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REPORT ON

GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER STUDY ST. ISIDORE COMMUNAL WATER SUPPLY WELLS

COPY

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February 2003

021-2805-50

EXECUTIVE SUMMARY

The following executive summary highlights key points only; for complete information and findings, as well as the limitations provided in Section 7.0, it is necessary for the reader to examine the complete report.

Golder Associates was retained by Lecompte Engineering Ltd. (Lecompte) on behalf of Nation Municipality to conduct a *Groundwater Under the Direct Influence of Surface Water* (GUDI) study for the four active communal wells (1, 2, 3, and 5) from which the water supply for the Village of St. Isidore is derived.

The purpose of the study was to determine if the wells are under the direct influence, or are potentially under the direct influence of surface water based on the criteria defined in the *Terms of Reference for Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water* outlined by the MOE in October, 2001. The study looked for physical evidence of surface water contamination, as well as the presence of surface water organisms. A detailed evaluation of bacteriological results for each well was completed. Aquifer characteristics were calculated and estimations of 50 day horizontal travel times were made. Water samples were collected to allow for the comparison of relative ion abundance in groundwater and surface water within the study area., and a particle count study was also completed at each of the four wells to determine if the aquifer was providing effective *in situ* filtration.

In accordance to the MOE Terms of Reference wells 1, 2, and 5 were deemed to be not under the direct influence of surface water and not requiring filtration, and Well 3 was deemed to be potentially under the direct influence of surface water and requiring filtration.

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by Lecompte Engineering Ltd. (Lecompte) on behalf of Nation Municipality to carry out a particle counting study on the four active St-Isidore water supply wells to establish whether the raw water is effectively filtered. The scope of work was outlined in the Golder Work Plan entitled "GUDI Study – Village of St. Isidore Particle Count Study Work Plan". The scope of work for the study addressed the particle count component (Section 3.5) as identified in the MOE GUDI Terms of Reference, and did not include the completion of a hydrogeological study as described in the GUDI Terms of Reference. The particle counting study was conducted between September 5 and October 4, 2002. It was decided that the results of the particle count study (included within this report) warranted the completion of a full GUDI study in accordance with the MOE Terms of Reference. The scope of work for the full GUDI study was outlined in the proposal entitled "Scope of Work and Cost Estimate for GUDI Study – St. Isidore Communal Wells". Authorization to proceed with the GUDI study was received from the Nation Municipality on November 11, 2002.

1.1 Background

The Village of St. Isidore is located approximately 80 km east of the City of Ottawa, within the Nation Municipality (see Key Plan, Figure 1).

The village derives its water supply from four pumping wells (wells 1, 2, 3, and 5) completed in a fractured limestone aquifer. The locations of the wells are illustrated on the Site Plan (Figure 2). Wells 1 through 3 are located south of St. Isidore on Mainville Street. Well 5 is located on the north side of the village on St. Isidore Street. Well number 4 was shutdown in September of 1997 due to concerns about water quality.

The water works system consists of four pumping wells, a water treatment plant, a water distribution system, and a water storage tower. The wells, delivery, storage, and treatment system is operated under a consolidated certificate of approval no. 2052-54FRY9. The water from wells 1, 2, and 3 is treated by aeration, potassium permanganate injection, greensand filtration and chlorination. The water from Well 5 is chlorinated and pumped directly into the water distribution system. Wells 1 through 3 cycle on and off to fill the storage reservoir, and typically run between 9 to 12 hours per day. Well 5 is pumped continuously into the water supply system.

The Ontario Clean Water Agency (OCWA) is the operating authority for the St. Isidore communal water supply system. Pumping and treatment is managed through a control center at the OCWA office located in Limoges.

1.2 Study Objectives

The purpose of the current study was to determine if water supply wells 1, 2, 3, and 5 are under the direct influence or are potentially under the direct influence of surface water based on the criteria defined in the *Terms of Reference for Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water* outlined by the MOE in October, 2001 (MOE, 2001b). These criteria are summarized in a flow chart illustrated in Figure 3.

2.0 INVESTIGATION PROCEDURES

For the purpose of characterizing the geological and hydrogeological conditions in the area of St. Isidore, a review of overburden geology, bedrock geology, drift thickness, and topographic maps, as well as various publications and reports pertaining to the geology and hydrogeology of the area was completed.

For the purpose of characterizing the local geology and hydrogeology in the immediate area surrounding each of the wells, a review of water well records and previous local studies was completed. Historical pumping test data was reviewed for each of the communal wells (WESA, 1984; Intera 1989; Intera 1991b; Intera 1991c). Estimates of transmissivity and storativity for the bedrock aquifer in the study area were obtained from the pumping test data. From this data the hydraulic conductivity of the aquifers was calculated according to equation 1, and an estimate of the average linear groundwater velocity was calculated according to equation 2.

$$T = Kb \tag{1}$$
$$v = (Ki)/n \tag{2}$$

where:

T = aquifer transmissivity
K = hydraulic conductivity
b = saturated thickness of the aquifer
v = average linear velocity
i = hydraulic gradient
n = porosity

Distance-drawdown data obtained from historical pumping tests were used to estimate the horizontal component of the hydraulic gradient around the wells. The gradient was then used in the calculation of the average linear groundwater velocity around each of the wells under pumping conditions. In each case the pumping rate used during the pumping test was slightly higher than the actual pumping rate presently used in the communal wells. As a result, the calculated average linear groundwater velocity should provide conservative estimates of horizontal travel times to the wells.

Capture zones for each of the bedrock wells under pumping conditions were calculated using equation 3 which estimates the extent of a capture zone for a confined aquifer when steady state conditions have been reached (Grub, 1993).

(3) $$x = -y/\tan(2\pi Tiy/Q)$$

where:

y = the half width of the capture zone perpendicular to groundwater flow
x = distance to the downgradient edge of the capture zone from the well
Q = pumping rate

Pumping rates, water levels under static and pumping conditions, and ground surface elevations at the locations of the wells were obtained from the Limoges branch of OCWA.

Surface water features around each of the wells were identified from examination of topographic maps, as well as on-site visits of the areas surrounding each of the wells.

2.1 Water Quality Investigation

Untreated water at each of the wells was sampled and analyzed for campylobacter and aerobic spores, as well as for a suite of parameters typically used to characterize municipal water supplies.

A review of concentrations of fecal coliforms, total coliforms, and heterotrophic plate counts measured weekly in raw water collected at each of the wells between January 1999 and November 2002 was conducted. The review was intended to determine if bacteria detections could be correlated with precipitation events.

A Microscopic Particulate Analysis (MPA) was completed on raw water from each of the four active communal wells. The analysis involves the filtration of a large volume of water (at least 2000 litres is recommended) and subsequent analysis of material trapped on the filter. The laboratory identifies surface water indicators such as diatoms, algae, insect parts, rotifers, plant debris etc. if they are present. The results are then used to assign a relative risk factor to the well tested. The relative risk factor provides a quantitative way to assess the risk that a given well is under the influence of surface water.

2.2 Particle Count Study

2.2.1 Particle Count Study Objectives

The objective of the particle count study was to evaluate the need for filtration in accordance with the conditions in Section 3.5 of the MOE GUDI Terms of Reference. Section 3.5(ii) of the Terms of Reference states that the all of the following conditions must be met in order to conclude that the aquifer is providing effective *in situ* filtration:

a) particle count data must show that the water consistently contains significantly less than 100 particles per millilitre that are 10 microns or greater in size;

b) it must be confirmed that the particle count is not likely to change during storm, season or other regular environmental changes; and,

c) the raw water must be characterized by good microbiological quality.

The specific objectives of the particle count studies were, therefore, to evaluate the raw water quality from each of the four wells in terms of the above conditions (a) and (b).

2.2.2 Particle Count Study Methodology

Particle counters were installed in-line at each of the wells to sample groundwater before it is pumped to the treatment facility. Wells 1 through 3 were cycled on and off simultaneously depending on system demand (usually pumped between 9 and 12 hours per day). Water from Well 5 is chlorinated and then pumped continuously into the water supply system.

The particle counting equipment used in the study for Wells 1 and 2 were Water Particle Counter Model WPC-22 manufactured by ARTI (Accurate, Reliable, Traceable Instruments) Inc. The particle counting equipment used at Wells 3 and 5 were 2200 PCX Online Particle Counting Sensors manufactured by HACH. Both units were capable of counting particle as small as 2 microns.

All particle counting equipment was rented and operated by Golder. The equipment was supplied by Pine Environmental Services Inc. and ClearTech Industries Inc. both of Mississauga, Ontario. The particle counting units were installed by trained individuals from each of the respective companies in order to ensure the quality of results. Golder was also provided instructions on the set-up, use and maintenance of the equipment and the related software. Calibration certificates for the particle counting equipment were provided by Pine Environmental Services Inc. and ClearTech Industries Inc.

The particle counters were configured to monitor the number of particles per millilitre that were 10 microns or greater in size. The intent was to record particle count measurements a minimum of approximately 30 times per hour for the duration of the study. The particle counter equipment used a personal computer as a data storage unit, and data was downloaded at least once per week.

Representative total daily precipitation data was obtained throughout the particle count study from a rain gauge installed and maintained by Lecompte in the Village of St. Isidore.

The particle counters were installed at each well for a minimum duration of two weeks to establish background particle count numbers for each well and for the identification any fluctuations in the particle count background values corresponding precipitation events. If no correlation between changes in the particle count data and large precipitation events could be made then this would be evidence that the particle count is not likely to change during storm, season or other regular environmental changes.

At the same time, the particle count values could be compared to the criteria stipulated in the MOE Terms of Reference (i.e., compared to 100 particles per millilitre in the size range 10 microns and greater). A time frame of two weeks was selected on the basis that two weeks might be sufficient time to span a significant precipitation event as well as demonstrate consistency in results during dry periods. A review of particle count and precipitation data following two weeks of monitoring would determine the need to extend the length of the monitoring period. At most wells the two-week duration had to be extended to one month.

Particle count study dates and duration are summarized in the following table:

Well	Start Date	End Date
1	September 5, 2002	October 4, 2002
2	September 5, 2002	October 4, 2002
3	September 12, 2002	October 4, 2002
5	September 5, 2002	October 4, 2002

Note: Data collection was interrupted at Well 2 from September 8 until September 11 due to a communication error in the particle counting equipment.

3.0 CONCEPTUAL MODEL OF STUDY AREA

3.1 Geology

3.1.1 Surficial Geology

The surficial geology of the study area is illustrated in Figure 4. The majority of the central area consists of low permeability Champlain Sea, clay deposits. To the north, areas of beach sand deposits overly the marine clay deposits. The southeastern portion of the study area consists primarily of glacial till with isolated areas of sand and gravel.

Within the study area the total drift thickness varies from 0 metres (bedrock outcrops) to approximately 60 metres in the northwestern portion of the study area (Gwyn and Thibault, 1973). The general overburden stratigraphy from bedrock surface to ground surface for the study area is as follows: glacial till unit overlain by a thick sequence of marine clay deposits, followed in isolated areas by fine to medium grained sand deposits (primarily found in the northern portion of the study area).

The till unit is a silt to sandy silt, pebbly till that occurs discontinuously within the study area. North of St. Isidore till thicknesses of up to 8 metres occur, where as in the immediate vicinity of the Village the till attains a maximum thickness of approximately 4 metres (MOE Water Well Records). Figure 5 displays a generalized East-West cross-section showing the thickness of surficial deposits in the vicinity of communal wells 1, 2, and 3. The till unit is exposed at surface over much of the southeastern portion of the study area and has been described as a basal till unit that is a cobbly to bouldery, sandy, silt till (Gwyn and Lohse, 1973).

The marine clay was deposited when the study area was inundated by the waters of the Champlain Sea. In areas where the till unit is absent, the sequence of marine clays overly the bedrock directly. The clays are interpreted to be a combination of deep-water deposits and intermediate- or confined-water sediments of interbedded clay and sandy clayey silt, which are indicative of the variations in depositional environments within the Champlain Sea. The thickness of the clay deposit varies between 9 to 14 metres in the vicinity of communal Wells 1, 2, and 3 (see Figure 5). The confining clay layer is approximately 25 to 30 metres thick in the vicinity of Well 5.

The fine to medium grained sand present to the north of St. Isidore were interpreted to be delta deposits left over the marine clay following the recession of the Champlain Sea.

3.1.2 Bedrock Geology

The bedrock geology of the study area is illustrated in Figure 6. The study area is primarily underlain by the Lindsay Formation changing to the Carlsbad Formation approximately 5 kilometres to the north of St. Isidore. The change in bedrock formation marks the location of the Russell Fault.

The Lindsay Formation consists of interbedded crystalline limestone, calcareous shale and calcarenite. The Carlsbad Formation consists of interbedded dark grey shale, fossiliferous calcareous siltstone, and silty bioclastic limestone.

The regional bedrock surface dips gently to the northwest (Gwyn and Girard, 1973). Abrupt changes in bedrock elevation and occasional bedrock depressions are likely a result of local bedrock fault displacements.

3.2 Hydrogeology

3.2.1 Surface Water and Drainage

The topography of the study area is flatlying with elevations ranging from approximately 60 to 70 metres above sea level (masl). All of the supply wells for St. Isidore are located within the watershed of the South Nation River which empties into the Ottawa River approximately 30 km to the north. The East Branch of the Scotch River flows within approximately 0.5 kilometres of the southwestern corner of the Village, and is the main surface water channel in the area. The abundance of low permeability clays and silts in the overburden contributes to ponding of water in areas of topographic lows. As a result, many of the natural drainage channels within the study area have been modified to improve field drainage.

3.2.2 Local Aquifers

An investigation of the local geology in conjunction with MOE water well records has identified three potential aquifers within the study area:

- a deeper bedrock aquifer;
- an upper fractured bedrock and basal till aquifer; and
- surficial sands and gravels aquifers.

Each of the aquifers will be discussed in detail in the following sections.

Deeper Bedrock Aquifer

Locally the deeper bedrock aquifer (defined as the zone below the upper 3 to 5 metres of fractured/weathered bedrock) has the capacity to supply domestic requirements but yields are highly variable depending on the number and size of fracture intersected by the well. Test wells completed within the study area found that the majority of significant water inflows were encountered within the upper 5 m of bedrock. In general, it was noted that well yield slightly increased with increasing penetration into the bedrock, but water quality tended to decrease with depth. Wells completed within the deeper bedrock aquifer in the study area typically exceed the MOE water quality standards for chloride and total dissolved solids. Overall the deeper bedrock aquifer is deemed to be a poor aquifer due to limited water quantity and poor water quality. As a result, this aquifer is seldom used within the study area.

Upper Fractured Bedrock and Basal Till Aquifer

The upper fractured bedrock and basal till aquifer is found at the contact zone between the overburden sediments and the underlying bedrock unit. The aquifer is made up of the till unit immediately on top of the bedrock and the upper fractured bedrock zone (usually 3 to 5 metres). Often the upper section of the bedrock is more weathered and fractured resulting in a higher hydraulic conductivity than the lower, more massive sections. Groundwater flow in fractured bedrock such as dolostone, limestone, and shales occurs primarily through horizontal fractures. These features are likely extension fractures resulting for erosional and glacial unloading. Overall, the direction of groundwater flow in the fractured rock portion of the aquifer is controlled by the governing hydraulic gradient, and the orientation of the high permeability fractures relative to that gradient. The quantity of water available depend on the thickness of the till and the number of conductive fractures in the fractured zone, as well as characteristics of the till (i.e. percent fine material in the matrix).

Hydraulic testing completed within the study area (MOE, 1982; WESA, 1982, 1984; Intera, 1989, 1990a, 1991b, 1991c) indicated zones of significant transmissivity exist within this aquifer (on the order of 1.0×10^{-3} m^2/s; Intera, 1991c). Wells completed within the upper fractured bedrock and basal till aquifer have been shown to easily supply domestic and small commercial/industrial demands.

According to Charron (1978), water quality within this aquifer depends on the residence time or proximity of the supply well to a recharge zone. Charron describes the evolution of groundwater as it migrates away from the recharge zone as follows: Water near the recharge zone begins with relatively low total dissolved soilds (TDS) (usually <300 mg/L). As the residence time increases, the water tends to evolve into a sulphate rich, and then eventually chloride rich water. As the groundwater progresses through the subsurface it dissolves salts from the aquifer materials resulting in increases in TDS and chloride.

The aerial extent of the till/bedrock aquifer in the study area are largely overlain by several meters to tens of metres of low permeability clays and silts that act as an aquitard by storing water and transmitting it slowly into the aquifer. Throughout the study area, this aquifer is classified as confined. The presence of an aquitard helps to preserve the quality of groundwater in the underlying aquifer by preventing rapid transport of contaminants from the surface into the bedrock.

Recharge to the aquifer is expected to occur in locations where the bedrock outcrops, where the overburden is thin, or in areas where relatively permeable sediments (such as the sandy till material in the southeastern portion of the study area) are in direct contact with the bedrock. Some recharge occurs from storage in the overlying aquitard, especially in areas of local topographic lows where depression focused recharge may occur. The surficial till located to the southeast of the study area is considered to be the main recharge zone with a minor contribution from fractured bedrock outcrops in the study area. The potentiometric head in the upper fracture bedrock and basal till aquifer within the study area generally decreases from southeast to northwest, thus groundwater flow is expected to be generally in a northwest direction (Intera, 1991a).

In general, the water quality and quantity within this aquifer is acceptable for domestic and small commercial/industrial use. Elevated levels of chloride and TDS, as well as sulphide odour have been reported for various locations. In addition, water quality often deteriorates with depth due to the increased age and elongated flow path of the groundwater, which give rise to increased mineralization of the water. This is the primary aquifer utilized within the study area. All four active communal wells in St. Isidore are cased into the top of the limestone bedrock, and are screened in the upper fractured/weathered portion of the bedrock.

Surficial Aquifers

The overburden sequence of marine clays and silty clays that overlie most of the study area have low values of hydraulic conductivity and therefore can not transmit large quantities of water. However, the surficial deposits consisting of beach sands in the northern part of the study area (near Fourier) are capable of supplying water for domestic use, but the supply may be seasonally dependent on precipitation. No water well records were found for wells completed in the marine sand and gravel deposits to the south and southeast of St. Isidore. This may indicate that the thickness of these deposits is not adequate to be utilized by drilled wells. Overall, the proximity of these sediments to the ground surface makes them potentially susceptible to contamination which can lead to significant variations in water quality with these aquifers. As a result these aquifers are seldom used for water supply within the study area.

4.0 GUDI STUDY RESULTS FOR ST. ISIDORE WELLS

4.1 Well 1

4.1.1 Well Characterization and Hydrogeological Setting

Well 1 was originally drilled by Intera as a test-well in November of 1988 (Intera, 1989). The well is located south of St. Isidore on Mainville Road, approximately 1.25 kilometres east of Country Road 9 (see Figure 2). The elevation of the ground surface at this location is 64.7 metres.

Well 1 was drilled to a depth of 17.4 metres below ground surface (mbgs). Three water bearing zones at 15.5, 16.1, and 17 mbgs were noted in the water well record. The borehole log completed by Intera indicates that overburden deposits at the well consisted of clay material approximately 12.2 metres thick. Underlying the clay is approximately 1.8 metres of till material. The low permeability fine grained soil acts as a confining layer, or aquitard to the underlying limestone bedrock aquifer. The borehole log and water well record for Well 1 are included in Appendix A.

A review of test-well logs and over 20 water well records for wells drilled within a 2 km radius of Well 1, indicate the thickness of the overburden clay deposit ranges from 6.4 to greater than 45 metres with most areas having at least 10 to 15 metres of clay cover. As a result, the bedrock aquifer at this location is classified as confined. The confining layer should provide protection from contaminants spilled or applied at ground surface, and limits the potential for direct interaction between groundwater and surface water. The extent of the confining layer is illustrated on Figure 5.

Well 1 is equipped with a submersible pump located 16 mbgs. It is currently pumped at a rate of approximately 2.9 L/s. According to data collected at the well head for 2002, static water levels in the well range from 6.1 to 7.2 mbgs. The maximum drawdown observed during a 72 hour pumping test completed at Well 1 was 2.1 metres (Intera, 1991c).

Based on a 72 hour pumping test and a 144 hour pumping test the transmissivity of the bedrock aquifer in the vicinity of Well 1 was estimated to be approximately 86 m^2/day (Intera, 1989, 1991c). Storativity of aquifer at this location was estimated to be between 2.5×10^{-5} to 3.4×10^{-4} (Intera, 1989, 1991c). Assuming a saturated thickness of 10 metres, the hydraulic conductivity of the bedrock aquifer was estimated to be 8.6 m/day. Using water levels from September 2002 the average horizontal component of the hydraulic gradient for the study area was estimated to be 0.004. The approximate direction of groundwater flow was determined to be North 57 degrees West. Using these values, and assuming a range in porosity of 0.01 to 0.05 for the aquifer, the average linear groundwater velocity within the bedrock aquifer under non-pumping conditions was calculated to be between 0.7 and 3.5 m/day. Thus in 50 days groundwater could travel between 35 and 175 metres under non-pumping conditions.

The horizontal hydraulic gradient for the study area during pumping conditions was estimated from pumping test data obtained from the four communal wells (WESA, 1984; Intera, 1991b, 1991c). The average increase to the horizontal hydraulic gradient observed during pumping tests was 0.0043. This number is added to the horizontal hydraulic gradient in the absence of pumping (0.004) to get the final estimate of horizontal hydraulic gradient for the aquifer during pumping (0.0083). Using the aquifer hydraulic conductivity of 8.6 m/day and assuming a range in porosity of 0.01 to 0.05 for the aquifer, the average linear groundwater velocity within the bedrock aquifer under pumping conditions was calculated to be between 1.4 and 7.2 m/day. Thus in 50 days groundwater could travel between 70 and 360 metres under pumping conditions. The estimated travel time to the well is considered to be conservative for two reasons: 1) the pumping rates used during the pumping test were greater than those used during the operation of the communal well system, and 2) the communal wells are not run continuously (usually only 9 to 12 hours per day) which will allow for recovery of the aquifer reducing the horizontal hydraulic gradient. Table 1 includes values used to calculate travel times.

4.1.2 Description of Local Surface Water Features

Figure 7 shows the location of the active communal wells and a 500-metre radius circle around each well. There are no perennial surface water bodies located within 500 metres of Well 1. The closest perennial surface water body is the East Branch of the Scotch River and is located approximately 750 meters southwest of Well 1. The depth of the East Branch of the Scotch River varies seasonally between 0.1 metres to greater than 1.5 metres. Small and discontinuous ephemeral watercourses, less than 0.20 metres in depth located along Mainville Road (ditches), and small ephemeral ponds, less than 0.20 metres deep located in fields around Well 1 were observed during Fall rains in 2002. The abundance of low permeability clays and silts in the overburden contributes to ponding of water in areas of topographic lows. However, it is considered that these ephemeral watercourses are not directly hydraulically connected to the bedrock aquifer given the presence of thick clay deposits in the vicinity of Well 1 (greater than 10 metres).

4.1.3 Evaluation of Groundwater Quality

Campylobacter was not detected in water collected from Well 1. The concentration of aerobic spores in water collected from Well 1 was measured at 19 CFU per 900 ml; this is considered to be within the range of typical concentrations for groundwater not affected by a surface water source. Certificates of Analysis are included in Appendix B.

Chemical analysis of untreated groundwater collected from Well 1 for a suite of parameters typically used to characterize municipal water supplies showed no exceedances of the Maximum Acceptable Concentration (MAC), Interim Maximum Acceptable Concentration (IMAC), or Aesthetic Objectives outlined in the Ontario Drinking Water Standards (ODWS). The hardness concentration exceeded the ODWS Operational Guidelines at Well 1. The results of these analysis along with the appropriate ODWS standards/objectives are included in Appendix C. Certificates of analysis are included in Appendix B.

In addition to the collection of groundwater samples, two surface water samples were collected and analyzed for general chemistry to allow for comparison of relative ion abundance (results of analysis are included in Appendix C). The surface water sample locations are shown on Figure 7. A Piper diagram was developed showing the relative ion abundance for groundwater samples collected from the communal wells and surface water samples collected within the study area (see Figure 8). In all three sections of the Piper diagram water from Well 1 plots away from the two surface water samples. This indicates the water at Well 1 is not likely directly connected to surface water.

Fecal coliforms and/or total coliforms were sporadically detected in groundwater samples collected on a weekly basis from Well 1 between 1999 and 2002. Levels of Heterotrophic Plate Counts (HPC) in groundwater samples was also monitored during this time period. Events of elevated HPC and/or detection of fecal coliforms and/or total coliforms were intermittent in nature and do not appear to be associated with precipitation events or spring melting. These events may be a results of improper sampling or laboratory error.

An MPA was completed on groundwater from Well 1. The analysis involved the filtration of a large volume of water (2366 litres) and subsequent analysis of material trapped on the filter. The MPA analysis indicated that there is a low risk that the groundwater is being impacted by surface water at this location. Certificates of analysis are included in Appendix B.

4.1.4 Particle Count Study Results and Discussion

Figures 9A and 9B illustrate the effects of pump start-up on the particle count data. Figure 9A displays the particle counts (i.e., the number of particles per millilitre equal to or greater than 10 microns in size) and the total daily precipitation (as measured in St. Isidore) for the entire duration of the particle count study at Well 1. When these results are compared to pump start-up times it is observed that many of the particle count spikes coincide with pump start-up. As a result, in Figure 9B the data for the first 10 minutes after pump start-up have been removed resulting in a more representative plot of particle counts at Well 1. Similar results were observed at Wells 2 and 3, accordingly, all remaining plots have the first ten minutes of particle count data after pump start-up removed (note: Well 5 ran continuously resulting in no spikes associated with pump start-ups).

Figure 9B illustrates the particle counts and the total daily precipitation at Well 1 for the entire duration of the particle count study in St. Isidore. The MOE GUDI Terms of Reference criteria of 100 particles per millilitre is labeled on Figure 9B.

Figure 10A presents the particle counts during a dry period when no precipitation occurred within the study area for Well 1. Figure 10B illustrates the particle counts and total precipitation during a period containing a large precipitation event immediately following the dry period for Well 1.

The number of particles equal to or greater than 10 microns in size measured at Well 1 were consistently less than 100 particles per millilitre with typical counts less than 15 particles per millilitre. Occasional spikes in the particle count data were observed at concentrations up to 120 particles per millilitre (however, spikes are typically below 100 particles per millilitre; Figure 9B). One large spike was observed at a concentration of 427 particles per millilitre on September 20 (Figure 9B). This spike did not occur during pump start-up or during a rainfall event. A spike of this magnitude was not observed at any other time during the particle count study, and is therefore not considered to be a typical result at this location.

The more typical spikes (maximum 120 particles per millilitre) occasionally observed were noted both during dry periods and during periods of significant precipitation (Figure 10A and 10B) indicating the particle counts do not change during storm events, and are unlikely to change due to seasonal or other regular environmental changes.

The presence of overburden deposits, including a confining layer consisting of clay material in the area surrounding St. Isidore likely prevents the direct infiltration of surface water into the underlying bedrock aquifer in which this well is completed. In consideration of the results of the particle counting, indicating an absence of correlation of spikes greater than 100 particles per millilitre greater than 10 microns with large or small precipitation events and overall particle count data showing less than 100 particles per millilitre greater than 10 microns, it is concluded that the aquifer is providing effective *in situ* filtration at Well 1.

4.1.5 Evaluation: Is Well 1 Under the Direct Influence of Surface Water?

Refer to Figure 3 for a summary of the MOE criteria used to classify a well as: 1) under the direct influence; 2) potentially under the direct influence; or 3) not under the direct influence of surface water. The discussion herein will follow the order of the flow chart of Figure 3.

Physical evidence of surface water contamination was not observed in Well 1. The surface water organism, campylobacter, was not detected in water collected from this well and aerobic spores were present in concentrations that are within the typical range for groundwater not affected by a surface water source. MPA analysis completed at Well 1 indicated there was a low risk that the groundwater is being influenced by surface water at this location.

Fecal coliforms and/or total coliforms were sporadically (not "regularly") detected in groundwater samples collected on a weekly basis from Well 1 between 1999 and 2002. There are no perennial surface water bodies located within 500 metres of Well 1. Using hydraulic parameters calculated from a 144 hour pumping test it was estimated that groundwater in the vicinity of Well 1 could travel between 70 and 360 metres in 50 days under pumping conditions. Given that the closest perennial surface water body is located approximately 750 metres away, Well 1 is not located within 50 days horizontal travel time from a surface water body.

The bedrock aquifer from which the well is drawing is confined with approximately 12 metres of clay material present at Well 1. The identified water bearing zones at Well 1 are all greater than 15 metres below ground surface. The well is not part of an enhanced recharge/infiltration project. Observation of changes in surface water levels or hydraulic gradients beside surface water bodies was not performed as part of the current study. However, it should be noted small, shallow ephemeral watercourses located in the vicinity of Well 1 are not expected to be hydraulically connected to the bedrock aquifer given the presence of the thick clay deposits surrounding Well 1 (greater than 10 metres). As illustrated by Figure 8 (Piper Plot) chemical water quality at Well 1 appears to be distinct from local surface water samples.

The results of a particle counting study undertaken at Well 1 indicated that the bedrock aquifer at this location is providing effective *in situ* filtration, and that particle counts are not likely to change during storm, season or other regular environmental changes.

In conclusion to these statements, in accordance with the MOE Terms of Reference Well 1 is classified as being not under the direct influence of surface water.

4.2 Well 2

4.2.1 Well Characterization and Hydrogeological Setting

Well 2 was originally drilled by Intera as a test-well in March of 1991 (Intera, 1991b). The well is located south of St. Isidore on Mainville Road, approximately 1.7 kilometres east of Country Road 9 (see Figure 2). The elevation of the ground surface at this location is 65.4 metres.

Well 2 was drilled to a depth of 22.3 mbgs. One water-bearing zone at 18.6 mbgs was noted in the water well record. The borehole log completed by Intera indicates that overburden deposits at the well consisted of clay material from surface to approximately 14 metres. Underlying the clay deposit was approximately 4 metres of gravel till. The low permeability clay deposit acts as a confining layer, or aquitard to the underlying limestone bedrock aquifer. The borehole log and water well record for Well 2 are included in Appendix A.

A review of test-well logs and over 20 water well records for wells drilled within a 2 km radius of Well 2, indicate the thickness of the overburden clay deposit ranges from 6.4 metres to greater than 45 metres with most areas having at least 10 to 15 metres of clay cover. As a result, the bedrock aquifer at this location is classified as confined. The confining layer should provide protection from contaminants spilled or applied at ground surface, and limits the potential for direct interaction between groundwater and surface water. The extent of the confining layer is illustrated in Figure 5.

Well 2 is equipped with a submersible pump located 20.1 mbgs. It is currently pumped at a rate of approximately 3.1 L/s. According to data collected at the well head from 2002, static water levels in the well range from 10.1 to 11.0 m below ground surface. The maximum drawdown observed during a 24 hour pumping test completed at Well 2 was 7.2 metres (Intera, 1990).

Based on a 24 hour pumping test the transmissivity of the bedrock aquifer in the vicinity of Well 2 was estimated to be 67 m^2/day, and storativity of aquifer at this location was estimated to be 1.6×10^{-4} (Intera, 1991b). Assuming a saturated thickness of 10 metres, the hydraulic conductivity of the bedrock aquifer was estimated to be 6.7 m/day. Using water levels from September 2002 the average horizontal component of the hydraulic gradient for the study area was estimated to be 0.004. The approximate direction of groundwater flow was determined to be North 57 degrees West. Using these values, and assuming a range in porosity of 0.01 to 0.05 for the aquifer, the average linear groundwater velocity within the bedrock aquifer under non-pumping conditions was calculated to be between 0.5 and 2.7 m/day. Thus in 50 days groundwater could travel between 25 and 135 metres under non-pumping conditions.

The horizontal hydraulic gradient for the study area during pumping conditions was estimated from pumping test data obtained from the four communal wells (WESA, 1984; Intera, 1991b, 1991c). The average increase to the horizontal hydraulic gradient observed during pumping tests was 0.0043. This number is added to the horizontal hydraulic gradient in the absence of pumping (0.004) to get the final estimate of horizontal hydraulic gradient for the aquifer during pumping (0.0083). Using the aquifer hydraulic conductivity of 6.7 m/day and assuming a range in porosity of 0.01 to 0.05 for the aquifer, the average linear groundwater velocity within the bedrock aquifer under pumping conditions was calculated to be between 1.1 and 5.6 m/day. Thus in 50 days groundwater could travel between 55 and 280 metres under pumping conditions. The estimated travel time to the well is considered to be conservative for two reasons: 1) the pumping rates used during the pumping test were greater than those used during the operation of the communal well system, and 2) the communal wells are not run continuously (usually only 9 to 12 hours per day) which will allow for recovery of the aquifer reducing the horizontal hydraulic gradient. Table 1 includes values used to calculate travel times.

4.2.2 Description of Local Surface Water Features

Figure 7 shows the location of the active communal wells and a 500-metre radius circle around each well. There are no perennial surface water bodies located within 500 metres of Well 2. The closest perennial surface water body is the East Branch of the Scotch River and is located approximately 1200 meters southwest of Well 2. The depth of the East Branch of the Scotch River varies seasonally between 0.1 metres to greater than 1.5 metres. A small perennial tributary to the East Branch of the Scotch River located approximately 700 metres south of Well 2. A surface water sample (SW1) was collected from the tributary to allow for comparison of groundwater and surface water characteristics (see location of SW1 of Figure 7). The tributary is approximately 2 metres wide and 0.3 metres deep. In addition, small and discontinuous ephemeral watercourses, less than 0.20 metres in depth located along Mainville Road (ditches), and small ephemeral ponds, less than 0.20 metres deep located in fields around Well 2 were observed during Fall rains in 2002. The abundance of low permeability clays and silts in the overburden contributes to ponding of water in areas of topographic lows. However, it is considered that these ephemeral watercourses are not directly hydraulically connected the bedrock aquifer given the presence of thick clay deposits in the vicinity of Well 2 (greater than 10 metres).

4.2.3 Evaluation of Groundwater Quality

Campylobacter was not detected in water collected from Well 2. The concentration of aerobic spores in water collected from Well 2 was measured at 2 CFU per 1000 ml; this is considered to be within the range of typical concentrations for groundwater not affected by a surface water source. Certificates of Analysis are included in Appendix B.

Chemical analysis of untreated groundwater collected from Well 2 for a suite of parameters typically used to characterize municipal water supplies showed no exceedances of the MAC, IMAC, or Aesthetic Objectives outlined in the ODWS. The pH at Well 2 and the hardness concentration exceeded the ODWS Operational Guidelines. The results of these analyses along with the appropriate ODWS standards/objectives are included in Appendix C. Certificates of Analysis are included in Appendix B.

In addition to the collection of groundwater samples, two surface water samples were collected and analyzed for general chemistry to allow for comparison of relative ion abundance (results of analysis are included in Appendix C). The surface water sample locations are shown on Figure 7. A Piper diagram was developed showing the relative ion abundance for groundwater samples collected from the communal wells and surface water samples collected within the study area (see Figure 8). In all three sections of the Piper diagram water from Well 2 plots away from the two surface water samples. This indicates the water at Well 2 is not likely directly connected to surface water.

Fecal coliforms and/or total coliforms were sporadically detected in groundwater samples collected on a weekly basis from Well 2 between 1999 and 2002. Levels of Heterotrophic Plate Counts (HPC) in groundwater samples was also monitored during this time period. Events of elevated HPC and/or detection of fecal coliforms and/or total coliforms were intermittent in nature and do not appear to be associated with precipitation events or spring melting. These events may be a result of improper sampling or laboratory error.

An MPA was completed on groundwater from Well 2. The analysis involved the filtration of a large volume of water (2369 litres) and subsequent analysis of material trapped in the filter. The MPA analysis indicated that there is a low risk that the groundwater is being impacted by surface water at this location. Certificates of analysis are included in Appendix C.

4.2.4 Particle Count Study Results and Discussion

Figure 11 illustrates the particle counts and the total daily precipitation at Well 2 for the entire duration of the particle count study in St. Isidore. The MOE GUDI Terms of Reference criteria of 100 particles per millilitre is labeled on Figure 11.

Figure 12A presents the particle counts during a dry period when no precipitation occurred within the study area for Well 2. Figure 12B illustrates the particle counts and total precipitation during a period containing a large precipitation event immediately following the dry period for Well 2.

The number of particles equal to or greater than 10 microns in size measured at Well 2 were consistently less than 100 particles per millilitre with typical counts less than 10 particles per millilitre. Occasional spikes in the particle count data were observed at concentrations up to 175 particles per millilitre (however, spikes are typically below 100 particles per millilitre; Figure 11). The spikes were noted both during dry periods and during periods of significant precipitation (Figure 12A and 12B) indicating the particle counts do not change during storm events, and are unlikely to change due to seasonal or other regular environmental changes.

The presence of overburden deposits, including a confining layer consisting of clay material in the area surrounding St. Isidore likely prevents the direct infiltration of surface water into the underlying bedrock aquifer in which this well is completed. In consideration of the results of the particle counting, indicating an absence of correlation of spikes greater than 100 particles per millilitre greater than 10 microns with large or small precipitation events and overall particle count data showing less than 100 particles per millilitre greater than 10 microns, it is concluded that the aquifer is providing effective *in situ* filtration at Well 2.

4.2.5 Evaluation: Is Well 2 Under the Direct Influence of Surface Water?

Refer to Figure 3 for a summary of the MOE criteria used to classify a well as: 1) under the direct influence; 2) potentially under the direct influence; or 3) not under the direct influence of surface water. The discussion herein will follow the order of the flow chart of Figure 3.

Physical evidence of surface water contamination was not observed in Well 2. The surface water organism, campylobacter, was not detected in water collected from this well and aerobic spores were present in concentrations that are within the typical range for groundwater not affected by a surface water source. MPA analysis completed at Well 2 indicated there was a low risk that the groundwater is being influenced by surface water at this location.

Fecal coliforms and/or total coliforms were sporadically (not "regularly") detected in groundwater samples collected on a weekly basis from Well 2 between 1999 and 2002. There are no perennial surface water bodies located within 500 metres of Well 2. Using hydraulic parameters calculated from a 24 hour pumping test it was estimated that groundwater in the vicinity of Well 2 could travel between 55 and 280 metres in 50 days under pumping conditions. Given that the closest perennial surface water body is located approximately 700 metres away, Well 2 is not located within 50 days horizontal travel time from a surface water body.

The bedrock aquifer from which the well is drawing is confined with approximately 14 metres of clay material present at Well 2. The identified water-bearing zone at Well 2 is greater than 15 metres below ground surface. The well is not part of an enhanced recharge/infiltration project. Observation of changes in surface water levels or hydraulic gradients beside surface water bodies was not performed as part of the current study. However, it should be noted small, shallow ephemeral watercourses located in the vicinity of Well 2 are not expected to be hydraulically connected to the bedrock aquifer given the presence of the thick clay deposits surrounding Well 2 (greater than 10 metres). As illustrated by Figure 8 (Piper Plot) chemical water quality at Well 2 appears to be distinct from local surface water samples.

The results of a particle counting study undertaken at Well 2 indicated that the bedrock aquifer at this location is providing effective *in situ* filtration, and that particle counts are not likely to change during storm, season or other regular environmental changes.

In conclusion to these statements, in accordance with the MOE Terms of Reference Well 2 is classified as being not under the direct influence of surface water.

4.3 Well 3

4.3.1 Well Characterization and Hydrogeological Setting

Well 3 was originally drilled by Intera as a test-well in March of 1991 (Intera, 1991b). The well is located south of St. Isidore on Mainville Road, approximately 2.4 kilometres east of Country Road 9 (see Figure 2). The elevation of the ground surface at this location is 67.4 metres.

Well 3 was drilled to a depth of 19.2 mbgs. During well development caving occurred below the casing. As a result, the casing was pulled back and the borehole was backfilled to 18.6 mbgs. One water-bearing zone from 16.5 to 18.3 mbgs was noted in the water well record. The borehole log completed by Intera indicates that overburden deposits at the well consisted of clay material from surface to approximately 13.5 metres. Underlying the clay deposit was approximately 2 metres of gravel till. The low permeability clay deposit acts as a confining layer, or aquitard to the underlying limestone bedrock aquifer. The borehole log and water well record for Well 3 are included in Appendix A.

A review of test-well logs and over 20 water well records for wells drilled within a 2 km radius of Well 3, indicate the thickness of the overburden clay deposits ranges from 6.4 metres to greater than 45 metres with most areas having at least 10 to 15 metres of clay cover. As a result, the bedrock aquifer at this location is classified as confined. The confining layer should provide protection from contaminants spilled or applied at ground surface, and limits the potential for direct interaction between groundwater and surface water. The extent of the confining layer is illustrated on Figure 5.

Well 3 is equipped with a submersible pump located 16.0 mbgs. It is currently pumped at a rate of approximately 0.9 L/s. According to data collected at the well head from 2002, static water levels in Well 3 range from 6.6 to 8.3 m below ground surface. The maximum drawdown observed during a 24 hour pumping test completed at Well 3 was 7.9 metres (Intera, 1990).

Based on a 24 hour pumping test the transmissivity of the bedrock aquifer in the vicinity of Well 3 was estimated to be 21 m^2/day, and storativity of aquifer at this location was estimated to be 1.1 x 10^{-4} (Intera, 1991b). Assuming a saturated thickness of 10 metres, the hydraulic conductivity of the bedrock aquifer was estimated to be 2.1 m/day. Using water levels from September 2002 the average horizontal component of the hydraulic gradient for the study area was estimated to be 0.004. The approximate direction of groundwater flow was determined to be North 57 degrees West. Using these values, and assuming a range in porosity of 0.01 to 0.05 for the aquifer, the average linear groundwater velocity within the bedrock aquifer under non-pumping conditions was calculated to be between 0.17 and 0.84 m/day. Thus in 50 days groundwater could travel between 8.5 and 42 metres under non-pumping conditions.

The horizontal hydraulic gradient for the study area during pumping conditions was estimated from pumping test data obtained from the four communal wells (WESA, 1984; Intera, 1991b, 1991c). The average increase to the horizontal hydraulic gradient observed in pumping tests was 0.0043. This number is added to the horizontal hydraulic gradient in the absence of pumping (0.004) to get the final estimate of horizontal hydraulic gradient for the aquifer during pumping (0.0083). Using the aquifer hydraulic conductivity of 2.1 m/day and assuming a range in porosity of 0.01 to 0.05 for the aquifer, the average linear groundwater velocity within the bedrock aquifer under pumping conditions was calculated to be between 0.35 and 1.7 m/day. Thus in 50 days groundwater could travel between 17 and 85 metres under pumping conditions. The estimated travel time to the well is considered to be conservative for two reasons: 1) the pumping rates used during the pumping test were greater than those used during the operation of the communal well system, and 2) the communal wells are not run continuously (usually only 9 to 12 hours per day) which will allow for recovery of the aquifer reducing the horizontal hydraulic gradient. Table 1 includes values used to calculate travel times.

4.3.2 Description of Local Surface Water Features

Figure 7 shows the location of the active communal wells and a 500-metre radius circle around each well. A small perennial tributary to the East Branch of the Scotch River is located approximately 400 metres south of Well 3. The tributary is approximately 2 metres wide and 0.3 metres deep. A surface water sample (SW1) was collected from the tributary to allow for comparison of groundwater and surface water characteristics (see location of SW1 on Figure 7). The East Branch of the Scotch River is located approximately 1850 meters southwest of Well 3. The depth of the East Branch of the Scotch River varies seasonally between 0.1 metres to greater than 1.5 metres. In addition, small and discontinuous ephemeral watercourses, less than 0.20 metres deep, located along Mainville Road (ditches), and small ephemeral ponds, less than 0.20 metres deep, located in fields around Well 3 were observed during Fall rains in 2002. The abundance of low permeability clays and silts in the overburden contributes to ponding of water in areas of topographic lows. However, it is considered that these ephemeral watercourses are not directly hydraulically connected the bedrock aquifer given the presence of thick clay deposits in the vicinity of Well 3 (greater than 10 metres).

4.3.3 Evaluation of Groundwater Quality

Campylobacter was not detected in water collected from Well 3. The concentration of aerobic spores in water collected from Well 3 was measured at 2 CFU per 900 ml; this is considered to be within the range of typical concentrations for groundwater not affected by a surface water source. Certificates of Analysis are included in Appendix B.

The number of particles equal to or greater than 10 microns in size measured at Well 3 were generally less than 100 particles per millilitre, however, random spikes well above 100 particles per millilitre were observed often on a daily basis. During the particle counting study approximately 10 to 15 spikes above 300 particles per millilitre were observed, and one spike above 1500 particles per millilitre was observed at Well 3 (Figure 13).

Spikes in particle count data were noted consistently during both dry periods, and during periods of significant precipitation (Figure 14A and 14B). This indicates the particle counts are not changing during storm events, and are unlikely to change due to seasonal or other regular environmental changes.

The presence of overburden deposits, including a confining layer consisting of clay material in the area surrounding St. Isidore likely prevents the direct infiltration of surface water into the underlying bedrock aquifer in which this well is completed. In consideration of the results of the particle counting, showing consistently a number of particles greater than 100 per millilitre greater than 10 microns in size, it is concluded that the aquifer is not providing effective *in situ* filtration at Well 3.

4.3.5 Evaluation: Is Well 3 Under the Direct Influence of Surface Water?

Refer to Figure 3 for a summary of the MOE criteria used to classify a well as: 1) under the direct influence; 2) potentially under the direct influence; or 3) not under the direct influence of surface water. The discussion herein will follow the order of the flow chart of Figure 3.

Physical evidence of surface water contamination was not observed in Well 3. The surface water organism, campylobacter, was not detected in water collected from this well and aerobic spores were present in concentrations that are within the typical range for groundwater not affected by a surface water source. MPA analysis completed at Well 3 indicated there was a moderate risk that the groundwater is being influenced by surface water at this location.

Fecal coliforms and/or total coliforms were sporadically (not "regularly") detected in groundwater samples collected on a weekly basis from Well 3 between 1999 and 2002. There is one perennial surface water body located within 500 metres of Well 3. Using hydraulic parameters calculated from a 24 hour pumping test it was estimated that groundwater in the vicinity of Well 3 could travel between 17 and 85 metres in 50 days under pumping conditions. Given that the closest perennial surface water body is located approximately 400 metres away, Well 3 is not located within 50 days horizontal travel time from a surface water body.

The bedrock aquifer from which the well is drawing is confined with approximately 13.5 metres of clay material present at Well 3. The identified water-bearing zone at Well 3 is greater than 15 metres below ground surface. The well is not part of an enhanced recharge/infiltration project.

Observation of changes in surface water levels or hydraulic gradients beside surface water bodies was not performed as part of the current study. However, it should be noted small, shallow ephemeral watercourses located in the vicinity of Well 3 are not expected to be hydraulically connected to the bedrock aquifer given the presence of the thick clay deposits surrounding Well 3 (greater than 10 metres). As illustrated by Figure 8 (Piper Plot) chemical water quality at Well 3 may not be distinct from local surface water samples.

The results of a particle counting study undertaken at Well 3 indicated that the bedrock aquifer at this location is not providing effective *in situ* filtration, however, the data did indicate that particle counts are not likely to change during storm, season or other regular environmental changes.

In conclusion, Well 3 is classified as potentially under the direct influence of surface water due to the identification of a moderate risk of groundwater being under the influence of surface water determined by the MPA analysis, the presence of one perennial surface water body within 500 metres, and the lack of effective *in situ* filtration. Installation of appropriate water filtration would be required for this well. Note, since the bedrock aquifer at Well 3 is not providing effective *in situ* filtration, this well has been abandoned and tagged off since December 12th, 2002 by the operating authority (OCWA).

4.4 Well 5

4.4.1 Well Characterization and Hydrogeological Setting

Well 5 was originally drilled by WESA as a test-well in 1982 (WESA, 1984). The well is located on the north side of the village on St. Isidore Street approximately 400 m east of Country Road 9 (see Figure 2). Well 5 was previously used as the sole source of water for St. Isidore's senior citizen's housing complex. After the completion of Wells 1, 2, and 3, Well 5 was integrated into the communal water supply. The elevation of the ground surface at this location is 62.3 metres.

Well 5 was drilled to a depth of 35.9 mbgs. There is no water well record available for Well 5. However, given the thickness of clay at this location (greater than 25 metres) the water-bearing zones will be at a depth greater than 15 metres. A review of over 30 water well records for wells drilled within a 2 km radius of Well 5, indicate the thickness of the overburden clay deposit ranges from 18.3 to greater than 45 metres with most areas having at least 25 to 30 metres of clay cover. As a result, the bedrock aquifer at this location is classified as confined. The confining layer should provide protection from contaminants spilled or applied at ground surface, and limits the potential for direct interaction between groundwater and surface water.

Well 5 is equipped with a submersible pump located 22.3 mbgs. It is currently pumped at a rate of approximately 1.8 L/s. According to data collected at the well head from 2002, static water levels in Well 5 are consistently less than 12.3 mbgs. The maximum drawdown observed during a 72 hour pumping test completed at Well 5 was 1.4 metres (WESA, 1984).

Based on a 72 hour pumping test the transmissivity of the bedrock aquifer in the vicinity of Well 5 was estimated to be approximately 86 m^2/day, and storativity of aquifer at this location was estimated to be 1.2 x 10^{-4} (WESA, 1984). Assuming a saturated thickness of 10 metres, the hydraulic conductivity of the bedrock aquifer was estimated to be 8.7 m/day. Using water levels from September 2002 the average horizontal component of the hydraulic gradient for the study area was estimated to be 0.004. The approximate direction of groundwater flow was determined to be North 57 degrees West. Using these values, and assuming a range in porosity of 0.01 to 0.05 for the aquifer, the average linear groundwater velocity within the bedrock aquifer under non-pumping conditions was calculated to be between 0.7 and 3.5 m/day. Thus in 50 days groundwater could travel between 35 and 175 metres under non-pumping conditions.

The horizontal hydraulic gradient for the study area during pumping conditions was estimated from pumping test data obtained from the four communal wells (WESA, 1984; Intera, 1991b, 1991c). The average increase to the horizontal hydraulic gradient observed during pumping tests was 0.0043. This number is added to the horizontal hydraulic gradient in the absence of pumping (0.004) to get the final estimate of horizontal hydraulic gradient for the aquifer during pumping (0.0083). Using the aquifer hydraulic conductivity of 8.7 m/day and assuming a range in porosity of 0.01 to 0.05 for the aquifer, the average linear groundwater velocity within the bedrock aquifer under pumping conditions was calculated to be between 1.4 and 7.2 m/day. Thus in 50 days groundwater could travel between 70 and 360 metres under pumping conditions. The estimated travel time to the well is considered to be conservative for two reasons: 1) the pumping rates used during the pumping test were greater than those used during the operation of the communal well system, and 2) the communal wells are not run continuously (usually only 9 to 12 hours per day) which will allow for recovery of the aquifer reducing the horizontal hydraulic gradient. Table 1 includes values used to calculate travel times.

4.4.2 Description of Local Surface Water Features

Figure 7 shows the location of the active communal wells and a 500-metre radius circle around each well. There are no perennial surface water bodies located within 500 metres of Well 5. The closest perennial surface water body is the East Branch of the Scotch River and is located approximately 1150 meters southwest of Well 5. The depth of the East Branch of the Scotch River varies seasonally between 0.1 metres and greater than 1.5 metres. Small and discontinuous ephemeral watercourses, less than 0.30 metres deep located along St. Isidore Road (ditches) and in nearby fields, as well as, small ephemeral ponds, less than 0.20 metres deep were observed during Fall rains in 2002. One such ephemeral watercourse flows within 10 metres of Well 5. However, it is considered that these ephemeral watercourses are not directly hydraulically connected the bedrock aquifer given the presence of thick clay deposits in the vicinity of Well 5 (greater than 25 metres).

4.4.3 Evaluation of Groundwater Quality

Campylobacter was not detected in water collected from Well 5. The concentration of aerobic spores in water collected from Well 5 was measured at 2 CFU per 1000 ml; this is considered to be within the range of concentrations for groundwater not affected by surface water. Certificates of Analysis are included in Appendix B.

Chemical analysis of untreated groundwater collected from Well 5 for a suite of parameters typically used to characterize municipal water supplies showed no exceedances of the MAC, IMAC, or Aesthetic Objectives outlined in the ODWS. The hardness concentration exceeded the ODWS Operational Guidelines at Well 5. The results of these analyses along with the appropriate ODWS standards/objectives are included in Appendix C. Certificates of analysis are included in Appendix B.

In addition to the collection of groundwater samples, two surface water samples were collected and analyzed for general chemistry to allow for comparison of relative ion abundance (results of analysis are included in Appendix C). The surface water sample locations are shown on Figure 7. A Piper diagram was developed showing the relative ion abundance for groundwater samples collected from the communal wells and surface water samples collected within the study area (see Figure 8). Overall Well 5 plot closer to the surface water sample than Wells 1 and 2, but still appears to have relative ion concentrations distinct from that of surface water.

Detection of Fecal coliforms and/or total coliforms were rare in groundwater samples collected on a weekly basis from Well 5 between 1999 and 2002. Levels of Heterotrophic Plate Counts (HPC) in groundwater samples was also monitored during this time period. These detections are likely a result of improper sampling or laboratory error.

A total of four MPAs were completed on groundwater from Well 5 (identified as Well 5, Well 6, Well 8 and Well 9). The analysis involved the filtration of a large volume of water and subsequent analysis of material trapped in the filter. The initial MPA analysis indicated that there was a moderate risk that the groundwater is being impacted by surface water at this location. The moderate risk was associated with the detection of diatoms and algae. This result was "suspect" given the geologic setting of Well 5. As a result three additional MPA analyses were completed. Each of the additional tests completed indicated Well 5 had a low risk that groundwater was being impacted by surface water. The moderate risk identified in the first MPA analysis was determined to be a result of sampling or laboratory error. Certificates of analysis are included in Appendix C.

4.4.4 Particle Count Study Results and Discussion

Figure 15 illustrates the particle counts and the total daily precipitation for the entire duration of the particle count study in St. Isidore. The MOE GUDI Terms of Reference criteria of 100 particles per millilitre is labeled on Figure 15.

Figure 16A presents the particle counts during a dry period when no precipitation occurred within the study area for Well 5. Figure 16B illustrates the particle counts and total precipitation during a period containing a large precipitation event immediately following the dry period for Well 5.

The number of particles equal to or greater than 10 microns in size measured at Well 5 were consistently less than 100 particles per millilitre with typical counts less than 5 particles per millilitre. Occasional spikes in the particle count data were observed at concentrations up to 130 particles per millilitre (spikes are typically below 100 particles per millilitre; Figure 15). The spikes were noted both during dry periods and during periods of significant precipitation (Figure 16A and 16B) indicating the particle counts do not change during storm events, and are unlikely to change due to seasonal or other regular environmental changes.

The presence of overburden deposits, including a confining layer consisting of clay material in the area surrounding St. Isidore likely prevents the direct infiltration of surface water into the underlying bedrock aquifer in which this well is completed. In consideration of the results of the particle counting, indicating an absence of correlation of spikes greater than 100 particles per millilitre greater than 10 microns with large or small precipitation events and overall particle count data showing less than 100 particles per millilitre greater than 10 microns, it is concluded that the aquifer is providing effective *in situ* filtration at Well 5.

4.4.5 Evaluation: Is Well 5 Under the Direct Influence of Surface Water?

Refer to Figure 3 for a summary of the MOE criteria used to classify a well as: 1) under the direct influence; 2) potentially under the direct influence; or 3) not under the direct influence of surface water. The discussion herein will follow the order of the flow chart of Figure 3.

Physical evidence of surface water contamination was not observed in Well 5. The surface water organism, campylobacter, was not detected in water collected from this well and aerobic spores were present in concentrations that are within the typical range for groundwater not affected by a surface water source. MPA analysis completed at Well 5 indicated there was a low risk that the groundwater is being influenced by surface water at this location.

Fecal coliforms and/or total coliforms were sporadically (not "regularly") detected in groundwater samples collected on a weekly basis from Well 5 between 1999 and 2002. There are no perennial surface water bodies located within 500 metres of Well 5. Using hydraulic parameters calculated from a 72 hour pumping test it was estimated that groundwater in the vicinity of Well 5 could travel between 70 and 360 metres in 50 days under pumping conditions. Given that the closest perennial surface water body is located approximately 1150 metres away, Well 5 is not located within 50 days horizontal travel time from a surface water body.

The bedrock aquifer from which the well is drawing is confined with approximately 25 to 30 metres of clay material present at Well 5. Water bearing zones at Well 5 are greater than 15 metres below ground surface. The well is not part of an enhanced recharge/infiltration project. Observation of changes in surface water levels or hydraulic gradients beside surface water bodies was not performed as part of the current study. However, it should be noted small, shallow ephemeral watercourses located in the vicinity of Well 5 are not expected to be hydraulically connected to the bedrock aquifer given the presence of the thick clay deposits surrounding Well 5 (greater than 25 metres).

The results of a particle counting study undertaken at Well 5 indicated that the bedrock aquifer at this location is providing effective *in situ* filtration, and that particle counts are not likely to change during storm, season or other regular environmental changes.

In conclusion to these statements, in accordance with the MOE Terms of Reference Well 5 is classified as being not under the direct influence of surface water.

5.0 ASSESSMENT OF THE PHYSICAL CONDITION OF ON-SITE WELLS

All four wells are constructed using a similar model. All wells are located within pump houses and have a well casing protected by a concrete seal. At the time of this study there was no standing water around the pump houses, and the potential for leakage seemed small due to well construction. For additional information refer to the Engineer's Report completed by Lecompte Engineering Ltd. in May, 2001.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Golder Associates was retained by Lecompte Engineering Ltd. (Lecompte) on behalf of Nation Municipality to conduct a *Groundwater Under the Direct Influence of Surface Water* (GUDI) study for the four active communal wells (1, 2, 3, and 5) from which the water supply for the Village of St. Isidore is derived.

The study was based on the criteria defined in the *Terms of Reference for Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water* outlined by the MOE in October, 2001. The study looked for physical evidence of surface water contamination, as well as the presence of surface water organisms. A detailed evaluation of bacteriological results for each well was completed. Aquifer characteristics were calculated and estimations of 50 day horizontal travel times were made. Water samples were collected to allow for the comparison of relative ion abundance in groundwater and surface water within the study area, and a particle count study was also completed at each of the four wells to determine if the aquifer was providing effective *in situ* filtration.

The results of the study showed communal wells 1, 2, and 5 are classified as being not under the direct influence of surface water and Well 3 is classified as being potentially under the direct influence of surface water. In addition, it was determined that appropriate water filtration/treatment would be required for Well 3 as the aquifer does not provide adequate *in situ* filtration.

7.0 LIMITATIONS AND USE OF REPORT

This report was prepared for the exclusive use of Lecompte Engineering Ltd., and the Nation Municipality. The report, which specifically includes all tables, figures and appendices, is based on data and information collected by Golder Associates and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by Golder Associates as described in this report. Each of these reports must be read and understood collectively, and can only be relied upon in their totality.

Golder Associates has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the reports as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The assessment of environmental conditions at this site has been made using the results of physical measurements and chemical analyses of liquids from a number of locations. The site conditions between sampling locations have been inferred based on conditions observed at borehole locations. Subsurface conditions may vary from these sampled locations.

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 science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. 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 conclusions of this report, and to provide amendments as required.

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Senior Hydrogeologist/Associate

JPAO:BJV:cr
N:\Active\2800\021-2805 GUDI Study - St-Isidore\Report\GUDI Study Report.doc

REFERENCES

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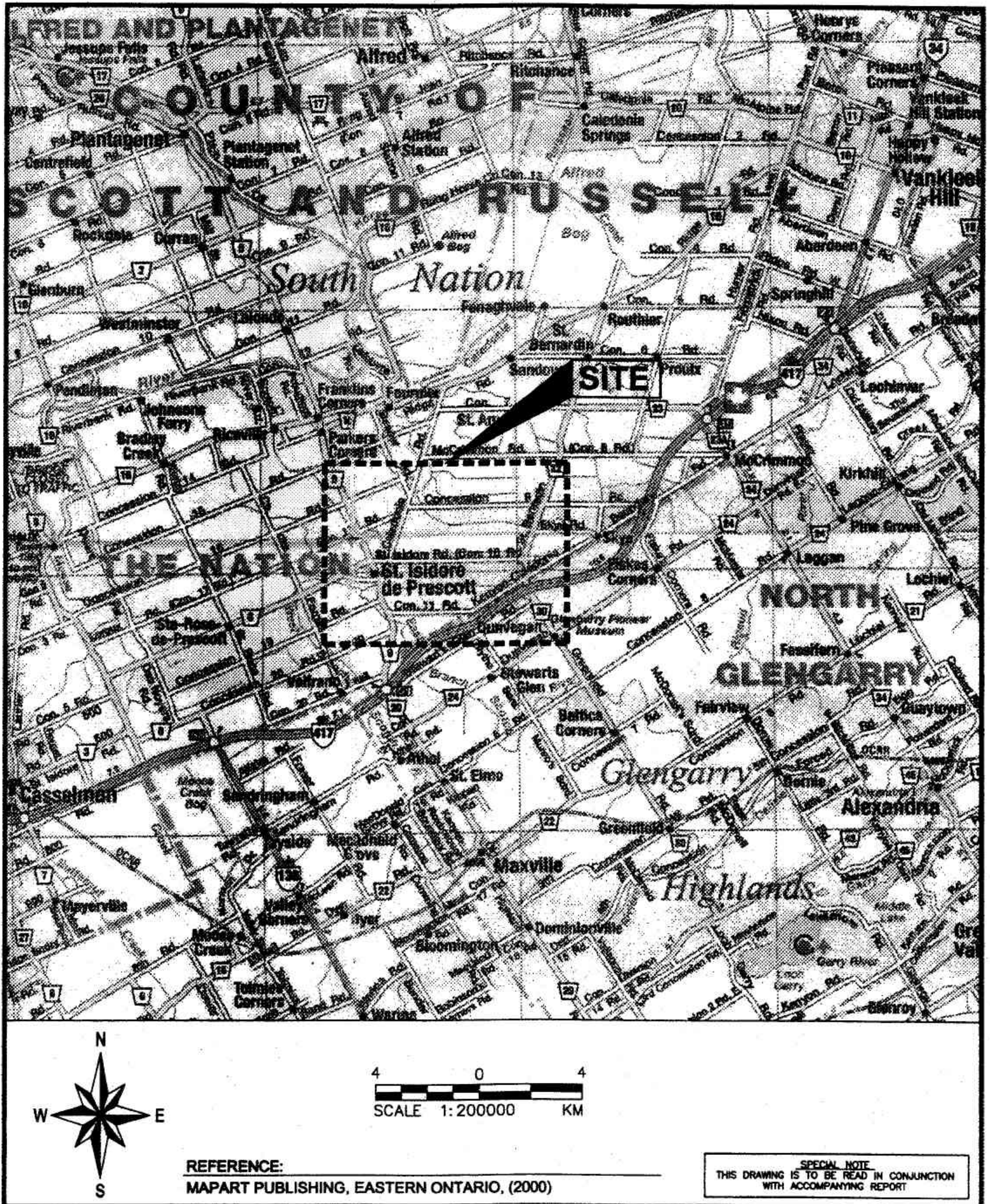


REFERENCE:

MAPART PUBLISHING, EASTERN ONTARIO, (2000)

SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT

Golder Associates
Ottawa, Ontario

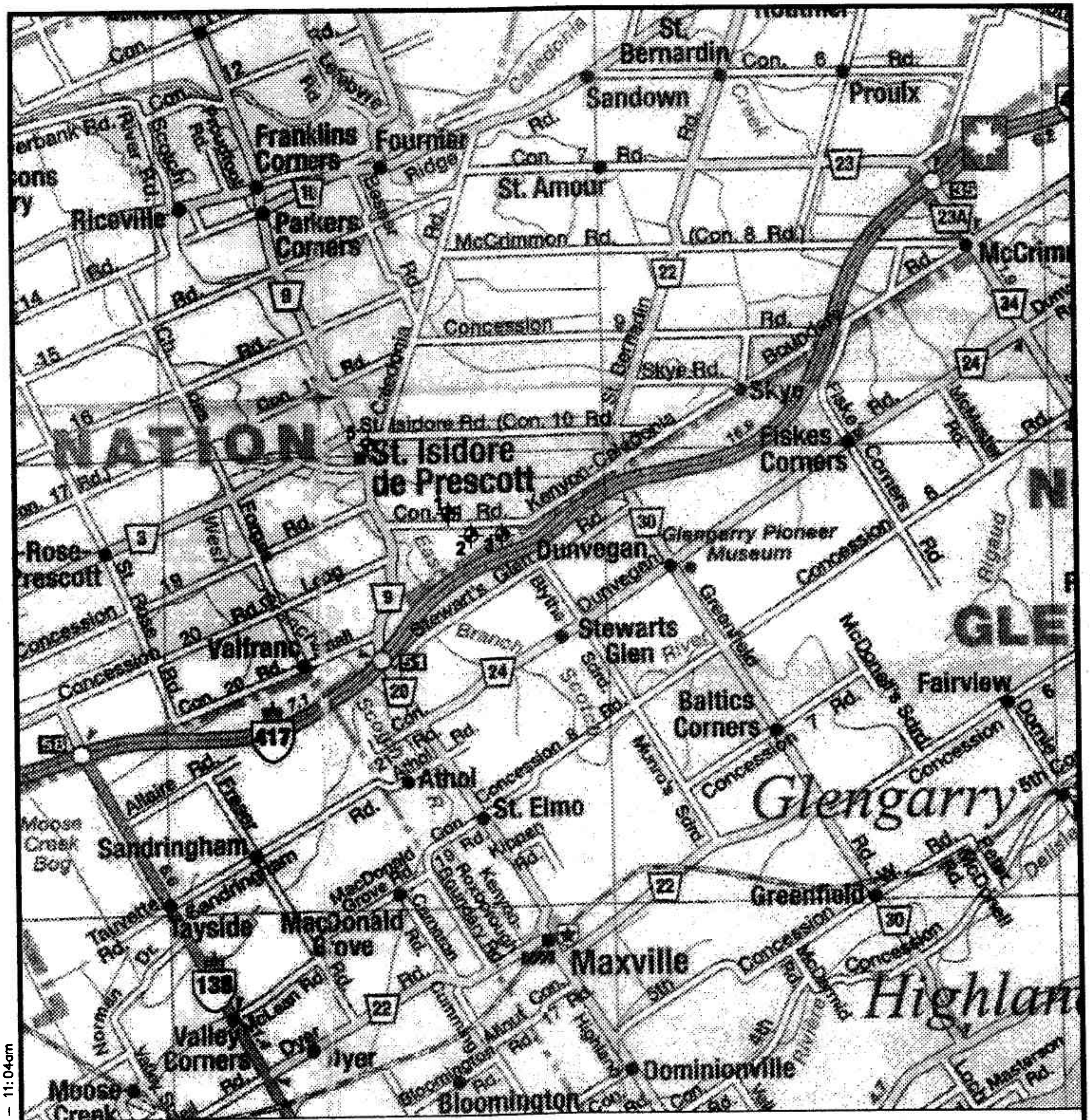
SCALE 1:200,000
DATE NOV. 2002
DESIGN
CADD S.L.
CHECK
REVIEW
FILE No. 0212805-5000-01.dwg
PROJECT No. 021-2805
REV.

TITLE

KEY PLAN

FIGURE 1

Drawing file: 0212805-5000-01.dwg Jan 20, 2003 - 11:16am



N

W E

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LEGEND

⌖ COMMUNAL WELL LOCATION IN PLAN

REFERENCE:
MAPART PUBLISHING, EASTERN ONTARIO, (2000)

SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT

Golder Associates
Ottawa, Ontario

SCALE	1:125,000	TITLE	
DATE	OCT. 2002		
DESIGN			**SITE PLAN**
CADD	S.L.		
CHECK			
REVIEW		FIGURE	2

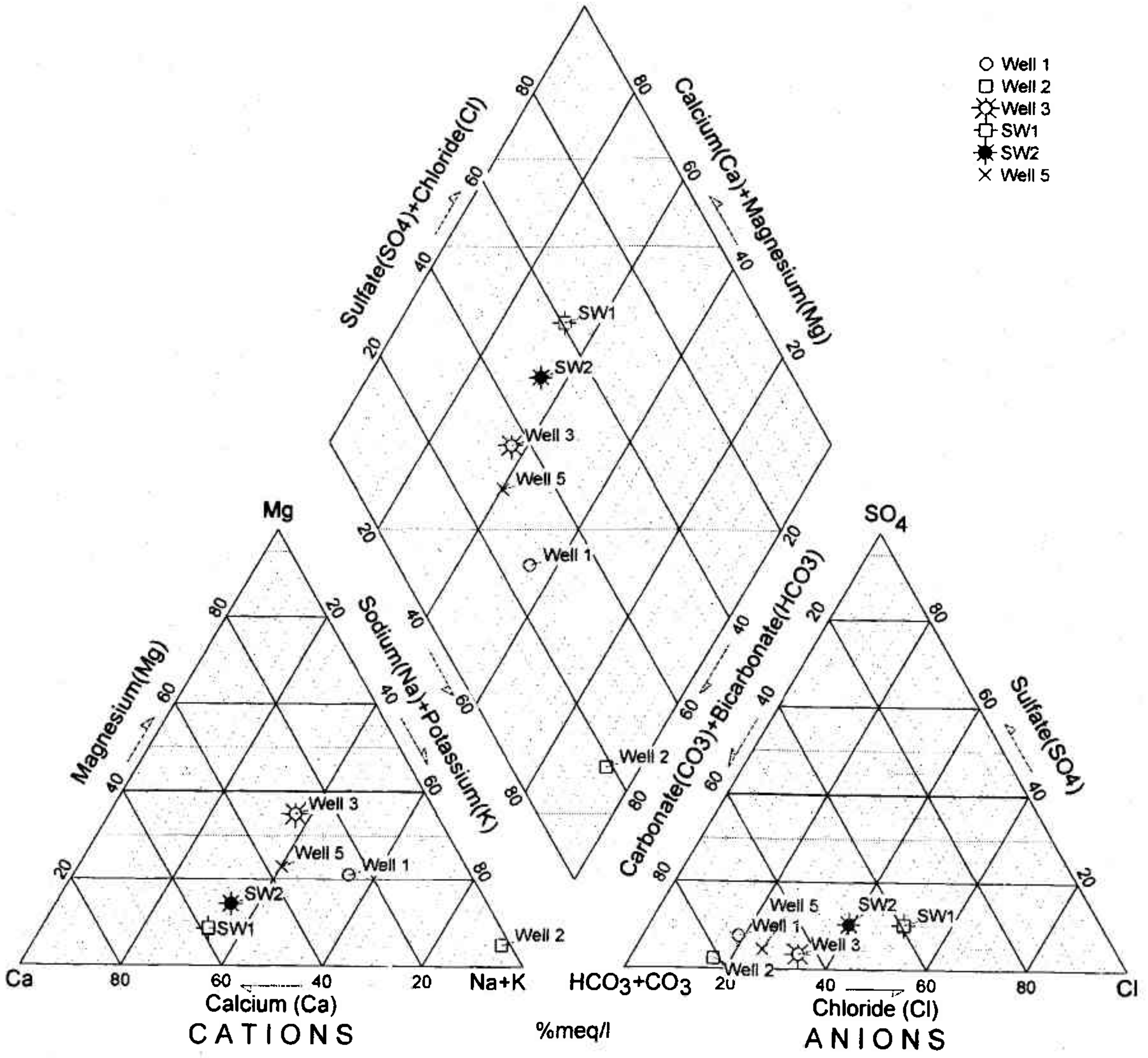
FILE No. 0212805-5000-02.dwg

PROJECT No. 021-2805 REV.

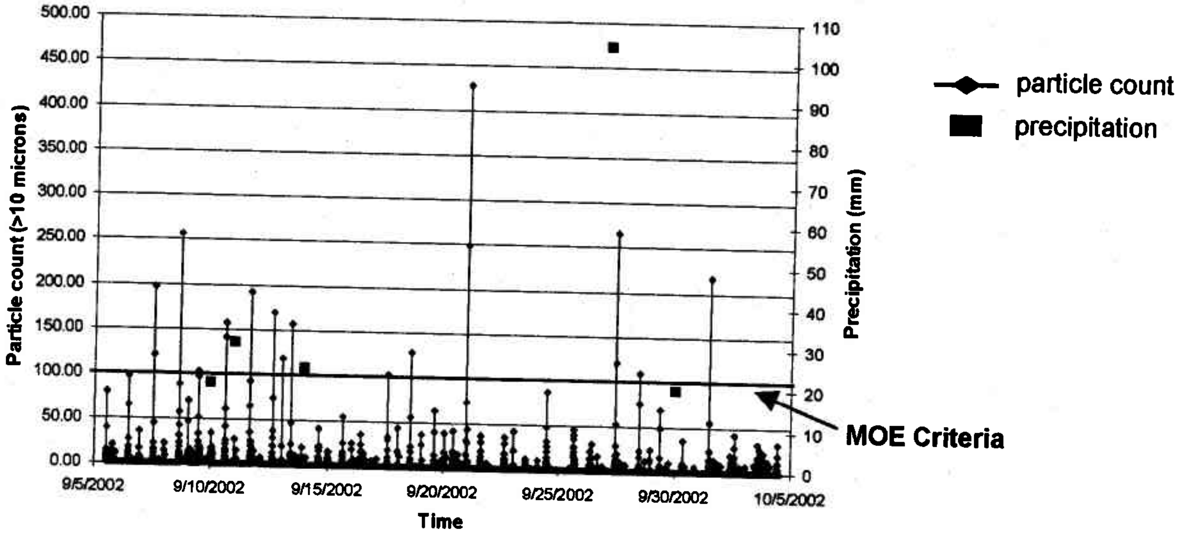
Drawing file: 0212805-5000-02.dwg Jan 20, 2003 - 11:04am

St. Isidore GUDI Study

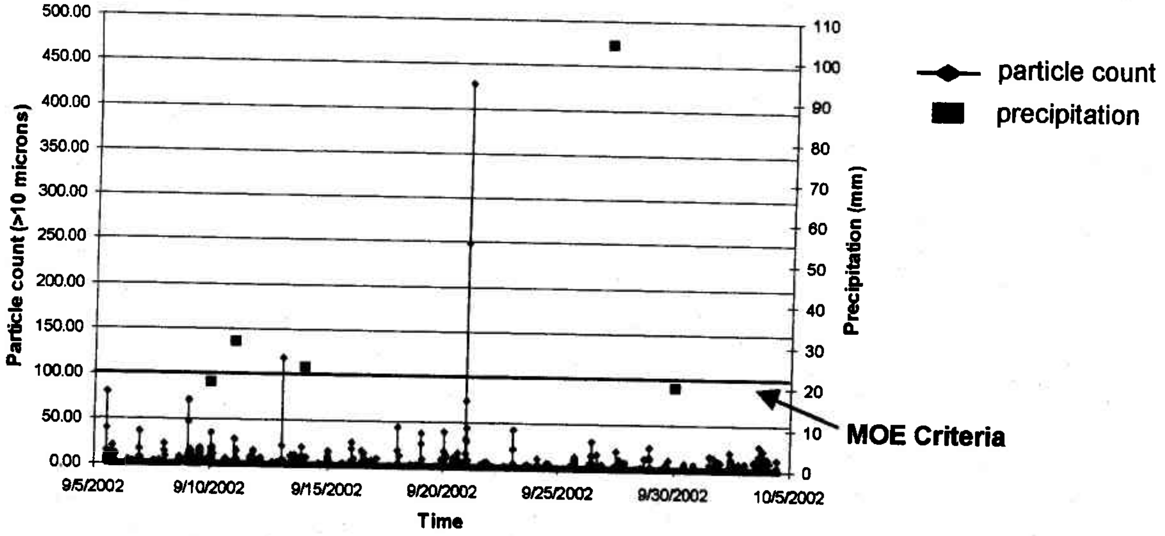
Figure 8 Piper Diagram



9A) St. Isidore Well 1 September 5 to October 4, 2002



9B) St. Isidore Well 1 Pump Start-Up Removed



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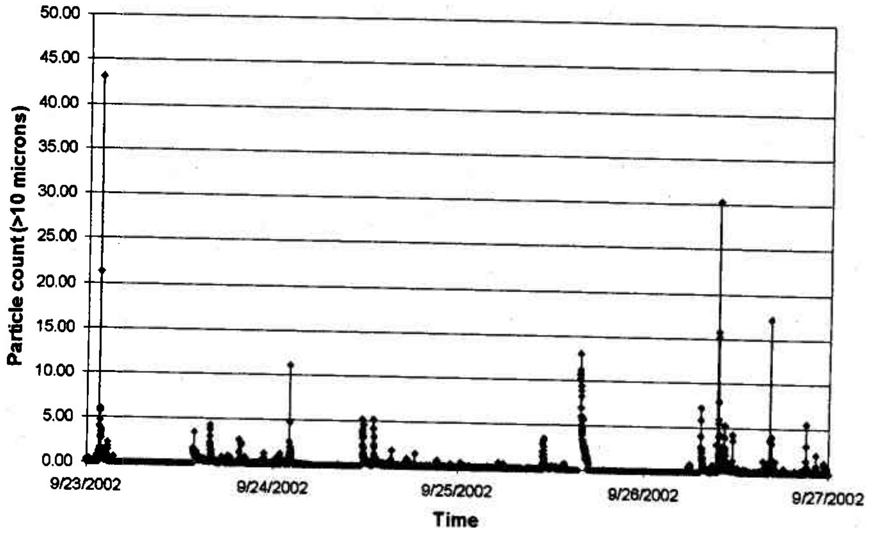
Date: Feb. 2003
Project: 021-2805
Drawn: J.P.A.O
Chkd: BJV

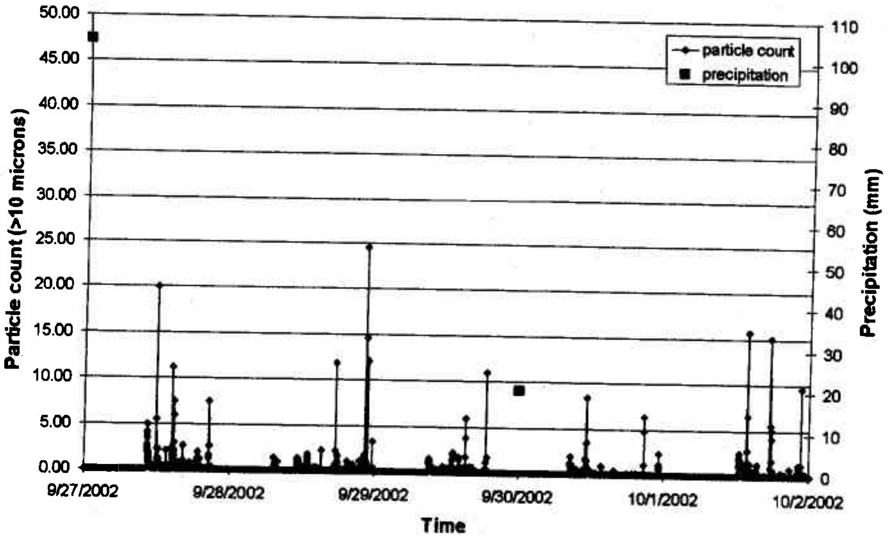
ST. ISIDORE PARTICLE COUNT AND PRECIPITATION RESULTS FOR WELL 1

FIGURE 9

10A) St. Isidore Well 1 Dry Period



10B) St. Isidore Well 1 Wet Period



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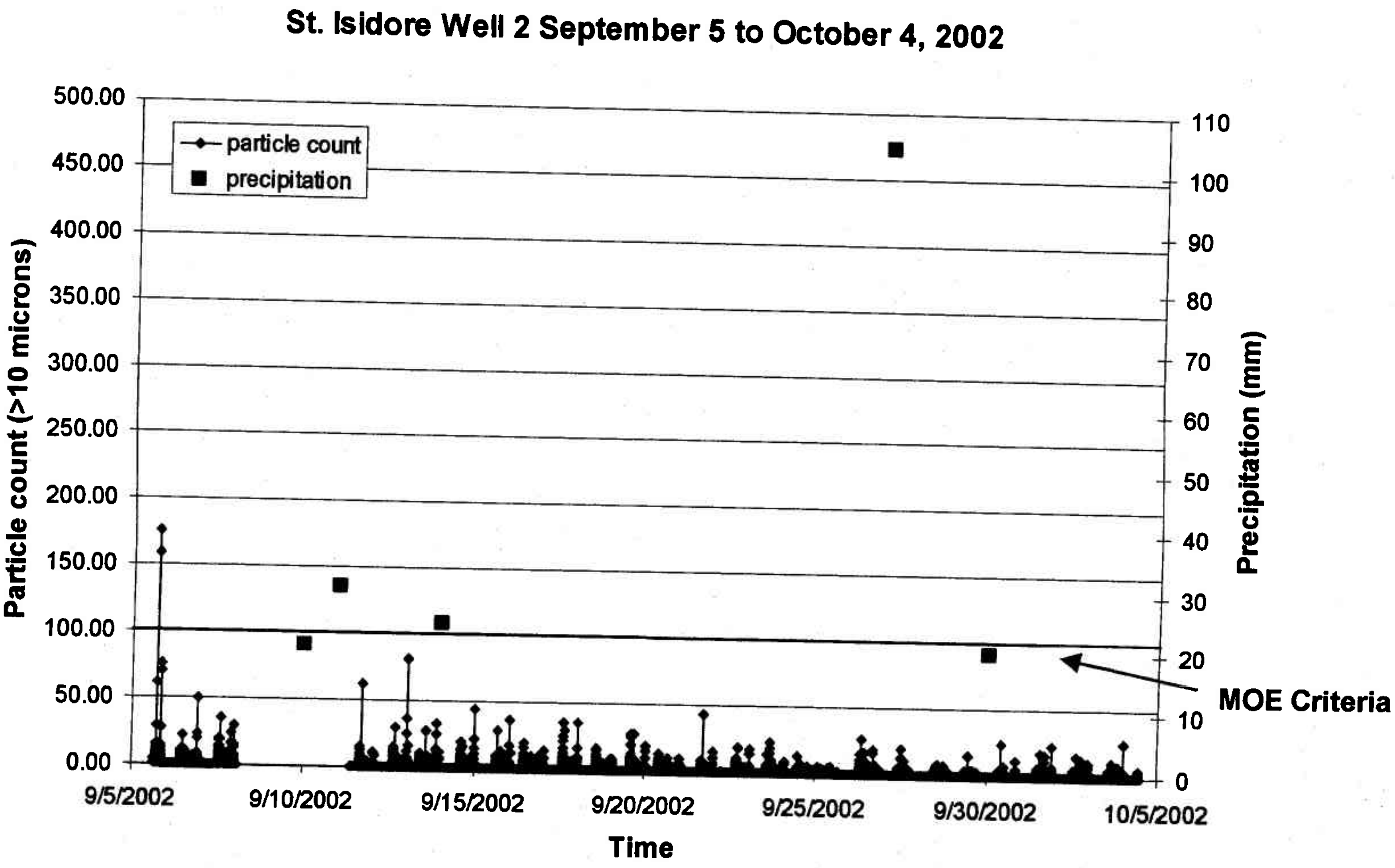
Project: 021-2805
Drawn: J.P.A.O
Chkd: BJV

ST. ISIDORE PARTICLE COUNT RESULTS DURING A DRY AND WET PERIOD FOR WELL 1

FIGURE 10



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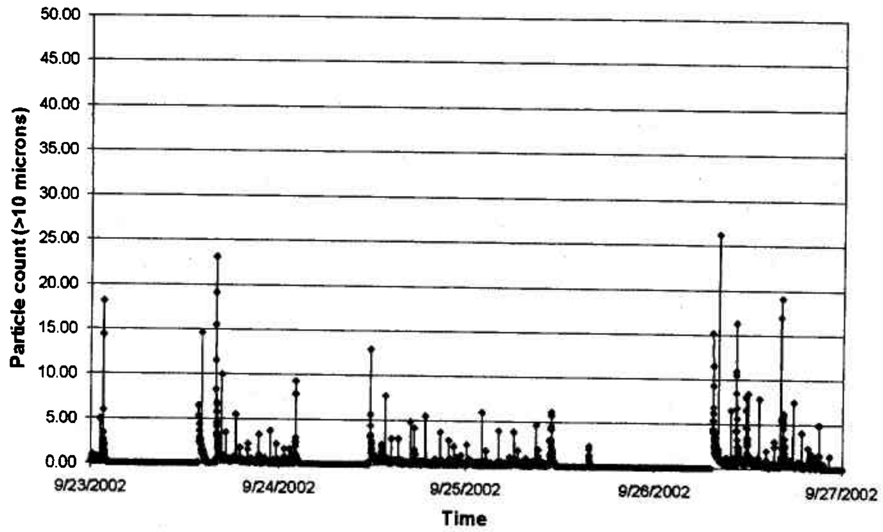
Date: Feb. 2003
Project: 021-2805
Drawn: J.P.A.O
Chkd: BJV

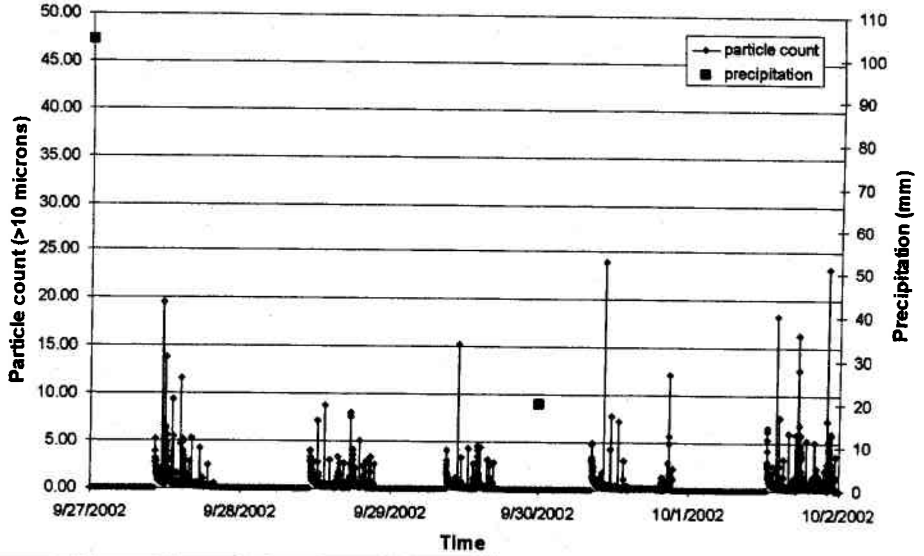
ST. ISIDORE PARTICLE COUNT AND PRECIPITATION RESULTS FOR WELL 2

FIGURE 11

12A) St. Isidore Well 2 Dry Period



12B) St. Isidore Well 2 Wet Period



Golder Associates

Date: Feb. 2003
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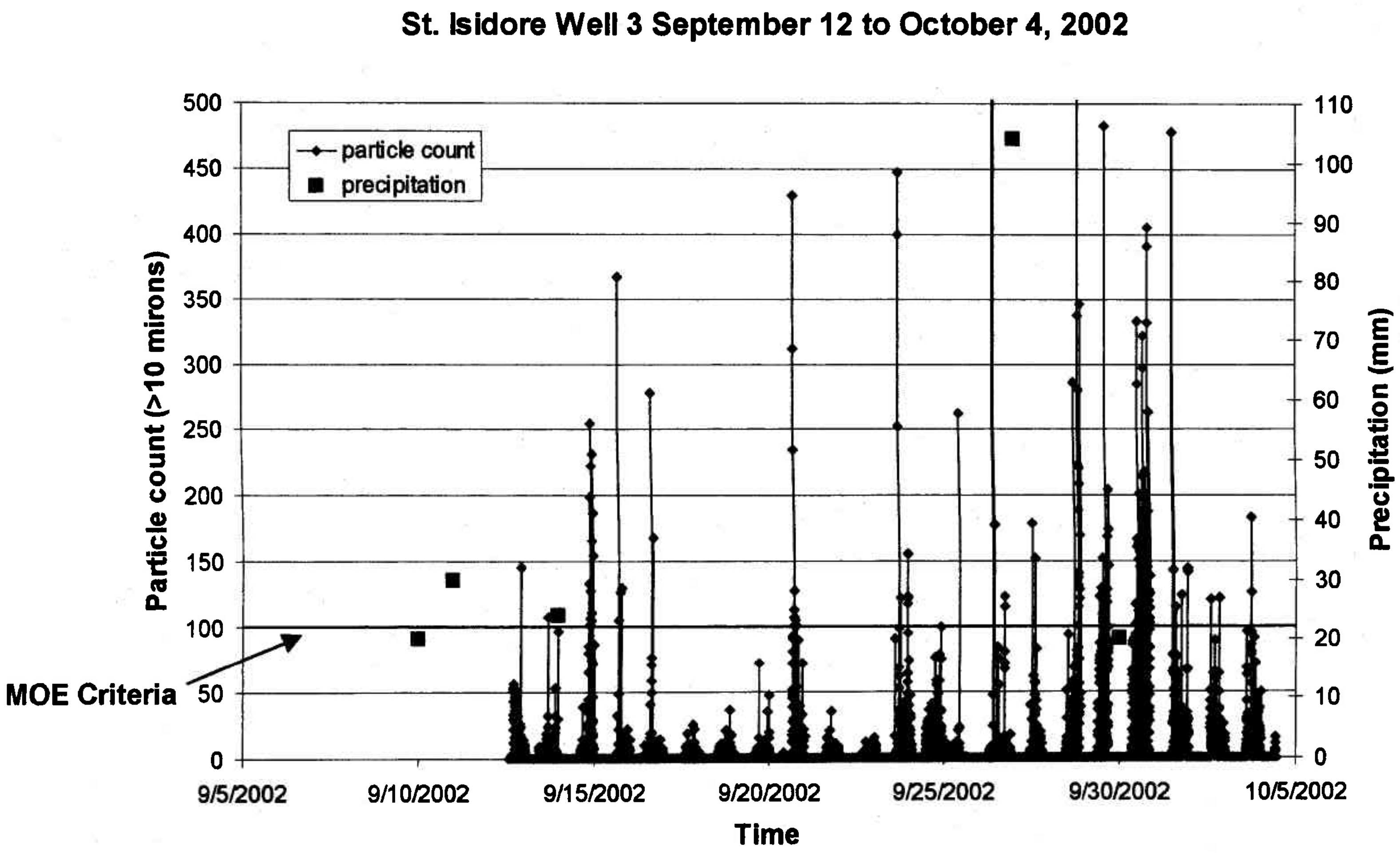
Project: 021-2805
Chkd: BJV

ST. ISIDORE PARTICLE COUNT RESULTS DURING A DRY AND WET PERIOD FOR WELL 2

FIGURE 12



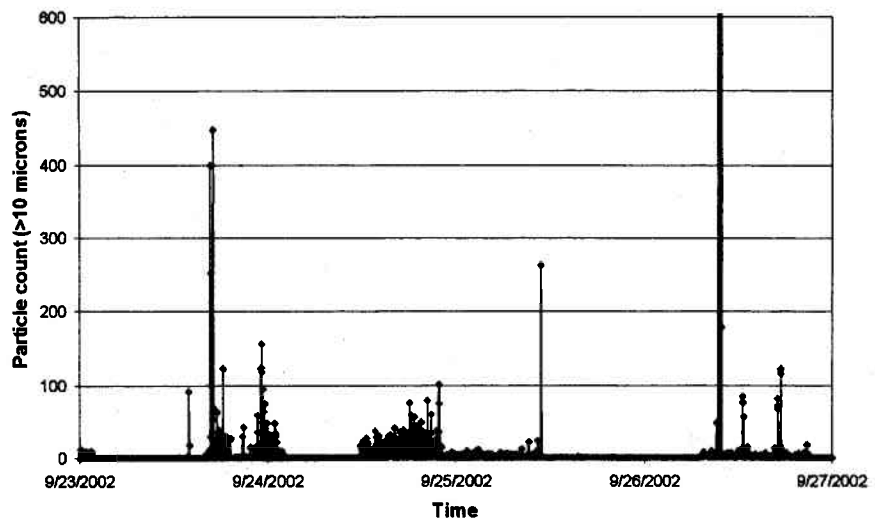
Golder Associates

Date: Feb, 2003
Drawn: J.P.A.O
Project: 021-2805
Chkd: BJV

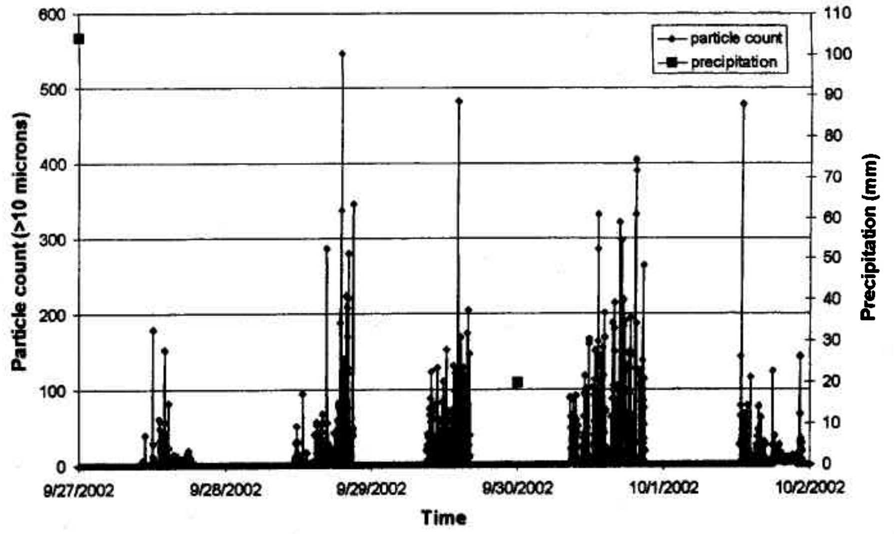
ST. ISIDORE PARTICLE COUNT AND PRECIPITATION RESULTS FOR WELL 3

FIGURE 13

14A) St. Isidore Well 3 Dry Period



14B) St. Isidore Well 3 Wet Period

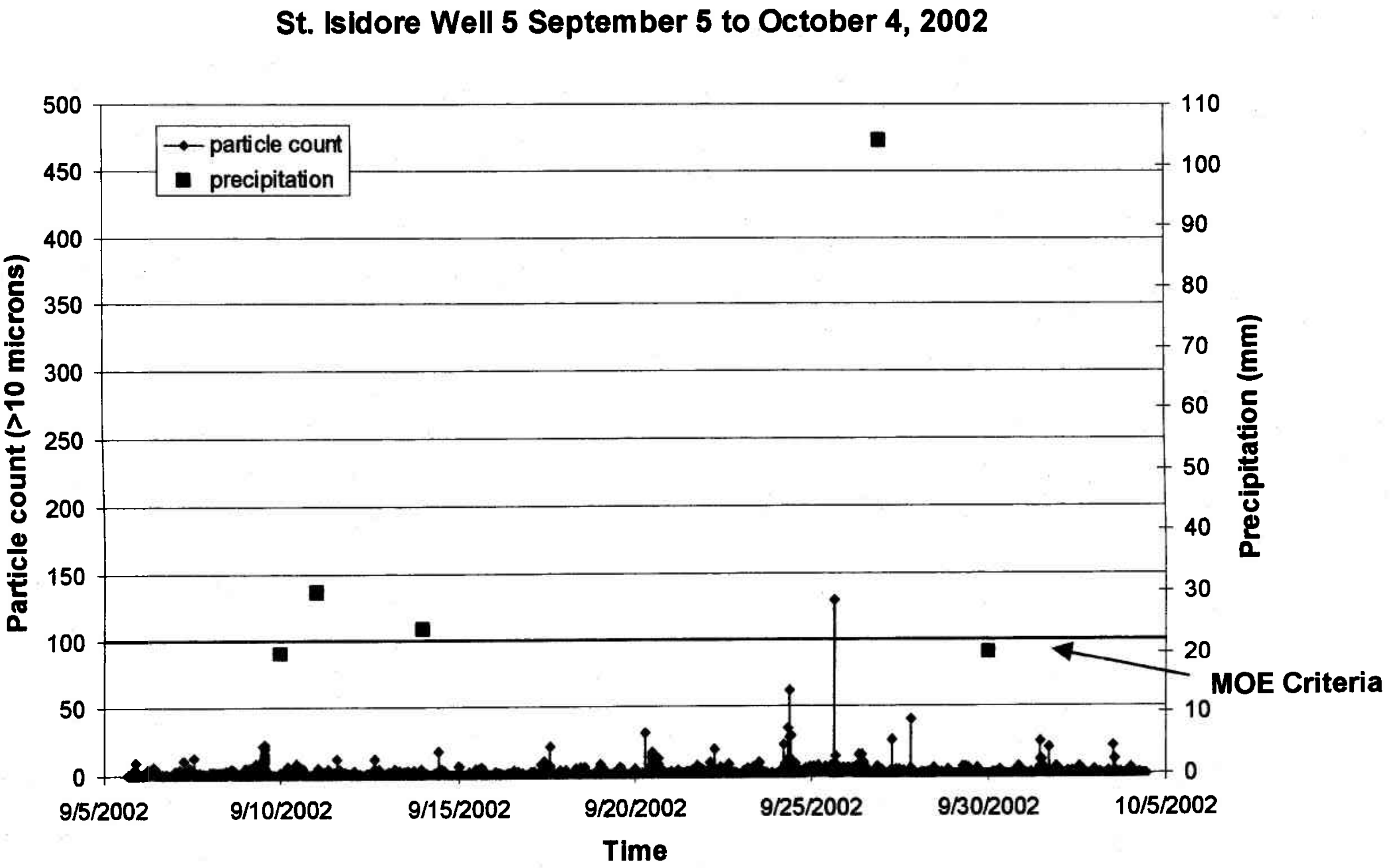


Golder Associates

Date: Feb. 2003
Drawn: J.P.A.O
Project: 021-2805
Chkd: BJV

ST. ISIDORE PARTICLE COUNT RESULTS DURING A DRY AND WET PERIOD FOR WELL 3

FIGURE 14



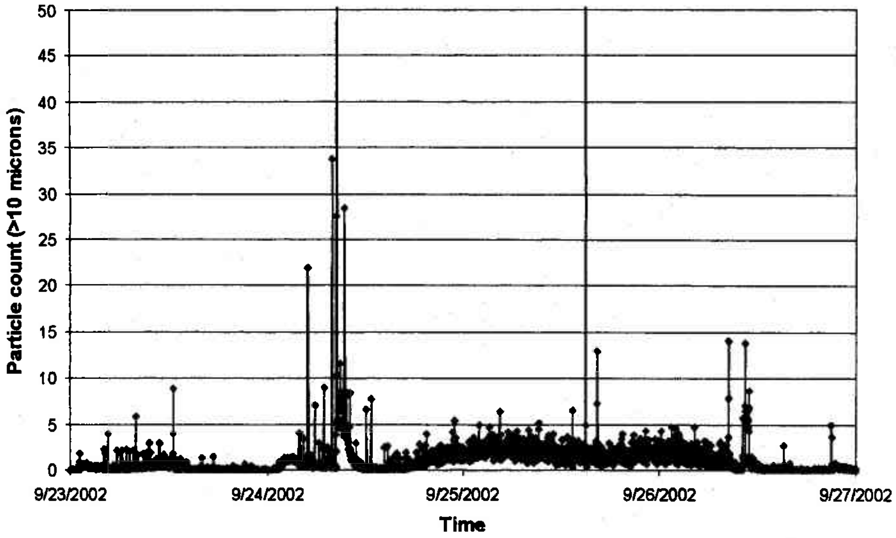
Golder Associates

Date: Feb. 2003
Drawn: J.P.A.O
Project: 021-2805
Chkd: BJV

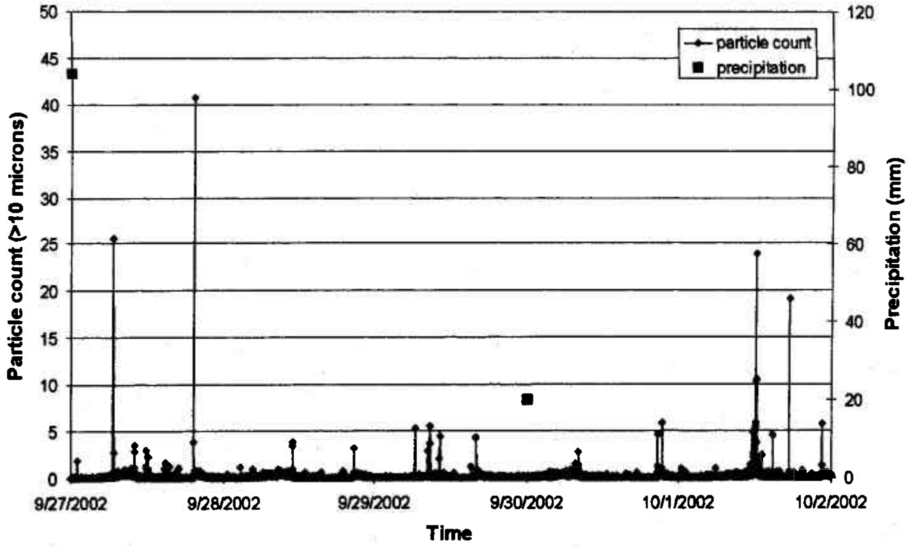
ST. ISIDORE PARTICLE COUNT AND PRECIPITATION RESULTS FOR WELL 5

FIGURE 15

16A) St. Isidore Well 5 Dry Period



16B) St. Isidore Well 5 Wet Period



Golder Associates

Date: Feb, 2003 Drawn: J.P.A.O
Project: 021-2805 Chkd: BJV

ST. ISIDORE PARTICLE COUNT RESULTS DURING A DRY AND WET PERIOD FOR WELL 5

FIGURE 16

APPENDIX A

AVAILABLE BOREHOLE LOGS AND WATER WELL RECORDS

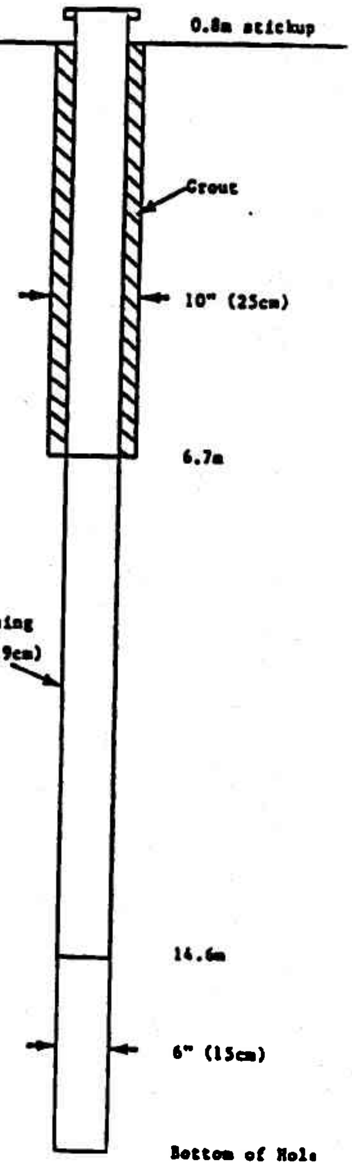
STRATIGRAPHIC AND INSTRUMENTATION LOG

WELL NO. 1

PROJECT NAME AND No.: St. Isidore, E88-003	BOREHOLE No.: Test Well - 1
CLIENT: Kostuch Engineering Ltd.	DATE COMPLETED: November 1, 1988
LOCATION: Township of Caledonia	DRILLING METHOD: Mud Rotary and Air Hammer
REFERENCE ELEVATION:	DRILL SUPERVISOR: A. Sweezey

DEPTH m BG	SAMPLE AND No.	STRATIGRAPHIC DESCRIPTION AND REMARKS	DEPTH m BG
0 2 4 6 8 10 12		Overburden, clay, grey	12.2
14		Clay with layers of shale Till Minor granitic and limestone pebbles	14.0
16		Limestone, grey	17.7
18 20			

INSTALLATION



INTERA Technologies Ltd.

Ministry of the Environment
Ontario

NOV [illegible] 1988

The Ontario Water Resources Act WELL No. 1

WATER WELL RECOR

1 PRINT ONLY IN SPACES PROVIDED
2 CHECK ☒ CORRECT BOX WHERE APPLICABLE

COUNTY OR DISTRICT	TOWNSHIP BOROUGH CITY TOWN VILLAGE	CON BLOCK TRACT SURVEY ETC	LOT
Prescott-Russell	South Plantagenet	II	

OWNER (SURNAME FIRST)	ADDRESS	DATE COMPLETED
Intera Technologies Ltd	St. Isidore, Ont.	DAY 01 MO 11 YR 8

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
grey			clay	0	40
grey		layers of brown slate	clay	40	47
grey			limestone	47	58

WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER	
51	☐ FRESH ☐ SALTY	☒ SULPHUR ☐ MINERALS ☐ GAS
53	☐ FRESH ☐ SALTY	☒ SULPHUR ☐ MINERALS ☐ GAS
56	☐ FRESH ☐ SALTY	☒ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY	☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY	☐ SULPHUR ☐ MINERALS ☐ GAS

CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
6¼	☒ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC	188	+3	48
6	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☒ OPEN HOLE ☐ PLASTIC		48	58
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER	LENGTH
	INCHES	

MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN
	FEET

PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT LEAD PACKER ETC.)
0	22	cement grout

PUMPING TEST

PUMPING TEST METHOD	PUMPING RATE	DURATION OF PUMPING
☐ PUMP ☐ BAILER air	100 approx. GPM	1 HOURS ____ MINS

STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING ☐ PUMPING ☒ RECOVERY 15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
16 FEET	55 FEET	16 FEET	16 FEET	16 FEET	16 FEET

IF FLOWING GIVE RATE	PUMP INTAKE SET AT	WATER AT END OF TEST
GPM	55 FEET	☐ CLEAR ☒ CLOUDY

RECOMMENDED PUMP TYPE	RECOMMENDED PUMP SETTING	RECOMMENDED PUMPING RATE
☐ SHALLOW ☒ DEEP	40 FEET	100 approx. GPM

FINAL STATUS OF WELL

- ☒ WATER SUPPLY
- ☐ OBSERVATION WELL
- ☐ TEST HOLE
- ☐ RECHARGE WELL
- ☐ ABANDONED, INSUFFICIENT SUPPLY
- ☐ ABANDONED POOR QUALITY
- ☐ UNFINISHED
- ☐ DEWATERING

WATER USE

- ☐ DOMESTIC
- ☐ STOCK
- ☐ IRRIGATION
- ☐ INDUSTRIAL
- ☐ OTHER
- ☐ COMMERCIAL
- ☒ MUNICIPAL
- ☐ PUBLIC SUPPLY
- ☐ COOLING OR AIR CONDITIONING
- ☐ NOT USED

METHOD OF CONSTRUCTION

- ☐ CABLE TOOL
- ☐ ROTARY (CONVENTIONAL)
- ☐ ROTARY (REVERSE)
- ☒ ROTARY (AIR)
- ☐ AIR PERCUSSION
- ☐ BORING
- ☐ DIAMOND
- ☐ JETTING
- ☐ DRIVING
- ☐ DIGGING
- ☐ OTHER

CONTRACTOR

NAME OF WELL CONTRACTOR: G.Charbonneau+Son DrillingLtd.
WELL CONTRACTOR'S LICENCE NUMBER: 1504
ADDRESS: R.R.2, Box 194, Orléans, O.t. K1C 1T1
NAME OF WELL TECHNICIAN: Benoît Charbonneau
WELL TECHNICIAN'S LICENCE NUMBER: T-0136
SIGNATURE OF TECHNICIAN/CONTRACTOR:
SUBMISSION DATE: DAY 01 MO 11 YR 88

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE INDICATE NORTH BY ARROW

DRILLERS REMARKS

17786

OFFICE USE ONLY

OWNER'S COPY

FORM NO. 0506 (11/86) FOR

STRATIGRAPHIC AND INSTRUMENTATION LOG WELL No.2

PROJECT NAME AND No.: ST. ISIDORE, H88-003

BOREHOLE No.: TEST WELL - 6 ②

CLIENT: KOSTUCH ENGINEERING LTD.

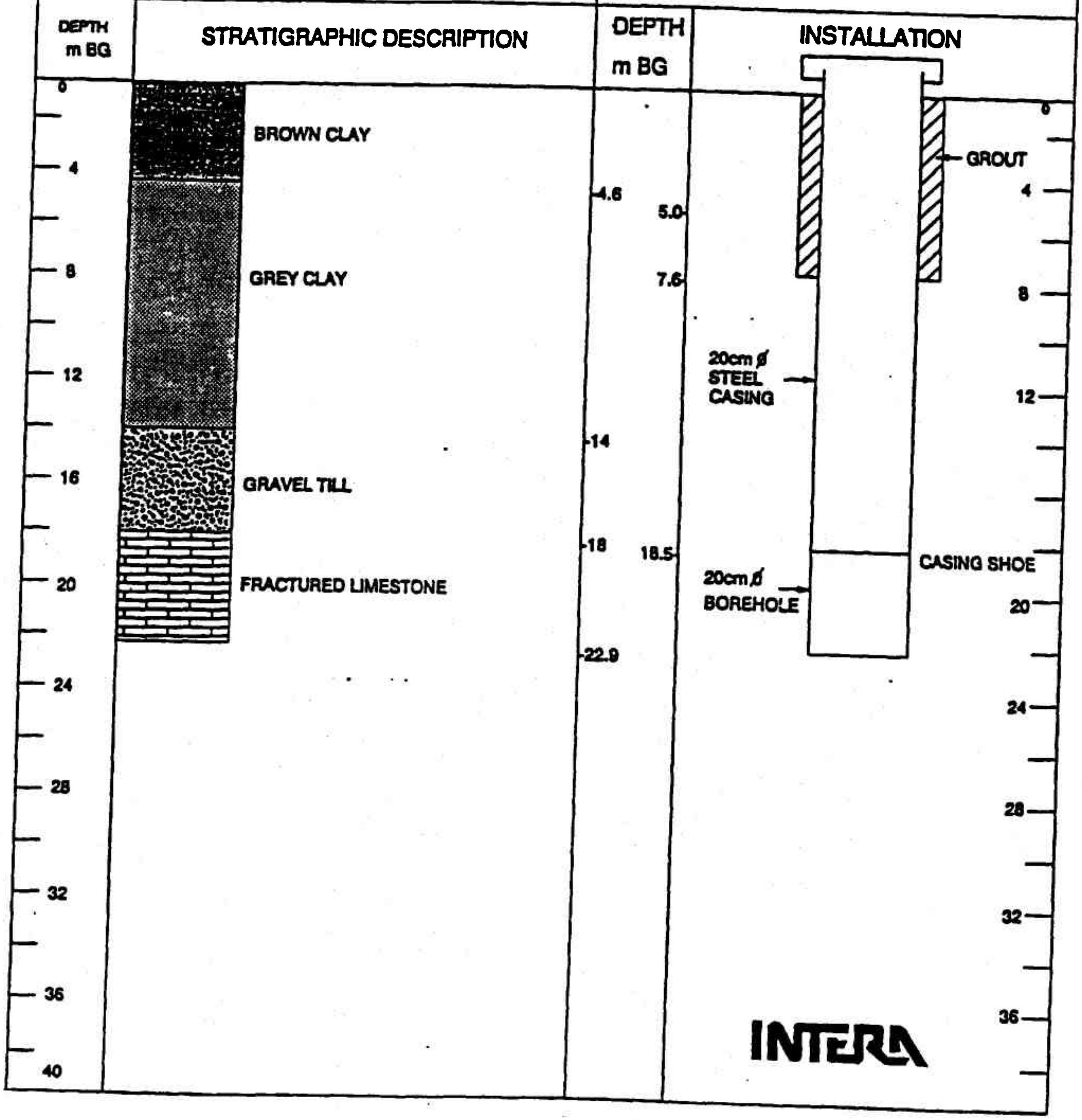
DATE COMPLETED: MARCH 6, 1991

LOCATION: TOWNSHIP OF CALEDONIA

DRILLING METHOD: TRICONE AND AIR HAMMER

REFERENCE ELEVATION: GROUND SURFACE

DRILL SUPERVISOR: R.A.S.



Ministry of the Environment
Ontario

The Ontario Water Resources Act WELL No.2

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

COUNTY OR DISTRICT PRESCOTT - RUSSELL	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE S. PLANTAGENET	CON, BLOCK, TRACT, SURVEY, ETC CON XI	LOT 19
OWNER (SURNAME FIRST) INTERA KENTING	ADDRESS ST. ISIDORE		DATE COMPLETED DAY 6 MO 3 YR 91

Test Well #6

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
BROWN	CLAY		PACKED	0'	15'
GREY	CLAY		MOIST	15'	42'
BLACK	TILL			42'	55'
BLACK	SHALE	LIMESTONE	SOFT.	55'	74'

WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
61	☒ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS

CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
8 5/8	☑ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC	.188	0'	59'
8"	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC		59'	74'
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER INCHES	LENGTH FEET
MATERIAL AND TYPE		DEPTH TO TOP OF SCREEN FEET

PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)
0	25	Cement Grout.

PUMPING TEST

PUMPING TEST METHOD ☑ PUMP ☐ BAILER	PUMPING RATE 40 GPM	DURATION OF PUMPING 24 HOURS ___ MINS	
STATIC LEVEL 15 FEET	WATER LEVEL END OF PUMPING 23.6 FEET	WATER LEVELS DURING ☑ PUMPING ☐ RECOVERY	
15 MINUTES - FEET	30 MINUTES - FEET	45 MINUTES - FEET	60 MINUTES - FEET
IF FLOWING GIVE RATE GPM	PUMP INTAKE SET AT 45 FEET	WATER AT END OF TEST ☑ CLEAR ☐ CLOUDY	
RECOMMENDED PUMP TYPE ☐ SHALLOW ☑ DEEP	RECOMMENDED PUMP SETTING 45 FEET	RECOMMENDED PUMPING RATE 40 GPM	

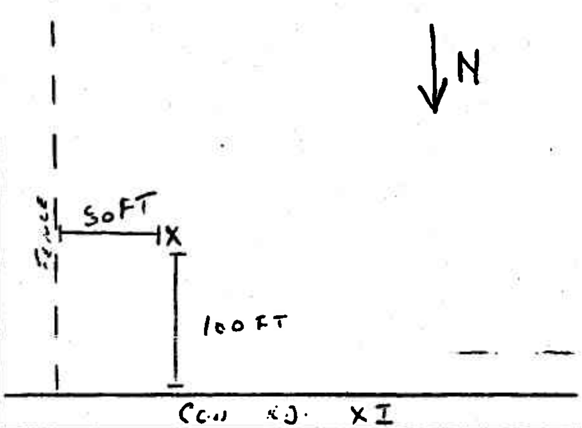
FINAL STATUS OF WELL
- ☑ WATER SUPPLY
- ☐ OBSERVATION WELL
- ☐ TEST HOLE
- ☐ RECHARGE WELL
- ☐ ABANDONED, INSUFFICIENT SUPPLY
- ☐ ABANDONED, POOR QUALITY
- ☐ UNFINISHED
- ☐ DEWATERING

WATER USE
- ☐ DOMESTIC
- ☐ STOCK
- ☐ IRRIGATION
- ☐ INDUSTRIAL
- ☐ OTHER
- ☐ COMMERCIAL
- ☑ MUNICIPAL
- ☐ PUBLIC SUPPLY
- ☐ COOLING OR AIR CONDITIONING
- ☐ NOT USED

METHOD OF CONSTRUCTION
- ☐ CABLE TOOL
- ☐ ROTARY (CONVENTIONAL)
- ☐ ROTARY (REVERSE)
- ☑ ROTARY (AIR)
- ☐ AIR PERCUSSION
- ☐ BORING
- ☐ DIAMOND
- ☐ JETTING
- ☐ DRIVING
- ☐ DIGGING
- ☐ OTHER

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW



DRILLERS REMARKS

095458

CONTRACTOR

NAME OF WELL CONTRACTOR Valley Drilling Inc	WELL CONTRACTOR'S LICENCE NUMBER 5222
ADDRESS P.O.Box 437 Carp. Ont	
NAME OF WELL TECHNICIAN Bill Bacon	WELL TECHNICIAN'S LICENCE NUMBER T-0190
SIGNATURE OF TECHNICIAN/CONTRACTOR	SUBMISSION DATE DAY ___ MO ___ YR ___

OFFICE USE ONLY

OWNER'S COPY

FORM NO 0506 (11/86) FORM

STRATIGRAPHIC AND INSTRUMENTATION LOG WELL NO.3

PROJECT NAME AND No.: ST. ISIDORE, H88-003

BOREHOLE No.: TEST WELL - 7 ③

CLIENT: KOSTUCH ENGINEERING LTD.

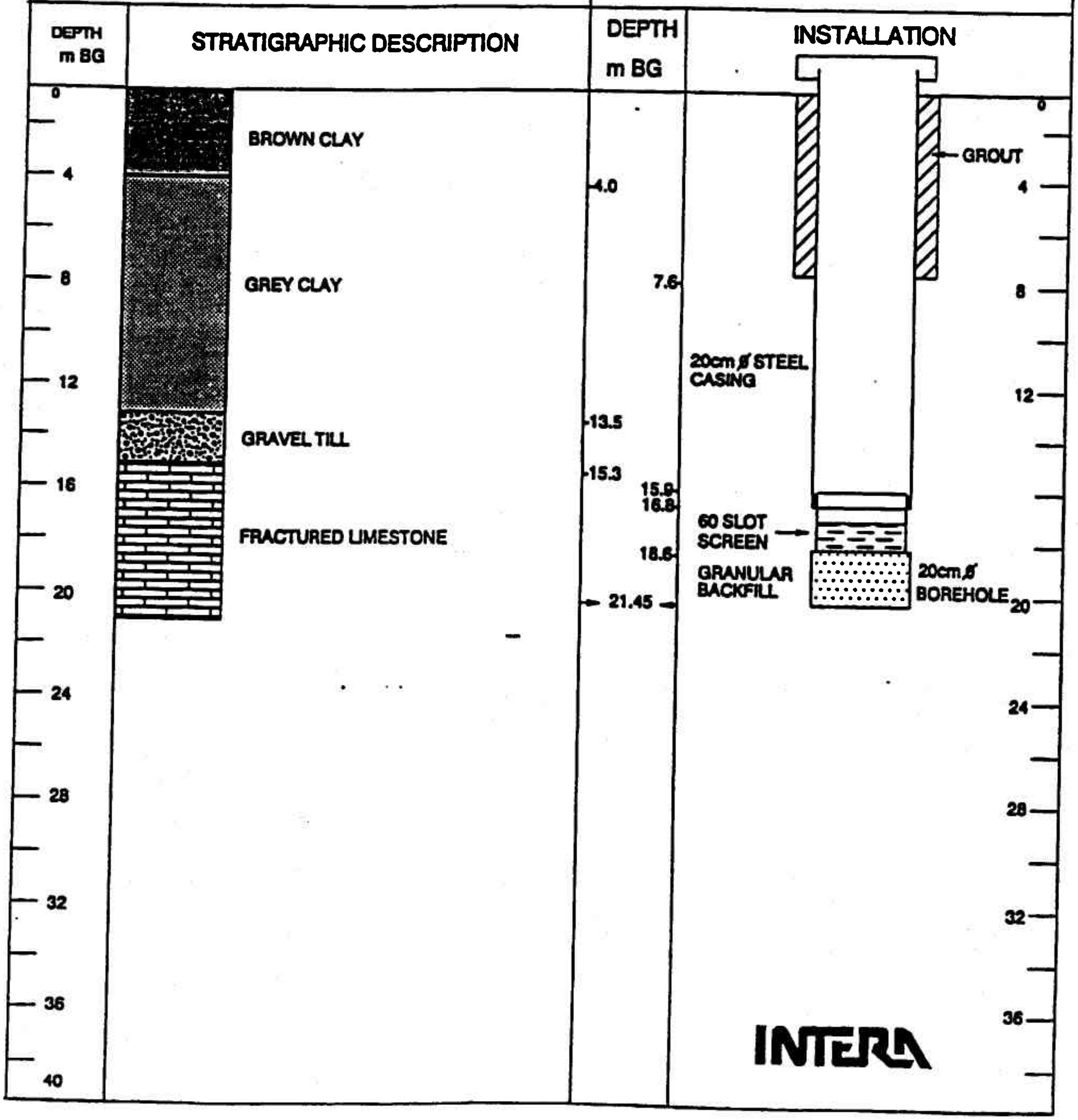
DATE COMPLETED: MARCH 13, 1991

LOCATION: TOWNSHIP OF CALEDONIA

DRILLING METHOD: TRICONE AND AIR HAMMER

REFERENCE ELEVATION: GROUND SURFACE

DRILL SUPERVISOR: R.A.S.



Ministry of the Environment
Ontario

The Ontario Water Resources Act WELL NO 3

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

C[illegible]Y OR DISTRICT	TOWNSHIP BOROUGH CITY TOWN VILLAGE	CON BLOCK TRACT SURVEY ETC	LOT
PRESCOTT - RUSSELL	S. PLANTAGENET	CON XI	17

OWNER (SURNAME FIRST)	ADDRESS	DATE COMPLETED
INTTRA [illegible]	ST. ISIDORE	DAY 13 MO 3 YR 91

Test Well # 7

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
Brown	Clay		Packed.	0	13
Grey	Clay	Silt	Moist	13'	44'
Black	Till			44'	50'
Black	Shale	Till	Semi Consolidated	50'	59'
Black	Shale	Limestone	Soft.	59'	70'

WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
54'-60'	☑ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS

CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
8 5/8	☑ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC	.188	0	54'
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC			
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER	LENGTH
60 (Sixty)	INCHES	6 FEET

MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN
[illegible]	52 FEET

PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT LEAD PACKER ETC.)
0	25	Cement Grout

PUMPING TEST

PUMPING TEST METHOD	PUMPING RATE	DURATION OF PUMPING		
☑ PUMP ☐ BAILER	29 GPM	24 HOURS ___ MINS		

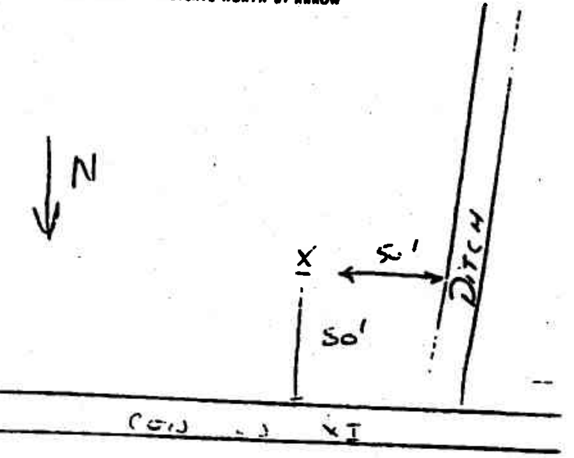
STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING ☒ PUMPING ☐ RECOVERY 15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
12.6 FEET	26 FEET	– FEET	– FEET	– FEET	– FEET

IF FLOWING, GIVE RATE	PUMP INTAKE SET AT	WATER AT END OF TEST
GPM	50 FEET	☒ CLEAR ☐ CLOUDY

RECOMMENDED PUMP TYPE	RECOMMENDED PUMP SETTING	RECOMMENDED PUMPING RATE
☐ SHALLOW ☑ DEEP	45 FEET	25 GPM

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE INDICATE NORTH BY ARROW



DRILLERS REMARKS

095457

FINAL STATUS OF WELL	☑ WATER SUPPLY ☐ OBSERVATION WELL ☐ TEST HOLE ☐ RECHARGE WELL ☐ ABANDONED INSUFFICIENT SUPPLY ☐ ABANDONED POOR QUALITY ☐ UNFINISHED ☐ DEWATERING
WATER USE	☐ DOMESTIC ☐ STOCK ☐ IRRIGATION ☐ INDUSTRIAL ☐ OTHER ☐ COMMERCIAL ☑ MUNICIPAL ☐ PUBLIC SUPPLY ☐ COOLING OR AIR CONDITIONING ☐ NOT USED
METHOD OF CONSTRUCTION	☐ CABLE TOOL ☐ ROTARY (CONVENTIONAL) ☐ ROTARY (REVERSE) ☑ ROTARY (AIR) ☐ AIR PERCUSSION ☐ BORING ☐ DIAMOND ☐ JETTING ☐ DRIVING ☐ DIGGING ☐ OTHER

CONTRACTOR

NAME OF WELL CONTRACTOR	WELL CONTRACTOR'S LICENCE NUMBER
Valley Drilling inc	5222

ADDRESS: P.O. Box 427 Carp, Ont

NAME OF WELL TECHNICIAN	WELL TECHNICIAN'S LICENCE NUMBER
Bill Bisson	T-0190

SIGNATURE OF TECHNICIAN/CONTRACTOR	SUBMISSION DATE
	DAY ___ MO ___ YR ___

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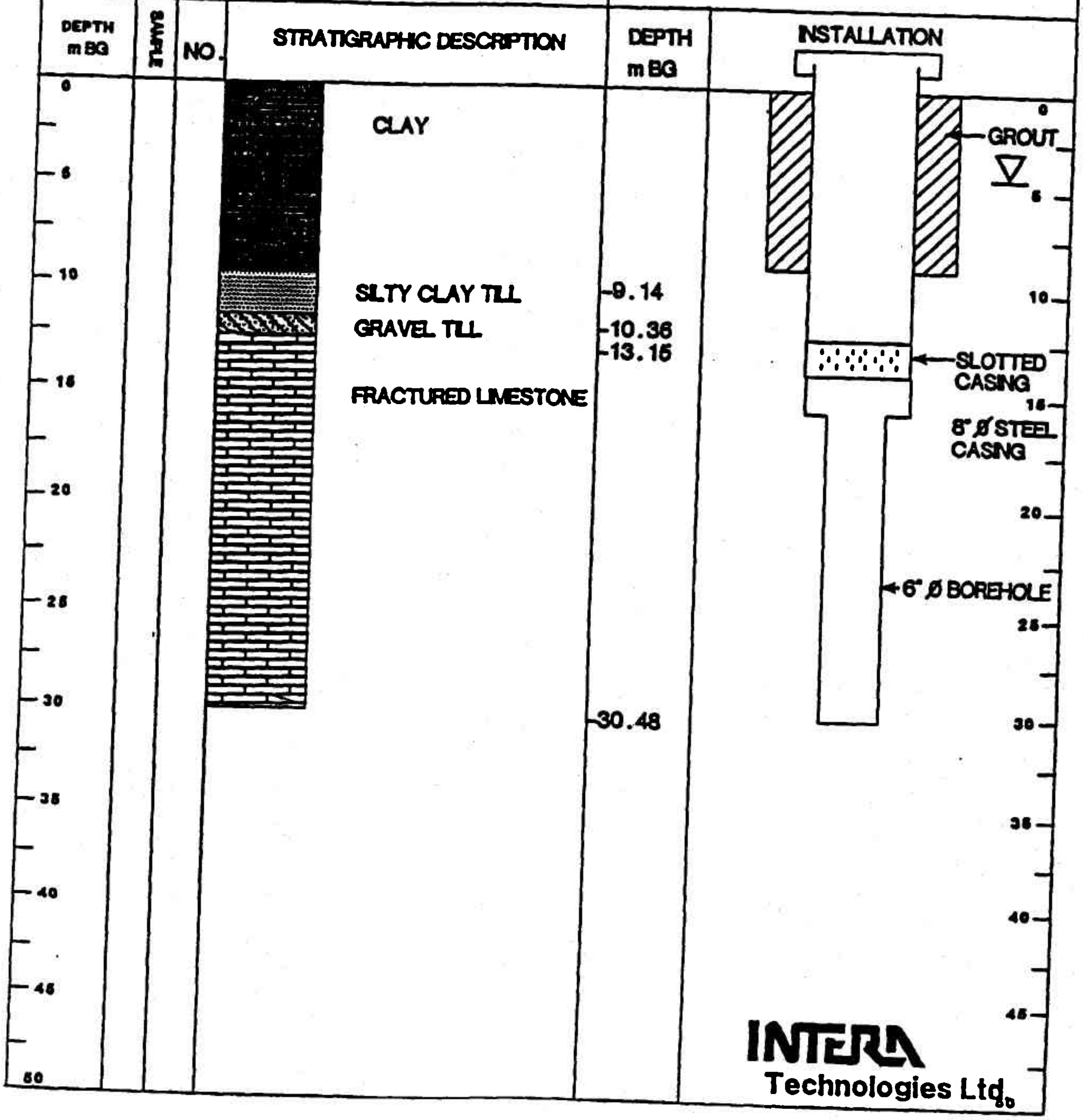
OWNER'S COPY

FORM NO. 0506 (11/86) FORM

STRATIGRAPHIC AND INSTRUMENTATION LOG WELL No. 4

PROJECT NAME AND No.: ST. ISIDORE, H88-003	**BOREHOLE No.:** TEST WELL - 4
CLIENT: KOSTUCH ENGINEERING LTD.	**DATE COMPLETED:** MAY 4, 1990
LOCATION: TOWNSHIP OF CALEDONIA	**DRILLING METHOD:** MUD ROTARY AND AIR HAMMER
REFERENCE ELEVATION: GROUND SURFACE	**DRILL SUPERVISOR:** R.A.S.



INTERA Technologies Ltd.

Ministry of the Environment
Ontario

The Ontario Water Resources Act WELL NO.4

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

COUNTY OR DISTRICT: [illegible]
TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE: [illegible]
CON, BLOCK, TRACT, SURVEY, ETC.: 11
LOT: 21
OWNER (SURNAME FIRST): [illegible]
ADDRESS: [illegible]
DATE COMPLETED: DAY ____ MO ____ YR ____

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
[illegible]	Clay			0	7,1
[illegible]	Clay	Till [illegible]		[illegible]	[illegible]
[illegible]	Gravel	Till	[illegible]	[illegible]	42
[illegible]	[illegible]		[illegible]	42	

WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
43	☑ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS

CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
8¼	☑ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC	.188	0	43
8¼	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☒ OPEN HOLE ☐ PLASTIC		43	49
6	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC		49	100

SCREEN

SIZE(S) OF OPENING (SLOT NO.): Slotted
DIAMETER: 8 INCHES
LENGTH: 4 FEET
MATERIAL AND TYPE: Steel
DEPTH TO TOP OF SCREEN: 43 FEET

PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	DEPTH SET AT - FEET TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)
0	29	Cement.

PUMPING TEST

PUMPING TEST METHOD: ☑ PUMP ☐ BAILER
PUMPING RATE: 12 GPM
DURATION OF PUMPING: 2 HOURS ____ MINS
STATIC LEVEL: 15 FEET
WATER LEVEL END OF PUMPING: ____ FEET
WATER LEVELS DURING ☐ PUMPING ☐ RECOVERY

15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
25 FEET	25 FEET	25 FEET	25 FEET

IF FLOWING GIVE RATE: ____ GPM
PUMP INTAKE SET AT: ____ FEET
WATER AT END OF TEST: ☐ CLEAR ☐ CLOUDY
RECOMMENDED PUMP TYPE: ☐ SHALLOW ☐ DEEP
RECOMMENDED PUMP SETTING: ____ FEET
RECOMMENDED PUMPING RATE: ____ GPM

FINAL STATUS OF WELL

- ☐ WATER SUPPLY
- ☐ OBSERVATION WELL
- ☑ TEST HOLE
- ☐ RECHARGE WELL
- ☐ ABANDONED INSUFFICIENT SUPPLY
- ☐ ABANDONED POOR QUALITY
- ☐ UNFINISHED
- ☐ DEWATERING

WATER USE

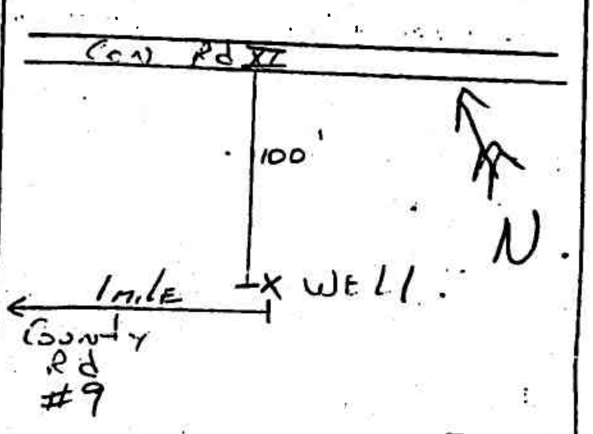
- ☐ DOMESTIC
- ☐ STOCK
- ☐ IRRIGATION
- ☐ INDUSTRIAL
- ☐ OTHER
- ☐ COMMERCIAL
- ☑ MUNICIPAL
- ☐ PUBLIC SUPPLY
- ☐ COOLING OR AIR CONDITIONING
- ☐ NOT USED

METHOD OF CONSTRUCTION

- ☐ CABLE TOOL
- ☐ ROTARY (CONVENTIONAL)
- ☐ ROTARY (REVERSE)
- ☐ ROTARY (AIR)
- ☑ AIR PERCUSSION
- ☐ BORING
- ☐ DIAMOND
- ☐ JETTING
- ☐ DRIVING
- ☐ DIGGING
- ☐ OTHER

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW



DRILLERS REMARKS

72101

CONTRACT

NAME OF WELL CONTRACTOR: [illegible]
WELL CONTRACTOR'S LICENCE NUMBER: 5777
ADDRESS: [illegible]
NAME OF WELL TECHNICIAN: [illegible]
WELL TECHNICIAN'S LICENCE NUMBER: [illegible]
SIGNATURE OF TECHNICIAN/CONTRACTOR:
SUBMISSION DATE: DAY ____ MO ____ YR ____

OFFICE USE ONLY

OWNER'S COPY

FORM NO. 0506 (11/86) FORM 9

APPENDIX B

CERTIFICATES OF ANALYSIS

APPENDIX B

CERTIFICATES OF ANALYSIS

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSIS

Client: Golder Associates Ltd.

ATT: Jamie Oxtabee

NVOICE: Golder Associates Ltd

Report Number: 2216183
Date: 2002-11-28
Date Submitted: 2002-11-14

Project: 021-2805 5000

P.O. Number:
Matrix: Supply Water

		LAB ID:	218051	218052	218053	218054		
		Sample Date:	2002-11-13	2002-11-13	2002-11-13	2002-11-13		
		Sample ID:	St. I Well 1	St. I Well 2	St. I Well 3	St. I Well 5	ODWS	
PARAMETER	**UNITS**	**MDL**	RAW WATER	RAW WATER	RAW WATER	RAW WATER		
Alkalinity as CaCO3	mg/L	5	334	340	265	300	30 - 500	
Ca	mg/L	1	44	3	44	61	- -	
Cl	mg/L	1	70	57	99	83	250	
Conductivity	uS/cm	5	885	809	796	818	- -	
F	mg/L	0.10	0.38	0.75	0.21	0.25	1.5	
Fe	mg/L	0.01	0.01	<0.01	0.05	0.09	0.3	
Hardness as CaCO3	mg/L	1	205	28	246	247	80 - 100	OG
Ion Balance		0.01	0.95	0.95	0.93	0.94		
Mg	mg/L	1	23	5	33	23	- -	
Mn	mg/L	0.005	0.014	<0.005	<0.005	0.015	0.05	
N-NO3	mg/L	0.10	<0.10	<0.10	<0.10	<0.10	10	
pH			8.12	8.84	8.18	8.09	6.5 - 8.5	OG
K	mg/L	1	9	5	13	9	- -	
Na	mg/L	2	107	174	58	71	200	
SO4	mg/L	1	38	11	14	20	500	

MDL = Method Detection Limit INC = Incomplete Method references available upon request.

Comment:

This is a correction certificate and supercedes all previous copies of this report.

APPROVAL:

Ewan McRobbie
Inorganic Lab Supervisor

ACCUTEST LABORATORIES LTD.

REPORT OF ANALYSIS

Client: Golder Associates Ltd.

ATT: Jaime Oxtobee

Report Number:	2216121
Date:	2002-11-20
Date Submitted:	2002-11-13
Project:	021-2805 5000
P.O. Number:	
Matrix:	Surfacewater

		LAB ID:	217829	217830			
		Sample Date:	2002-11-13	2002-11-13			
		Sample ID:	SW1	SW2			
PARAMETER	**UNITS**	**MDL**					
Alkalinity as CaCO3	mg/L	5	203	176			
Ca	mg/L	1	113	77			
Cl	mg/L	1	153	116			
Conductivity	uS/cm	5	1000	810			
Escherichia Coli	ct/100mL		76	18			
F	mg/L	0.10	0.14	0.23			
Fe	mg/L	0.01	0.03	0.30			
Hardness as CaCO3	mg/L	1	323	246			
Ion Balance		0.01	1.01	0.97			
Mg	mg/L	1	10	13			
Mn	mg/L	0.005	<0.005	0.007			
N-NO3	mg/L	0.10	4.70	1.05			
pH			8.24	8.19			
K	mg/L	1	2	3			
Na	mg/L	2	72	58			
SO4	mg/L	1	42	41			
Total Coliforms	ct/100 mL		320	280			

MDL = Method Detection Limit INC = Incomplete Method references available upon request.

Comment:

APPROVAL:

Ewan McRobbie
Inorganic Lab Supervisor

GAP
EnviroMicrobial Services

FINAL RESULTS FORM

GAP EnviroMicrobial Services
1020 Hargrieve Road, Unit 14
London, ON N6E 1P5
Tel: (519) 681-0571 Fax: (519) 681-7150

GAP JOB #: A2716	**DATE SAMPLED:** 13-Nov-02	**REPORT TO:** Jaime Oxtobee	**INVOICE TO:** same
PAGE #: 1 of 1	**COLLECTED BY:** Jaime Oxtobee	**ADDRESS:** 1796 Courtwood Cres. Ottawa, ON K2L 2B5	**ADDRESS:** same
CLIENT / PROJECT NAME: Golder Associates	**DATE RECEIVED:** 14-Nov-02		
	RECEIVED BY: C. Bryant	**TEL:** 613-224-5864	**TEL:**
	DATE ANALYZED 14-Nov-02	**FAX:** 613-224-9928	**FAX:**

LAB #	SENDERS #	MATRIX	SAMPLE DESCRIPTION	COMMENTS
18018		Water	St. Isidore Well #1	
18019		Water	St. Isidore Well #2	
18020		Water	St. Isidore Well #3	
18021		Water	St. Isidore Well #5	

TEST RESULTS

These test results relate only to the samples submitted and the analyses requested.

LAB #	SENDERS #	Total Aerobic Spore formers CFU per 500 mL MF	*Campylobacter* PA			
18018		19	Absent per 900 mL			
18019		2	Absent per 1000 mL			
18020		2	Absent per 900 mL			
18021		2	Absent per 1000 mL			

Calculated by: C. Bryant Position: Environmental Scientist

Signature: CBryant

Approved by: M. Walsh (Quality Manager) or [✓ S. Unger (Laboratory Manager)]

Signature:

Date: Dec 3/2002

L = Less Than ; G = Greater Than ; TNTC = To Numerous To Count ; NR = No Result ; LA = Laboratory Accident ; A = Approximate Value ; C = Crowded Filter
CFU = Colony Forming Unit ; PFU = Plaque Forming Unit ; MF = Membrane Filtration ; MPN = Most Probable Number ; SP = Spread Plate
Accredited Method Codes: Presence/Absence Test = PA-0001 ; Numerical Value Tests = TCMF-0001, ECMF-0001, FCMF-0001, HPCMF-0001, MS2PHAGE-0001, LEG-0001.

GAP
EnviroMicrobial Services
a division of Conestoga Rovers & Associates Ltd.

1020 Hargrieve Road, Unit 14
London, Ontario, Canada N6E 1P5
Telephone: (519) 681-0571
Fax: (519) 681-7150
Email: info@gapenviromic.com
Website: www.gapenviromic.com

Reference No. 17500-A2730

December 10, 2002

Golder Associates
1796 Courtwood Cres.
Ottawa, Ontario
K2C 2B5
Attention: Jamie Oxtobee

Tel: (613) 224-5864
Fax: (613) 228-9928
Email: joxtobee@golder.com

Date Samples Collected: November 18-19, 2002
Date Samples Processed: November 20, 2002

Client Project Number: 021-2805
Location: St. Isidore Well #1
GAP Sample Number: 18169
Total Volume Filtered: 2366 Litres (623 gallons)
Total Filter Sediment Collected: 300µL
Biological packed sediment: 20µL

Indicators of Surface Water	Indicators Counted/100 gallons	Relative Amounts	Relative Risk Factor
Diatoms	0	Not Significant	0
Other Algae	3	Rare	4
Insects/Larvae	<1	Not Significant	0
Rotifers	0	Not Significant	0
Plant Debris	<1	Not Significant	0

Total Relative Risk Factor: 4

The risk of surface water contamination is given by the following key:
A total Relative Risk Factor with a value
> 19 indicates a high risk
10-19 indicates a moderate risk
< 10 indicates a low risk

This Microscopic Particulate Analysis indicates that there is a **low risk** that the groundwater is being impacted by surface waters.

GAP
EnviroMicrobial Services
A Division of Conestoga-Rovers & Associates Ltd.

1020 Hargrieve Road, Unit 14
London, Ontario, Canada N6E 1P5
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Fax: (519) 681-7150
Email: info@gapenviromic.com
Website: www.gapenviromic.com

Reference No. 17500-A2730

Relative Concentrations of other Particulates

Particulate	Relative Concentration per 100 gallons
Large Amorphous Debris	Rare
Small Amorphous Debris	Moderate
Minerals	Rare
Pollen	Not Detected
Nematodes	Not Detected
Crustacia	Not Detected
Ameoba	Rare
Ciliates/Flagellates	Not Detected

Analyst: Josh Tuininga
Analytical Technologist

Approved By: Maureen Walsh
Quality Manager

Signature:

Signature: Maureen Walsh

Date: December 10, 2002

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Email: info@gapenviromic.com
Website: www.gapenviromic.com

Reference No. 17500-A2730

December 10, 2002

Golder Associates
1796 Courtwood Cres.
Ottawa, Ontario
K2C 2B5
Attention: Jamie Oxtobee

Tel: (613) 224-5864
Fax: (613) 228-9928
Email: joxtobee@golder.com

Date Samples Collected: November 19-20, 2002
Date Samples Processed: November 20, 2002

Client Project Number: 021-2805
Location: St. Isidore Well #2
GAP Sample Number: 18184
Total Volume Filtered: 2369 Litres (623 gallons)
Total Filter Sediment Collected: 300µL
Biological packed sediment: 300µL

Indicators of Surface Water	Indicators Counted/100 gallons	Relative Amounts	Relative Risk Factor
Diatoms	0	Not Significant	0
Other Algae	12	Rare	4
Insects/Larvae	0	Not Significant	0
Rotifers	0	Not Significant	0
Plant Debris	<1	Not Significant	0

Total Relative Risk Factor: 4

The risk of surface water contamination is given by the following key:
A total Relative Risk Factor with a value
> 19 indicates a high risk
10-19 indicates a moderate risk
< 10 indicates a low risk

This Microscopic Particulate Analysis indicates that there is a **low risk** that the groundwater is being impacted by surface waters.

GAP
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a division of Conestoga-Rovers & Associates Ltd.

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London, Ontario, Canada N6E 1P5
Telephone: (519) 681-0571
Fax: (519) 681-7150
Email: info@gapenviromic.com
Website: www.gapenviromic.com

Reference No. 17500-A2730

Relative Concentrations of other Particulates

Particulate	Relative Concentration per 100 gallons
Large Amorphous Debris	Rare
Small Amorphous Debris	Moderate
Minerals	Rare
Pollen	Not Detected
Nematodes	Not Detected
Crustacia	Not Detected
Ameoba	Not Detected
Ciliates/Flagellates	Not Detected

Analyst: Josh Tuininga
Analytical Technologist

Signature:

Approved By: Maureen Walsh
Quality Manager

Signature: Maureen Walsh

Date: December 10, 2002

GAP EnviroMicrobial Services
a division of Conestoga-Rovers & Associates Ltd.

1020 Hargrieve Road, Unit 14
London, Ontario, Canada N6E 1P5
Telephone: (519) 681-0571
Fax: (519) 681-7150
Email: info@gapenviromic.com
Website: www.gapenviromic.com

Reference No. 17500-A2730

December 10, 2002

Golder Associates
1796 Courtwood Cres.
Ottawa, Ontario
K2C 2B5
Attention: Jamie Oxtobee

Tel: (613) 224-5864
Fax: (613) 228-9928
Email: joxtobee@golder.com

Date Samples Collected: November 20-21, 2002
Date Samples Processed: November 22, 2002

Client Project Number: 021-2805
Location: St. Isidore Well #3
GAP Sample Number: 18354
Total Volume Filtered: 1529 Litres (402 gallons)
Total Filter Sediment Collected: 900µL
Biological packed sediment: 350µL

Indicators of Surface Water	Indicators Counted/100 gallons	Relative Amounts	Relative Risk Factor
Diatoms	4	Rare	6
Other Algae	30	Moderate	9
Insects/Larvae	4	Rare	3
Rotifers	0	Not Significant	0
Plant Debris	0	Not Significant	0

Total Relative Risk Factor: 18

The risk of surface water contamination is given by the following key:
A total Relative Risk Factor with a value
> 19 indicates a high risk
10-19 indicates a moderate risk
< 10 indicates a low risk

This Microscopic Particulate Analysis indicates that there is a **moderate risk** that the groundwater is being impacted by surface waters.

GAP
EnviroMicrobial Services
a division of Conestoga-Rovers & Associates Ltd.

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London, Ontario, Canada N6E 1P5
Telephone: (519) 681-0571
Fax: (519) 681-7150
Email: info@gapenviromic.com
Website: www.gapenviromic.com

Reference No. 17500-A2730

Relative Concentrations of other Particulates

Particulate	Relative Concentration per 100 gallons
Large Amorphous Debris	Moderate
Small Amorphous Debris	Moderate
Minerals	Rare
Pollen	Rare
Nematodes	Not Detected
Crustacia	Not Detected
Ameoba	Not Detected
Ciliates/Flagellates	Not Detected

Analyst: Josh Tuininga
Analytical Technologist

Approved By: Maureen Walsh
Quality Manager

Signature:

Signature: Maureen Walsh

Date: December 10, 2002

GAP
EnviroMicrobial Services
A division of Conestoga-Rovers & Associates Ltd.

ASSOCIATES
DEC 09 2002
OTTAWA

November 28, 2002

Reference 17500-A2716

Jaime Oxtobee
Golder Associates
1796 Courtwood Cres.
Ottawa, Ontario
K2C 2B5

Tel: (613) 224-5864
Fax: (613) 224-9928
Email: joxtobee@golder.com

Date Samples Collected	November 13, 2002
Date Samples Processed	November 14, 2002

Sample Information

Location	St. Isidore Well #5
GAP Sample Number	18022
Total Volume Filtered	3272 Liters (861.1 gallons)
Volume of Filter Sediment Collected	19 000 µL
Volume of Biological Packed Sediment Recovered	2000 µL

Microscopic Particulate Analysis (MPA) results

Indicators of Surface Water	Indicators Counted/100 gallons	Relative Amounts	Relative Risk Factor
Diatoms	5	Rare	6
Other Algae	115	High	12
Insects/Larvae	0	Not Significant	0
Rotifers	0	Not Significant	0
Plant Debris	0	Not Significant	0

Total Relative Risk Factor: 18

The risk of groundwater under the influence of surface water (GUDI) is determined using the following key:

Total Relative Risk Factor	Risk of GUDI
> 19	High
10 – 19	Moderate
<10	Low

This MPA indicates that there is a <u>**Moderate Risk**</u> that the groundwater is under the influence of surface water.

Relative Concentrations of other Particulates

Particulate	Relative Concentration per 100 gallons
Large Amorphous Debris	Rare
Small Amorphous Debris	Moderate
Minerals	Moderate
Pollen	Not Significant
Nematodes	Not Significant
Crustacia	Not Significant
Ameoba	Not Significant
Ciliates/Flagellates	Not Significant
Other	Moderate amounts of filamentous bacteria

Analyzed by:

CBryant

Christine Bryant
Environmental Scientist

Approved By:

SRamsay
LAB MANAGER

Maureen Walsh
Quality Manager

GAP
EnviroMicrobial Services
a division of Conestoga-Rovers & Associates Ltd

December 23, 2002

Reference 17500-A2841

Jaime Oxtobee
Golder Associates
1796 Courtwood Cres.
Ottawa, Ontario
K2C 2B5

Tel: (613) 224-5864
Fax: (613) 224-9928
Email: joxtobee@golder.com

Date Samples Collected	December 19, 2002
Date Samples Processed	December 20, 2002

Sample Information

Location	St. Isidore Well #6 Dup of Well #5
GAP Sample Number	19176
Total Volume Filtered	4863 Liters (1279.7 gallons)
Volume of Filter Sediment Collected	15 000 μL
Volume of Biological Packed Sediment Recovered	1400 μL

Microscopic Particulate Analysis (MPA) results

Indicators of Surface Water	Indicators Counted/100 gallons	Relative Amounts	Relative Risk Factor
Diatoms	0	Not Significant	0
Other Algae	22	Moderate	9
Insects/Larvae	0	Not Significant	0
Rotifers	0	Not Significant	0
Plant Debris	0	Not Significant	0

Total Relative Risk Factor: 9

The risk of groundwater under the influence of surface water (GUDI) is determined using the following key:

Total Relative Risk Factor	Risk of GUDI
> 19	High
10 – 19	Moderate
<10	Low

This MPA indicates that there is a **Low Risk** that the groundwater is under the influence of surface water.

Relative Concentrations of other Particulates

Particulate	Relative Concentration per 100 gallons
Large Amorphous Debris	Moderate
Small Amorphous Debris	Abundant
Minerals	Moderate
Pollen	Not Significant
Nematodes	Not Significant
Crustacia	Not Significant
Ameoba	Not Significant
Ciliates/Flagellates	Not Significant
Other	Abundant amounts of filamentous bacteria

Analysed by:

C Bryant

Christine Bryant
Environmental Scientist

Approved By:

Maureen Walsh

Maureen Walsh
Quality Manager

GAP
EnviroMicrobial Services
a division of Conestoga-Rovers & Associates Ltd.

January 10, 2003

Reference 17500-A2868

Jaime Oxtobee
Golder Associates
1796 Courtwood Cres.
Ottawa, Ontario
K2C 2B5

Tel: (613) 224-5864
Fax: (613) 224-9928
Email: joxtobee@golder.com

Date Samples Collected	January 7, 2003
Date Samples Processed	January 8, 2003

Sample Information

Location	St. Isidore Well #8
GAP Sample Number	98
Total Volume Filtered	3391 Liters (892.4 gallons)
Volume of Filter Sediment Collected	20 500 µL
Volume of Biological Packed Sediment Recovered	500 µL

Microscopic Particulate Analysis (MPA) results

Indicators of Surface Water	Indicators Counted/100 gallons	Relative Amounts	Relative Risk Factor
Diatoms	0	Not Significant	0
Other Algae	10	Rare	4
Insects/Larvae	0	Not Significant	0
Rotifers	0	Not Significant	0
Plant Debris	0	Not Significant	0

Total Relative Risk Factor: 4

The risk of groundwater under the influence of surface water (GUDI) is determined using the following key:

Total Relative Risk Factor	Risk of GUDI
> 19	High
10 – 19	Moderate
<10	Low

This MPA indicates that there is a **Low Risk** that the groundwater is under the influence of surface water.

Relative Concentrations of other Particulates

Particulate	Relative Concentration per 100 gallons
Large Amorphous Debris	Rare
Small Amorphous Debris	Moderate
Minerals	Not Significant
Pollen	Not Detected
Nematodes	Not Detected
Crustacia	Not Detected
Ameoba	Not Detected
Ciliates/Flagellates	Not Detected
Other	None

Analysed by:

CBryant

Christine Bryant
Environmental Scientist

Approved By:

S Ramsay

Shelley Ramsay
Laboratory Manager

GAP
EnviroMicrobial Services
a division of Conestoga-Rovers & Associates Ltd.

January 13, 2003

Reference 17500-A2874

Jaime Oxtobee
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Date Samples Collected	January 9, 2003
Date Samples Processed	January 10, 2003

Sample Information

Location	St. Isidore Well #9
GAP Sample Number	167
Total Volume Filtered	3704 Liters (974.7 gallons)
Volume of Filter Sediment Collected	26 000 μL
Volume of Biological Packed Sediment Recovered	1000 μL

Microscopic Particulate Analysis (MPA) results

Indicators of Surface Water	Indicators Counted/100 gallons	Relative Amounts	Relative Risk Factor
Diatoms	0	Not Significant	0
Other Algae	10	Rare	4
Insects/Larvae	0	Not Significant	0
Rotifers	0	Not Significant	0
Plant Debris	0	Not Significant	0

Total Relative Risk Factor: 4

The risk of groundwater under the influence of surface water (GUDI) is determined using the following key:

Total Relative Risk Factor	Risk of GUDI
> 19	High
10 – 19	Moderate
<10	Low

This MPA indicates that there is a **Low Risk** that the groundwater is under the influence of surface water.

Relative Concentrations of other Particulates

Particulate	Relative Concentration per 100 gallons
Large Amorphous Debris	Abundant
Small Amorphous Debris	Abundant
Minerals	Abundant
Pollen	Not Detected
Nematodes	Not Detected
Crustacia	Not Detected
Ameoba	Not Detected
Ciliates/Flagellates	Not Detected
Other	None

Analysed by:

C Bryant

Christine Bryant
Environmental Scientist

Approved By:

S Ramsay

Shelley Ramsay
Laboratory Manager

APPENDIX C

RESULTS OF CHEMICAL ANALYSIS OF GROUNDWATER AND SURFACE WATER

ST. ISIDORE GUDI STUDY
REPORT OF GROUNDWATER MONITORING RESULTS

Sample Date Sample Location Parameter	ODWS	November 14/02 Well 1	November 14/02 Well 2	November 14/02 Well 3	November 14/02 Well 5
Alkalinity (as CaCO3)	30-500	334	340	265	300
Calcium	- -	44	3	44	61
Chloride	250	70	57	99	83
Conductivity (uS/cm)	- -	885	809	796	818
Fluoride	1.5	0.38	0.75	0.21	0.25
Iron	0.3	0.01	<0.01	0.05	0.09
Hardness as (CaCO3)	80-100	205	28	246	247
Magnesium	- -	23	5	33	23
Manganese	0.05	0.014	<0.005	<0.005	0.015
Nitrate (as N)	10	<0.1	<0.1	<0.1	<0.1
pH	6.5-8.5	8.12	8.84	8.18	8.09
Potassium	- -	9	5	13	9
Sodium	200	107	174	58	71
Sulphate	500	38	11	14	20

All values reported in mg/L unless otherwise noted

ST. ISIDORE GUDI STUDY
REPORT OF GROUNDWATER MONITORING RESULTS

Sample Date **Sample Location** **Parameter**	November 14/02 SW1	November 14/02 SW2
Alkalinity (as CaCO3)	203	176
Calcium	113	77
Chloride	153	116
Conductivity (uS/cm)	1000	810
Fluoride	0.14	0.23
Iron	0.03	0.3
Hardness as (CaCO3)	323	246
Magnesium	10	13
Manganese	<0.005	0.007
Nitrate (as N)	4.7	1.05
pH	8.24	8.19
Potassium	2	3
Sodium	72	58
Sulphate	42	41
Escherichia Coli	76	18
Tolal Coliforms	320	280

All values reported in mg/L unless otherwise noted