Golder Associates Ltd.

32 \$teacie Drive Kanata, Ontario, Canada K2K 2A9 Telephone 613-592-9600 Fax 613-592-9601



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MINISTRY OF THE ENVIRONMENT . ENVIRONMENTÁL ÁSSESSMENT & APPROVALS BRANCH

GROUNDWATER MONITORING REFORT ENVIRONMENTAL MONITORING PROGRAM OCTOBER 2003 TO MARCH 2008

FINDLAY CREEK VILLAGE

OTTAWA, ONTARIO

MINISTRY OF THE ENVIRONMENT

JUL 1 4 2008

KINGSTON - - ONTARIO REGIONAL OFFICE

Submitted to:

Leitrim Monitoring Technical Advisory Committee c/o City of Ottawa 110 Laurier Avenue West, 4th floor Ottawa, Ontario K1P JJ1

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1.0 INTRODUCTION

The Findlay Creek development is located on a parcel of land between Highway 31 (Bank Street) and Albion Road, and extends approximately 2 kilometres south from Leitrim Road in Ottawa, Ontario (Figure 1). The site slopes gently towards the east, with major features including the Leitrim Wetland to the west and southwest of the existing and future development area and Findlay Creek to the south, flowing in an easterly direction. Surrounding land uses are predominantly rural in nature, and include both residential and commercial buildings. The first and second Stages of the Findlay Creek development are under construction in the northeast and central portions of the site. The general land uses and features of the site are shown on Figure 2.

The southwest quadrant of the development area is occupied by a natural wetland. The Environmental Management Plan (EMP) (Cumming Cockburn Ltd. and Golder Associates Ltd., 2003) and updated EMP (IBI Group and Golder Associates Ltd., 2005) for this project defined monitoring programs during the construction phase and for a period post-construction to ensure that the development does not significantly affect the groundwater levels and associated natural biological ecosystem in the area that has been designated as the core wetland.

Golder Associates Ltd. (Golder Associates) has carried out several previous subsurface geotechnical and hydrogeologic investigations on this site. A geotechnical investigation was carried out in 1994 for the pre-design of the stormwater management facility. The results of that investigation along with guidelines on the pre-design were provided in a report titled "Hydrogeological and Geotechnical Considerations, Pre-Design of Stormwater Management Works, Leitrim Development Area, Gloucester, Ontario," dated August 1994 (report number 931-2360).

Golder Associates carried out further investigation as part of a groundwater and surface water monitoring program. The results of that investigation, as well as the results of the monitoring, were provided in a combined Golder Associates and Cumming-Cockburn report titled "Baseline Monitoring Program, Groundwater and Surface Water Regimes, Leitrim Development Area, City of Gloucester, Ontario," dated May 1999 (report number 971-2925/3029-MU-01).

In addition to these investigations, a number of earlier investigations have been carried out across this site. More recent investigations have also been carried out for final design of portions of the development area, both for site servicing and structure foundations.

2.0 SITE DESCRIPTION

2.1 Site Geology

Geological conditions in the area of the site are known from the results of site-specific subsurface investigation, as well as published information and the MOE water well records. In the western and central portions of the Findlay Creek Village land there is a significant thickness of fine-grained overburden (silt, sandy silt) overlying glacial till. In the southwest portion of the site (within the core wetland) there is a layer of peat/organic soil overlying the fine-grained soils. The silty and glacial till soils are relatively low to moderate permeability soils. The thickness of overburden decreases towards the east as the elevation of both the surfaces of the glacial till and underlying dolomitic bedrock rise to shallower depth. The upper bedrock is typically highly fractured. In the southeast part of the site adjacent to Bank Street, the bedrock is within about 2-4 metres of ground surface. The northern and castern portions of the site are also underlain by surficial sandy/silty soils over glacial till.

Bedrock underlying the Leitrim residential development area has been shown through investigation to consist of dolomite of the Oxford Formation.

2.2 Groundwater Flow

Groundwater is transmitted under natural conditions or under the influence of pumping wells, primarily through permeable layers of surficial deposits and through networks of fractures in bedrock (bedding planes, and joints).

In the overburden, groundwater flows onto the Leitrim Village lands from a sand and gravel ridge to the southwest, and from the topographically higher lands to the north towards Findlay Creek in the southeast. Groundwater flow across the Leitrim lands is generally eastward in the overburden. Regional groundwater flow in the bedrock is known from previous studies to also be eastward. The interpolated groundwater level contours and flow direction in the overburden from August 24, 1998 are illustrated in Figure 3; this is reproduced from the Baseline Monitoring Program, with the approximate limit of the core wetland and wetland berm added for reference purposes.

2.3 Site Construction

Construction of trunk servicing and residential site servicing has taken place at the Findlay Creek development over several periods. The construction of deeper sections of trunk servicing and residential site servicing has involved the excavation of a trench through overburden, with some excavation into the upper portion of the underlying bedrock. The sewer excavations have extended below the groundwater table, with certain areas of the excavation extending into the upper few metres of bedrock. Due to the highly permeable and fractured nature of the upper

bedrock, temporary groundwater control by pumping along the alignment has been required to complete the construction. The periods of groundwater control in bedrock and the allowable pumping rates as per associated Permit To Take Water are summarized in the following table.

Trench Section	Period of Groundwater Control	Permit No.	Maximum Allowable Pumping Rate
Findlay Creek Drive (Bank Street to Long Point Circle)	January 2003 – May 2003	03-P-4001	6,456,240 L/day
Findlay Creek Drive (Long Point Circle to Kelly Farm Drive)	January 2004 – April 2004	04-P-4004	10,476,984 L/day
Kelly Farm Drive (Findlay Creek Drive to north end)	January 2005 – May 2005	5246- 66JMCD	13,747,380 L/day
Findlay Creek Drive west of Kelly Farm Drive and Deep trunk storm sewer to SWMP	September 2005 – November 2006	3860- 6G9PVQ	51,580,800 L/day

The approximate extent of the four trench sections described in the above table are shown in Figure 2. Available pumping rates for the trunk storm sewer construction on both the east and the west sides of Bank Street from September 7, 2005 to August 8, 2006 are shown on Figure 14 and were typically on the order of 1,000,000 L/day with peaks for several days up to 10,000,000 L/day and 18,000,000 L/day in July 2006. Note that the peak pumping rates during this period are only about one-third of the allowable pumping rate. This is fairly typical of actual construction pumping requirements compared to the maximum allowable pumping rate and total duration of pumping. A conservatively high maximum pumping rate is requested to try to ensure that the trench can be initially pumped hard enough to get the water levels down quickly; a lower pumping rate is then needed to maintain the lowered water level to complete the construction.

A berm was built around the northern and eastern sides of the wetland area in the first part of 2004 to separate the wetland regime from the development drainage and to enable baseline surface water flow data to be collected for the design of the Findlay Creek Extension and habitat compensation measures.

Groundwater pumped from the excavations was discharged in one of three manners: to a settling pond, then to Findlay Creek (prior to October 2006); to the storm sewer system and Stormwater Management Pond (SMWP) (following its completion in October 2006); or to a settling pond, then into the wetland fringe (in early 2006) to encourage recharge in the wetland fringe as required. As the construction of the trunk storm sewer proceeded westwards in late 2005 and 2006, the depth to bedrock increased, thereby decreasing the depth of the sewer installation and amount of groundwater pumping required from the trenches. Although the depths of the trenches varied, most of the water entering the trenches came from the upper 1 to 2 metre fractured

bedrock zone. Groundwater control requirements in trenches completed in the overburden were much smaller and not at a rate requiring a Permit To Take Water.

In addition to the above groundwater control by pumping, the construction of the portion of the Findlay Creek Extension, a 1 to 1.5 metre deep ditch, along the northwest boundary of the designated wetland area in September to October 2007 encountered surface water flowing northwards out of the wetland towards Findlay Creek. The surface water reaching the work area was intercepted and pumped to sedimentation ponds and then returned to Findlay Creek.

2.4 Background Information and Historical Groundwater Levels

Historical reports (Golder 1990, Golder 1999) contain manual groundwater levels measured at various monitors from 1990 to 1998, which are presented in Table 1. Baseline groundwater levels were measured at monitors BH97-2a and BH97-2b during February/April to November of 1998 and at monitors BH90-2 and BH90-3 during 1998. Monitors BH90-2 and BH97-2 are located along the northern and eastern edge of the wetland, respectively, and monitor BH90-3 is located approximately 500 m south of BH90-2 deep within the wetland (Figure 3). The groundwater elevations from 1998 (Table 1) are presented in Figure 4.

Groundwater monitors at BH90-2 and BH-90-3 consist of overburden wells, while in BH97-2 there is an overburden monitor and bedrock monitor installed. An overburden well is a shallower well constructed in the soil, while a bedrock well is a deeper well constructed within the bedrock. Fractures within the bedrock aquifer may or may not be well connected, since it depends on how well the fracture zones are connected. The screened interval, or portion of the well into which groundwater enters, in a bedrock well will be deeper than the screened interval in an overburden well. Overburden and bedrock wells may exist at the same location either as multilayer wells in the same borehole or in separate but nearby boreholes. These types of monitoring well installations are illustrated on the Record of Boreholes in Appendix A.

The water level in a monitoring well represents the hydraulic head at the centre of the screened interval. Two wells at the same location or at nearby locations which are screened at different depths may have different water levels (i.e., the hydraulic head at the centre of the screened interval is different). Groundwater flow is 3-dimentional and occurs in the direction of decreasing hydraulic head. If a bedrock and an overburden well at the same location or at a nearby location have different water levels, the groundwater flow direction at that location also has a vertical component. If the water level (hydraulic head) in the bedrock well is higher than the water level in the overburden well, the groundwater at that location is moving vertically upwards (or discharging), as well as horizontally. If the bedrock water level is lower than the overburden water level, the groundwater at that location is moving downwards (recharging), as well as horizontally.

The 1998 monitoring indicates that the groundwater levels were fairly consistent and typically near surface at all three monitors within the wetland. The groundwater level varies typically less than 0.3 m at BH90-2 and BH90-3 and up to 1 m at BH97-2. The higher variability at BH97-2 may be a result of this monitor being close to a ditch where the water level could be quite variable, depending on both precipitation and beaver dam activity. The difference between the groundwater level in the overburden and bedrock at BH97-2 was consistent over the monitoring period in 1998, which is likely indicative of a hydraulic connection between the overburden and bedrock. At BH97-2, the groundwater level in bedrock was consistently 0.1 to 0.2 m above the groundwater level in the overburden, indicating an upward vertical hydraulic gradient. Artesian conditions (groundwater level above ground surface) were observed at this location from late February to mid-May 1998.

3.0 GROUNDWATER MONITORING RATIONALE

As discussed in Section 2.3, temporary groundwater control has been required to complete portions of the construction of trunk sewer and site servicing installations. Temporary groundwater control was also required for the construction of the SWMP. Future trunk sewer and site servicing installations on some parts of the site will also necessitate groundwater control to allow the installation of site servicing. As well, as a part of fish habitat compensation at the site, a section of Findlay Creek will be realigned by construction of a new water course (the Findlay Creek Extension) to pass just along the north edge of the core wetland. As described in the updated EMP, the predicted potential effects from construction and operation of the above works included:

- Groundwater movement to the Findlay Creek Extension resulting in a lowering of groundwater elevations along the northern fringe area of the core wetland;
- A potential lowering of surface water levels in the wetland; and,
- Potential biological impacts to the core wetland in terms of its structure and ability to maintain current wetland habitat and function. Specifically, the most sensitive features identified in the core of the wetland are considered to be a fen, located in the eastern part of the wetland (Figure 2).

Potential biological impacts to the core wetland and fen were not expected to manifest during relatively brief construction periods. The potential migration of groundwater to the proposed Findlay Creek Extension is the most immediate potential effect that in turn could potentially result in the other effects listed above. The potential mechanisms by which site construction could affect groundwater levels are identified below.

The SWMP is located in the area northeast of the intersection of Blais Road and Bank Street, more than 800 metres from the Leitrim Wetland. The construction of the pond was anticipated to require temporary groundwater control from the upper bedrock zone for temporary pressure relief for the duration of construction. Because of the separation distance, it was not expected that this temporary groundwater control would affect groundwater levels below the core wetland area.

Temporary groundwater control by pumping from the overburden was anticipated to be required to construct the Findlay Creek Extension. In the silty soils, however, the amount and duration of pumping required was expected to be small. As noted previously, interception and pumping of surface water was required during September to October 2007 to construct the north central portion of the Extension. It was predicted that the post-construction operation of the Extension would have little effect on groundwater levels in the overburden (drawdown cone extending less than 20 metres from the creek alignment), and because of the shallow nature of the Extension relative to the overburden thickness and type, no effect on groundwater in the bedrock.

Future site servicing installations will require temporary groundwater control that may cause temporary groundwater level lowering in the bedrock beneath the wetland. Due to the short duration of construction periods, biological impacts to the core wetland are not anticipated.

In order to prevent the predicted potential effects listed above, a groundwater monitoring program, a trigger mechanism and a contingency plan were developed and submitted as a part of the original EMP and updated EMP. By means of regular review of the groundwater monitoring program results, implementation of the contingency plan was considered to prevent impacts to the core wetland.

The groundwater monitoring program included the installation of groundwater monitors at key locations within the core wetland area and adjacent to the Findlay Creek Extension. Overburden monitors were installed near the Findlay Creek Extension, while both overburden and bedrock monitors were installed in the east end portion of the wetland. Pressure transducers and dataloggers were installed to provide a continuous record of water levels in the monitoring wells. Monitoring results were reviewed on an approximate monthly basis to assess potential water level lowering in the bedrock, serving as an indicator for the potential for underdrainage of the overburden soils.

Fens are sensitive to water level changes as these types of wetlands are groundwater-dependent and rely on relatively stable conditions. There is no set "limit" to the amount of water level change that fen vegetation can withstand. Despite the uncertainty involved with predicting or preventing community change, one way to minimize the possibility of negative effects is to monitor wetland water levels and implement mitigation measures if levels fall below established trigger levels. The trigger mechanism included the development of groundwater trigger levels from seasonally low levels recorded during baseline groundwater level monitoring ("baseline" monitoring hereafter refers to monitoring in 1998), pre-berm groundwater level monitoring ("pre-berm" monitoring hereafter refers to monitoring in September to December 2003) and monitoring from May to December 2004, which corresponds to a period with no groundwater control. If a groundwater trigger was reached, precipitation conditions were compared with historical measurements to determine whether the trigger was due to low precipitation conditions or was a result of the works. If the measured overburden groundwater levels were due to the works, then the contingency measures would be put into effect.

The objective of the contingency measures was to maintain overburden groundwater levels in the core wetland. The measures to be put in place if the trigger mechanism was activated included:

- addition of surface water and shallow groundwater to the wetland fringe area in order to encourage replenishment of overburden groundwater levels;
- use of the wetland outlet control structure, once constructed, to regulate the discharge of surface water from the wetland; and,

• construction of a low-permeability liner along the Findlay Creek Extension to reduce the discharge of groundwater to the creek.

Due to delays in the issuance of regulatory approvals, the wetland outlet control structure has not yet been constructed as of April 2008.

4.0 METHODS

4.1 Monitoring Well and Pressure Transducer Installation

Groundwater monitors BH03-1, BH03-2, BH03-3, BH03-4, BH03-5, BH03-6, BH03-7A, BH03-7B, BH03-8A, BH03-8B, BH03-9A, BH03-9B, BH03-10A and BH03-10B were constructed between August 26 and October 17, 2003 at the locations shown on Figure 2 in order to conduct groundwater level monitoring adjacent to the ecologically sensitive areas. The location and design of these groundwater monitor installations was as proposed in the March 2003 EMP.

The drilling program included both portable and track mounting drilling equipment. Portable drilling equipment operated by OGS Inc. was used to drill in and around the core wetland. Care was taken to minimize disturbance to the wetland during well installation. A CME 55 track mounted drilling rig operated by Marathon Drilling Ltd. was used to install some of the monitoring wells outside of the core wetland.

Standard penetration tests were carried out in all the boreholes at 0.76 metre intervals, and soil samples were recovered using split spoon type samplers. In addition to the overburden monitoring wells, bedrock monitors were installed in boreholes BH03-07 through BH03-10. HQ-sized diamond drilling equipment was used to advance the coreholes. All monitoring wells were completed with 0.03 metre (1.25 inch) diameter monitoring well casing and well screen. Details of the well completions and the subsurface conditions encountered in the boreholes are provided in Appendix A, along with the logs from the previous boreholes installed at the site. All monitoring wells were completed with locking steel protective casings. Prior to commencing drilling, the proposed borehole locations were surveyed by Stantee Consulting Ltd.

The field work was supervised throughout by Golder Associates engineering staff who located the boreholes, directed drilling operations, and logged the boreholes and samples. All soil and rock samples were subsequently reviewed by a professional geoscientist.

Three monitoring well pairs were installed in the overburden to monitor groundwater elevations near the Findlay Creek Extension. Two monitoring well pairs were installed to monitor groundwater elevations in the overburden and bedrock near the residential area, along with existing monitors BH97-2A and BH97-2B. Two monitoring well pairs were installed to monitor groundwater elevations in the overburden and bedrock in the wetland fen area. The areas monitored by each monitoring well are summarized in the following table.

Monitor	Unit Monitored	Area Monitored
BH03-1	Overburden monitor at limit of development	
BH03-2	Overburden monitor 20 m south of BH03-01	Findlay Creek
BH03-3	Overburden monitor at limit of development	
BH03-4	Overburden monitor 20 m south of BH03-03	Extension
BH03-5	Overburden monitor at limit of development	
BH03-6	Overburden monitor 20 m south of BH03-05	
BH97-2A	Bedrock monitor ~ 30 m west of the east limit of the core wetland	
BH97-2B	Overburden monitor at same location	Th
BH03-8A	Bedrock monitor north of BH97-2	Residential Subdivision
BII03-8B Overburden monitor at same location		Area
BH03-10A	103-10A Bedrock monitor located just east of core wetland	
BH03-10B	Overburden monitor at same location	
BH03-7A	Bedrock monitor near northeast edge of wetland fen	
BH03-7B	Overburden monitor at same location	Wetland Fen
BH03-9A	Bedrock near southeast edge of wetland fen	
BH03-9B	Overburden monitor at same location	

In order to continue to monitor groundwater elevations during the winter months, several wells that were prone to freezing were equipped with insulated boxes. The goal was to prevent freezing in wells with groundwater levels very near to or above ground surface. The boxes, which are approximately 1.2 m high by 0.8 m wide by 0.8 m long, were filled with insulation and installed at boreholes BH03-7, BH03-8 and BH03-9.

The groundwater level monitoring program included both manual and automated groundwater measurements with pressure transducers/data loggers in the monitoring wells. The pressure transducers used (Model 3001 LT M5 manufactured by Solinst Inc.) were accurate to within 0.005 metres, and had a pressure range of up to 4 metres of water column. The transducers were set such that the water level in each well was recorded every hour. During transducer installations, manual measurement of groundwater levels was performed to confirm that the transducers were providing accurate measurements. Subsequent manual checks with a water level meter were continued on a monthly basis to ensure that automated readings were representative of site conditions.

In order to compensate for changes in atmospheric barometric pressure, a pressure transducer/barologger was installed near monitoring well BH97-2. The pressure readings from the barologger were used to calculate the barometric efficiency of each well (see Section 5.2) and to calculate compensated groundwater elevations from the raw datalogger data. Due to flooding in the eastern wetland fringe, the barologger was submerged from October 19, 2005 to November 23, 2005, and the data collected by the barologger was unusable. Note that the data collected

during this period at BH97-2 was usable since groundwater levels can be above the ground surface provided the top of the well casing is not submerged. None of the wells were known to have been submerged during the monitoring period, indicating that groundwater data collected is reliable; however, compensated groundwater elevations are not available from October 19, 2005 to November 23, 2005. The barologger was subsequently moved to a location along the wetland berm, nearest to BH03-7.

4.2 Groundwater Elevation Monitoring

Groundwater level monitoring started upon the completion of each monitoring well. The following table summarizes the monitoring wells included in the groundwater level monitoring program and identifies the period during which data was collected.

Monitoring Well	Monitoring Period
BH03-01	October 1, 2003 - present
BH03-02	October 2, 2003 - present
BH03-03	October 2, 2003 - present
BH03-04	October 2, 2003 - present
BH03-05	October 2, 2003 - present
BH03-06	October 2, 2003 - present
BH03-07a	October 7, 2003 - present
BH03-07b	October 12, 2003 - present
BH03-08a	October 12, 2003 - present
BH03-08b	October 12, 2003 - present
BH03-09a	October 17, 2003 - present
BH03-09b	October 17, 2003 - present
BH03-10a	October 7, 2003 - present ²
BH03-10b	September 30, 2003 - present ²
BH97-2A	February 3, 1998 - November 6, 1998
	October 22, 2003 - present
BH97-2B	April 7, 1998 - November 6, 1998
	October 22, 2003 - present

Notes: Datalogger sent for repairs on Feb. 9, 2007 and reinstalled on May 1, 2007

Data was downloaded from the dataloggers and reviewed on an approximately monthly frequency, with a higher download frequency (i.e. every two weeks) during periods of temporary groundwater control during sewer construction at the site. Due to high water conditions in the wetland eastern fringe from 2005 to 2007, data downloading was not conducted during the early winter and late spring due to safety hazards associated with partially-frozen water.

Wells and dataloggers were damaged on or around Nov. 9, 2005; new dataloggers were installed in the repaired wells on Dec. 28, 2005

5.0 RESULTS

5.1 Baseline and Pre-Berm Elevations

Baseline water levels were measured and compared with pre-berm water levels at BH97-2, as shown in Figure 4. The 2003 groundwater levels are close to the 1998 groundwater levels and generally within 0.5 m of the 1998 groundwater levels.

Monitors BH03-1 through BH03-10 were installed from August to October 2003; therefore, no water level data exists for these monitors prior to or during the period of groundwater control from January to May 2003. It is noted, however, that groundwater levels have been shown to recover quickly from groundwater pumping and that long-term effects of groundwater control on water levels have not been observed. Therefore, pre-berm water levels from these monitors are considered to be representative of baseline water levels.

5.2 Groundwater Trigger Elevations

Groundwater trigger elevations were developed based on baseline data, pre-berm monitoring data and data collected from May to December 2004, which corresponds to a period with no groundwater control. The trigger water level elevations, as proposed in the updated 2005 EMP, are 0.1 m less than the seasonal minimum levels measured during the above-mentioned three periods to account for seasonal variations. Note that the pre-berm data were acquired during periods of heavy precipitation (approximately 20 to 60mm above normal monthly precipitation) based on the Ottawa Airport station data (Appendix B). Since water levels (both groundwater and surface water) fluctuate with the seasons, seasonal values were used at monitors that showed seasonal variation in water levels (i.e., BH03-5, BH03-6 and BH03-8B). For example, spring water levels should be between x (the lowest level historically measured) and y (the highest level historically measured). If, after construction commenced, levels fell below x during the spring, then mitigation measures would be triggered. The water level measurements were interpreted along with local precipitation data, such that unusually dry years did not trigger unnecessary actions. The trigger elevations and maximum groundwater elevations measured during baseline and pre-berm conditions, are given in the table below:

Monitor	Ground Surface Elevation (m)	Season	Trigger Water Level Elevation (m)	Maximum Groundwater Elevation (m) (Baseline and Pre- Berm Conditions)
BH97-2A	92.84	All	91.3	93.0
BH97-2B	92.85	All	91.2	92.6
BH03-1	94.87	All	94.5	94.8
BH03-2	94.88	All	94.5	95.0
BH03-3	94.07	All	93.2	93.9
BH03-4	94.08	All	93.5	94.0
BH03-5	93.44	Spring/summer (Apr-Sept) Fall/winter (Oct-Mar)	91.9 92.5	93.4
BH03-6	93.43	Spring/summer (Apr-Sept) Fall/winter (Oct-Mar)	91.9 92.5	93.0
BH03-7A 93.47		All	93.4	94.1
BH03-7B	93.40	All	92.6	93.4
BH03-8A	93.02	All	91.0	92.4
BH03-8B	93.01	Spring/summer (Apr-Sept) Fall/winter (Oct-Mar)	91.1 91.8	92.9
BH03-9A			92.4	93.4
BH03-9B	93.78	All	93.0	93.6
BH03-10A	92.47	All	90.9	92.7
BH03-10B 92.47 All		90.7	92.5	

The maximum values from the above table could be used to establish upper trigger elevations. However, the upper trigger elevations could be above the maximum values considering the intensity and duration of precipitation events and beaver activity.

5.3 Groundwater Elevation Monitoring

Barometric pressure changes cause water level fluctuations in most aquifers. The load associated with an increase in atmospheric pressure will push down on the water column in an open well, resulting in a relatively large drop in water level. Subsequent pressurization of the aquifer will result in a very small rise in water level. The overall effect is that in a well open to the atmosphere, an increase in barometric pressure causes a near instantaneous drop in water level. These fluctuations are highest in confined aquifers and smallest (to nil) in wells open to shallow unconfined aquifers.

Barometric pressure changes, as measured by the on-site barologger, were subtracted from the pressure transducer measurements in order to provide water level data that was unbiased by short-term changes in barometric pressure. In order to correct the water level data for changes in atmospheric pressure, the barometric efficiency of the aquifer was determined. The barometric efficiency is defined as the ratio of change in water level in a well to the corresponding change in atmospheric pressure. The transducer measurements in the wells were compared to the manually measured water level measurements, and an appropriate barometric efficiency was selected to correct the transducer measurements so that they were equal, on average, to the manually measured water levels. As summarized in the following table, the barometric efficiency of the bedrock wells ranged from 30% (BH03-7A) to 135% (BH03-10A).

Monitoring Well	Barometric Efficiency
BH03-01	1.0
BH03-02	0.72
BH03-03	0.72
BH03-04	0.80
BH03-05	0.76
BH03-06	0.80
BH03-07a	0.30
BH03-07b	1.0
BII03-08a	1.0
BH03-08b	0.85
BH03-09a	0.84
BH03-09b	0.72
BH03-10a	1.35 ¹ ; 0.83 ²
BH03-10b	0.85^{1} ; 1.0^{2}
BH97-2a	1.0
BH97-2b	1.2

Notes: ¹ prior to November 9, 2005 ² after December 28, 2005

The downloaded groundwater level data was compiled in a database... The groundwater elevation data were compared with climate data collected at the Ottawa Airport by Environment Canada data as well as precipitation data collected from three locations in Ottawa (Manotick, Riverside South, and Hawthorne) by the City of Ottawa. The location of the weather stations is shown in Figure 5. Figure 6 shows the total monthly precipitation data from all four locations from October 2003 to March 2008. Typically, the data from the stations were similar and the difference in the total monthly precipitation at the four locations was less than 20 mm. The Ottawa Airport station is closest to the site and is the only data set with values during the winter months; therefore, only the Ottawa Airport data were used for evaluation with the groundwater elevation data. The climate data from Environment Canada is presented in Appendix B for

reference. Groundwater elevation data for the monitoring wells is summarized in Figures 7 through 13.

The average water elevations for each monitor from baseline and pre-berm data, and post-berm data ("post-berm" data hereafter refers to data collected after the construction of the berm in the first part of 2004) are presented in the table below:

	Average Water I		
Monitor	Data Collected from 1998 and 2003 (Baseline and Pre-Berm Conditions)	Data Collected from 2004 to 2008 (Post-Berm Conditions)	Water Elevation Difference (m)
BH03-1	94.69	94.74	-0.05
BH03-2	94.91	94.86	0.06
BH03-3	93.77	93.77	0.00
BH03-4	93.87	93.97	-0.11
BH03-5	93.18	93.14	0.04
BH03-6	92.83	92.88	-0.04
BH03-7a	93.51	93.46	0.06
BH03-7b	93.21	93.01	0.20
BH03-8a	91.77	91.12	0.65
BH03-8b	92.60	92.90	-0.30
BH03-9a	93.10	· 92.81	0.28
BH03-9b	93.49	93.35	0.14
BH03-10a	91.87	91.11	0.76
BH03-10b	91.97	91.01	0.96
BH97-2a	92.68	92.05	0.63
BH97-2b	92.43	91.78	0.65

Horizontal lines corresponding to the average water elevations given in the above table are given on Figures 7 to 13 for reference. The average water elevation from pre-berm to post-berm increased at BH03-1, BH03-4, BH03-6, and BH03-8b and decreased at the remainder of the monitors, except for BH03-3, where average water elevations were the same. The largest difference (0.96 m) was observed at monitor BH03-10b, which is located outside of the wetland and adjacent to the Findlay Creek Extension. At monitors where temporary declines in the water level occurred during pumping periods, this could cause the calculated average post-berm water level to be lower, even if the actual water level after pumping, or post-berm, was similar to the pre-berm level. Although post-berm average water levels are lower then pre-berm levels at many of the monitors, the groundwater levels quickly recover after groundwater controls cease, indicating that there are likely no long-term effects of groundwater pumping.

5.3.1 Area of Findlay Creek Extension

As described in Section 4.1, groundwater monitors BH03-1, BH03-2, BH03-3, BH03-4, BH03-5 and BH03-6 were used to monitor groundwater levels along the northern fringe of the core wetland in the area of the Findlay Creek Extension. Figure 7 illustrates the groundwater levels measured at these monitors. At the time of preparation of this report, temporary groundwater control during construction of the Extension had been conducted starting in September 2007 to October 22, 2007, but the realigned section of Findlay Creek was not yet operational.

Monitoring wells BH03-1 and BH03-2 are located approximately 300 metres east of Albion Road, and are the monitors located the farthest from previous temporary groundwater control activities at the site. As can be seen on Figure 7, groundwater elevations measured at these monitors from 2003 to the present varied between approximately 94.5 masl and 95.1 masl, and were unaffected by groundwater control activities at the site.

Monitoring wells BH03-3 and BH03-4 are located approximately 380 metres east of BH03-1 and BH03-2. As can be seen on Figure 7, groundwater elevations measured at these monitors from 2003 to the present varied between approximately 93.4 masl and 94.3 masl, and were affected by groundwater control activities during site servicing in early 2004 and early 2005. The groundwater level drawdown over these periods was approximately 0.5 metres. Approximately 0.2 metres of decline was recorded in these monitors in July and August 2006 during groundwater control activities associated with construction of the deep trunk sewer. Drawdown was not induced in the fall of 2007 during surface water control activities associated with the Findlay Creek Extension. Precipitation had a significant effect on groundwater levels, as evidenced by low groundwater levels in January to March 2004, July 2004, January to March 2005, August 2006, August 2006, January to March 2007, May to June 2007 and September 2007 during periods of low rainfall. Groundwater levels quickly rose in response to periods of high rainfall during August to September 2004, April and September 2005, September 2006, April, July and October 2007.

Monitoring wells BH03-5 and BH03-6 are located approximately 300 metres east of BH03-3 and BH03-4. As can be seen on Figure 8, groundwater elevations measured at these monitors from 2003 to the present varied between approximately 90.6 masl and 93.8 masl, and were affected by groundwater control activities during site servicing in early 2004, and early April 2005. The groundwater level drawdown over these periods was approximately 2.0 metres to 2.5 metres. Approximately 1.5 metres of drawdown was induced in these monitors in July and August 2006 during groundwater control activities associated with construction of the deep trunk sewer. Drawdown was not induced in the fall of 2007 during surface water control activities associated with the Findlay Creek Extension. Precipitation had a similar effect on groundwater levels as in monitoring wells BH03-3 and BH03-4. A summary of the periods of groundwater level drawdown and the associated reason for the drawdown in given below for monitors BH03-1 to BH03-6.

Monitor	Period of Groundwater Level Drawdown	Reason for Drawdown
BH03-1 and BH03-2	None	N/A
	January to March 2004	Groundwater control and low precipitation in January to March 2004. Groundwater levels rose within two days after groundwater control activities stopped.
	July to August 2004	Low precipitation in July 2004. Water levels rose within several days of heavy rainfall in August and September 2004.
BH03-3, BH03-4, BH03-5 and	January to March 2005	Groundwater control and low precipitation in January, February and March 2005. Groundwater levels rose within a week due to either heavy rainfall in April 2005 and/or groundwater control activities ceasing.
BH03-6	August 2005	Low precipitation in August 2005.
	July to August 2006	Groundwater control and low precipitation in August 2006. Groundwater levels rose within a day after either heavy rain in September 2006 and/or groundwater control activities ceasing.
	January to March 2007	Low precipitation in January to March 2007.
	June to September 2007	Low precipitation in May, June and September 2007. Groundwater levels rose during heavy rainfall in July and October 2007.

As seen on Figures 7 and 8, overburden groundwater levels at BH03-3, BH03-4, BH03-5 and BH03-6 recovered within hours to several days to baseline levels once temporary groundwater control activities ceased and after heavy rainfall. Groundwater levels at BH03-3 through BH03-6 recovered within two days of the pumping rates being lowered from approximately 18,000,000 L/day to 1,000,000 L/day in August 2006, as shown in Figure 14. Seasonal effects on groundwater levels were noted, particularly during the summer months when precipitation and recharge are lower.

5.3.2 Residential Subdivision Area

As described in Section 4.1, groundwater monitors BH03-8, BII03-10 and BH97-2 were used to monitor groundwater levels in the residential subdivision area. Figures 10, 12 and 13 (respectively) illustrate the groundwater levels measured at these monitors.

Monitoring well BH03-8 is located in the eastern wetland fringe, approximately 75 metres west of the wetland berm. As can be seen on Figure 10, groundwater elevations measured at the

overburden monitor 03-8b from 2003 to the present varied between approximately 91.0 masl and 94.0 masl, and were affected by groundwater control activities during site servicing in early 2004, and early 2005. The groundwater level drawdown over these periods ranged from approximately 0.5 metres to 1.8 metres. Groundwater elevations measured at the bedrock monitor 03-8a varied between approximately 89.2 masl and 92.8 masl, and were affected by groundwater control activities during site servicing in early 2004 and early 2005. The groundwater level drawdown over these periods ranged from approximately 0.8 metres to 3.3 metres. Approximately 0.5 metres and 2.5 metres of drawdown were induced in the overburden and bedrock monitors, respectively, in 2006 during groundwater control activities associated with construction of the deep trunk sewer. Drawdown was not induced in the fall of 2007 during construction activities associated with the Findlay Creek Extension. Precipitation had a significant effect on groundwater levels, as evidenced by low groundwater levels in January to March 2004, July 2004, January to March 2005, August 2005, March to April 2006, August 2006, January to March 2007, May to June 2007 and September 2007 during periods of low rainfall. Groundwater levels quickly rose in response to periods of high rainfall during August to September 2004, April and September 2005, May and September 2006, April, July and October 2007.

Monitoring well BH03-10 is located immediately east of the Findlay Creek Extension, approximately 15 metres east of the wetland berm. As can be seen on Figure 12, groundwater elevations measured at the overburden (03-10b) and bedrock (03-10a) monitors varied between approximately 89.3 masl and 92.7 masl, and were affected by groundwater control activities during site servicing in early 2004, early 2005, and October 2005 (BH03-10a only). The groundwater level drawdown over these periods was approximately 3.2 metres, and the overburden groundwater level was drawn down below the overburden pressure transducer (approximately 90.1 masl). As can be seen on Figure 12, approximately 2.1 metres of drawdown was induced in the monitors in 2006 during groundwater control activities associated with construction of the deep trunk sewer. The overburden groundwater level during both events was drawn down below the overburden pressure transducer (approximately 90.2 masl). Drawdown was not induced in the fall of 2007 during construction activities associated with the Findlay Creek Extension. Precipitation had a similar effect on groundwater levels as in monitoring well BH03-8.

Monitoring well BH97-2 is located approximately 60 metres west of the proposed Wetland Outlet Control Structure. As can be seen on Figure 13, groundwater elevations measured at the overburden (97-2b) and bedrock (97-2a) monitors from 2003 to the present varied between approximately 90.0 masl and 93.8 masl, and were affected by groundwater control activities during site servicing in early 2004 and early 2005. The groundwater level drawdown over these periods was approximately 2.5 metres. Approximately 2.5 metres of drawdown was induced in these monitors in 2006 during groundwater control activities associated with construction of the deep trunk sewer. Drawdown was not induced in the fall of 2007 during construction activities associated with the Findlay Creek Extension. Precipitation had a similar effect on groundwater

levels as in monitoring wells BH03-8 and BH03-10. High groundwater levels were also noted in October and November of 2005, which correspond to periods of high precipitation. A summary of the periods of groundwater level drawdown and the associated reason for the drawdown in given below for monitors BH03-8, BH03-10 and BH97-2.

Monitor	Groundwater Level Drawdown	Reason for Drawdown
	January to March 2004	Groundwater control and low precipitation in January to March 2004. Groundwater levels rose within two days after groundwater control activities stopped.
	July to August 2004	Low precipitation in July 2004. Water levels rose within several days of heavy rainfall in August and September 2004.
BH03-8a, BH03-8b, BH03-10a, BH03-10b,	January to March 2005	Groundwater control and low precipitation in January, February and March 2005. Groundwater levels rose within several days due to either heavy rainfall in April 2005 and/or groundwater control activities ceasing.
BH97-2a,	August and September 2005	Low precipitation in August 2005.
and	October 2005 (BH03-10a only)	Groundwater control.
BH97-2b	February to April 2006 (except for BH03-8b)	Groundwater control and low precipitation in March and April 2006.
	August to September 2006	Groundwater control and low precipitation in August 2006. Groundwater levels rose over a few weeks after either heavy rain in September 2006 and/or groundwater control activities ceasing.
	January to March 2007	Low precipitation in January to March 2007.
	June to September 2007	Low precipitation in May, June and September 2007. Groundwater levels rose during heavy rainfall in July and October 2007.

As seen on Figures 10, 12 and 13, overburden and bedrock groundwater levels typically recovered within hours to several days to baseline levels once temporary groundwater control activities ceased and after heavy rainfall. Groundwater levels fluctuated by approximately 2 m (except for overburden monitor BH03-8b) during groundwater control activities from October 2005 to August 2006 (Figure 14) and recovered within hours to several days of the pumping rates being lowered. Seasonal effects on groundwater levels were noted, particularly during the summer months when precipitation and recharge are lower.

5.3.3 Wetland Fen Area

As described in Section 4.1, groundwater monitors BH03-7 and BH03-9 were used to monitor groundwater levels in the wetland fen area. Figures 9 and 11 illustrate the groundwater levels measured at these monitors.

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Monitoring well BH03-7 is located approximately 150 metres west of BH97-2, near the wetland fen arca. As can be seen on Figure 9, groundwater elevations measured at the overburden monitor from 2003 to the present varied between approximately 91.6 masl and 94.0 masl, and were affected by groundwater control activities during site servicing in early 2004 and early 2005. The groundwater level drawdown over these periods was approximately 1.7 metres and 0.5 metres, respectively. Groundwater elevations measured at the bedrock monitor varied between approximately 92.7 masl and 93.7 masl, and were affected by groundwater control activities during site servicing in early 2004 and early 2005. The groundwater level drawdown over these periods was approximately 0.6 metres. Approximately 0.7 metres of drawdown was induced in both monitors in 2006 during groundwater control activities associated with construction of the deep trunk sewer. Drawdown was not induced in the fall of 2007 during construction activities associated with the Findlay Creek Extension. Precipitation had a significant effect on groundwater levels, as evidenced by low groundwater levels in January to March 2004, July 2004, January to March 2005, August 2005, March to April 2006, August 2006, January to March 2007, May to June 2007 and September 2007 during periods of low rainfall. Groundwater levels quickly rose in response to periods of high rainfall during August to September 2004, April and September 2005, May and September 2006, April, July and October 2007.

Monitoring well BH03-9 is located approximately 250 metres south of the northern arm of the wetland berm and 280 metres west of the eastern arm of the wetland berm, near the wetland fen area. As can be seen on Figure 11, groundwater elevations measured at the overburden monitor (03-9b) from 2003 to the present varied between approximately 92.7 masl and 94.0 masl, and were affected by groundwater control activities during site servicing in early 2004 and early 2005. The groundwater level drawdown over these periods was approximately 0.8 metres and 1.0 metres, respectively. Groundwater elevations measured at the bedrock monitor (03-9a) varied between approximately 91.6 masl and 93.5 masl, and were affected by groundwater control activities during site servicing in early 2004 and early 2005. The groundwater level drawdown over these periods was approximately 1.8 metres. Approximately 1.4 metres of drawdown was induced in these monitors in 2006 during groundwater control activities associated with construction of the deep trunk sewer. Drawdown was not induced in the fall of 2007 during construction activities associated with the Findlay Creek Extension. Precipitation had a similar effect on groundwater levels as in monitoring well BII03-7. A summary of the periods of groundwater level drawdown and the associated reason for the drawdown in given below for monitors BH03-7 and BH03-9.

Monitor	Groundwater Level Drawdown	Reason for Drawdown
	January to March 2004	Groundwater control and low precipitation in January to March 2004. Groundwater levels rose within several days after groundwater control activities stopped.
	July to August 2004	Low precipitation in July 2004. Water levels rose within several days of heavy rainfall in August and September 2004.
BH03-7a, BH03-7b, BH03-9a,	January to March 2005	Groundwater control and low precipitation in January, February and March 2005. Groundwater levels rose within several days due to either heavy rainfall in April 2005 and/or groundwater control activities ceasing.
and	August and September 2005	Low precipitation in August 2005.
BH03-9b,	February to April 2006 (except for BH03-7a and BH03-7b)	Groundwater control and low precipitation in March 2006 and April.
	July to August 2006	Groundwater control and low precipitation in August 2006. Groundwater levels rose over a few weeks after either heavy rain in September 2006 and/or groundwater control activities ceasing.
	January to March 2007	Low precipitation in January and March 2007.
	June to September 2007	Low precipitation in May, June and September 2007. Groundwater levels rose during heavy rainfall in July and October 2007.

As seen on Figures 9 and 11, once temporary groundwater control activities ceased and after heavy rainfall, overburden groundwater levels typically recovered within hours to several days to baseline levels. Groundwater levels at BH03-7a and BH03-7b recovered within two days of the pumping rates being lowered from approximately 18,000,000 L/day to 1,000,000 L/day in August 2006 (Figure 14). Groundwater levels at BH03-10a and BH03-10b fluctuated by approximately 1 metre during groundwater control activities from October 2005 to August 2006 (Figure 14) and recovered within hours to several days of the pumping rates being lowered. Seasonal effects on groundwater levels were noted, particularly during the summer months when precipitation and recharge are lower.

5.4 Groundwater Trigger Evaluation

During monthly review of monitoring data, groundwater levels at each of the monitoring wells were evaluated to determine if the groundwater elevations had dropped below groundwater

trigger elevations. A summary of periods when groundwater levels dropped below trigger elevations is shown in Table 2 along with the interpreted reason for groundwater levels dropping below the triggers (either groundwater control activities or seasonally low water levels due to low precipitation).

The spring and early fall of 2007 were unusually dry, with much less precipitation falling during this time as compared to previous years. Groundwater elevations were observed to drop at many of the monitors through the summer and fall of 2007; these water level changes are attributed to seasonally dry conditions and not groundwater control at the site. It is noted that in a number of the overburden monitors, i.e., 03-5, 03-6, 03-7b, 03-8b, 03-9b, 03-10b, the natural decline in the groundwater level during the fall of 2007 was similar to that interpreted to be associated with groundwater control during trunk sewer construction in 2006. Water levels were observed to recover rapidly following precipitation events in July and October of 2007.

During the groundwater trigger events in early 2006, water was pumped behind the wetland berm in an effort to encourage recharge to the overburden along the wetland fringe and prevent groundwater elevation drawdown further into the wetland core. In general, this method did not prove to be an effective method at recharging groundwater elevations. However, on Figures 7 to 13, it is noted that the water levels increased by 0.5 to 1.0 m on January 15 to 17, 2006. This period did not coincide with heavy precipitation (a total of 2.5 mm of precipitation fell from January 15 to 17, 2006 (Appendix B)). Therefore, this increase in groundwater levels may have been a result of the pumping behind the wetland berm.

5.5 Vertical Hydraulic Gradients

The direction of the vertical hydraulic gradients within the eastern fringe of the wetland is generally consistent at each well but varies across the wetland as summarized in the table below.

Monitor	Direction of Vertical Hydraulic Gradient
BH03-7a and BH03-7b	Upwards
BH03-8a and BH03-8b	Downwards
BH03-9 and BH03-9b	Downwards
BH03-10a and BH03-10b	Upwards
BH97-2a and BH097-2b	Upwards

Differences in vertical hydraulic gradients result from varying recharge and geological conditions. The bedrock may have a significant impact on the vertical gradient since intact bedrock may limit groundwater flow while more fractured bedrock may promote groundwater flow. The upward gradient wells (BH03-7, BH03-10 and BH97-2) are all located within proximity to a ditch; therefore, potential groundwater discharge may be occurring into the nearby ditch. Typically, the direction of the vertical hydraulic gradient will not have a significant impact

on the response of groundwater to pumping-induced drawdown. The groundwater levels in both upward and downward gradient wells responded quickly (i.e., within hours to a few days) to the cessation of groundwater pumping.

At BH03-10, the vertical hydraulic gradient is downwards during early 2004, early 2005 and 2006, which correspond to periods of temporary groundwater control. This is likely caused by the groundwater level in the bedrock being lowered due to temporary groundwater control, resulting in a temporary reversal of the vertical gradient.

6.0 DISCUSSION AND CONCLUSIONS

Temporary groundwater control activities carried out since 2004 for deep sewer construction purposes in Findlay Creek Village have caused temporary groundwater level drawdown in overburden and bedrock groundwater monitors installed along the Findlay Creek Extension, in the residential subdivision area, and near the wetland fen area. Temporary groundwater control activities have typically involved minor groundwater extraction from the overburden and relatively high groundwater extraction from the upper bedrock zones beneath the site.

Groundwater levels were compared to the trigger groundwater elevations established in the EMP, and groundwater levels fell below the triggers on occasion at many of the monitors. As a result of the trigger occurrences that were likely caused by groundwater control activities, contingency measures were initiated in 2006, and pumped water was directed behind the wetland berm to encourage recharge to overburden materials.

As seen on Figures 7 through 13, once temporary groundwater control activities ceased, overburden groundwater levels recovered within hours to several days to baseline levels. Seasonal effects on groundwater levels can also be noted, particularly during the summer months when precipitation and recharge are lower. Climate data collected at the Ottawa Airport by Environment Canada is included in Appendix B for reference; precipitation is plotted on Figure 6 together with data provided by the City of Ottawa from three other locations.

Few trigger occurrences due to groundwater control activities were recorded at overburden monitors and these occurrences were typically short-term and during the winter months. As a result of the rapid recovery of overburden groundwater levels and the relatively short duration of trigger occurrences, negative impacts to vegetation in the core wetland are not expected to have occurred. Observations in 2006 and 2007 by Golder biologists conducting a photo monitoring program in the wetland areas, as described in the EMP and required by the Fisheries Authorization applicable to construction of the external storm system (September 2005 to November 2006), have not indicated adverse effects. Monitoring of vegetation within the wetland is ongoing as directed by the Wetlands Advisory Committee.

Future site servicing activities may necessitate groundwater control. Due to the distance between the core wetland and Stage 2 (Figure 2), the effects of the groundwater control activities on overburden groundwater levels near the core wetland are expected to be small. Due to the distance between the core wetland and the future southeastern stage (Figure 2), the effects of the groundwater control activities on overburden groundwater levels near the core wetland are also expected to be small. Due to the larger thickness of overburden in the western portion of the site, groundwater control activities in the future western stage (Figure 2) are expected to be less extensive than in previously constructed stages. As less groundwater is anticipated to need to be controlled during site servicing of the western future stage, the effects of the groundwater control activities on overburden groundwater levels near the core wetland are expected to be minimal. In

all three cases (Stage 2, future southeastern stage, future western stage), negative impacts to vegetation in the core wetland are not anticipated due to groundwater control activities.

7.0 RECOMMENDATIONS

The dataloggers near the Findlay Creek Extension are currently downloaded monthly and manual measurements are recorded at those times to confirm the transducer readings. During construction of the Findlay Creek Extension, the dataloggers will be downloaded bi-weekly with coinciding manual measurements. After completion of the Findlay Creek Extension, downloading of the dataloggers and manual measurements will occur monthly for a period of 3 months. After 3 months, the program for continued monitoring in the immediate area of the Findlay Creek Extension will be re-evaluated.

The dataloggers near the residential subdivision area and the wetland fen area are currently downloaded monthly and manual measurements are recorded at those times to confirm the transducer readings. The revised EMP specified that after completion of the SWMP and trunk sewer, downloading of the dataloggers and manual measurements was to occur monthly for a period of 12 months (i.e., until November 2007). The program for continued monitoring in the eastern wetland fringe and the wetland fen area should be re-evaluated based on the schedule for future site servicing installations and associated groundwater control activities; however, ongoing monthly monitoring and data review is considered appropriate at this time.

8.0 LIMITATIONS

This report was prepared by Golder Associates Ltd. (Golder Associates) for the use of the Leitrim Monitoring Technical Advisory Committee. Should additional parties require reliance on this report, written authorization from Golder Associates will be required. The report, which specifically includes all tables, figures and appendices is based on data and information collected during the site investigation conducted by Golder Associates and is based solely on the conditions of the property at the time of the field investigation, supplemented by historical information and data obtained by Golder Associates and others as described in this report.

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Except where specifically stated to the contrary, the information contained in this report was compiled or provided to Golder Associates by others and has not been independently verified or otherwise examined by Golder Associates to determine its accuracy or completeness. Golder Associates has relied in good faith on this information and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the information as a result of omissions, misinterpretation or fraudulent acts.

The services performed as described in this report were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and geoscience professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services. Golder Associates accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates should be requested to re-evaluate the findings of this report, and to provide amendments as required.

This report provides a professional opinion in light of the information available at the time of this report and therefore no warranty is either expressed, implied, or made as to the conclusions, advice or recommendations offered in this report.

The monitoring wells installed to carry out this work are the property of Findlay Creek Co-Tenancy, not Golder Associates.

9.0 CLOSURE

If there are any questions concerning this document, please do not hesitate to contact the undersigned.

Yours truly,

GOLDER ASSOCIATES LTD.

Andrea Catley, M.A.Sc

Junior Environmental Consultant

Paul Smolkin, P.Eng. Principal

CAMC/AC/PAS/th/tb

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TABLE 1
PRE-DEVELOPMENT GROUNDWATER ELEVATIONS FROM 1990 TO 1998

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	88-4	Ground Surface 92.16 95.25 95.25 94.32 94.32			90.92 95.19 95.07 93.92 94.13		91.80 95.30 95.20 94.32 94.32			92.16 95.31 95.09 94.32 94.42	91.24 95.01 94.72 94.31			91.01		91.35 95.25 95.03 94.32	
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	ci.	Surfa	Date	24-Jul-90	13-Sep-90	4-Mar-94	6-Nov-95	3-Feb-98	7-Apr-98	22-Apr-98	28-May-98	10-Jul-98	14-Jul-98	24-Aug-98	30-Sep-98	5-Nov-98	6-Nov-98
	Well No.	round	Ω	24-	13-6	4-₹	Z -6	9-F	7-A	22-7	28-№	₽,	4,	24-A	30-5	Ž	9-V
	\$	<u>o</u>															

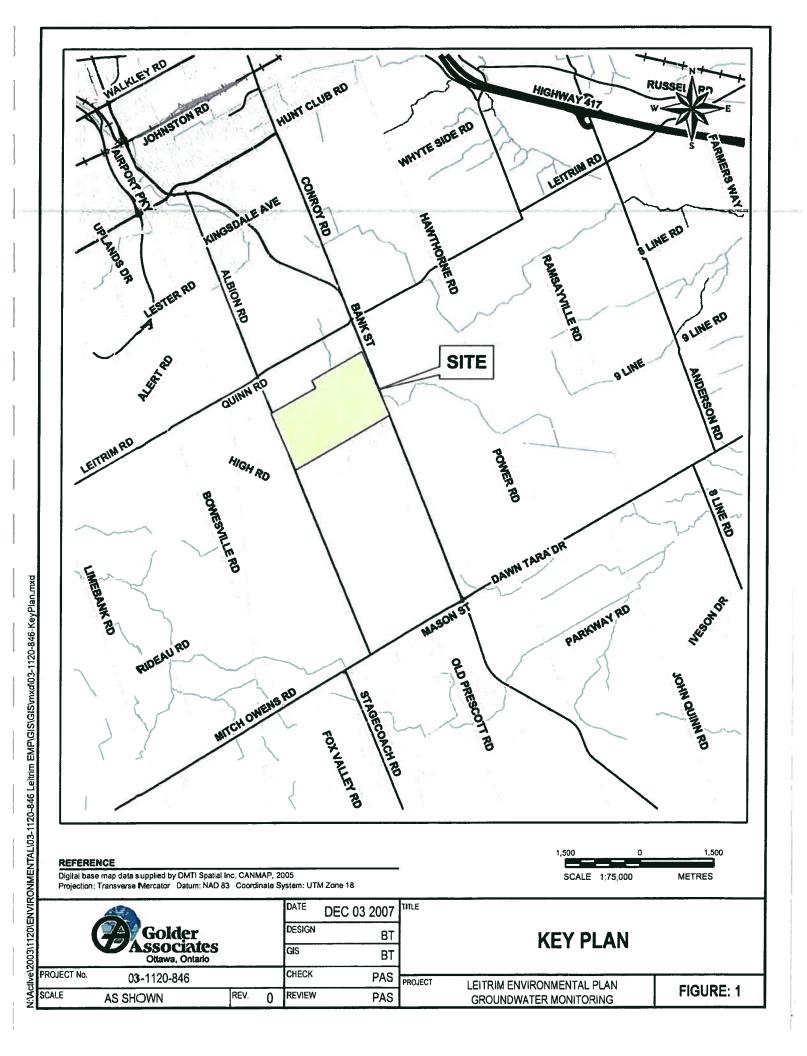
Notes:

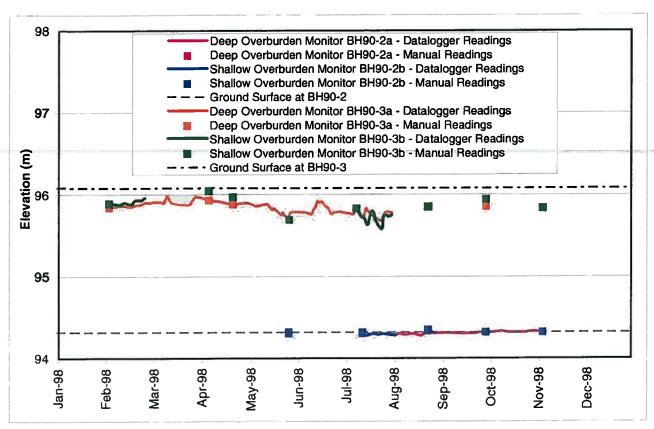
A, B - Deep and shallow monitoring wells, respectively All monitoring wells in overburden, except 97-2a in bedrock. For monitoring well locations, refer to Figure 3.

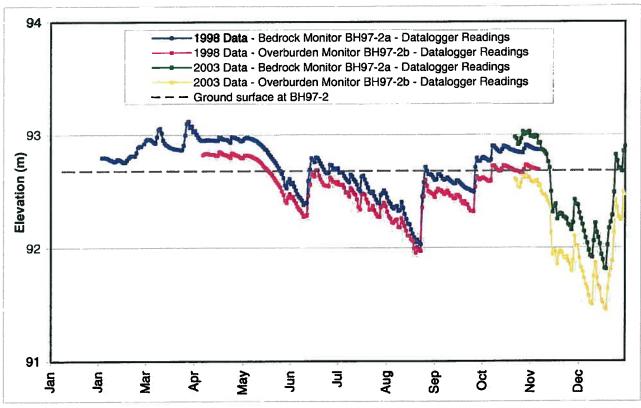
TABLE 2 GROUNDWATER TRIGGER EVALUATION

			ingger-Water-t-evelow		A SEMINUMENT	
				Most automore Edvarion en a	Valence of	il a diocente con a
BH03-1 BH03-2	Overburder		94.5	None		
BH03-3			94.5 93.2	None None		•
BH03-4			93.5	None		•
				January-March 2004	91.24	Groundwater control
D. 100 a	l		91.9 (Apr-Sept)	February-March 2005	90.96	Groundwater control
BH03-5	Overburder	FCE*	92.5 (Oct-Mar)	August 24 - September 1, 2006	91.84	Seasonal low water levels
				March 2007 July-August 2007	92.32 91.96	Seasonal low water levels Seasonal low water levels
	 			January-March 2004	90.94	Groundwater control
1	Edu Lina	FCE*	91.9 (Apr-Sept)	February-March 2005	90.63	Groundwater control
BH03-6	Overburder		92.5 (Oct-Mar)	August 24 - September 2, 2006	91.61	Seasonal low water levels
			, ,	March, 2007	92.06	Seasonal low water levels
				July-August 2007 December 2003	91.76 93.3	Seasonal low water levels Seasonal low water levels
	1	Wetland Fen		January-March 2004	93.02	Groundwater control
				July-August 2004	93.27	Seasonal low water levels
03-7A	Bedrock		93.4	February-March 2005	93.1	Groundwater control
				August 2005	93.27	Seasonal low water levels
		<u> </u> -		March 2006 July-October 2006	93.28 93.11	Groundwater control Groundwater control
				July-October 2007	92.66	Seasonal low water levels
03-7B	Overburden	Wetland	92.6	January-February 2004	91.61	Groundwater control
		Fen	02.0	July-October 2007	91.86	Seasonal low water levels
		1 1		December 2003	90.9 89.2	Seasonal low water levels
		Residential		January-March 2004 January-March 2005	89.54	Groundwater control Groundwater control
03-8A	Bedrock	Subdivision	91.0	January-May 2006	89.58	Groundwater control
		Area		July-October 2006	90.02	Groundwater control
				February-March 2007	90.79	Seasonal low water levels
		Danidastial		June-November 2007	90.2	Seasonal low water levels
03-8B	Overburden	Residential Subdivision	91.1 (Apr-Sept)	January-February 2004 July 8, 2007	90.96 91.03	Groundwater control Seasonal low water levels
		Area	91.8 (Oct-Mar)	October 2007	91.17	Seasonal low water levels
	Bedrock	Wetland Fen		February-March 2004	91.59	Groundwater control
				February-March 2005	91.55	Groundwater control
03-9A			92.4	March 2006	92.1	Groundwater control
				July 19-31, 2006	92.35 91.89	Groundwater control
				August 14-September 19, 2006 August-October 2007	92.24	Groundwater control Seasonal low water levels
		Wetland Fen		February-March 2004	92.67	Groundwater control
				February-March 2005	92.56	Groundwater control
03-9B	Overburden		93.0	July 22-31, 2006	92.89	Groundwater control
				August 28-September 2, 2006 July-October 2007	92.88	Groundwater control
- 1				January-March 2004	92.68 89.37	Seasonal low water levels Groundwater control
				January-March 2005	89.35	Groundwater control
		Residential		October 6-19, 2005	89.82	Groundwater control
03-10A	Bedrock	Subdivision	90.9	February-April 2006	89.85	Groundwater control
		Area	1	July-September 2006	89.87	Groundwater control
1				February-March 2007 June-November 2007	90.74 90.27	Seasonal low water levels Seasonal low water levels
				January-March 2004	90.27	Groundwater control
				January-March 2005	89.94	Groundwater control
		Residential	İ	August-September 2005	90.53	Groundwater control
03-10B	Overburden	Subdivision	90.7	February-April 2006	90.17	Groundwater control
J		Area		June-October 2006	90.18	Groundwater control
				January-March 2007 May-December 2007	90.36 90.17	Seasonal low water levels Seasonal low water levels
		Residential Subdivision		January-March 2004	90.34	Groundwater control
İ				February-March 2005	90.72	Groundwater control
97-2A	Bedrock		91.3	February-March 2006	90.92	Groundwater control
		Area	- 1	August-September 2006	90.94	Groundwater control
	1			August 22 October 11 2007	. 91.16	Seasonal low water levels
				August 22-October 11, 2007		
		Residential		January-March 2004	89.92	Groundwater control
97-2B	Overburden	Residential Subdivision	91.2	January-March 2004 February-March 2005	89.92 90.6	Groundwater control Groundwater control
97-2B (Overburden	Tar. 1991 C. C.	91.2	January-March 2004	89.92	Groundwater control

*FCE - Findlay Creek Extension

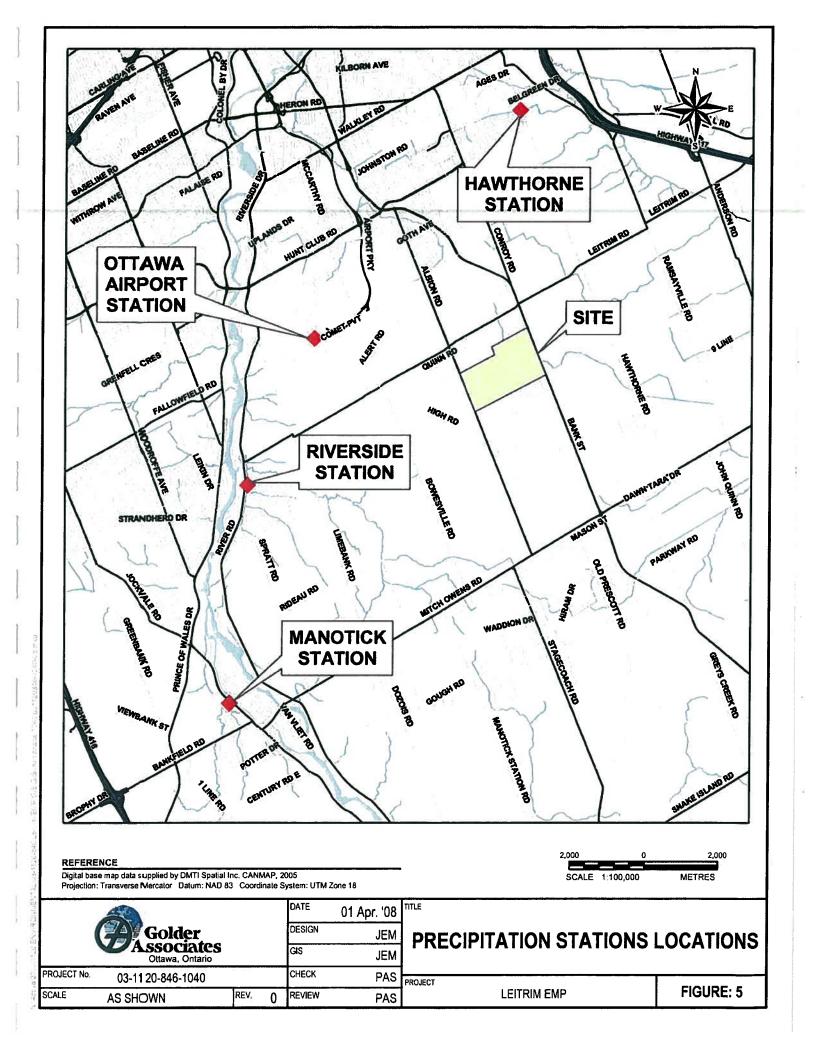


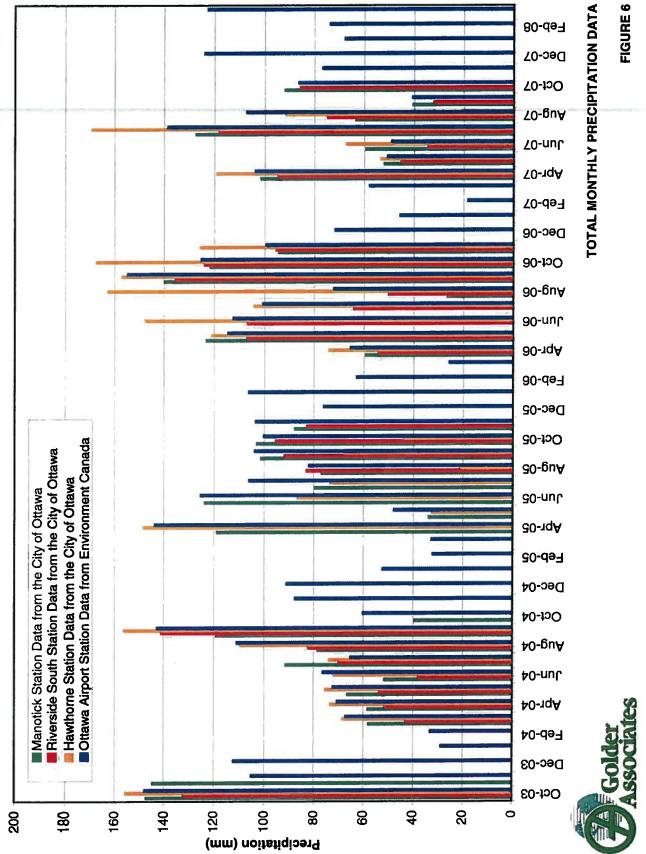






GROUNDWATER ELEVATIONS, BH90-2 AND BH90-3 (TOP)
AND BH97-2 (BOTTOM) IN 1998 AND 2003

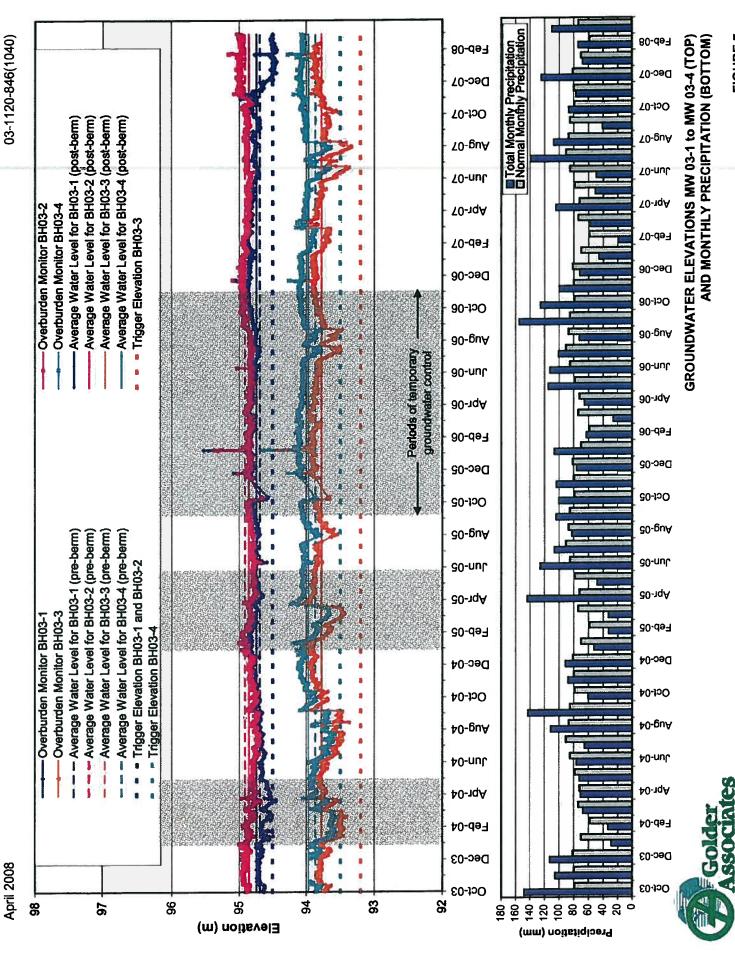


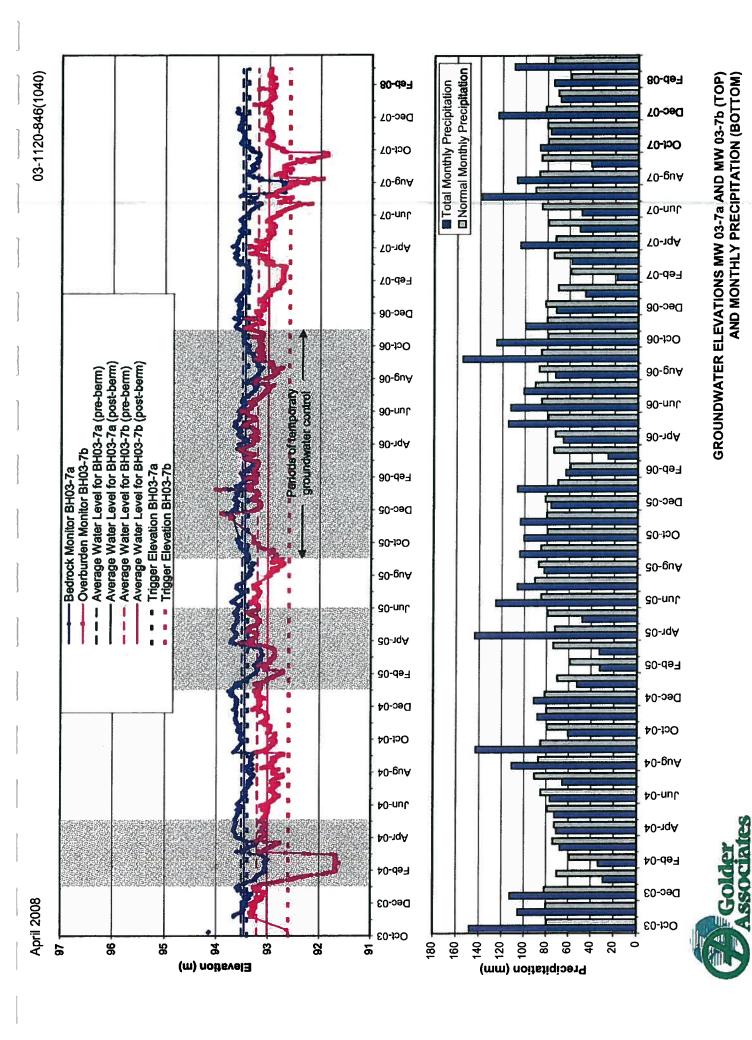


TOTAL MONTHLY PRECIPITATION DATA

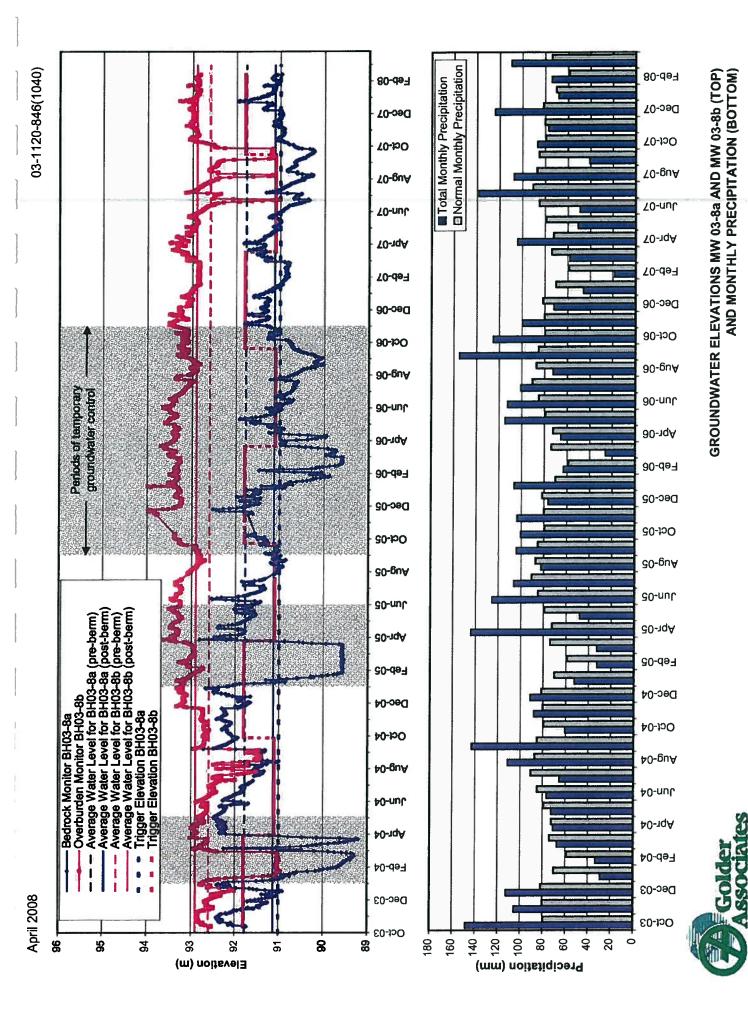
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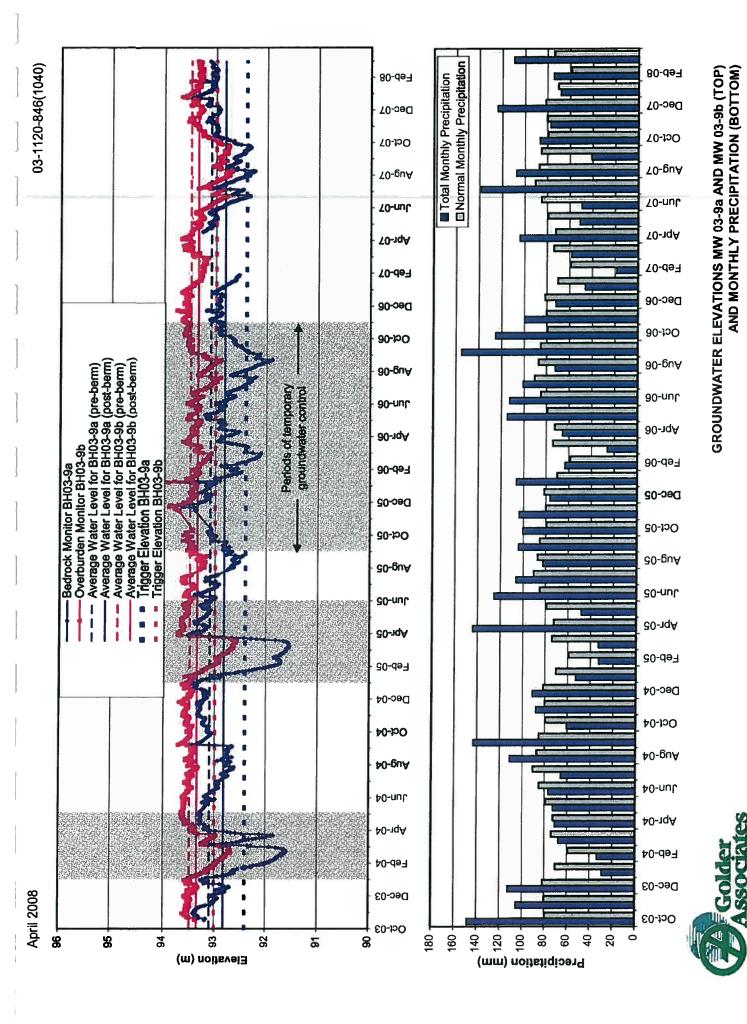




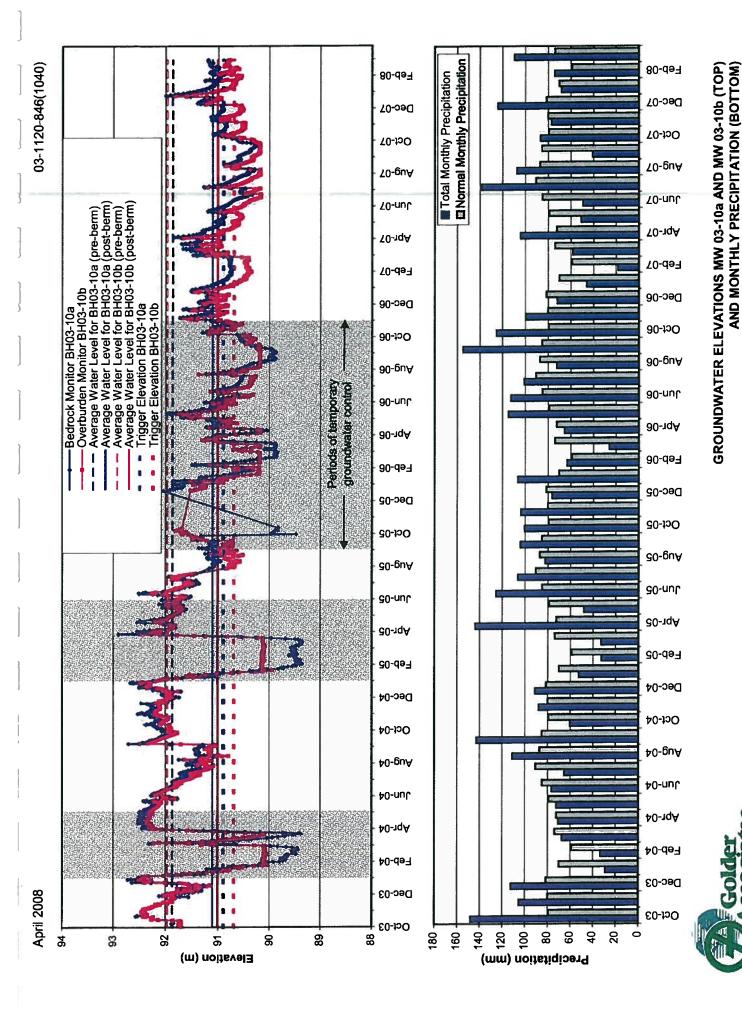
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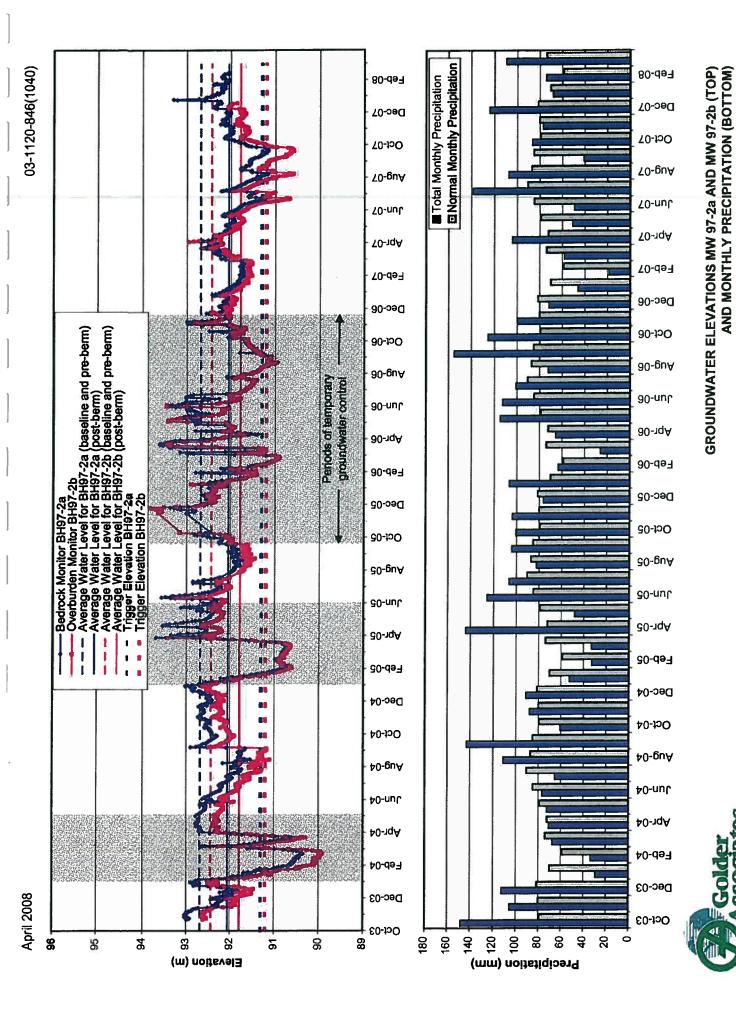
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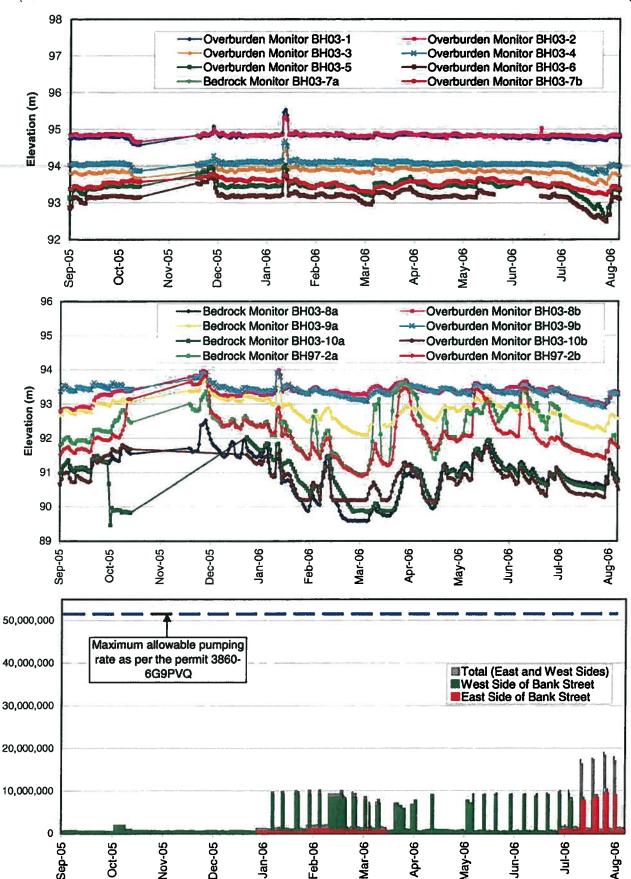
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GROUNDWATER ELEVATIONS AND PUMPING RECORDS FOR SEPTEMBER 2005 TO AUGUST 2006

ssociates

Total Litres Pumped Per Day

APPENDIX A RECORD OF BOREHOLE SHEETS

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

AS Auger sample (a) Cohesionless Soils BS Block sample N CS Chunk sample N DO Drive open (Relative Density) Blows/300 mm DS Denison type sample Or Blows/ft. FS Foil sample Very loose 0 to 4 RC Rock core Loose 4 to 10 SC Soil core Compact 10 to 30 ST Slotted tube Dense 30 to 50 TO Thin-walled, open Very dense over 50 TP Thin-walled, piston Cohesive Soils WS Wash sample (b) Cohesive Soils Consistency Cu2Sa Psf Very soft 0 to 12 0 to 250 Standard Penetration Resistance (SPT), N: Soft 12 to 25 250 to 500
CS Chunk sample Density Index N DO Drive open (Relative Density) Blows/300 mm DS Denison type sample Or Blows/ft. FS Foil sample Very loose 0 to 4 RC Rock core Loose 4 to 10 SC Soil core Compact 10 to 30 ST Slotted tube Dense 30 to 50 TO Thin-walled, open Very dense over 50 TP Thin-walled, piston (b) Cohesive Soils WS Wash sample (b) Cohesive Soils Consistency Cu ₂ S _u II. PENETRATION RESISTANCE Kpa Psf Very soft 0 to 12 0 to 250
DO Drive open (Relative Density) Blows/300 mm DS Denison type sample Or Blows/ft. FS Foil sample Very loose 0 to 4 RC Rock core Loose 4 to 10 SC Soil core Compact 10 to 30 ST Slotted tube Dense 30 to 50 TO Thin-walled, open Very dense over 50 TP Thin-walled, piston (b) Cohesive Soils WS Wash sample (b) Cohesive Soils Consistency Cu ₂ S _u II. PENETRATION RESISTANCE Kpa Psf Very soft 0 to 12 0 to 250
DS Denison type sample Very loose Or Blows/ft. FS Foil sample Very loose 0 to 4 RC Rock core Loose 4 to 10 SC Soil core 10 to 30 ST Slotted tube Dense 30 to 50 TO Thin-walled, open Very dense over 50 TP Thin-walled, piston (b) Cohesive Soils WS Wash sample (b) Cohesive Soils Consistency Cu ₂ S _u II. PENETRATION RESISTANCE Kpa Psf Very soft 0 to 12 0 to 250
FS Foil sample Very loose 0 to 4 RC Rock core Loose 4 to 10 SC Soil core Compact 10 to 30 ST Slotted tube Dense 30 to 50 TO Thin-walled, open Very dense over 50 TP Thin-walled, piston (b) Cohesive Soils WS Wash sample (b) Cohesive Soils Consistency Cu ₂ S _u II. PENETRATION RESISTANCE Kpa Psf Very soft 0 to 12 0 to 250
RC Rock core Loose 4 to 10 SC Soil core Compact 10 to 30 ST Slotted tube Dense 30 to 50 TO Thin-walled, open Very dense over 50 TP Thin-walled, piston (b) Cohesive Soils WS Wash sample (b) Cohesive Soils Consistency Cu ₂ S _u II. PENETRATION RESISTANCE Kpa Psf Very soft 0 to 12 0 to 250
SC Soil core Compact 10 to 30 ST Slotted tube Dense 30 to 50 TO Thin-walled, open Very dense over 50 TP Thin-walled, piston (b) Cohesive Soils WS Wash sample Consistency Cu ₂ S _u II. PENETRATION RESISTANCE Kpa Psf Very soft 0 to 12 0 to 250
ST Slotted tube Dense 30 to 50 TO Thin-walled, open Very dense over 50 TP Thin-walled, piston (b) Cohesive Soils WS Wash sample Consistency Cu ₂ S _u II. PENETRATION RESISTANCE Kpa Psf Very soft 0 to 12 0 to 250
TO Thin-walled, open Very dense over 50 TP Thin-walled, piston (b) Cohesive Soils WS Wash sample (b) Cohesive Soils Consistency Cu ₂ S _u II. PENETRATION RESISTANCE Kpa Psf Very soft 0 to 12 0 to 250
Thin-walled, piston WS Wash sample (b) Cohesive Soils Consistency Cu ₂ S _u
WS Wash sample (b) Cohesive Soils Consistency $C_{u2}S_u$ II. PENETRATION RESISTANCE Kpa Psf Very soft 0 to 12 0 to 250
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$
II. PENETRATION RESISTANCE Kpa Psf Very soft 0 to 12 0 to 250
Very soft 0 to 12 0 to 250
· · · · · · · · · · · · · · · · · · ·
Standard Penetration Resistance (SPT), N: Soft 12 to 25 250 to 500
The number of blows by a 63.5 kg. (140 lb.) Firm 25 to 50 500 to 1,000
hammer dropped 760 mm (30 in.) required Stiff 50 to 100 1,000 to 2,000
to drive a 50 mm (2 in.) drive open Very stiff 100 to 200 2,000 to 4,000
Sampler for a distance of 300 mm (12 in.) Hard Over 200 Over 4,000
DD- Diamond Drilling
Dynamic Penetration Resistance; N _d : IV. SOIL TESTS
The number of blows by a 63.5 kg (140 lb.)
hammer dropped 760 mm (30 in.) to drive w water content
Uncased a 50 mm (2 in.) diameter, 60^{0} cone w_{p} plastic limited
attached to "A" size drill rods for a distance w ₁ liquid limit
of 300 mm (12 in.). C consolidation (oedometer) test
CHEM chemical analysis (refer to text)
PH: Sampler advanced by hydraulic pressure CID consolidated isotropically drained triaxial test ¹
PM: Sampler advanced by manual pressure CIU consolidated isotropically undrained triaxial test
WH: Sampler advanced by static weight of hammer with porewater pressure measurement ¹
WR: Sampler advanced by weight of sampler and D_R relative density (specific gravity, G_s)
rod DS direct shear test
M sieve analysis for particle size
Peizo-Come Penetration Test (CPT): MH combined sieve and hydrometer (H) analysis
An electronic cone penetrometer with MPC modified Proctor compaction test
a 60° conical tip and a projected end area SPC standard Proctor compaction test
of 10 cm ² pushed through ground OC organic content test
at a penetration rate of 2 cm/s. Measurements SO ₄ concentration of water-soluble sulphates
of tip resistance (Q ₁), porewater pressure UC unconfined compression test
(PWP) and friction along a sleeve are recorded UU unconsolidated undrained triaxial test
Electronically at 25 mm penetration intervals. V field vane test (LV-laboratory vane test)
γ unit weight

Note:

Tests which are anisotropically consolidated prior shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I.	GENERAL		(a) Index Properties (cont'd.)
π	= 3.1416	w	water content
	ogarithm of x	$\mathbf{w_1}$	liquid limit
	x logarithm of x to base 10	$\mathbf{w}_{\mathbf{p}}$	plastic limit
g	Acceleration due to gravity	I,	plasticity Index=(w ₁ -w _p)
t	time	w,	shrinkage limit
F	factor of safety	ĬL	liquidity index=(w-w _p)/I _p
V	volume	$\mathbf{I_c}$	consistency index=(w _i -w)/I _p
W	weight	e _{max}	void ratio in loosest state
		emin	void ratio in densest state
П.	STRESS AND STRAIN	I_D	density index-(e _{max} -e)/(e _{max} -e _{min})
			(formerly relative density)
γ	shear strain		
Δ	change in, e.g. in stress: $\Delta \sigma'$		(b) Hydraulic Properties
ε	linear strain		
٤٠	volumetric strain	h	hydraulic head or potential
η	coefficient of viscosity	q	rate of flow
ν	Poisson's ratio	v	velocity of flow
σ	total stress	i	hydraulic gradient
ď	effective stress ($\sigma' = \sigma''-u$)	k	hydraulic conductivity (coefficient of permeability)
σ' _{vo}	initial effective overburden stress	j	seepage force per unit volume
$\sigma_1 \sigma_2 \sigma_3$	principal stresses (major, intermediate,		
	minor)		(c) Consolidation (one-dimensional)
$\sigma_{\rm oct}$	mean stress or octahedral stress		
	$= (\sigma_1 + \sigma_2 + \sigma_3)/3$	C _c	compression index (normally consolidated range)
τ	shear stress	C_r	recompression index (overconsolidated range)
u	porewater pressure	C _s	swelling index
E	modulus of deformation	C _a	coefficient of secondary consolidation
G	shear modulus of deformation	$\mathbf{m}_{\mathbf{v}}$	coefficient of volume change
K	bulk modulus of compressibility	Cv	coefficient of consolidation
		T_{v}	time factor (vertical direction)
П.	SOIL PROPERTIES	U	degree of consolidation
		σ' _p	pre-consolidation pressure
	(a) Index Properties	OCR	Overconsolidation ratio=o'p/o'vo
ρ(γ)	bulk density (bulk unit weight*)		(d) Shear Strength
$P_d(\gamma_d)$	dry density (dry unit weight)		
ρω(γω)	density (unit weight) of water	$ au_p au_r$	peak and residual shear strength
ρ _s (γ _s)	density (unit weight) of solid particles	φ	effective angle of internal friction
γ	unit weight of submerged soil (γ=γ-γ _w)	δ	angle of interface friction
D_R	relative density (specific gravity) of	μ	coefficient of friction=tan δ
- K	solid particles (D _R = p _s /p _w) formerly (G _s)	c'	effective cohesion
e	void ratio	C _{U,} S _U	undrained shear strength (\$\phi=0\$ analysis)
n	porosity	p	mean total stress $(\sigma_1 + \sigma_3)/2$
S	degree of saturation	p'	mean effective stress (o'1+o'3)/2
-		q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma_3)/2$
*	Density symbol is p. Unit weight	q _u	compressive strength $(\sigma_1 - \sigma_3)$
	symbol is γ where γ =pg(i.e. mass	S _t	sensitivity
	density x acceleration due to gravity)	٠,	
	county a accordance due to gravity)		Notes: 1. 7=c'o' tan
			2. Shear strength=(Compressive strength)/2
			To aware arrandme (aguilizador da anaistin), a

: (#8=4----Steen You is dering water the ladged CONTROL Sec Figure 2 DATEM Telescolo SAMPLER HAMMER USING BROD TOOMS MEDITALISM CERTIFICATION (CONTROL MODERN BYNAMIC PENETRATION RESISTANCE, BLOWS/0,3m HYDRAULIC CONDUCTIVITY. SOIL PROFILE BORING METHOD DEPTH SCALE METRES ADDITIONAL LAB. TESTING TYPE BLOWS/0.8M PIEZOMETER STRATA PLOT OR STANDPIPE SHEAR STRENGTH natv.- + Q.- • Cu, kPa rem.v.- @ U.- O ELEV. WATER CONTENT, PERCENT DESCRIPTION INSTALLATION DEPTH (M) Ground Surface TOPSOIL 92.10 0.00 881-2426 Bentonite Sezi Backfill 50 00 21 Compact brown sandy silt, some clay and gravel, numerous cobbies and boulders from 1.65 - 3.02 metre depth (GLACIAL TILL) 2 BX RG 8 RECOVERY 89.14 3 3,02 R.Q.D. 3 BX 8.C.R. Faintly weathered grey CORE DOLOMITE BEDROCK, some fractured zones 4 BX RC 58 87.41 End of Hole 4.75 W.U. In Standpipe at Elev. 90.98 Dec. 19, 1988 10 11 12 - PERCENT AXIAL STRAIN AT FAILUR DEPTH SCALE LOGGED J.COBISA Golder Associates 1: 60 CHECKED /

PROJECT: 901-2831

LOCATION: See Figure 2

RECORD OF BOREHOLE 90-1A

BORING DATE: July 10, 1988

SHEET 1 OF 1

DATUM: GEORGIC

BAMPLER HAMMER; Its Sug: DRCP 750mm

PENETRATION TEST HAMMER, SCANG, DROP, TROMB

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PROJECT: 901-2831* LOCATION: See Figure 2

RECORD OF BOREHOLE 90-18

BORING DATE: July 10, 1990

SHEET (OF)

DATUM: GEODETIC

BAMPLER HAMMER 63 Sig; DROP, 780min

Ţ	8	SOIL PROFILE			Ts	AMP	LES	DYNAMIC PENETRA	TION		TION TEST HAMMER &			ann V
METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH	NUMBER	TAPE	BLOWBAD.3m	RESISTANCE, BLOW SHEAR STRENGTH Cu, MPa 20 40	netV-+ Q		WATER CONTENT, PE	10 ⁻³ I	ADDITIONAL LAB. TESTING	PIEZOMETER ORI STANDPIPE INSTALLATION
·	F	Ground Surface TOPSOIL	3	95.25 0.00		F	İ				29 40 90	80		y
		Loose gray brown SANDY SILT to SILTY SAND		0.37		50 00							9	Native Backfill
1		Brown SILTY FINE SAND	#	94,03 1,22 93,81					++	+		+		
2				1.44	H	50 DO	•							
Named Associates	75mm Solid Stem	Loose grey SANDY SILT, occasional silty fine sand layers, some clay			3	se DO	8					+		
1		rejons, some day				se DO	•			1				
5		10		8	•	50 DO								Bentonite Soal
			,											Native Backfill
,		Loose gray sitty sand, some Losy and gravel (GLACIAL TILL) End of Hole		88.66 8.37 6.55	•	800	•							W.L in Well
														W.L in Well Screen 8 at Elev.95.37 July 24, 1990
		-												3
Ц			Ц	\perp			_	S PERCENT AXAL S	FRAIN AT FAILURE	*				
	H 8	CALE					L							D: S.Leighton
_	_		-		_			Golder Asso	Ciates			CH	IECK	ED: DB

PROJECT, MILORIA

RECORD OF BOREHOLE 90-2A

SHEET I OF I

LOCATION: See Figure 2:

BORING DATE: JULY 12, 1990

DATUM: GEOGETIC

SAUPTER HAMMER 61-Sig. ORCP: 750mm

PENETRATION TEST HAMMER, 83.5kg; ORCH, 760mm

114		SOIL PROFILE			8/	WP	. 23	DYNA	AIC PÉN TANCE,	ETPATK	N.		HYOR	AUŲCO	<u> PNDUC</u>	IVITY,	T		
DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	CEPTH (m)	NUMBER	TYPE	BLOWB/0.3m	SHEAS Cu, kp	I STREN	GTH (net.V - +	U-0		Wp	ONTENI	, PERC	ENT	ADOITIONAL LAB. TEBTING	PIEZOMETER OR STANDPIPE INSTALLATION
	П	Ground Burface		94.32		-					-								
	Hand Auger	FOR SUBSURFACE STRATIGRAPHY, SEE RECORD OF BOREHOLE 90-28		0.00												Ī			Bentonite Cr Scal
				91,49 2.63		,													
3		End of Hole		2.83										affirerefrerefrerefrerefrestliste (Egyddesithala					W.L in Well Screen B at Elov.94,07 July 24, 1990
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	Ц				Ц			15 4 5 P	ERCENT	AXIAL ST	FWH AT F	ALURE						Ш	
DI	EPTH	ISCALE									5.4		•					LOGO	GEO: S.Leighton

1 to 50

Golder Associates

LOGGED: S.Leighton
CHECKED: DB

PROJECT, ID1-2831

LOCATION: See Figure 2

RECORD OF BOREHOLE 90-28

BORING DATE: July 12, 1990

SHEET 1 OF 1

DATUM: GEODETIC

SAMPLER HUNMER, 62 Skg; CROP, 760mm

PENETRATION TEST HAMMER, 83.5kg; DROP, FROMING

112	~	9	90%, PROFILE			_	MAP	LES	DYNAMIC P	ENETRA	TION		HYDRA	WŲCO	ONDUCT	IIVITY.	-		
DEPTH SCALE		BORING METHOD	DESCRIPTION	FOT	ELEV.	╆		BLOWS/0.2m	RESISTANC	XE, BLOW	S/0.3m		10	-8 10	, 10 10	4 1	<u>, </u>	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANOPPE
- E		BORIN	DESCRIPTION	STRATA PLOT	DEPTH (m)	NUMBER	٤	BLOW	SHEAR STE Cu, kPs 20	NENGTH 40	nm.V- G			M			ENT '	ABO!	INSTALLATION
٠.	H	╀	Ground Surface	15	94.32								1996		57.0				
	A CONTRACTOR OF THE PARTY OF TH		PEAT												·				Native V Backfill
2					1.31	-	88	4								20			
•	Manual Association	7Emm Solid Stem	Loses to compact gray SANCY SILT to SILTY SAND, trace gravel, occasional fine to medium sand layers			8	50 DO							5					
•						3	se DO	8							Ť				Bentoeite Seel
			,			•	800							The second secon					Native Backfill
,			Compact grey sitty sand, some clay and gravel (GLACIAL TILL) End of Hole		87.46 8.86 87.00 7.32	5	# 100	15				·			1				
7			GAVA TROP																W.L in Wali Screen A at Elev.94,17 July 24, 1990
10			8													8			
DI	EP	TH:	SCALE				_	-	5 6 PERCEI	T AXCAL S	TRAIN AT F	ALURE	- 1						
1		ю.							Golder	Asso	ciates	}							ED: 8.Leighton KED: 7512

PROJECT: 971-2925

RECORD OF BOREHOLE 90-2 SHALLOW

BORING DATE: July 18, 1998

NEW

SHEET I OF 1 DATUM



SAMPLER HAMMER, 63.6kg; DROP, 760mm

LOCATION: 0.75m Ease of Edisting 8H 90-2 Deep

PENETRATION TEST HAMMER, 63.6kg; DROP, 760mm

4	윷	SOIL PROFILE	-		SA	MPL		DYNAMIC PENETRA RESISTANCE, BLOW	TION S/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s	T	
DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa 20 40	natV-+ q		WATER CONTENT, FERCENT WP W W 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETE OR STANDPIPE INSTALLATIO
		GROUND SURFACE		94,32	П					\dashv		+	
		PEAT.											Nativo Backfit
,	Hand Auger 90 mm Dlem.	Organic, CLAYEY SILT.		93.12 93.02 1.30									Bentonite Seal
ż		Grey layered, SILTY fine SAND, SANDY SILT and CLAYEY SILT.											Stilica Sand
			╨	92.12 2.20									25mm PVC #10 slot Screen
7													×
5 DEI	PTH:	SCALE											GED: PAH

1 to 25

Golder Associates

CHECKED:

PROJECTO BOT 2801 LOCATION: See Figure 2

RECORD OF BOREHOLE 90-3A

BORING DATE: July 18, 1890

BHEFFL OF

DATUM SECCETIC



SAMPLER HAMMER GLOGE DROP, Johns.

PERETRATION TEST HANNER, ISSNIC DROP, TRANS

*****	***	~~~					2000	****	DYNAM	NC DEM										
ij		봊	SOIL PROFILE		- ST	S.	WP		RESIST	ANCE, I	BLOWS	/0.3m		HYDH	AULCO	ONDUC /9 -5	INTY,	. T	ם ב	_
DEPTH BOALE		BORING METHOD		BTRATA PLOT	ELEV.	5	ш	BLOWB/0.3m		1	Щ.			10	10	10 10 L	-4 10 	,3 <u> </u>	ADDITIONAL LAB. TESTINIG	PIEZOMETER OR
Ê	뿔	S	DESCRIPTION	¥	DEPTH	NUMBER	٤	8	SHEAR Ou, kPa			net.V- +			VATER C	ONTEN			9. T.	STANDPIPE INSTALLATION
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	Ţ	I	Ground Surface		98.08								·							9
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•	ı	Hend Auger 75mm Bolld Ster	FOR SURSUIDEACE STORTIGUADLAY										l	ĺ				1		
ļ.	1	Hend Auger	FOR SUBSURFACE STRATIGRAPHY, SEE RECORD OF BOREHOLE 90-3B								S.				6)					
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ŧ	ł	l	End of Hole		94.56 1.52												1			
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	νE								Gali	dos =		ninė								ED: S.Leighton
		100	50		72				GOI	uer A	.880	ciates	5						CHEC	KED: 18

PROJECT: 901-2831

LOCATION: See Figure 2

RECORD OF BOREHOLE 90-3B ... SHEET I GET

BORING DATE: July 18, 1990

DATUM: GEODETIC

SAMPLER HAMMER, 63,5kg; DROP, 760mm PENETRATION TEST HAMMER, 83.5

		CERTIFICAÇÃO DOS LACIS, FOLDAS										EREI	MITOI	• 1E31	HAMM	A, 63	Mag. CH	IOP. TE	Omen 🔌	55/
L.	8	SOIL PROFILE			8	AMP	_	DYNA	AIC PEN TANCE,	ETRATI BLOWS	ON /0.3m		HYD	wucc	XONDUC Na	TIVITY,	T	ور ا		
18C	197		١	BLEV.	5	l a	E S	L						1	9 1	4 1	°3 T	AND SE	PIEZO	METER OR
DEPTH BCALE METRES	ROBING METHOD	DESCRIPTION	STRATA PLOT	DEPTH	NUMBER	Type	BLOWB/0.3m	SHEAR Cu, kP	STREM	IGTH	net.V - i rem.V - E			WATER	CONTEN		ENT W	ADDITIONAL LAB. TESTING	STAN INSTAL	LATION
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•	H	Ground Surface	13	98.00			t	\vdash		一	 		\vdash	H		-1700		1	- 품	- WA
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	11	PEAT, occasional cobble or	3								9 8							1	Native Beckfill	
Ļ٠	П	DOUGH	3					\vdash		-	\vdash	<u> </u>			 	<u> </u>	_		CHEMIN	
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	11		M	1.52		50 00	l.												2	
- 2	$\ \ $		III		Ĺ	00		Ш					<u>_</u>	_			_		Sentonite Seal	
		Loose to compact grey fine to coarse SAND, some gravel	H	Ī									ľ							w. w.
	Hand Auger	Pio C	W																Nativo	
Ε,	Ť	E	M							<u></u>			L						Native Backfill	
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	П		H		-															
	П			92.12 3.98																
	П	Compact grey coarse	OF CATOMOTOR CAT																	
1	П	Compact grey coarse SAND and GRAVEL, some fine to medium sand, trace cobbles			-								l						8	
	Н		0 10 10 10 10 10 10 10 10 10 10 10 10 10	91.05	•	50 DO	24											ш	6	
	П	End of Hote	100	5.03						,			Г							WIIIA.
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DE		H SCALE					1												ED: S.Leig	
1	₩.	50						Gold	ier A	\sso(ciates	•						CHEC	KED: TB	

CHECKED: LB

PROJECT: 301-2831 LOCATION: See Figure 2

HEGORD OF BOREHOLE 90-4A

BORING DATE: July 19816 1980

SHEET I OF I

DATUM: GEODETIC

(2)

SAMPLER HAMMER, 65 Skg: DEGP, 760min

PENETRATION TEST HAMMER, 63.5kg: DROF, 780mm

	-	SOIL PROFILE			T e	UMPI	E0	DYNA	MIC PER	NETRAT	iON .	200	Liver	PALK C	OMO IC				
DEPTH BCALE METRES	BORING METHOD		ğ		Н			RESIS	TANCE,	BLOW	/9.3m				4	-4 -	`]	Z Z	PIEZOMETER OR
	ORING	DESCRIPTION	STRATA PLOT	DEPTH	NUMBER	7	BLOWS/0.3m	SHEAF Cu, kP	STREE	NGTH	netV- + ren.V- 6			WATER O	ONTÉN	T, PE	ACENT 	ADOITIONAL LAB. TESTING	STANOPIPE INSTALLATION
Н		Ground Surface	=	(m)	Н		9	2	· ·	40	00 (×	<u> </u>		-	90	00],3	2
F "	T		F	97.03 9.00	Н			(III) I 1 1 1 1					-	-	-	\vdash	+-	-	2
- 1		FOR SUBSURFACE STRATIGRAPHY, SEE RECORD OF BOREHOLE 90-48																	Bentonibe Seel Native BackER
2	Pland Auger 75mm Bolid Stem	are recoun or bonehole 30-48		-			MANUAL MANUE												
	İ			94.44															
	1	End of Hole		2.59								OTE SAFE							44773
																			W.L in Well Screen at Elev.97.07 July 24, 1990
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DEF	TH S	BCALE	_				ť	18 PE	nGeNT/	VOAL ST	RAIN ATFA	WLURE					1	_J,	
	to							Gold	ier A	8800	iates								ED: 3.Leighton CED: 763

PROJECT: 101-2811

LOCATION: See Figure 2

RECORD OF BOREHOLE 90-48

BORING DATE: July 13416 1650

SHEET 1 OF E

DATUM: GEODETIC

SAMPLERHAMMER, 63-540; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; 0806, 280mm

3	Ş	SOIL PROFILE			S		LES	DYNAMIC PENETRY RESISTANCE, BLOW	ATION VS/0.3re	HYDE	WUC CO	OUCTIVITY,	T	Τ.,	
DEPTH GCALE METRES	BORING METHOD	DESCRIPTION	BTRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH C4, MPa 29 40		3 7		NTENT, PER	<u>, 1</u>	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE NSTALLATION
١.	Н	Ground Surface	1	97,00			-			1	H				*
-		PEAT		85.96											Madre Sacidis
		Very loose grey fine to medium SAND, some silt			1	50 DO	3								
				94.51 2.52					11_						
	Hend Auger	Louse grey medium to coarse SAND			3	50 CC	•								
	Herd			82.05		50 50 50	7					,			
		Loose grey fine to medium		92.05 4.98							7				Bentonite Seel
		Loose grey fine to medium SAND, some six tayers			4	50 DO	6							-AGH	Native Backf8
7					•	\$0	2								
		End of Hole		89.41 7.82											
															W.L in Well Screen A at Elev.97.19 July 24, 1990
				1 14											
- 10															
$\vdash \vdash$		<u> </u>			Ш		_	5 - 5 PERCENT AXIAL	STRAIN AT FAILURE						5-9
1		1 SCALE					L	Golder Acce							ED: 8.Leighton
Щ_	Ð	50				_		Golder Asso)Cla(e8		1 1			CHEC	KED: JB

PROJECT -901-2851

COCATION: Secregire 2

RECORD OF BOREHOLE 90:54

BORING DATE: Judy ID 1980

BHEET 1 OF 1

DATUM: GEOGETIC



SAMPLER HAMMER, 61 Skg; DRCP: 780mm

PENETRATION TEST HAMMER 63-549, DROP, 760mm

***			***		*****																
	METRES	3	BOYFING METHOD	BOILPROFILE			L	AMP	3.55	RESIS	MIC PEI TANCE,	NETRATI BLOWS	ON V0.3m		HYDR	ALLICO K on	ONDUCT	IVITY,	. T	-1 G	
			¥		ğ		E E		F		,				10	10	10	. 14	·3 T	N S	PIEZOMETER OR
		1	2	DESCRIPTION	ž	ELEV.	NUMBER	٤	\$		A STREE	NGTH	neLV- +		V	VATER C	ONTENT	PERC	ENT	Ē.	STANDPIPE INSTALLATION
ľ	5	3	ğ		BTRATA PLOT	DEPTH (PI)	ž	[BLC/WB/0.3m	Cut, let		40	19 - V.mari 11 00	u-0		Wp			WI II	ADOITIONAL LAB. TEBTING	
H		h	П	Ground Surface	-	95.21	┝	┝	H			1	1	-	├ ─				90		
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ŀ	1			2				8		52	1									15	Native Backfill
F	ч	٤١	E	FOR SUBSURFACE STRATIGRAPHY, SEE RECORD OF BOREHOLE 90-5B					1]	l			Т	1		
E		3		SEE RECORD OF BOREHOLE 90-5B				l	l	 	 		-	\vdash	 					1.74	
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PROJECT, BOT-2831

LOCATION: See Figure 2

RECORD OF BOREHOLE 90-48

BORING DATE: July 10,1999

SHEET 1 OF 1

CATUME GEODETIC

SAMPLER HAMMER, 63.5kg; CHOP, 760mm

PENETRATION TEST HANNER, \$1.5kg, DROP, 786m

															•				Ann 🔾
y 8	F	SOIL PROFILE			8	AMP		PERMIT		NETRAI , BLOW			HTO	WULC C	XONDUC	TMIY,	T		
DEPTH SCALE METRES SORING METHOD		Parameter -	Ę	ELEV.	ĕ	in in	70.9m			1,			i 1	,	5 1: 1	o 1	· 1	ANDE	PIEZOMETE OR
DEPTH SCALE METRES BORING METHOD		DESCRIPTION	BTRATA PLOT	ОЕРТН	NUMBER	٤	BLOWB/0.8m	SHEAR Cu, MP	8	NGTH	netV-	q-0		HATER Her	XONTEN OV	T, PERC	ENT W	ADDITIONAL LAB. TEBTING	STANDPIPE INSTALLATIO
\dashv	+-	and Surface	투	(m) 95.21	╀	- 20	F	l a	•	40	60	**	_	20	40		60		
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'[]	Co	mpact brown to gray SILT and NDY SILT		* 8	S												59		
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Mand Auger			H		H				_										Bentonite Seel
2	[Ш	<u>92.7</u> 7 2.44															1
				244							3.57					T			Native Backfill
•	Loo	se grey SANDY SILT and IY SAND with silty fine	腊		Ц														
	san	seem			2	30 00	9											МН	
Fit			H		П														
•	De	nae silty sand to sandy silt,		91.25 3.98 91.03	,	30 DO	41					- 27				Ц			
		nse silty sand to sandy silt, ne gravel, accessional cobbles LACIAL TILL) of Hole		4.18	H										40				
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l to	50							Gold	er A	lssoc	iates								ED: S.Leighton (ED: DE

PROJECT: 901-2881 LOCATION: See Figure 2

RECORD OF BOREHOLE 90-6A

BORNG DATE: July 12 1980

SHEET 1 OF 1

DATUM: BEQUETIC



SAMPLER HAMNER 63 Skg: DRCP, 760mm

PERETRATION TEST HANDLER (\$5.5kg DROP, 200mm

			SOIL PROFILE				MP		DYNAA	HC PEN	ETPATE							_		unin 🔘
DEPTH SCALE METRES	1	BORING METHOD	- COLITICALE	ь				_	RESIST	ANCE,	BLOWS	0.3m			AUUC C	/3 -5	-4 -4 +	. a I	32	PIEZOMETER
METH	,	2	DESCRIPTION	TA PL	ELEV.	NUMBER	TYPE	BLOWB/0,3m	SHEAR	STREN	ETH (9.0	-		<u> </u>	T. PERC	-	AODITIONAL LAB. TESTING	OR STANDPIPE
0	000		9)	BTRATA PLOT	DEPTH (pr)	₹	-	ğ	CULLER			wm.V- @			Wp	O#		įw m	32	INSTALLATION
- 0			Ground Surface		93.82															∇
					4.00												-			Sentonite VVV
		E																		
	- V	olid B	FOR SUBSURFACE STRATIGRAPHY, SEE RECORD OF BOREHOLE 90-6B												 	-		-		Native Backriss
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PRÉMECT: NOT-2831

RECORD OF BOREHOLE 90-68

LOCATICAL See Figure 2 SAMPLER HAMMER, 62 Skg: DROP, 760mm. BORING DATE: July 13 1990 DATUM. GEODETIC

PERETRATION TEST HAMMER, 85.580; DRICH 708

																				
y		BORING METHOD	SOIL PROFILE			8	AMP		DYNAMIC PEN RESISTANCE, I	ETRAT BLOWS	ION 1/0.3m		HYDR	WUUC C	ONDUC	IMIY,	T			
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PROJECT: 831-260 LOCATION: See Plan

RECORD OF BOREHOLE 94-1

BORING DATE: Feb. 4, 1998

SHEET 1 OF 1

DATUM: Geodetic



SAMPLER HAMMER 63 Sky: DROP, 760mm

PENETRATION TEST HAMMER 63 Skir DROP 7870-0

			SOIL PROFILE			, .			I CROWN BO								akigo (2) s		
SALE		O FO	SOLFHORIZ	Ī'n	$\overline{}$	┢	AMP		DYNAMIC RESISTAN	CE, BLOW	5/0.3m)	HYDE	K, c	TVS	TIMIY,	T	숙일	PEZOMETER
DEPTH SCALE METHES		BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOW8/0.3m	SHEAR ST Ca, k/Pa	RENGTH	rsst,V-	- Q-0 - U-O		VATER C	بە—س		ENT WI 80	ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATION
- •			Ground Surface	✝	B2.09	T	Т				T	T		T		_	-		
Brist selfs		===	Dark brown silly TOPSOIL	57.72	1		170.00		F. F. F. F. F. F. F. F. F. F. F. F. F. F	a a a a a a			22 -22 -22			2 22.0° per 10°			Bentonite Seal
			Loose brown SANDY SILT, some sity sand layers																Seed VIVI
1	ret Auger	200mm Diam (Hallow Stem)	Compact brown to grey sandy silt, some clay, gravel, cobbles and boulders (GLACIAL TILL)			1	50 DO	8											Native Backsii
	Por	200mm Dia	and boulders (GLACIAL TILL)			2	50 00	29											50mm PVC #10 Slot
						3	50 DG	15											Screen
- 3	_		End of Hole Refusal to Auger	拼	89,17 2.92														
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DEI	<u></u>	18	CALE															1000	

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Golder Associates

CHECKED: RAM

PROJECT 931-2960 LOCATIONS Sew Plan

RECORD OF BOREHOLE 94.2

BORING DATE: F68:7, 1964

SHEET I OF I



SAMPLER HAMMER, 63 Skg: DROP, 700mm.

PERETRATION TEST HAMMER 65.50g, DROP, 700mm

a k	HOOF		SOIL PROFILE	Ŀ		H	WPL		DYNAM RESIST	RC PEN ANCE,	ETRATI BLOWS	ON /0.3m	<u> </u>	HYDE	wulc d	XONDUC Na	TMIY,	T	75		
METHEB	- BORING METHOD	4	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR Cu, kPt	STREN		net.V - 4 rem.V - 6		1	₩p }	ONTÉM OVENI		NT WI 80	ADDITIONAL LAB. TEBTING	PIEZOM OR STÁND INSTALL	PIPE
•	W 1		Top of ice ICE		92,61 0.00 92,46	1,000	100		F 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			t e John S		· · · · · ·						Nathe	7
			Dark brown sitty TOPSOIL		0.15 92.15					9										Native Becklift	
	l				0.48					-	<u></u>	*	- 2	_		-	-				
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			Loose brown to grey SILTY SAND, some fine to coarse sand and			L								-						Bentonite Seal	
			sandy silt																	- 1	
						2	50 DO	4							0					99 95 93	† *. *
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ı	Power Auger	Hodow Sta			90.32 2.29	3	88	20						c							
	Power		v ·												-					Native Backsii	
,	1		8											5				81			
		۱				٠	50 CC	10						0						50mm PVC #18 Slot Screen	
			Loose to compact gray sandy silt, trace clay, some gravel and cobbles, some pockets of line to medium sand (GLACIAL, TILL)									(1)								4	
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1 to 30

Golder Associates

LOGGED: RAM
CHECKED:

PROJECT R31-2360

RECORD OF BOREHOLE 943

SHEET 1.0F s

PENETRATION TEST HAMMER, 83,58G, DROP, 788mm

LOCATION: See Plan: SAMPLER HAMMER, 63 Sky: DRGP: 750mm

BORING DATE: Feb. 8, 1964

DATUM: Geodetic

CHECKED



DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3ml SOIL PROFILE HYDRAULIC CONDUCTIVITY, PIEZOMETER OR BTRATA PLOT TYPE ELEV. STANDPIPE INSTALLATION DESCRIPTION SHEAR STRENGTH Cu, kPa ruty- + Q-0 WATER CONTENT, PERCENT OEPTH (m) Top of ice 92,95 ICE Dark brown silty TOPSOIL Brown SANDY SILT 50 7 00 7 50 DO 10 50mm PVC #10 Slot Scmen Loose brown to grey SILTY SAND, some sandy six 30 8 00 8 MH 50 23 DO 23 0 Compact grey sandy silt, trace clay, some gravel and cobbles (GLACIAL TILL) 50 Za 50 17 0 88.07 4.88 End of Hole Refusal to Auger **DEPTH SCALE** LOGGED: RAM 1 to 30 **Golder Associates**

PROJECT: 921-2360 LOCATION: Bee Plan

t to 30

RECORD OF BOREHOLE 94-4

BORING DATE: Feb. 7, 1994

SHEET FOF F

CHECKED:



SAMPLER HAMMER, 63 Skg; DROP, 760 mm

PENETRATION TEST HAMMER, 63-5kg; OHOP, 780mm

**********	-	-	******																
¥.	<u>ן</u>	SOILPROFILE	1 -		s	AMPI		OYNAMIC PE RESISTANCE	BLOWS	10N 3/0.3m	1	HYO	PAULIC (CONDUC 10/3	CHVITY,	Ī			<i>*************************************</i>
DEPTH SCALE	CONTEN ONIGO	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STREE C4, kPa	HGTH:		+ q.e		WATER C	o		ENT -{WI	ADDITIONAL LAB. TESTING	PIEZON OI STAND INSTALL	A PPE
	Ц	Top of fee		93,11	Г	1	十		Т	T	T	╁┯	-	-	-	1	┿	ļ	
	-	Clark brown silty TOPSOIL	26.66.65	6.00		-			tay da ngapar dan da					A				Bentonite Seal	ma
- 1 - 1		Loose brown to gray SILTY SAND		92,68	1	50 DO												Native Becksil	
2				91.59 1.52	2	Se DO	22					0						Section 1 Sectio	
	Power Auger	SOUTH LANK POOREN SIGN)	A A A A A A A A A A A A A A A A A A A		3	\$0 OO	34					0						Native Backfill	
		Compact to dense grey sandy silt, trace clay, some gravel and colbites (GLACIAL TILL)	*****		4	50 DO	14					0					мн	50mm PVC #10 Slot Screen	
- 4					5	50 DQ	22					0						8	
- 5		End of Hole	A STATE OF THE STA	88.05 5.06	•	SO DO	> 100					0				32	-		
- 6		End of Hote Refusal to Sampler		3.00					5%									W.L in Screen at Elev.82.25m Mar. 4, 1994	
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DE	PTH	SCALE															LOCG	ED- BAM	\neg

Golder Associates

STATE OF STATE LOCATIONS HEREIGIPLAN BOHING DATE: NOV 25/02 DATUM PERETRATION TEST HAMMER 21/249; DROP, FRAME SAMPLER HAMMER, 21 2kg; DROP, 760mm. DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m BORING METHOD DEPTH SCALE METRES ADDITIONAL LAB. TESTING PIEZOMETER OR STANDPIPE INSTALLATION BLOWS/0.3m 3 ELEV. SHEAR STRENGTH Cu, kPa + -Vann Q-**6** U-0 WATER CONTENT, PERCENT DESCRIPTION DEPTH <u>o₩</u> Wp |-(m) GROUND SURFACE Dark brown silty TOPSOIL BENTONITE SEAL NOTE TO WALLES CORRECTED FOR 1/3 W . HAMINER Brown SANOY SILT acattered trace of gravel. 203mm CME 55 POWER AUGER 06mm LD, HCLLOW STEK AUGER 50 DQ 11 Loose to compact, brown to grey stratified SILTY fine SAND. 50 00 2 SAND Compact, grey SILTY SAND, some gravel, trace clay. (Glacial Till) 50 DO END OF BOREHOLE Auger Refusal

DEPTH SCALE

1 to 50 Golder Associates

LOGGED: PH

CHECKED: PAS

PROJECT: 97 (-2025)

Recorded of Edget (018=39/2

BORING DATE: DEG.18-19/9/

SHEET I GE 1

DATE OF

LOCATION BEFORE TO PLAN

SAMPLER HAMMER 21 Pkg, DROP, 760mm PENETRATION TEST HAMMER 21,2kg DROP 780 DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m SOIL PROPILE SAMPLES ADDITIONAL LAB. TESTING PEZOMETER BLOW8/0.3m OR STANDPIPE INSTALLATION NUMBER ELEV. TYPE DESCRIPTION SHEAR STRENGTH nat.V- + Q-0 WATER CONTENT, PERCENT DEPTH Cu, kPa Wp |--0W-(re) GROUND SURFACE PEAT CONCRETE NOTE CORRECTED FOR 1/3 W . HAMINER Grey SILTY fine SAND. 50 7 92.42 1.22 50 13 BENTONITE 8W 00 50 12 DO 12 SAND 50 20 DO 20 Compact, grey SANDY SiLT, some gravel, cobbles, coc. boulder. (Gladal Till) 8W DO 8W | DO BENTONITE SEAL 00 NATIVE CAVED SELICA SAND AW DD 11 50 DO 12 00 13 14 AW 00 BENTONITE SEAL Sound, grey DOLOMITIC LIMESTONE (BEDROCK) T.C.R 89.5% 8.C.R 99% R.Q.D. 75% 15 AW DO SILICA END OF BOREHOLE

DEPTH SCALE

1 to 50

DATA INPUT:

Golder Associates

LOGGED: PH

CHECKED: PAS

PROJECT: 971-2925

LOCATION: REFER TO PLAN

RECORD OF BOREHOLE 97-3

BORING DATE: JAN.14-18/98

SHEET 1 OF 1

DATEM:



SAMPLER HAMMER, 21.2kg; DROP, 750mm

PENETRATION TEST HAMMER, 21.26q; DROP, 760mm

STA DESCRIPTION & ELEV. W S CHIEF PROPERTY AND A WATER COMPANY OF STA	OMETER OR NOPIPE NULATION
STA DESCRIPTION LE U. STA STRENGTH DALV- + Q. O WATER CONTENT, PERCENT OL, MPA CAL,	NOPIPE
E (m) 2 (3 Cr xer venv. a 0.0 Mb - 0 Mm 43	
0 GROUND SURFACE 93.79 9.00	
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DEPTH SCALE LOCGED, BU	
1 to 50 Golder Associates LOGGED: PH CHECKED: PAS	1

PROJECT: 03-1120-846

RECORD OF BOREHOLE: 03-1

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 24, 2003

DATUM:

SAMPLER HAMMER, 64kg; OROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

	Г	7	SOIL PROFILE			1.	1200	ES	DYNA	MIC PE	NETRA	non	-	НУС	-2-0					, 64kg; DROP, 760m
METRES	BORING METHOD		SUL PROFILE	15			-	_	1	STANCE 20	E, BLOV	110K 1870.3m 60	80		4, en		CTIVITY,	101	ZŽ.	PIEZOMETER OR
F	2		DESCRIPTION	STRATA PLOT	ELEV. DEPTH	NUMBER	E	BLOWSALZm		R STRI	NGTH		+ Q. @			CONTE	NT PERC		ADDITIONAL LAB. TESTING	STANDPIPE INSTALLATION
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PROJECT: 03-1120-846

RECORD OF BOREHOLE: 03-2

BORING DATE: September 24, 2003

SHEET 1 OF 1

DATUM:

LOCATION: See Site Plan

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

SIALE	THOD	SOIL PROFILE	7=	r	L.	WPE	_			NETRATI BLOWS		1	HVD		CONDUC			₹2	PIEZOMETER
DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLCMB/0.3m	SHEA Cu, ki	R STRE	HQTH'	nst V. + rem V. E	B0 Q - 0 U - O		WATER Vp I	CONTEN	IT PERC	f W(ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATION
		Ground Surface Very loose black fibrous PEAT	1	94.68							Ī	L		Ť	Ĩ.	Ī	Ĭ		
		Very loose diack distous PEA!		4.50	1,	50 50	PM												Bentonite Seal
		Loose to compact grey SANDY SILT		93.87 10.0	2	38	١.									1		ŀ	Silica Sand
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			H		3	50 00	15			1		,					1.		PVC #10 Slot Screen
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		End of Borehole Sampler Refusal		3.43	Sec. 0.50						5								0 E 0
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RECORD OF BOREHOLE: 03-3

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 22, 2003

DATUM:

Ī	8	SOIL PROFILE	_		SAA	_	_	DYNAM RESIST	IC PENETRA VANCE, BLOV	TION VS/0.3m	1	HYDR	AUUC CO	ONDUÇTI	MTY. T	ود	PIEZOMETER	R
	BORÍNG METHOO	DESCRIPTION	STRATAPLOT	ELEV. DEPTH (m)	NUMBER	TYPE	LOWS/0.3m	SHEAR 'Cu, kPa	STRENGTH		90 ' 0 · 0	W		ONTENT	r ⁴ tọ ^{3 1} PËRCENT ——— I WI	ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATION	i
ł	<u>—</u>	Ground Burlace	<u> </u>	V-4	Н	-	-	- 29	40	60	80		0 2	Î	40	\vdash		
1	T	Very loose black fibrous PEAT		00.9		88 00	2										Bentonite Seal	
-		Compact grey SANDY SILT		0.97	_	50 50 50 50	10				١						Stice Send	
	Coen Hole	Compact to dense grey fine sand and gravel (GLACIAL TILL)	H	1,52	-	80 80 80	22		ŀ								Bentonite Seal	
State of Street, or other Designation of the last of t			U		⊣	50 00	42								·		32mm Diam, PVC #10 Slot	
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RECORD OF BOREHOLE: 03-4

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 23, 2003

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

_	8		SOIL PROFILE			SA	MPI	1	DYNA	MIC PE	NETRAT	10N S/0.3m	X	HYDR	K cm	CHOUC	TIVITY.	Ī	ود	PIEZOMETER
METRES	BORUNG METHOD		ē	STRATA PLOT	ELEV.	2	'n	6.0 E.0		<u> </u>	40 NCTVi	60	80 '	1		<u> </u>	<u></u>	103	ADDITIONAL LAB. TESTING	OR. STANOPIPE
₹.	SER		DESCRIPTION	RATA	DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	Cu, Id	R STRE	NGIN	nat V.	U-0	\ w	PI-		T PERCI	≥NT WI	88	SSTALLATION
-	_	+	Ground Surface	8	\ -	H	-	F	-	20.	40	60	80 -		10	20	30	40 . ·	+	Ē.
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ı	١	١	· 8 8			Ľ	50 DO	'				1]		1		Bentonite Seel
1			Loose grey brown SANDY SILT, trace	謂	0.91	Z,	50 DO	,					1		1				9)	404 X
	1	1	gravet	韤	1.16	H	Ι.	ŀ		- 54		1	1 8	0		1		1	١.	
-	5	8	some gravet, trace day (GLACIAL TILL)		*	3	50 00	17	3 H	100		9.				1	1			Silica Sand
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	1	1	ii ⊕ 1	al l		H	1			:		1			ł	40	-			
,	1	1	Compact grey SILTY SAND, some		2.90	5 1	50 00	٥		۱.					1			22		32mm Diam. PVC #10 Slot Screen
	l	١	gravel, trace clay, interbedded with fine to medium sand (GLACIAL TILL)	1		6	50 DO	15	(3)]		, in	28		1		ĺ			Screen
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RECORD OF BOREHOLE: 03-5

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 22, 2003

DATUM:

CHECKED:

SAMPLER HAMMER, 64kg; DROP, 760mm

_	1 8	SOIL PROFILE			34	MPL	£S.	OYNA	MIC PE	NETRAT	ION	7	HYDI	RAULIC (XONDUC	TIVITY,	Ť	1	l	
83	BORING METHOD		ħ		╁	_	_					ە			20		10° I	ADDITIONAL LAB. TESTING	PIEZOME OR	TÉR
METRES	2	DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	V80				nat V.	a . e		WATER C	ONTEN	F PERCI	-	麗	STANDP	IPE TION
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		Ground Surface			T				20	1	60	80 ·		10		30 	ľ			
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PROJECT: 03-1120-846 LOCATION: See Site Plan

RECORD OF BOREHOLE: 03-6

SHEET 1 OF 1

DATUM;

SAMPLER HAMMER, 64kg; DROP, 760mm

BORING DATE: September 22, 2003

<u>.</u> 1	Ş	-	SOIL PROFILE			s	MPI	E\$	DYNA	MIC PE	NETRAT	NON SAD, Sm	Ţ	HM	RAUUC L on	CONDU	CTIVITY		T] .0	-
METRES	BORING METHOD	DE	SCRIPTION	STRATA PLOT	ELEV. DEPTH		778	BLOWS/0.3m		20 R STRE	40 NGTH	net V.	80 . + α. € ⊕ υ. α	-	10 ⁴ WATER	10°	10 ¹ .	10 ⁴ ÆNT	ADDITIONAL LAB. TESTING	PREZOMÈTER OR STANDPIPE INSTALLATION
-	- B	Ground Surface		E S	(m)	ž	L	3	ı			60	80	_	₩p I	20 1	30	1 WI	₹3	
		Very toose black			0.00		\$0 00	2		E 75 C	T	T		T		T	T	1	T	Bentonite Seal
		Compact to dent trace gravel, fine	se grey SANDY SILT, sand at depth		0.71		50 DO	7												Silica Sand
	Porteble Drift BW Casho		*a*			Н	50 DO	•							ľ				١.	Í
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RECORD OF BOREHOLE: 03-7A

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 30, 2003

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

8	SOIL PROFILE		11	SAI	MPLE	ES	DYNA	MIC PE	ENETE E, BLC	XTAT)N 10.3m	7	HYDI	RAULIC k, car	CONDI As	CT	MITY.	1	rl.,	,	
BORING METHOD	2. 2.	Po	ELEY.	ER .	<u>"</u>	10.3m		9	40	6	ا م	BO .	1		104	. 10		O ₀	ADDITIONAL	PIEZOMETER OR STANOPIPE	
BORIN	DESCRIPTION .	STRATA	DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	CU, KP	*				u- 0	, T	Vp		W		w	8	installatio	M
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	Very loose black fibrous PEAT		9.00		1	I	50					ļ				I			1	Bentonite Seal	ı
1	Loose to compact gray SANDY SILT		0.84	1						8			1	ĺ	1	1					1
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	Compact grey fine to medium sand, gravel, cobbles, some boulders (GLACIAL TILL)	财	2.29			-				109				١.							11
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Π	Grey DOLOSTONE with black shale interbeds		. 7.92	10	NO RC		100	Π,	,	67				1						Silica Sand	
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RECORD OF BOREHOLE: 03-7B

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 30, 2003

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

Ī	백	g		SOIL PROFILE				SA	MPLE	:8	DYNA	MIC PEN	ETRAT BLOW	ION 5/0.3m	Y	HYD	RAULIC (ONDUC	TIVITY,	T	.0	
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	DEPTH SCALE JAETRES	BORING METHOD		DESCRIPTION		STRATAPLOT	DEPTH (m)	NUMBER	TYPE.	BLOWS/0.3m	Cu, kP	R STRE	истн.	nat V. rem V.	+ à. € 9 U- C		WATER (—— <i>₀</i> и	<u>'</u>	ENT Wi	ADDITIONAL LAB. TESTING	INSTALLATION
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RECORD OF BOREHOLE: 03-8A

SHEET 1 OF 1

LOCATION: See Site Plan

1:75

BORING DATE: October 7, 2003

DATUM:

CHECKED: -

SAMPLER HAMMER, 64kg; DROP, 760mm

Γ	8	SOIL PROFILE		·	s	MPL	E\$	DYNA	MIC PE	NETR/	ATIC WSA)N V.3m	7	HYDR	AULIC (CONDUC	πνιτΥ,	T	סר	PIEZOMÉTER
	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV.	-13	TYPE	BLOWS/0.3m		20 R STRI	40	6	0	90 U- Q	· v	VATER C	ONTEN	T PERC		ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATION
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H	Г	Ground Surface Very loose black fibrous PEAT		0.00	-	H	H	-	-	-			-		-		-	-		
		Loose to compact grey SANDY SILY		0.04					3											Bentonite Seal
		Compact grey fine to medium sand and gravel (GLACIAL TILL)		1.33						S4		٠								
Pillo	를				١.							·								Silica Sand
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	L	Dark gray dolomite boulders, trace gray fine sand (GLACIAL TILL)		\$.11		NQ	00	- 1.50				•								Bentonite Seal
		Light grey to dark grey DOLOSTONE with black shale interbeds at depth		5.64].[ŀ				Silica Sand
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RECORD OF BOREHOLE: 03-8B

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: October 7, 2003

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

METRES	BORING METHOD	F		 0€	SCRIPT	IL PROF	FILE		STRATA PLOT	ELEV.	E	TYPE	£			40		30 · O	v	VATER C	ONTEN	O ⁴ PERCE		ADCITIONAL LAB. TESTING	PIEZOMET OR STANDPII INSTALLAT	PE
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RECORD OF BOREHOLE: 03-9A

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: October 17, 2003

DATUM:

SAMPLER HAMMER, 64kg; OROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

ğ	SOIL PROFILE			2	AMPI	UES	RES	STAN	IÇE, E	LOW	ON 2/0.3m		l nio	k, an	CONDUC /s	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		1 3 E	PIEZOME	TER
BORING METHOD	• 4	STRATA PLOT	ELEV.	15		Ø.3m	<u> </u>	20	40			80			_	•	10"	ADDITIONAL LAB. TESTING	OR STANDP	
ZZ.	DESCRIPTION	RATA	ОЕРТН		1	BLOWS/0.3m	CILL	AR S1 LPa	KEN	His	rem V. 4	0.0	•	VATER	CONTEN	•	ENT J WI	98	INSTALLA	
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H	Compact grey line to medium sand and	W.	- 4.00	1		П		1	- [1	1	1				
П	Compact grey fine to medium sand and gravel (GLACIAL TILL)	H										1	l			1	1		1	111
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2	Dense grey fine cand and gravel, some cobbles and boulders (GLACIAL TILL)	1	9.30				- 39	1				1			1	1			İ	
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l	with interbeds of black, very fine grained, Inicidy laminated to thinly bedded shale	異			25.25.25.25.25.25.25.25.25.25.25.25.25.2	500	10		0	0	1				1	-			32mm Diam	18
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DEPTH SCALE 1 : 75

LOGGED: H.E.C.

CHECKED: -----

RECORD OF BOREHOLE: 03-9B

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: October 17, 2003

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

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RECORD OF BOREHOLE: 03-10A

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 29, 2003

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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The same of the sa		Ground Surface Fibrous black PEAT Loase mindled grey brown SANDY St.T., occasional thinly bedded brown medium to coarse sand Loase grey SANDY St.T. trace gravel and day (St.ActAL Tit.L) Fractured tank grey to light grey subtitiographic to medium crystaline, thinly to thickly bedded DOLOSTONE with interbeds of fresh black, very fine grained, thickly laminated to thinly bedded thate, catche filled vugs and fractures are common	Ground Surface Fibrous black PEAT Loase midtled grey brown SANDY SR.T., occasional thinly bedded brown medium to coarse sand Loase grey SANDY SILT. Compact grey SANDY SILT, trace gravel and day (GLACIAL TILL) Frechared dark grey to light grey subdithographic to medium crystaline, thinly to thickly bedded DOLOSTONE with interbeds of frash black, very fine grained, thickly laminated to thinly bedded shale, calcile filled vugs and fractures are common	Cround Surface Ground Surface Fibrous black PEAT Loase middled grey brown SANDY SE.T., occasional thinly bedded brown medium to coarse sand Loase grey SANDY SE.T., trace gravel and day (GLACIAL THLL) Frechared dark grey to light grey subdithographic to medium crossinine, thinly to thickly bedded DOLOSTONE with interbeds of fresh black, very fine grained, thickly laminated to thinly bedded shale, calcie filed vugs and fractures are common	DESCRIPTION Ground Surface Ground Surface Fibrous black PEAT Loase midtled grey brown SANDY SR.T., occasional thirty bedded brown medium to course sand Loase grey SANDY SR.T., trace gravel 3.10 and day (GLACIAL TRLL) Frechared dark grey to light grey subtithographic to medium crystaline, thirty to thickly bedded DOLOSTONE with interbeds of fresh black, very fine grained, thickly laminated to thirty bedded shale, calcite filed vugs and fractures are common 8 8 8 8 8 8 8 8 8 8 8 8 8	DESCRIPTION DESCR	DESCRIPTION Coround Surface Fibrous black PEAT Loose motified grey brown SANDY SILT, occasional thinly bedded brown medium to coerse sand Loose grey SANDY SILT Frackured dark grey to light grey subdifflographic to medium crystaline, thinly to thickly bedded DOLOSTONE with inherbeds of fresh black, very fine grained, thickly taminated to finity bedded shale, calche filled wags and fractures are common 8 NO DO REC DO REC	DESCRIPTION SLEV. By St. St. EA. Cu, ki Cherrit. (m) Coround Surface Fibrous black PEAT Loase motited grey brown SANDY SR.T., occasional thinly bedded brown medium to coarse sand Loase grey SANDY SR.T., trace gravel and clay (SLACIAL TILL) Fractured dark grey to light grey substitiographic to medium crystaline, thinly to thickly bedded DOLOSTONE with interbeds of fresh black, very fine grained, thickly laminated to thinly bedded shale, celcite filled vugs and fractures are common 8 Mg DD RG 9 Mg DD PAA 9 Mg DD PAA 9 Mg DD PAA 9 Mg DD PAA 9 Mg DD PAA 9 Mg DD PAA	DESCRIPTION DESCR	DESCRIPTION Loss provided grey brown SANDY SILT, occasional thinly bedded brown medium to coarse sand Loss grey SANDY SILT Compact grey SANDY SILT, trace gravel and clay (GLACIAL TILL) Frechared dark grey to light grey sublifregraphic to medium dystaline, thinly to thicky bedded brown filed was and fractures are common Frequency filed was and fractures are common SANDY SILT SANDY	DESCRIPTION Compact Surface SAMPLES SAM	DESCRIPTION DESCR	DESCRIPTION LELEY, WE WILL STRENGTH net V. + Q. • • • • • • • • • • • • • • • • • •	DESCRIPTION DESCR	DESCRIPTION DESCR	DESCRIPTION DESCR	DESCRIPTION Second Surface Second S	DESCRIPTION Secret

DEPTH SCALE

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Golder Associates LOGGEO: H.E.C.

CHECKED: -

RECORD OF BOREHOLE: 03-10B

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 25, 2003

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

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