquifer pumping test at 1477 Litres per minute (325 Igpm), which is somewhat above the requirement of 1364 Litres per minute (300 Igpm), would be feasible and practical based on the available drawdown and the proposed duration of the long term test.

3.3.2 30 Day Aquifer Test

Prior to conducting the 30 day aquifer test, a Permit to Take Water (dated July 21, 1994) was obtained from the Ministry of Environment and Energy. A copy of the Permit To Take Water is provided in Appendix I. In accordance with Condition 2 of the Permit To Take Water, groundwater samples were collected from the Lafleur and Groves drilled wells prior to conducting the test and the water levels in these two private wells were monitored during the testing period. The groundwater quality data from these domestic wells are presented in Appendix D.

Prior to commencing the pumping test, static water levels were taken in the test well, the Lafleur and Groves drilled wells and all available/accessible monitoring wells. The 30 day pumping test was conducted at a pumping rate of 1477 Litres per minute (325 Imperial gallons per minute) using a temporary Ontario Hydro service for pump power. The 30 day pumping test was conducted between October 5 and November 4, 1994. The pumping rate was maintained at a constant flow value by means of an orifice meter with flow control valve. The discharge from the pumping test was directed through a pipeline to a municipal drain located about 400 metres northeast of the test well.

Drawdown data were collected on a regular basis for a group of key monitors and three private drilled wells spread over a distance of approximately 3.5 kilometres north and south along the Morewood esker alignment. Authorization to monitor water levels in the Misener well was not received until after the pumping test started and thus the static water level prior to pumping is not known. Permission to access monitoring wells in the 1989 and 1992 series boreholes was not granted by the property owners and therefore water levels in these monitors could not be obtained during the pumping test.

The drawdown data and the hydrogeological evaluation of this drawdown data (where possible) using an in-house digital system based on the conventional Cooper and Jacob (1946) methodology are presented in Appendix F.

Upon completion of the 30 day pumping period, the pump was turned off and collection of recovery data commenced. The recovery data were collected between November 4 and December 19, 1994. The recovery data and the hydrogeological evaluation of this recovery data (where possible) using an in-house digital system based on the conventional Cooper and Jacob (1946) methodology are presented in Appendix G.

A comprehensive groundwater quality sampling and analytical testing program was conducted during the 30 day aquifer pumping test. Groundwater samples for general water quality characterization were collected from the test well on October 5, October 18 and October 26, 1994. A comprehensive water analysis encompassing the full scope of the Ontario Drinking Water Objectives (Ministry of Environment and Energy, 1994) was carried out on a sample collected on November 3, 1994.

The nitrate and atrazine levels in groundwater in the vicinity of the test well were periodically assessed during the pumping test. Additional groundwater samples were collected from the test well on October 11 and 28, 1994 and submitted for nitrate analyses only. Atrazine was monitored in the groundwater from the test well based on a sample collected on October 18, 1994. Groundwater samples were collected on October 18, October 26 and November 3, 1994 from the monitoring wells in boreholes 94-1 through 94-7; these samples were submitted for nitrate analyses. The temperature, pH, conductivity, turbidity, hydrogen sulphide and residual chlorine levels of the groundwater pumped from the test well were monitored periodically during the pumping test. All groundwater quality data obtained from the test well and monitoring wells during the 30 day aquifer test are presented in Appendix H.

All groundwater samples were collected using appropriate sampling and preservation techniques, placed in coolers with ice packs and delivered to Accutest Laboratories Ltd. in Nepean, Ontario.

Information on the general groundwater quality on the portion of the D. St. Pierre property in the vicinity of the St. Pierre Pit is available from work completed by Golder Associates in 1992. These data are provided in Appendix K.

4.0 GEOLOGICAL CONDITIONS

Geological logs for boreholes drilled during previous investigations by Water and Earth Science Associates Ltd. (1988) and Golder Associates (1990, 1992b) are provided in Appendices A-I and A-II, respectively. A log of the geological conditions encountered in each of the 12 boreholes drilled during the 1994 investigation program together with details of the monitoring well installations are given on the Record of Borehole Sheets in Appendix A-III. It is noted that the boundaries between strata on the Record of Borehole Sheets have been inferred from observations during drilling and non-continuous sampling and, as such, their positions should be considered as transitional in nature rather than an exact plane of geologic change. Natural variations other than those encountered in the boreholes should also be expected to exist. The overburden samples submitted for laboratory analyses are identified on the Record of Borehole Sheets; the results of the grain size distribution analyses are provided in Appendix B. The locations of all boreholes are shown on Figure 3.

This section of the report is a general overview of the general geological conditions within the study area based on the data from the available boreholes and with specific reference to the hydrostratigraphic cross-sections which are presented on Figures 5, 6 and 7. These cross-sections were prepared for the purpose of illustrating the interpreted extent of the Morewood esker in the subsurface and the relationship between the granular deposits of this linear feature and the geological units which flank the east and west sides of the esker. The locations of the section lines are shown on Figure 3. These sections have been prepared based on the geological data obtained from a limited number of boreholes which are widely distributed across the study area. Geological correlations between boreholes have been interpolated and are presented on the sections for illustrative purposes only.

In general, eight overburden stratigraphic units have been identified within the study area. These stratigraphic units are as follow: fill, topsoil, silty sand and gravel, silty clay/clayey silt, sand and gravel/sandy gravel/gravel, sand, silty sand/sandy silt/silt, and glacial till. Data pertaining to the underlying limestone bedrock were obtained from the reported depths to bedrock in the Groves drilled well and the St. Pierre bedrock well.

Hydrostratigraphic Cross-Section A-A (Figure 5)

Figure 5 presents a north-south cross-section along the long axis of the Morewood esker. This section illustrates that the coarser grained sand and gravel deposits are more predominant along the northern part of the section between boreholes 94-7 and 92-4 where the Provost Cartage pit and present extent of the D. St. Pierre pit are located. This characteristic may indicate that the northern part of the section line is coincident with the coarser core of the linear esker deposit. The thickness of the sand and gravel deposits along the northern part of cross-section A-A likely ranges from about 10 to 15 metres. The sand and gravel is underlain by glacial till. The actual thickness of the glacial till is not known because bedrock was not proven by coring at any of the borehole locations.

Along the southern part of cross-section A-A, the predominant overburden geological unit in the vicinity of County Road 3 is sand although some sand and gravel zones were encountered in boreholes 89-1, 89-3 and 89-16. In boreholes 89-1, a near surface layer of silty clay and silty sand and gravel was reported. The silty sand and gravel was encountered as the surficial layer in borehole 89-3.

The interpreted thickness of the glacial till deposit varies considerably along the southern part of cross-section A-A from about 2 metres between borehole 92-6 and the St. Pierre bedrock well to greater than 8 metres in borehole 89-3.

Hydrostratigraphic Cross-Section B-B (Figure 6)

Figure 6 presents an east-west cross-section just south of Thompson Road which is perpendicular to the long axis of the Morewood esker. This section illustrates the stratigraphic relationships between the coarser deposits which comprise the aquifer material and the finer grained material which lap onto the granular deposits. The sand and gravel core of the deposit was encountered in boreholes 94-1 and 94-2 where it attains a maximum thickness of about 9 metres. The core is interpreted to be up to 150 metres wide. In boreholes 94-3 and 94-4, the sand and gravel core is absent as it appears to pinch out or grade into a more sandy aquifer material which flanks the core.

It is understood (P. Provost, personal communication) that greater than 10 years ago sand and gravel material had been excavated from the pit northward to reach near the edge of the Thompson Road. It was necessary to re-instate this required buffer area between the limit of excavation and Thompson Road. This was done by infilling with clay, boulders and concrete from a nearby construction project; as well, the fill contains some stumps and the remains from a burnt shed. As such, the upper part of the subsurface along the north edge of the Option to Purchase consist of fill materials.

In boreholes 94-8 and 94-9 further to the west, the sand deposit is overlain by about 5.5 to 6 metres of finer grained silty clay/clayey silt deposits. In borehole 94-9, the sand is underlain by a finer silty sand unit.

At borehole 94-10 to the east, the granular deposits of the aquifer are absent and the silty clay/clayey silt directly overlies the glacial till. This indicates that the sand deposit pinches out between boreholes 94-3 and 94-10. Along cross-section B-B, the glacial till slopes from about elevation 74 metres in borehole 94-10 down to at least elevation 63 metres in the area of borehole 94-9.

Based on the interpretation presented on cross-section B-B, the width of the Morewood esker in the subsurface could range from 600 to 1000 metres with the unit being confined along its west and east flanks by the silty clay/clayey silt deposit.

Hydrostratigraphic Cross-Section C-C (Figure 7)

Cross-section C-C on Figure 7 also presents an east-west cross-section which is perpendicular to the long axis of the Morewood esker. The sand and gravel core of the deposit was encountered in borehole 94-11 where it is interpreted to attain a maximum thickness of about 17 metres. The core is interpreted to be up to 150 metres wide. At boreholes 92-5 and 89-13, the sand and gravel core is absent as it appears to pinch out or grade into a more sandy aquifer material. In boreholes 92-5 and 92-8A, the sand is overlain at surface by finer grained sandy silt, silty sand, and clayey silt. Glacial till was encountered in boreholes 92-5 and 92-8A at about elevations 67 metres and 72 metres, respectively.

Hydrostratigraphic Cross-Section D-D (Figure 7)

Cross-section D-D on Figure 7 presents an east-west cross-section which is perpendicular to the long axis of the Morewood esker near its southern limit at County Road 3. A sand and gravel zone was encountered at surface (above the groundwater table) in borehole 89-16 where it attains a thickness of about 4 metres. The sand and gravel is underlain by a sand sheet which is interpreted to be laterally extensive in the subsurface based on the geological data available from boreholes 89-4, 89-11, 89-12A and 89-16. Along the eastern and central parts of cross-section D-D, the sand is overlain by 2 to 3 metres of silty sand, sandy silt and silt. An interbed of silty clay/clayey silt was reported in borehole 89-11. The elevation of the glacial till surface is variable along this section line.

5.0 PHYSICAL HYDROGEOLOGY

The static groundwater levels measured on October 5, 1994 are shown on Figure 8. The static water levels measured on October 5, 1994 are also shown on Figures 5, 6 and 7 and on the Record of Borehole Sheets in Appendix A-III. For the monitoring wells constructed prior to the present investigation, static water levels from various dates are presented on Figures 5, 6 and 7 and on the logs presented in Appendices A-I and A-II.

Based on the results of the rising head tests (Appendix C), correlations with the grain size distribution curves presented in Appendix B using the Hazen formula (Freeze and Cherry, 1979), and experience from previous projects, the estimated horizontal hydraulic conductivities (K) of the major overburden geological units within the study area are presented below:

Geological Units	Estimated Range for K	Comments
Sand and Gravel	10^{-2} or greater	Coarse granular deposits comprising core of Morewood esker
Sand	10^{-2} to 10^{-4}	Granular deposits flanking core; grades into silty sand along west and east limits of feature
Glacial Till	10^{-4} to 10^{-5}	Underlies the esker deposits and overlies bedrock
Silty Clay/Clayey Silt	10^{-6}	Confining layer which blankets flanks of Morewood esker

The measured groundwater levels indicate that there is some 9 metres of saturated thickness in the overburden aquifer. The direction of local groundwater flow, under natural conditions, was assessed based on the October 5, 1994 water level elevation data. As would be expected in permeable coarse grained deposits, the variation in groundwater elevations across the study area is small.

As shown on Figure 8, the water level data suggest that there are components of groundwater flow to the northeast and to the southwest from monitoring well 94-11. The horizontal hydraulic gradients across the study area and within the esker complex (i.e., between monitoring wells 94-11/94-7 and monitoring wells 94-11/WESA16) are estimated to range from 0.0001 to 0.0004 (i.e., about 10^{-4}).

The natural groundwater flow velocity under non-pumping conditions can be estimated from Darcy's Law:

$$v = Ki/\Theta$$

where:

where:	v	=	average linear groundwater flow velocity (cm/s)
	K	=	average hydraulic conductivity; estimated from grain size correlation, rising head test data and pumping test analyses (cm/s)
	i	=	horizontal hydraulic gradient
	Θ	=	effective porosity

Assuming a horizontal hydraulic conductivity of 10^{-2} cm/s, a hydraulic gradient of 0.0001 to 0.0004, and an effective porosity of 0.25, an average linear groundwater flow velocity of 4×10^{-6} centimetres per second or about 1 to 5 metres per year is estimated along the long axis of the Morewood esker. A similar groundwater flow velocity of 10 metres per year was presented in Golder Associates (1992a).

6.0 AQUIFER PUMPING TEST ANALYSIS

6.1 Aquifer Properties and Hydraulic Response

The pumping test data and analysis of time/drawdown response based on Cooper and Jacob (1946) methods for each monitored well are presented in Appendix F and summarized in Table F-1. The transmissivity estimates based on the time/drawdown relationship for the 1477 Litres per minute (325 Igpm) pumping rate range from approximately 490 to 970 square metres per day (m^2/day). These values are lower than the transmissivity value defined from the test well based on the initial 48 hours of the pumping test (2100 m^2/day), due to the somewhat steeper yet constant time/drawdown relationship which developed during the later stages of the pumping test as a result of the drawdown cone intercepting the anticipated lower permeability or barrier boundaries. The transmissivity value defined from the test well based on the later time/drawdown data is about 340 m^2/day; this value is lower because the saturated thickness of the unconfined aquifer in the vicinity of the test well decreased considerably (about 50 percent) during the course of the pumping test. The extra drawdown in the immediate area of the test well reflects the actual reduction in the transmissivity of the aquifer as it locally becomes partially dewatered.

Transmissivities of 490 to 970 m^2/day are representative of the highly permeable sands and gravels that make up the core of the aquifer. Similar transmissivity values ranging from 400 to 700 m^2/day were determined from a 28 day pumping test in a sand and gravel esker feature in the Limoges area (Golder Associates, 1994). Aquifer transmissivity values of about 1000 m^2/day were reported for the existing Chesterville and Embrun production wells, although these values are based on data from 72 hour pumping tests, i.e. relatively high calculated transmissivity after only several days of pumping.

The recovery data and analysis of time/residual drawdown response based on Cooper and Jacob (1946) methods for each monitored well are presented in Appendix G and summarized in Table G-1. The transmissivity estimates based on the time/residual drawdown relationship for the 1477 Litres per minute (325 Igpm) pumping rate range from approximately 1100 to 1500 m^2/day. These values are higher than transmissivity values defined from time/drawdown data.

The distance-drawdown plot of Figure 9, for the test well and selected monitoring wells and private drilled wells along the long axis of the esker to the north (1567 metres) and south (1748 metres) of the Provost property indicate the highly permeable nature of the aquifer with an estimated transmissivity of 1100 m^2/day. The transmissibility values developed from the time/drawdown plots of Appendix F, are in the order of 50 to 75 percent of these values, apparently showing the influence of the negative boundary associated with lower permeability materials along the esker flanks. The transmissibility values developed from the time/residual drawdown plots of the recovery data in Appendix G, are generally similar to those obtained from the distance-drawdown plot of Figure 9.

The storage coefficient of unconfined aquifers (such as the central core of the Morewood esker) is much higher than the storativities of confined aquifers. The higher values reflect the fact that releases from storage in unconfined aquifers represent an actual dewatering of the pore spaces, whereas releases from storage in confined aquifers represent only the secondary effects of water expansion and aquifer skeleton (sand and gravel) expansion caused by changes in fluid pressure. The favourable storage properties of unconfined aquifers, coupled with the potential for local recharge on an annual basis, can make them more efficient for exploitation by wells than confined aquifers. When compared to confined aquifers, the same yield can be realized with smaller head changes over less extensive areas. An artesian aquifer can be converted to a quasi water table condition by over pumping or mining of aquifer water. The usual range for the storage coefficient for unconfined aquifers is 0.01 to 0.30 (Freeze and Cherry, 1979). The storage coefficient estimates based on the time/drawdown relationship for the 1477 Litres per minute (325 Igpm) pumping rate range from approximately 0.02 to 0.32 which is within the typical range for unconfined aquifers.

The average storage coefficient for the 30 day pumping test can be estimated from the approximate volume of the drawdown cone relative to the total pumping volume. The drawdown cone at the end of the 30 day test was approximately 5,000 metres long (see Figure 9) and 800 metres wide with an estimated average drawdown of 0.4 metres. The total pumping volume over the 30 days was approximately 64,000 cubic metres. The average aquifer storage coefficient at the end of 30 days is estimated approximately by the following:

$$Storage\ Coefficient = \frac{Pumping\ Volume\ (m^3)}{Drawdown\ Cone\ Volume\ (m^3)}$$

$$Storage\ Coefficient = \frac{64{,}000\ m^3}{1{,}600{,}000\ m^3} = 0.04$$

An average storage coefficient in the order of 0.04 suggests a significant proportion of the aquifer is under artesian conditions; this condition could exist below much of the clay capped areas on the aquifer flanks. Alternatively, some delayed yield or incomplete drainage of the water table component of the aquifer is occurring or even more likely, a combination of the two.

The hydraulic response defined during the 30 day pumping test demonstrated a slowly expanding cone of influence. The area characterized by maximum drawdowns (based on November 4, 1994 water level data) in excess of 1 metre is limited to the zone within about 130 metres of the test well. It is noted that during the pumping test there was very little precipitation with the exception of the rainfall event near the end of the pumping period (see Appendix J) and, as such, the pumping test was conducted under extreme conditions with very little recharge occurring during the 30 day period. As discussed above, the substantial drawdown in the test well reflects the actual reduction in the transmissivity of the aquifer as it becomes locally partially dewatered. The extra drawdown in the test well is due to the reduction in the saturated thickness of the aquifer and is not considered as representing inefficiency in the test well. In order to determine the well efficiency, the measured maximum drawdown in the test well is adjusted by the following equation derived from Driscoll (1986):

$$S_{adj} = S_a - \frac{S_a^2}{2b}$$

where:

S_{adj} = adjusted drawdown value

S_a = actual or measured drawdown

b = saturated thickness of unconfined aquifer when no pumping is taking place

Based on this equation using the measured maximum drawdown of 4.77 metres in the test well and a saturated thickness of 9 metres, the adjusted drawdown value is 3.51 metres. Based on the adjusted drawdown value, the test well efficiency is calculated to be about 80 percent.

On December 19, 1994, the water level in the test well had recovered from 4.77 metres of drawdown to 0.24 metres of drawdown or about 95 percent recovered. In contrast, the water levels in monitoring wells 94-1 through 94-5 and 94-7 (i.e., monitors closest to the test well) had recovered between 60 and 85 percent. It can be expected that a reduced percentage of recovery will be observed away from the pumping well unless recovery is complete or 100 percent through the zone of drawdown.

The long term pumping test data, as presented in Appendix F and G, demonstrate a uniform long term drawdown cone expansion and these data enable the long term aquifer yield to be evaluated as discussed in the following section.

6.2 Long Term Aquifer Yield

6.2.1 Empirical Methods

The Morewood esker is an extensive north-south trending linear feature that is mappable from about 2 kilometres south of the Provost Cartage property to about 6 kilometres north (Figure 2). The Village of Embrun draws its groundwater supply from wells completed in what may be a northern extension of the Morewood glaciofluvial complex (Figure 2). The Village of Chesterville draws a component of its municipal water supply from a well which is completed in a glaciofluvial complex located about 5 kilometres west of the Village at Maple Ridge (Figure 2). The relationship or interconnection between this feature near Maple Ridge and the Morewood complex is uncertain; however, during the borehole investigation carried out as part of the Village of Winchester water supply study in 1990, coarse granular deposits were generally not found in the land area between these two identified complexes. Based on available geological data, it appears possible that a northern extension of the Morewood esker may be the source for the communal water supply for the Village of Embrun.

As previously discussed, the long term (20 year) water supply requirement of the Village of Winchester is an additional 23 Litres per second (300 Igpm). As such, the long term safe yield of the aquifer must be sufficient to furnish the water supply requirements of the Village of Winchester (including a reasonable safety factor) without creating unacceptable impact on adjacent water supplies.

The 30 day pumping test was conducted at a continuous, uniform pumping rate of 1477 Litres per minute (325 Igpm) with regular water level measurements made at both established monitoring wells and domestic wells. These drawdown data are presented in Appendix F in conjunction with Cooper and Jacob (1946) time drawdown evaluations. The recovery data from the field monitoring are included in Appendix G. The above information provided the data base for the evaluation of the long term safe yield for the Morewood esker aquifer system. The safe yield has been based on the estimated infrastructure life of 20 years.

One rather simple methodology, described by Ceroici (1980) is based on an empirical formula. This particular formula estimates the 20 year safe yield for an aquifer. The 20 year safe yield is defined by:

$$Q_{20} = \frac{86.4\ TH}{127}$$

where Q_{20} = 20 year safe yield (m^3/day)

T = transmissivity (m^2/day)

H = total available drawdown (m)

For this estimate, the lower transmissivity values, representative of the long term, time/drawdown data of approximately 500 m^2/day were utilized to provide a conservative estimate. Similarly, the total available drawdown was estimated at 7 metres for the aquifer. The corresponding Q_{20} for the aquifer is calculated to be about 2380 m^3/day (364 Igpm). This estimate provides a safety factor of nearly 20 percent over the long term requirements of 1960 cubic metres per day (300 Igpm).

A second methodology for estimating the long term safe yield of an aquifer as presented in Bibby (1979) is a somewhat more rigorous method based on the extrapolation of the long term pumping test data. The 20 year safe yield formula is as follows:

$$Q_{20} = \frac{A_d}{\frac{S_t}{Q} + \frac{\Delta S_L}{Q} \cdot (7 - \log(t))}$$

where	ΔS_L	=	$0.183\ Q\ /\ T_L$
	T_t	=	long term transmissive capacity (m^2/day)
	Q	=	pump test rate (m^3/day)
	A_d	=	available drawdown (m)
	t	=	duration of pump test (min)
	S_t	=	drawdown at time t (m)
	Q_{20}	=	20 year safe yield (m^3/day)
	ΔS_L	=	slope per log cycle of drawdown curve corresponding to long term transmissive capacity (m)

Based on the measured conditions at the end of 30 day pumping test (43,200 minutes) at a flow rate of 2127 m^3/day (325 Imperial gallons per minute), a measured drawdown in the test well of 4.77 metres, an available drawdown of 7 metres and a long term transmissivity of 500 m^2/day, the estimated 20 year safe yield is 2252 m^3/day (344 Igpm). This estimate provides a safety factor of nearly 15 percent over the long term requirements of 1960 m^3/day (300 Igpm). Furthermore, this methodology does not include a recharge component which is very important for unconfined aquifers as defined for this study.

In summary, the estimated 20 year safe yield for the Morewood esker complex, based on the results of the 30 day pumping test, is well above the projected 20 year maximum day demand of the Village of Winchester. There are few situations where such long term pumping test data are available for estimating long term safe yields and the consistency of the drawdown data over all of the defined aquifer zones provides for highly reliable evaluations of long term aquifer response and associated safe yields. As noted above, this is especially true for a water table which normally is recharged from local precipitation on an annual basis.

6.2.2 Infiltration Water Balance Assessment

The previous techniques for the evaluation of the long term aquifer yield were based on empirical methods using correlation from pumping test data and long term well hydraulic observations. These methodologies can be quite practical but can be somewhat overly conservative in terms of the estimation of long term aquifer yield especially for unconfined aquifers. For unconfined aquifers, the long term yields can be anticipated to be related to the annual average infiltration from precipitation and potentially somewhat higher when potential induced recharge from the flanks, the confining layer beyond the core, and the base of the aquifer are included.

The annual recharge rate from precipitation can be estimated from the surface area of the unconfined aquifer which is exposed and the Net Potential Infiltration (NPI). For the study area, the surface expression of the Morewood esker is approximately 8 kilometres long by approximately 450 metres wide (Geological Survey of Canada, 1982). The average width of the aquifer is closer to 800 metres, however, much of the aquifer flanks are clay covered such that direct infiltration is inhibited. Previous estimates of the NPI for sandy soils in the Embrun area is 210 millimetres per year (Geo-analysis, 1988). The estimated annual recharge rate for the above aquifer dimension and infiltration value is 760,000 cubic metres per year or 2100 cubic metres per day (320 Igpm). In actuality however, the largest window for recharge to the aquifer is located 1 to 1.5 kilometres to the north and to a lesser degree to the south of the Provost Cartage property such that much of the recharge is quite localized. Furthermore, significant parts of the local area are or were sand and gravel operations with open pit areas which could be expected to have higher NPI compared to vegetated granular areas and, as such, drawdown beyond 2 to 3 kilometres is generally not anticipated.

This information indicates that the annual NPI for the aquifer system is near or potentially greater than the long term communal water demands of approximately 1960 cubic metres per day (300 Igpm) and that much of this recharge is within a few kilometres of the Provost Cartage property. Furthermore, calculation of in situ aquifer water volumes based on an aquifer approximately 8 kilometres long, 600 to 1000 metres wide, 9 metres saturated thickness and a 25 percent porosity demonstrates 11 to 18 million cubic metres of in situ aquifer storage or approximately 15 to 25 years of consumption at 1960 cubic metres per day (300 Igpm). This in place groundwater volume alone is very near and potentially exceeds the requirements of the projected 20 year design life period for the communal water system.

In summary, the water supply to the production well(s) on the Provost Cartage property will come from aquifer storage which is replenished by infiltrating precipitation on an ongoing basis. The majority of the recharge will occur where the coarse granular central core and sandy flanks of the esker are exposed at surface.

7.0 GROUNDWATER QUALITY ASSESSMENT

In accordance with the Permit to Take Water, groundwater samples were collected from the Lafleur and Groves drilled wells. The Groves well is reportedly completed in limestone at a depth of 30 metres below ground surface. The overburden thickness at this well location is reported to be 16 metres. Details pertaining to the Lafleur drilled well are not available.

The water quality in the Groves well meets the Ontario Drinking Water Objectives (ODWOs) with the exception of turbidity. The water quality in the Lafleur well meets the ODWOs with the exceptions of the bacteriological counts. Copies of the chemical analysis reports were provided to the property owners.

The groundwater quality within the Morewood esker deposit was assessed by collecting water samples from the test wells and selected monitoring wells during the 30 day aquifer test. The results of these analyses are presented in Appendix H. These analyses demonstrate that the water quality meets the ODWOs for all parameters monitored.

A groundwater sample collected from the test well on October 11, 1994 exhibited an elevated concentration of nitrate (5.40 mg/L) and thus a more comprehensive monitoring program was implemented for the remainder of the aquifer test to assess the presence and concentration of nitrate in the groundwater in the area of the test well. With the exception of the one sample which exhibited an elevated nitrate level, the remaining five samples collected from the test well all exhibited nitrate levels of 0.25 mg/L or less. Nitrate analyses on groundwater samples collected from monitoring wells in close proximity to the test well indicate that only the samples collected from monitoring well 94-6 were characterized by nitrate levels exceeding 1 mg/L. The nitrate concentrations in monitoring well 94-6 increased from 3.90 mg/L on October 18, 1994 to 7.60 mg/L on October 26, 1994 and ultimately to 9.00 mg/L on November 3, 1994. The presence of nitrate in the groundwater collected from monitoring well 94-6 is likely related to agricultural activities in the vicinity of this monitor.

Based on the limited data available from monitoring wells on the D. St. Pierre property to the south, it is concluded that the water quality in the monitors sampled during 1992 is generally similar to that encountered on the Provost Cartage property during 1994. The water quality on the D. St. Pierre property is indicated to meet the ODWOs for all parameters monitored, with nitrate detected only at monitoring well 92-12 at 6.88 mg/L.

As discussed in Section 2.3, water quality in the wells which serve the Village of Embrun has deteriorated to the point where a treatment system is proposed to remove a number of natural constituents. The water quality in the test well on the Provost Cartage Property is similar to that encountered in the D. St. Pierre property and the Village of Chesterville wells, all of which are superior and different than the less than ideal quality which originally characterized the Embrun well water. Based on the continued favourable quality of the Chesterville well during its operation, it is indicated that a water supply for the Village of Winchester constructed on the Provost Cartage property will likely be similar to the Chesterville well in terms of water quality.

As noted above, elevated nitrate was measured at isolated monitoring wells in the area. In terms of a communal water supply, it is the bulk groundwater quality which is relevant. In this regard, it is expected that the bulk water supply transmitted to a production well(s) on the Option to Purchase at the Provost Cartage property will be favourable for communal supply.

8.0 WATER RESOURCES PROTECTION STRATEGY

8.1 Introduction

A water resources protection strategy is a comprehensive plan aimed at protecting a groundwater resource and minimizing the potential for contamination of that resource through some form of development controls coupled with a monitoring program of the aquifer system. The development controls are required to minimize activities which could result in potential contamination of the aquifer and ultimately the communal drinking water supply or private water supplies derived from the aquifer. The monitoring program typically includes groundwater level measurements to evaluate the effect of communal well operations on the groundwater levels in the area, and the sampling of a selected number of monitoring wells to characterize groundwater quality within the aquifer at specific distances from the pumping well(s). The purpose of the groundwater quality monitoring program is to detect the presence of contaminants prior to arrival at the well(s) and to permit appropriate mitigation measures to be developed, evaluated and implemented prior to adverse impact on the water supplied to the users.

It is proposed that the water resources protection strategy for the Morewood esker comprise the delineation of a wellhead protection area (WHPA) in association with the development of a "Best Management Plan" (BMP) for activities associated with specific sub-areas within the WHPA. A proposed WHPA and BMP are presented in Sections 8.2 and 8.3, respectively. Although it is recognized that the definition of a WHPA, as well as the components of the BMP, is an evolving process that includes both technical and political issues, the WHPA and BMP presented in the following sections are based on knowledge of general land use in the area and present groundwater quality, and on the technical factors such as long term pumping rates and the estimated travel time for groundwater to the pumping well(s) based on the physical hydrogeological setting of the Morewood esker.

8.2 Wellhead Protection Area

The overall limits of the proposed wellhead protection area (WHPA) have been defined based on the following three criteria.

1) The mapped surficial limits of the Morewood esker based on the Geological Survey of Canada (1982) as shown on Figure 8 as this represents the surface exposure of the unconfined geological feature of interest.

2) The west and east limits of the WHPA are defined based on the imposition of a minimum 300 metre wide envelope around the surface exposure of the Morewood esker. The overall width of the WHPA is no less than 800 metres which corresponds with the interpreted average width of the Morewood esker in the subsurface.

3) The north and south limits of the WHPA are defined based on the estimated 365 day distance-drawdown plot presented on Figure 9. This plot is based on a very conservative approach because it assumes that the aquifer will be pumped continuously at a rate of 2127 m^3/day (325 Igpm) for a 365 day period with no aquifer recharge. The north and south limits are based on the 0.3 metre (1 foot) drawdown contour which would be located approximately 2000 metres from the test well. The 0.3 metre drawdown value has been selected as opposed to zero drawdown in order to account for the fact that there are natural seasonal fluctuations in the position of the groundwater table. In permeable soils, such as those which comprise the esker, seasonal fluctuations are expected to be greater than 0.3 metres.

The overall limits of the WHPA based on the above criteria are shown on Figure 8.

Within the overall WHPA, three sub-areas have been delineated within the WHPA based on technical factors such as the long term pumping rate, the interpreted physical size and porosity of the aquifer, and the travel time for groundwater to the well field.

Based on proposed long term pumping rate of 1960 m^3/day (300 Igpm), an average aquifer width of 800 metres, a 9 metre thick saturated zone, and a porosity of 0.25, the fluid travel rate is approximately 400 metres per year. Based on a fluid travel rate of 400 metres per year, the 1 year, 2 year and 5 year travel sub-areas have been delineated within the overall WHPA as shown on Figure 8. These three sub-areas have been identified for the purpose of developing the groundwater monitoring program for the BMP and for developing additional protection strategies within these travel sub-areas.

The groundwater monitoring proposed as part of the Water Resources Protection Strategy (see Section 8.3.2) will provide additional hydrogeological data pertaining to the physical properties of the aquifer system and the influence of recharge.

8.3 Best Management Plan

It is proposed that the primary components of the BMP include the following items:

- an inventory of potential contaminant sources and contaminant pathways within the WHPA
- a groundwater monitoring program
- a public education program
- a Water Resources Protection Committee, and
- a compensation policy

Each of these components are discussed in the following sections.

8.3.1 Inventory Program

The WHPA shown on Figure 8 comprises a total land area of about 470 hectares (1160 acres). Although a detailed analysis of land use within the WHPA has not yet been performed, in general it appears that the land use is approximately 90 percent agricultural and 10 percent existing or previously worked mineral extraction operations and municipal road allowances.

Based on the present favourable water quality within the aquifer and the historical use of the land in the area primarily for farming/agricultural purposes, it is concluded that the historical land uses have not presently impacted significantly on water quality within the aquifer. As such, the BMP for activities within the delineated WHPA need not include any land use restrictions which affect the current land use in the area but rather an inventory of potential contaminants and contaminant pathways within the WHPA. The inventory would be carried out as a component of the final design of the water supply system.

The lower permeability clay cover over the flanks of the Morewood esker minimizes the potential for contaminants to enter the aquifer over broad areas and, more importantly, from areas adjacent to the aquifer. The major concern is therefore related to possible migration paths through openings in the silt and clay such as improperly grouted wells, pile foundations or similar openings, as well as those areas where the aquifer is unconfined and exposed at ground surface.

Based on the fact that development has preceded the proposed communal well development, consideration must be given to a general condition assessment of all possible openings through the lower permeability clay cover area as well as an inventory of possible sources of contamination. The assessment of possible "windows" through the silt and clay cover would include wells (both drilled and dug), foundation piles, utility poles and the like. An inventory of possible point sources of contamination would include farms with fuel storage, pesticides/herbicides storage, liquid and solid manure storage, as well as residences with heating fuel storage. Non-point sources would potentially include application of fertilizer, manure and chemicals for agricultural purposes as well as application of road de-icing salt.

It may be prudent for the Winchester water supply expansion project to assist with the cost of "spill proofing" these potential sources of contamination or possibly removing such sources through conversion to alternative systems for the area within the 2 year travel sub-area within the WHPA.

The "closing of windows" to the aquifer through inadequate casing seals could be accomplished by restorative well grouting.

8.3.2 Groundwater Monitoring Program

Consideration should be given to the establishment of a suitable network of monitoring wells coupled with a regular monitoring program as an integral part of the communal well development program to allow groundwater contamination to be detected and mitigation to occur prior to it entering the pumping well(s). As such, the monitoring wells should be established (if not already existing) at the approximate boundaries of the 1, 2 and 5 year travel sub-areas. Monitoring wells should also be established downgradient of any potential contaminant sources identified in the inventory program. The groundwater monitoring program could include seasonal to semi-annual monitoring at the boundaries of the 1 and 2 year travel sub-areas and annual monitoring at the boundaries of the 5 year travel sub-area. The chemical and physical parameters monitored should include potential parameters of concern such as nitrate, iron, manganese, hardness, chloride, atrazine, benzene, toluene, ethylbenzene, xylenes, etc. As well, groundwater levels would be monitored.

The specifics of the groundwater monitoring program would be finalized based on consultation with the public and the Ministry of Environment and Energy, and would be a component of the final design of the water supply system.

8.3.3 Public Education Program

The development of a BMP for activities within the WHPA should also include a public education program to ensure that all residents fully appreciate the importance of the WHPA and understand local contamination issues and understand the rationale for proper handling of hazardous materials, wastes and prompt reporting of spills. The public education program would include all residents, as well as other groups such as fuel oil and chemical suppliers who work in the area.

8.3.4 Water Resources Protection Committee

A Water Resources Protection Committee (WRPC) could be established and remain in place during the lifetime of the Village communal water supply in the Morewood esker area. The WPRC members could be comprised of members of the public (local landowners), representatives of the Village of Winchester and Township of Winchester and the regulatory agencies.

The WRPC could perform the following functions:

- Review monitoring results and an annual monitoring from the Village's Consultant on water quality and water levels in the monitoring wells.

- Review water quantity and quality data from the well operating authority (i.e., OCWA Annual Report on the water supply).

- Be aware of the potential future demands on the groundwater resources within the Morewood esker.

- Monitor land use and practices within the WHPA.

- Promote water resource protection awareness.

- Act as a liaison or "conduit" to and from the public.

- Examine any concerns which may arise, including those related to groundwater quality, land use practices, etc. and recommend the most effective and feasible course of action to the Village.

- If land restriction or land acquisition are considered to be the best course of action, to recommend to the Village of Winchester a fair level of compensation to the affected property owner or user.

In the event of future water quality concerns or known/suspected contamination of the aquifer within the WHPA, the WRPC could develop and evaluate alternative mitigative measures aimed at addressing the contaminant problem and then recommend the Village of Winchester implement one or more mitigative measures. Typical mitigative measures could include continued monitoring; establishment of additional monitoring wells to better identify the source and delineate the extent and nature of the problem; source containment or removal; active groundwater remediation; land use restriction for a specific area of concern; or, land acquisition.

8.3.5 Compensation Policy

In the event that a preferred mitigative measure for a possible future contamination issue is restriction on land use or land acquisition, a compensation policy should be established for landowners in the area who may be affected in the future by the Village of Winchester's water supply operations in the Morewood esker. Specific details concerning the compensation policy should be presented in the Environmental Study Report.

9.0 OTHER ENVIRONMENTAL CONSIDERATIONS

9.1 Impact on Local Domestic Wells and Other Communal Supplies

The nearest domestic wells to the Provost Cartage property are the Lafleur and Groves drilled wells. Although the pumping test created drawdown effects in these private wells there were no complaints from the property owners during the pumping test due to water shortages.

The maximum drawdowns during the 30 day pumping test in the Lafleur and Groves wells were 0.36 and 1.02 metres, respectively (Figure 8). The maximum drawdowns in the Lafleur and Groves wells based on 365 days of continuous pumping at 2127 m^3/day (325 Igpm) with no aquifer recharge are estimated to be approximately 0.8 and 1.7 metres, respectively. These estimated drawdowns are not likely to impact on the performance of the water supply wells.

On Figure 9, the point of zero drawdown is estimated to be located at a distance of about 3500 metres from the test well. As such, based on the large separation distances between the Provost Cartage property and the Embrun/Marionville and Chesterville wells (Figure 2), it is concluded that the development of the communal water supply on the Provost Cartage property will not adversely impact these other municipal supply wells. This conclusion is supported by the work of Geo-analysis Inc. (1988) through the definition of the groundwater recharge area for the Embrun well which is interpreted to extend approximately 1000 metres to the south of the Embrun production well; therefore the southern limit of this recharge zone is greater than 6000 metres from the test well on the Provost Cartage property.

The Village of Russell wells are completed in bedrock and it is concluded that there will not be interaction between these wells and the communal water supply proposed on the Provost Cartage site.

9.2 Impact on Existing Land Uses Within WHPA

9.2.1 Sand Pit Operations

The existing sand pit operations closest to the test well are located on the Provost Cartage property which abuts the limits of the Option to Purchase to the south and west and the D. St. Pierre pit located about 1 kilometre to the south of the test well. Based on Oliver, Mangione, McCalla &

Associates Limited (1994), it is understood that material will be excavated on the St. Pierre property from below the groundwater table and that there will be no dewatering for extraction purposes. A similar sand pit operation is proposed for the Provost Cartage property based on previous discussions with the property owner.

These sand pit operations have a potential for contamination of groundwater by fuel and therefore it is considered that the issue of equipment refuelling should be approached as follows:

- no storage of fuel shall be permitted on the unconfined portion of the aquifer

- no refuelling of equipment shall be permitted on the unconfined portion of the aquifer; equipment shall travel off the aquifer to be refuelled. Alternatively, a secure spill containment area could be designed and constructed on the site and refuelling carried out only within this containment area.

- an emergency spill response plan should be developed for the site, submitted for approval and, once approved, any necessary spill containment materials should be maintained on site. Site personnel should receive training in spill response procedures.

Dust control may be necessary periodically during the operation of the sand pits. Calcium chloride is the most common chemical used for this purpose, however it is considered preferable that at these sand pits the abundant on-site groundwater be applied when necessary for dust control in order to avoid the introduction of any unnecessary chemicals to the groundwater.

These types of practices are becoming common in modern pit and quarry operations, and should be a requirement for these sites as well. These are prudent protection measures for these components of extraction operations over top of an unconfined aquifer, regardless of whether or not the groundwater is being currently utilized for water supply.

At the Provost Cartage property, the sand pit operations should be set back a minimum of 30 metres from the limits of the Option to Purchase as shown on Figure 3.

A number of previously worked sand pits exist along the Morewood esker feature to the north of the Provost Cartage property between Thompson Road and the Morewood Road. If sand and gravel extraction operations were to commence in future in this area, or further north, operation requirements as discussed above are also considered to be appropriate.

9.2.2 Agricultural/Farming Activities

As discussed in Section 8.3.1, the historical use of the land in the area primarily for farming/agricultural purposes has not presently impacted significantly on water quality within the aquifer. As such, the BMP for activities within the delineated WHPA need not include any land use restrictions which affect the current land use in the area. As discussed previously, it is proposed that an inventory of potential contaminants and contaminant pathways within the WHPA be prepared.

It is suggested however, that the land application of manure and chemicals be carried out in an environmentally responsible manner. Application of nutrients and chemicals in proper amounts and at the appropriate times of year is intended to maximize crop yield and at the same time minimize their potential for leaching to the groundwater. Guidance documents relating to land application of these compounds are available from the Ontario Ministry of Agriculture and Food and Agriculture and Agri-Food Canada.

9.3 Potential Impacts on Consolidation of Silty Clay

Pumping from the aquifer system will result in some lowering of the piezometric level within the sands and sand and gravel in the long term. Where these soils are overlain by silty clay, the lowering of the piezometric pressure will result in a small but finite increase in effective stress at the base of the clay deposit which could result in consolidation settlement of the clay stratum. Such settlement would be manifested at the ground surface in the form of relatively uniform settlement of the ground surface in the area affected. The settlement effects would not be noticeable in general since it would be widespread and fairly uniform, having originated at the base of the clay stratum. This process is non reversible and the related settlement has impacted some structures in eastern Ontario in the past but only where such structures have had deep (unyielding) foundations and slabs on grade (floating) or embankments on grade adjacent to these. The settlement effects for structures founded on granular soils will be less and will not be measurable.

A quantification of potential settlement effects could be provided in greater detail following strength measurements within the silty clay and possibly consolidation testing.

10.0 WELL FIELD DESIGN CONSIDERATIONS

The design for a communal well field requires sufficient water supply capacity for peak demands as well as some redundancy for well and pump maintenance and possible failure scenarios. The 30 day pumping test on the Morewood aquifer system has demonstrated that the test well was adequate for the short term (30 to 90 days) demands at approximately 2127 cubic metres per day (325 Igpm) but would be marginal for extended duration pumping at this near design rate. The ultimate well field design for the Village of Winchester within the Option to Purchase at the Provost Cartage site is anticipated to include at least one additional well similar to that presently in place, (i.e., the test well is suitable for use as a production well). A third well could also be necessary depending on the capacity of the second well, although this is not expected. The final well field design can be defined once other significant factors such as power supply and energy requirements are decided upon as discussed below. The well(s) should be located along the long axis (north-south) of the aquifer, if possible, in order to enhance aquifer hydraulic conditions. The well spacing should be as large as possible within the limits of the Option to Purchase, but must be within the coarsest granular material. The precise well design at a given area would require several augerholes to define the most permeable and thickest aquifer units. These augerholes would also provide the necessary sand and gravel samples to facilitate a practical well design at a particular location. It is desirable, for most of the time, to operate two wells in order to avoid prolonged stressing of one well, however, each well or combination of wells if more than two should be capable of providing the design supply in the short term.

Also, the site is presently serviced by only single phase, 220 volt power and this limits the maximum submersible pump motor to 7.5 kilowatts (10 horsepower), but is not highly practical for line shaft turbine pumps. A three phase electric power supply could be connected to the site to facilitate a full range of submersible or line shaft pump capabilities, however, the costs for such power lines can be significant and needs to be further evaluated. It would be possible to incorporate this single phase power to the piped delivery system initially if costs for three phase power are significant and there is a desire to defer or possibly eliminate such power costs. The final requirement for power at the well site will depend on the energy requirements for the delivery and pumping system. Flexibility can be incorporated into each to reduce total power requirements with two smaller diameter wells with lower individual power requirements when compared to one additional larger diameter well. It should be noted that the cost for two smaller diameter wells would be quite competitive with one larger diameter well.

11.0 CONCLUSIONS

- The August 1992 Preliminary Findings report prepared by J.L. Richards & Associates Limited has concluded that the existing Village of Winchester water supply needs to be augmented by an additional 23 Litres per second (300 Igpm) to satisfy the projected maximum day demand for a 20 year design period.

- The target for a groundwater supply of this magnitude is the Morewood esker deposit at a location where it outcrops on the Provost Cartage property. The Morewood esker is an extensive north-south trending linear feature that is mappable from about 2 kilometres south of the Provost Cartage property to about 6 kilometres north.

- Field observations coupled with a borehole drilling and monitoring well installation program permitted the selection of a desirable location for a test well on the Provost Cartage property to assess the potential for the Morewood esker to meet the water supply requirements for the Village of Winchester.

- Based on a review of available geological data, the Morewood esker aquifer is interpreted to be about 600 to 1000 metres in width with the central gravel core indicated to be up to 150 metres wide. The saturated thickness of the aquifer is interpreted to be about 9 metres. The central part of the esker is unconfined whereas the east and west flanks are confined by (overlain by) a silty clay/clayey silt deposit.

- Olympic Drilling Co. Ltd. was contracted to construct a 30 centimetre diameter test well. The well is located near the southwest corner of the land comprising the Option to Purchase.

- A long term pumping test was conducted for a period of 30 days at a pumping rate of 2127 cubic metres per day (325 Imperial gallons per minute). The hydraulic response defined during the 30 day pumping test demonstrated a slowly expanding cone of influence. The area characterized by maximum drawdowns (based on November 4, 1994 water level data) in excess of 1 metre is limited to the zone within about 130 metres of the test well. It is noted that during the pumping test there was very little precipitation with the exception of the rainfall event near the end of the pumping period and, as such, the pumping test was conducted under extreme conditions with very little recharge occurring during the 30 day period.

- The 20 year safe yield of the aquifer is estimated to range from 2252 to 2380 m^3/day (344 to 364 Igpm) based on empirical methods.

- The maximum drawdowns during the 30 day pumping test in the closest domestic Lafleur and Groves wells were 0.36 and 1.02 metres, respectively. The maximum drawdowns in the Lafleur and Groves wells based on 365 days of continuous pumping at 2127 m^3/day (325 Igpm) with no aquifer recharge are estimated to be approximately 0.8 and 1.7 metres, respectively. These estimated drawdowns are not likely to impact on the water supply wells.

- Based on data obtained during the pumping test, the point of zero drawdown was estimated to be located at a distance of about 3500 metres from the test well. As such, based on the large separation distances between the Provost Cartage property and the Embrun and Chesterville wells, it is concluded that the development of the communal water supply on the Provost Cartage property will not adversely impact the other municipal supply wells.

- The water quality testing conducted during the 30 day pumping test demonstrated that the groundwater quality meets Ontario Drinking Water Objectives.

- Based on the information collected during the water supply investigation, a proposed water resources protection strategy was prepared for the Morewood esker. The proposed water resources protection strategy comprises the delineation of a wellhead protection area (WHPA) in association with the development of a "Best Management Plan" (BMP) for activities associated with specific sub-areas within the WHPA. The primary components of the BMP include an inventory of potential contaminants and contaminant pathways within the WHPA; a groundwater monitoring program; a public education program; a Water Resources Protection Committee; and, a compensation policy. The historical use of the land in the area primarily for farming/agricultural purposes has not presently impacted significantly on water quality within the aquifer. As such, the BMP for activities within the delineated WHPA need not include any significant restrictions which affect the current land use in the area.

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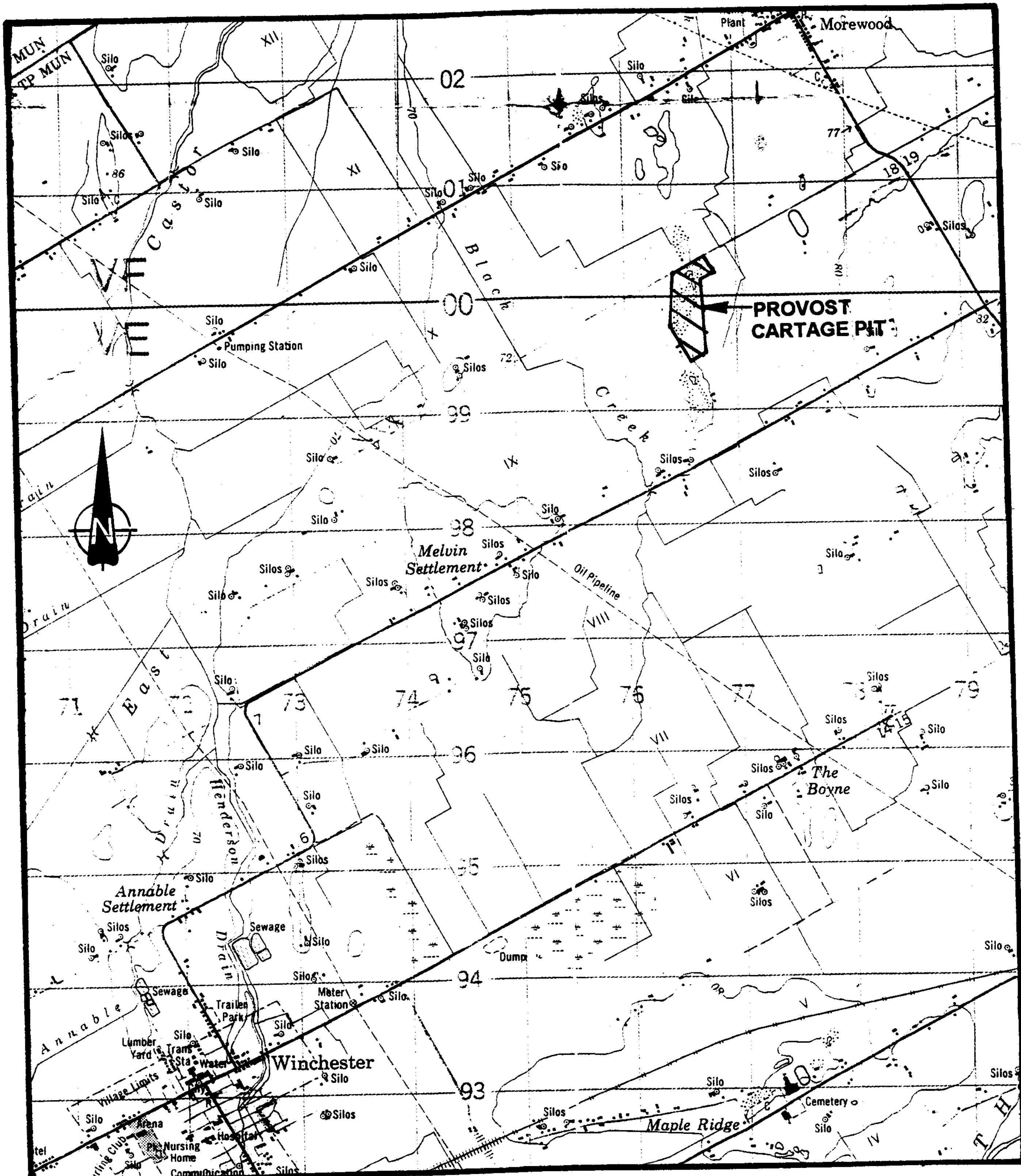
KEY PLAN

FIGURE 1



SCALE : 1 : 50,000

SPECIAL NOTE
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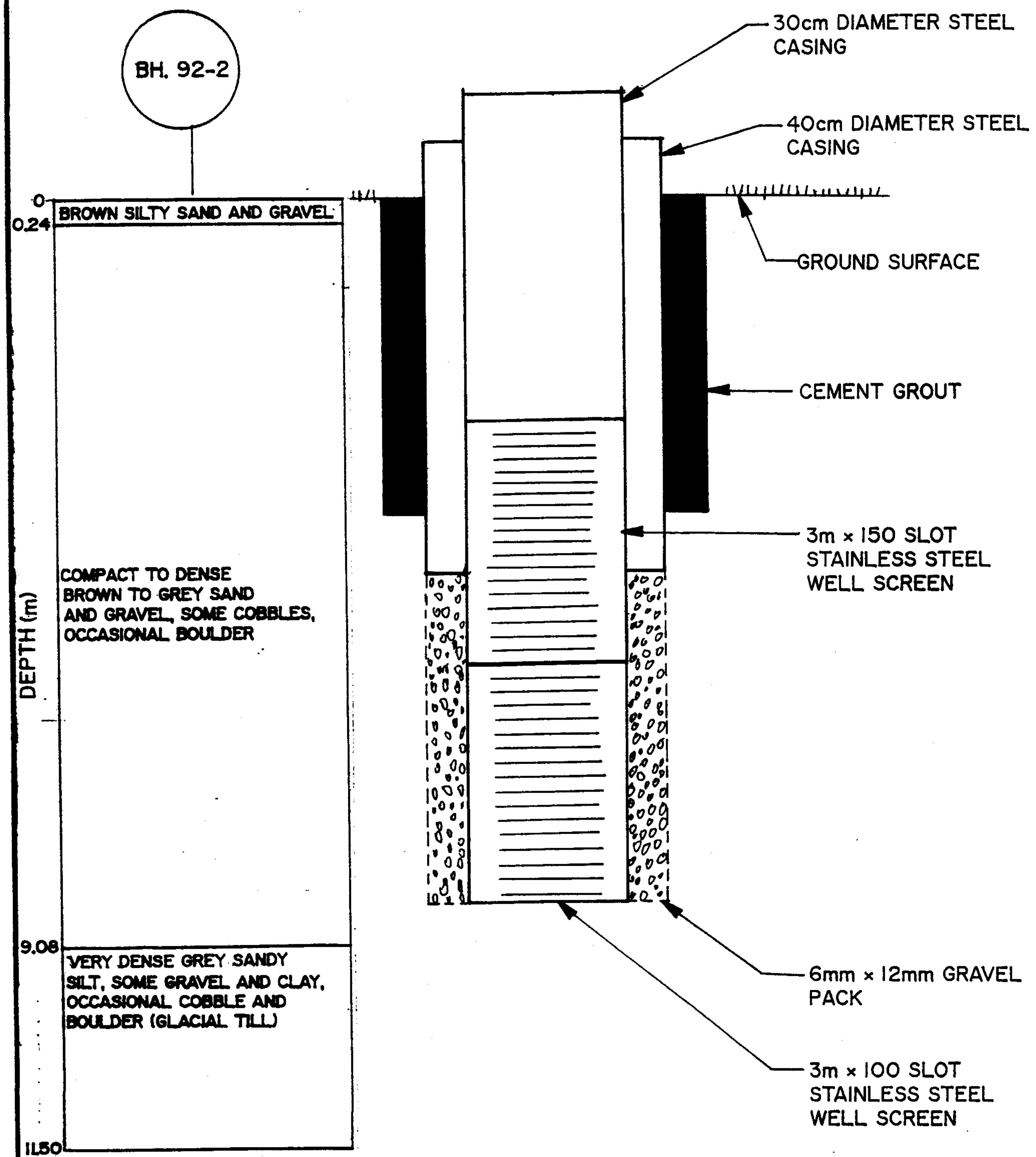
Date NOV 16 1994
Project 941-2747

Golder Associates

Drawn K.M
Chkd. KAM

TEST WELL SCHEMATIC DRAWING

FIGURE 4



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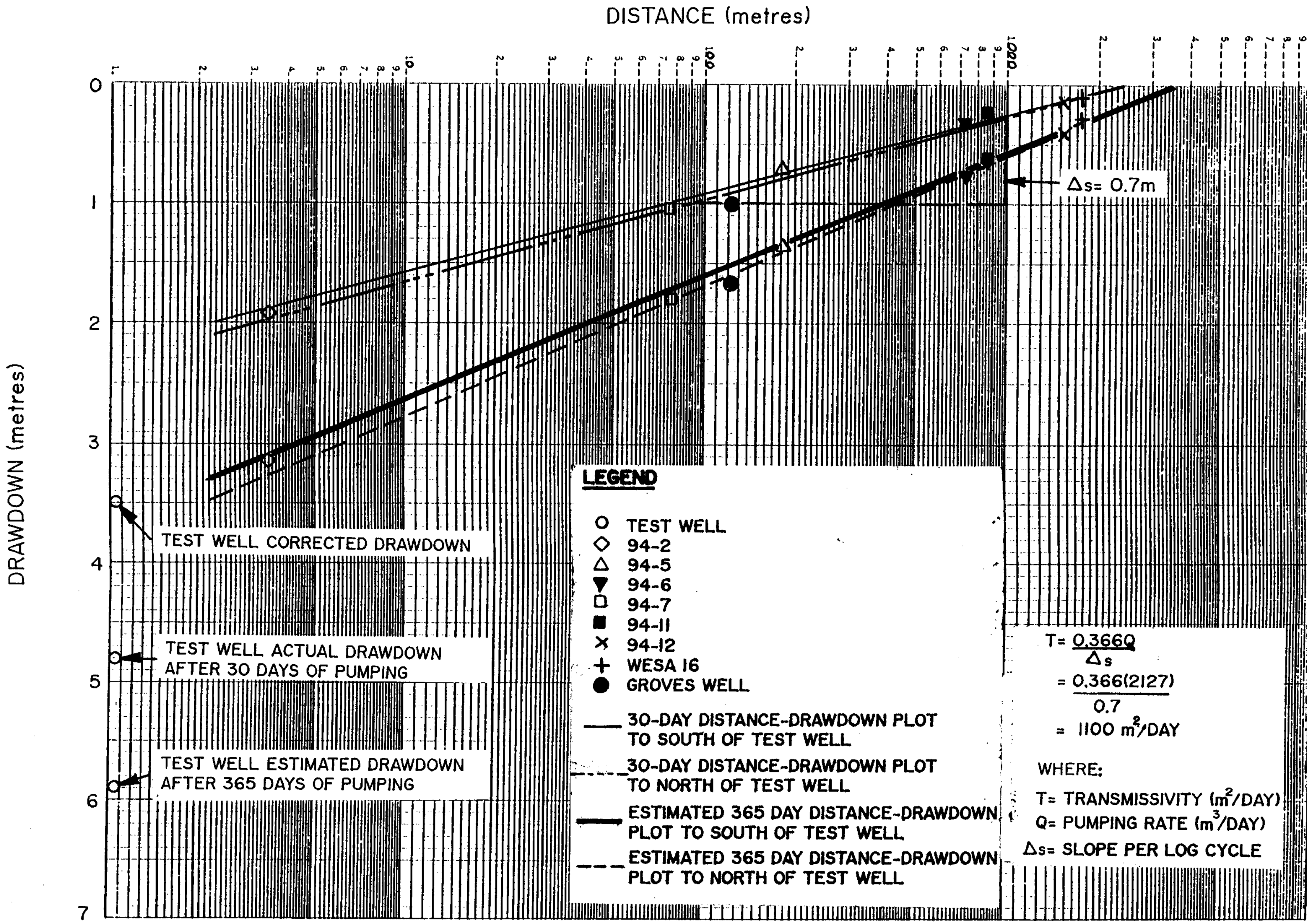
Date DEC 21 1994

Project 941-2747

Golder Associates

Drawn K.M.

Chkd. KAM



JACOB DISTANCE-DRAWDOWN PLOTS	Date JAN 05 1995 Project 941-2747	Golder Associates	Drawn K.M. Chkd. KAM	FIGURE 9

APPENDIX A

RECORD OF BOREHOLE SHEETS

APPENDIX A-I - PREVIOUS INVESTIGATIONS BY
WATER AND EARTH SCIENCE ASSOCIATES LTD.

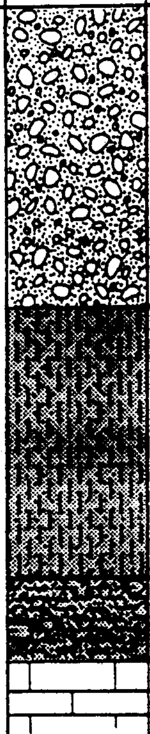
APPENDIX A-II - PREVIOUS INVESTIGATIONS BY GOLDER ASSOCIATES

APPENDIX A-III - PRESENT INVESTIGATION BY GOLDER ASSOCIATES

APPENDIX A-I

PREVIOUS INVESTIGATIONS BY WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 16

DEPTH ft m	DRILLERS LOG		GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER
			SAND & GRAVEL: fine grained brown sand and silt mixed with gravel clasts up to 5cm (2") in diameter	3.18cm (1¼") PVC PIPE 0.3cm (⅛) SCREEN WITH NYTEX WRAP TIP AT 7.0m (23')
10		3.7m	SAND: fine grained silty sand, dark brown	
5, 20		7.0m	TILL: grey clay with sand layers mixed with pebble gravel clasts	
		8.2m	BEDROCK	
30, 10, 40, 15, 50, 60, 20, 70				

WATER AND EARTH SCIENCE ASSOCIATES LTD.

APPENDIX A-II

PREVIOUS INVESTIGATIONS BY GOLDER ASSOCIATES

LIST OF ABBREVIATIONS

The abbreviation commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

AS auger sample
CS chunk sample
DO drive open
DS Denison type sample
FS foil sample
RC rock core
ST slotted tube
TO thin-walled, open
TP thin-walled, piston
WS wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 0.3 m (12 in.).

Standard Penetration Resistance, *N*:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 0.3 m (12 in.).

WH sampler advanced by static weight—weight, hammer

PH sampler advanced by pressure—pressure, hydraulic

PM sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) *Cohesionless Soils*

Relative Density	*'N'* Blows/0.30m or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) *Cohesive Soils*

Consistency	*'Cu'* kPa	psf.
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very stiff	100 to 200	2000 to 4000
Hard	over 200	over 4000

IV. SOIL TESTS

C consolidation test
H hydrometer analysis
M sieve analysis
MH combined analysis, sieve and hydrometer[1]
Q undrained triaxial[2]
R consolidated undrained triaxial[2]
S drained triaxial
U unconfined compression
V field vane test

NOTES:
[1]Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.
[2]Undrained triaxial tests in which pore pressures are measured are shown as $\bar{Q}$ or $\bar{R}$.

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$

e = base of natural logarithms 2.7183

$\log_e a$ or $\ln a$, natural logarithm of a

$\log_{10} a$ or $\log a$, logarithm of a to base 10

- t time
- g acceleration due to gravity
- V volume
- W weight
- M moment
- F factor of safety

II. STRESS AND STRAIN

- u pore pressure
- σ normal stress
- σ' normal effective stress ($\bar{\sigma}$ is also used)
- τ shear stress
- ϵ linear strain
- ϵ_{xy} shear strain
- ν Poisson's ratio (μ is also used)
- E modulus of linear deformation (Young's modulus)
- G modulus of shear deformation
- K modulus of compressibility
- η coefficient of viscosity

III. SOIL PROPERTIES

(a) *Unit weight*

- γ unit weight of soil (bulk density)
- γ_s unit weight of solid particles
- γ_w unit weight of water
- γ_d unit dry weight of soil (dry density)
- γ' unit weight of submerged soil
- G_s specific gravity of solid particles $G_s = \gamma_s/\gamma_w$
- e void ratio
- n porosity
- w water content
- S_r degree of saturation

(b) *Consistency*

- w_L liquid limit
- w_P plastic limit
- I_P plasticity index
- w_S shrinkage limit
- I_L liquidity index $= (w - w_P)/I_P$
- I_C consistency index $= (w_L - w)/I_P$
- e_{max} void ratio in loosest state
- e_{min} void ratio in densest state
- D_r relative density $= (e_{max} - e)/(e_{max} - e_{min})$

(c) *Permeability*

- h hydraulic head or potential
- q rate of discharge
- v velocity of flow
- i hydraulic gradient
- k coefficient of permeability
- j seepage force per unit volume

(d) *Consolidation (one-dimensional)*

- m_v coefficient of volume change $= -\Delta e/(1+e)\Delta\sigma'$
- C_c compression index $= -\Delta e/\Delta \log_{10} \sigma'$
- c_v coefficient of consolidation
- T_v time factor $= c_v t/d^2$ (d, drainage path)
- U degree of consolidation

(e) *Shear strength*

- τ_f shear strength
- c' effective cohesion intercept; ϕ' effective angle of shearing resistance, or friction — in terms of effective stress $\tau_f = c' + \sigma' \tan \phi'$
- c_u apparent cohesion*; ϕ_u apparent angle of shearing resistance, or friction — in terms of total stress $\tau_f = c_u + \sigma \tan \phi_u$
- μ coefficient of friction
- S_t sensitivity

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

RECORD OF BOREHOLE 89-1 .

LOCATION See Figure 6 | BORING DATE Nov.24,1989 | DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm | PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

DEPTH SCALE METRES | BORING METHOD: Power Auger 200mm Diam (Hollow Stem)

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

HYDRAULIC CONDUCTIVITY, k, CM/SEC

SHEAR STRENGTH Cu, kPa — nat.V.- + Q.- ● rem.V.- ⊕ U.- O

WATER CONTENT, PERCENT — Wp W Wl — 20 40 60 80

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (M)	SAMPLES NUMBER	TYPE	BLOWS/0.3M	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
Ground Surface	78.36					
TOPSOIL	0.00					Bentonite Seal Backfill
Grey brown SILTY CLAY	0.18					
Loose brown SILTY SAND and GRAVEL, occasional cobble	0.46 / 76.07	1	50 DO	7		Native Sand Backfill
Grey brown SILTY CLAY (Weathered Crust)	2.29 / 75.46					
Grey SILTY CLAY with thin fine sand seams	2.90 / 75.01	2	50 DO	1		
Loose dark grey SILTY fine SAND	3.35 / 74.40					
Loose dark grey fine SAND, trace silt, occasional silty clay and clayey silt seams with increasing depth	3.96 / 71.14	3	50 DO	5	M	
		4	50 DO	5	M	
Very dense grey SAND and GRAVEL, occasional cobble	7.22 / 69.83	5	50 DO	69	M	38mm PVC #10 Slot Screen
Very dense dark grey sandy silt, some gravel and clay (TILL)	8.53 / 68.61	6	50 DO	74		
End of Hole	9.75					

W.L in Screen at Elev.74.67 Dec.22,1989

15-⊕-5 PERCENT AXIAL STRAIN AT FAILURE (0 / 10)

DEPTH SCALE 1 : 75

Golder Associates

LOGGED S.Leighton

CHECKED DB

RECORD OF BOREHOLE 89-2

SHEET 1 of 1

LOCATION See Figure 6

BORING DATE Nov.24,1989

DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

PROJECT 89...

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (M)	SAMPLES: NUMBER	TYPE	BLOWS/0.3M	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		75.46					
		Brown clayey TOPSOIL		0.00					Bentonite Seal Backfill
1–2	Power Auger 200mm Diam (Hollow Stem)	Very stiff to stiff grey brown SILTY CLAY (Weathered Crust)		0.18	1	50 DO	3		
3–5		Firm dark grey SILTY CLAY, occasional black organic particles		72.87 / 2.59	2	50 DO	WH		Native Sand & Clay Backfill
					3	50 DO	PM		
6–8		Very loose dark grey SILTY fine SAND, occasional silt and silty clay seams		69.67 / 5.79	4	50 DO	1		
					5	50 DO	WR	MH	Caved
9–10		Loose dark grey fine to medium SAND, some silt		66.77 / 8.69	6	50 DO	5	M	Native Caved Sand
11–12		Loose dark grey SILTY fine to medium SAND, trace to some gravel and coarse sand, occasional cobble		65.10 / 10.36	7	50 DO	9	MH	38mm PVC #10 Slot Screen
					8	50 DO	-		
12.44		End of Hole Auger Refusal		63.02 / 12.44					

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

SHEAR STRENGTH Cu, kPa nat.V.- + Q.- ● rem.V.- ⊕ U.- ○

HYDRAULIC CONDUCTIVITY, k, CM/SEC

WATER CONTENT, PERCENT Wp W Wl 20 40 60 80

15 ⊕ 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

W.L. in Well screen at elev. 74.57m Dec. 22, 1989

DEPTH SCALE 1 : 75

Golder Associates

LOGGED S.Leighton

CHECKED DB

RECORD OF BOREHOLE 89-3

SHEET 1 of 1

LOCATION See Figure 6

BORING DATE Nov.30,1989

DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

BORING METHOD: Power Auger, 200mm Diam (Hollow Stem)

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (M)	SAMPLE NUMBER	TYPE	BLOWS/0.3M	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Ground Surface	77.53					
0–1.68	Brown SILTY SAND and GRAVEL	0.00 / 75.85					Bentonite Seal Backfill; Native Backfill
1.68–2.44	Loose brown fine to coarse SAND	1.68 / 75.09	1	50 DO	4		
2.44–3.60	Compact brown to grey SILTY fine SAND with occasional silty clay and clayey silt seam	2.44 / 73.93	2	50 DO	20		
3.60–5.76	Compact grey fine SAND, with occasional grey silty fine sand seams	3.60 / 71.77	3	50 DO	15		
5.76–10.36	Loose to dense grey sandy silt, some gravel and clay, occasional cobble and boulder (TILL)	5.76 / 67.17	4	50 DO	31		
			5	50 DO	15		
			6	50 DO	9		
10.36–11.83	Dense grey fine to coarse SAND and GRAVEL	10.36 / 65.70	7	50 DO	42	M	
11.83–13.66	Compact grey sandy silt, some gravel and clay, occasional boulder (TILL)	11.83 / 63.87	8	50 DO	21		38mm PVC #10 Slot Screen
13.66	End of Hole Auger Refusal	13.66					

W.L. in Well Screen At elev. 74.52m Dec. 22, 1989

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

HYDRAULIC CONDUCTIVITY, k, CM/SEC

SHEAR STRENGTH Cu, kPa — nat.V.- + Q.- ● rem.V.- ⊕ U.- ○

WATER CONTENT, PERCENT — Wp W Wl — 20 40 60 80

15 —◆— 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DEPTH SCALE 1 : 75

Golder Associates

LOGGED S.Leighton

CHECKED DB

RECORD OF BOREHOLE 89-4

SHEET 1 of 1

LOCATION See Figure 6

BORING DATE Nov.25,1989

DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

PROJECT 891-2827

BORING METHOD: Power Auger 200mm Diam (Hollow Stem)

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (M)	SAMPLES NUMBER	TYPE	BLOWS/0.3M	PIEZOMETER OR STANDPIPE INSTALLATION
0	Ground Surface	77.45				
	Dark grey sandy TOPSOIL	0.00				Bentonite Seal Backfill
	Loose brown to light brown SILTY fine to medium SAND	0.20				
1		76.11 / 1.34				Native Sandy Backfill
2	Compact to loose dark grey SILTY fine SAND, occasional silt and medium sand seams		1	50 DO	10	
		74.86 / 2.59				
3	Loose dark grey to black fine to medium SAND, occasional silt		2	50 DO	5	38mm PVC #10 Slot Screen
4						Caved
		72.65 / 4.80				
5	Dark grey SILT	4.94	3	50 DO	21	Native Caved Sand
6	Compact to dense dark grey sandy silt with gravel (TILL)		4	50 DO	29	
		70.74				
7	End of Hole	6.71				

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

SHEAR STRENGTH Cu, kPa — nat.V.- + Q.- ● rem.V.- ⊕ U.- O

HYDRAULIC CONDUCTIVITY, k, CM/SEC

WATER CONTENT, PERCENT — Wp W Wl — 20 40 60 80

ADDITIONAL LAB. TESTING

15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

W.L. in Well Screen At elev. 75.58m Dec. 22, 1989

DEPTH SCALE 1 : 75

Golder Associates

LOGGED S.Leighton

CHECKED DB

RECORD OF BOREHOLE 89-5

SHEET 1 of 1

LOCATION See Figure 6 | BORING DATE Nov.25,1989 | DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm | PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. DEPTH (M)	NUMBER	TYPE	BLOWS/0.3M	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger 200mm Diam (Hollow Stem)	Ground Surface	77.73					
		0.00-0.21 Dark brown silty TOPSOIL; 0.21-0.52 Brown SILTY fine to medium SAND; 0.52-0.70 Brown SILTY CLAY with fine to medium sand seams	0.00 / 77.03 0.70					Bentonite Seal Backfill
1		Stiff grey brown SILTY CLAY, some silty sand seams	76.21 1.52					
2		Stiff to firm dark grey SILTY CLAY, some silt seams and some fine sand seams at depth		1	50 DO	3		Native Clay & Sand Backfill
3			74.10 3.63	2	50 DO	WH		
4–5		Loose dark grey SILTY fine SAND, some medium sand and silty seams	72.09 5.64	3	50 DO	5		
6–7		Very loose dark grey fine to medium SAND, some silt	70.41 7.32	4	50 DO	1		Native Caved Sand
8–9		Loose to compact dark grey sandy silt with gravel, trace clay (TILL)	67.98 9.75	5	50 DO	3		
				6	50 DO	13	M	
10		End of Hole						

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

SHEAR STRENGTH Cu, kPa — nat.V.- + Q.- ● rem.V.- ⊕ U.- O

HYDRAULIC CONDUCTIVITY, k, CM/SEC

WATER CONTENT, PERCENT Wp W Wl — 20 40 60 80

15 ⌖ 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

W.L. in Well Screen At elev. 76.47m Dec. 22, 1989

DEPTH SCALE 1 : 75

Golder Associates

LOGGED S.Leighton

CHECKED DB

RECORD OF BOREHOLE 89-11

SHEET 1 of 1

LOCATION See Figure 6 | BORING DATE Dec.1,1989 | DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm | PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

PR-891-

BORING METHOD: Power Auger 200mm Diam (Hollow Stem)

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (M)	SAMPLE NUMBER	TYPE	BLOWS/0.3M	ADDITIONAL LAB. TESTING
0	Ground Surface	76.83				
	TOPSOIL	0.00 / 76.34				
	Brown sandy silt, some gravel	0.49				
1	Very stiff grey brown SILTY CLAY (Weathered Crust)	0.73 / 75.00	1	50 DO	5	
2	Loose grey SANDY SILT and CLAYEY SILT, occasional silty clay seam	1.83 / 74.09				
3–4	Loose grey SILTY fine SAND	2.74 / 72.56	2	50 DO	6	
5–9	Loose grey fine to medium SAND, trace silt	4.27 / 67.53	3	50 DO	5	M
			4	50 DO	7	
			5	50 DO	6	M
10	Loose grey SILTY fine SAND	9.30 / 66.77	6	50 DO	4	
11	Compact grey sandy silt, some gravel and clay (TILL)	10.06 / 65.83	7	50 DO	11	
	End of Hole Auger Refusal	11.00				

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

SHEAR STRENGTH Cu, kPa — nat.V.- + Q.- ● rem.V.- ⊕ U.- O

HYDRAULIC CONDUCTIVITY, k, CM/SEC

WATER CONTENT, PERCENT — Wp W Wl — 20 40 60 80

15 -◆- 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

PIEZOMETER OR STANDPIPE INSTALLATION:
- Bentonite Seal
- Backfill
- Native Backfill
- 38mm PVC #10 Slot Screen
- W.L. in Well Screen at Elev. 74.97m Dec. 22, 1989

DEPTH SCALE 1 : 75

Golder Associates

LOGGED S.Leighton

CHECKED DB

RECORD OF BOREHOLE 89-12

SHEET 1 of 1

LOCATION See Figure 6 | BORING DATE Dec. 15, 1989 | DATUM Geodetic

SAMPLER HAMMER, 63.5kg, DROP, 760mm | PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (M)	SAMPLES NUMBER	TYPE	BLOWS/0.3M	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat.V.- + Q.- ● rem.V.- ⊕ U.- O)	HYDRAULIC CONDUCTIVITY, k, CM/SEC / WATER CONTENT, PERCENT Wp W Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		78.43							
	Power Auger 200mm Diam. (Hollow Stem)	TOPSOIL		0.00							
1		Loose grey and brown layered silty fine SAND and clayey SILT		0.18							
2				76.60	1	50 DO	7				
		Loose brown fine SAND		1.83							▽
3				75.38							
		Grey SANDY SILT, some gravel		3.05	2	50 DO	44				
				75.08							
		End of Hole Auger and Split Spoon refusal		3.35							W.L. in Open hole at elev. 75.99m upon completion of drilling

16 —◆— 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DEPTH SCALE 1 : 50

Golder Associates

LOGGED J.COBISA

CHECKED DB

RECORD OF BOREHOLE 89-12A

SHEET 1 of 1

LOCATION See Figure 6 | BORING DATE Dec.15&18, 1989 | DATUM Geodetic

SAMPLER HAMMER, 63.5kg, DROP, 760mm | PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

Boring method: Power Auger, 200mm Diam. (Hollow Stem)

Description	Elev. / Depth (m)	Sample Number	Type	Blows/0.3m
Ground Surface	78.43			
Loose grey and brown layered SILTY fine SAND and CLAYEY SILT	0.00			
Loose brown fine SAND, trace silt	76.60 / 1.83			
Very dense grey silty sand to sandy silt, some gravel (TILL)	75.38 / 3.05	1	50 DO	100
		2	50 DO	74
End of Hole Auger Refusal	70.57 / 7.86			

Column headings: DEPTH SCALE METRES; BORING METHOD; SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. DEPTH (M)); SAMPLES (NUMBER, TYPE, BLOWS/0.3M); DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa nat.V.- + Q.- ● rem.V.- ⊕ U.- O; HYDRAULIC CONDUCTIVITY, k, CM/SEC; WATER CONTENT, PERCENT Wp W Wl 20 40 60 80; ADDITIONAL LAB. TESTING; PIEZOMETER OR STANDPIPE INSTALLATION

Depth scale: 0 1 2 3 4 5 6 7 8 9 10

15 0 5 10 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE 1 : 50

Golder Associates

LOGGED J.COBISA

CHECKED DB

RECORD OF BOREHOLE 89-13

SHEET 1 of 2

LOCATION See Figure 6

BORING DATE Dec.18&19, 1989

DATUM Geodetic

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (M)	SAMPLE NUMBER	TYPE	BLOWS/0.3M	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger 200mm Diam. (Hollow Stem)	Ground Surface	82.26					
		TOPSOIL	0.00					Bentonite Seal
		Compact to dense brown fine SAND, some silt, trace gravel, occasional silt seam	0.21					Backfill
2				1	50 DO	21		
3			79.00 / 3.26					
		Very dense to compact grey medium to fine SAND, trace silt and some gravel		2	50 DO	65		
5				3	50 DO	56		
6				4	50 DO	34		
7								▽ (water level)
8				5	50 DO	27	M	
9				6	50 DO	29	M	
10		Hole Continued	72.26 / 10.00					Caved Backfill

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

SHEAR STRENGTH Cu, kPa — nat.V.- + Q.- ● rem.V.- ⊕ U.- ○

HYDRAULIC CONDUCTIVITY, k, CM/SEC

WATER CONTENT, PERCENT Wp — W — Wl: 20 40 60 80

PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE 1 : 50

Golder Associates

LOGGED J.COBISA

CHECKED DB

RECORD OF BOREHOLE 89-13

LOCATION See Figure 6
BORING DATE Dec.18&19, 1989
DATUM Geodetic
SAMPLER HAMMER, 63.5kg, DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE – DESCRIPTION	STRATA PLOT	ELEV. DEPTH (M)	SAMPLES NUMBER	TYPE	BLOWS/0.3M	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat.V.- + Q.- ● rem.V.- ⊕ U.- O)	HYDRAULIC CONDUCTIVITY, k, CM/SEC / WATER CONTENT, PERCENT Wp W Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10		Hole Continued		72.26 / 10.00							Caved Backfill
11	Power Auger 200mm Diam. (Hollow Stem)	Compact grey fine to medium SAND, trace gravel			7	50 DO	27				38mm PVC #10 Slot Screen
12				69.89	8	50 DO	0				
		End of Hole Auger Refusal		12.37							W.L. in Well Screen at elev. 75.45m Dec. 22, 1989
13											
14											
15											
16											
17											
18											
19											
20											

16 ⊕ 6 (0, 10) PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED J.COBISA
CHECKED DB

RECORD OF BOREHOLE 89-16

SHEET 1 of 2

LOCATION See Figure 6 | BORING DATE JAN.16&17, 1990 | DATUM Geodetic

SAMPLER HAMMER, 63.5kg, DROP, 760mm | PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

Boring method: Power Auger, 200mm Diam. (Hollow Stem)

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (M)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Ground Surface	80.00 / 0.00					Bentonite Seal
0–3.96	Dense to compact grey brown SAND and GRAVEL, trace silt	76.04 / 3.96	1	50 DO	34		Backfill (from ~1.9 m)
			2	50 DO	13		
3.96–5.18	Loose grey layered fine SAND, clayey silt and silty clay seams	74.82 / 5.18	3	50 DO	7		Water level ▽ (~4.8 m)
5.18–8.84	Compact to loose brown to grey fine SAND, some gravel	71.16 / 8.84	4	50 DO	20	M	Granular Filter (from ~6.8 m)
			5	50 DO	3	M	38mm PVC #10 Slot Screen (~7.5–9.0 m)
8.84–9.08	Grey CLAYEY SILT & SANDY SILT	9.08					
9.08–9.20	Grey SAND and GRAVEL	9.20					
9.20–10.00	Compact grey sandy silt, some gravel, occasional cobbles (TILL)	70.00 / 10.00	6	50 DO	22		
10	Hole Continued						

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

HYDRAULIC CONDUCTIVITY, k, CM/SEC

SHEAR STRENGTH Cu, kPa — nat.V.- + Q.- ● rem.V.- ⊕ U.- ○

WATER CONTENT, PERCENT — Wp W Wl — 20 40 60 80

15 -◆- 5 PERCENT AXIAL STRAIN AT FAILURE (0 / 10)

DEPTH SCALE 1 : 50

Golder Associates

LOGGED J.COBISA

CHECKED DB

RECORD OF BOREHOLE 89-16

SHEET 2 of 2

LOCATION See Figure 2 | BORING DATE JAN.16&17, 1990 | DATUM Geodetic

SAMPLER HAMMER, 63.5kg, DROP, 760mm | PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (M)	SAMPLES: NUMBER	TYPE	BLOWS/0.3M	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V.- + Q.- ● rem.V.- ⊕ U.- O)	HYDRAULIC CONDUCTIVITY, k, CM/SEC; WATER CONTENT, PERCENT (Wp W Wl; 20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10	Power Auger 200mm Diam. (Hollow Stem)	Hole Continued		70.00							
		Compact grey sandy silt, some gravel, occasional cobbles (TILL)		10.00	7	50 DO	11				Granular Filter
11				68.97							
		End of Hole Auger Refusal		11.03							W.L. in Well Screen at Elev. 75.28m Jan. 24, 1990
12											
13											
14											
15											
16											
17											
18											
19											
20											

15 -◆- 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DEPTH SCALE 1 : 50

Golder Associates

LOGGED J.COBISA

CHECKED DB

PROJECT: 921-2709
LOCATION: See Plan
DIP:

RECORD OF BOREHOLE 92-1

BORING DATE: Mar.11to13,1992

SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES: 0 – 15
BORING METHOD: Power Auger, 200mm Diam (Hollow Stem)

SOIL PROFILE

DESCRIPTION	ELEV. / DEPTH (m)
Ground Surface	76.98 / 0.00
Very dense brown SAND and GRAVEL, trace silt, some cobbles, nested cobbles from 2.3 to 2.8 metres	71.58 / 5.40
Compact to dense grey fine to coarse GRAVEL, some sandier zones, many cobbles	67.07 / 9.91
Very dense dark grey sandy silt, some gravel, trace clay, some cobbles and boulders (GLACIAL TILL)	63.32 / 13.66
End of Hole Auger Refusal	

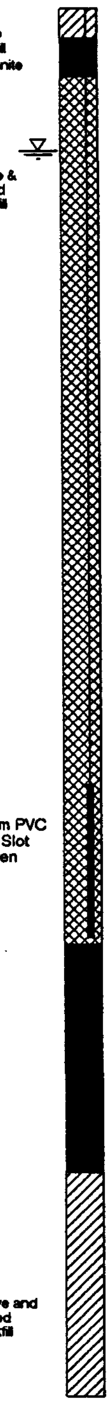
SAMPLES

NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING
1	50 DO	47		
2	50 DO	75		MH
3	50 DO	61		
4	50 DO	34		
5	50 DO	29		MH
6	50 DO	53		
7	50 DO	138		
8	50 DO	76		MH

Combustible Vapour ⊕ ( )
% LEL □
HYDRAULIC CONDUCTIVITY, k, cm/s
WATER CONTENT, PERCENT
Wp — W — Wl
20 40 60 80

INSTALLATIONS

A B C



Native Backfill
Bentonite Seal
Native & Caved Backfill
50mm PVC #10 Slot Screen
Native and Caved Backfill
W.L in Screen at Elev.75.61m Apr. 1, 1992

DATA INPUT: Disk 11, Stever

DEPTH SCALE (ALONG HOLE)
1 to 75

Golder Associates

LOGGED: P.A.S
CHECKED: LDC

PROJECT: 921-2709
LOCATION: See Plan
DIP:

RECORD OF BOREHOLE 92-2

BORING DATE: Mar.16,1992

SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	INSTALLATIONS A
		Ground Surface		76.48						
0	Power Auger 200mm Diam (Hollow Stem)	Compact brown SAND and GRAVEL, trace silt, some cobbles		0.00						Bentonite Seal
2					1	50 DO	18			Native and Caved Backfill
3					2	50 DO	30			
4.3		Dense grey SANDY GRAVEL, some cobbles		72.18 / 4.30	3	50 DO	34			
6					4	50 DO	43			
8					5	50 DO	35		M	50mm PVC #10 Slot Screen
9					6	50 DO	34			Bentonite Seal
10.2		Compact to very dense grey sandy silt, some gravel, trace clay (GLACIAL TILL)		66.27 / 10.21	7	50 DO	27			Native Backfill
12					8	50 DO	>100			
13.9		End of Hole		62.55 / 13.93	9	50 DO	>100			W.L in Screen at Elev.75.60m Apr. 1, 1992

GAS CONCENTRATION ⊕ ( ) — % LEL □
HYDRAULIC CONDUCTIVITY, k, cm/s
WATER CONTENT, PERCENT Wp —O W— Wl 20 40 60 80

DEPTH SCALE (ALONG HOLE) 1 to 75

Golder Associates

LOGGED: P.A.S
CHECKED: [handwritten initials]

DATA INPUT: Disk 11, Stever

PROJECT: 921-2709

RECORD OF BOREHOLE 92-3

SHEET 1 OF 1

LOCATION: See Plan

BORING DATE: Mar.18,1992

DATUM: Geodetic

DIP:

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	GAS CONCENTRATION ( ) / % LEL	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp W Wl 20 40 60 80	INSTALLATIONS A
		Ground Surface		77.04								
0	Power Auger 200mm Diam (Hollow Stem)	Dense grey brown SAND and GRAVEL, trace silt		0.00								Bentonite Seal
2				74.94 / 2.10	1	50 DO	39					
		Compact to dense grey fine to medium SAND, trace gravel, some gravelly sand bands			2	50 DO	10					Native and Caved Backfill
					3	50 DO	22					
					4	50 DO	43					
8				69.14 / 7.90	5	50 DO	20					50mm PVC #10 Slot Screen
		Compact grey medium to coarse SAND, trace to some fine gravel			6	50 DO	21					
				66.31 / 10.73	7	50 DO	27					
		Compact to dense grey sandy silt, some gravel and cobbles, trace clay, boulders (GLACIAL TILL)										Bentonite Seal
				64.39 / 12.65								Native and Caved Backfill
		End of Hole Auger Refusal										W.L in Screen at Elev.75.61m Apr. 1, 1992

DATA INPUT: Disk 11, Stever

DEPTH SCALE (ALONG HOLE)
1 to 75

Golder Associates

LOGGED: P.A.S
CHECKED: PAS

PROJECT: 921-2709

LOCATION: See Plan

DIP:

RECORD OF BOREHOLE 92-4

BORING DATE: Mar.17,1992

SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	INSTALLATIONS A
0	Power Auger 200mm Diam (Hollow Stem)	Ground Surface		76.36 / 0.00						
		Compact brown to grey fine to coarse GRAVEL, trace sand, occasional cobbles			1	50 DO	12			Native and Caved Backfill
					2	50 DO	9			
					3	50 DO	25			
					4	50 DO	16			
					5	50 DO	20			50mm PVC #10 Slot Screen
					6	50 DO	14			
		Compact grey SAND and GRAVEL, some silt		65.84 / 10.52	7	50 DO	35			
		Probably Glacial Till		65.38 / 10.98						Bentonite Seal; Native and Caved Backfill
13		End of Hole		63.25 / 13.11						W.L in Screen at Elev.75.60m Apr. 1, 1992

GAS CONCENTRATION ⊕ ( ) — % LEL □

HYDRAULIC CONDUCTIVITY, k, cm/s — WATER CONTENT, PERCENT Wp —○W— Wl 20 40 60 80

DATA INPUT: Disk 11, Stever

DEPTH SCALE (ALONG HOLE) 1 to 75

Golder Associates

LOGGED: P.A.S

CHECKED:

RECORD OF BOREHOLE 92-5

PROJECT: 921-2709
LOCATION: See Plan
DIP:

BORING DATE: Mar.20,1992

SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 63.5kg; DROP, 760 mm

BORING METHOD: Power Auger, 200mm Diam (Hollow Stem)

DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING
Ground Surface	78.31					
TOPSOIL	0.00					
Brown SILTY SAND, trace gravel, occasional cobble	0.18					
Brown CLAYEY SILT	77.40 / 0.91	1	AS	-		
Loose brown SILTY fine SAND	76.79 / 1.52	2	50 DO	9		
Compact grey fine SAND, occasional sandy silt to clayey silt layer	76.16 / 2.15	3	50 DO	12		
Loose to compact grey fine to medium SAND	74.61 / 3.70	4	50 DO	5		
		5	50 DO	11		M
		6	50 DO	12		
Dense grey sandy silt, some gravel, trace clay (GLACIAL TILL)	67.03 / 11.28	7	50 DO	>100		
End of Hole Auger Refusal	65.60 / 12.71					

GAS CONCENTRATION ⊕ ( )
% LEL □

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT
Wp —○W— Wl
20 40 60 80

INSTALLATIONS
A

- Bentonite Seal
- Native and Caved Backfill
- 38mm PVC #10 Slot Screen
- Bentonite Seal
- Native and Caved Backfill

W.L in Screen at Elev.75.59m Apr. 1, 1992

DATA INPUT: Disk 11, Stever

DEPTH SCALE (ALONG HOLE)
1 to 75

Golder Associates

LOGGED: P.A.S
CHECKED: PKS

PROJECT: 921-2709

LOCATION: See Plan

DIP:

RECORD OF BOREHOLE 92-6

BORING DATE: Mar.19,1992

SHEET 1 OF 2

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	Combustible Vapour ( ) ⊕ / % LEL □	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp W Wl 20 40 60 80	INSTALLATIONS A B C
		Ground Surface		80.72								
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL		0.00								Bentonite Seal
		Loose to compact brown SILTY SAND to fine SAND, some gravel		0.21								
1					1	AS	-					
2					2	50 DO	9					
		Compact grey fine to medium SAND, trace to some silt to SILTY fine SAND, occasional sandy silt layer, medium sand layer from 9.0 - 10.0 metre depth		78.43 2.29								
3					3	50 DO	17					
4												Native and Caved Backfill
5												▽
6					4	50 DO	14					
7												
8					5	50 DO	11					
9					6	50 DO	13					
10												
11					7	50 DO	14					
12					8	50 DO	15					50mm PVC #10 Slot Screen
13												
14												
		Dense grey sandy silt, some gravel, trace clay (GLACIAL TILL)		65.78								
15		CONTINUED ON NEXT PAGE										

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DATA INPUT: Disk 11, Stever

DEPTH SCALE (ALONG HOLE)

1 to 75

Golder Associates

LOGGED: P.A.S

CHECKED: LDC

PROJECT: 921-2709

RECORD OF BOREHOLE 92-6

SHEET 2 OF 2

LOCATION: See Plan

BORING DATE: Mar.19,1992

DATUM: Geodetic

DIP:

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	Combustible Vapour ( ) % LEL	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp—W—Wl 20 40 60 80	INSTALLATIONS A B C
	Power Auger 200mm Diam (Hollow Stem)	CONTINUED FROM PREVIOUS PAGE										
15		Dense grey sandy silt, some gravel, trace clay (GLACIAL TILL)		64.87	9	50 DO	57					Native and Caved Backfill
16		End of Hole		15.85								W.L in Screen at Elev.75.43m Apr. 1, 1992
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												

DATA INPUT: Disk 11, Stever

DEPTH SCALE (ALONG HOLE)
1 to 75

Golder Associates

LOGGED: P.A.S
CHECKED: CDC

PROJECT: 921-2752

LOCATION: See Plan

DIP:

RECORD OF BOREHOLE 92-7

BORING DATE: July 16, 1992

SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	Combustible Vapour ( ) ⊕ % LEL □	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT Wp W Wl 20 40 60 80	INSTALLATIONS A B C
		Ground Surface		81.13								
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL		0.03								
		Loose to compact brown to dark brown fine to medium SAND, trace silt			1	50 DO	10					
					2	50 DO	18		M			
					3	50 DO	18					
6		Compact dark grey fine to medium SAND, occasional silt layers		74.89 6.24	4	50 DO	24					
		End of Hole		74.43 6.70								W.L in Open Hole at Elev.75.65m July 16, 1992

DATA INPUT: Disk 12: S.Leighton

DEPTH SCALE (ALONG HOLE)

1 to 50

Golder Associates

LOGGED: L.D.L

CHECKED: LDC

PROJECT: 921-2752

LOCATION: See Plan

DIP:

RECORD OF BOREHOLE 92-8

BORING DATE: July 16, 1992

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

SHEET 1 OF 1

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	Combustible Vapour ( ) ⊕ / % LEL □	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp —O^W— Wl 20 40 60 80	INSTALLATIONS A B C
		Ground Surface		75.76								
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL		0.03								
		Dark brown SANDY SILT		74.54 1.22								
1		Compact grey fine to medium SAND, trace silt		73.63 2.13	1	50 DO	10					∇
2		End of Hole										W.L. in open hole at elev. 74.25m July 16, 1992
3												
4												
5												
6												
7												
8												
9												
10												

DATA INPUT: Disk 12. S.Leighton

DEPTH SCALE (ALONG HOLE)

1 to 50

Golder Associates

LOGGED: L.D.L

CHECKED: LDL

PROJECT: 921-2752

LOCATION: See Plan

DIP:

RECORD OF BOREHOLE 92-8A

BORING DATE: July 20, 1992

SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

SHEET 1 OF 1

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	INSTALLATIONS
		Ground Surface		75.72						
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL		0.03						Bentonite Seal
		Dark brown SANDY SILT		74.50 / 1.22						
1		Compact grey fine to medium SAND, trace silt		74.05 / 1.67						Native Backfill
2		Compact grey fine to medium SAND, some silt		72.01 / 3.71	1	50 DO	14		M	38mm PVC #10 Slot Screen
4		Compact grey silty sand, some gravel (GLACIAL TILL)		70.54 / 5.18	2	50 DO	27			
5		End of Hole								W.L in Screen at Elev.74.61m July 22, 1992

Combustible Vapour ( ) ⊕ / % LEL □

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT Wp —o W— Wl: 20 40 60 80

INSTALLATIONS: A B C

DEPTH SCALE (ALONG HOLE) 1 to 50

Golder Associates

LOGGED: L.D.L

CHECKED: LDC

PROJECT: 921-2752

LOCATION: See Plan

DIP:

RECORD OF BOREHOLE 92-9

BORING DATE: July 16, 1992

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

SHEET 1 OF 1

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	Combustible Vapour ( ) ⊕ / % LEL □	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp—W—Wl 20 40 60 80	INSTALLATIONS A B C
		Ground Surface		76.50								
0	Power Auger 200mm Diam (Hollow Stem)	Brown SANDY SILT		0.00								
				74.83 1.67								
		Compact grey fine to medium SAND, occasional thin silt seams			1	50 DO	12					
2				74.37 2.13								W.L. in open hole at elev. 75.00m July 16, 1992
		End of Hole										

DEPTH SCALE (ALONG HOLE)

1 to 50

DATA INPUT: Disk 12. S.Leighton

Golder Associates

LOGGED: L.D.L

CHECKED: LDL

PROJECT: 921-2752

LOCATION: See Plan

DIP:

RECORD OF BOREHOLE 92-10

BORING DATE: July 16, 1992

SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	INSTALLATIONS
		Ground Surface		80.63						
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL		0.03						Bentonite Seal
1–2		Compact brown fine to coarse SAND and fine GRAVEL		78.35 2.28	1	50 DO	25		M	Native Backfill
2–3		Brown CLAYEY SILT		77.58 3.05						
3–8		Dense to compact brown fine to medium SAND, trace silt		72.41 8.22	2	50 DO	35			
					3	50 DO	14		M	
					4	50 DO	12			38mm PVC #10 Slot Screen
8–10		End of Hole								W.L in Screen at Elev.75.49m July 22, 1992

Combustible Vapour ( ) ⊕ — % LEL □

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT Wp —o W — Wl 20 40 60 80

INSTALLATIONS A B C

DATA INPUT: Disk 12. S.Leighton

DEPTH SCALE (ALONG HOLE) 1 to 50

Golder Associates

LOGGED: L.D.L

CHECKED: LDC

RECORD OF BOREHOLE 92-11

PROJECT: 921-2752
LOCATION: See Plan
DIP:

BORING DATE: July 17, 1992

SHEET 1 OF 2
DATUM: Geodetic
SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m)) | SAMPLES (NUMBER, TYPE, BLOWS/0.3m, RECOVERY %, LAB. TESTING) | Combustible Vapour ⊕ ( ) / % LEL □ | HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp —o W— Wl (20 40 60 80) | INSTALLATIONS (A, B, C)

Boring method (0 to 10 m): Power Auger, 200mm Diam (Hollow Stem)

Ground Surface: 81.88

Elev. / Depth (m)	Description
81.88 / 0.00	Loose to compact brown uniform fine to medium SAND, occasional silt layers
77.16 / 4.72	Dense to compact brown fine to coarse SAND and GRAVEL
74.72 / 7.16	Loose grey fine to medium SAND, trace silt

Number	Type	Blows/0.3m	Recovery %	Lab. Testing
1	50 DO	9		M
2	50 DO	11		
3	50 DO	34		M
4	50 DO	18		M
5	50 DO	5		

Installations (A): Bentonite Seal; Native Backfill; 38mm PVC #10 Slot Screen; water level ▽ (approx. 6.4 m)

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DATA INPUT: DISK 12: S.Leighton

DEPTH SCALE (ALONG HOLE)
1 to 50

Golder Associates

LOGGED: L.D.L
CHECKED: LDL

PROJECT: 921-2752

LOCATION: See Plan

DIP:

RECORD OF BOREHOLE 92-11

BORING DATE: July 17, 1992

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	Combustible Vapour ⊕ ( ) / % LEL □	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp —O^W— Wl 20 40 60 80	INSTALLATIONS A B C
10	Power Auger 200mm Diam (Hollow Stem)	CONTINUED FROM PREVIOUS PAGE										
		Loose grey fine to medium SAND, trace silt		70.30 / 11.58								
12–13		Compact grey fine to coarse SAND and fine GRAVEL, trace silt		67.68 / 14.20	6	AS						
14–15		Grey silty sand, some gravel (GLACIAL TILL)		66.64 / 15.24	7	AS						
		End of Hole										W.L in Screen at Elev.75.49m July 22, 1992

DEPTH SCALE (ALONG HOLE)

1 to 50

Golder Associates

LOGGED: L.D.L

CHECKED: LDL

DATA INPUT: Disk 12.5.Leighton

RECORD OF BOREHOLE 92-12

PROJECT: 921-2752
LOCATION: See Plan
DIP:

BORING DATE: July 20, 1992

SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	INSTALLATIONS
		Ground Surface		81.29						
0				0.00						Bentonite Seal
2					1	50 DO	16		M	Native Backfill
3		Compact brown fine to medium SAND, trace silt, occasional thin seams			2	50 DO	20			
5	Power Auger 200mm Diam (Hollow Stem)				3	50 DO	23			
6					4	50 DO	20		M	
8										38mm PVC #10 Slot Screen
9				72.15 9.14						
		End of Hole								W.L in Screen at Elev.75.49m July 22, 1992

Combustible Vapour ( ) ⊕ — % LEL ☐

HYDRAULIC CONDUCTIVITY, k, cm/s — WATER CONTENT, PERCENT Wp —O W— Wl 20 40 60 80

INSTALLATIONS A B C

DATA INPUT: Disk 12 S.Leighton

DEPTH SCALE (ALONG HOLE) 1 to 50

Golder Associates

LOGGED: L.D.L
CHECKED: LDC

RECORD OF BOREHOLE 92-13

PROJECT: 921-2752
LOCATION: See Plan
DIP:
BORING DATE: July 20, 1992
SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING
		Ground Surface	76.68					
0	Power Auger 200mm Diam (Hollow Stem)	Brown SILTY SAND	0.00					
1		Compact dark grey fine to medium SAND	75.46 / 1.22	1	50 DO	13		
3		Compact grey silty sand, some gravel (GLACIAL TILL)	73.48 / 3.20	2	50 DO	21		
				3	50 DO	6		
5		End of Hole	71.50 / 5.18					

Combustible Vapour ⊕ ( ) — % LEL □

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT Wp ⊢—○W—⊣ Wl: 20 40 60 80

INSTALLATIONS (A, B, C):

- Bentonite Seal
- Native Backfill
- 38mm PVC #10 Slot Screen
- W.L in Screen at Elev.75.53m July 22, 1992

DATA INPUT: Disk 12, S.Leighton

DEPTH SCALE (ALONG HOLE) 1 to 50

Golder Associates

LOGGED: L.D.L
CHECKED: LDL

RECORD OF BOREHOLE 92-14

PROJECT: 921-2752
LOCATION: See Plan
DIP:

BORING DATE: July 20, 1992

SHEET 1 OF 2
DATUM: Geodetic
SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

Boring method: Power Auger, 200mm Diam (Hollow Stem)

Depth Scale (m)	Description	Elev. / Depth (m)	Sample Number	Type	Blows/0.3m	Recovery %	Lab. Testing
	Ground Surface	79.09 / 0.00					
0	Brown fine to coarse SAND, some gravel	78.18 / 0.91					
1–2	Brown CLAYEY SILT, some sand	76.66 / 2.43	1	50 DO	11		
2–3	Brown fine SAND	76.04 / 3.05					
3–9	Compact to loose grey fine to medium SAND, trace to some silt	69.65 / 9.44	2	50 DO	18		M
			3	50 DO	PM		
9–10	Grey fine to coarse SAND, some gravel						
10	CONTINUED ON NEXT PAGE						

Combustible Vapour ( ) ⊕ — % LEL □

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT Wp —○W— Wl: 20 40 60 80

INSTALLATIONS A B C

DEPTH SCALE (ALONG HOLE) 1 to 50

Golder Associates

LOGGED: L.D.L
CHECKED: LDC

DATA INPUT: Disk 12. S.Leighton

PROJECT: 921-2752

RECORD OF BOREHOLE 92-14

LOCATION: See Plan

BORING DATE: July 20, 1992

DATUM: Geodetic

DIP:

SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	Combustible Vapour ( ) ⊕ / % LEL □	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp —O^W— Wl 20 40 60 80	INSTALLATIONS A B C
		CONTINUED FROM PREVIOUS PAGE										
10 – 14	Power Auger 200mm Diam (Hollow Stem)	Grey fine to coarse SAND, some gravel		65.07 14.02								
14 – 15		Grey silty sand, some gravel (GLACIAL TILL)		63.88 15.21	4	AS						
		End of Hole Auger Refusal										W.L in open hole at elev.75.60m July 20, 1992

DEPTH SCALE (ALONG HOLE) 1 to 50

DATA INPUT: Disk 12, b.Leighton

Golder Associates

LOGGED: L.D.L

CHECKED: LDL

PROJECT: 921-2752

RECORD OF BOREHOLE 92-15

SHEET 1 OF 1

LOCATION: See Plan

BORING DATE: July 20, 1992

DATUM: Geodetic

DIP:

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

Depth Scale (metres)	Boring Method	Description	Strata Plot	Elev. / Depth (m)	Sample Number	Type	Blows/0.3m	Recovery %	Lab. Testing
		Ground Surface		79.99					
0	Power Auger 200mm Diam (Hollow Stem)	Brown fine to coarse SAND, and fine gravel, trace silt		0.00					
1		Brown fine to medium SAND		78.77 / 1.22					
2		Brown SILTY CLAY		78.32 / 1.67	1	50 DO	4		
		Grey fine to medium SAND		77.25 / 2.74					
3		Grey CLAYEY SILT, trace gravel		76.79 / 3.20	2	50 DO	13		
4		Compact brown fine to medium SAND, occasional silt seams		75.72 / 4.27	3	50 DO	28		
5		End of Hole		74.81 / 5.18					

Combustible Vapour ( ) ⊕ — % LEL □

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT Wp ⊢—O W —⊣ Wl: 20 40 60 80

INSTALLATIONS: A B C

DATA INPUT: Disk 12. S.Leighton

DEPTH SCALE (ALONG HOLE) 1 to 50

Golder Associates

LOGGED: L.D.L

CHECKED: LDL

APPENDIX A-III

PRESENT INVESTIGATION BY GOLDER ASSOCIATES

RECORD OF BOREHOLE 94-1

PROJECT: 941-2747
LOCATION: See Plan
DIP:

BORING DATE: May 20, 1994

SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 63.5kg; DROP, 760 mm

BORING METHOD: Power Auger, 200mm Diam (Hollow Stem)

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	INSTALLATIONS
	Ground Surface	76.26				
0	Brown sand and gravel, some silt (FILL)	0.00				Bentonite Seal
	Compact dark grey fine to medium SAND, trace silt	75.80 / 0.46				
2			1	50 DO	13	
3	Compact dark grey to grey SAND and GRAVEL, trace to some silt, occasional cobble	73.06 / 3.20	2	50 DO	16	Native Backfill
5			3	50 DO	25	
6			4	50 DO	12	
8			5	50 DO	15	50mm PVC #10 Slot Screen
9			6	50 DO	14	
10	Dense grey sandy silt, some gravel and clay, occasional cobble (GLACIAL TILL)	66.51 / 9.75				
11			7	50 DO	30	
	End of Hole Auger Refusal	65.04 / 11.22				W.L in Screen at Elev.75.09m Oct.5, 1994

Other columns: STRATA PLOT; RECOVERY %; LAB. TESTING; HNu ( ) ⊕; LEL % □; HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT Wp—W—Wl

Depth scale: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

DATA INPUT: Disk 18, S.Leighton

DEPTH SCALE (ALONG HOLE)
1 to 75

Golder Associates

LOGGED: K.A.M
CHECKED: KAM

RECORD OF BOREHOLE 94-2

PROJECT: 941-2747
LOCATION: See Plan
DIP:

BORING DATE: May 20,24,1994

SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 63.5kg; DROP, 760 mm

BORING METHOD: Power Auger, 200mm Diam (Hollow Stem)

SOIL PROFILE

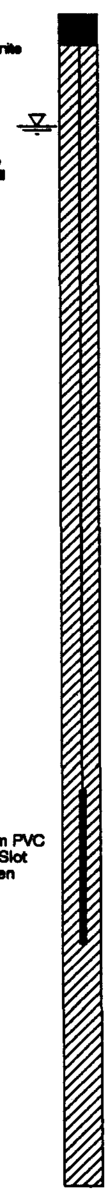
DESCRIPTION	ELEV. / DEPTH (m)
Ground Surface	76.19
Brown SILTY SAND and GRAVEL	0.00
Compact to dense brown to grey SAND and GRAVEL, some cobbles, occasional boulder	0.24
Very dense grey sandy silt, some gravel and clay, occasional cobble and boulder (GLACIAL TILL)	67.11 / 9.08
End of Hole Auger Refusal	64.69 / 11.50

SAMPLES

NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING
1	63 DO	34		
2	63 DO	92		
3	63 DO	43		MH
4	63 DO	66		
5	63 DO	38		MH
6	63 DO	> 100		
7	50 DO	69		

HNu ( ) ⊕
LEL % □
HYDRAULIC CONDUCTIVITY, k, cm/s
WATER CONTENT, PERCENT Wp —O^W— Wl

INSTALLATIONS



DEPTH SCALE METRES: 0–15

DEPTH SCALE (ALONG HOLE) 1 to 75

DATA INPUT: Disk 18, S.Leighton

Golder Associates

LOGGED: K.A.M
CHECKED: KAM

RECORD OF BOREHOLE 94-3

PROJECT: 941-2747
LOCATION: See Plan
DIP:

BORING DATE: May 24,1994
SAMPLER HAMMER, 63.5kg; DROP, 760 mm

SHEET 1 OF 1
DATUM: Geodetic

Depth (m)	Boring Method	Description	Strata Plot	Elev. / Depth (m)	Sample Number	Type	Blows/0.3m	Recovery %	Lab. Testing	Installations
		Ground Surface		76.24 / 0.00						Bentonite Seal
0.00–5.18	Power Auger, 200mm Diam (Hollow Stem)	Compact dark brown to grey fine to medium SAND, trace silt			1	63 DO	15		MH	Native Backfill
					2	63 DO	21			
5.18–8.08		Loose to compact grey fine SAND, trace silt		71.06 / 5.18	3	63 DO	14			50mm PVC #10 Slot Screen
					4	63 DO	7			
		End of Hole		68.16 / 8.08						W.L in Screen at Elev.75.14m Oct.5, 1994

HNu ( ) ⊕ — LEL % □
HYDRAULIC CONDUCTIVITY, k, cm/s
WATER CONTENT, PERCENT Wp ⊢—○W—⊣ Wl

DEPTH SCALE (ALONG HOLE) 1 to 75

Golder Associates

LOGGED: K.A.M
CHECKED: KAM

DATA INPUT: Disk 18, S.Leighton

PROJECT: 941-2747

LOCATION: See Plan

DIP:

RECORD OF BOREHOLE 94-4

BORING DATE: May 25,1994

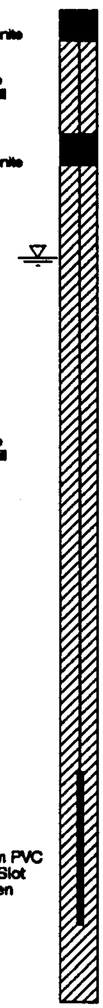
SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	INSTALLATIONS
		Ground Surface	77.52				
0	Power Auger 200mm Diam (Hollow Stem)	Brown silty sand, some gravel (FILL)	0.00				Bentonite Seal; Native Backfill
		Dark brown SILTY SAND, trace gravel	76.91 / 0.61				Bentonite Seal
2		Compact dark brown fine to medium SAND, trace silt	75.84 / 1.68	1	50 DO	14	
3				2	50 DO	11	Native Backfill
5		Compact brown fine SAND, trace silt	72.73 / 4.79	3	50 DO	23	
6		Compact brown fine to medium SAND, occasional 50 to 75mm fine to coarse sand seams with scattered gravel	71.73 / 5.79	4	50 DO	24	
8				5	50 DO	17	50mm PVC #10 Slot Screen
9				6	50 DO	14	
10		End of Hole	67.77 / 9.75				W.L in Screen at Elev.75.11m Oct.5, 1994

Other column headings: STRATA PLOT; RECOVERY %; LAB. TESTING; HNu ( ) ⊕; LEL % □; HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT Wp —○W— Wl



DATA INPUT: Disk 18, S.Leighton

DEPTH SCALE (ALONG HOLE)
1 to 75

Golder Associates

LOGGED: K.A.M

CHECKED: KAM

RECORD OF BOREHOLE 94-5

PROJECT: 941-2747
LOCATION: See Plan
DIP:

BORING DATE: May 25,1994

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

SHEET 1 OF 1
DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	INSTALLATIONS
0	Power Auger 200mm Diam (Hollow Stem)	Ground Surface		76.23 0.00						Bentonite Seal
2		Compact to very dense brown to grey SAND and GRAVEL, some cobbles, occasional boulder, trace silt			1	50 DO	19			Native Backfill
5					2	50 DO	26			
6					3	50 DO	61		MH	
8					4	50 DO	44			50mm PVC #10 Slot Screen
9		Very dense grey SILTY SAND and GRAVEL		66.93 9.30	5	50 DO	>100			
		End of Hole		9.42						
10										W.L in Screen at Elev.75.13m Oct.5, 1994

HNu ( ) ⊕ ; LEL % □

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT Wp —O W— Wl

DATA INPUT: Disk 18, S.Leighton

DEPTH SCALE (ALONG HOLE)
1 to 75

Golder Associates

LOGGED: K.A.M
CHECKED: KAM

RECORD OF BOREHOLE 94-6

PROJECT: 941-2747
LOCATION: See Plan
DIP:

BORING DATE: May 26&27,1994
SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	INSTALLATIONS
		Ground Surface		82.79						
0	Power Auger 200mm Diam (Hollow Stem)	Brown SILTY SAND and GRAVEL, occasional cobble		0.00						Bentonite Seal
1		Very dense brown SAND, GRAVEL, COBBLES and BOULDERS		81.88 / 0.91						Native Backfill
3					1	50 DO	>100		MH	
5										Bentonite Seal
6										Native Backfill
7	Rotary Drill NQ Core				2	NQ RC	-			
8					3	NQ RC	-			50mm PVC #10 Slot Screen
9.69		End of Hole		73.10 / 9.69						W.L in Screen at Elev.75.21m Oct.5, 1994

HNu ( ) ⊕ | LEL % □ | HYDRAULIC CONDUCTIVITY, k, cm/s | WATER CONTENT, PERCENT Wp —O— Wl

DEPTH SCALE (ALONG HOLE) 1 to 75

Golder Associates

LOGGED: K.A.M
CHECKED: KAM

DATA INPUT: Disk 18, S.Leighton

PROJECT: 941-2747

RECORD OF BOREHOLE 94-7

SHEET 1 OF 1

LOCATION: See Plan

BORING DATE: Sept. 19, 1994

DATUM: Geodetic

DIP:

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	HNu ( ) ⊕ / LEL % □	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp—W—Wl	INSTALLATIONS
0		Ground Surface		80.56								
		Brown silty TOPSOIL		0.06								Bentonite Seal
1												Native Backfill
2					1	50 DO	22					
3					2	50 DO	>100					
4												Bentonite Seal
5	Power Auger 200mm Diam (Hollow Stem)	Compact to very dense brown SAND and GRAVEL, some cobbles, occasional boulder			3	50 DO	52					Native Backfill
6					4	50 DO	38					
7												
8					5	50 DO	20					
9					6	50 DO	39					
10				69.74								38mm PVC #10 Slot Screen
11		End of Hole Auger Refusal		10.82								W.L in Screen at Elev.75.11m Oct.5, 1994
12												
13												
14												
15												

DATA INPUT: Disk 19, S.Leighton

DEPTH SCALE (ALONG HOLE)
1 to 75

Golder Associates

LOGGED: D.J.S
CHECKED: KAM

RECORD OF BOREHOLE 94-8

PROJECT: 941-2747
LOCATION: See Plan
DIP:

BORING DATE: Sept. 20, 1994

SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	HNu / LEL %	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp—W—Wl	INSTALLATIONS
0	Power Auger 200mm Diam (Hollow Stem)	Ground Surface	74.65								
		Brown SILTY SAND	0.09						0.00-0.09 Brown silty TOPSOIL		Bentonite Seal
1		Grey brown SILTY CLAY (Weathered Crust)	0.30								Native Backfill
		Grey SILTY CLAY	73.28 / 1.37	1	50 DO	1					Bentonite Seal
2											Granular Filter
3				2	50 DO	1					38mm PVC #10 Slot Screen B
4		Very stiff grey layered SILTY CLAY and CLAYEY SILT	70.14 / 4.51	3	50 DO	2					Bentonite Seal
6		Loose grey fine SAND, occasional 0.03-0.09m silty clay layer	68.86 / 5.79	4	50 DO	WR					Native Backfill
8				5	50 DO	3					38mm PVC #10 Slot Screen A
9				6	50 DO	3					
		End of Hole	64.90 / 9.75								W.L in Screen A at Elev.74.43m Screen B at Elev.73.79m Oct.5, 1994

DATA INPUT: Disk 19, S.Leighton

DEPTH SCALE (ALONG HOLE)
1 to 75

Golder Associates

LOGGED: D.J.S
CHECKED: KAM

PROJECT: 941-2747

LOCATION: See Plan

DIP:

RECORD OF BOREHOLE 94-9

BORING DATE: Sept.20&21,1994

SAMPLER HAMMER, 63.5kg; DROP, 760 mm

SHEET 1 OF 1

DATUM: Geodetic

BORING METHOD: Power Auger, 200mm Diam (Hollow Stem)

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
0	Ground Surface	73.08			
	Dark brown silty TOPSOIL	0.00			
	Very stiff grey brown SILTY CLAY (Weathered Crust)	0.18	1	50 DO	2
	Grey SILTY CLAY, occasional sand seam	70.64 / 2.44	2	50 DO	WH
			3	50 DO	WH
	Probably layered Silty Clay and Clayey Silt	67.75 / 5.33			
	Grey fine SAND, occasional silty clay layer	67.14 / 5.94	4	50 DO	WR
	Loose grey SILTY fine SAND with occasional sandy silt and clayey silt seam	66.07 / 7.01	5	50 DO	4
			6	50 DO	WR
	End of Hole	63.33 / 9.75			

Column headings: DEPTH SCALE METRES; BORING METHOD; SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m)); SAMPLES (NUMBER, TYPE, BLOWS/0.3m, RECOVERY %, LAB. TESTING); HNu ( ) ⊕; LEL % □; HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT Wp—W—Wl; INSTALLATIONS

Depth scale: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

INSTALLATIONS

W.L in Screen A at Elev.71.83m Screen B at Elev.71.47m Oct.5, 1994

DATA INPUT: Disk 19, S.Leighton

DEPTH SCALE (ALONG HOLE) 1 to 75

Golder Associates

LOGGED: D.J.S

CHECKED: KAM

RECORD OF BOREHOLE 94-10

PROJECT: 941-2747
LOCATION: See Plan
DIP:
BORING DATE: Sept.21,1994
SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 63.5kg; DROP, 760 mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	HNu ( ) ⊕ / LEL % □	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp —o W— Wl	INSTALLATIONS
		Ground Surface		76.59								
0	Power Auger 200mm Diam (Hollow Stem)	Brown sandy TOPSOIL		0.09								Bentonite Seal
		Brown SILTY SAND		76.10 / 0.49								
1		Grey brown SILTY CLAY (Weathered Crust)		75.07 / 1.52								Native Backfill
		Loose grey layered SANDY SILT and CLAYEY SILT		74.61 / 1.98	1	50 DO	8					
2		Grey SILTY CLAY, some sand seams		74.00 / 2.59								
3		Compact to dense grey sandy silt, some gravel, trace clay, occasional boulder and fine sand seams (GLACIAL TILL)			2	50 DO	11					
4–5					3	50 DO	11					Bentonite Seal
5–6												Granular Filter
6					4	50 DO	34					
8				67.66 / 8.93	5	50 DO	48					38mm PVC #10 Slot Screen
9		End of Hole Auger Refusal										W.L in Screen at Elev.75.30m Oct.5, 1994
10–15												

DATA INPUT: Disk 19, S.Leighton

DEPTH SCALE (ALONG HOLE)
1 to 75

Golder Associates

LOGGED: D.J.S
CHECKED: KAM

RECORD OF BOREHOLE 94-11

PROJECT: 941-2747
LOCATION: See Plan
DIP:
BORING DATE: Sept.21,1994
SAMPLER HAMMER, 63.5kg; DROP, 760 mm
SHEET 1 OF 1
DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	RECOVERY %	LAB. TESTING	HNu ( ) ⊕ / LEL % □	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp W Wl	INSTALLATIONS
		Ground Surface		82.62								
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL		0.06								Bentonite Seal; Native Backfill; Bentonite Seal
1												Native Backfill
5		Compact to very dense brown SAND and GRAVEL, some cobbles, trace silt			1	50 DO	26					
6					2	50 DO	31					
7												▽
8					3	50 DO	25					
9					4	50 DO	44					
11					5	50 DO	57					38mm PVC #10 Slot Screen
12				70.37								
		End of Hole		12.25								
13												W.L in Screen at Elev.75.19m Oct.5, 1994

DATA INPUT: Disk 19, S.Leighton

DEPTH SCALE (ALONG HOLE)
1 to 75

Golder Associates

LOGGED: D.J.S
CHECKED: KAM

RECORD OF BOREHOLE 94-12

PROJECT: 941-2747
LOCATION: See Plan
DIP:

BORING DATE: Sept.22,1994

SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 63.5kg; DROP, 760 mm

Boring method: Power Auger, 200mm Diam (Hollow Stem)

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
Ground Surface	79.58			
Dark brown TOPSOIL	0.08			
Brown SAND and GRAVEL, occasional cobble, some silt	77.75 / 1.83	1	50 DO	16
Brown SANDY SILT, some gravel and clay	77.14 / 2.44			
Grey-brown SILTY CLAY, scattered trace fine gravel	76.38 / 3.20	2	50 DO	11
Brown fine to coarse SILTY SAND, trace to some gravel	75.62 / 3.96			
Compact brown fine to medium SAND	73.48 / 6.10	3	50 DO	19
Compact brown fine to coarse SAND, trace gravel	71.20 / 8.38	4	50 DO	22
		5	50 DO	17
Compact brown to grey SAND and GRAVEL	69.06 / 10.52	6	50 DO	23
Grey fine SAND, some silt	68.61 / 10.97	7	50 DO	19
Grey sandy silt (GLACIAL TILL)	11.13			
End of Hole				

Columns (no data entered): RECOVERY %; LAB. TESTING; HNu ( ); LEL %; HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)

INSTALLATIONS:
- Bentonite Seal
- Native Backfill
- Bentonite Seal
- Native Backfill
- Bentonite Seal
- Native Backfill
- 38mm PVC #10 Slot Screen
- W.L in Screen at Elev.72.16m Oct.5, 1994

DATA INPUT: Disk 19, S.Leighton

DEPTH SCALE (ALONG HOLE) 1 to 75

Golder Associates

LOGGED: D.J.S
CHECKED:

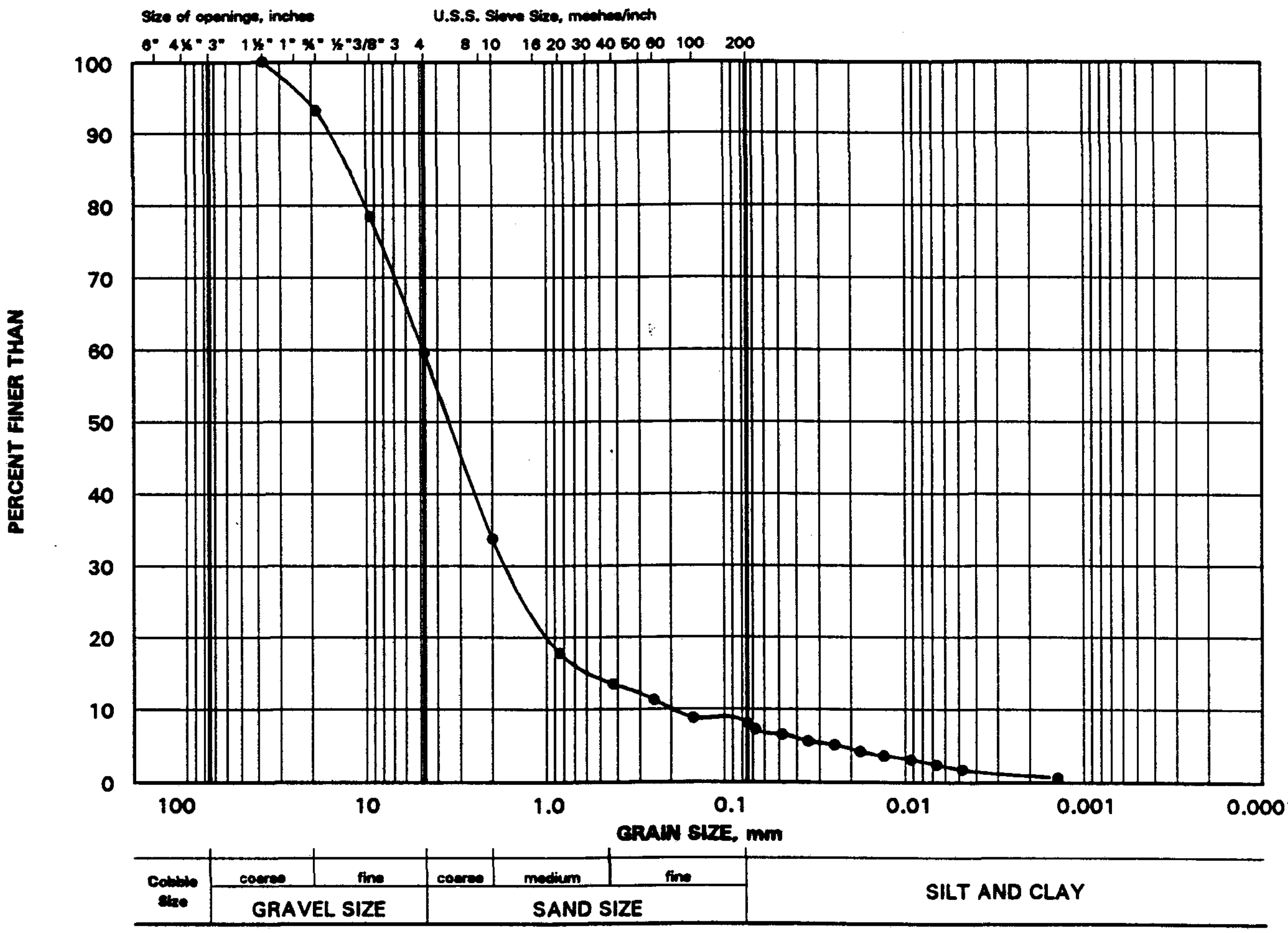
APPENDIX B

GRAIN SIZE DISTRIBUTION CURVES

GRAIN SIZE DISTRIBUTION

FIGURE B-1

SAND and GRAVEL



LEGEND			
SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
●	94-2	3	4.7

ProGrain ver. 2.01

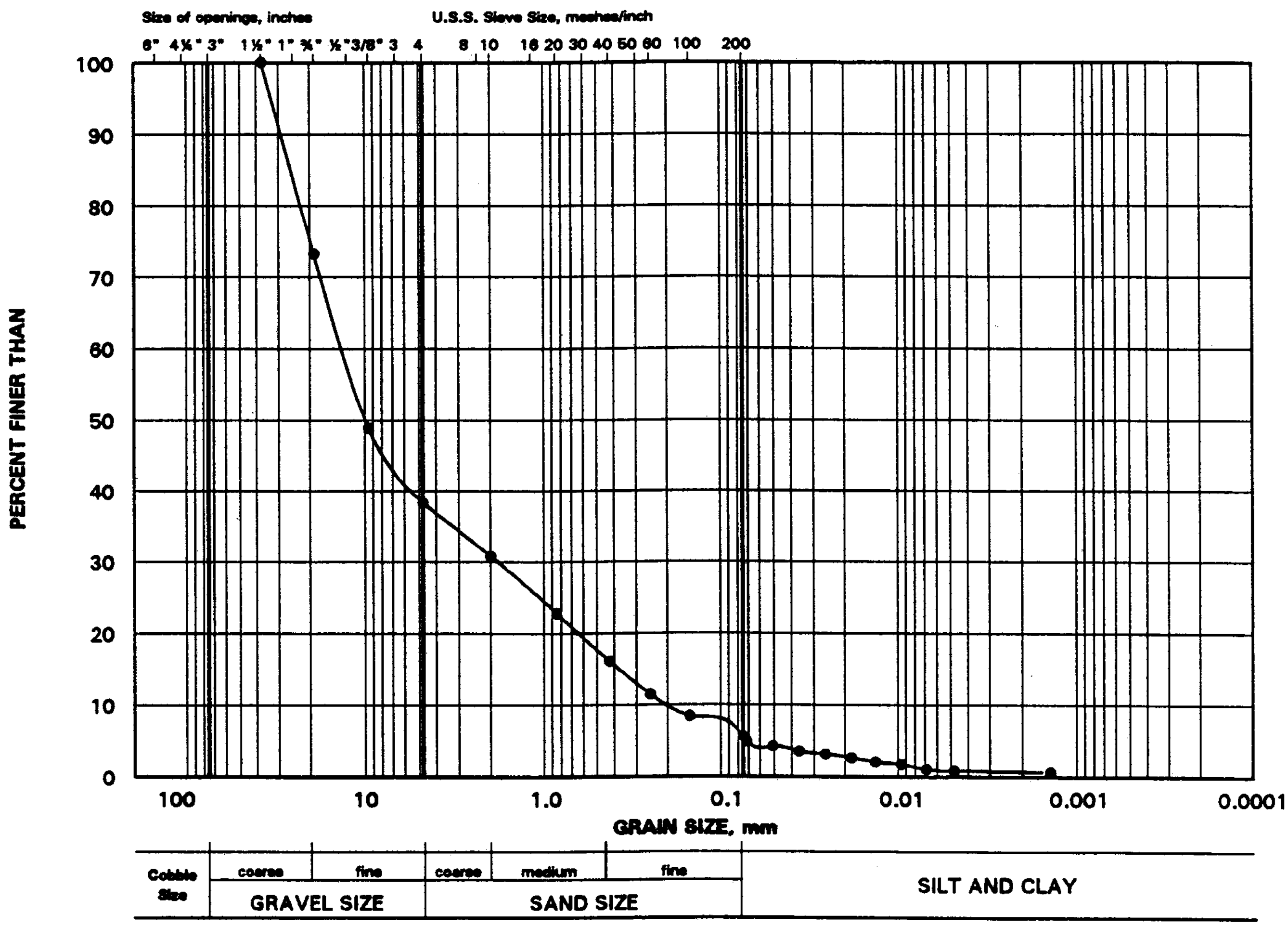
Project 941-2747

Golder Associates

GRAIN SIZE DISTRIBUTION

FIGURE B-2

SAND and GRAVEL



LEGEND				
SYMBOL	BOREHOLE	SAMPLE	DEPTH	(m)
●	94-2	5		7.8

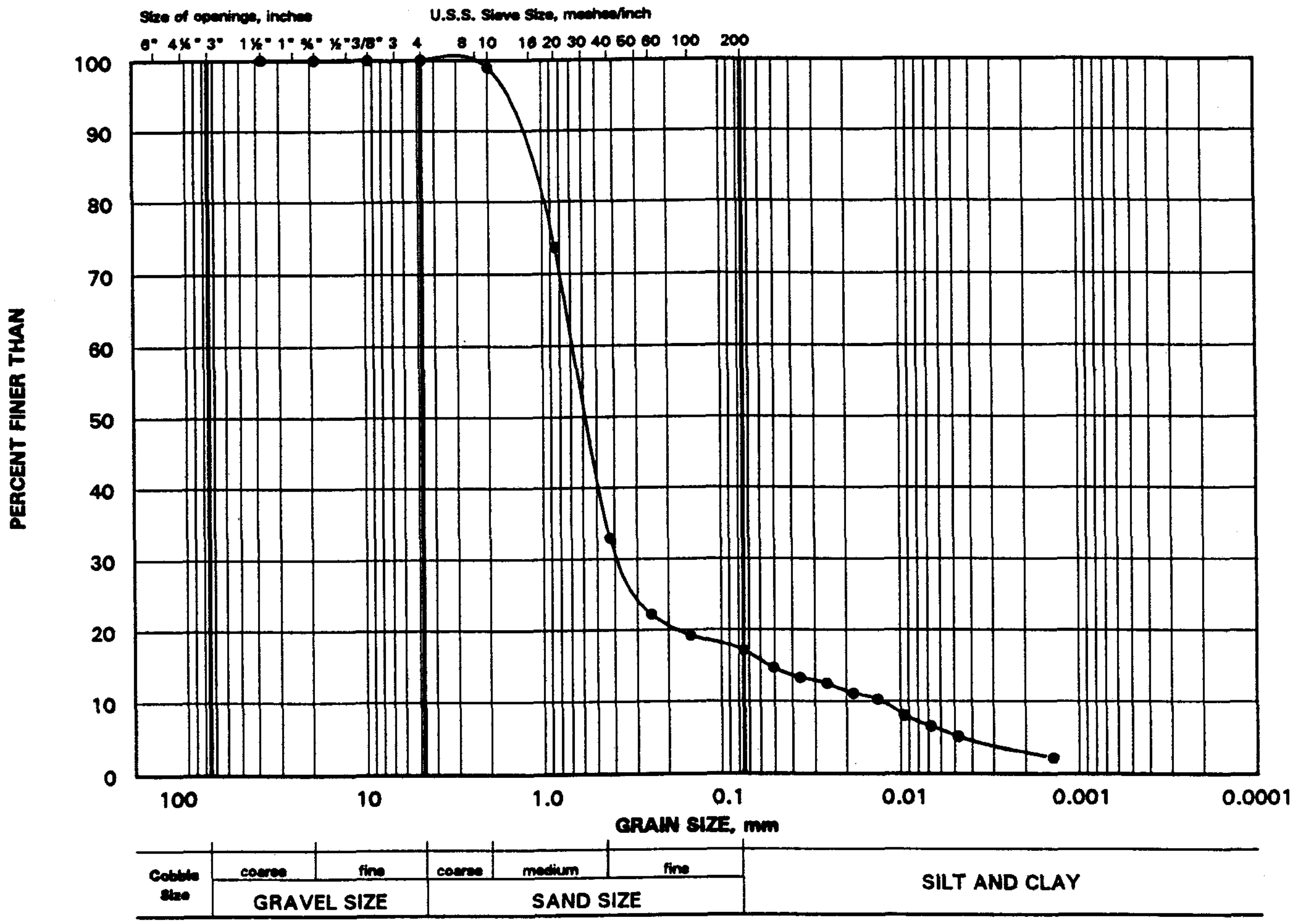
ProGrain ver. 2.01

Project 941-2747

Golder Associates

GRAIN SIZE DISTRIBUTION	FIGURE B-3

fine to medium SAND



LEGEND			
SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
●	94-3	1	1.7

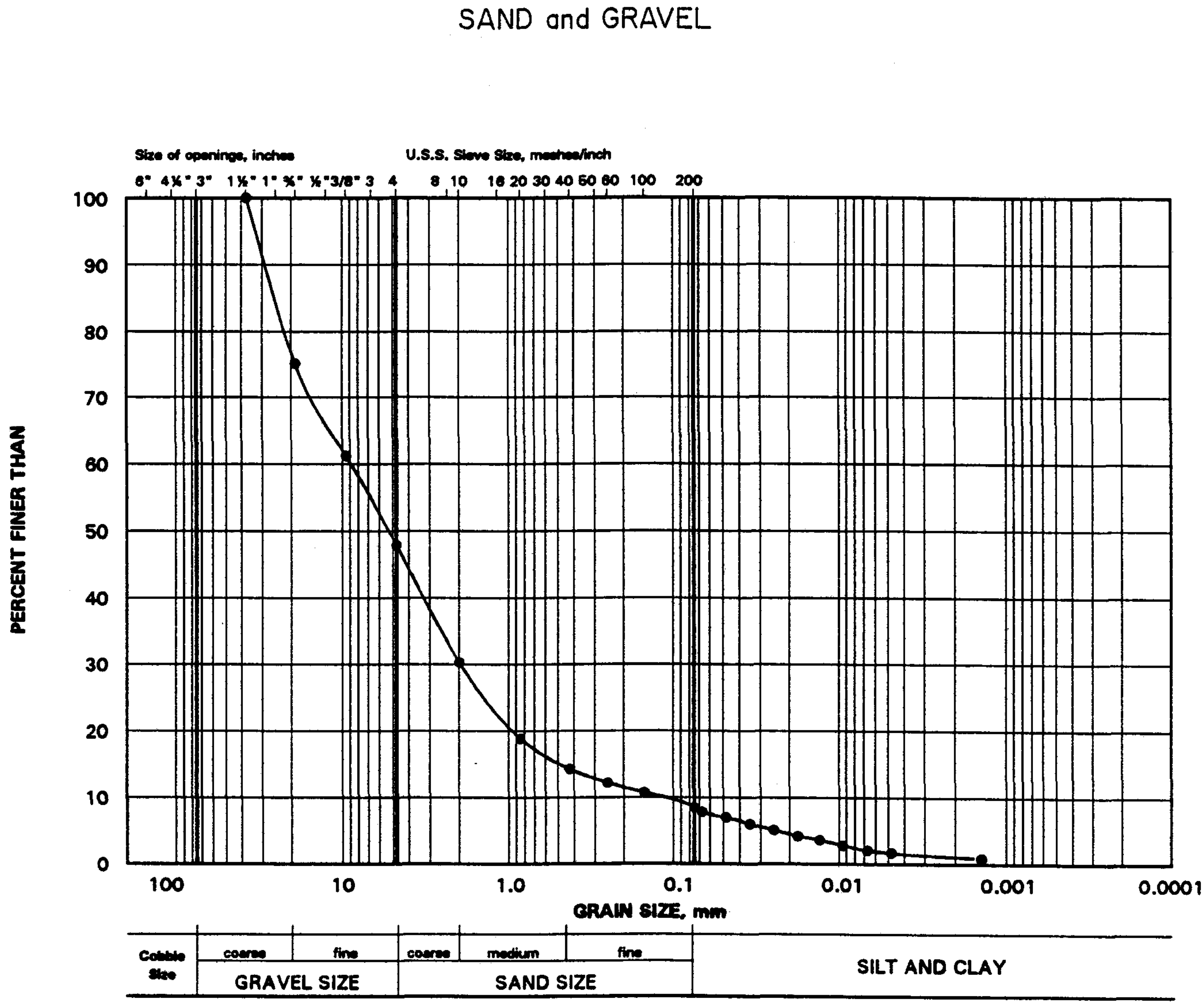
ProGrain ver. 2.01

Project 941-2747

Golder Associates

GRAIN SIZE DISTRIBUTION

FIGURE B-4



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
●	94-5	3	6.4

ProGrain ver. 2.01

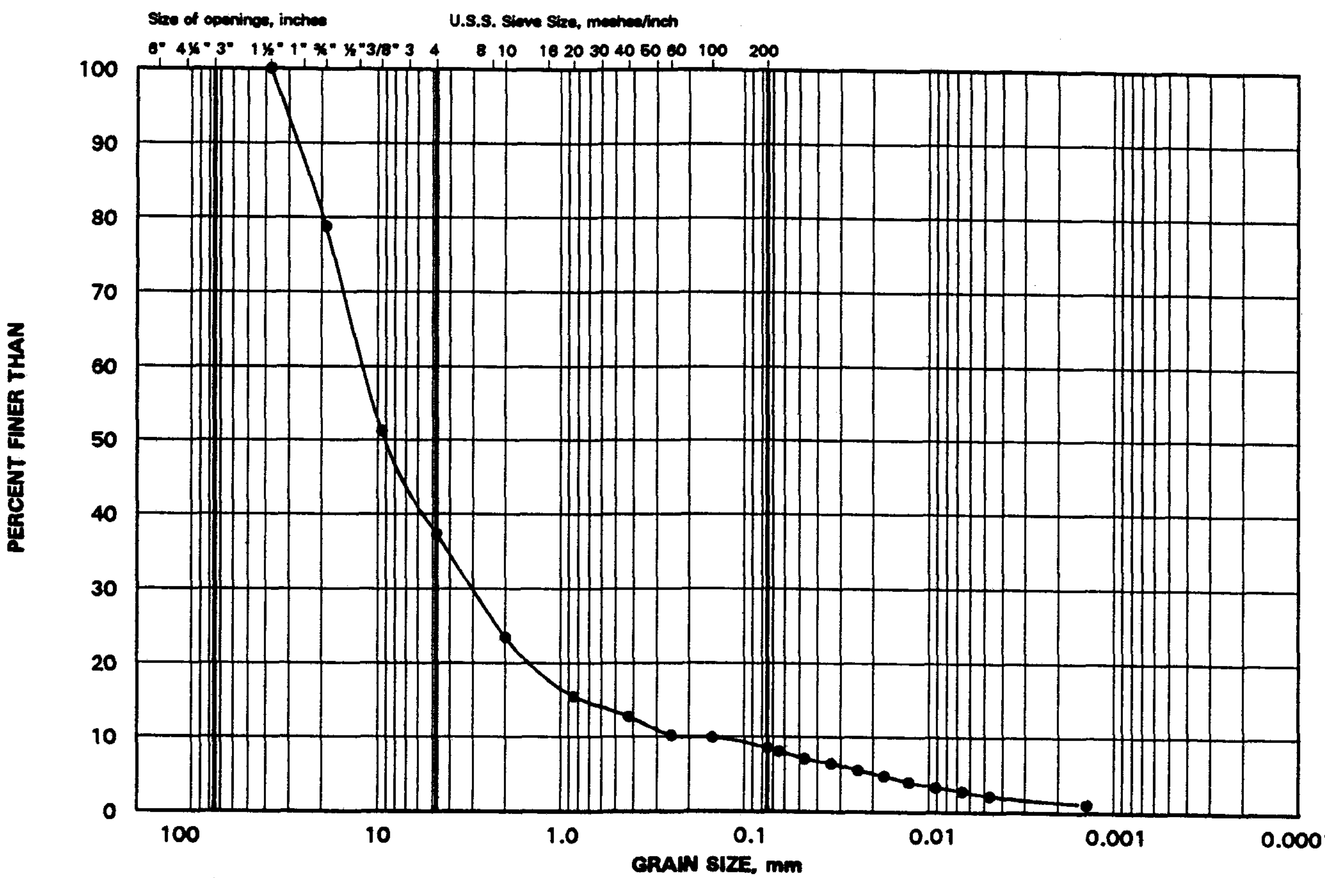
Project 941-2747

Golder Associates

GRAIN SIZE DISTRIBUTION

FIGURE B-5

SAND and GRAVEL



Cobble Size	coarse	fine	coarse	medium	fine	SILT AND CLAY
	GRAVEL SIZE		SAND SIZE			

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
●	94-6	1	3.2

ProGrain ver. 2.01

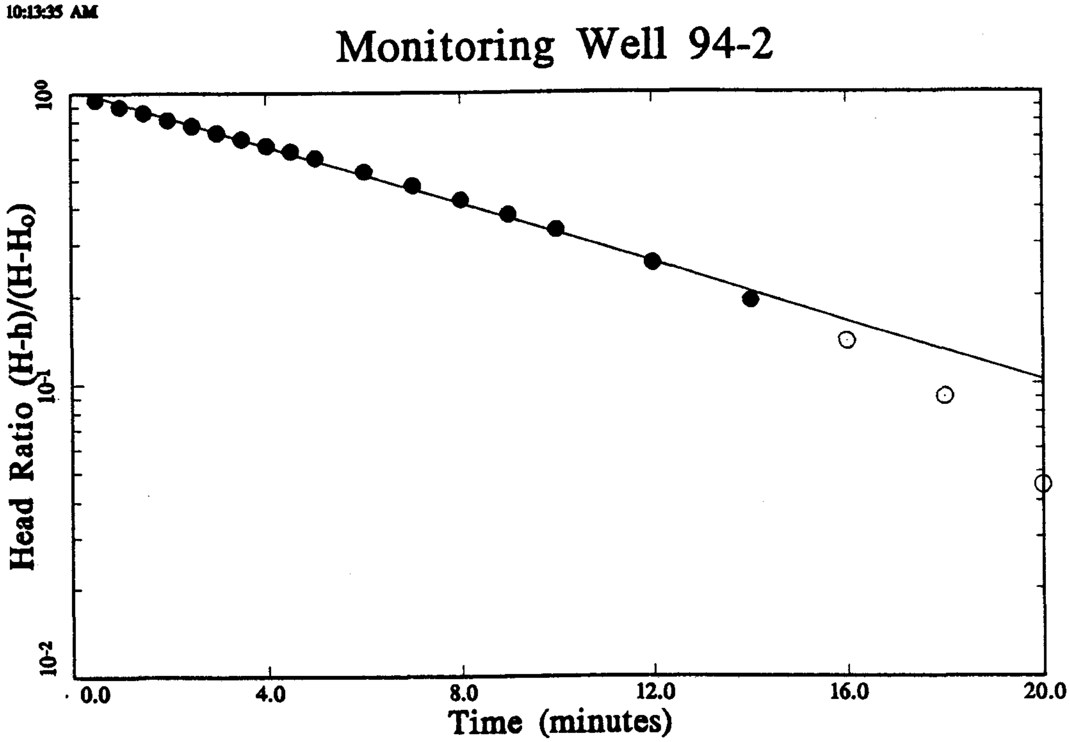
Project 941-2747

Golder Associates

APPENDIX C

RESULTS OF RISING HEAD TESTS

Oct. 31, 1994 10:13:35 AM



Hydraulic Conductivity, K = 1.0E-04 cm/sec
Basic Time Lag, T_o = 9 minutes

Project Number : 941-2747
Date Tested : September 27, 1994
Type of Test : Rising Head
Reference : Hvorslev (1951)

Title: Monitoring Well 94-2

Project Number: 941-2747
Date Tested: September 27, 1994
Type of Test: Rising Head
Analysis Method: Hvorslev (1951)

Water Level vs. Time Records

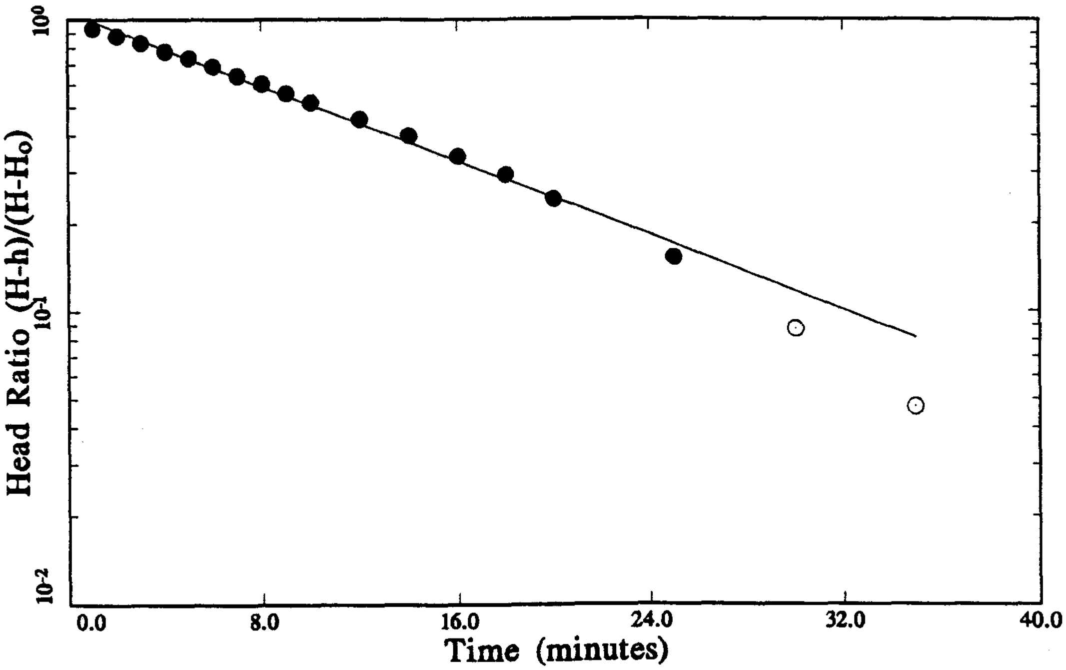
Reading Number	Time (min)	Water Level (m)
1	0.500	8.650
2	1.000	8.300
3	1.500	7.990
4	2.000	7.680
5	2.500	7.420
6	3.000	7.130
7	3.500	6.880
8	4.000	6.630
9	4.500	6.420
10	5.000	6.200
11	6.000	5.770
12	7.000	5.370
13	8.000	5.010
14	9.000	4.680
15	10.000	4.380
16	12.000	3.850
17	14.000	3.400
18	16.000	3.040
19	18.000	2.700
20	20.000	2.390

Radius of Borehole = 10.00 cm
Radius of Well = 2.50 cm
Length of Well Screen = 152.00 cm
Static Water Level = 2.08 m
Initial Water Level = 8.95 m

Hydraulic conductivity, K = 1.0E-04 cm/sec
Basic time lag, To = 9 minutes

Oct. 31, 1994 10:16:20 AM

Monitoring Well 94-7



Hydraulic Conductivity, K = 3.7E-05 cm/sec
Basic Time Lag, T_o = 14 minutes

Project Number : 941-2747
Date Tested : September 27, 1994

Type of Test : Rising Head
Reference : Hvorslev (1951)

Title: Monitoring Well 94-7

Project Number: 941-2747
Date Tested: September 27, 1994
Type of Test: Rising Head
Analysis Method: Hvorslev (1951)

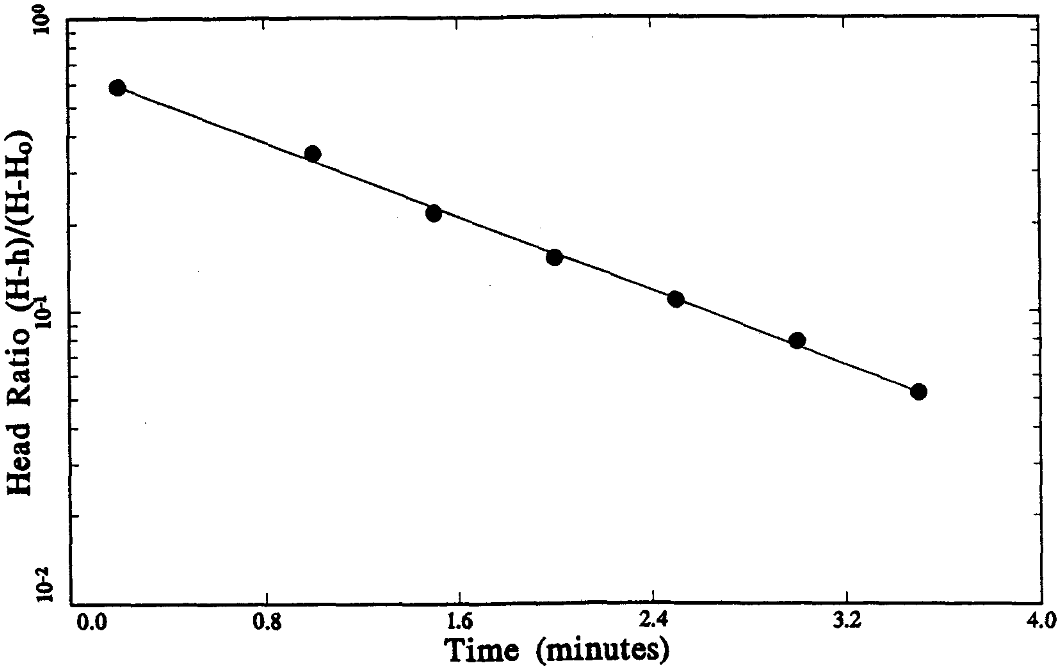
Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	1.000	9.300
2	2.000	9.070
3	3.000	8.870
4	4.000	8.640
5	5.000	8.470
6	6.000	8.270
7	7.000	8.050
8	8.000	7.890
9	9.000	7.700
10	10.000	7.530
11	12.000	7.260
12	14.000	7.020
13	16.000	6.760
14	18.000	6.560
15	20.000	6.340
16	25.000	5.960
17	30.000	5.680
18	35.000	5.510

Radius of Borehole = 10.00 cm
Radius of Well = 1.90 cm
Length of Well Screen = 152.00 cm
Static Water Level = 5.31 m
Initial Water Level = 9.57 m

Hydraulic conductivity, K = 3.7E-05 cm/sec
Basic time lag, To = 14 minutes

Monitoring Well 94-8A



Hydraulic Conductivity, K = 6.4E-04 cm/sec
Basic Time Lag, T_o = 0.84 minutes

Project Number : 941-2747
Date Tested : September 27, 1994
Type of Test : Falling Head
Reference : Hvorslev (1951)

Title: Monitoring Well 94-8A

Project Number: 941-2747
Date Tested: September 27, 1994
Type of Test: Falling Head
Analysis Method: Hvorslev (1951)

Water Level vs. Time Records

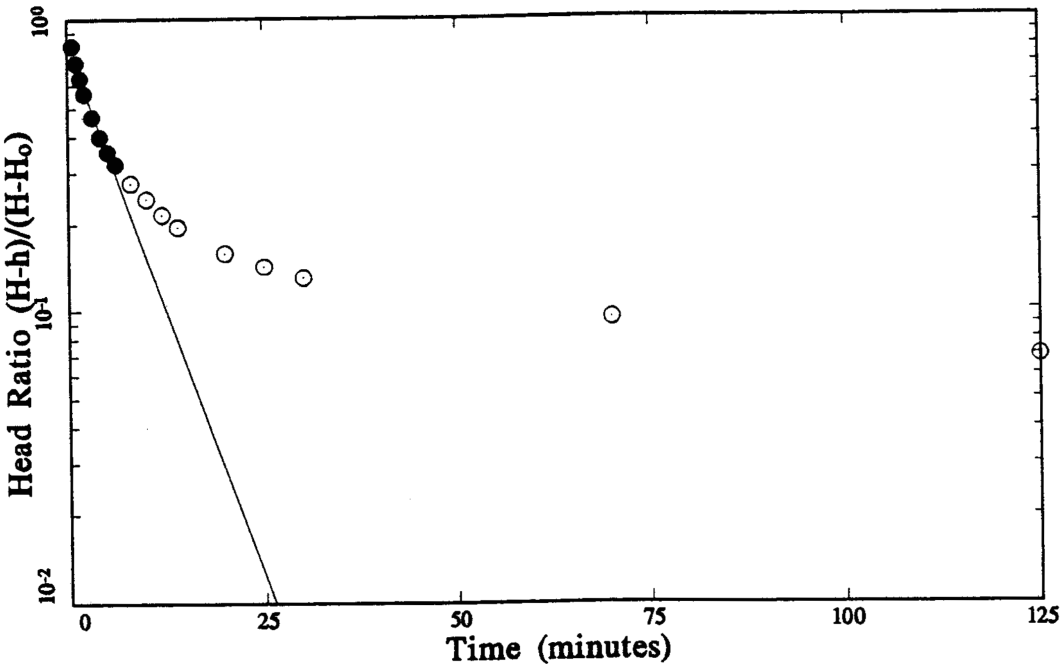
Reading Number	Time (min)	Water Level (m)
1	0.200	1.550
2	1.000	1.000
3	1.500	0.700
4	2.000	0.550
5	2.500	0.450
6	3.000	0.380
7	3.500	0.320

Radius of Borehole = 10.00 cm
Radius of Well = 1.90 cm
Length of Well Screen = 152.00 cm
Static Water Level = 0.20 m
Initial Water Level = 2.50 m

Hydraulic conductivity, K = 6.4E-04 cm/sec
Basic time lag, To = 0.84 minutes

Oct. 31, 1994 10:18:31 AM

Monitoring Well 94-9A



Hydraulic Conductivity, K = 1.1E-04 cm/sec
Basic Time Lag, T_o = 4.8 minutes

Project Number : 941-2747
Date Tested : October 3, 1994
Type of Test : Rising Head
Reference : Hvorslev (1951)

Title: Monitoring Well 94-9A

Project Number: 941-2747
Date Tested: October 3, 1994
Type of Test: Rising Head
Analysis Method: Hvorslev (1951)

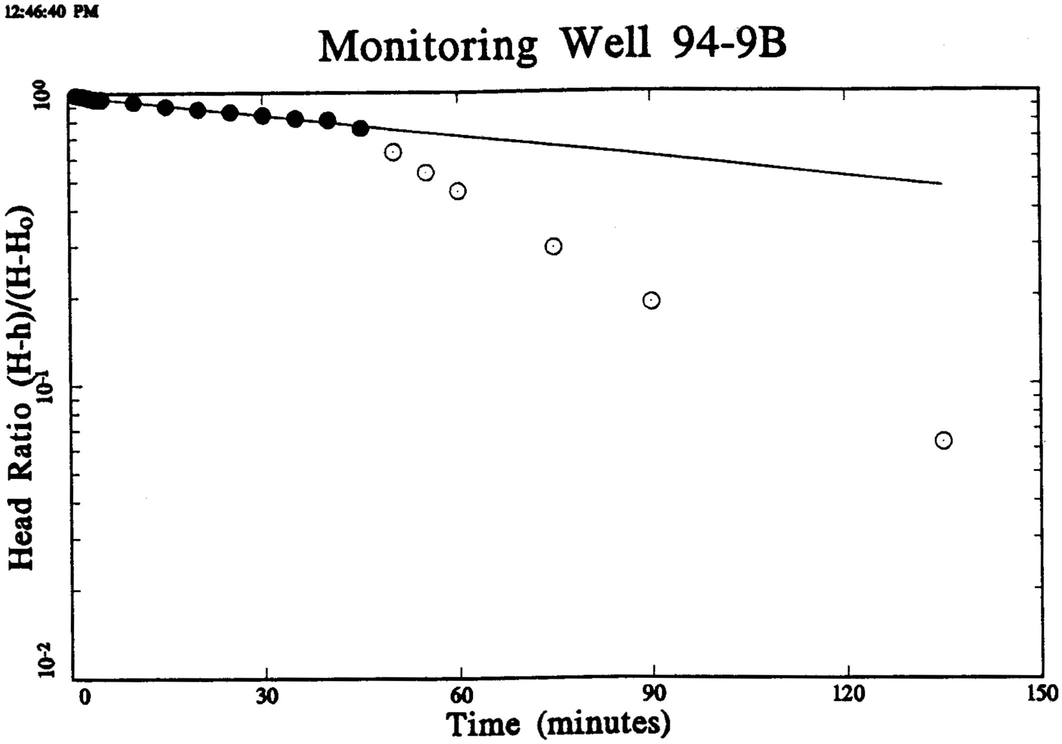
Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	0.500	3.250
2	1.000	3.000
3	1.500	2.800
4	2.000	2.630
5	3.000	2.400
6	4.000	2.230
7	5.000	2.120
8	6.000	2.040
9	8.000	1.930
10	10.000	1.850
11	12.000	1.780
12	14.000	1.730
13	20.000	1.640
14	25.000	1.600
15	30.000	1.570
16	70.000	1.480
17	125.000	1.420

Radius of Borehole = 10.00 cm
Radius of Well = 1.90 cm
Length of Well Screen = 152.00 cm
Static Water Level = 1.25 m
Initial Water Level = 3.70 m

Hydraulic conductivity, K = 1.1E-04 cm/sec
Basic time lag, To = 4.8 minutes

Oct. 31, 1994 12:46:40 PM



Hydraulic Conductivity, K = 3.0E-06 cm/sec
Basic Time Lag, T_o = 180 minutes

Project Number : 941-2747
Date Tested : October 3, 1994
Type of Test : Rising Head
Reference : Hvorslev (1951)

File: RHTBH9S.RPT
Saved: 10-31-94 at 01:31:04 pm

Title: Monitoring Well 94-9B

Project Number: 941-2747
Date Tested: October 3, 1994
Type of Test: Rising Head
Analysis Method: Hvorslev (1951)

Water Level vs. Time Records

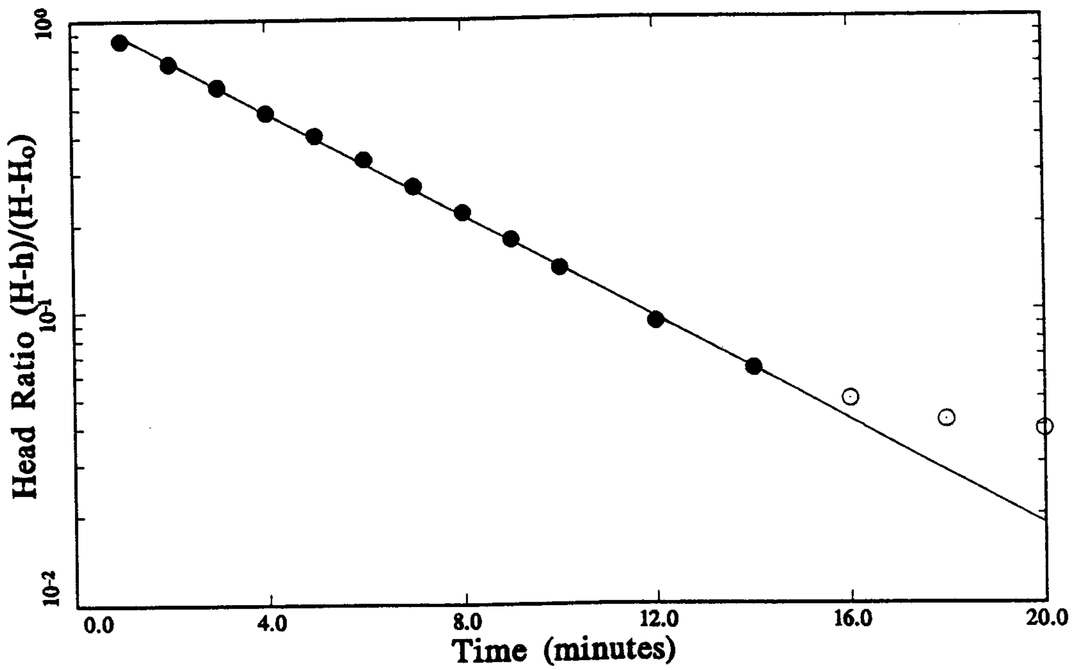
Reading Number	Time (min)	Water Level (m)
1	1.000	2.530
2	2.000	2.520
3	3.000	2.510
4	4.000	2.500
5	5.000	2.500
6	10.000	2.480
7	15.000	2.450
8	20.000	2.430
9	25.000	2.410
10	30.000	2.390
11	35.000	2.370
12	40.000	2.360
13	45.000	2.310
14	50.000	2.190
15	55.000	2.100
16	60.000	2.030
17	75.000	1.870
18	90.000	1.770
19	135.000	1.650

Radius of Borehole = 10.00 cm
Radius of Well = 1.90 cm
Length of Well Screen = 152.00 cm
Static Water Level = 1.59 m
Initial Water Level = 2.54 m

Hydraulic conductivity, K = 3.0E-06 cm/sec
Basic time lag, To = 180 minutes

Oct. 31, 1994 1:32:47 PM

Monitoring Well 94-10



Hydraulic Conductivity, K = 1.0E-04 cm/sec
Basic Time Lag, T_o = 5.3 minutes

Project Number : 941-2747
Date Tested : October 3, 1994
Type of Test : Rising Head
Reference : Hvorslev (1951)

Title: Monitoring Well 94-10

Project Number: 941-2747
Date Tested: October 3, 1994
Type of Test: Rising Head
Analysis Method: Hvorslev (1951)

Water Level vs. Time Records

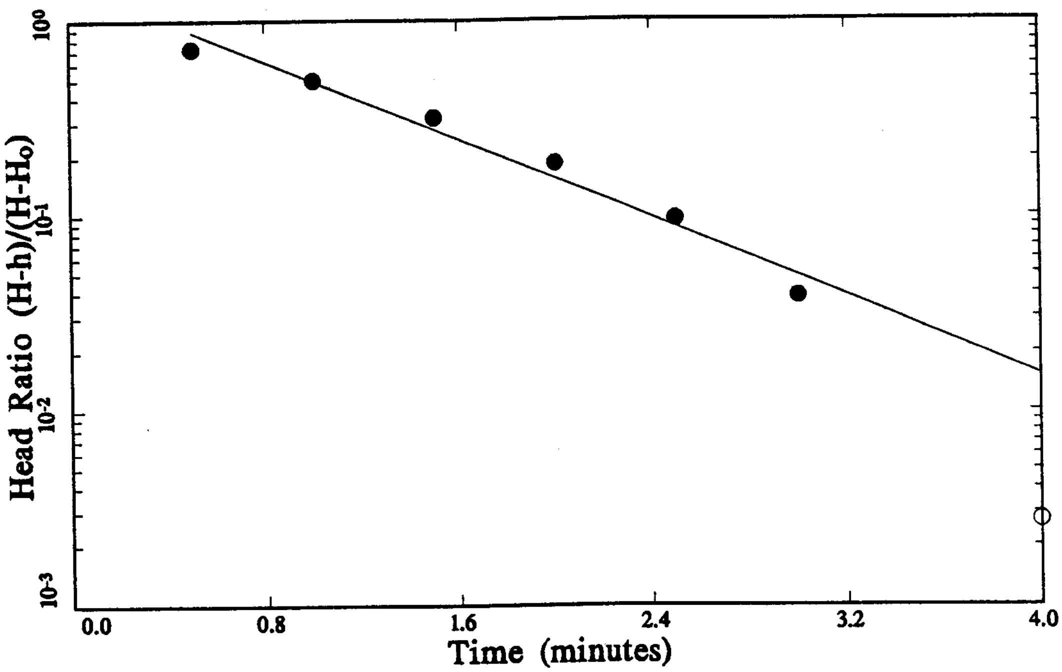
Reading Number	Time (min)	Water Level (m)
1	1.000	7.250
2	2.000	6.300
3	3.000	5.500
4	4.000	4.750
5	5.000	4.220
6	6.000	3.750
7	7.000	3.320
8	8.000	2.980
9	9.000	2.690
10	10.000	2.450
11	12.000	2.120
12	14.000	1.930
13	16.000	1.840
14	18.000	1.790
15	20.000	1.770

Radius of Borehole = 10.00 cm
Radius of Well = 1.90 cm
Length of Well Screen = 152.00 cm
Static Water Level = 1.51 m
Initial Water Level = 8.20 m

Hydraulic conductivity, K = 1.0E-04 cm/sec
Basic time lag, To = 5.3 minutes

Oct. 31, 1994 1:35:34 PM

Monitoring Well 94-11



Hydraulic Conductivity, K = 4.3E-04 cm/sec
Basic Time Lag, T_o = 1.2 minutes

Project Number : 941-2747
Date Tested : October 3, 1994
Type of Test : Rising Head
Reference : Hvorslev (1951)

Title: Monitoring Well 94-11

Project Number: 941-2747
Date Tested: October 3, 1994
Type of Test: Rising Head
Analysis Method: Hvorslev (1951)

Water Level vs. Time Records

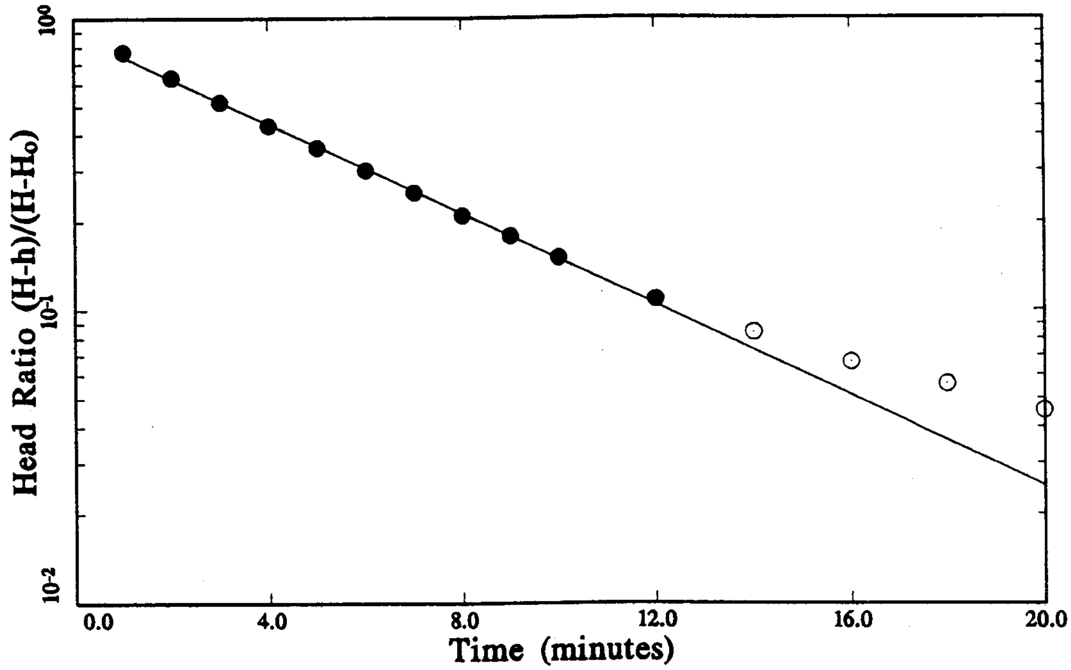
Reading Number	Time (min)	Water Level (m)
1	0.500	10.000
2	1.000	9.150
3	1.500	8.500
4	2.000	8.000
5	2.500	7.670
6	3.000	7.460
7	4.000	7.330

Radius of Borehole = 10.00 cm
Radius of Well = 1.90 cm
Length of Well Screen = 152.00 cm
Static Water Level = 7.32 m
Initial Water Level = 11.00 m

Hydraulic conductivity, K = 4.3E-04 cm/sec
Basic time lag, To = 1.2 minutes

Oct. 31, 1994 1:38:09 PM

Monitoring Well 94-12



Hydraulic Conductivity, K = 1.1E-04 cm/sec
Basic Time Lag, T_o = 4.9 minutes

Project Number : 941-2747
Date Tested : October 3, 1994
Type of Test : Rising Head
Reference : Hvorslev (1951)

Title: Monitoring Well 94-12

Project Number: 941-2747
Date Tested: October 3, 1994
Type of Test: Rising Head
Analysis Method: Hvorslev (1951)

Water Level vs. Time Records

Reading Number	*Time* (min)	Water Level (m)
1	1.000	9.550
2	2.000	9.150
3	3.000	8.830
4	4.000	8.570
5	5.000	8.370
6	6.000	8.200
7	7.000	8.060
8	8.000	7.940
9	9.000	7.850
10	10.000	7.770
11	12.000	7.650
12	14.000	7.580
13	16.000	7.530
14	18.000	7.500
15	20.000	7.470

Radius of Borehole = 10.00 cm
Radius of Well = 1.90 cm
Length of Well Screen = 152.00 cm
Static Water Level = 7.34 m
Initial Water Level = 10.20 m

Hydraulic conductivity, K = 1.1E-04 cm/sec
Basic time lag, To = 4.9 minutes

APPENDIX D

GROUNDWATER QUALITY DATA

DOMESTIC WELLS

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

LAB REPORT NO: A4-2631
DATE: Sept. 30, 1994
DATE SUBMITTED: Sept. 21, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample Groves Well	Sample	Sample	Sample	Sample
Fe	mg/L	0.01	0.18				
Mn	mg/L	0.01	0.04				
Hardness	mg/L CaCO3	1	226				
Alkalinity	mg/L CaCO3	1	177				
pH			8.01				
Conductivity	umhos/cm	3	452				
F	mg/L	0.1	0.14				
Na	mg/L	1	8				
N-NO3	mg/L	0.1	nd				
N-NO2	mg/L	0.1	nd				
N-NH3	mg/L	0.02	0.13				
SO4	mg/L	3	52				
Cl	mg/L	1	8				
Phenols	mg/L	0.002	nd				
Turbidity	NTU	0.1	3.9				
Colour	Pt/Co units	2	nd				
Ca	mg/L	1	64				
Mg	mg/L	1	16				
Tannin & Lignin	mg/L	0.1	nd				
Total Kjeldahl Nitrogen	mg/L	0.02	0.13				
K	mg/L	1	2				
TOC	mg/L	0.2	0.4				
TDS	mg/L	1	280				
H2S	mg/L	0.01	0.01				
Ion Balance			1.01				

ND = Not Detected (<MDL) MDL = Method Detection Limit

COMMENT:

ANALYST: ______________

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

LAB REPORT NO: A4-2631
DATE: Sept. 30, 1994
DATE SUBMITTED: Sept. 21, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample Groves Well	Sample	Sample	Sample	Sample
Total Coliforms	cts/100mls		0				
Faecal Coliforms	cts/100mls		0				
Faecal Streptococci	cts/100mls		0				
E.Coli	cts/100mls		0				
Standard Plate Count (48hrs)	cts/1ml		300				

ND = Not Detected (<MDL)   MDL = Method Detection Limit

COMMENT:

ANALYST: ____________

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Attention: Kris Marentette

LAB REPORT NO: A4-2611
DATE: Sept. 30, 1994
DATE SUBMITTED: Sept. 20, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample SA 1 Lafleur Well	Sample	Sample	Sample	Sample
Fe	mg/L	0.01	0.02				
Mn	mg/L	0.01	0.03				
Hardness	mg/L CaCO3	1	273				
Alkalinity	mg/L CaCO3	1	192				
pH			7.80				
Conductivity	umhos/cm	3	580				
F	mg/L	0.1	nd				
Na	mg/L	1	6				
N-NO3	mg/L	0.1	1.46				
N-NO2	mg/L	0.1	nd				
N-NH3	mg/L	0.02	nd				
SO4	mg/L	3	87				
Cl	mg/L	1	13				
Phenols	mg/L	0.002	nd				
Turbidity	NTU	0.1	0.3				
Colour	Pt/Co units	2	nd				
Ca	mg/L	1	78				
Mg	mg/L	1	19				
Tannin & Lignin	mg/L	0.1	nd				
Total Kjeldahl Nitrogen	mg/L	0.02	0.08				
K	mg/L	1	1				
TOC	mg/L	0.2	0.4				
TDS	mg/L	1	360				
H2S	mg/L	0.01	nd				
Ion Balance			0.94				

ND = Not Detected (<MDL) MDL = Method Detection Limit

OCT - 5 1994 ... OTTAWA

COMMENT:

ANALYST: ____________

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Attention: Kris Marentette

LAB REPORT NO: A4-2611
DATE: Sept. 30, 1994
DATE SUBMITTED: Sept. 20, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample SA 1 Lafleur Well	Sample	Sample	Sample	Sample
Total Coliforms	cts/100mls		300				
Faecal Coliforms	cts/100mls		50				
Faecal Streptococci	cts/100mls		270				
E.Coli	cts/100mls		0				
Standard Plate Count (48hrs)	cts/1ml		14				

ND = Not Detected (<MDL) MDL = Method Detection Limit

COMMENT:

ANALYST: ____________

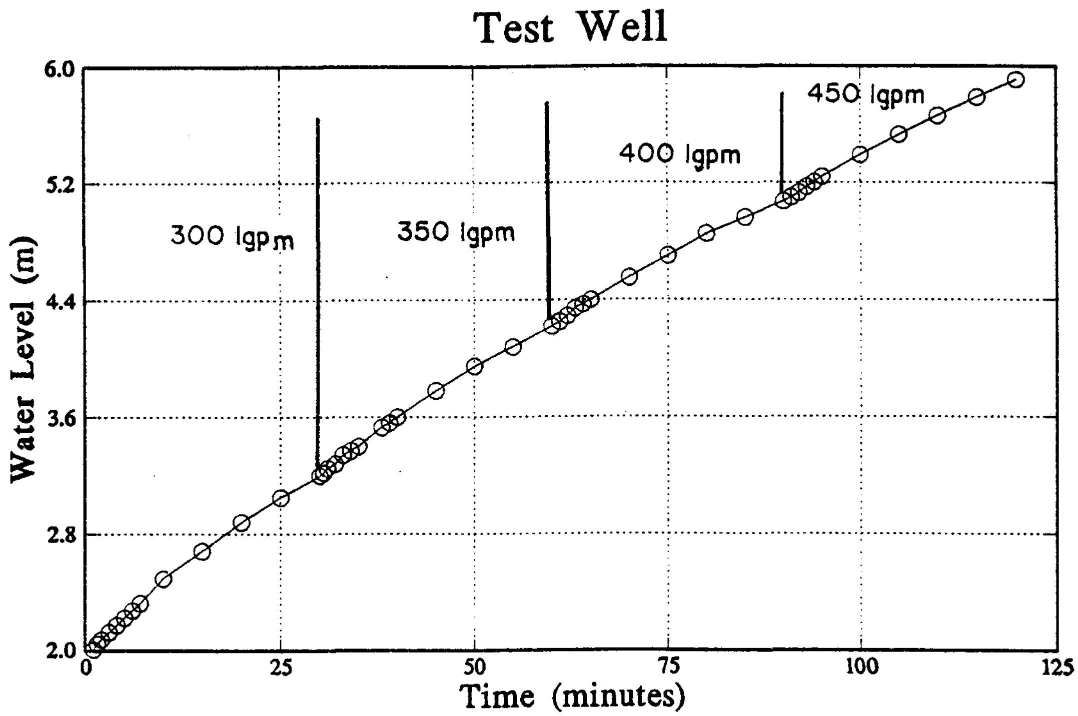
146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

APPENDIX E

DRAWDOWN DATA AND PLOT OF DRAWDOWN DATA

STEP TESTS

Dec. 19, 1994 4:47:19 PM



Project Number : 941-2747
Date Tested : September 23, 1994

Title: Test Well

Project Number: 941-2747
Date Tested: September 23, 1994
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	1.000	2.030
2	1.500	2.070
3	2.000	2.100
4	3.000	2.150
5	4.000	2.200
6	5.000	2.250
7	6.000	2.300
8	7.000	2.350
9	10.000	2.520
10	15.000	2.710
11	20.000	2.910
12	25.000	3.080
13	30.000	3.230
14	30.500	3.250
15	31.000	3.280
16	32.000	3.310
17	33.000	3.370
18	34.000	3.400
19	35.000	3.430
20	38.000	3.560
21	39.000	3.590
22	40.000	3.630
23	45.000	3.810
24	50.000	3.980
25	55.000	4.110
26	60.000	4.250
27	61.000	4.280
28	62.000	4.320
29	63.000	4.370
30	64.000	4.400
31	65.000	4.430
32	70.000	4.580
33	75.000	4.730
34	80.000	4.880
35	85.000	4.990
36	90.000	5.100
37	91.000	5.130
38	92.000	5.160
39	93.000	5.200
40	94.000	5.230
41	95.000	5.270

42	100.000	5.420
43	105.000	5.560

44	110.000	5.690
45	115.000	5.820
46	120.000	5.940

Static Water Level = 2.00 m

APPENDIX F

DRAWDOWN DATA AND
PLOTS OF DRAWDOWN DATA

30 DAY AQUIFER TEST

TABLE F-1

SUMMARY OF AQUIFER PARAMETERS
DRAWDOWN DATA

Well	Transmissivity (T) (m^2/day)	Storage Coefficient(S)	Remarks
Test Well (Time=0 to 2929 min)	2100	--	Local T value representative of deposits prior to boundaries encountered by drawdown cone
Test Well (Time=3410 to 43200 min)	340	--	Low T value influenced by local aquifer partial dewatering
94-1	510*	2	
94-2	490*	10	
94-3	520*	0.23*	
94-4	510*	0.21*	
94-5	630*	0.087*	
94-6	970*	0.02*	
94-7	530*	0.32*	
94-8A	810*	0.033*	
94-8B	920	0.051	Well not completed in aquifer
94-9A	3300	0.043	Well completed in silty sand along flanks of aquifer; minimal drawdown (0.12 metres) during pumping test; later water level data influenced by precipitation event
94-9B	2400	0.028	Well not completed in aquifer
94-10	4000	0.052	Well completed in glacial till; minimal drawdown (0.11 metres) during pumping test; later water level data influenced by precipitation event
94-11	1300	0.015	Water level data likely influenced by pumping from well in St. Pierre pit
94-12	2100	0.0088	Minimal drawdown (0.16 metres) during pumping test
WESA16	5900	$8.4x10^{-6}$	Minimal drawdown (0.29 metres) during pumping test; later water levels influenced by precipitation event
Lafleur well	910*	0.02*	
Groves well	570*	0.086*	

*Values used to estimate T and S ranges based on drawdown data

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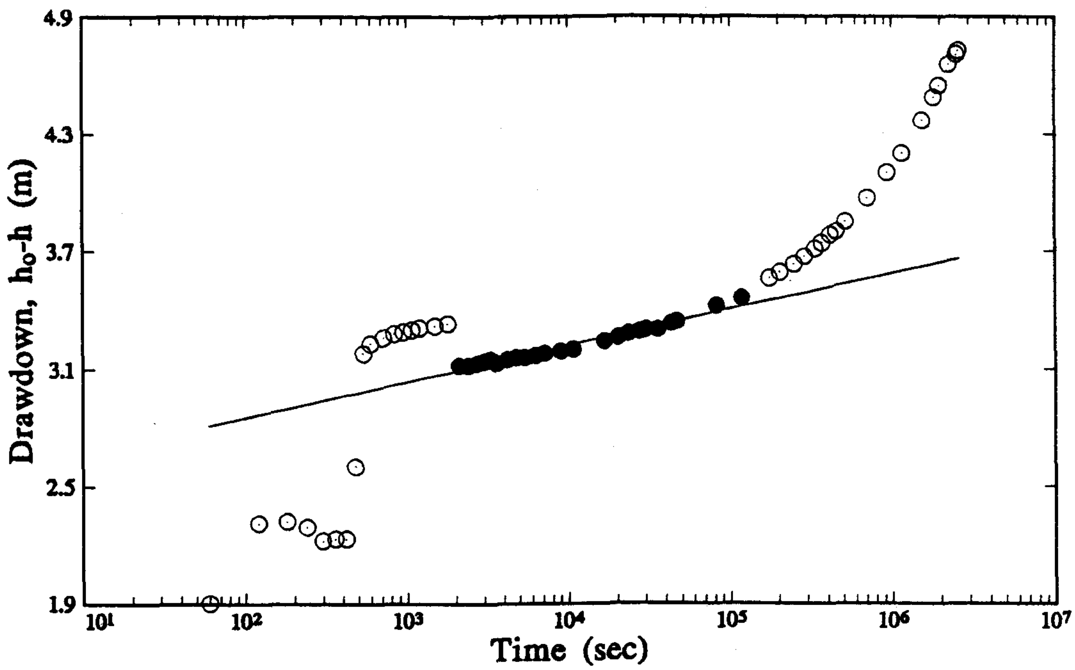
Test Well



Transmissivity, T = 2.1E+03 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94

Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

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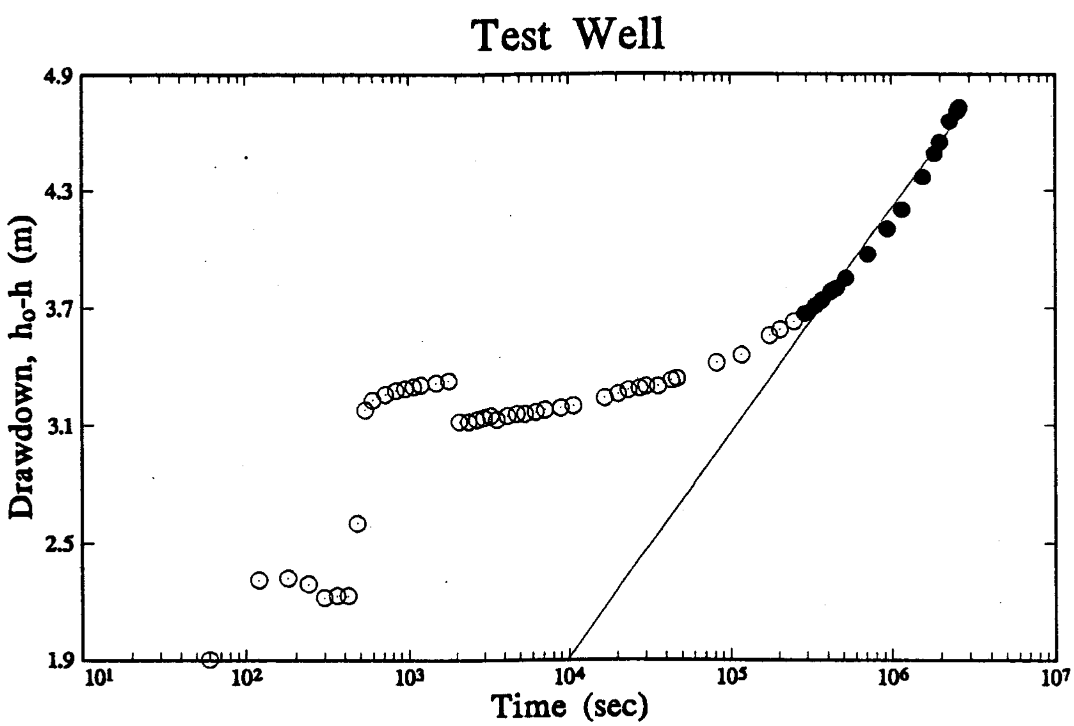


Transmissivity, T = 340 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94

Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Test Well

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	1.000	3.500
2	2.000	3.910
3	3.000	3.920
4	4.000	3.890
5	5.000	3.820
6	6.000	3.830
7	7.000	3.830
8	8.000	4.200
9	9.000	4.780
10	10.000	4.830
11	12.000	4.860
12	14.000	4.880
13	16.000	4.890
14	18.000	4.900
15	20.000	4.910
16	25.000	4.920
17	30.000	4.930
18	35.000	4.720
19	40.000	4.720
20	45.000	4.730
21	50.000	4.740
22	55.000	4.750
23	60.000	4.730
24	70.000	4.750
25	80.000	4.760
26	90.000	4.760
27	105.000	4.770
28	120.000	4.780
29	150.000	4.790
30	180.000	4.800
31	281.000	4.840
32	341.000	4.860
33	395.000	4.880
34	463.000	4.890
35	510.000	4.900
36	600.000	4.900
37	724.000	4.930
38	783.000	4.940
39	1374.000	5.020
40	1960.000	5.060
41	2929.000	5.160

42	3410.000	5.190
43	4180.000	5.230

44	4843.000	5.270
45	5615.000	5.310
46	6201.000	5.340
47	7018.000	5.380
48	7658.000	5.400
49	8720.000	5.450
50	11936.000	5.570
51	15707.000	5.700
52	19322.000	5.800
53	25892.000	5.970
54	30676.000	6.090
55	32975.000	6.150
56	37875.000	6.260
57	42078.000	6.310
58	43176.000	6.330
59	43200.000	6.330

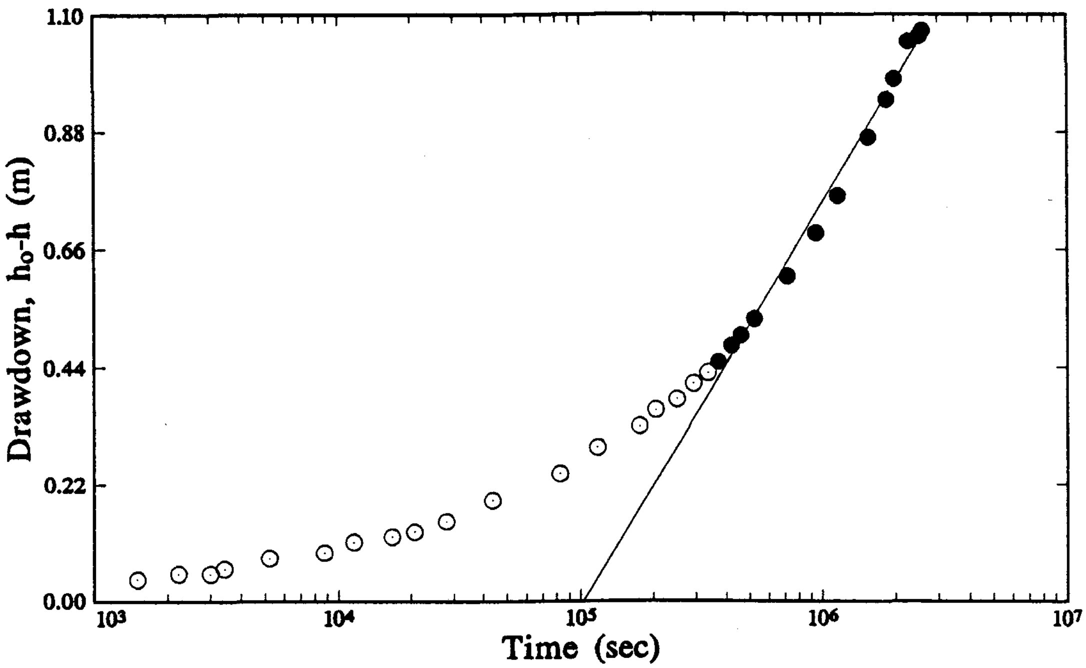
Static Water Level = 1.56 m

Distance to Monitoring Well = 0.08 m
Pumping Rate = 1477.00 L/min

Transmissivity, T = 2.1E+03 m sq./day

Dec. 15, 1994 12:26:03 PM

Monitoring Well 94-1



Storativity, S	=	2.0E+00
Transmissivity, T	=	510 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94

Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-1

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	25.000	2.260
2	37.000	2.270
3	50.000	2.270
4	57.000	2.280
5	87.000	2.300
6	146.000	2.310
7	193.000	2.330
8	278.000	2.340
9	344.000	2.350
10	466.000	2.370
11	727.000	2.410
12	1378.000	2.460
13	1963.000	2.510
14	2931.000	2.550
15	3412.000	2.580
16	4181.000	2.600
17	4894.000	2.630
18	5616.000	2.650
19	6202.000	2.670
20	6983.000	2.700
21	7653.000	2.720
22	8722.000	2.750
23	11937.000	2.830
24	15708.000	2.910
25	19323.000	2.980
26	25894.000	3.090
27	30721.000	3.160
28	33002.000	3.200
29	37876.000	3.270
30	42080.000	3.280
31	43177.000	3.290
32	43200.000	3.290

Static Water Level = 2.22 m

Distance to Monitoring Well = 26.30 m
Pumping Rate = 1477.00 L/min

Storativity, S = 2E+00
Transmissivity, T = 510 m sq./day

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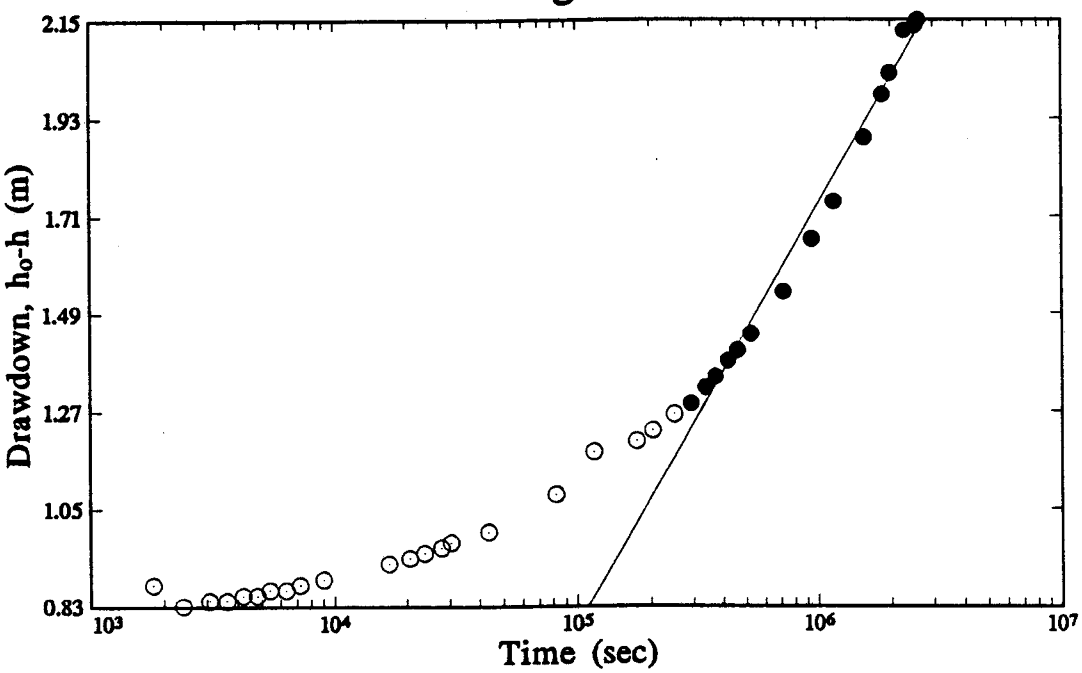
Monitoring Well 94-2



Storativity, S = 1.0E+01
Transmissivity, T = 490 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov.4/94
Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-2

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov.4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	30.000	2.930
2	40.000	2.890
3	51.000	2.900
4	60.000	2.900
5	70.000	2.910
6	80.000	2.910
7	90.000	2.920
8	105.000	2.920
9	120.000	2.930
10	150.000	2.940
11	280.000	2.970
12	342.000	2.980
13	394.000	2.990
14	464.000	3.000
15	509.000	3.010
16	725.000	3.030
17	1375.000	3.100
18	1961.000	3.180
19	2929.000	3.200
20	3411.000	3.220
21	4179.000	3.250
22	4892.000	3.270
23	5614.000	3.300
24	6200.000	3.320
25	6977.000	3.350
26	7657.000	3.370
27	8721.000	3.400
28	11934.000	3.480
29	15706.000	3.580
30	19321.000	3.650
31	25893.000	3.770
32	30718.000	3.850
33	32999.000	3.890
34	37874.000	3.970
35	42079.000	3.980
36	43175.000	3.990
37	43200.000	3.990

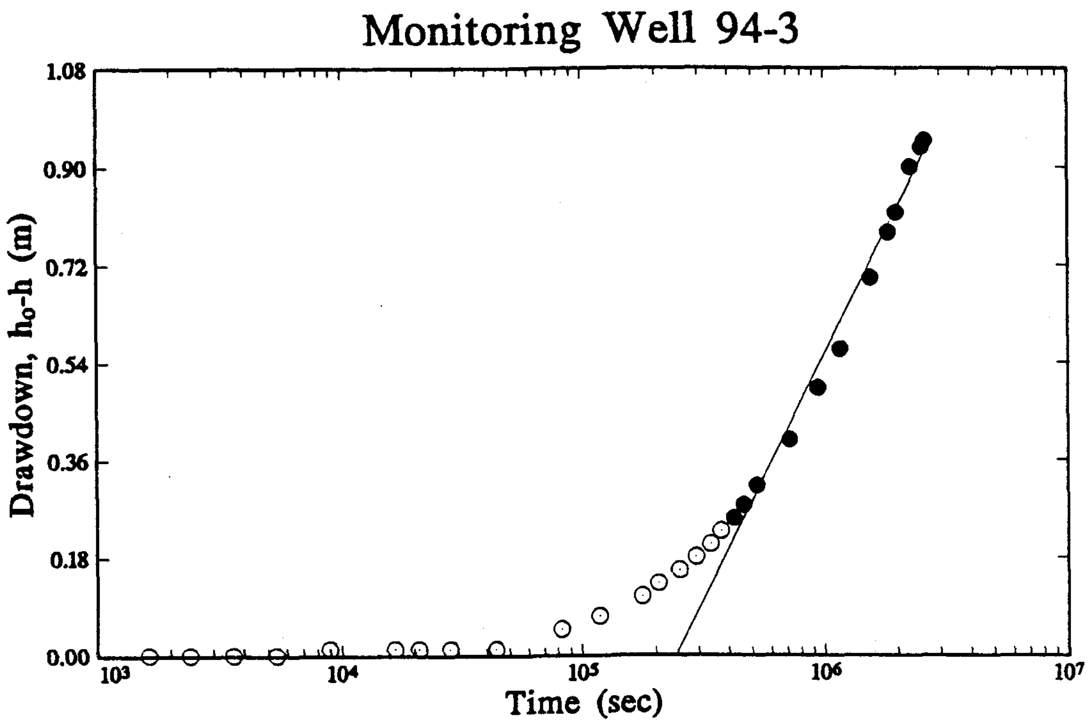
Static Water Level = 2.06 m

Distance to Monitoring Well = 3.50 m

Storativity, S	= 1E+01
Transmissivity, T	= 490 m sq./day

Pumping Rate = 1477.00 L/min

Dec. 15, 1994 1:18:10 PM



Storativity, S = 2.3E-01
Transmissivity, T = 520 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94
Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-3

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	27.000	2.110
2	40.000	2.110
3	60.000	2.110
4	90.000	2.110
5	149.000	2.120
6	276.000	2.120
7	346.000	2.120
8	467.000	2.120
9	730.000	2.120
10	1380.000	2.150
11	1964.000	2.170
12	2935.000	2.200
13	3415.000	2.220
14	4183.000	2.240
15	4895.000	2.260
16	5618.000	2.280
17	6205.000	2.300
18	6985.000	2.320
19	7661.000	2.340
20	8725.000	2.370
21	11939.000	2.440
22	15709.000	2.520
23	19325.000	2.580
24	25895.000	2.690
25	30724.000	2.760
26	33003.000	2.790
27	37878.000	2.860
28	42081.000	2.890
29	43179.000	2.900
30	43200.000	2.900

Static Water Level = 2.11 m

Distance to Monitoring Well = 118.80 m
Pumping Rate = 1477.00 L/min

Storativity, S = 2E-01
Transmissivity, T = 520 m sq./day

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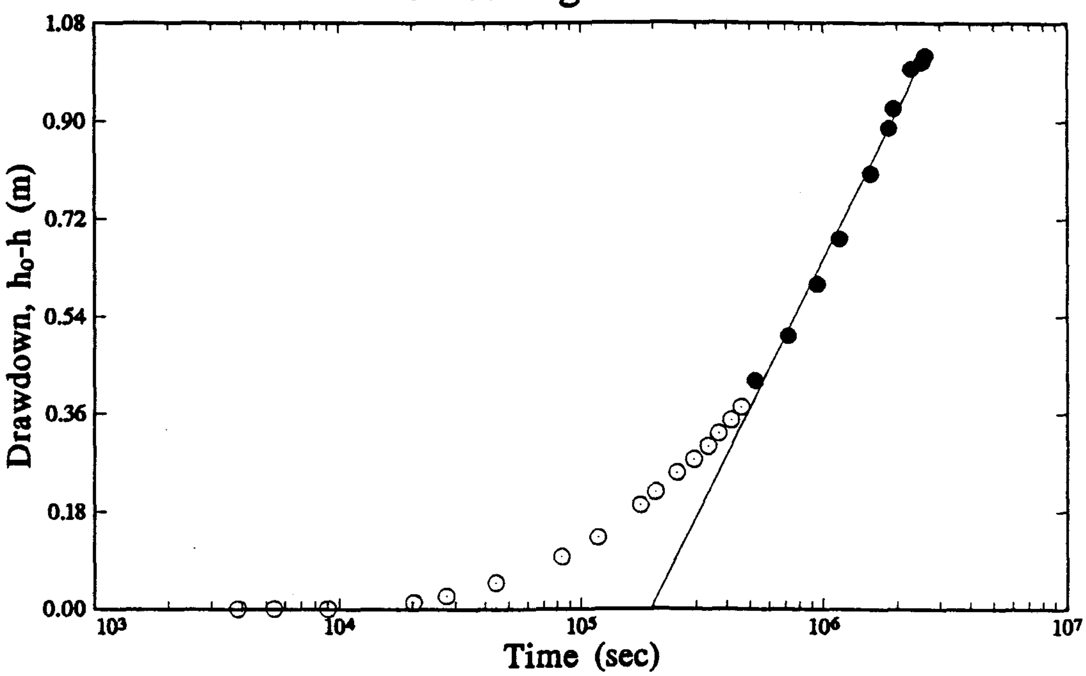
Monitoring Well 94-4



Storativity, S	=	2.1E-01
Transmissivity, T	=	510 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94

Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-4

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	64.000	3.490
2	90.000	3.490
3	150.000	3.490
4	337.000	3.500
5	460.000	3.510
6	738.000	3.530
7	1390.000	3.570
8	1969.000	3.600
9	2939.000	3.650
10	3418.000	3.670
11	4172.000	3.700
12	4888.000	3.720
13	5608.000	3.740
14	6195.000	3.760
15	6972.000	3.780
16	7653.000	3.800
17	8732.000	3.840
18	11930.000	3.910
19	15702.000	3.990
20	19316.000	4.060
21	25888.000	4.160
22	30713.000	4.230
23	32095.000	4.260
24	37870.000	4.320
25	42074.000	4.330
26	43171.000	4.340
27	43200.000	4.340

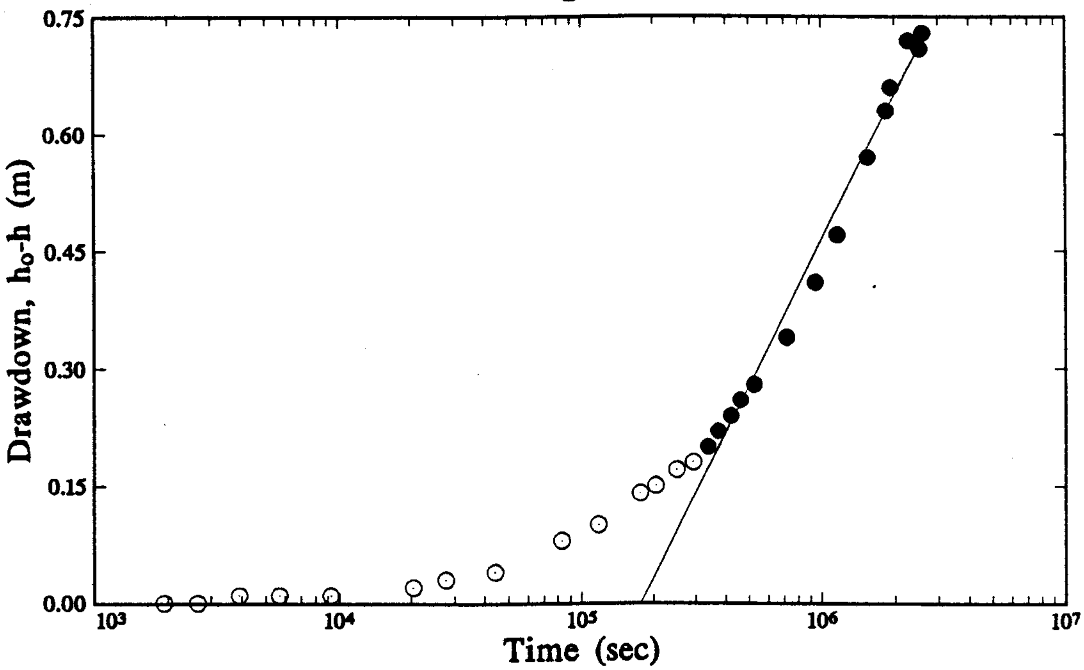
Static Water Level = 3.49 m

Distance to Monitoring Well = 111.80 m
Pumping Rate = 1477.00 L/min

Storativity, S = 2E-01
Transmissivity, T = 510 m sq./day

Dec. 15, 1994   1:23:22 PM

Monitoring Well 94-5



Storativity, S = 8.7E-02

Transmissivity, T = 630 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94

Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-5

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	32.000	2.030
2	44.000	2.030
3	65.000	2.040
4	95.000	2.040
5	154.000	2.040
6	339.000	2.050
7	461.000	2.060
8	735.000	2.070
9	1387.000	2.110
10	1967.000	2.130
11	2937.000	2.170
12	3416.000	2.180
13	4174.000	2.200
14	4890.000	2.210
15	5612.000	2.230
16	6198.000	2.250
17	6975.000	2.270
18	7655.000	2.290
19	8730.000	2.310
20	11932.000	2.370
21	15704.000	2.440
22	19318.000	2.500
23	25890.000	2.600
24	30715.000	2.660
25	32097.000	2.690
26	37872.000	2.750
27	42076.000	2.740
28	43173.000	2.760
29	43200.000	2.760

Static Water Level = 2.03 m

Distance to Monitoring Well = 182.50 m
Pumping Rate = 1477.00 L/min

Storativity, S = 9E-02
Transmissivity, T = 630 m sq./day

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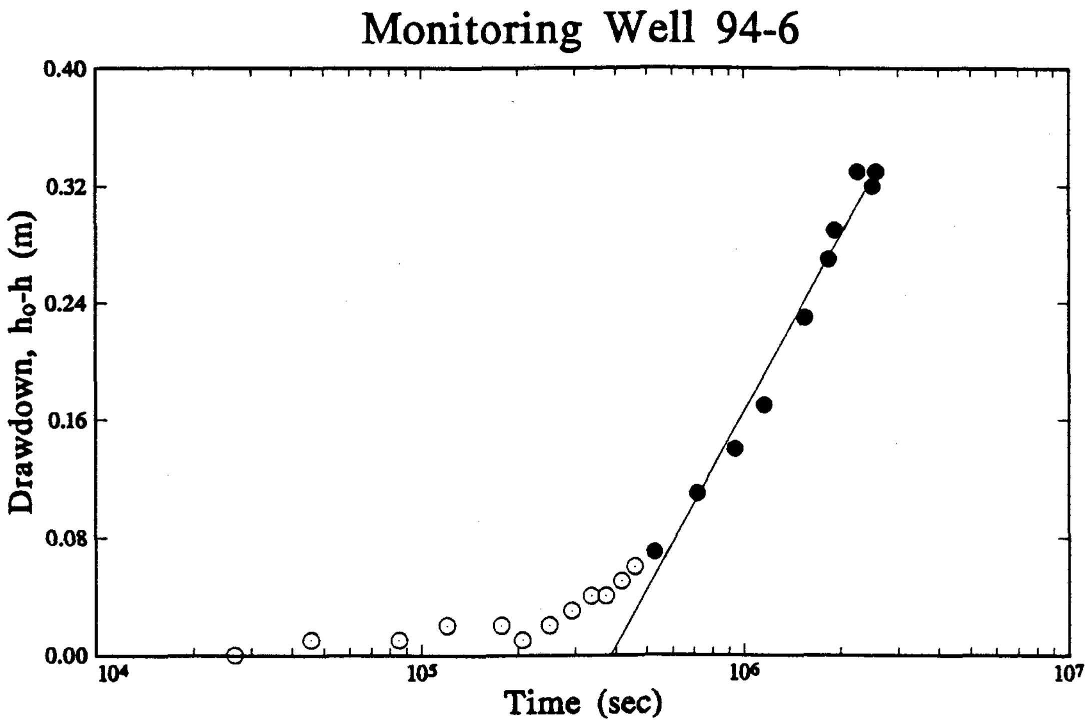

Storativity, S = 2.0E-02
Transmissivity, T = 970 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94
Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-6

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	444.000	8.340
2	762.000	8.350
3	1425.000	8.350
4	2009.000	8.360
5	2959.000	8.360
6	3436.000	8.350
7	4162.000	8.360
8	4879.000	8.370
9	5598.000	8.380
10	6219.000	8.380
11	6960.000	8.390
12	7644.000	8.400
13	8770.000	8.410
14	11968.000	8.450
15	15692.000	8.480
16	19306.000	8.510
17	25921.000	8.570
18	30695.000	8.610
19	32085.000	8.630
20	37860.000	8.670
21	42062.000	8.660
22	43088.000	8.670
23	43200.000	8.670

Static Water Level = 8.34 m

Distance to Monitoring Well = 709.10 m
Pumping Rate = 1477.00 L/min

Storativity, S = 2E-02
Transmissivity, T = 970 m sq./day

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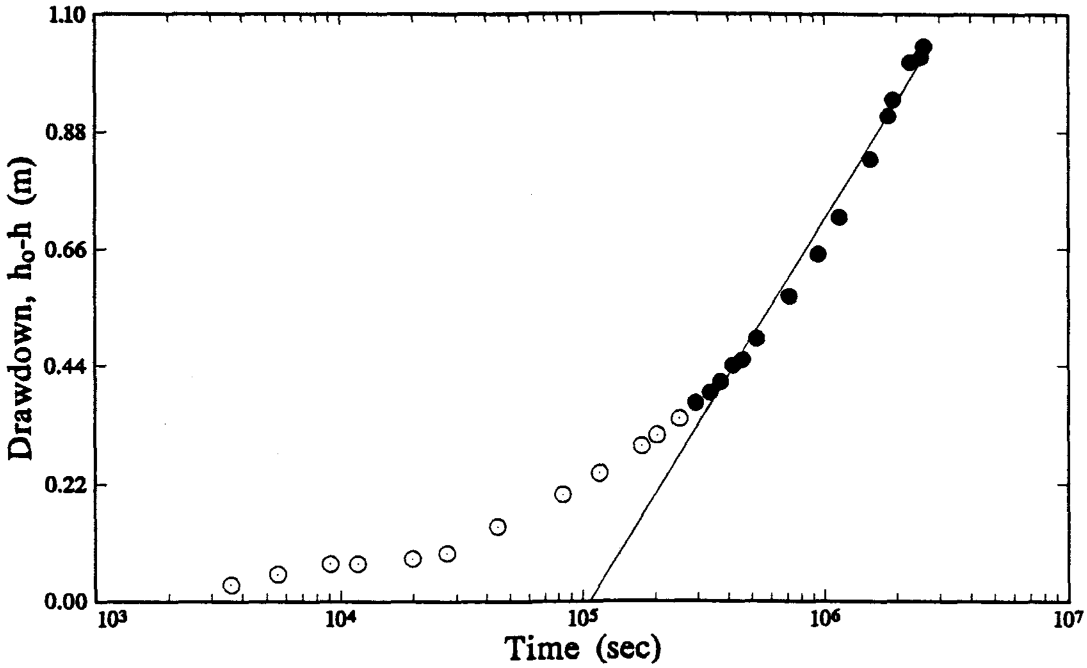
Monitoring Well 94-7



Storativity, S = 3.2E-01
Transmissivity, T = 530 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94
Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-7

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	60.000	5.390
2	93.000	5.410
3	152.000	5.430
4	197.000	5.430
5	331.000	5.440
6	458.000	5.450
7	741.000	5.500
8	1393.000	5.560
9	1971.000	5.600
10	2942.000	5.650
11	3420.000	5.670
12	4217.000	5.700
13	4902.000	5.730
14	5624.000	5.750
15	6190.000	5.770
16	6992.000	5.800
17	7669.000	5.810
18	8736.000	5.850
19	11947.000	5.930
20	15715.000	6.010
21	19288.000	6.080
22	25905.000	6.190
23	30705.000	6.270
24	32109.000	6.300
25	37886.000	6.370
26	42089.000	6.380
27	43119.000	6.400
28	43200.000	6.400

Static Water Level = 5.36 m

Distance to Monitoring Well = 67.80 m
Pumping Rate = 1477.00 L/min

Storativity, S = 3E-01
Transmissivity, T = 530 m sq./day

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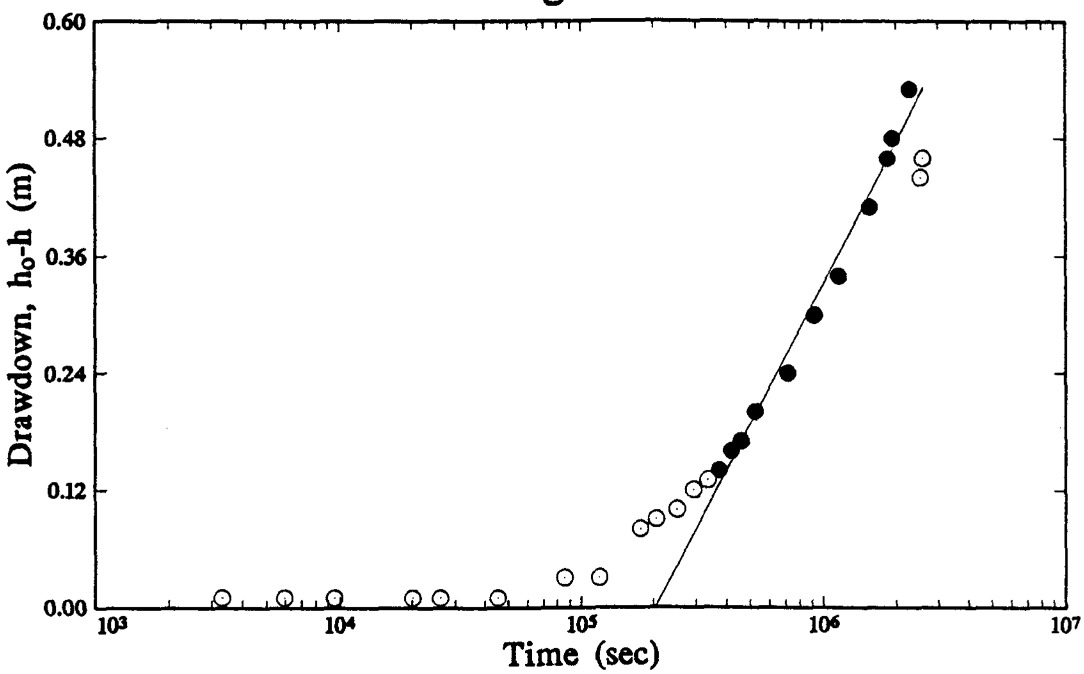
Monitoring Well 94-8A



Storativity, S = 3.3E-02
Transmissivity, T = 810 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94
Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-8A

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	55.000	0.210
2	99.000	0.210
3	159.000	0.210
4	334.000	0.210
5	435.000	0.210
6	755.000	0.210
7	1425.000	0.230
8	1987.000	0.230
9	2951.000	0.280
10	3431.000	0.290
11	4170.000	0.300
12	4886.000	0.320
13	5605.000	0.330
14	6212.000	0.340
15	6968.000	0.360
16	7650.000	0.370
17	8749.000	0.400
18	11926.000	0.440
19	15316.000	0.500
20	19282.000	0.540
21	25885.000	0.610
22	30702.000	0.660
23	32092.000	0.680
24	37867.000	0.730
25	42071.000	0.640
26	43099.000	0.660
27	43200.000	0.660

Static Water Level = 0.20 m

Distance to Monitoring Well = 362.20 m
Pumping Rate = 1477.00 L/min

Storativity, S = 3E-02
Transmissivity, T = 920 m sq./day

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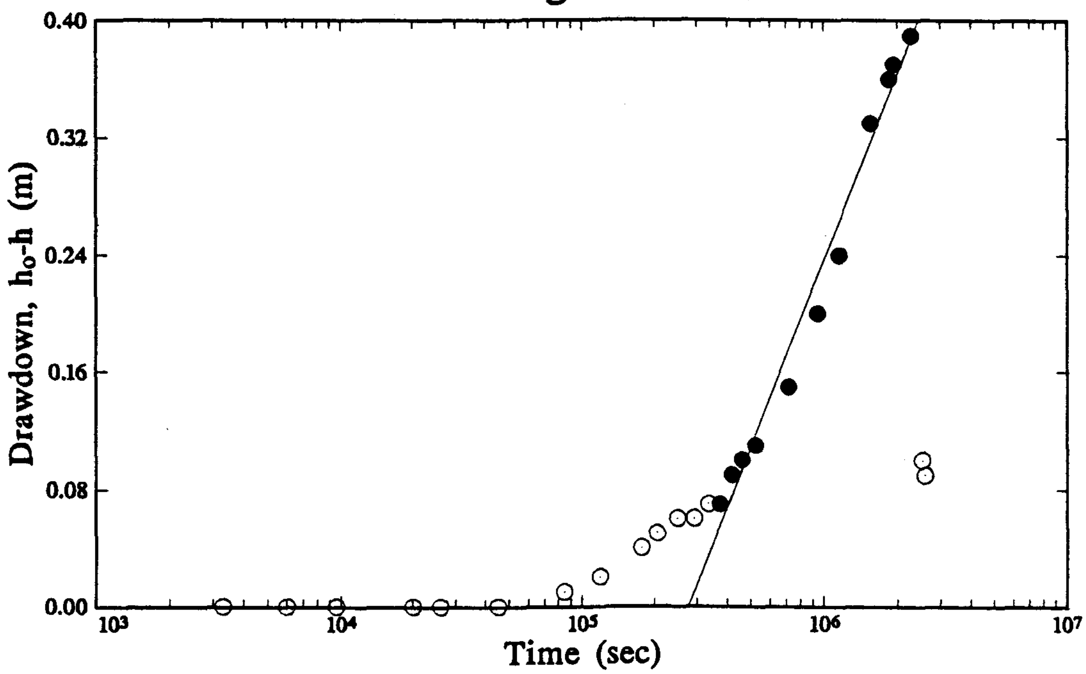
Monitoring Well 94-8B



Storativity, S = 5.1E-02
Transmissivity, T = 920 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94

Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-8B

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	55.000	0.850
2	100.000	0.850
3	160.000	0.850
4	334.000	0.850
5	435.000	0.850
6	753.000	0.850
7	1414.000	0.860
8	1987.000	0.870
9	2952.000	0.890
10	3430.000	0.900
11	4170.000	0.910
12	4886.000	0.910
13	5605.000	0.920
14	6212.000	0.920
15	6968.000	0.940
16	7650.000	0.950
17	8750.000	0.960
18	11927.000	1.000
19	15699.000	1.050
20	19283.000	1.090
21	25885.000	1.180
22	30703.000	1.210
23	32093.000	1.220
24	37868.000	1.240
25	42072.000	0.950
26	43098.000	0.940
27	43200.000	0.940

Static Water Level = 0.85 m

Distance to Monitoring Well = 362.20 m
Pumping Rate = 1477.00 L/min

Storativity, S = 5E-02
Transmissivity, T = 920 m sq./day

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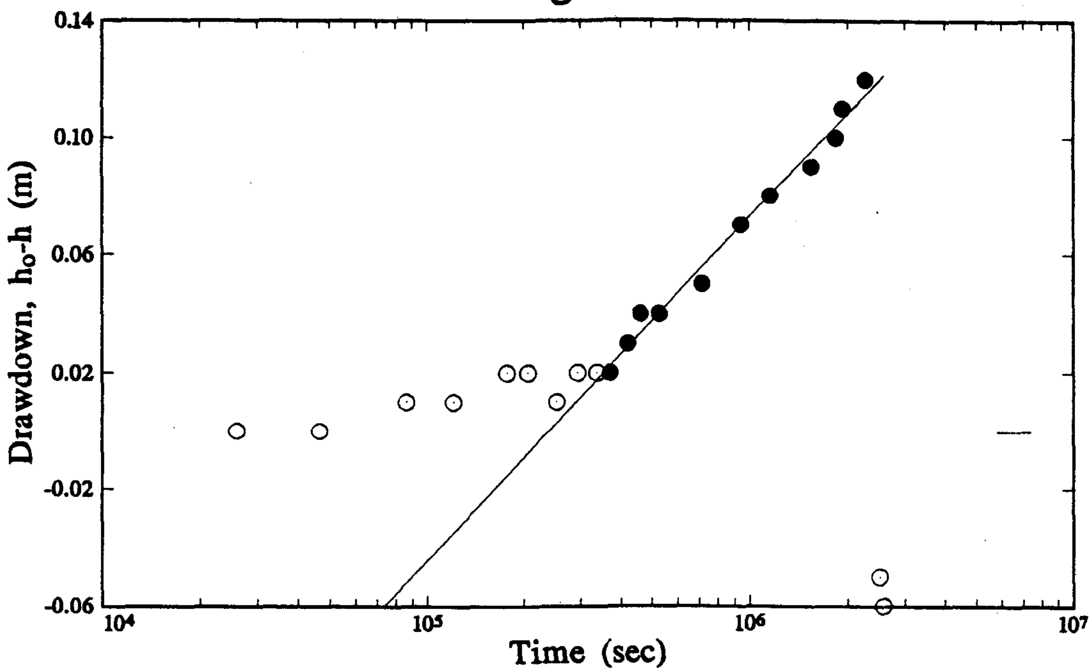
Monitoring Well 94-9A



Storativity, S	= 4.3E-02
Transmissivity, T	= 3.3E+03 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94

Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-9A

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	433.000	1.250
2	778.000	1.250
3	1440.000	1.260
4	2014.000	1.260
5	2969.000	1.270
6	3447.000	1.270
7	4224.000	1.260
8	4909.000	1.270
9	5637.000	1.270
10	6182.000	1.270
11	7003.000	1.280
12	7679.000	1.290
13	8787.000	1.290
14	11924.000	1.300
15	15728.000	1.320
16	19279.000	1.330
17	25883.000	1.340
18	30681.000	1.350
19	32134.000	1.360
20	37892.000	1.370
21	42097.000	1.200
22	43100.000	1.190
23	43200.000	1.190

Static Water Level = 1.25 m

Distance to Monitoring Well = 694.30 m
Pumping Rate = 1477.00 L/min

Storativity, S = 4E-02
Transmissivity, T = 3.3E+03 m sq./day

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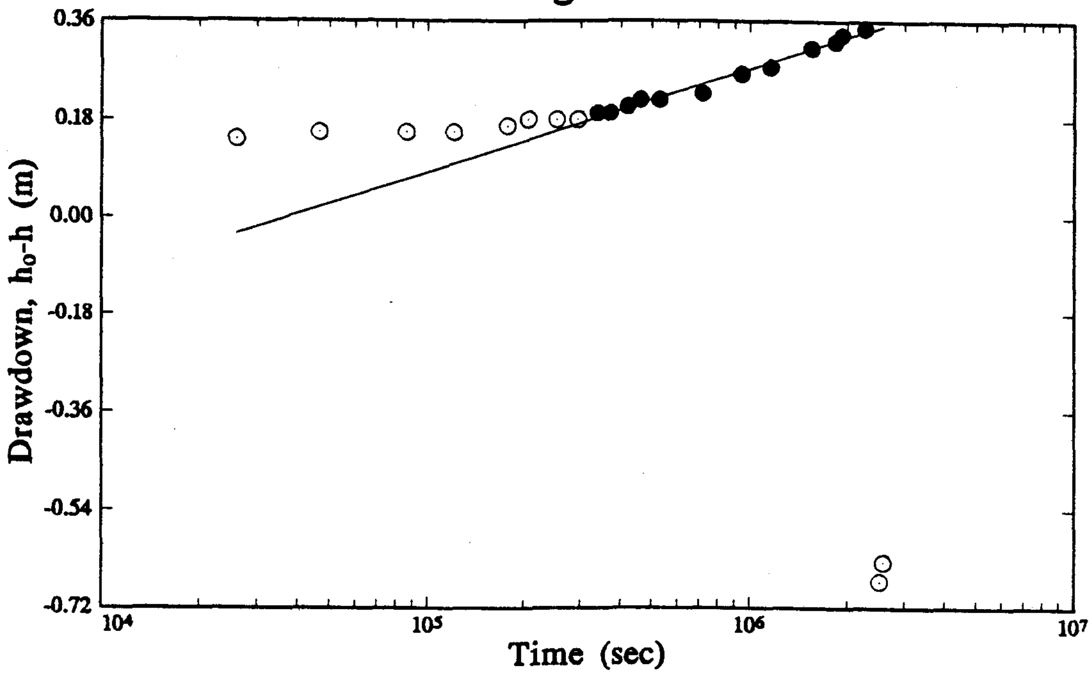
Monitoring Well 94-9B



Storativity, S = 2.8E-02

Transmissivity, T = 2.4E+03 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94
Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-9B

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	432.000	1.610
2	778.000	1.620
3	1441.000	1.620
4	2015.000	1.620
5	2970.000	1.630
6	3447.000	1.640
7	4224.000	1.640
8	4909.000	1.640
9	5637.000	1.650
10	6182.000	1.650
11	7003.000	1.660
12	7679.000	1.670
13	8788.000	1.670
14	11923.000	1.680
15	15728.000	1.710
16	19278.000	1.720
17	25883.000	1.750
18	30682.000	1.760
19	32133.000	1.770
20	37893.000	1.780
21	42098.000	0.930
22	43101.000	0.960
23	43200.000	0.960

Static Water Level = 1.61 m

Distance to Monitoring Well = 694.30 m
Pumping Rate = 1477.00 L/min

Storativity, S = 3E-02
Transmissivity, T = 2.4E+03 m sq./day

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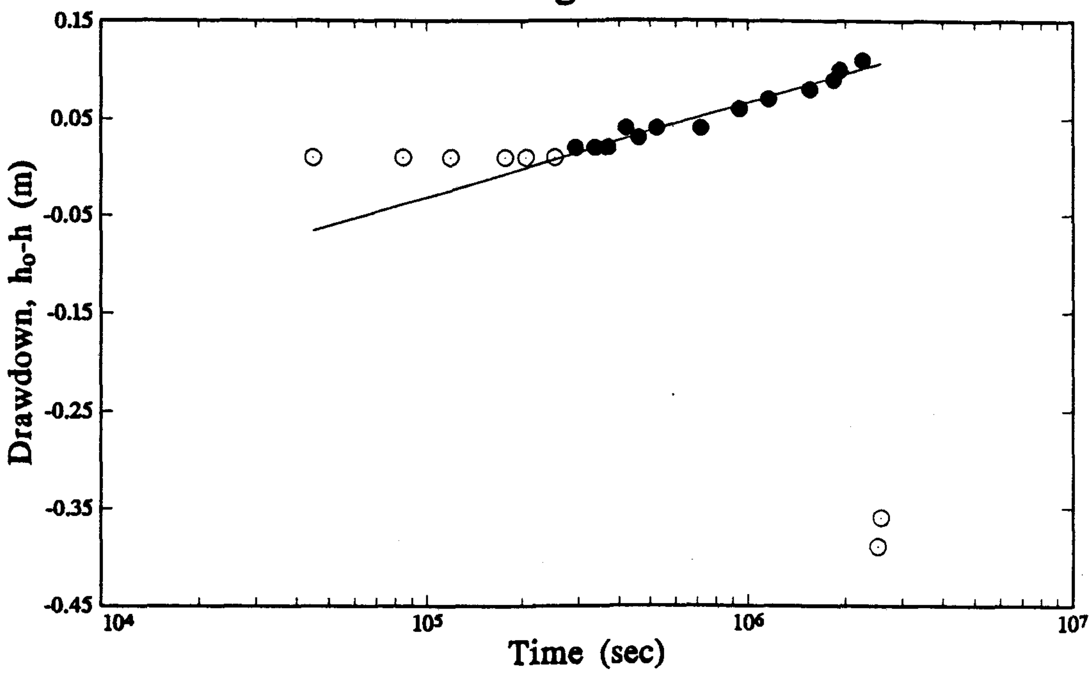
Monitoring Well 94-10



Storativity, S = 5.2E-02
Transmissivity, T = 4E+03 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94
Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-10

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	747.000	1.480
2	1410.000	1.480
3	1984.000	1.480
4	2947.000	1.480
5	3427.000	1.480
6	4219.000	1.480
7	4906.000	1.490
8	5632.000	1.490
9	6177.000	1.490
10	7000.000	1.510
11	7676.000	1.500
12	8744.000	1.510
13	11959.000	1.510
14	15725.000	1.530
15	19286.000	1.540
16	25914.000	1.550
17	30710.000	1.560
18	32113.000	1.570
19	37890.000	1.580
20	42094.000	1.080
21	43113.000	1.110
22	43200.000	1.110

Static Water Level = 1.47 m

Distance to Monitoring Well = 648.60 m
Pumping Rate = 1477.00 L/min

Storativity, S = 5E-02
Transmissivity, T = 4E+03 m sq./day

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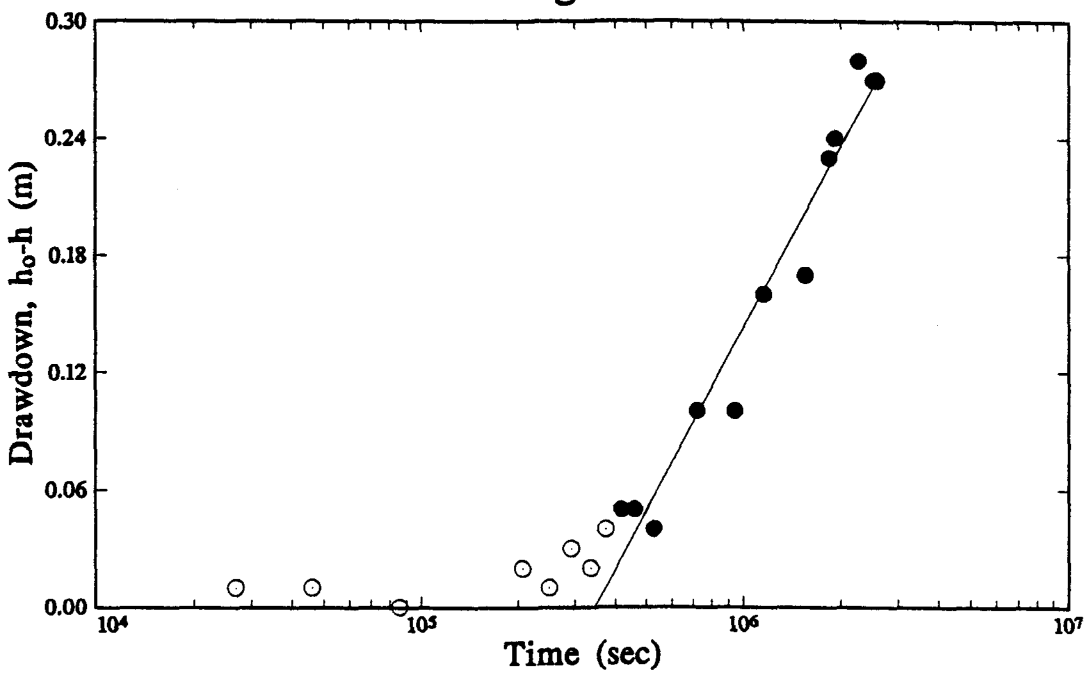
Monitoring Well 94-11



Storativity, S = 1.5E-02
Transmissivity, T = 1.3E+03 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94
Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-11

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	447.000	7.340
2	766.000	7.340
3	1430.000	7.330
4	3439.000	7.350
5	4158.000	7.340
6	4876.000	7.360
7	5595.000	7.350
8	6223.000	7.370
9	6957.000	7.380
10	7641.000	7.380
11	8774.000	7.370
12	11971.000	7.430
13	15689.000	7.430
14	19308.000	7.490
15	25925.000	7.500
16	30692.000	7.560
17	32082.000	7.570
18	37858.000	7.610
19	42065.000	7.600
20	43085.000	7.600
21	43200.000	7.600

Static Water Level = 7.33 m

Distance to Monitoring Well = 875.40 m
Pumping Rate = 1477.00 L/min

Storativity, S = 1E-02
Transmissivity, T = 1.3E+03 m sq./day

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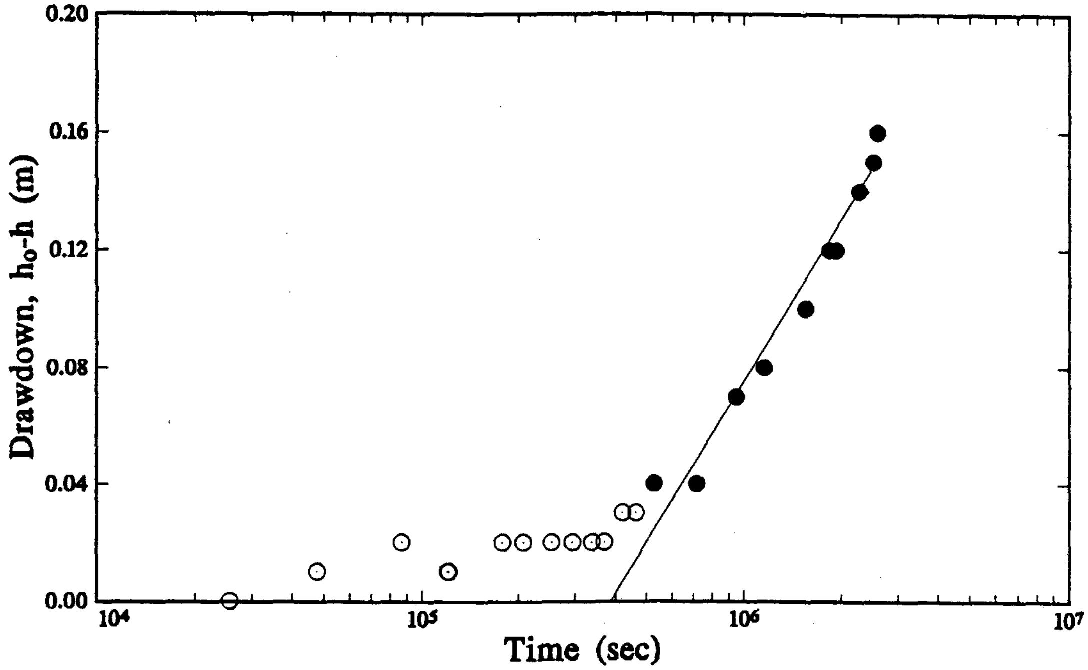
Monitoring Well 94-12



Storativity, S = 8.8E-03
Transmissivity, T = 2.1E+03 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94
Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-12

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	427.000	7.350
2	794.000	7.360
3	1447.000	7.370
4	2001.000	7.360
5	2022.000	7.360
6	2977.000	7.370
7	3455.000	7.370
8	4231.000	7.370
9	4915.000	7.370
10	5645.000	7.370
11	6167.000	7.370
12	7010.000	7.380
13	7706.000	7.380
14	8794.000	7.390
15	11915.000	7.390
16	15735.000	7.420
17	19271.000	7.430
18	25875.000	7.450
19	30676.000	7.470
20	32140.000	7.470
21	37900.000	7.490
22	42103.000	7.500
23	43107.000	7.510
24	43200.000	7.510

Static Water Level = 7.35 m

Distance to Monitoring Well = 1567.00 m
Pumping Rate = 1477.00 L/min

Storativity, S = 9E-03
Transmissivity, T = 2.1E+03 m sq./day

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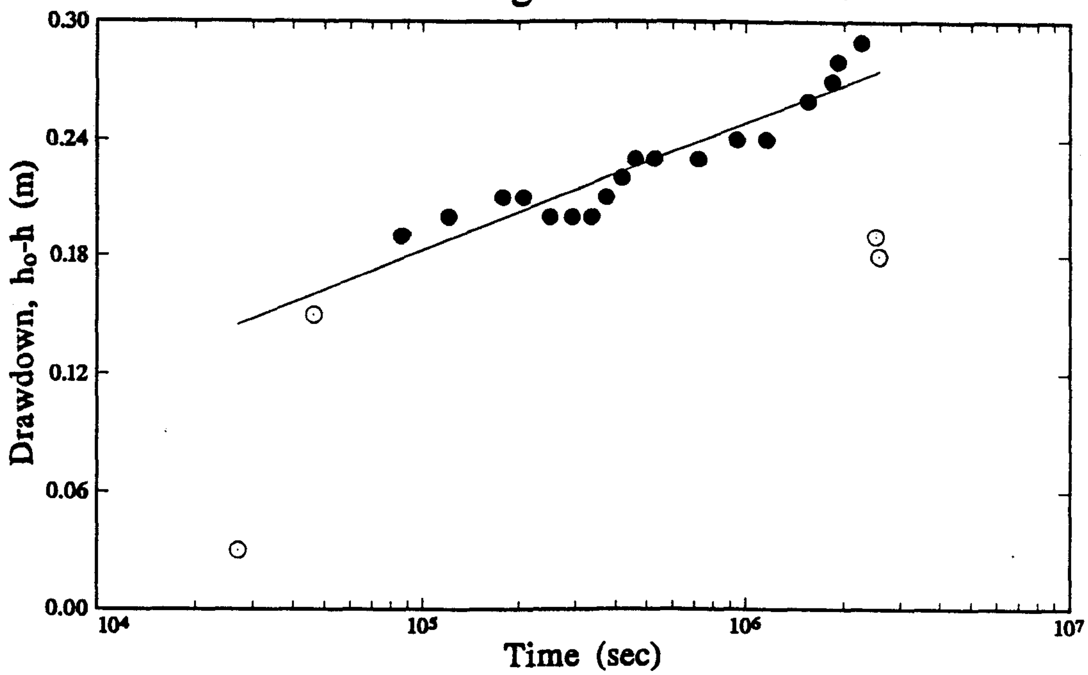
Monitoring Well WESA-16



Storativity, S = 8.4E-06

Transmissivity, T = 5.9E+03 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94

Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well WESA-16

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	451.000	3.800
2	772.000	3.920
3	1434.000	3.960
4	2004.000	3.970
5	2964.000	3.980
6	3442.000	3.980
7	4153.000	3.970
8	4873.000	3.970
9	5591.000	3.970
10	6216.000	3.980
11	6953.000	3.990
12	7635.000	4.000
13	8778.000	4.000
14	11978.000	4.000
15	15683.000	4.010
16	19298.000	4.010
17	25932.000	4.030
18	30686.000	4.040
19	32075.000	4.050
20	37850.000	4.060
21	42056.000	3.960
22	43072.000	3.950
23	43200.000	3.950

Static Water Level = 3.77 m

Distance to Monitoring Well = 1747.70 m
Pumping Rate = 1477.00 L/min

Storativity, S = 1E-05
Transmissivity, T = 5.7E+03 m sq./day

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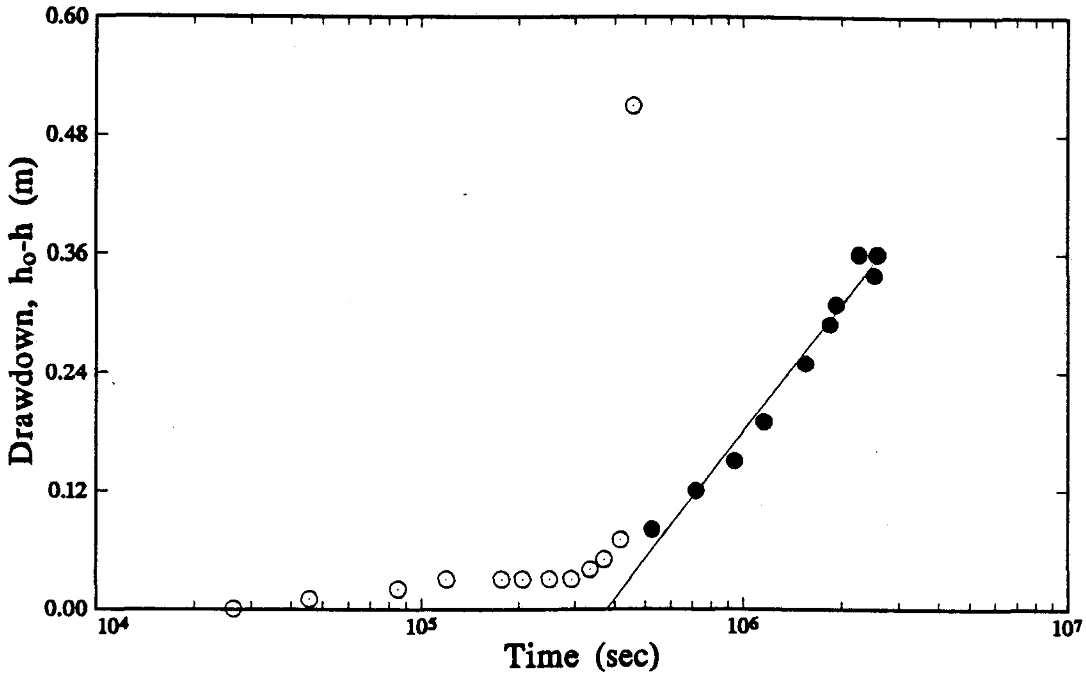
Lafleur Drilled Well



Storativity, S = 2.0E-02
Transmissivity, T = 910 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94
Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Lafleur Drilled Well

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	440.000	5.510
2	758.000	5.520
3	1419.000	5.530
4	1991.000	5.540
5	2955.000	5.540
6	3433.000	5.540
7	4166.000	5.540
8	4883.000	5.540
9	5602.000	5.550
10	6205.000	5.560
11	6964.000	5.580
12	7648.000	6.020
13	8763.000	5.590
14	11965.000	5.630
15	15696.000	5.660
16	19312.000	5.700
17	25918.000	5.760
18	30688.000	5.800
19	32089.000	5.820
20	37865.000	5.870
21	42068.000	5.850
22	43092.000	5.870
23	43200.000	5.870

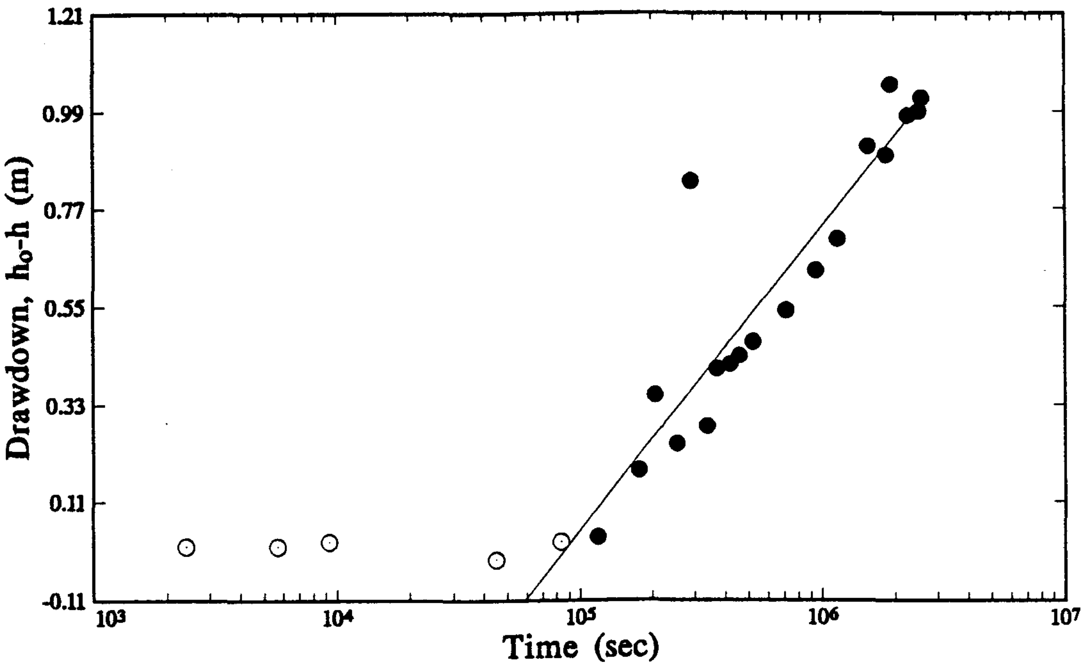
Static Water Level = 5.51 m

Distance to Monitoring Well = 678.00 m
Pumping Rate = 1477.00 L/min

Storativity, S = 2E-02
Transmissivity, T = 910 m sq./day

Dec. 15, 1994 3:22:12 PM

Groves Drilled Well



Storativity, S = 8.6E-02
Transmissivity, T = 570 m^2/day

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94

Type of Test : Pump Test
Reference : Cooper and Jacob (1946)

Title: Groves Drilled Well

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	40.000	6.770
2	95.000	6.770
3	155.000	6.780
4	750.000	6.740
5	1397.000	6.780
6	1980.000	6.790
7	2944.000	6.940
8	3424.000	7.110
9	4221.000	7.000
10	4850.000	7.590
11	5626.000	7.040
12	6193.000	7.170
13	7037.000	7.180
14	7673.000	7.200
15	8702.000	7.230
16	11946.000	7.300
17	15717.000	7.390
18	19291.000	7.460
19	25904.000	7.670
20	30707.000	7.650
21	32111.000	7.810
22	37884.000	7.740
23	42091.000	7.750
24	43117.000	7.780
25	43200.000	7.780

Static Water Level = 6.76 m

Distance to Monitoring Well = 122.00 m
Pumping Rate = 1477.00 L/min

Storativity, S = 9E-02
Transmissivity, T = 570 m sq./day

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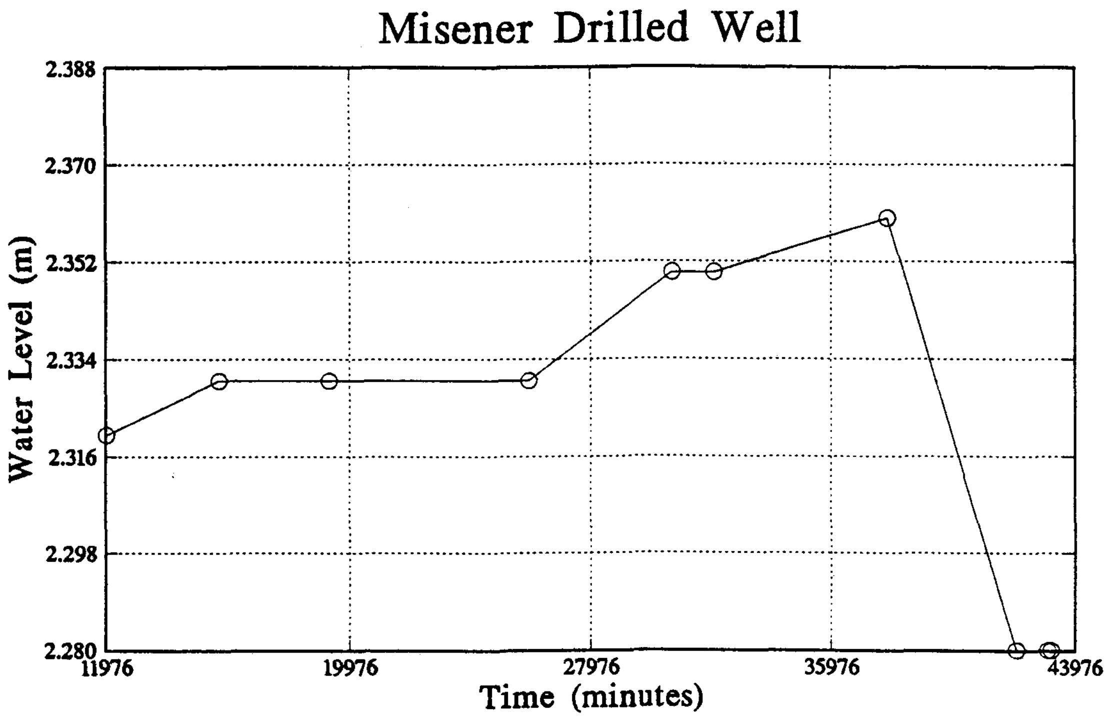

Project Number : 941-2747
Date Tested : Oct. 5/94 - Nov. 4/94

Title: Misener Drilled Well

Project Number: 941-2747
Date Tested: Oct. 5/94 - Nov. 4/94
Type of Test: Pump Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	11976.000	2.320
2	15685.000	2.330
3	19301.000	2.330
4	25929.000	2.330
5	30688.000	2.350
6	32078.000	2.350
7	37854.000	2.360
8	42058.000	2.280
9	43080.000	2.280
10	43200.000	2.280

Static Water Level = 0.00 m

Distance to Monitoring Well = 1674.30 m
Pumping Rate = 1477.00 L/min

Storativity, S = -1E+00
Transmissivity, T = -1 m sq./day

APPENDIX G

RECOVERY DATA AND PLOTS OF RECOVERY DATA

30 DAY AQUIFER TEST

TABLE G-1

SUMMARY OF AQUIFER PARAMETERS
RECOVERY DATA

Well	Transmissivity(T) (m^2/day)	Remarks
Test Well	1100*	
94-1	1400*	
94-2	1300*	
94-3	1400*	
94-4	1100*	
94-5	1400*	
94-6	2100	Erratic water levels during recovery period possibly influenced by pumping in St. Pierre pit
94-7	1100*	
94-8A	1500*	
94-8B	18000	Erratic water levels during recovery period; well not completed in aquifer
94-9A	1100	Well completed in silty sand along flanks of aquifer; minimal drawdown (0.12 metres) during pumping test
94-9B	--	Erratic water levels during recovery period; well not completed in aquifer
94-10	11000	Erratic water levels during recovery period
94-11	--	See comments above for well 94-6
94-12	--	Water levels declined during recovery period
WESA16	6200	Erratic water levels during recovery period; water level recovered above static conditions as measured prior to pumping test
Lafleur well	--	Erratic water levels during recovery period due to pumping of domestic well
Groves well	1400*	

*Values used to estimate T range and average value based on recovery data

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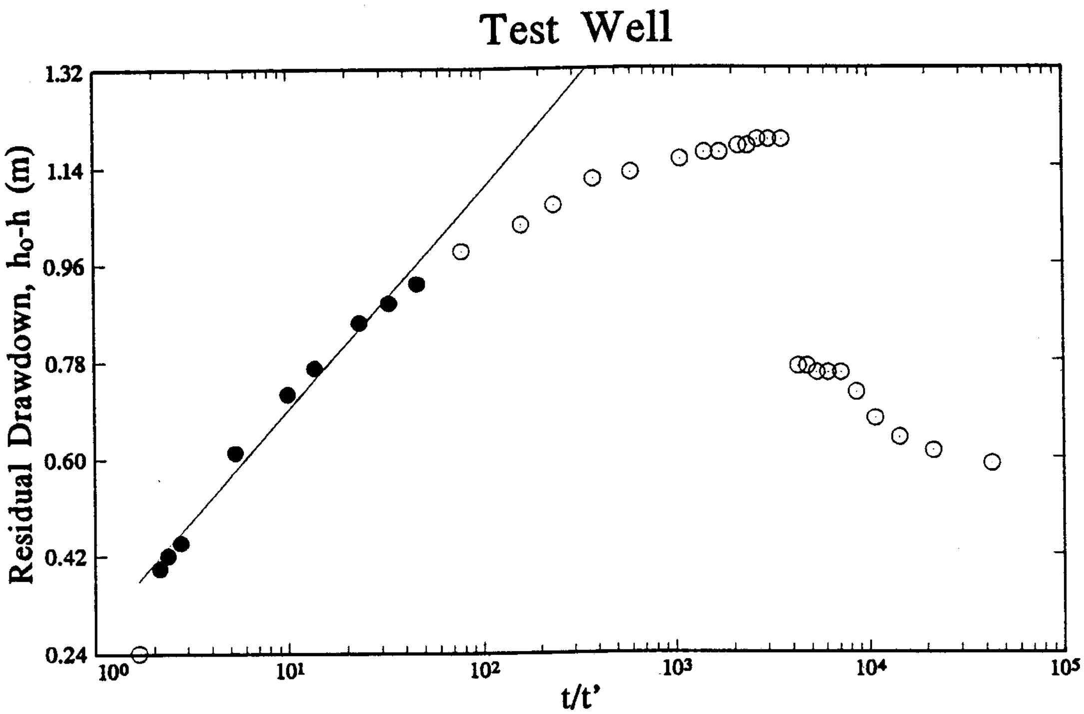

Transmissivity, T = 1.1E+03 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94
Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Test Well

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43201.000	2.090
2	43202.000	2.110
3	43203.000	2.130
4	43204.000	2.160
5	43205.000	2.200
6	43206.000	2.230
7	43207.000	2.230
8	43208.000	2.230
9	43209.000	2.240
10	43210.000	2.240
11	43212.000	2.590
12	43214.000	2.590
13	43216.000	2.590
14	43218.000	2.580
15	43220.000	2.580
16	43225.000	2.570
17	43230.000	2.570
18	43240.000	2.560
19	43272.000	2.540
20	43313.000	2.530
21	43382.000	2.490
22	43471.000	2.460
23	43758.000	2.420
24	44158.000	2.370
25	44548.000	2.340
26	45138.000	2.310
27	46602.000	2.240
28	48041.000	2.200
29	53295.000	2.110
30	67910.000	1.970
31	74842.000	1.950
32	81119.000	1.930
33	107940.000	1.800

Static Water Level = 1.56 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 1.1E+03 m sq./day

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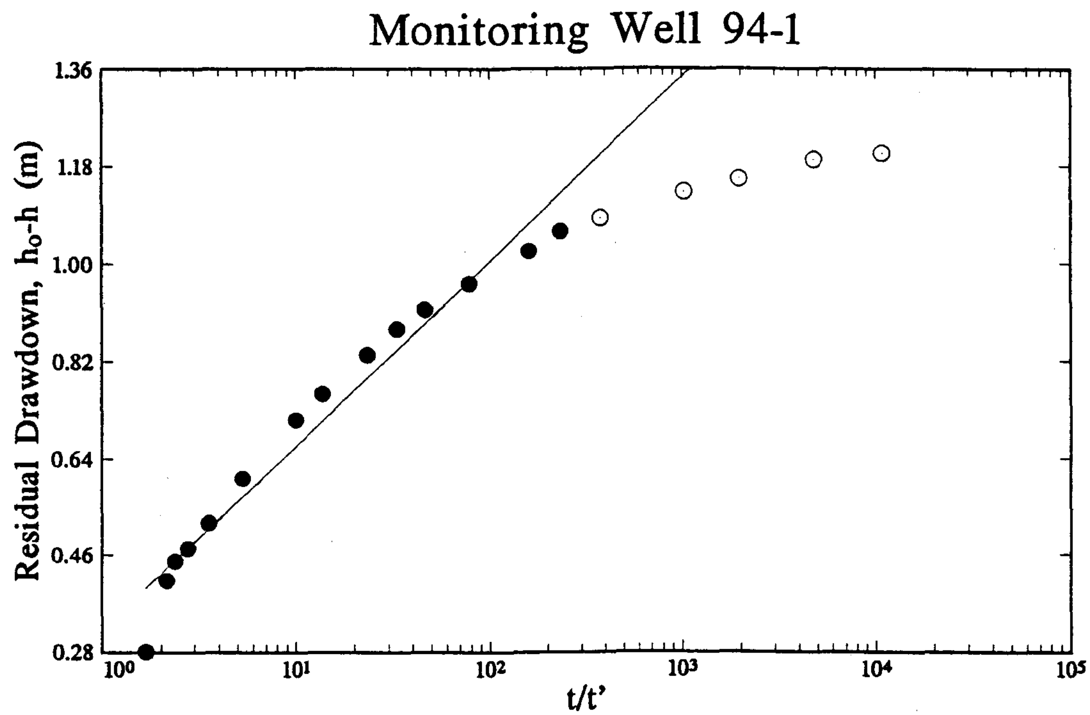

Transmissivity, T = 1.4E+03 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94

Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-1

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43204.000	3.270
2	43209.000	3.260
3	43222.000	3.230
4	43242.000	3.210
5	43315.000	3.170
6	43387.000	3.150
7	43473.000	3.120
8	43761.000	3.070
9	44160.000	3.030
10	44550.000	3.000
11	45140.000	2.960
12	46605.000	2.900
13	48043.000	2.860
14	53293.000	2.770
15	60385.000	2.700
16	67912.000	2.660
17	74844.000	2.640
18	81122.000	2.610
19	107942.000	2.500

Static Water Level = 2.22 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 1.4E+03 m sq./day

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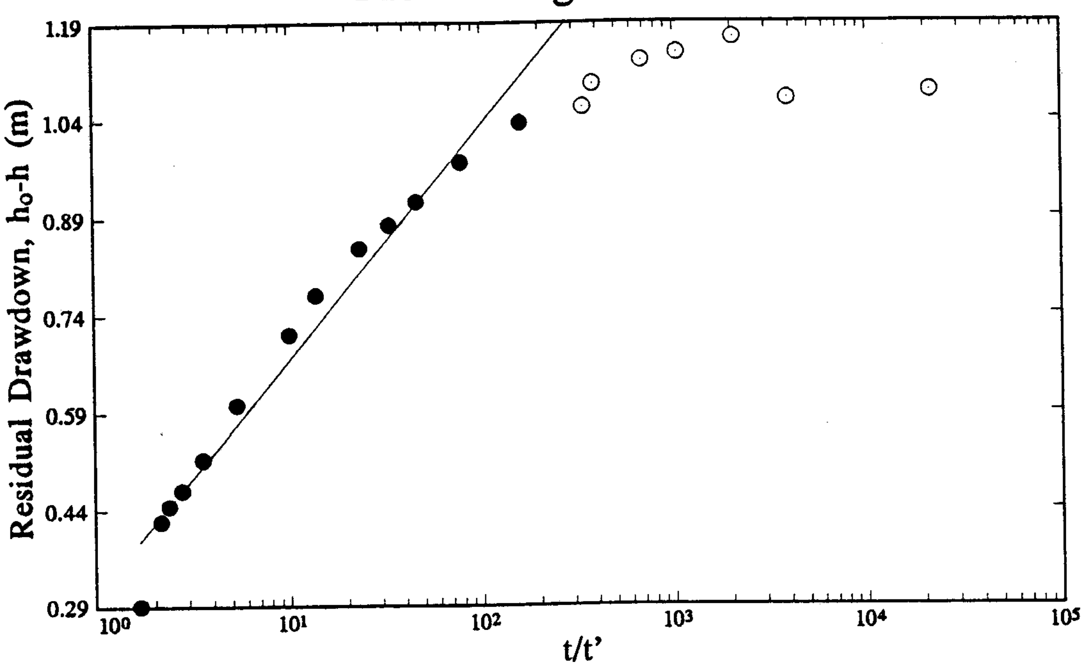
Monitoring Well 94-2



Transmissivity, T = 1.3E+03 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94

Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-2

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43202.000	3.010
2	43211.000	3.000
3	43221.000	3.080
4	43241.000	3.060
5	43263.000	3.050
6	43313.000	3.020
7	43327.000	2.990
8	43472.000	2.970
9	43760.000	2.920
10	44159.000	2.870
11	44549.000	2.840
12	45139.000	2.810
13	46603.000	2.750
14	48042.000	2.700
15	53294.000	2.610
16	60383.000	2.540
17	67908.000	2.500
18	74843.000	2.480
19	81120.000	2.460
20	107944.000	2.350

Static Water Level = 2.06 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 1.3E+03 m sq./day

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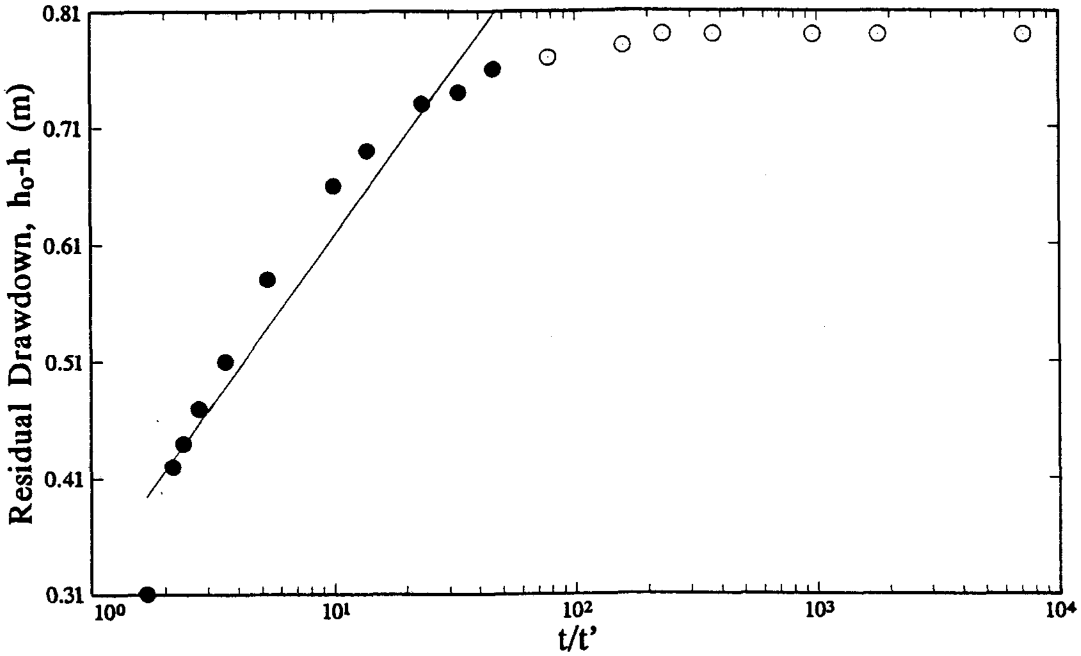
Monitoring Well 94-3



Transmissivity, T = 1.4E+03 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94

Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-3

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43206.000	2.900
2	43224.000	2.900
3	43245.000	2.900
4	43316.000	2.900
5	43387.000	2.900
6	43474.000	2.890
7	43762.000	2.880
8	44163.000	2.870
9	44551.000	2.850
10	45142.000	2.840
11	46607.000	2.800
12	48045.000	2.770
13	53291.000	2.690
14	60387.000	2.620
15	67914.000	2.580
16	74846.000	2.550
17	81124.000	2.530
18	107946.000	2.420

Static Water Level = 2.11 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 1.4E+03 m sq./day

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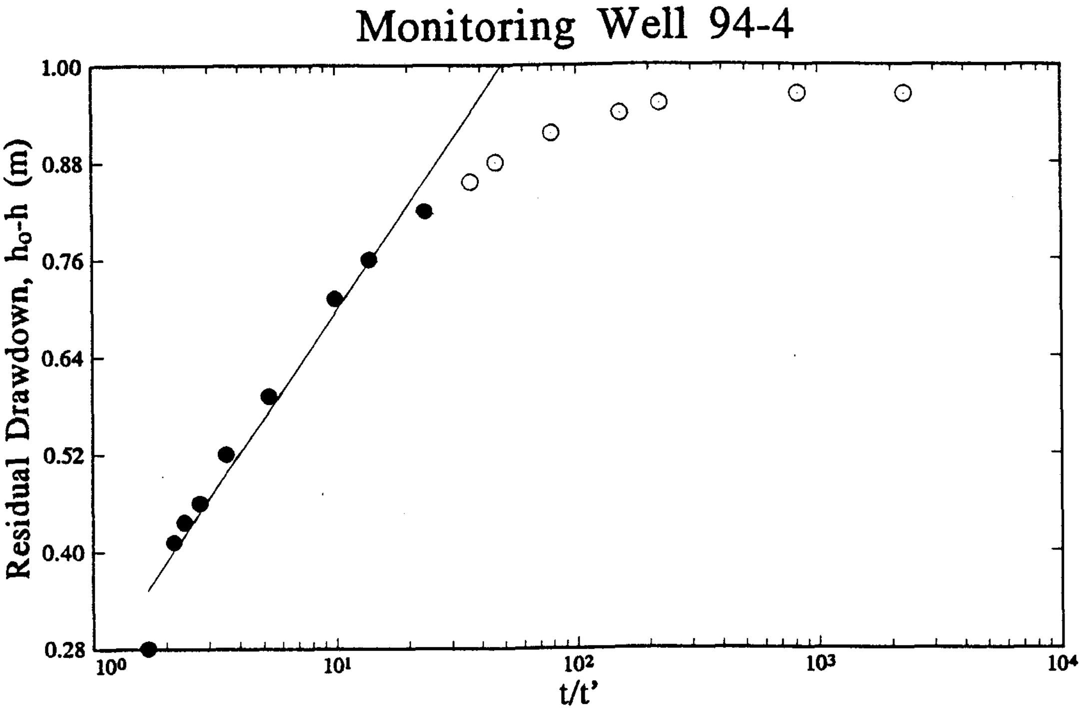


Transmissivity, T = 1.1E+03 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec.19/94
Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-4

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec.19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

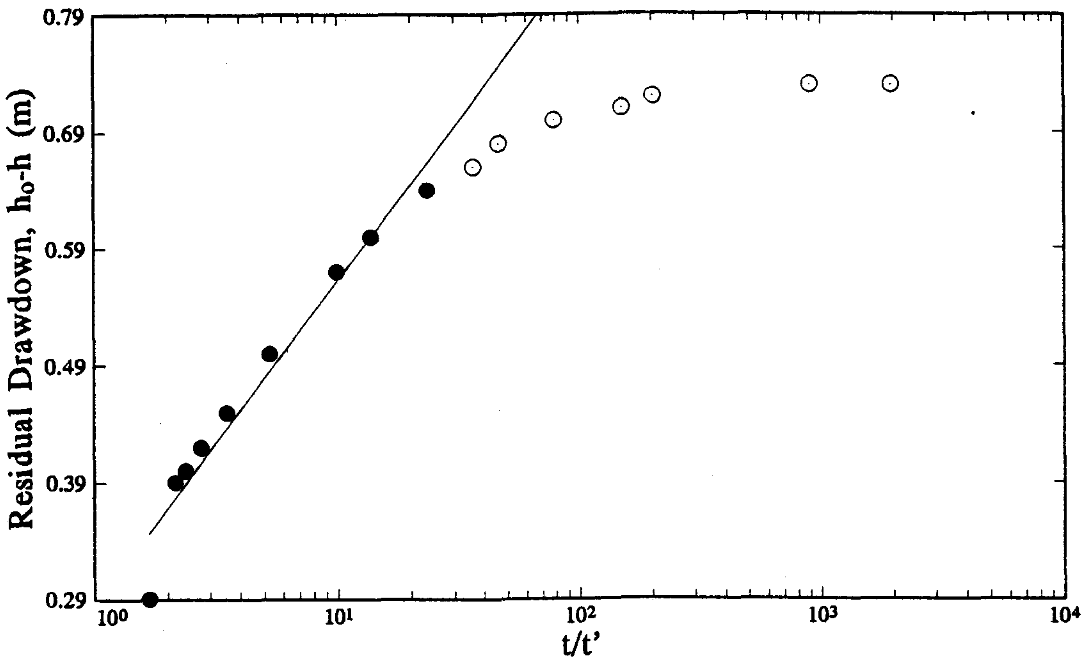
Reading Number	Time (min)	Water Level (m)
1	43219.000	4.340
2	43252.000	4.340
3	43394.000	4.330
4	43486.000	4.320
5	43754.000	4.300
6	44153.000	4.270
7	44423.000	4.250
8	45133.000	4.220
9	46596.000	4.170
10	48036.000	4.130
11	53286.000	4.030
12	60379.000	3.970
13	67904.000	3.920
14	74837.000	3.900
15	81113.000	3.880
16	107950.000	3.770

Static Water Level = 3.49 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 1.1E+03 m sq./day

Dec. 23, 1994 1:45:28 PM

Monitoring Well 94-5



Transmissivity, T = 1.4E+03 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94
Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-5

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43222.000	2.760
2	43248.000	2.760
3	43414.000	2.750
4	43489.000	2.740
5	43756.000	2.730
6	44155.000	2.710
7	44426.000	2.690
8	45135.000	2.670
9	46599.000	2.630
10	48039.000	2.600
11	53288.000	2.530
12	60381.000	2.480
13	67906.000	2.450
14	74839.000	2.430
15	81115.000	2.420
16	107955.000	2.320

Static Water Level = 2.03 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 1.4E+03 m sq./day

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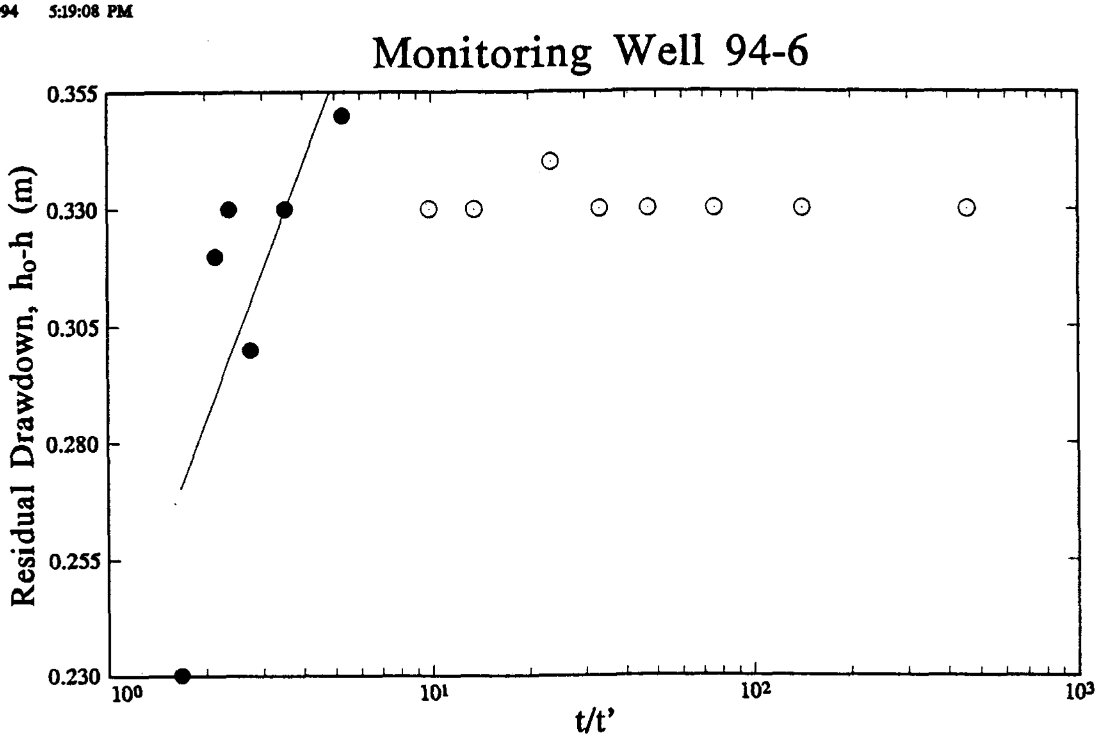

Transmissivity, T = 2.1E+03 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94
Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-6

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43294.000	8.670
2	43505.000	8.670
3	43777.000	8.670
4	44135.000	8.670
5	44534.000	8.670
6	45123.000	8.680
7	46630.000	8.670
8	48067.000	8.670
9	53272.000	8.690
10	60370.000	8.670
11	67895.000	8.640
12	74828.000	8.670
13	81098.000	8.660
14	107960.000	8.570

Static Water Level = 8.34 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 2.1E+03 m sq./day

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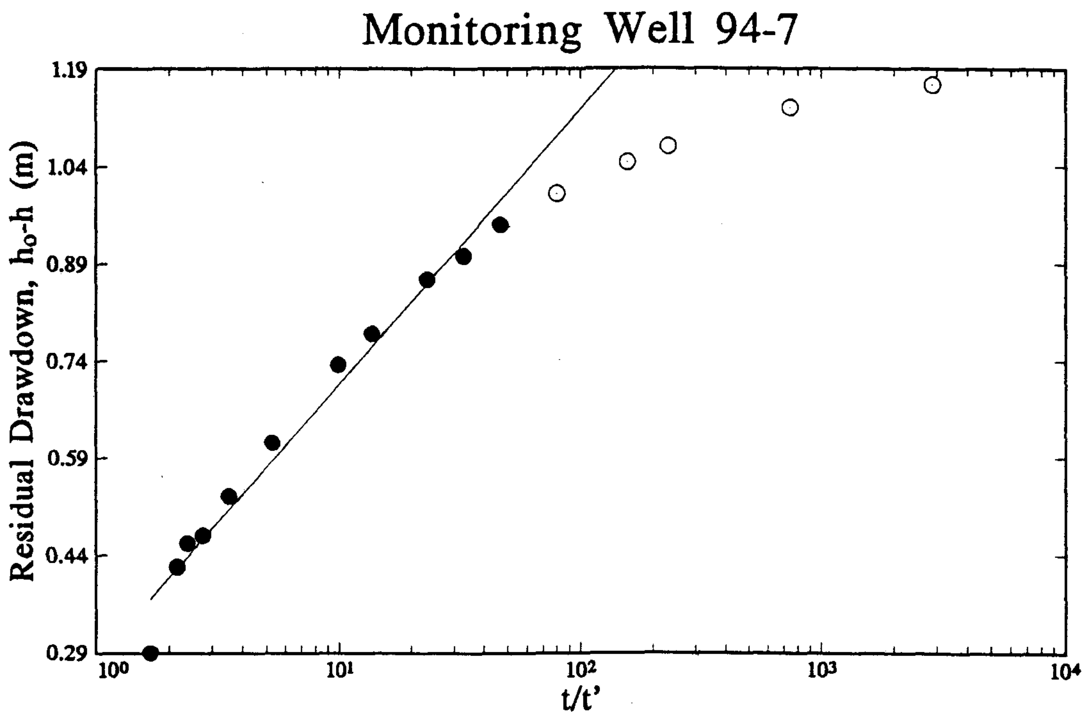

Transmissivity, T = 1.1E+03 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94
Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-7

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43215.000	6.380
2	43258.000	6.350
3	43387.000	6.300
4	43477.000	6.280
5	43748.000	6.240
6	44148.000	6.200
7	44558.000	6.160
8	45148.000	6.130
9	46615.000	6.060
10	48054.000	6.020
11	53302.000	5.920
12	60394.000	5.850
13	67920.000	5.800
14	74851.000	5.790
15	81141.000	5.760
16	107962.000	5.650

Static Water Level = 5.36 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 1.1E+03 m sq./day

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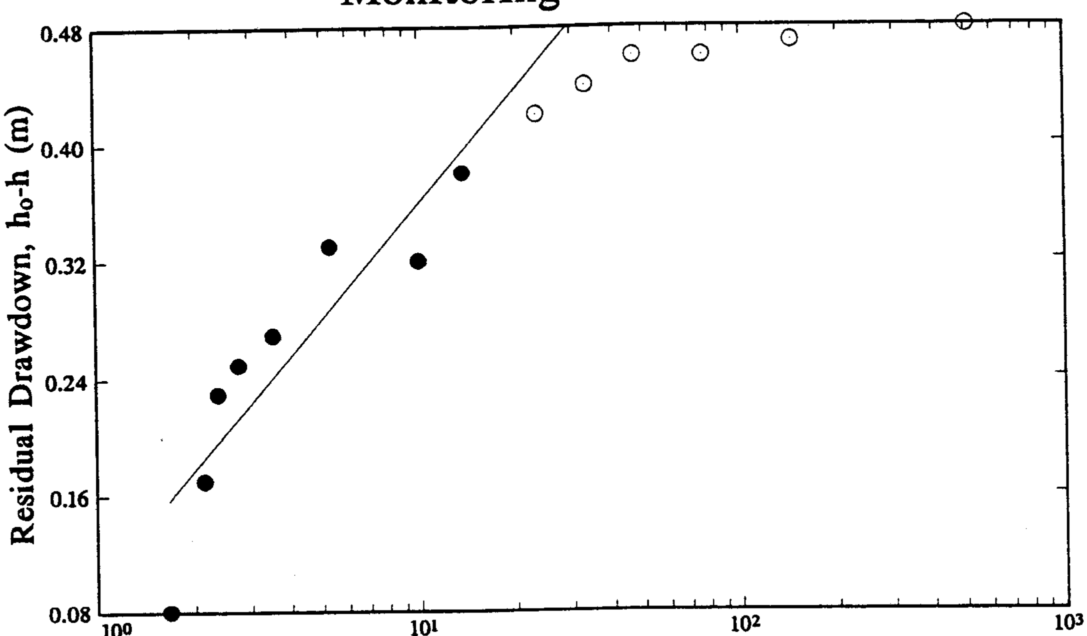
Monitoring Well 94-8A



Transmissivity, T = 1.5E+03 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/04
Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-8A

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/04
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43285.000	0.680
2	43498.000	0.670
3	43769.000	0.660
4	44141.000	0.660
5	44540.000	0.640
6	45129.000	0.620
7	46592.000	0.580
8	48032.000	0.520
9	53260.000	0.530
10	60377.000	0.470
11	67901.000	0.450
12	74834.000	0.430
13	81107.000	0.370
14	107965.000	0.280

Static Water Level = 0.20 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 1.5E+03 m sq./day

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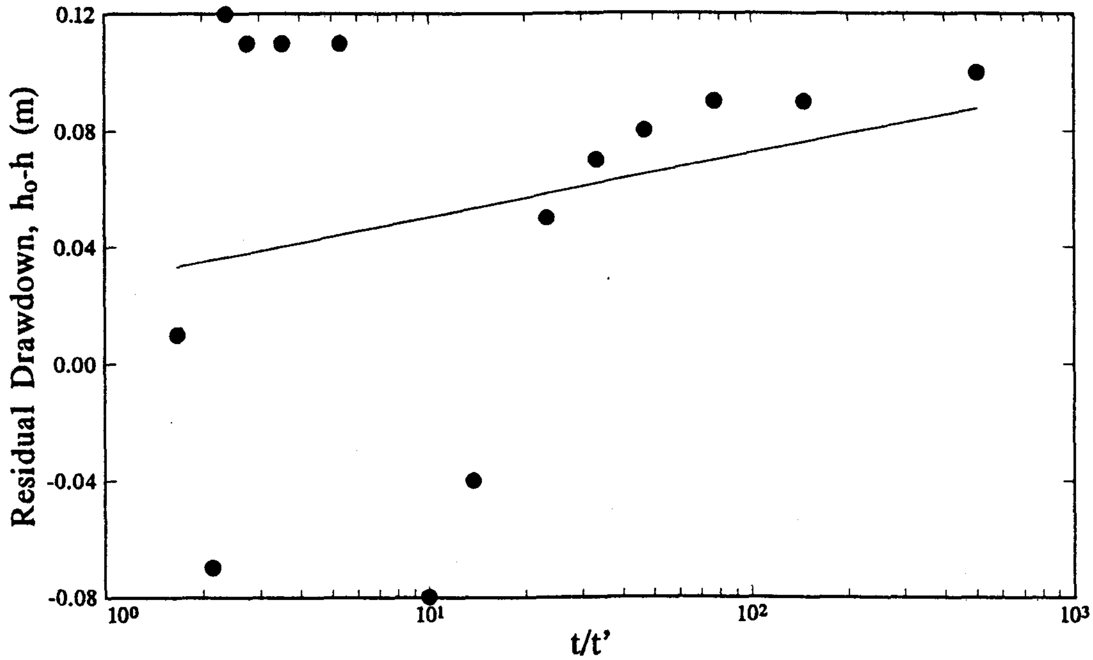
Monitoring Well 94-8B



Transmissivity, T = 1.8E+04 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94

Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-8B

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43286.000	0.950
2	43499.000	0.940
3	43770.000	0.940
4	44142.000	0.930
5	44541.000	0.920
6	45130.000	0.900
7	46593.000	0.810
8	48033.000	0.770
9	53260.000	0.960
10	60377.000	0.960
11	67902.000	0.960
12	74858.000	0.970
13	81108.000	0.780
14	107965.000	0.860

Static Water Level = 0.85 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 1.8E+04 m sq./day

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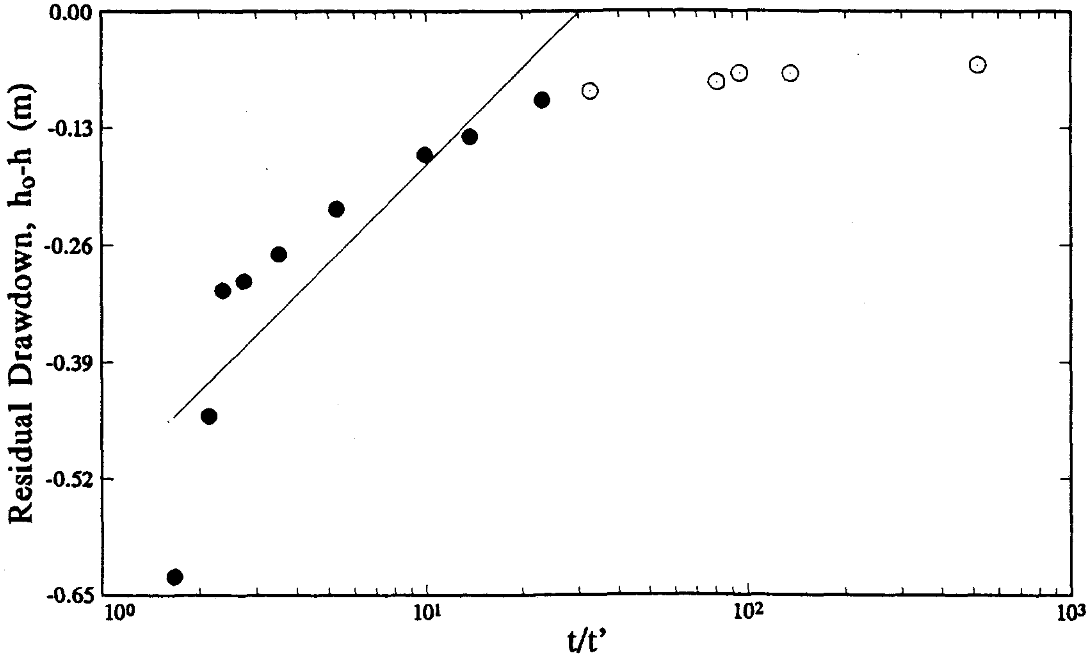
Monitoring Well 94-9A



Transmissivity, T = 1.1E+03 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94

Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-9A

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43283.000	1.190
2	43519.000	1.180
3	43740.000	1.170
4	43659.000	1.180
5	44566.000	1.160
6	45157.000	1.150
7	46589.000	1.110
8	48029.000	1.090
9	53258.000	1.030
10	60405.000	0.980
11	67937.000	0.950
12	74857.000	0.940
13	81148.000	0.800
14	107970.000	0.620

Static Water Level = 1.25 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 1.1E+03 m sq./day

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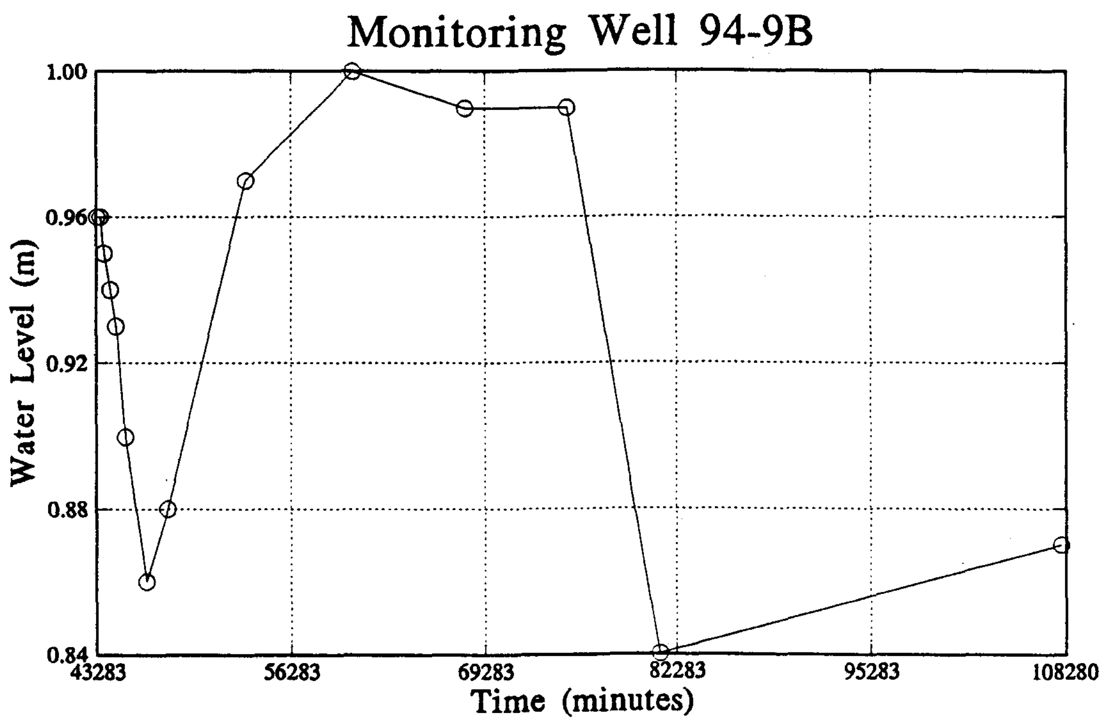

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94

Title: Monitoring Well 94-9B

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43283.000	0.960
2	43520.000	0.960
3	43741.000	0.950
4	44170.000	0.940
5	44567.000	0.930
6	45158.000	0.900
7	46590.000	0.860
8	48030.000	0.880
9	53258.000	0.970
10	60404.000	1.000
11	67938.000	0.990
12	74858.000	0.990
13	81149.000	0.840
14	107970.000	0.870

Static Water Level = 1.61 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = -1 m sq./day

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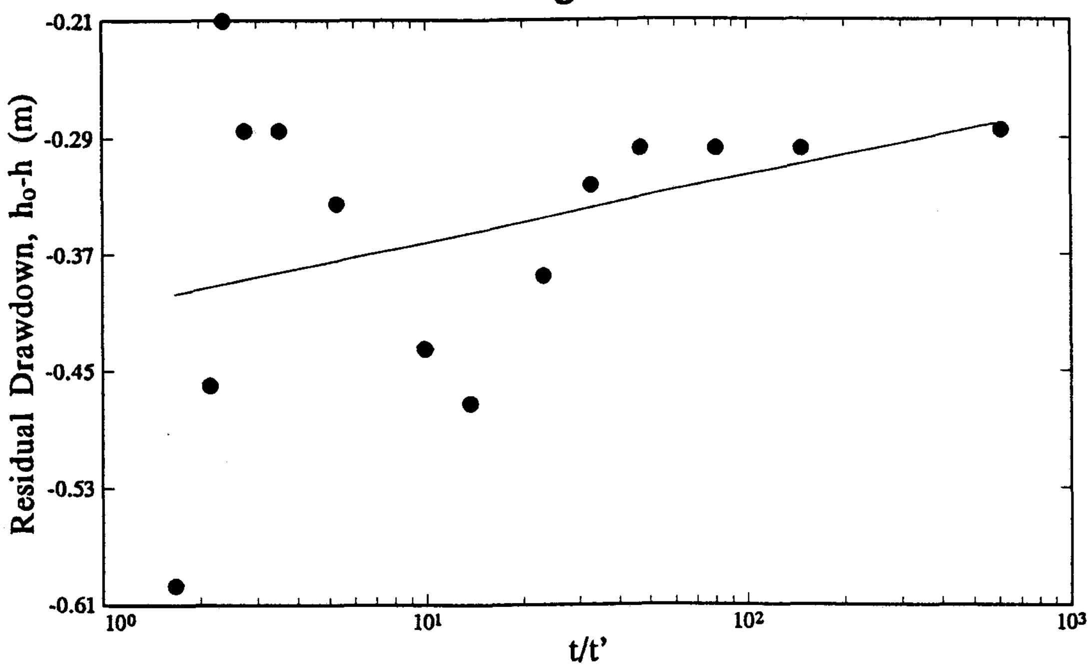
Monitoring Well 94-10



Transmissivity, T = 1.1E+04 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94

Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well 94-10

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43271.000	1.120
2	43495.000	1.110
3	43746.000	1.110
4	44145.000	1.110
5	44563.000	1.090
6	45154.000	1.040
7	46622.000	0.970
8	48060.000	1.000
9	53305.000	1.080
10	60402.000	1.120
11	67922.000	1.120
12	74854.000	1.180
13	81144.000	0.980
14	107980.000	0.870

Static Water Level = 1.47 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 1.1E+04 m sq./day

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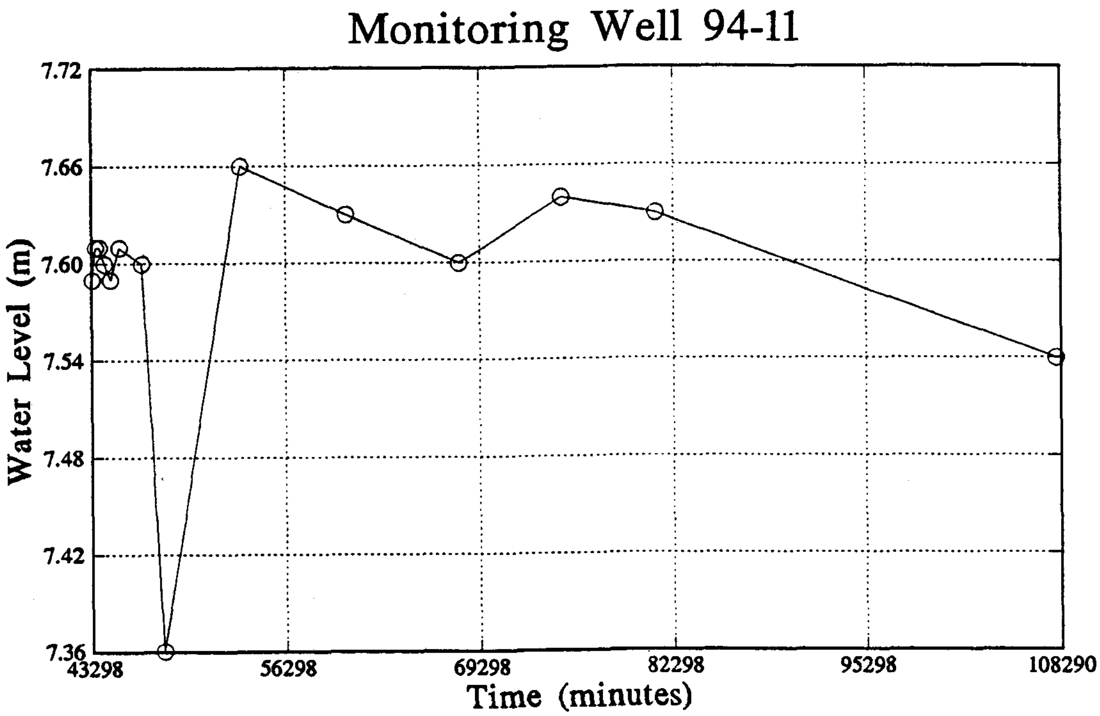


Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94

Title: Monitoring Well 94-11

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

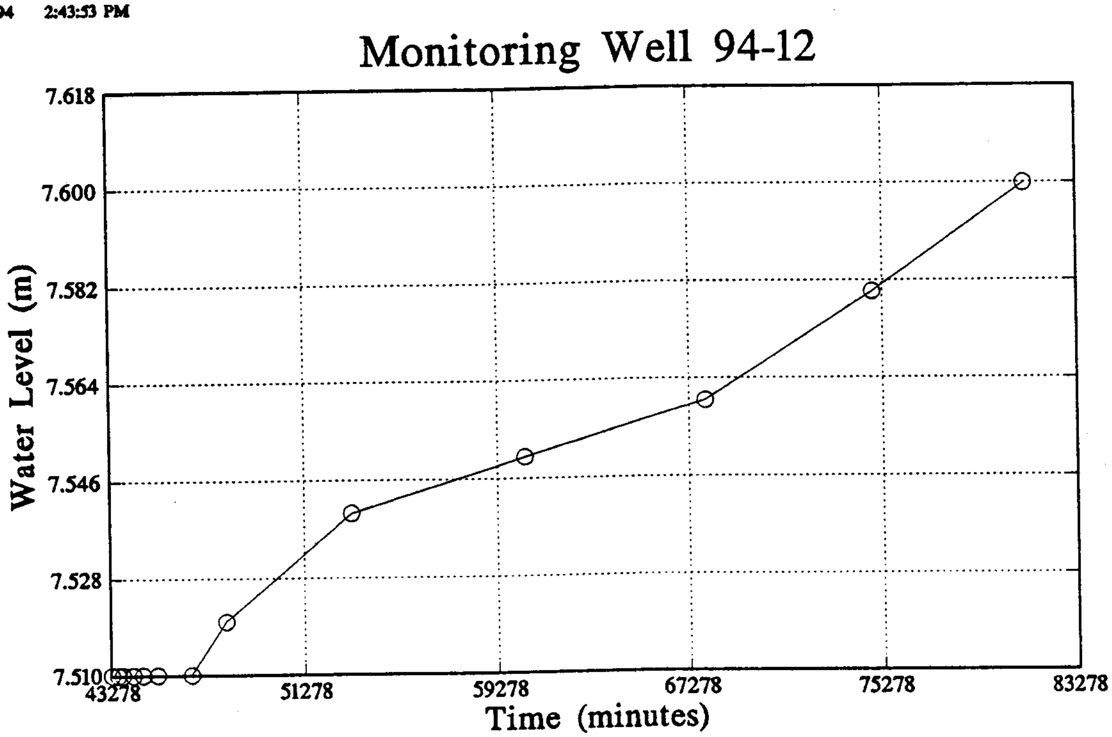
Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43298.000	7.590
2	43508.000	7.610
3	43780.000	7.610
4	44131.000	7.600
5	44531.000	7.590
6	45119.000	7.610
7	46633.000	7.600
8	48071.000	7.360
9	53274.000	7.660
10	60368.000	7.630
11	67892.000	7.600
12	74825.000	7.640
13	81102.000	7.630
14	107985.000	7.540

Static Water Level = 7.33 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = -1 m sq./day

Dec. 30, 1994 2:43:53 PM



Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94

Title: Monitoring Well 94-12

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

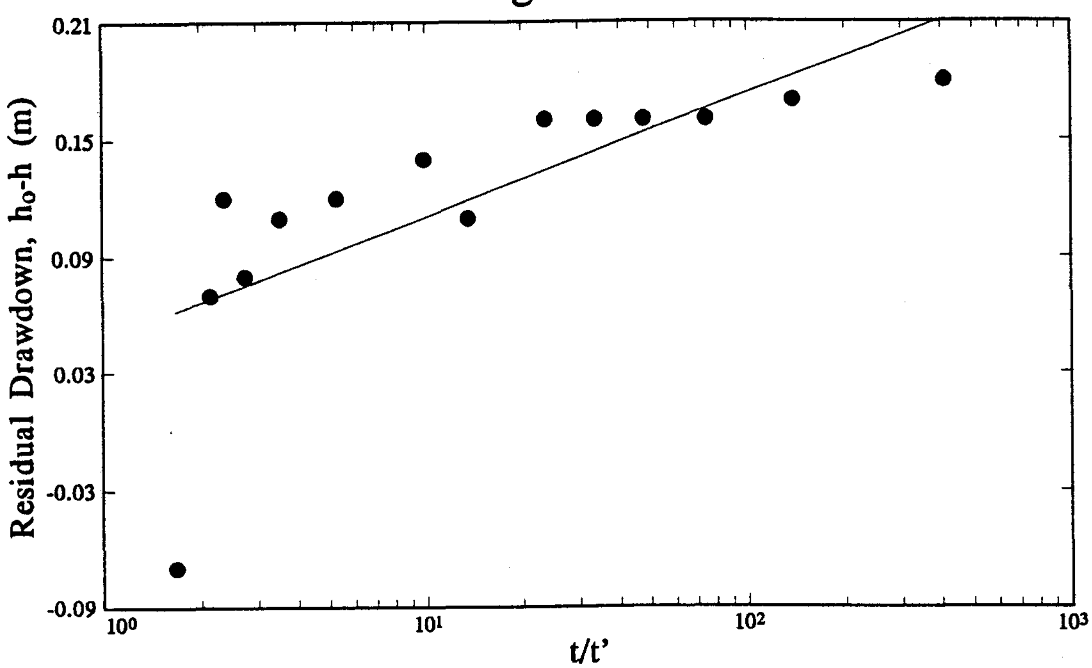
Reading Number	Time (min)	Water Level (m)
1	43278.000	7.510
2	43525.000	7.510
3	43734.000	7.510
4	44177.000	7.510
5	44574.000	7.510
6	45165.000	7.510
7	46582.000	7.510
8	48022.000	7.520
9	53250.000	7.540
10	60411.000	7.550
11	67944.000	7.560
12	74865.000	7.580
13	81155.000	7.600

Static Water Level = 7.35 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = -1.2E+04 m sq./day

Dec. 22, 1994 5:56:44 PM

Monitoring Well WESA-16



Transmissivity, T = 6.2E+03 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94

Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Monitoring Well WESA-16

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

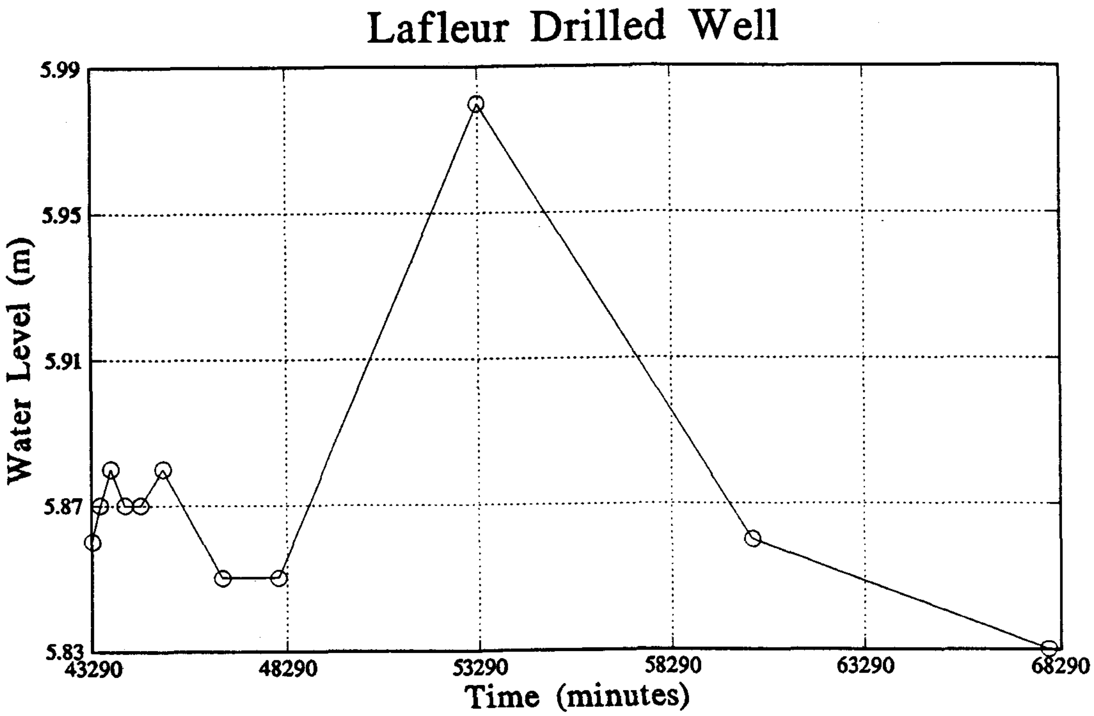
Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43306.000	3.950
2	43514.000	3.940
3	43787.000	3.930
4	44125.000	3.930
5	44524.000	3.930
6	45111.000	3.930
7	46641.000	3.880
8	48079.000	3.910
9	53280.000	3.890
10	60360.000	3.880
11	67885.000	3.850
12	74818.000	3.890
13	81090.000	3.840
14	107990.000	3.700

Static Water Level = 3.77 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 6.2E+03 m sq./day

Dec. 23, 1994 2:16:14 PM



Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94

Title: Lafleur Drilled Well

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

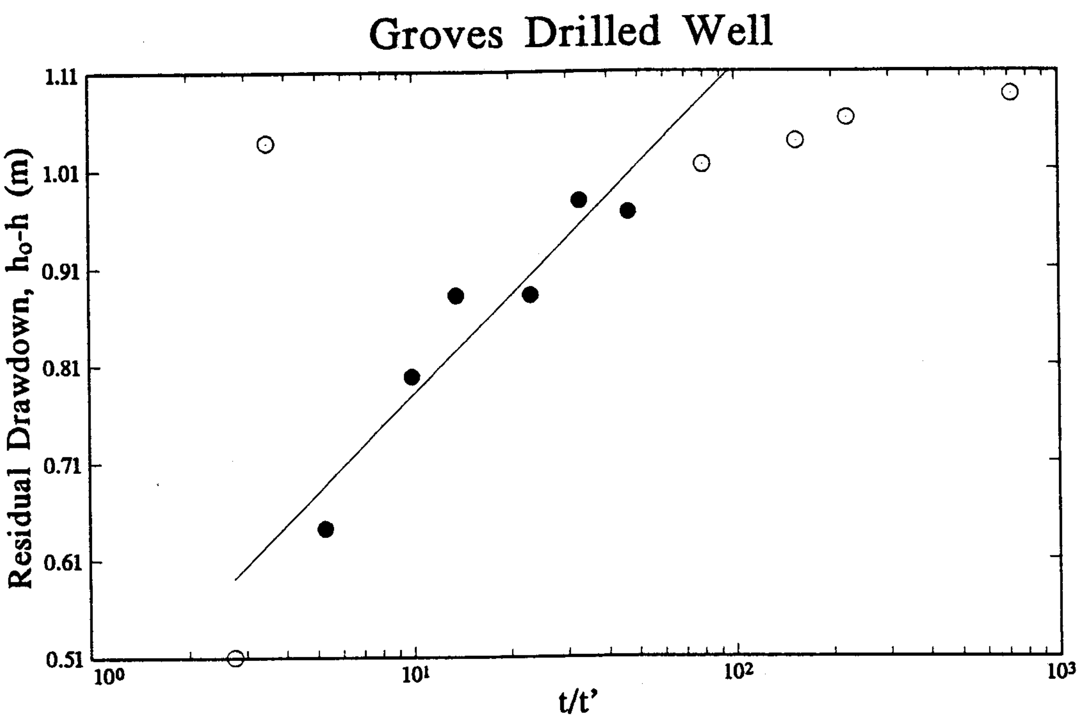
Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43290.000	5.860
2	43502.000	5.870
3	43773.000	5.880
4	44138.000	5.870
5	44537.000	5.870
6	45126.000	5.880
7	46626.000	5.850
8	48064.000	5.850
9	53265.000	5.980
10	60375.000	5.860
11	67989.000	5.830

Static Water Level = 5.51 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = -1 m sq./day

Dec. 22, 1994 6:01:39 PM



Transmissivity, T = 1.4E+03 m^2/day

Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94
Type of Test : Recovery Test
Reference : Cooper and Jacob (1946)

Title: Groves Drilled Well

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

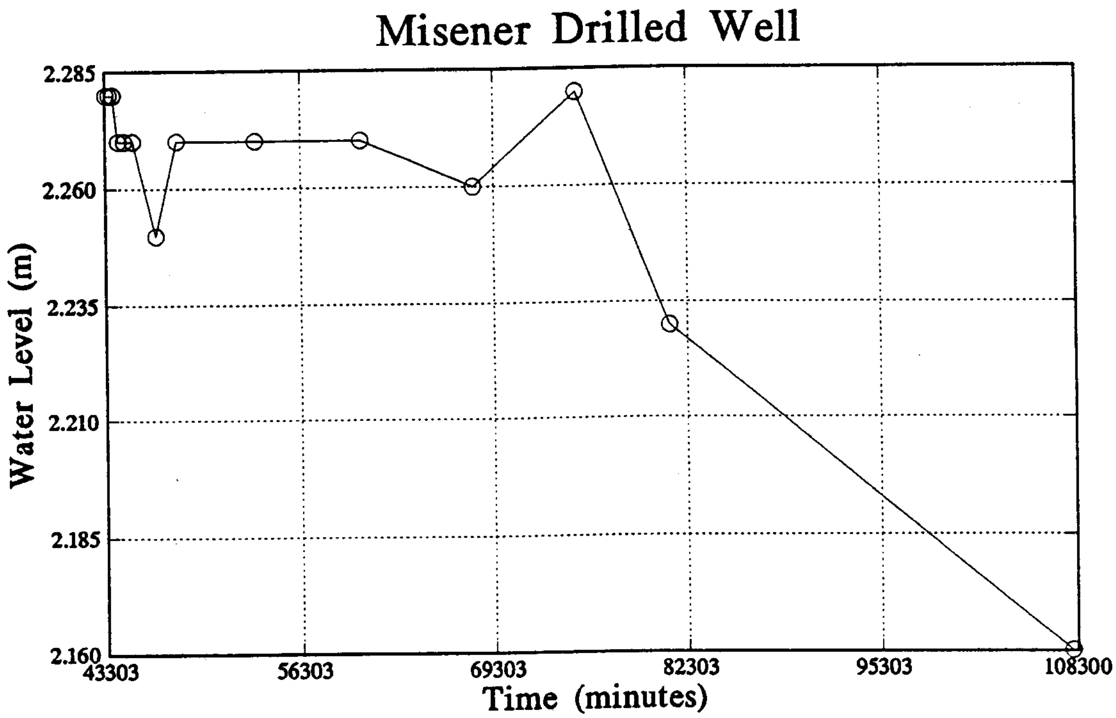
Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43260.000	7.750
2	43394.000	7.730
3	43479.000	7.710
4	43750.000	7.690
5	44150.000	7.650
6	44560.000	7.660
7	45150.000	7.580
8	46619.000	7.580
9	48056.000	7.510
10	53300.000	7.380
11	60396.000	7.710
12	67925.000	7.270

Static Water Level = 6.76 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = 1.4E+03 m sq./day

Dec. 23, 1994 2:34:56 PM



Project Number : 941-2747
Date Tested : Nov. 4/94 - Dec. 19/94

Title: Misener Drilled Well

Project Number: 941-2747
Date Tested: Nov. 4/94 - Dec. 19/94
Type of Test: Recovery Test
Analysis Method: Cooper and Jacob (1946)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	43303.000	2.280
2	43512.000	2.280
3	43784.000	2.280
4	44127.000	2.270
5	44527.000	2.270
6	45114.000	2.270
7	46638.000	2.250
8	48076.000	2.270
9	53278.000	2.270
10	60365.000	2.270
11	67887.000	2.260
12	74820.000	2.280
13	81092.000	2.230
14	108000.000	2.160

Static Water Level = 0.00 m
Pumping Rate = 1477.00 L/min
Time Pumping Stopped = 43200.00 min

Transmissivity, T = -1 m sq./day

APPENDIX H

GROUNDWATER QUALITY DATA

30 DAY AQUIFER TEST

MONITORING WELLS AND TEST WELL

TABLE H-1

SUMMARY OF FIELD MEASURED WATER QUALITY PARAMETERS
TEST WELL

Date	Conductivity (μS/cm)	Temperature (°C)	pH	Turbidity (NTU)	Residual Chlorine (mg/L)	Sulphide (mg/L)
Oct. 5/94	340	12	7.0	<1	0	0
Oct. 6/94	400	10	7.0	<1	0	0
Oct. 7/94	400	10	7.0	<1	0	0
Oct. 8/94	400	10	7.0	<1	0	0
Oct. 9/94	420	10	7.0	<1	0	0
Oct. 10/94	430	10	7.0	<1	0	0
Oct. 13/94	430	10.5	6.7	<1	0	0
Oct. 16/94	440	9	7.0	<1	0	0
Oct. 18/94	465	10	7.0	<1	0	0
Oct. 23/94	440	11	7.0	<1	0	0
Oct. 26/94	430	10	7.0	<1	0	0
Oct. 28/94	450	10	7.3	<1	0	0
Oct. 31/94	440	10	7.0	<1	0	0
Nov. 3/94	450	10	7.1	<1	0	0
Nov. 4/94	450	10	7.1	<1	0	0

NOTES: °C - degrees Celsius
μS/cm - microsiemens per centimetre
mg/L - milligrams per Litre
NTU - nephelometric turbidity unit

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Assoicates

Attention: Rob Sinclair

LAB REPORT NO: A4-2799
DATE: Oct. 24, 1994
DATE SUBMITTED: Oct. 5, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample TW #1 2 1/2 hrs.	Sample	Sample	Sample	Sample
Fe	mg/L	0.01	0.12				
Mn	mg/L	0.01	0.05				
Hardness	mg/L CaCO3	1	205				
Alkalinity	mg/L CaCO3	1	163				
pH			8.20				
Conductivity	umhos/cm	3	436				
F	mg/L	0.10	0.89				
Na	mg/L	1	7				
N-NO3	mg/L	0.1	nd				
N-NO2	mg/L	0.1	nd				
N-NH3	mg/L	0.02	nd				
SO4	mg/L	3	52				
Cl	mg/L	1	9				
Phenols	mg/L	0.002	nd				
Turbidity	NTU	0.1	0.7				
Colour	Pt/Co units	2	nd				
Ca	mg/L	1	59				
Mg	mg/L	1	14				
Tannin & Lignin	mg/L	0.1	nd				
Total Kjeldahl Nitrogen	mg/L	0.02	0.08				
K	mg/L	1	2				
TOC	mg/L	0.2	0.5				
TDS	mg/L	1	260				
H2S	mg/L	0.01	nd				
Ion Balance			0.96				

ND = Not Detected (<MDL)   MDL = Method Detection Limit

COMMENT:

ANALYST: ______________

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Assoicates

Attention: Rob Sinclair

LAB REPORT NO: A4-2799
DATE: Oct. 24, 1994
DATE SUBMITTED: Oct. 5, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample TW #1 2 1/2 hrs.	Sample	Sample	Sample	Sample
Total Coliforms	cts/100mls		0				
Faecal Coliforms	cts/100mls		0				
Faecal Streptococci	cts/100mls		0				
E.Coli	cts/100mls		0				
Standard Plate Count (48hrs)	cts/1ml		10				

ND = Not Detected (<MDL) MDL = Method Detection Limit

COMMENT:

ANALYST: ____________________

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Attention: Kris Marentette

LAB REPORT NO: A4-2852
DATE: Oct. 17, 1994
DATE SUBMITTED: Oct. 11, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample Prevost Well Winchester	Sample	Sample	Sample	Sample
N-NO3	mg/L	0.01	5.40				

ND = Not Detected (<MDL)

MDL = Method Detection Limit

COMMENT:

ANALYST: ____________

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates
Attention: Kris Marentette

LAB REPORT NO: A4-2942
DATE: Nov. 9, 1994
DATE SUBMITTED: Oct. 19, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample TW 1	Sample 94-1	Sample 94-2	Sample 94-3	Sample 94-4
Fe	mg/L	0.01	0.10				
Mn	mg/L	0.01	0.02				
Hardness	mg/L CaCO3	1	236				
Alkalinity	mg/L CaCO3	1	187				
pH			7.95				
Conductivity	umhos/cm	3	466				
F	mg/L	0.10	nd				
Na	mg/L	1	4				
N-NO3	mg/L	0.10	0.25	nd	nd	nd	0.40
N-NO2	mg/L	0.1	nd				
N-NH3	mg/L	0.01	0.01				
SO4	mg/L	3	51				
Cl	mg/L	1	9				
Phenols	mg/L	0.002	0.008				
Turbidity	NTU	0.1	0.8				
Colour	Pt/Co units	2	nd				
Ca	mg/L	1	73				
Mg	mg/L	1	13				
Tannin & Lignin	mg/L	0.1	nd				
Total Kjeldahl Nitrogen	mg/L	0.01	0.11				
K	mg/L	1	2				
TOC	mg/L	0.2	0.6				
TDS	mg/L	1	290				
H2S	mg/L	0.01	nd				
Ion Balance			0.98				
Atrazine	mg/L	0.05	nd				

ND = Not Detected (<MDL) MDL = Method Detection Limit

COMMENT:

ANALYST: ____________

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Attention: Kris Marentette

LAB REPORT NO: A4-2942
DATE: Nov. 9, 1994
DATE SUBMITTED: Oct. 19, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample 94-5	Sample 94-6	Sample 94-7	Sample	Sample
Fe	mg/L	0.01					
Mn	mg/L	0.01					
Hardness	mg/L CaCO3	1					
Alkalinity	mg/L CaCO3	1					
pH							
Conductivity	umhos/cm	3					
F	mg/L	0.10					
Na	mg/L	1					
N-NO3	mg/L	0.10	nd	3.90	nd		
N-NO2	mg/L	0.1					
N-NH3	mg/L	0.01					
SO4	mg/L	3					
Cl	mg/L	1					
Phenols	mg/L	0.002					
Turbidity	NTU	0.1					
Colour	Pt/Co units	2					
Ca	mg/L	1					
Mg	mg/L	1					
Tannin & Lignin	mg/L	0.1					
Total Kjeldahl Nitrogen	mg/L	0.01					
K	mg/L	1					
TOC	mg/L	0.2					
TDS	mg/L	1					
H2S	mg/L	0.01					

ND = Not Detected (<MDL) MDL = Method Detection Limit

COMMENT:

ANALYST: ______

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Attention: Kris Marentette

LAB REPORT NO: A4-2942
DATE: Nov. 9, 1994
DATE SUBMITTED: Oct. 19, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample TW 1	Sample	Sample	Sample	Sample
Total Coliforms	cts/100mls		0				
Faecal Coliforms	cts/100mls		0				
Faecal Streptococci	cts/100mls		0				
E.Coli	cts/100mls		0				
Standard Plate Count (48hrs)	cts/1ml		<1				

ND = Not Detected (<MDL) MDL = Method Detection Limit

COMMENT:

ANALYST: ______________

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Attention: Kris Marentette

LAB REPORT NO: A4-3061
DATE: Nov. 10, 1994
DATE SUBMITTED: Oct. 27, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample TW 1	Sample 94-1	Sample 94-2	Sample 94-3	Sample 94-4
Fe	mg/L	0.01	0.04				
Mn	mg/L	0.01	0.05				
Hardness	mg/L CaCO3	1	227				
Alkalinity	mg/L CaCO3	1	182				
pH			8.20				
Conductivity	umhos/cm	3	472				
F	mg/L	0.10	nd				
Na	mg/L	1	4				
N-NO3	mg/L	0.10	0.17	nd	nd	nd	0.38
N-NO2	mg/L	0.1	nd				
N-NH3	mg/L	0.01	0.07				
SO4	mg/L	3	53				
Cl	mg/L	1	10				
Phenols	mg/L	0.002	nd				
Turbidity	NTU	0.1	0.8				
Colour	Pt/Co units	2	nd				
Ca	mg/L	1	66				
Mg	mg/L	1	15				
Tannin & Lignin	mg/L	0.1	nd				
Total Kjeldahl Nitrogen	mg/L	0.01	0.10				
K	mg/L	1	1				
TOC	mg/L	0.2	0.7				
TDS	mg/L	1	290				
H2S	mg/L	0.01	nd				
Ion Balance			0.94				

ND = Not Detected (<MDL)　　MDL = Method Detection Limit

COMMENT:

ANALYST: ____________

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client:	Golder Associates	LAB REPORT NO:	A4-3061
		DATE:	Nov. 10, 1994
	Attention: Kris Marentette	DATE SUBMITTED:	Oct. 27, 1994
		PROJECT:	941-2747
		SAMPLE MATRIX:	WATER

PARAMETER	UNITS	MDL	Sample 94-5	Sample 94-6	Sample 94-7	Sample	Sample
Fe	mg/L	0.01					
Mn	mg/L	0.01					
Hardness	mg/L CaCO3	1					
Alkalinity	mg/L CaCO3	1					
pH							
Conductivity	umhos/cm	3					
F	mg/L	0.10					
Na	mg/L	1					
N-NO3	mg/L	0.10	nd	7.60	0.27		
N-NO2	mg/L	0.1					
N-NH3	mg/L	0.01					
SO4	mg/L	3					
Cl	mg/L	1					
Phenols	mg/L	0.002					
Turbidity	NTU	0.1					
Colour	Pt/Co units	2					
Ca	mg/L	1					
Mg	mg/L	1					
Tannin & Lignin	mg/L	0.1					
Total Kjeldahl Nitrogen	mg/L	0.01					
K	mg/L	1					
TOC	mg/L	0.2					
TDS	mg/L	1					
H2S	mg/L	0.01					

ND = Not Detected (<MDL)   MDL = Method Detection Limit

COMMENT:

ANALYST: ____________

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client:	Golder Associates	LAB REPORT NO:	A4-3061
		DATE:	Nov. 10, 1994
	Attention: Kris Marentette	DATE SUBMITTED:	Oct. 27, 1994
		PROJECT:	941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample TW 1	Sample	Sample	Sample	Sample
Total Coliforms	cts/100mls		0				
Faecal Coliforms	cts/100mls		0				
Faecal Streptococci	cts/100mls		0				
E.Coli	cts/100mls		0				
Standard Plate Count (48hrs)	cts/1ml		1				

ND = Not Detected (<MDL)

MDL = Method Detection Limit

COMMENT:

ANALYST: ______________

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client:	Golder Associates	LAB REPORT NO:	A4-3086
		DATE:	Nov. 4, 1994
	Attention: Kris Marentette	DATE SUBMITTED:	Oct. 28, 1994
		PROJECT:	941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample TW #1	Sample	Sample	Sample	Sample
N-NO3	mg/L	0.1	nd				

ND = Not Detected (<MDL)

MDL = Method Detection Limit

COMMENT:

ANALYST: ____________________

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Attention: Kris Marentette

LAB REPORT NO: A4-3170
DATE: Dec. 1, 1994
DATE SUBMITTED: Nov. 4, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	MAC	Chemical/ Physical objectives			Sample TW #1 Nov 3/94
Fe	mg/L	0.01		0.30			0.03
Mn	mg/L	0.01		0.05			0.05
Hardness	mg/L CaCO3	1		80-100			234
Alkalinity	mg/L CaCO3	1		30-500			180
pH				6.5-8.5			8.12
Conductivity	umhos/cm	3					474
F	mg/L	0.01	1.5				nd
Na	mg/L	1		200			7
N-NO3	mg/L	0.1	10.0				0.16
N-NO2	mg/L	0.1	1.0				nd
N-NH3	mg/L	0.01					0.01
SO4	mg/L	3		500			63
Cl	mg/L	1		250			10
Phenols	mg/L	0.002					nd
Turbidity	NTU	0.1	1.0				0.3
Colour	Pt/Co units	2		5			nd
Ca	mg/L	1					74
Mg	mg/L	1					12
Tannin & Lignin	mg/L	0.1					nd
Total Kjeldahl Nitrogen	mg/L	0.01					0.07
K	mg/L	1					nd
DOC	mg/L	0.2		5.0			0.8
TDS	mg/L	1		500			240
H2S	mg/L	0.01		0.05			nd
Organic Nitrogen	mg/L	0.01		0.15			0.06
Ion Balance							0.96

ND = Not Detected (<MDL)

COMMENT:

MDL = Method Detection Limit
MAC = Maximum Acceptable Concentration
IMAC= Interim Maximum Acceptable Concentration
AO = Aesthetic Objectives
Pg/L = picograms/litre Toxic Equivalents

ANALYST:

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Attention: Kris Marentette

LAB REPORT NO: A4-3170
DATE: Dec. 1, 1994
DATE SUBMITTED: Nov. 4, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	MAC	IMAC	Chemical/ Physical Objectives		Sample TW #1 Nov 3/94
Al	mg/L	0.03			0.1		nd
As	mg/L	0.01		0.025			nd
Ba	mg/L	0.01	1.0				0.36
B	mg/L	0.01		5.0			0.04
Cd	mg/L	0.002	0.005				nd
CN-	mg/L	0.01	0.2				nd
Cr	mg/L	0.01	0.05				nd
Cu	mg/L	0.01			1.0		nd
Hg	mg/L	0.001	0.001				nd
Pb	mg/L	0.002	0.01				nd
Se	mg/L	0.01	0.01				nd
U	mg/L	0.01	0.1				nd
Zn	mg/L	0.01			5.0		nd
Radionuclides							
Cs 137	Bq/L	1	50				nd
I 131	Bq/L	1	10				nd
Ra 226	Bq/L	0.1	1				0.1
Sr 90	Bq/L	1	10				nd
Tritium	Bq/L	1000	40000				nd

ND = Not Detected (<MDL)

COMMENT:

MDL = Method Detection Limit
MAC = Maximum Acceptable Concentration
IMAC= Interim Maximum Acceptable Concentration
AO = Aesthetic Objectives
Pg/L = picograms/litre Toxic Equivalents

ANALYST: [signature]

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Attention: Kris Marentette

LAB REPORT NO: A4-3170
DATE: Dec. 1, 1994
DATE SUBMITTED: Nov. 4, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	MAC	IMAC	AO		Sample TW #1 Nov 3/94
Total Coliforms	cts/100mls		5				0
Faecal Coliforms	cts/100mls		0				0
Faecal Streptococci	cts/100mls						0
E.Coli	cts/100mls		0				0
Aerobic Plate Count	cts/1ml				500		1

ND = Not Detected (<MDL)

MDL = Method Detection Limit
MAC = Maximum Acceptable Concentration
IMAC= Interim Maximum Acceptable Concentration
AO = Aesthetic Objectives
Pg/L = picograms/litre Toxic Equivalents

COMMENT:

ANALYST: [signature]

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Attention: Kris Marentette

LAB REPORT NO: A4−3170
DATE: Dec. 1, 1994
DATE SUBMITTED: Nov. 4, 1994
PROJECT: 941−2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	MAC	IMAC	AO		Sample
							TW #1 Nov 3/94
Alachlor	mg/L	0.005		0.005			nd
Aldicarb	mg/L	0.0025	0.009				nd
Aldrin & Dieldrin	mg/L	0.000025	0.0007				nd
Atrazine	mg/L	0.005		0.005			nd
Azinphos−methyl	mg/L	0.02	0.02				nd
Bendiocarb	mg/L	0.02	0.04				nd
Benzene	mg/L	0.0005	0.005				nd
Benzo(a)pyrene	mg/L	0.00001	0.00001				nd
Bromoxynil	mg/L	0.0005		0.005			nd
Carbaryl	mg/L	0.02	0.09				nd
Carbofuran	mg/L	0.02	0.09				nd
Carbon Tetrachloride	mg/L	0.0003	0.005				nd
Chlordane	mg/L	0.007	0.007				nd
Chlorpyrifos	mg/L	0.000025	0.09				nd
Cyanazine	mg/L	0.01		0.01			nd
Diazinon	mg/L	0.01	0.02				nd
Dicamba	mg/L	0.02	0.12				nd
1,2−Dichlorobenzene	mg/L	0.0004	0.2		0.003		nd
1,4−Dichlorobenzene	mg/L	0.0004	0.005		0.001		nd
DDT	mg/L	0.01	0.03				nd
1,2−Dichloroethane	mg/L	0.0007		0.005			nd
Dichloromethane	mg/L	0.004	0.05				nd
2,4−Dichlorophenol	mg/L	0.01	0.9		0.0003		nd
2,4−D	mg/L	0.02		0.1			nd
Diclofop−methyl	mg/L	0.009	0.009				nd
Dimethoate	mg/L	0.005		0.02			nd
Dioseb	mg/L	0.01	0.01				nd
Vinyl Chloride	ug/L	2	2				nd

ND = Not Detected (<MDL)

COMMENT:

MDL = Method Detection Limit
MAC = Maximum Acceptable Concentration
IMAC= Interim Maximum Acceptable Concentration
AO = Aesthetic Objectives
Pg/L = picograms/litre Toxic Equivalents

ANALYST:

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727−5692 Fax:(613)727−5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Attention: Kris Marentette

LAB REPORT NO: A4–3170
DATE: Dec. 1, 1994
DATE SUBMITTED: Nov. 4, 1994
PROJECT: 941–2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	MAC	IMAC	AO		Sample TW #1 Nov 3/94
Dioxins & Furans	Pg/L	15		15			nd
Diquat	mg/L	0.005	0.07				nd
Diuron	mg/L	0.001	0.15				nd
Ethylbenzene	mg/L	0.0005			0.0024		nd
Glyphosate	mg/L	0.1		0.28			nd
Heptachlor + Heptachlor Epoxide	mg/L	0.003	0.003				nd
Lindane	mg/L	0.004	0.004				nd
Malathion	mg/L	0.005	0.19				nd
Methoxychlor	mg/L	0.02	0.9				nd
Metolachlor	mg/L	0.005		0.05			nd
Metribuzin	mg/L	0.005	0.08				nd
Monochlorobenzene	mg/L	0.0002	0.08		0.03		nd
Nitrilotriacetic Acid	mg/L	0.05	0.4				nd
NDMA	mg/L	0.000005		0.000009			nd
Paraquat	mg/L	0.005		0.01			nd
Parathion	mg/L	0.01	0.05				nd
Pentachlorophenol	mg/L	0.01	0.06		0.03		nd
Phorate	mg/L	0.002		0.002			nd
Picloram	mg/L	0.02		0.19			nd
PCB's	mg/L	0.00005		0.003			nd
Prometryne	mg/L	0.001		0.001			nd
Simazine	mg/L	0.005		0.01			nd
Temephos	mg/L	0.0025		0.28			nd
Terbufos	mg/L	0.001		0.001			nd
2,3,4,6–Tetrachlorophenol	mg/L	0.01	0.1		0.001		nd
Toluene	mg/L	0.0005			0.024		nd

ND = Not Detected (<MDL)

COMMENT:

MDL = Method Detection Limit
MAC = Maximum Acceptable Concentration
IMAC= Interim Maximum Acceptable Concentration
AO = Aesthetic Objectives
Pg/L = picograms/litre Toxic Equivalents

ANALYST: 2gl

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727–5692 Fax:(613)727–5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Attention: Kris Marentette

LAB REPORT NO: A4-3170
DATE: Dec. 1, 1994
DATE SUBMITTED: Nov. 4, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	MAC	IMAC	AO		Sample TW #1 Nov 3/94
Triallate	mg/L	0.01	0.23				nd
Trichloroethylene	mg/L	0.0003	0.05				nd
2,4,6-Trichlorophenol	mg/L	0.002	0.005		0.002		nd
2,4,5 TP	mg/L	0.01	0.28		0.02		nd
Trifluralin	mg/L	0.005		0.045			nd
Trihalomethanes	mg/L	0.01	0.35				nd
m/p Xylene	mg/L	0.001			0.3		nd
o Xylene	mg/L	0.0005			0.3		nd
Methane	L/m^3	0.005			3		nd

ND = Not Detected (<MDL)

COMMENT:

MDL = Method Detection Limit
MAC = Maximum Acceptable Concentration
IMAC= Interim Maximum Acceptable Concentration
AO = Aesthetic Objectives
Pg/L = picograms/litre Toxic Equivalents

ANALYST: [signature]

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSIS

Client: Golder Associates Ltd.

Lab Report No: A4-3170
Date: Nov 15,1994
Date Submitted: Nov 04,1994
Project: 941-2747

Sample Matrix: water

PARAMETER	UNITS	MDL	Sample TW#1 Nov 3/94	Sample	Sample	Sample	Sample
Benzene	ug/L	0.5	ND				
Bromodichloromethane	ug/L	0.3	ND				
Bromoform	ug/L	0.4	ND				
Bromomethane	ug/L	0.5	ND				
Carbon Tetrachloride	ug/L	0.9	ND				
Chlorobenzene	ug/L	0.2	ND				
Chloroethane	ug/L	1.0	ND				
Chloroform	ug/L	0.5	ND				
Chloromethane	ug/L	1.0	ND				
Dibromochloromethane	ug/L	0.3	ND				
1,2-Dibromoethane	ug/L	1.0	ND				
m-Dichlorobenzene	ug/L	0.4	ND				
o-Dichlorobenzene	ug/L	0.4	ND				
p-Dichlorobenzene	ug/L	0.4	ND				
1,1-Dichloroethane	ug/L	0.4	ND				
1,2-Dichloroethane	ug/L	0.7	ND				
1,1-Dichloroethylene	ug/L	0.5	ND				
c-1,2-Dichloroethylene	ug/L	0.4	ND				
t-1,2-Dichloroethylene	ug/L	0.4	ND				
1,2-Dichloropropane	ug/L	0.7	ND				
c-1,3-Dichloropropylene	ug/L	0.2	ND				
t-1,3-Dichloropropylene	ug/L	0.2	ND				
Ethylbenzene	ug/L	0.5	ND				
Methylene Chloride	ug/L	4.0	ND				
Styrene	ug/L	0.5	ND				

ND = Not Detected (< MDL)   MDL = Method Detection Limit

Comment:

ANALYST: [signature]

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSIS

Client: Golder Associates Ltd.

Lab Report No: A4-3170
Date: Nov 15,1994
Date Submitted: Nov 04,1994
Project: 941-2747

Sample Matrix: water

PARAMETER	UNITS	MDL	Sample TW#1 Nov 3/94	Sample	Sample	Sample	Sample
1,1,2,2-Tetrachloroethane	ug/L	0.6	ND				
Tetrachlorethylene	ug/L	0.3	ND				
Toluene	ug/L	0.5	ND				
1,1,1-Trichloroethane	ug/L	0.4	ND				
1,1,2-Trichloroethane	ug/L	0.4	ND				
Trichloroethylene	ug/L	0.3	ND				
Trichlorofluoromethane	ug/L	0.5	ND				
1,3,5-Trimethylbenzene	ug/L	0.3	ND				
Vinyl Chloride	ug/L	2.0	ND				
m/p-Xylene	ug/L	0.5	ND				
o-Xylene	ug/L	0.5	ND				
1,2-Dichloroethane-d4	% Recovery	1	99				
Toluene-d8	% Recovery	1	95				
4-Bromofluorobenzene	% Recovery	1	96				

ND = Not Detected (< MDL)   MDL = Method Detection Limit

Comment:

ANALYST: [signature]

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Attention: Kris Marentette

LAB REPORT NO: A4-3169
DATE: Nov. 8, 1994
DATE SUBMITTED: Nov. 4, 1994
PROJECT: 941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample 94-1	Sample 94-2	Sample 94-3	Sample 94-4	Sample 94-5
N-NO3	mg/L	0.1	nd	nd	nd	0.32	nd

ND = Not Detected (<MDL) MDL = Method Detection Limit

COMMENT:

ANALYST:

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client:	Golder Associates	LAB REPORT NO:	A4-3169
		DATE:	Nov. 8, 1994
	Attention: Kris Marentette	DATE SUBMITTED:	Nov. 4, 1994
		PROJECT:	941-2747

SAMPLE MATRIX: WATER

PARAMETER	UNITS	MDL	Sample 94-6	Sample 94-7	Sample	Sample	Sample
N-NO3	mg/L	0.1	9.00	0.27			

ND = Not Detected (<MDL) MDL = Method Detection Limit

COMMENT:

ANALYST: [signature]

APPENDIX I

PERMIT TO TAKE WATER

Ontario

1-613/549-4000 1-800/267-0974 Fax: 613/548-6908

Ministry of Environment and Energy
Ministère de l'Environnement et de l'Énergie

133 Dalton Avenue
P O Box 820
Kingston ON K7L 4X6

133 avenue Dalton
C.P. 820
Kingston ON K7L 4X6

GOLDER ASSOCIATES
JUL 25 1994

21 July 1994

Golder Associates Ltd.
1796 Courtwood Crescent
OTTAWA, Ontario
K2C 2B5

Attention: K.A. Marentette, Hydrogeologist

Dear Sir or Madam:

Re: Approval to Take Water Under Section 34 of the Ontario Water Resources Act as Requested by the Letter dated July 14, 1994 to Ms. P. Sutcliffe, Ontario Ministry of Environment and Energy from K.A. Marentette, Golder Associates Ltd.

Purpose :	Pumping Test, Village of Winchester, Water Supply Study
Applicant:	Village of Winchester
Property Owner:	Provost Cartage
Location :	A Borrow Pit on Lot 15, Concession 9, Township of Winchester
No. Wells:	One
Test date:	July - December 1994
Max. Rate:	1,000 Imperial Gallons per Minute
Duration :	30 days

This letter constitutes approval to take water under Section 34 of the Ontario Water Resources Act. Pursuant to Section 101 of the Ontario Water Resources Act, you are hereby notified that this approval is subject to the following conditions:

1) The pumping rate and period of pumping must not result in the exceedence of the total water withdrawal requested without the further written approval of the Director under the Ontario Water Resources Act (hereafter referred to as "the Director").

2) All supply wells within 300 metres of the test well(s) shall be located and monitored for water quality and static water levels prior to test pumping. Water level drawdown during pumping and recovery after pumping shall also be monitored. Water level monitoring during the pumping test must follow standard pumping test protocols.

   The well owners must be contacted and written permission obtained to access their well at least 10 days prior to the test pumping. If the owner agrees, water level and quality sampling shall be carried out. The accessibility of the well remains the responsibility of the owner. If the owner does not agree to the testing, the owner's refusal must be recorded by the Applicant.

3) All well supply water and surface discharge problems associated with the testing must be reported to the Director expeditiously.

4) If the taking of water is forecast to interfere seriously, or is observed to interfere seriously with other water supplies obtained from any adequate sources that were in use prior to initial issuance of the approval for this water taking, the Applicant shall take such action as will make available to those affected a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of so doing, or shall reduce the rate and amount of taking so as to prevent the forecast interference or alleviate the observed interference. Pending permanent restoration of the affected supplies, the Applicant shall provide, to those affected, temporary water supplies adequate to meet their normal requirements, or shall compensate such persons for their reasonable costs of doing so. A contingency plan for alternate water supplies shall be developed prior to commencing the pumping test.

5) A written report of the pumping test must be submitted to the Director, within 60 days of completion of the testing.

6) When the water taken is discharged to a watercourse, the quality and temperature of the groundwater shall be substantially the same as the receiving stream to ensure that the stream's water quality and flora and fauna are not adversely affected by the discharge. If the rate of discharge is substantial, energy absorbing padding shall be used to prevent erosion. The rate of discharge shall be controlled to prevent downstream flooding and property damage.

7) The Director must be advised in writing of any intent to abandon the test well(s) as approved under this letter of approval.

8) If the test well(s) is abandoned or not used for any extended period of time, it shall be properly sealed to prevent any groundwater contamination.

9) This Approval shall be kept available for inspection at all times during the testing.

The testing shall be carried out under these general conditions. The reason for the imposition of these conditions is to ensure that the water quality and quantity of all surface water, groundwater and water supplies in the area of the testing are protected.

This approval is for the temporary taking only (30 days). If the well(s) is put into service for an extended period of time, a Permit to Take Water will be required if the taking is in excess of 50,000 litres per day.

This approval does not release you from any legal liability or obligation and remains in force subject to all limitations, requirements and liabilities imposed by law. It shall not be construed as estopping or limiting any legal claims or rights of action that any person, including the Crown in Right of Ontario or any agency thereof, has or may have against you, your officers, employees, agents and your contractors.

You may, by written notice served upon me and the Environmental Appeal Board within 15 days after receipt of this approval, require a hearing by the Board. Section 101 of the Ontario Water Resources Act, R.S.O. 1990, C. O.40, as amended, provides that the Notice requiring the hearing shall state:

1) The portion of each Term or Condition in the approval in respect of which the hearing is required, and;

2) The grounds on which you intend to rely at the hearing in relation to each portion appealed.

In addition to these statutory requirements, the Notice should include:

3) The name of the appellant;
4) The address of the appellant;
5) The date of the Approval;
6) The name of the Director;
7) The municipality within which the taking is located;

and the Notice should be signed and dated by the appellant.

This Notice should be served upon:

The Secretary
Environmental Appeal Board
112 St. Clair Ave. West
5th Floor
Toronto, Ontario
M4V 1N3

The Director
Section 34, O.W.R.A.
Ministry of Environment and Energy
133 Dalton Avenue, Box 820
Kingston, Ontario
K7L 4X6

If you have any questions concerning the approval or wish to request an amendment or an extension please contact Penny Sutcliffe at this office.

Yours truly,

G. Carpentier, Director
Section 34, R.S.O. 1990
Ontario Water Resources Act
Ministry of Environment and Energy
PLS/ds

APPENDIX J

PRECIPITATION DATA

APPENDIX J

PRECIPITATION DATA

Measurement Date	Precipitation Measurement (millimetres)
Oct. 5/94	0
Oct. 6/94	0
Oct. 7/94	0
Oct. 8/94	0
Oct. 9/94	4.0
Oct. 10/94	0
Oct. 11/94	0
Oct. 13/94	0
Oct. 16/94	0
Oct. 18/94	1.2
Oct.23/94	7.2
Oct. 26/94	1.6
Oct. 28/94	0
Oct. 31/94	0.6
Nov. 3/94	55.2
Nov. 4/94	2.6
Nov. 5/94	5.6
Nov. 6/94	5.5
Nov. 7/94	1.0
Nov. 11/94	0
Nov. 16/94	Frozen - Rain Gauge Dismantled

APRENDIX K

GROUNDWATER QUALITY DATA

D. ST. PIERRE PROPERTY

MONITORING WELLS

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Larry Luba

LAB REPORT NO: A2-2643
DATE: Dec. 7,1992
DATE SUBMITTED: Nov. 13,1992
PROJECT: 921-2760A

SAMPLE MATRIX:

PARAMETER	UNITS	MDL	Sample 92-10	Sample 92-11	Sample	Sample	Sample
Pesticides							
Aldrin & Dieldrin	mg/L	0.0007	nd	nd			
Carbaryl	mg/L	0.07	nd	nd			
Chlordane	mg/L	0.007	nd	nd			
DDT	mg/L	0.03	nd	nd			
Diazinon	mg/L	0.014	nd	nd			
Endrin	mg/L	0.0002	nd	nd			
Heptachlor + Heptachlor Epoxide	mg/L	0.003	nd	nd			
Lindane	mg/L	0.004	nd	nd			
Methoxychlor	mg/L	0.1	nd	nd			
Methyl Parathion	mg/L	0.007	nd	nd			
Parathion	mg/L	0.035	nd	nd			
Toxaphene	mg/L	0.005	nd	nd			
2,4-D	mg/L	0.1	nd	nd			
2,4,5-TP	mg/L	0.01	nd	nd			
Atrazine	mg/L	0.005	nd	nd			
Simazine	mg/L	0.005	nd	nd			

ND = Not Detected (<MDL) MDL = Method Detection Limit

COMMENT:

ANALYST: ____________

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Larry Luba

LAB REPORT NO: A2-2643
DATE: Dec. 7,1992
DATE SUBMITTED: Nov. 13,1992
PROJECT: 921-2760A

SAMPLE MATRIX:

PARAMETER	UNITS	MDL	Sample 92-6	Sample 92-8A	Sample 92-10	Sample 92-11	Sample 92-12
Fe	mg/L	0.01					
Mn	mg/L	0.01					
Hardness	mg/L CaCO3	1					
Alkalinity	mg/L CaCO3	1					
pH							
Conductivity	umhos/cm	3					
F	mg/L	0.01					
Na	mg/L	1					
N-NO3	mg/L	0.1	0.11	nd	nd	nd	6.88
N-NO2	mg/L	0.1	nd	nd	nd	nd	nd
N-NH3	mg/L	0.1	nd	nd	nd	nd	nd
SO4	mg/L	3					
Cl	mg/L	1					
Phenols	mg/L	0.002					
Turbidity	NTU	0.1					
Colour	Pt/Co units	2					
Ca	mg/L	1					
Mg	mg/L	1					
Tannin & Lignin	mg/L	0.1					
Total Kjeldahl Nitrogen	mg/L	0.1	nd	nd	nd	nd	nd
K	mg/L	1					
TOC	mg/L	0.2					
TDS	mg/L	1					
H2S	mg/L	0.01					

ND = Not Detected (<MDL) MDL = Method Detection Limit

COMMENT:

ANALYST: [signature]

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSES

Client: Golder Associates

Larry Luba

LAB REPORT NO: A2-2643
DATE: Dec. 7,1992
DATE SUBMITTED: Nov. 13,1992
PROJECT: 921-2760A

SAMPLE MATRIX:

PARAMETER	UNITS	MDL	Sample 92-13	Sample	Sample	Sample	Sample
Fe	mg/L	0.01					
Mn	mg/L	0.01					
Hardness	mg/L CaCO3	1					
Alkalinity	mg/L CaCO3	1					
pH							
Conductivity	umhos/cm	3					
F	mg/L	0.01					
Na	mg/L	1					
N-NO3	mg/L	0.1	nd				
N-NO2	mg/L	0.1	nd				
N-NH3	mg/L	0.1	nd				
SO4	mg/L	3					
Cl	mg/L	1					
Phenols	mg/L	0.002					
Turbidity	NTU	0.1					
Colour	Pt/Co units	2					
Ca	mg/L	1					
Mg	mg/L	1					
Tannin & Lignin	mg/L	0.1					
Total Kjeldahl Nitrogen	mg/L	0.1	nd				
K	mg/L	1					
TOC	mg/L	0.2					
TDS	mg/L	1					
H2S	mg/L	0.01					

ND = Not Detected (<MDL)　　MDL = Method Detection Limit

COMMENT:

ANALYST: ____________

146 Colonnade Road, Unit 8, Nepean, Ontario K2E 7Y1 Tel:(613)727-5692 Fax:(613)727-5222