

HYDROGEOLOGICAL SCREENING

FINAL REPORT

SITE 2 - STATION 12+980 MCNAB-BRAESIDE TWP.

SITE 3 - STATION 22+700 HORTON TWP.

SITE 4 - STATION 19+080 HORTON TWP.

**Highway 17 Twinning Campbell Drive to Scheel Drive
GWP 4067-03-00**

Geocres #31F-162

August 2007

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1.0 INTRODUCTION

McCormick Rankin Corporation (MRC) and Ecoplans Limited (Ecoplans) have been retained by the Ministry of Transportation - Eastern Region (MTO) in the detail design of Highway 17 Twinning Campbell to Scheel Drive Project. This project includes the twinning of approximately 5.5 kilometres (km) of Highway 17, pavement rehabilitation, one new interchange at Campbell Drive, two new bridge structures (Campbell and Scheel Drive underpasses), and other associate highway infrastructure improvements. In addition, the MTO has engaged MRC to carry out additional technical studies along Highway 17 between Scheel Drive and Bruce Street (north of Renfrew).

As part of these studies, Ecoplans will be undertaking Hydrogeological Screening Investigations of the following locations (sites) along Highway 17:

- **Site 1** - Station 25+000 to 25+500 McNab-Braeside Twp. located approximately 500 metres west of Campbell Drive
- **Site 2** – Station 12+980 McNab-Braeside Twp. located approximately 500 metres west of McCallum Drive.
- **Site 3** – Station 22+700 Horton Twp. located approximately 250 metres east of the CPR Overpass.
- **Site 4** – Station 19+080 Horton Twp. located approximately 500 metres south of Bruce Street

This report documents the Hydrogeological Screening Investigations for Sites 2, 3 and 4. The Hydrogeological Screening Investigation for Site 1 is covered under a separate report.

1.1 Purpose of Study

The purpose of the Hydrogeological Screening Investigations is to evaluate the geology, and surface and subsurface hydrology of each location, and provide an assessment on potential groundwater impacts from the proposed highway construction.

1.2 Scope of Study

The scope of the study consisted of a site history review (“background information review”) and site reconnaissance (“site inspection”). Each is briefly discussed below.

1.2.1 Background Information Review

The background information review included reviewing and evaluating the following information sources:

- Topographic maps (Ontario Base Maps and National Topographic Survey Maps);
- Current and historical aerial photographs;
- Ministry of the Environment (MOE) water well records;
- Geological Maps (surficial and bedrock);
- Federal, provincial and municipal groundwater studies; and
- Background studies (geotechnical, environmental and drainage)

In addition, the local municipalities (Towns of Renfrew and Arnprior, and Counties of McNab-Braeside and Horton) were contacted to verify the location and nature of any municipal and communal water supply wells, land use, and water servicing for each location and all areas within 2 km of each location.

1.2.2 Site Inspection

Site inspections were completed at each location to document and evaluate existing conditions such as surface topography, surface and subsurface hydrology, water well locations, land use and structures, and municipal servicing. The site inspections included the following items:

- Describing the general topography and drainage characteristics of each location;
- Describing any significant geological features on and directly adjacent to each location including kettle holes and exposed bedrock;
- Verifying the location and nature of all permanent water courses and tributaries within one kilometer (km) of each locations;
- Describing the location and nature of all significant water courses and associated features including wetlands, tributaries, closed depressions, kettle holes, and drainage ditches on and directly adjacent to each location;
- Verifying existing lands use and presence of structures within 500 metres of each location;
- Verifying the presence of municipal piped water to each location and surrounding areas;
- Verifying the location and nature of any significant groundwater discharge/seepage areas; and
- Completing a private water well survey of all wells within 500 m of each location.

1.2.3 Documentation

The results of the background information review and site inspection were documented into a written Hydrogeological Screening Report. The report provides an assessment of the local and regional groundwater system, and its vulnerability to potential highway construction activities. The vulnerability assessment includes the considerations:

- Location and significance of surface water courses at and around each location;

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- Current and future use of groundwater in the vicinity of each location for water supply;
- Groundwater susceptibility to surface contamination;
- Presence of sensitive receptors (water wells and surface water courses) hydraulically downgradient of each location; and
- Hydraulic connectivity between shallow groundwater system and surface water courses.

The focus of this report is on the following sites:

Site 2: Station 12+980 McNab-Braeside Twp.

Site 3: Station 22+700 Horton Twp.

Site 4: Station 19+080 Horton Twp.

At these locations, groundwater springs were observed during site inspections as documented in the *Transportation Environmental Study Report of Highway 17 Twinning from County Road 29 to 3.0 km West of Bruce Street WP 647-92-00* (December 2003). Since the proposed twinning of Highway 17 at these locations will include new westbound or eastbound lanes, there is the potential for intercepting and obstructing the springs.

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SITE 2

Station 12+980 McNab-Braeside Twp.

2.0 SITE 2 - Station 12+980 McNab-Braeside Twp.

2.1 Site Description

The site is located on the south side of Highway 17 approximately 450 metres west of McCallum Drive, i.e. Station 12+980. Figure 2-1 shows the site location and Figure 2-2 shows the significant site features plotted on a 2005 aerial photograph. Site photographs have been included in Appendix 2-A. These features are described below:

- The site consists of a culvert discharge located at the base of slope on the south side of Highway 17.
- The culvert discharges surface water from the small wetland located on the north side of the highway and into a larger wetland to the immediate south of the highway. This drainage system is part of a small tributary system feeding into the main branch of Locha Creek located approximately 1.6 km southeast of the site.
- The slope is mostly forested and the base of slope is wet with standing water in the adjacent wetland.
- The landscape surrounding the site is predominantly upland forest on thin soil overlying bedrock, and low lying areas dominated by wetlands.

Current Land Use

According to the McNab-Braeside Township Official Plan, the site falls within the following land designations:

- *Environmental Protection* – Permitted land uses include: agricultural, conservation, horticultural nurseries, forestry, wildlife areas, public or private parks, and other recreational outdoor uses.

Ecoplans also completed a ground survey of the surrounding area to document current land use and any significant structures and water courses within 500 metres of the site. Figure 2-2 shows the site and significant structures documented during the survey. The following relevant data from the ground survey is included below:

- The site is surrounded by forest to the north, east and west; and by a large wetland to the south. A small wetland is located further to the north of the highway. These wetlands appear to be the headwaters of a small tributary of Locha Creek running to the southeast and into the main branch of the creek.
- Liffey Creek passes through a culvert and under Highway 17 approximately 260 metres east of the site. The tributary drains a large wetland to the south of the highway at this location. Flow in the

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tributary is to the northeast and into the main branch of Locha Creek located approximately 2.3 km northeast of the site.

- Highway 17 is approximately 30 metres upslope to the north of the site.
- There are seven residences to the northeast (within 500 metres of the site) of the site along the east and west sides of McCallum Drive.

Current Municipal and Private Servicing

Ecoplans completed a request for information from the County of Renfrew for existing water and sanitary sewer systems. The information was used to identify and confirm the presence of municipal servicing of areas within two (2) kilometers of the site. Based on the information obtained from the County, no municipal servicing is within 2 km of the site.

In addition to completing a request for information from the County, Ecoplans also carried out a ground survey to confirm the presence of private servicing of the site and the immediate surrounding area. At the time of inspection, Ecoplans did not identify any private servicing to the site. Ecoplans did confirm that the surrounding area is serviced privately, with each residence serviced by a septic system and associated weeping tile bed; and water well (See Section 2.4).

There are no municipal and communal wells within 2 km of the site.

2.2 Background Information Review

Ecoplans completed a background information review for the site. The purpose of the review was to gain a general understanding of the regional and local geology and hydrogeology of the site. This was achieved by reviewing topographic and geological maps, water well records, current and historical aerial photographs, local and regional groundwater studies, and background geotechnical and environmental studies.

2.2.1 Topography

The site is located within the physiographic region known as the Ottawa Valley Clay Plains (Chapman and Putnam, 1984). This region is characterized by flat-lying tracts of clayey soils ranging from 10 to 30 km wide. The average topography of the area surrounding the site can range from approximately 120 to 140 m above sea level (asl), due to the presence of ridges of rock or sand interspersed through the region.

The site itself is located at the base of the highway embankment next to a wetland which is surrounded by bedrock ridges. Highway 17 at this location rises moderately to the west through a bedrock ridge.

2.2.2 Drainage

Regional drainage is to the east towards the Ottawa River largely controlled by major bedrock faults in the region (Chapman and Putnam, 1984). Both Locha and Liffey Creeks collect and convey local drainage to the Ottawa River.

Site drainage is to the south and into the large wetland which drains into Locha Creek located approximately 1.6 km southeast of the site.

2.2.3 Geology

Surficial Geology

According to the groundwater report completed by Golder Associates Ltd (2003) for the Mississippi Valley Conservation Authority (MVCA), the site is overlain by surficial deposits of marine clay. The fine-grained deposits were laid down in quiet water environments, such as bedrock valleys or in depressions between drumlinized terrain. The thickness of the clay varies, and depends on the depth of depressions in which the clay was deposited. On average, the overburden surrounding the site is approximately 10-30 m thick.

According to the Geological Survey of Canada (Quinn, 1956), the site is located on a large bedrock outcrop of granite consisting of pegmatites (the site itself) and granodiorites. Glacial drift deposits of boulders, sand, clay, marl, peat and muck surround the north, west and south side of the bedrock outcrop; and marine clays to the east.

Figure 2-3 shows the surficial geology of the site and surrounding area.

Bedrock Geology

The bedrock geology of the site and surrounding area is composed of Precambrian igneous rock associated with the Mazinaw Terrane (OGS, 1991). The Mazinaw Terrane is located southeast of the Bancroft Terrane and consists of mafic metavolcanic, and meta-volcanoclastic rocks that appear in long thin bands. There are several major faults in the north portion of the Mazinaw Terrane, which are part of the Ottawa-Bonnechere Graben system (Golder Associates Ltd, 2003)

2.2.4 Hydrogeology

Preamble

Groundwater is found in water bearing zones below the ground. Less permeable or impermeable layers called aquitards may separate these water bearing zones or aquifers. The aquitards restrict groundwater movement typically between the shallow groundwater zone and the deeper groundwater zone. The shallow groundwater zone is usually perched, unconfined (i.e. not under hydrostatic pressure), limited in areal extent, and generally reflects the surface topography. On the other hand, the deeper groundwater zone is usually at depth, confined (i.e. under hydrostatic pressure/artesian conditions), regional in extent, and does not generally reflect the surface topography. The regional aquifer, or groundwater system, is usually the potable water supply source for human and agricultural consumption.

Site

The hydrogeology of the site is predominantly characterized by the bedrock (regional) aquifer system. Since the overburden is largely composed of silt and clay, the overburden across the site would be considered a major confining unit (aquitard), and not an adequate source of potable groundwater. Hydraulic conductivities in the weathered clay deposits (top 3.0 to 5.0 m) have been measured by Dillon Consulting (1997) at 10^{-4} to 10^{-5} cm/s.

The regionally extensive aquifer beneath the site is the Precambrian bedrock. In general, fracture zones in the Precambrian aquifer yield marginal to adequate quantities of water for individual wells (Golder Associates Ltd, 2003). Groundwater flow is through secondary porosity from these fractures, while primary porosity will only account for approximately 2% of all flow (Freeze and Cherry, 1979). Near the bedrock surface stress releases can cause bedrock sheeting that result in the development of

horizontal fractures parallel to the topographic surface. Vertical fractures can also form which may result in unconfined aquifer conditions where the bedrock is exposed at ground surface without adequate overburden cover, increasing the potential for surface contamination. Freeze and Cherry (1979) estimate the hydraulic conductivity of fractured igneous and metamorphic rocks at 10^{-6} to 10^{-2} cm/s.

2.2.5 Water Well Records

Preamble

The Ministry of the Environment's Water Well Database is a compilation of water wells drilled in the Province of Ontario for the purpose of human, agricultural and industrial consumption. Pursuant to the Ontario Water Resources Act, any well drilled for these purposes must be drilled by an MOE licensed well drilling contractor and documented on a Water Well Record. The record is then filed with the MOE. Examples of data recorded on a water well record include: location of well, date drilled, depth to water, static water level and subsurface stratigraphy. Since well records have been completed by many different drillers during the past 50 or so years, data accuracy and consistency is sometimes questionable. The most important data recorded on a record are the depth of the water supply aquifer and the subsurface stratigraphy. This information helps in determining whether the aquifer is hydraulically connected to the surface hydrology of an area through groundwater recharge and discharge. It is also important to realize that water wells are drilled into aquifers that can yield appreciable quantities of water for their intended purpose. The majority of these aquifers are normally found at depth in the deep groundwater zones. Therefore, shallow perched aquifers are rarely exploited as a resource due to high susceptibility to contamination, low yields, and potential impacts to surface water baseflow. Water well records seldom identify shallow perched aquifers.

However, given their limitations, water well records still provide a very useful source of both local and regional geological and hydrogeological information.

Site and Surrounding Area

Ecoplans completed a water well record search to within two (2) kilometers of the site. The results of the search identified a total of 49 water wells located in the vicinity of the site. The well locations are shown in Figure 2-4. However, it should be noted that the well locations are approximate and based on coordinate information provided within the water well records database, which are all subject to some margin of error. Documentation of the water well records has been included in Appendix 2-B. The following relevant data from the records is included below:

- The earliest water well records available were from 1950 to as recent as 2006;

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- Six (6) water wells are drilled into the overburden aquifer, and 43 water wells are drilled into the bedrock aquifer;
- Water wells drilled into the overburden aquifer terminate between 15 and 40 metres below ground surface (m bgs), and wells drilled into the bedrock aquifer terminate between 12 metres to 108 metres below ground surface;
- Twenty-eight (28) wells are drilled into granite deposits, and 11 wells are drilled into limestone deposits;
- The wells drilled into granite deposits are generally located north and south of the site, and wells drilled into limestone deposits are generally located southwest of the site. There are two (2) wells drilled into limestone bedrock within 500 metres of the site;
- The depth to water for water wells drilled into the overburden aquifer range between 14.6 metres to 40.0 m bgs, and the depth to water for wells drilled into the bedrock aquifer range between 9.8 metres to 103.6 m bgs;
- Eight (8) wells encounter water less than 15 m bgs (i.e. shallow wells), 19 wells encounter water between 15 metres and 30 m bgs (i.e. intermediate wells), and 21 wells encounter water greater than 30 m bgs (i.e. deep wells);
- Shallow wells are generally located north-northwest of the site. Intermediate wells are located north and south of the site, of which two (2) wells are located within 500 metres of the site. Deep wells are largely present southwest of the site, of which one (1) well is located within 500 metres of the site;
- The groundwater elevations range from 56.4 m above sea level (ASL) to 164 metres ASL;
- Seven (7) wells are stock water wells, one (1) well is a municipal well, 39 wells are domestic water wells, and two (2) wells are public supply water wells. The municipal supply well (5515828) is located approximately 2.0 kilometres north of the site. The two (2) public supply wells (5500840 and 5501183) are located approximately 2.0 kilometres north and 1.5 kilometres south, respectively; and
- The general groundwater flow direction is south-southeast.

Figures 2-5a and 2-5b show the geological interpretation of the site and surrounding area (geological cross-sections) based on those well records within 300 metres of a two-kilometer transect through the site. Figure 2-5a shows a geological cross-section based on 3 well records through the site and along Highway 17 while Figure 2-5b shows a cross-section based on 6 well records through the site and roughly perpendicular to Highway 17. It should be noted that some of the well records did not show surface elevations and therefore surface elevations were estimated based on OBM maps.

Based on interpretation of the cross-sections, the site and surrounding area to the north and west of the site is predominantly underlain by Precambrian bedrock with the exception of the area to the northwest of the site which according to well record 5511829, is underlain by Paleozoic limestone. Limestone bedrock is also found approximately 1.6 km south of the site based on well record 5506644. The

bedrock is covered with a thin veneer of overburden consisting of predominantly clays and sands. However, thick deposits of sand and clay occur to the north of the site with approximately 25 metres of sand occurring approximately 700 metres north of the site. Water was encountered in the bedrock at elevations between 91.1 m amsl (approximately 1.2 km west of the site) to 160.6 m amsl (approximately 500 metres northwest of the site) with an average elevation of 131.7 m amsl. This represents the regional bedrock aquifer system.

2.2.6 Aerial Photographs

Current (2005) and historical aerial photographs (for the years 1959, 1969, and 1987) for the site and surrounding area were reviewed by Ecoplans to identify any surface features that are of potential hydrogeological significance (surface water bodies, vegetation cover and human development impacts). A description of the notable features for each aerial photo is summarized in Table 2-1.

Table 2-1
Review of Aerial Photographs – Significant Site Features

Year	Significant Site Features
1959	<ul style="list-style-type: none">- Hwy 17 not present- Site and immediate surrounding area are densely forested.- Immediately south of the site is a long and narrow water course (wetland) oriented in a northwest-southeast direction.- To the northwest of the site is a small water course (wetland?)- Surrounding lands predominantly agricultural with the exception to the southeast which is forested associated with the Locha Creek Watershed.
1969	<ul style="list-style-type: none">- Highway 17 not present.- The forested area surrounding the site appears to be less dense – possibly logged.- The surface water courses (wetlands) to the northwest and southeast of the site are larger (i.e. more standing water)- Surrounding lands still predominantly agricultural with the exception to the southeast which is forested associated with the Locha Creek watershed.- No other significant changes since the 1959 aerial photo
1987	<ul style="list-style-type: none">- Highway 17 present.- The highway runs between the two surface water courses/wetlands noted in the 1959 and 1969 aerials. These wetlands now appear to be dry with no standing water.- Further to the southeast of the dry wetlands are two small linear surface water courses oriented in the northwest-southeast direction. These are all part of the Locha Creek watershed.- No other significant changes since the 1969 aerial photo.
2005	<ul style="list-style-type: none">- No significant changes since the 1987 aerial photo with the exception of the

Table 2-1
Review of Aerial Photographs – Significant Site Features

Year	Significant Site Features
	wetlands located to the north of the highway and to the southeast of the large wetland – these are noted to contain standing water indicative of high flow conditions (spring).

The most significant observations noted on the aerial photos are:

- The forest cover surrounding the site had decreased sometime between 1959 and 1969 and then increased sometime after 1969. There may have been some selective logging which thinned out the forest.
- The two surface water courses/wetlands to the northwest and southeast of the site increased in size sometime between 1959 and 1969 and according to the 1987 and 2005 aerial photos, the water courses were dry in the 1987 photo and wet in the more recent 2005 photo. It appears that the wetlands are susceptible to temporal fluctuations largely dependant on spring melt and storm events, and on groundwater baseflow.
- Sometime between 1969 and 1987, two narrow linear surface water courses/wetlands appeared to the southeast of the above-noted dried wetlands.

2.2.7 Background Studies

This section summarizes the background studies that were reviewed noting significant relevant information.

- i) *Existing Conditions Report- Volume 3, Appendix F. Highway 17 Twinning Arnprior to Renfrew WP 647-92-00.* Prepared by Totten Sims Hubicki Associates (TSH) and National Capital Engineering (NCE). November 2002.

Significant relevant information included:

- Based on the MOE Water Well Data Set, 4 water wells were identified within 1 km of the site.
- The Towns of Arnprior and Renfrew are on municipal water systems.
- The bedrock along Highway 17 between Renfrew and Arnprior is Precambrian including granite, gneiss and carbonate rocks and crystalline limestone outcrops in certain areas.
- The soils at the site are predominantly White Lake soils (gravelly sandy loams) associated with the Precambrian upland. These soils are not very productive for agricultural purposes.

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- The physiography along Highway 17 between Arnprior and Renfrew consists mainly of clay plains (Ottawa Valley Clay Plains Physiographic Region) interrupted by shallow till and rock ridges, sand plains and a small area of kame moraines at County Road 6. The site itself lies within shallow till and rock ridges. The clay plains are extremely susceptible to surface erosion and are underlain with very soft blue-grey silt, silty clay and clay referred to as “leda clay”. Leda clay is extremely unstable and vulnerable to slope failure.
 - Land use within and surrounding the site consists predominantly of natural areas/woodlots which flank Highway 17 next to the site.
 - McNab-Braeside Township Official Plan describes the following land designations for the site:
 - *Environmental Protection* – found along Locha and Dochart Creek watersheds. Permitted land uses include: agricultural, conservation, horticultural nurseries, forestry, wildlife areas, public or private parks, and other recreational outdoor uses.
 - The existing highway drainage system within the site is typical of many current provincial highway drainage systems, i.e. open ditch and culverts. Ditches flank each side of the highway and flow to the east following the moderately sloped topography. There is a culvert running under Highway 17 (Station 13+240) which drains an extensive marsh south of Highway 17 as part of the West Tributary of Locha Creek. Flow in the culvert is to the north and towards the main branch of Locha Creek.
 - The site lies within a forested area. The forest cover is predominantly mixed and swampy. Typical tree species include White Cedar, Black Ash and Tamarack swamp. On the bedrock outcropping located next to the site is wooded upland highlands supporting a young to submature upland forest of Sugar Maple, Red Maple, Ironwood, White Pine, Bitternut Hickory and White Ash. On the drier portions, White Pine and Red Oak dominate. Beaver created wetlands are extensive south of the highway included the large wetland the spring discharges into.
- ii) *Renfrew County-Mississippi-Rideau Groundwater Study, Volume 1 and 2, Summary Report and Technical Appendices.* Prepared by Golder Associates Limited. September 2003.

Significant relevant information has been incorporated into Section 2.2.3 and Section 2.2.4.

- iii) *Hydrogeology of Southern Ontario, Second Edition.* Prepared by S.N. Singer, C.K. Cheng and M.K. Scafe; Ministry of the Environment. 2003.

Significant relevant information has been incorporated into Section 2.2.3 and Section 2.2.4.

2.3 Site Inspection

A site inspection was carried out on May 10, 2007. The purpose of the site inspections was to observe and document any significant features of hydrogeologic concern such as surface water courses, seepage zones and springs (groundwater discharge), topography and surficial geology. Site photographs have been included in Appendix 2-A. The results of the inspections are summarized below.

- The site represents a culvert discharge located at the base of the treed south slope embankment of Highway 17. At this location Highway 17 slopes upward to the west and cuts through bedrock.
- The culvert discharges surface water from the small wetland to the north of the highway and into the adjacent wetland south of the highway.
- There is some channelized flow from the culvert and into the north end of the wetland.
- The ground surface in the vicinity of the discharge point was saturated.
- The wetland was observed to contain standing water and wetland vegetation such as cattails and tall grasses.

2.4 Water Well Survey

Ecoplans completed a door-to-door water well survey of all wells within 500 metres of the site. The purpose of the door-to-door well survey was to confirm the presence, location and construction details of each well, access permitting. The results of the survey identified eight (8) residences using private water wells within 500 metres of the site. Of the eight (8) residents, seven (7) were surveyed. There was no response at one (1) residence (113 MacCallum Drive). All surveyed wells are shown on Figure 2-4.

All surveyed wells tap into the bedrock aquifer of the area with well depths ranging from 13.5 to 91.44 m below ground surface. At accessible wells, groundwater levels are relatively shallow and are close to groundwater surface. All residents reported overall good water quality and quantity.

Table 2-2 summarizes the well survey results for the water wells within 500 metres of the site.

Table 2-2
Water Wells Within 500 Metres of the Site

Address	GPS Coordinates	Date Installed*	Well Diameter (cm)	Well Type	Well Depth (m)	Static Water Level (m bgs)	Notes
22 McCallum Drive	377406E 5035088E	~1967*	I	I	I	I	No access, in the basement
41 McCallum Drive	I	1992*	0.4	Dug	U	U	Good water quality and quantity
49 McCallum Drive	377675E 5033960N	~1989*	0.15	Drilled	39.6*	1.22	- Hard water, water softener installed - Improper well seal
64 McCallum Drive	377692E 5034020N	~2005*	0.15	Drilled	13.5	1.24	Good water quality and quantity

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Table 2-2
Water Wells Within 500 Metres of the Site

Address	GPS Coordinates	Date Installed*	Well Diameter (cm)	Well Type	Well Depth (m)	Static Water Level (m bgs)	Notes
77 McCallum Drive	375553E 5034024N	1992*	0.15	Drilled	91.44*	I	- Well in very good condition - Regular sampling, no water quality or quantity concerns
88 McCallum Drive	377578E 5034121N	1975*	0.15	Drilled	36.2*	~2*	_ - Good water quality and quantity*
97 McCallum Drive	377523E 5034122N	~1995*	0.15	Drilled	33.5*		_ - Good water quality and quantity* - Can pump up to 60 gpm
113 MaCallum Drive	377485E 5034181N	I	I	I	I	I	No one home

Notes:

* = Well information based on information obtained through occupant interview.

U = Unknown

I = Inaccessible

2.5 Evaluation of Groundwater Resources and Vulnerability

The surficial geology of the site and surrounding area consists of predominantly Precambrian bedrock with minor occurrences of Paleozoic bedrock (limestone). The site itself is located on a bedrock ridge which rises to the west above the relatively flat clay plains to the east of the site. Highway 17 cuts through the bedrock ridge and runs between two wetlands; one smaller wetland to the north of the highway and a larger wetland to the south. The north end of this larger wetland is the site itself. The area to the south and southeast of the site is dominated by a series of wetlands which are all hydraulically connected to the Locha Creek drainage basin.

The hydrogeology of the site and surrounding area is dominated by bedrock driven groundwater systems found in the fractures and joints of the Precambrian (igneous) rock, and in the fractures and bedding planes of the Paleozoic (predominantly dolostone and limestone) rock. Within two kilometres of the site, six (6) water wells are drilled into the overburden aquifer, and 43 water wells are drilled into the bedrock aquifer. The depth to water for water wells drilled into the overburden aquifer range between 14.6 metres to 40.0 m bgs, and the depth to water for wells drilled into the bedrock aquifer range between 9.8 metres to 103.6 metres bgs. Based on the water well records and well survey, there are shallow wells (i.e. aquifer is <15 m bgs) to the northeast (64 McCallum Drive) and southeast (well records 5510560 and 5502528) of the site. Groundwater flow in the bedrock aquifer system is generally to the south-southeast.

The site inspection identified the presence of a culvert running beneath Highway 17. Upstream of the culvert is a small wetland with observable standing water. The wetland appears to drain through the culvert and discharges into the larger wetland located south of the highway. The area around the culvert discharge was noted to be saturated with small pools of standing water. This predominantly surface water system drains into Locha Creek (located approximately 1.6 km southeast of the site) through a series of wetlands and connecting creeks oriented in a northwest-southeast direction. There likely is groundwater contribution (baseflow) to the system.

Surface Water and Groundwater Impacts and Vulnerability

The proposed twinning of Highway 17 at Site 2 will involve the construction of eastbound lanes to the north of the existing highway. This will involve both bedrock cuts and fills. The most direct impact of the construction would be the impact to the wetland drainage system. Fill operations will impede surface water flow between the north and south wetlands which could impact the wetlands to the south of the site. The result could be a net loss to the surface water flow through the wetland system which could ultimately reduce surface water flow into Locha Creek. This could easily be mitigated through appropriate highway drainage design which would include installing a culvert at the base of the new westbound lanes to facilitate surface water flow through the wetland system.

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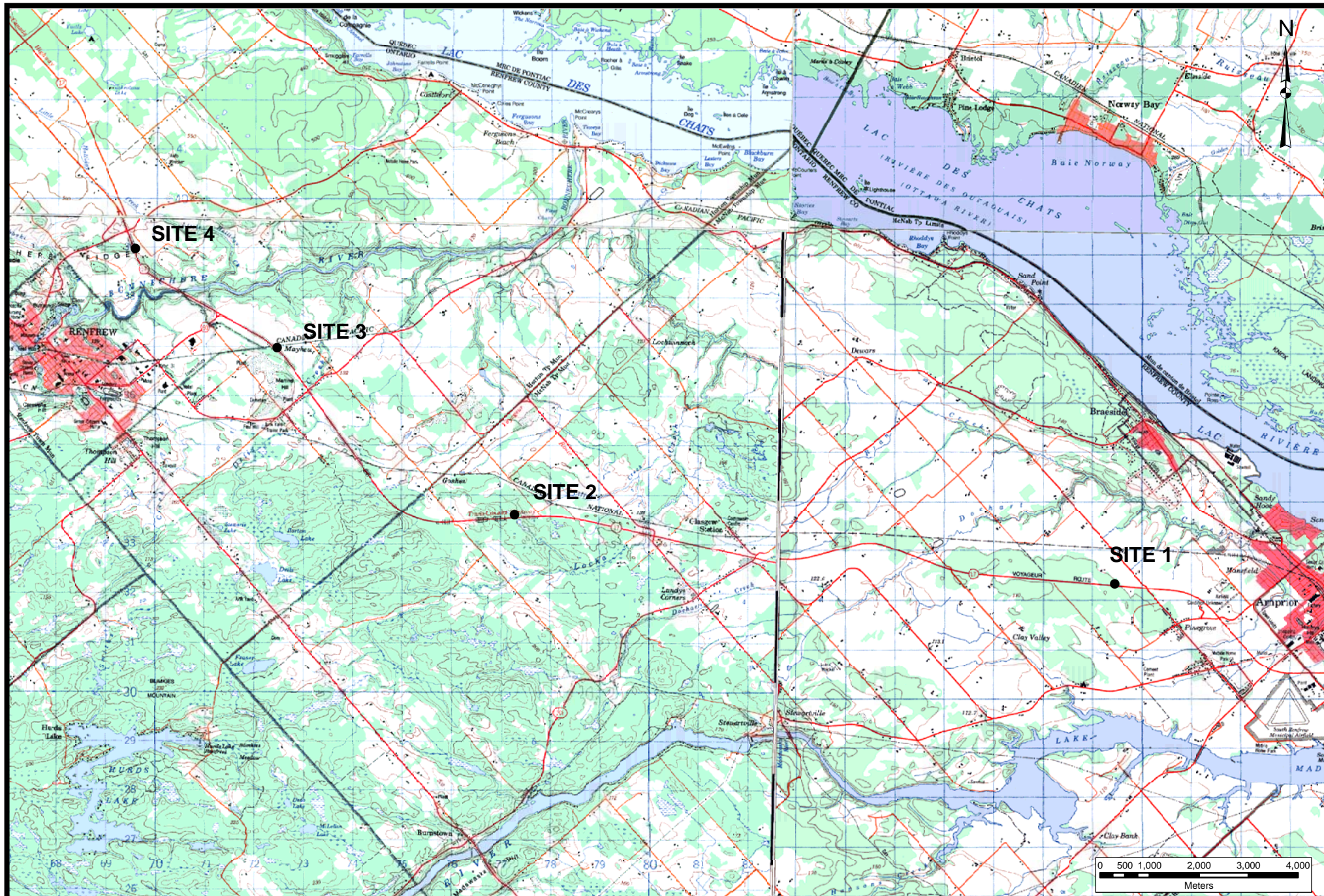
The potential impacts to the groundwater system would likely not be significant due to the following reasons:

- Any bedrock cuts through the area would not be significant, i.e. they would not be deep cuts which could potentially intercept the regional bedrock groundwater system.
- The regional bedrock system is at an average elevation of 131.7 m amsl significantly deeper than the ground surface elevation of the highway at Site 2 which is approximately 168 m amsl. Based on the well records, the shallowest elevation of the bedrock aquifer identified within 500 metres of the site is at 158.8 m amsl, approximately 10 metres below the surface elevation of the highway at the site. This well is located approximately 300 metres southeast of the site.
- The closest water wells are associated with the residences along McCallum Drive (approximately 400 metres northeast of the site) and the residence located approximately 300 metres southwest of the site and because they are located hydraulically upgradient (the residences along McCallum Drive) and cross-gradient (residence to the southwest of the site), any highway construction work would likely not have a significant impact on the wells.

The potential chemical impacts (i.e. groundwater and surface water quality) to the groundwater and surface water systems could be of a concern due to winter maintenance (road salting) activities and spills without implementing adequate mitigation measures.

Based on the above, the overall vulnerability of the local and regional groundwater and surface water systems to highway construction activities would be considered low with respect to groundwater and surface water quantity issues, and moderate with respect to groundwater and surface water quality issues. Provided adequate mitigation measures are implemented, any potential construction related groundwater and surface water impacts could be minimized.

FIGURES
Site 2 – Station 12+980 McNab-Braeside Twp.



Source: National Topographic System (NTS)

Scale: 1:100,000



HYDROGEOLOGICAL SCREENING REPORT
HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
 GWP 4067-03-00
SITE LOCATION PLAN - SITE 2

DATE:
AUGUST 2007
PROJECT:
R07-0261

FIGURE
2-1



Source: Aerial Photograph 2005

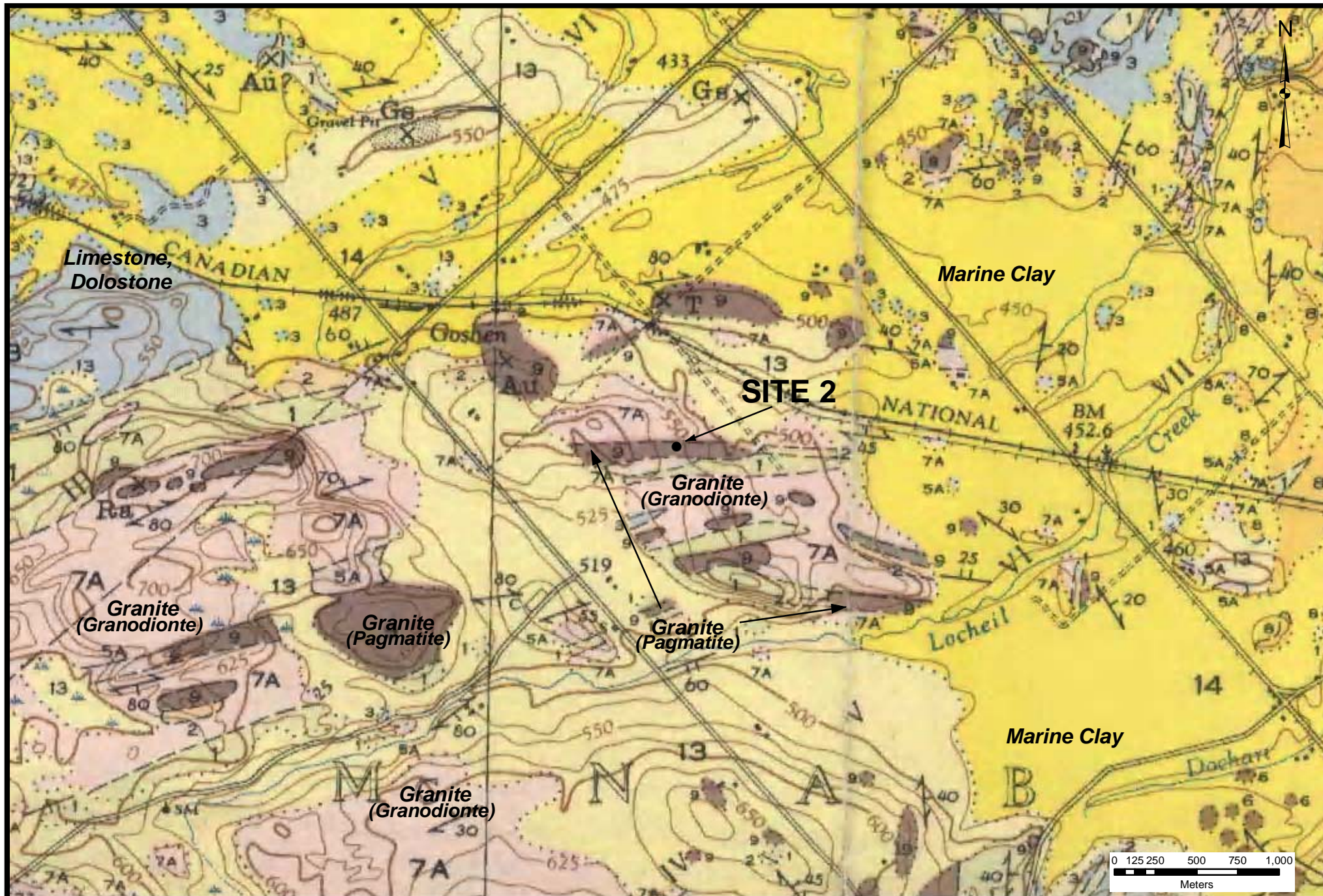
Scale: 1:7,000



HYDROGEOLOGICAL SCREENING REPORT
 HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
 GWP 4067-03-00
SITE PLAN - SITE 2

DATE:
AUGUST 2007
 PROJECT:
R07-0261

FIGURE
2-2



Source: Geological Survey of Canada, 2003

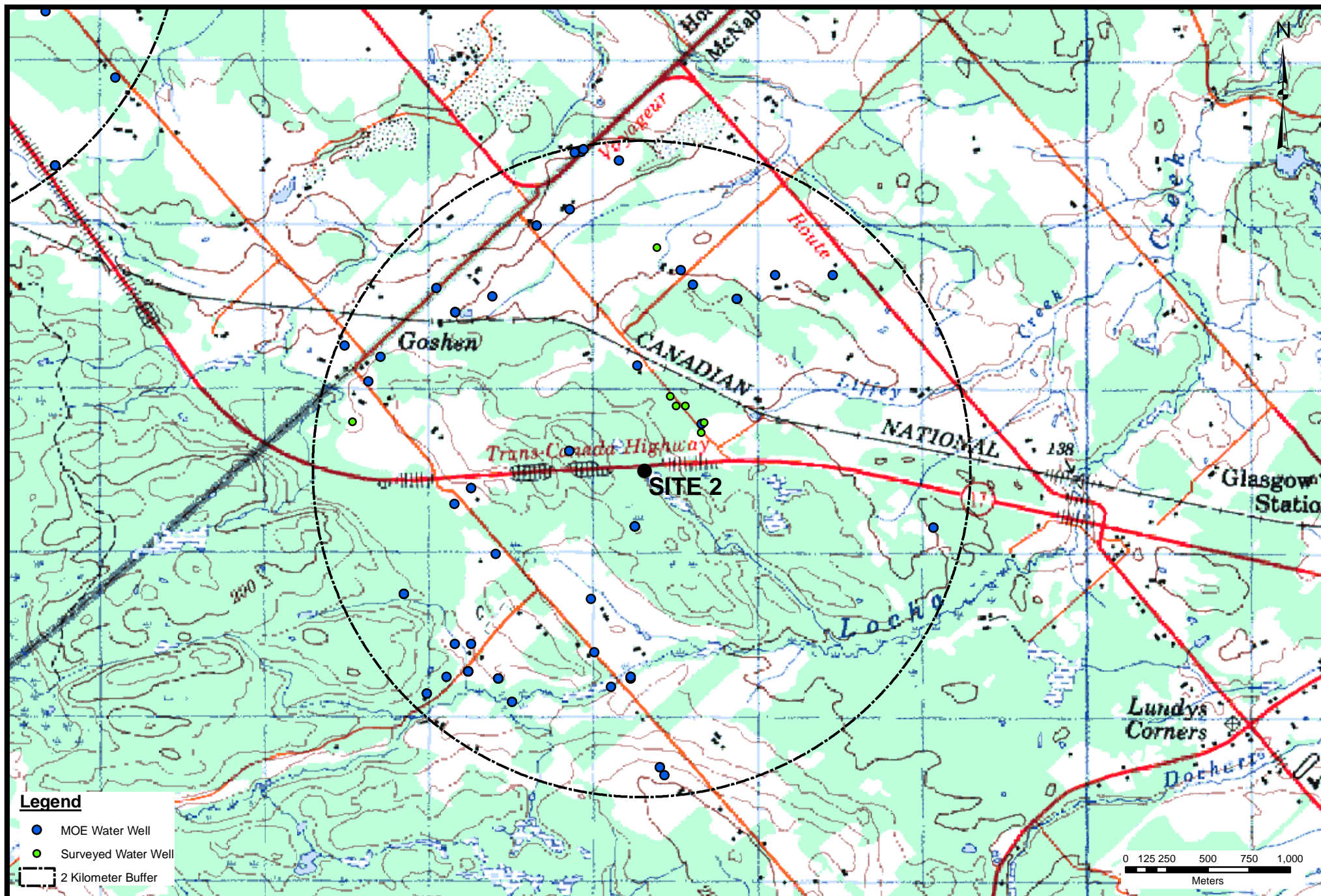
Scale: 1:30,000



HYDROGEOLOGICAL SCREENING REPORT
 HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
 GWP 4067-03-00
SURFICIAL GEOLOGY OF THE SITE AND SURROUNDING AREA - SITE 2

DATE:
AUGUST 2007
 PROJECT:
R07-0261

FIGURE
2-3



Source: National Topographic System (NTS)

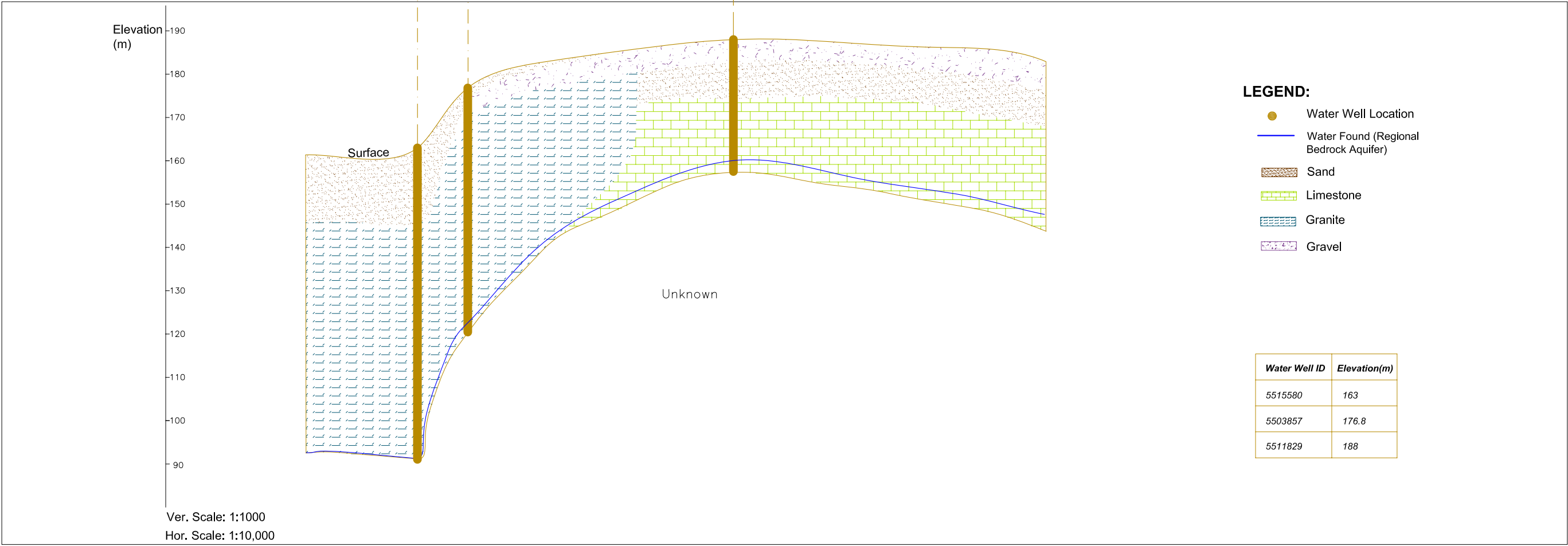
Scale: 1:30,000



HYDROGEOLOGICAL SCREENING REPORT
 HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
 GWP 4067-03-00
WATER WELL LOCATION PLAN

DATE:
AUGUST 2007
 PROJECT:
R07-0261

FIGURE
2-4



FILE LOCATION: I:\Ecoplans\03 - Remediation\PROJECTS\R07-0261 17 Twinning - Campbell to Scheel\0261-700 Drawings
DRAWING NAME: R07-0261 Cross Section.DWG
DRAWN BY: G. Yang
MODIFIED: 07/05/30 12:06:16 Revised

FILE LOCATION-I:\ECOPLANS\03 - REMEDIATION\PROJECTS\R07-0261 17 Twinning - Campbell to Scheel\0261-700 Drawings
DRAWING NAME: R07-0261 Cross Section.DWG
DRAWN BY: G. Yang
MODIFIED: 07/05/30 12:06:16 Revised



Geological Cross-Section B - B' of Site 2

Highway 17 Twinning from Campbell Drive to Scheel Drive
GWP 4067-03-00

DATE:
August 2007

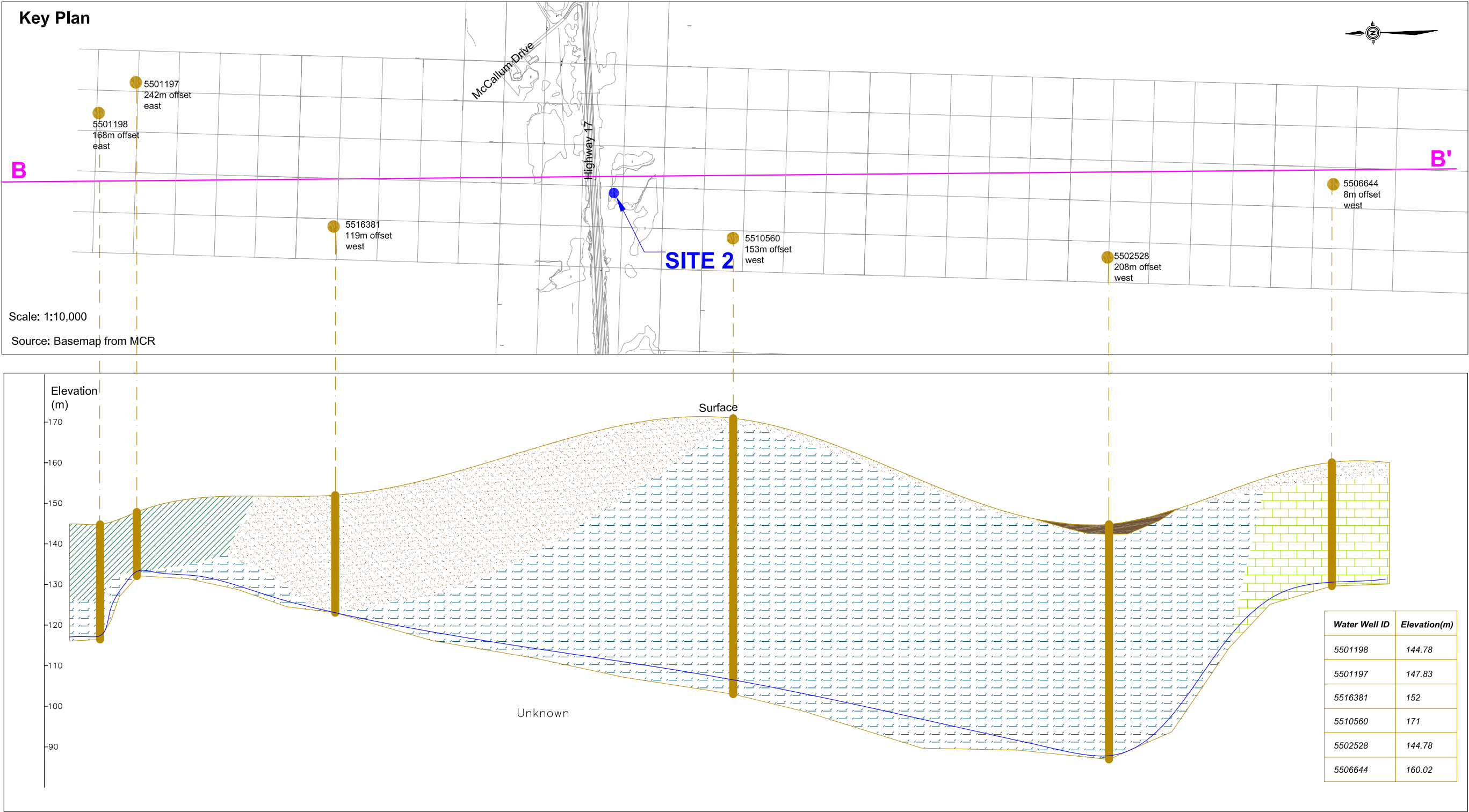
PROJECT NO.:
R07-0261

DRAWN BY:
G. Yang

CHECKED BY:
D. Stewart

FIGURE NO.:

2-5b



APPENDIX 2-A

Site 2 – Site Photographs



← Photo 1
Photo showing Highway 17 and general location of Site 2 (bottom of embankment at right side of photo). Photo taken facing east.

Photo 2 →
Photo showing Highway 17 forested embankment from Site 2. Photo taken facing northeast.



← Photo 3
Wetland on south side of highway located immediately south of Site 2. Photo taken facing southwest.



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Hydrogeological Screening Report
Highway 17 Twinning Campbell Drive to Scheel Drive
GWP 4067-03-00
SITE 2: Site Photographs

Date:
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Figure No.

2-A1



← Photo 4
Wetland on south side of Highway 17.
Photo taken facing south.



Photo 5 →
Wet area located north of Highway 17
flowing south into culvert and discharging
into wetland south of the highway (Site 2).
Photo taken facing northwest.



← Photo 6
Close up of culvert located on the north
side of Highway 17 which drains under
the highway and into the wetland on the
south side of the highway. Photo taken
facing north.



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Hydrogeological Screening Report
Highway 17 Twinning Campbell Drive to Scheel Drive
GWP 4067-03-00
SITE 2: Site Photographs

Date:
August 2007

Project No.:
R07-0261

Figure No.

2-A2

APPENDIX 2-B

Site 2 – Ministry of the Environment (MOE) Water Well Records

Summary of Water Well Records Within 2 km of Site 2

Hydrogeological Screening Report
Highway 17 Twinning Campbell Drive to Scheel Drive
GWP 4067-03-00

<i>MOE</i>	<i>UTM Coordinates</i>		<i>Ground Surface</i>	<i>Depth</i>	<i>Depth</i>	<i>Depth</i>	<i>Groundwater</i>	<i>Date</i>	<i>Water</i>	<i>Well Type</i>	<i>Bedrock</i>
<i>Well ID</i>	<i>Easting</i>	<i>Northing</i>	<i>Elevation</i>	<i>of Well</i>	<i>to Bedrock</i>	<i>to Water</i>	<i>Elevation</i>	<i>Constructed</i>	<i>Supply Type</i>		<i>Unit</i>
			<i>(m ASL)</i>	<i>(m bgs)</i>	<i>(m)</i>	<i>(m bgs)</i>	<i>(m ASL)</i>				
5504904	376100	5032250	161.5	88.4	64.0	86.9	74.7	5/26/1977	Domestic	Bedrock	Granite
5503056	376650	5035000	144.8	57.9	48.8	54.9	89.9	7/20/1972	Domestic	Bedrock	Limestone
5505581	378450	5034700	137.2	24.4	NA	24.4	112.8	5/4/1979	Domestic	Overburden	NA
5501192	376380	5034570	144.8	33.8	5.5	32.0	112.8	7/26/1966	Domestic	Bedrock	Granite
5503295	376150	5032450	160.0	48.2	9.8	47.2	112.8	9/26/1973	Domestic	Bedrock	Limestone
5506304	376499	5032099	152.4	38.1	1.2	36.6	115.8	10/7/1980	Domestic	Bedrock	Granite
5501198	377525	5034730	144.8	28.3	18.9	27.4	117.3	6/28/1965	Domestic	Bedrock	Granite
5506882	378099	5034699	144.8	25.9	NA	25.9	118.9	8/27/1982	Domestic	Overburden	NA
5503857	376250	5033400	176.8	56.4	6.1	54.3	122.5	9/3/1975	Domestic	Bedrock	Granite
5506879	376399	5032999	160.0	38.1	4.0	36.0	124.1	9/5/1982	Domestic	Bedrock	Granite
5501191	375625	5034050	156.4	22.9	8.5	22.9	133.5	5/23/1958	Domestic	Bedrock	Granite
5503638	375700	5034200	158.5	25.9	14.6	24.4	134.1	8/27/1974	Domestic	Bedrock	Granite
5500839	376040	5034620	147.8	12.8	3.7	12.2	135.6	11/7/1957	Domestic	Bedrock	Limestone
5502736	375480	5034270	149.4	15.2	9.8	13.7	135.6	12/5/1971	Domestic	Bedrock	Limestone
5506208	376999	5032399	160.0	31.4	15.2	24.4	135.6	9/8/1980	Domestic	Bedrock	Limestone
5506644	377399	5031699	160.0	30.5	4.3	16.8	143.3	10/22/1981	Domestic	Bedrock	Limestone
5504167	375980	5032150	163.1	22.9	4.3	12.8	150.3	6/30/1976	Domestic	Bedrock	Limestone
5510995	376232	5032284	NA	68.6	3.7	11.6	NA	8/28/1992	Domestic	Bedrock	NA
5510560	377246	5033167	NA	68.0	1.5	12.2	NA	6/19/1991	Domestic	Bedrock	Granite
5511914	376847	5033628	NA	21.3	11.0	19.8	NA	5/2/1994	Domestic	Bedrock	Granite
5508970	375841	5032756	NA	38.1	15.2	24.4	NA	6/10/1988	Domestic	Bedrock	Granite
5515785	376415	5032239	NA	67.1	2.4	26.5	NA	10/8/2004	Domestic	Bedrock	Granite
5512352	375841	5032756	NA	27.4	25.3	26.8	NA	6/10/1995	Domestic	Bedrock	Granite
5508935	379061	5033160	NA	38.7	6.4	27.4	NA	5/3/1988	Domestic	Bedrock	Granite
5511829	376847	5033628	NA	30.5	12.2	27.4	NA	3/18/1994	Domestic	Bedrock	Limestone
5516233	377651	5033792	NA	31.1	NA	28.0	NA	9/8/2005	Domestic	Bedrock	Granite
5516381	377262	5034149	NA	29.0	28.7	29.0	NA	5/4/2006	Domestic	Bedrock	Granite
5513157	376154	5034474	NA	32.0	23.2	29.0	NA	10/31/1997	Domestic	Bedrock	Granite
1517037	377867	5034555	NA	45.7	NA	35.1	NA	6/16/1979	Domestic	Bedrock	Granite
5511650	376232	5032284	NA	42.7	21.9	35.4	NA	8/2/1993	Domestic	Bedrock	Limestone
5507256	377150	5035397	NA	37.5	NA	37.5	NA	8/12/1983	Domestic	Overburden	NA

Summary of Water Well Records Within 2 km of Site 2

Hydrogeological Screening Report
Highway 17 Twinning Campbell Drive to Scheel Drive
GWP 4067-03-00

<i>MOE</i>	<i>UTM Coordinates</i>		<i>Ground Surface</i>	<i>Depth</i>	<i>Depth</i>	<i>Depth</i>	<i>Groundwater</i>	<i>Date</i>	<i>Water</i>	<i>Well Type</i>	<i>Bedrock</i>
<i>Well ID</i>	<i>Easting</i>	<i>Northing</i>	<i>Elevation</i>	<i>of Well</i>	<i>to Bedrock</i>	<i>to Water</i>	<i>Elevation</i>	<i>Constructed</i>	<i>Supply Type</i>		<i>Unit</i>
5514692	375841	5032757	NA	41.5	28.3	39.9	NA	3/22/2002	Domestic	Bedrock	Granite
5511324	377246	5033167	NA	42.7	8.2	41.1	NA	7/16/1991	Domestic	Bedrock	Limestone
5513374	376232	5032284	NA	48.8	20.7	42.7	NA	8/14/1998	Domestic	Bedrock	Granite
5513375	376154	5034474	NA	103.6	11.0	54.9	NA	8/12/1998	Domestic	Bedrock	Granite
5507483	376154	5034474	NA	64.0	14.6	63.1	NA	4/27/1984	Domestic	Bedrock	NA
5509549	376232	5032284	NA	69.5	8.5	68.3	NA	6/14/1989	Domestic	Bedrock	Granite
5515580	376148	5033304	NA	71.9	17.7	71.9	NA	5/25/2004	Domestic	Bedrock	Granite
5511850	377866	5034555	NA	32.0	30.5	NA	NA	4/29/1994	Domestic	Bedrock	NA
5515828	376934	5035466	NA	108.8	43.3	96.0	NA	10/15/2004	Municipal	Bedrock	Granite
5500840	376920	5035450	141.7	40.2	NA	40.2	101.5	8/15/1958	Public Supply	Overburden	NA
5501183	377100	5032190	146.3	19.8	NA	17.4	128.9	12/15/1950	Public Supply	Overburden	NA
5505125	376250	5032450	160.0	105.5	103.6	103.6	56.4	2/12/1978	Stock	Bedrock	NA
5504105	376850	5035100	143.3	93.3	39.3	83.8	59.4	3/27/1976	Stock	Bedrock	Granite
5502529	377220	5032250	144.8	25.9	2.1	14.3	130.5	11/9/1970	Stock	Bedrock	Granite
5501197	377600	5034640	147.8	15.2	NA	14.6	133.2	8/2/1956	Stock	Overburden	NA
5501190	376980	5032725	157.0	61.0	0.0	22.6	134.4	5/21/1958	Stock	Bedrock	Limestone
5502528	377220	5032240	144.8	57.9	2.4	9.8	135.0	11/23/1970	Stock	Bedrock	Granite
5501182	377425	5031650	182.9	18.9	14.3	18.6	164.3	6/11/1965	Stock	Bedrock	Granite

Notes:

UTM - Universal Transverse Mercator

m ASL - metres above sea level

m bgs - metres below ground surface

NA - No information recorded in the well record

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SITE 3

Station 22+700 Horton Twp.

3.0 SITE 3 - Station 22+700 Horton Twp.

3.1 Site Description

The site is located on the south side of Highway 17 approximately 250 metres east of CP Rail Overpass, i.e. Station 22+700. Figure 3-1 shows the site location and Figure 3-2 shows the significant site features plotted on a 2005 aerial photograph. Site photographs have been included in Appendix 3-A. These features are described below:

- The site consists of a discrete groundwater discharge zone (seep) located at the exposed edge of a shallow bedrock terrace on the south side of Highway 17. The bedrock terrace appears to extend out (i.e. south) from the base of the Highway 17 slope embankment for approximately 50 metres and then truncates as a shallow ledge into a wetland. The terrace, which extends for approximately 250 metres parallel to the highway, appears to be approximately 1.5 metres above the wetland. The bedrock terrace is vegetated with scattered trees and the adjacent wetland is densely vegetated with tall grasses and cattails on its northwest portion and forested on its south and east portion.
- There is channelized water flow in the wetland extending from the seep towards the west end of the wetland next to the CPR tracks.
- The wetland occupies an area extending east-west from 750 metres west of County Road 6 to the CPR tracks, and north-south from the south highway slope embankment to the gravel pits located approximately 300 metres south of the highway.
- The landscape surrounding the site is a mixture of forest, agricultural and resource extraction (aggregates).

Current Land Use

According to the Renfrew County Official Plan describes the following land designations for the site:

- *Mineral Aggregate* – found south of Highway 17 from Gillan Road to CNR and northwest of the highway at Mullins Road. Permitted land uses include pits and quarries with associated manufacturing use and uses that do not preclude future mineral extraction activities.

Ecoplans also completed a ground survey of the surrounding area to document current land use and any significant structures and water courses within 500 metres of the site. Figure 3-2 shows the site and significant structures documented during the survey. The following relevant data from the ground survey is included below:

- The site is surrounded by agricultural land to the north and west; wetland, forest and gravel pit to the south; and wetland and forest to the east.

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- Canadian Pacific Rail (CPR) tracks run along in a northeast-southwest direction to the west of the site.
- Aggregate resource extraction activities occur to the south and southeast of the site. A total of three pits occupy the lands on the north side of Whitton Road from the CPR tracks to County Road 6. These include the larger Jamieson Pit south of the tracks; and smaller Kluk and Francon Pits between the Jamieson Pit and County Road 6.
- There are no residences or buildings within 500 metres of the site with the exception of the buildings and structures associated with the Jamieson Pit to the south of the site.

Current Municipal and Private Servicing

Ecoplans completed a request for information from the County of Renfrew for existing water and sanitary sewer systems. The information was used to identify and confirm the presence of municipal servicing of areas within two (2) kilometers of the site. Based on the information obtained from the County, the closest municipal servicing is approximately 1 km to the northwest of the site servicing an industrial/commercial area on the south side of Highway 60 west of Mullins Road.

In addition to completing a request for information from the County, Ecoplans also carried out a ground survey to confirm the presence of private servicing of the site and the immediate surrounding area. At the time of inspection, Ecoplans did not identify any private servicing to the site. Ecoplans did confirm that the surrounding area is serviced privately, with each residence serviced by a septic system and associated weeping tile bed; and water well (See Section 3.4).

There are no municipal and communal wells within 2 km of the site.

3.2 Background Information Review

Ecoplans completed a background information review for the site. The purpose of the review was to gain a general understanding of the regional and local geology and hydrogeology of the site. This was achieved by reviewing topographic and geological maps, water well records, current and historical aerial photographs, local and regional groundwater studies, and background geotechnical and environmental studies.

3.2.1 Topography

The site is located within the physiographic region known as the Ottawa Valley Clay Plains (Chapman and Putnam, 1984). This region is characterized by flat-lying tracts of clayey soils ranging from 10 to 30 km wide. The average topography of the area surrounding the site can range from approximately 120 to 140 m above sea level (asl), due to the presence of ridges of rock or sand interspersed through the region.

The site itself is located at the base of a flat narrow bedrock terrace next to the highway embankment which flanks the north side of a wetland. Highway 17 at this location rises over the CPR tracks and descends to flat clay plains to the east and west.

3.2.2 Drainage

The site is located south of the Bonnechere River, and west of Deil's Creek (a tributary of the Bonnechere River). The Bonnechere River takes a general southeasterly course largely controlled by major bedrock faults in the region (Chapman and Putnam, 1984). In the vicinity of Renfrew there are waterfalls below which the river has cut a trench over 30 m deep in the Pleistocene deposits, and there is a succession of deep lateral gullies.

Site drainage is to the east through the wetland which discharges into a small tributary of Deil's Creek located to the east of the site.

3.2.3 Geology

Surficial Geology

According to the groundwater report completed by Golder Associates Ltd (2003) for the Mississippi Valley Conservation Authority (MVCA), the site is overlain by surficial deposits of marine clay. The fine-grained deposits were laid down in quiet water environments, such as bedrock valleys or in depressions between drumlinized terrain. The thickness of the clay varies, and depends on the depth of depressions in which the clay was deposited. On average, the overburden surrounding the site is approximately 10-30 m thick.

According to the Geological Survey of Canada (Quinn, 1956), the site and immediate surrounding area is located on marine clays. There is a relatively large isolated deposit of glacial drift (gravel, sand and clay) located to the south and southwest of the site. This deposit is presently being mined for aggregate resources.

Figure 3-3 shows the surficial geology of the site and surrounding area.

Bedrock Geology

The bedrock geology of the site and surrounding area is predominantly composed of Precambrian igneous rock associated with the Bancroft Terrane (OGS, 1991). The Bancroft Terrane is the largest of the four terranes in the Central Metasedimentary Belt, and is composed of highly-metamorphosed, continental shelf sediments (Golder Associates et al. 2003). The terrane shows an abundance of marble, clastic sediments, gneiss, and felsic plutonic rocks.

3.2.4 Hydrogeology

Preamble

Groundwater is found in water bearing zones below the ground. Less permeable or impermeable layers called aquitards may separate these water bearing zones or aquifers. The aquitards restrict groundwater movement typically between the shallow groundwater zone and the deeper groundwater zone. The shallow groundwater zone is usually perched, unconfined (i.e. not under hydrostatic pressure), limited in areal extent, and generally reflects the surface topography. On the other hand, the deeper groundwater zone is usually at depth, confined (i.e. under hydrostatic pressure/artesian conditions), regional in extent, and does not generally reflect the surface topography. The regional aquifer, or groundwater system, is usually the potable water supply source for human and agricultural consumption.

Site

The hydrogeology of the site is predominantly characterized by the bedrock (regional) aquifer system. Since the overburden is largely composed of silt and clay, the overburden across the site would be considered a major confining unit (aquitard), and not an adequate source of potable groundwater. Hydraulic conductivities in the weathered clay deposits (top 3.0 to 5.0 m) have been measured by Dillon Consulting (1997) at 10^{-4} to 10^{-5} cm/s.

The regionally extensive aquifer beneath the site is the Precambrian bedrock. In general, fracture zones in the Precambrian aquifer yield marginal to adequate quantities of water for individual wells (Golder Associates Ltd, 2003). Groundwater flow is through secondary porosity from these fractures, while primary porosity will only account for approximately 2% of all flow (Freeze and Cherry, 1979).

Near the bedrock surface stress releases can cause bedrock sheeting that result in the development of horizontal fractures parallel to the topographic surface. Vertical fractures can also form which may result in unconfined aquifer conditions where the bedrock is exposed at ground surface without adequate overburden cover, increasing the potential for surface contamination. Freeze and Cherry (1979) estimate the hydraulic conductivity of fractured igneous and metamorphic rocks at 10^{-6} to 10^{-2} cm/s.

3.2.5 Water Well Records

Preamble

The Ministry of the Environment's Water Well Database is a compilation of water wells drilled in the Province of Ontario for the purpose of human, agricultural and industrial consumption. Pursuant to the Ontario Water Resources Act, any well drilled for these purposes must be drilled by an MOE licensed well drilling contractor and documented on a Water Well Record. The record is then filed with the MOE. Examples of data recorded on a water well record include: location of well, date drilled, depth to water, static water level and subsurface stratigraphy. Since well records have been completed by many different drillers during the past 50 or so years, data accuracy and consistency is sometimes questionable. The most important data recorded on a record are the depth of the water supply aquifer and the subsurface stratigraphy. This information helps in determining whether the aquifer is hydraulically connected to the surface hydrology of an area through groundwater recharge and discharge. It is also important to realize that water wells are drilled into aquifers that can yield appreciable quantities of water for their intended purpose. The majority of these aquifers are normally found at depth in the deep groundwater zones. Therefore, shallow perched aquifers are rarely exploited as a resource due to high susceptibility to contamination, low yields, and potential impacts to surface water baseflow. Water well records seldom identify shallow perched aquifers.

However, given their limitations, water well records still provide a very useful source of both local and regional geological and hydrogeological information.

Site and Surrounding Area

Ecoplans completed a water well record search to within two (2) kilometers of the site. The results of the search identified a total of 84 water wells located in the vicinity of the site. The well locations are shown in Figure 3-4. However, it should be noted that the well locations are approximate and based on coordinate information provided within the water well records database, which are all subject to some margin of error. Documentation of the water well records has been included in Appendix 3-B. The following relevant data from the records is included below:

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- The earliest water well records available were from 1949 to as recent as 2005;
- Four (4) water wells are drilled into the overburden aquifer, and 80 water wells are drilled into the bedrock aquifer;
- Water wells drilled into the overburden aquifer terminate between 11 and 18 metres below ground surface (m bgs), and wells drilled into the bedrock aquifer terminate between 9.4 metres to 68 metres bgs;
- Four (4) wells are drilled into granite deposits, 71 wells are drilled into limestone deposits, two (2) wells are drilled into dolomite deposits, and three (3) wells are drilled into sandstone deposits;
- The wells drilled into granite deposits are generally located southwest of the site, and wells drilled into limestone deposits are generally located south, in the vicinity of Martins Hill;
- The depth to water for water wells drilled into the overburden aquifer range between 11.6 metres to 15.8 metres bgs, and the depth to water for wells drilled into the bedrock aquifer range between 8.5 metres to 61.9 metres bgs;
- Twenty-seven (27) wells encounter water less than 15 m bgs (i.e. shallow wells), 39 wells encounter water between 15 metres and 30 metres bgs (i.e. intermediate wells), and 15 wells encounter water greater than 30 m bgs (i.e. deep wells);
- Shallow and intermediate wells are generally located south of the site in the vicinity of Martins Hill. Deep wells are generally located southeast of the site;
- The groundwater elevations range from 82.3 metres above sea level (ASL) to 140.8 m ASL;
- Four (4) wells are stock water wells, two (2) wells are industrial water wells, one (1) well is commercial water well, 71 wells are domestic water wells, and five (5) wells are public supply water wells. The public supply wells (5500828, 5508426, 5508424, 5508546, and 5500850) are generally located either east or south of the site, between 1.5 kilometres and 2.0 kilometres ; and
- The general groundwater flow direction is north towards the Bonnechere River.

Figures 3-5a and 3-5b show the geological interpretation of the site and surrounding area (geological cross-sections) based on those well records within 300 metres of a two-kilometre transect through the site. Figure 3-5a shows a geological cross-section based on 9 well records through the site and along Highway 17 while Figure 6b shows a cross-section based on 11 well records through the site and roughly perpendicular to Highway 17. It should be noted that some of the well records did not show surface elevations and therefore surface elevations were estimated based on OBM maps.

Based on interpretation of the cross-sections, the site and surrounding area is underlain by Paleozoic bedrock (predominantly limestone with the exception of three areas located to the north, south and east of the site which are underlain with sandstone). The bedrock is covered with mostly clay (marine) overburden with an average thickness of 15 metres. There are however, localized sand deposits of up to 10 metres thick. One location is in the vicinity of the Gillan Road/Highway 17 intersection, east of the site; and the other southwest of the site. Water was encountered in the bedrock at elevations

between 65.1 m amsl (approximately 1.7 km northeast of the site) to 134 m amsl (approximately 1.5 km east of the site) with an average elevation of 109.2 m amsl. This represents the regional bedrock aquifer system.

3.2.6 Aerial Photographs

Current (2005) and historical aerial photographs (for the years 1946, 1959, 1978 and 1987) for the site and surrounding area were reviewed by Ecoplans to identify any surface features that are of potential hydrogeological significance (surface water bodies, vegetation cover and human development impacts). A description of the notable features for each aerial photo is summarized in Table 3-1.

Table 3-1
Review of Aerial Photographs – Significant Site Features

Year	Significant Site Features
1959	<ul style="list-style-type: none">- CPR tracks present- Hwy 17 not present- Site and immediate surrounding area consists of a relatively small isolated patch of densely forested land surrounded by agricultural land.- A small creek appears to emerge from southeast portion of the forest patch and join a tributary of the Deil's Creek to the east of the site.- A small patch of disturbed land is present to the south of the site. This may represent the early stages of a gravel pit which later becomes the Jamieson Pit.
1966	<ul style="list-style-type: none">- Hwy. 17 not present- No significant changes since the 1959 aerial photo with the exception of the gravel pit to the south of the site which has slightly increased in size.
1987	<ul style="list-style-type: none">- Hwy. 17 present.- Aggregate resource extraction activities have increased substantially to the south and southeast of the site. The largest pit south of the site now covers a large area with a small water body (gravel pit pond) on its southeast portion. Two other pits are now present to the southeast of the large pit.- An access road runs from Highway 17 to the large gravel pit.- The base of Highway 17 south slope embankment (in the vicinity of the site itself) appears to be cleared of trees in a narrow linear strip extending from the CPR tracks eastwards to the gravel pit access road referred to above.- The areas between cleared strip and the large gravel pit, and to the east are still densely forested.- A small creek still emerges from the southeast portion of the forested area and joins a tributary of the Deil's Creek.
2005	<ul style="list-style-type: none">- No significant changes since the 1987 aerial photo.

The most significant observations noted on the aerial photos are:

- The site and immediate surrounding land has always remained densely forested (wetland).
- A small creek to the southeast of the site drains the site's wetland. The creek eventually flows into Deil's Creek east of the site.
- Aggregate resource extraction south of the study area appeared to commence pre-1959 and substantially increased (two more pits) sometime between 1966 and 1987.
- The 1987 aerial photo shows a narrow strip of cleared land along the base of the Highway 17 south slope embankment between the CPR tracks and a former access road to the large gravel pit from Highway 17. This strip of land represents the bedrock terrace referred to elsewhere in this report, i.e. the location of the groundwater seep.

3.2.7 Background Studies

This section summarizes the background studies that were reviewed noting significant relevant information.

- i) *Existing Conditions Report- Volume 3, Appendix F. Highway 17 Twinning Arnprior to Renfrew WP 647-92-00.* Prepared by Totten Sims Hubicki Associates (TSH) and National Capital Engineering (NCE). November 2002.

Significant relevant information included:

- Based on the MOE Water Well Data Set, approximately 9 water wells were identified within 1 km of the site.
- The Towns of Arnprior and Renfrew are on municipal water systems.
- The bedrock along Highway 17 between Renfrew and Arnprior is Precambrian including granite, gneiss and carbonate rocks and crystalline limestone outcrops in certain areas.
- The soils at the site are predominantly White Lake soils (gravelly sandy loams) associated with the Precambrian upland. These soils are not very productive for agricultural purposes.
- The physiography along Highway 17 between Arnprior and Renfrew consists mainly of clay plains (Ottawa Valley Clay Plains Physiographic Region) interrupted by shallow till and rock ridges, sand plains and a small area of kame moraines at County Road 6. The gravel pits located south of the site extract aggregates from the kame moraines. The clay plains are extremely susceptible to surface erosion and are underlain with very soft blue-grey silt, silty clay and clay referred to as "leda clay". Leda clay is extremely unstable and vulnerable to slope failure.
- Land use within and surrounding the site consists predominantly of natural areas/woodlots which flank Highway 17 through the site. Agricultural land is found to the northwest of the site.
- Renfrew County Official Plan describes the following land designations for the site:

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- *Mineral Aggregate* – found south of Highway 17 from Gillan Road to CNR and northwest of the highway at Mullins Road. Permitted land uses include pits and quarries with associated manufacturing use and uses that do not preclude future mineral extraction activities.
 - The existing highway drainage system at the site is urban with storm sewers collecting storm water from the highway and discharging via culverts located along the mid-slope of the south highway embankment next to the CPR tracks and further to the east. The discharge water then drains overland down the embankment and into the wetland.
 - The site lies within an agricultural and young upland deciduous forest area. Most of the habitat is severely disturbed with upland deciduous forest and scrubby wetland habitat occupying the area south of the site.
- ii) *Renfrew County-Mississippi-Rideau Groundwater Study, Volume 1 and 2, Summary Report and Technical Appendices.* Prepared by Golder Associates Limited. September 2003.
- Significant relevant information has been incorporated into Section 3.2.3 and Section 3.2.4.
- iii) *Hydrogeology of Southern Ontario, Second Edition.* Prepared by S.N. Singer, C.K. Cheng and M.K. Scafe; Ministry of the Environment. 2003.

Significant relevant information has been incorporated into Section 3.2.3 and Section 3.2.4.

3.3 Site Inspection

A site inspection was carried out on May 10, 2007. The purpose of the site inspections was to observe and document any significant features of hydrogeologic concern such as surface water courses, seepage zones and springs (groundwater discharge), topography and surficial geology. Site photographs have been included in Appendix 3-A. The results of the inspections are summarized below.

- The discrete groundwater seep observed during the site inspection appears to emerge from the base of a shallow exposed bedrock terrace next to a wetland.
- The bedrock terrace appears to extend out (i.e. south) from the base of the Highway 17 slope embankment for approximately 50 metres and then truncates as a shallow ledge into a wetland. The terrace, which extends for approximately 250 metres parallel to the highway, appears to be approximately 1.5 metres above the wetland. The bedrock terrace is vegetated with scattered trees and the adjacent wetland is densely vegetated with tall grasses and cattails on its northwest portion and forested on its south and east portion.
- The seep pools at the base of the terrace in the wetland and flows through a narrow open channel within the wetland. It is unclear as to the direction of flow within the wetland channel but the overall wetland appears to discharge into a small creek at the southeast corner of the forested area. From there the creek flows to the east into a small tributary of Deil's Creek.
- There are two culverts located along the south embankment of Highway 17 between the site and the CPR tracks. One culvert is located at mid-slope closer to the tracks and while the other culvert is located near the base of slope further to the east of the first culvert. Both culverts discharge into the wetland. It appears that the CPR tracks act as a hydraulic barrier to the west limits of the wetland.

3.4 *Water Well Survey*

Ecoplans completed a door-to-door water well survey of wells within 500 metres of the site. The purpose of the door-to-door well survey was to confirm the presence, location and construction details of each well, access permitting. The results of the survey did not identify any water well within 500 metres of the site.

3.5 *Evaluation of Groundwater Resources and Vulnerability*

The surficial geology of the site and surrounding area consists of marine clays overlying Paleozoic bedrock (mostly limestone with isolated sandstone deposits). There is a relatively large isolated deposit of glacial drift (gravel, sand and clay) located to the south and southwest of the site. This deposit is presently being mined for aggregate resources. The site itself is located on a limestone bedrock terrace adjacent to a small wetland at the base of the highway embankment for the CPR Overpass.

The hydrogeology of the site and surrounding area is dominated by bedrock driven groundwater systems found in the fractures and bedding planes of the Paleozoic (predominantly limestone) rock. Within two kilometres of the site, four (4) water wells are drilled into the overburden aquifer, and 80 water wells are drilled into the bedrock aquifer. The depth to water for water wells drilled into the overburden aquifer range between 11.6 metres to 15.8 metres bgs, and the depth to water for wells drilled into the bedrock aquifer range between 8.5 metres to 61.9 metres bgs. Based on the water well records and well survey, there are no wells within 500 metres of the site. The closest well is approximately 600 metres southwest of the site on Whitton Road immediately east of the CPR tracks. The well record at this location (5505512) shows the aquifer to be approximately 45.7 m bgs (elevation of 91.4 m amsl). Groundwater flow in the bedrock aquifer system is generally to the north towards the Bonnechere River.

The site inspection identified a discrete groundwater seep emerging from the base of a shallow exposed bedrock terrace next to the wetland. The seep could represent a localized aquifer in the upper strata of the limestone bedrock. The bedrock terrace appears to extend out (i.e. south) from the base of the Highway 17 slope embankment for approximately 50 metres and then truncates as a shallow ledge into a wetland. The terrace extends for approximately 250 metres parallel to the highway, and appears to be approximately 1.5 metres above the wetland. The seep pools at the base of the terrace in the wetland and flows through a narrow open channel within the wetland. Overall drainage of the wetland appears to be to the east into a small creek at the southeast corner of the wetland. From there the creek flows to the east into a small tributary of Deil's Creek.

Groundwater and Surface Water Impacts and Vulnerability

The proposed twinning of Highway 17 at Site 3 will involve the construction of eastbound lanes to the south of the existing highway encroaching on the wetland. This will involve significant fill to construct the CPR overpass with some excavation work to establish competent embankment base footing. The most direct impact of the construction would be the impact to the wetland drainage system. Fill operations will likely impede groundwater and surface water flow, and will ultimately reduce the wetland catchment area. Any cuts into the shallow bedrock could reduce groundwater baseflow into

the wetland. The result could be a net loss to the groundwater and surface water flow through the wetland system which could ultimately reduce surface water flow into Deil's Creek. This could be mitigated through appropriate highway drainage design which would include installing culverts at the base of the eastbound lanes to facilitate surface water flow through the wetland system.

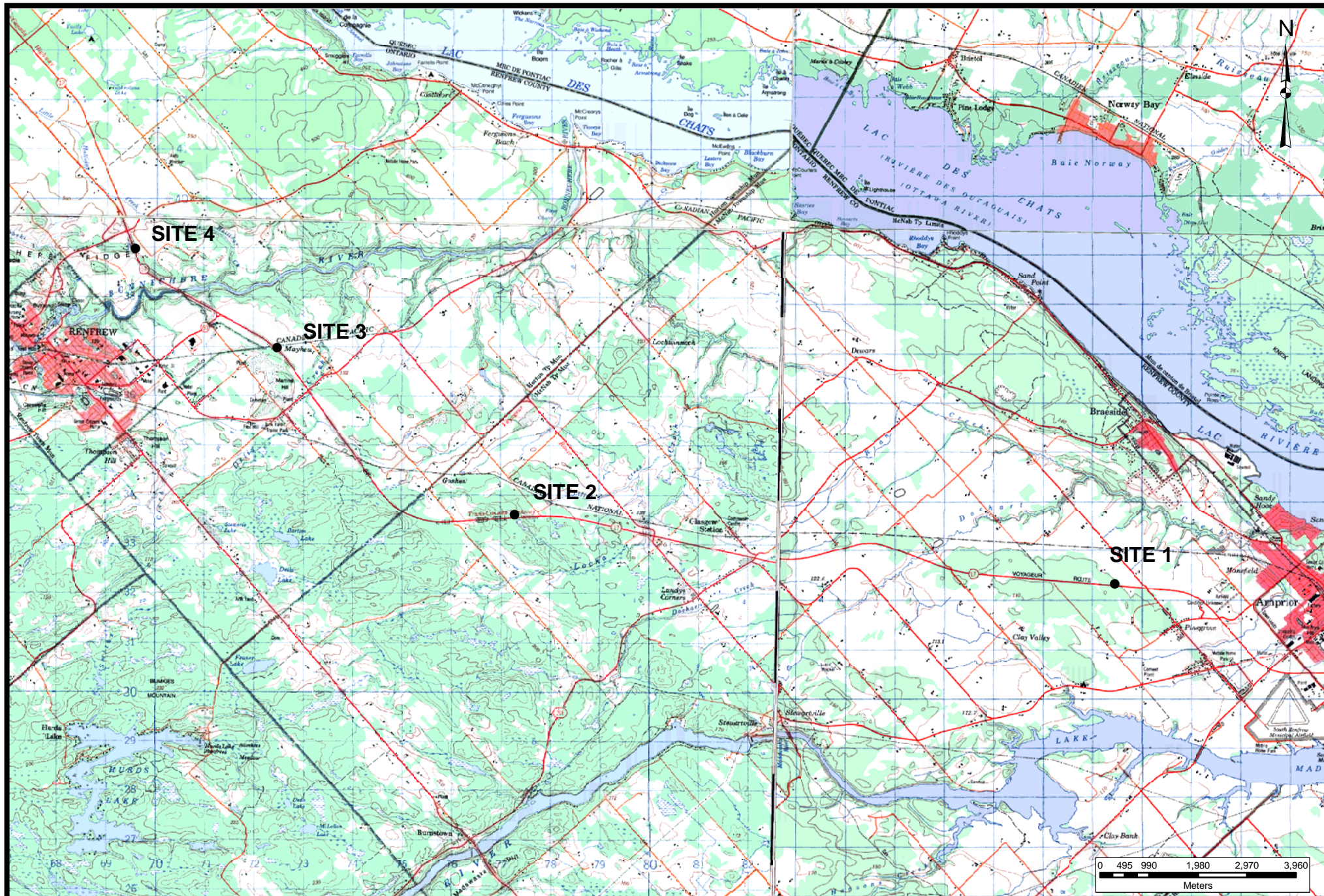
The potential impacts to the regional groundwater system would likely not be significant due to the following reasons:

- The regional bedrock aquifer system is at an average elevation of 109.2 m amsl significantly deeper than the natural ground surface elevation at Site 2 which is approximately 130 m amsl. Based on the well records, the shallowest elevation of the bedrock aquifer identified within 500 metres of the site is at 158.8 m amsl, approximately 10 metres below the surface elevation of the highway at the site. This well is located approximately 300 metres southeast of the site.
- The closest well is approximately 600 metres southwest of the site on Whitton Road immediately east of the CPR tracks (Figure 3-4 shows this well to be on the west side of the CPR tracks which is likely a location error on the well record). Since the aquifer at this location is deep (approximately 45.7 m bgs and an elevation of 91.4 m amsl) and the well is hydraulically upgradient of the site, any highway construction work would likely not have an impact on the well.

The potential impacts to the shallow bedrock aquifer system could be significant because the seep appears to be shallow (i.e. within the upper 2 metres of limestone) and could be intercepted during any shallow bedrock cuts. This could reduce baseflow into the wetland which could impact surface water discharge into Deil's Creek. The potential chemical impacts (i.e. groundwater and surface water quality) to the groundwater and surface water systems could be of a concern due to winter maintenance (road salting) activities and spills without implementing adequate mitigation measures.

Based on the above, the overall vulnerability of the local and regional groundwater and surface water systems to highway construction activities would be considered low with respect to regional bedrock groundwater supply; high with respect to local bedrock groundwater and surface water supply; and moderate with respect to groundwater and surface water quality issues. Provided adequate mitigation measures are implemented, any potential construction related groundwater and surface water impacts could be minimized.

FIGURES
Site 3 – Station 22+700 Horton Twp.



Source: National Topographic System (NTS)

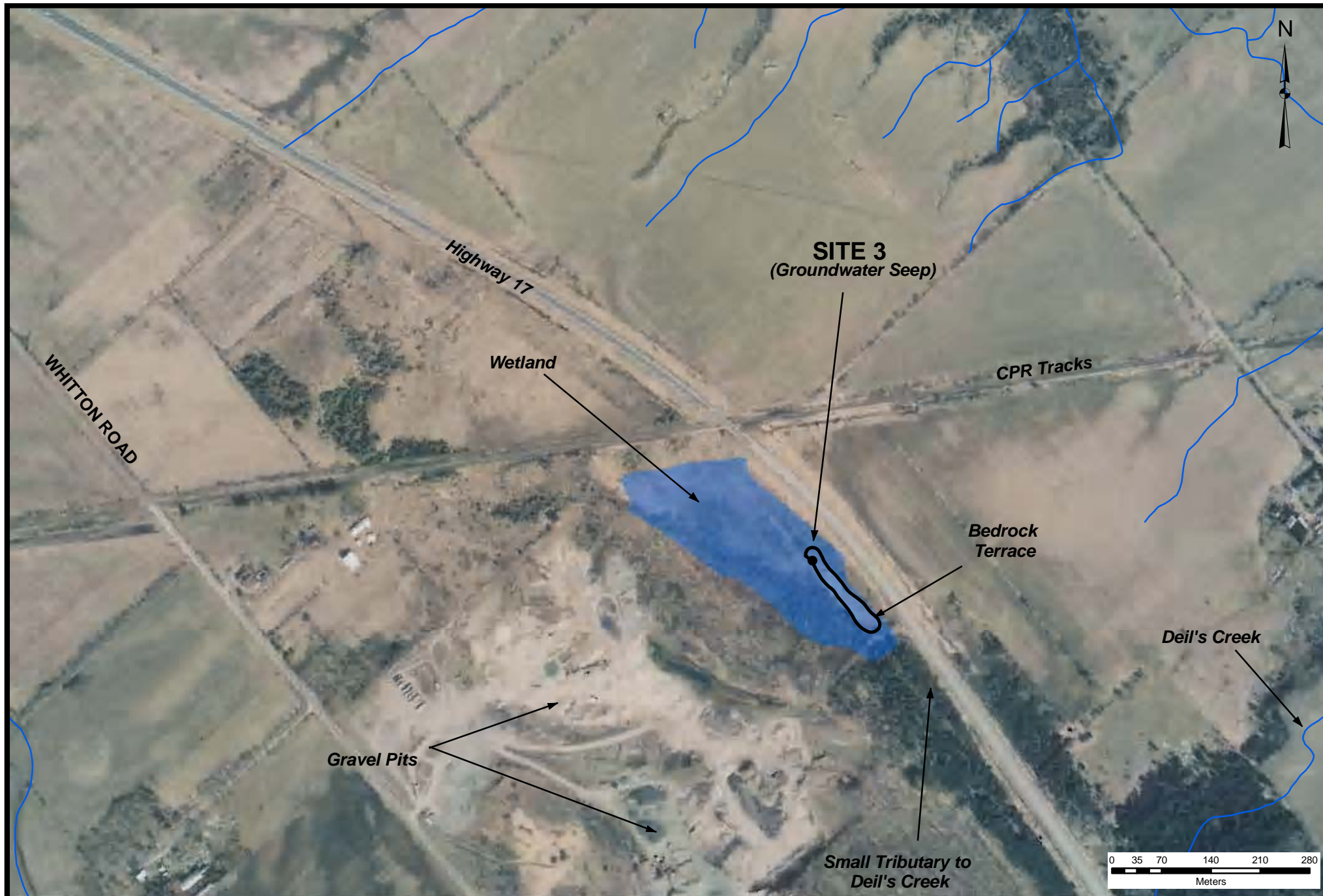
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HYDROGEOLOGICAL SCREENING REPORT
HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
 GWP 4067-03-00
SITE LOCATION PLAN - SITE 3

DATE:
AUGUST 2007
 PROJECT:
R07-0261

FIGURE
3-1



Source: 2005 Aerial Photograph (Provided by the Ministry of Transportation)

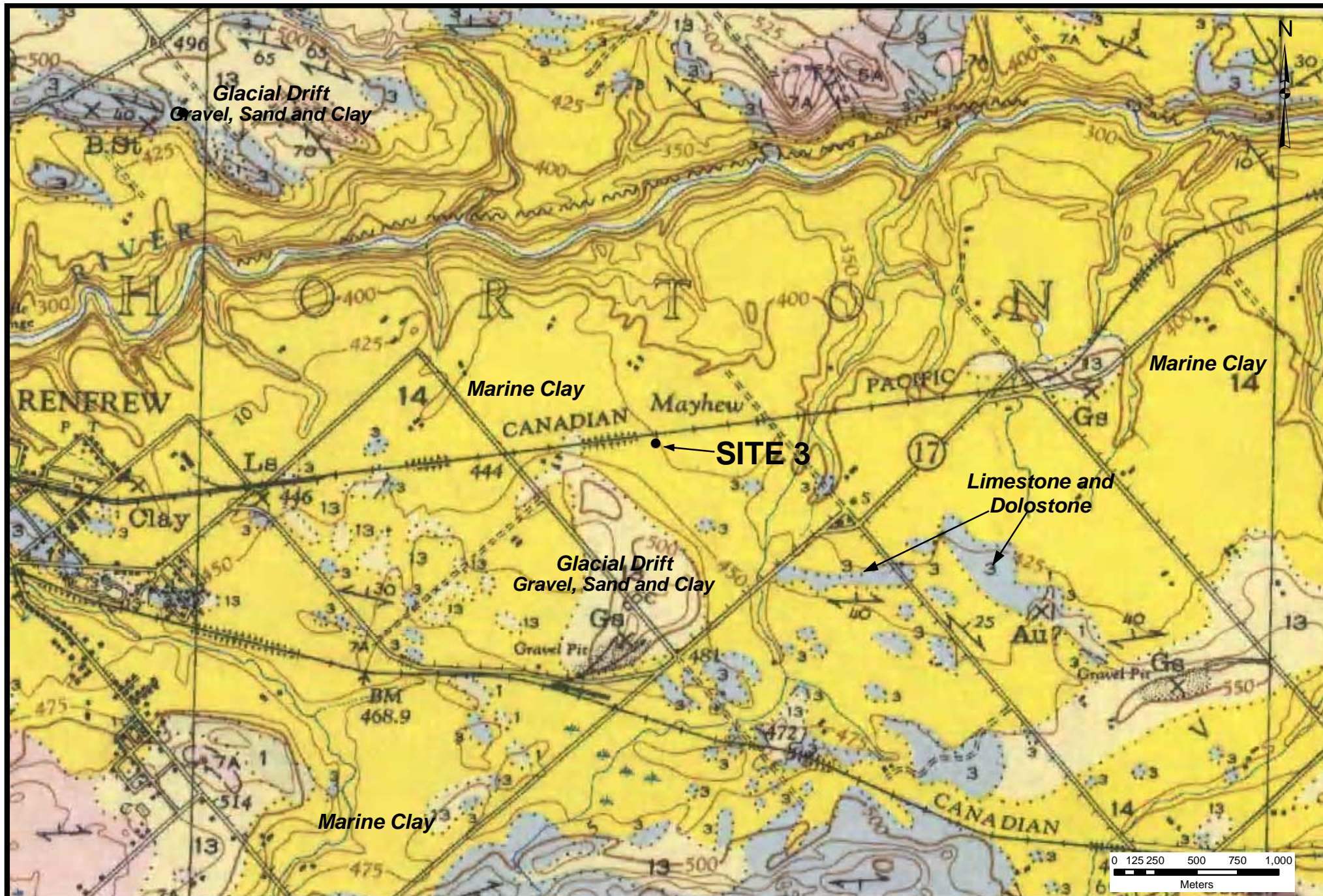
Scale: 1:7,000



HYDROGEOLOGICAL SCREENING REPORT
 HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
 GWP 4067-03-00
SITE PLAN - SITE 3

DATE:
AUGUST 2007
 PROJECT:
R07-0261

FIGURE
3-2



Source: Geological Survey of Canada, 2003

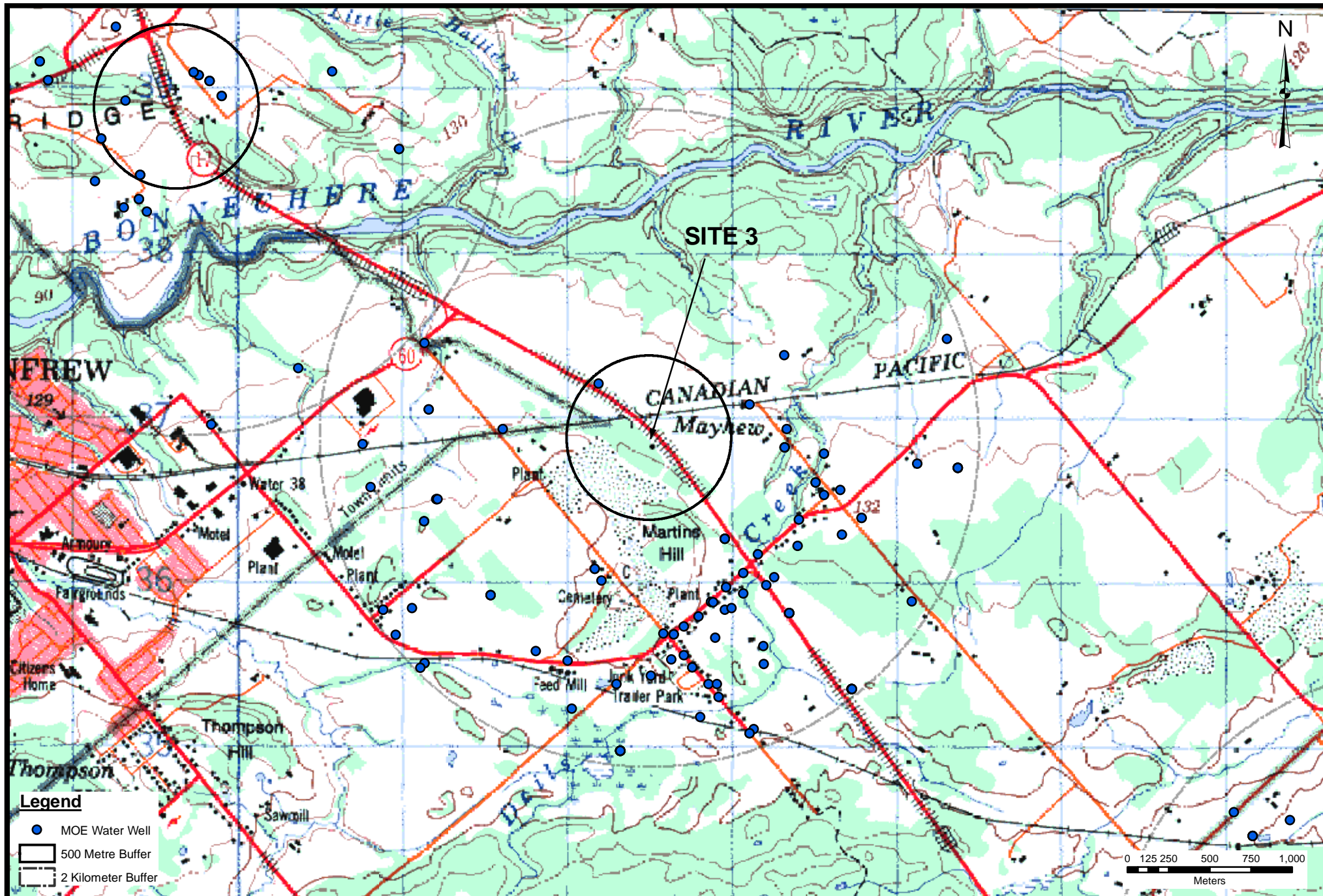
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HYDROGEOLOGICAL SCREENING REPORT
 HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
 GWP 4067-03-00
SURFICIAL GEOLOGY OF THE SITE AND SURROUNDING AREA - SITE 3

DATE:
AUGUST 2007
 PROJECT:
R07-0261

FIGURE
3-3



Source: National Topographic System (NTS)

Scale: 1:30,000



HYDROGEOLOGICAL SCREENING REPORT
 HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
 GWP 4067-03-00
WATER WELL LOCATION PLAN

DATE:
AUGUST 2007
 PROJECT:
R07-0261

FIGURE
3-4

FILE LOCATION: I:\ECOPLANS\03 - REMEDIATION\PROJECTS\R07-0261 17 Twinning - Campbell to Scheel\0261-700 Drawings
DRAWING NAME: R07-0261 Cross Section.DWG
DRAWN BY: G. Yang
MODIFIED: 07/05/30 12:06:16 Revised

Geological Cross-Section A - A' of Site 3

Highway 17 Twinning from Campbell Drive to Scheel Drive
GWP 4067-03-00

DATE:
August 2007

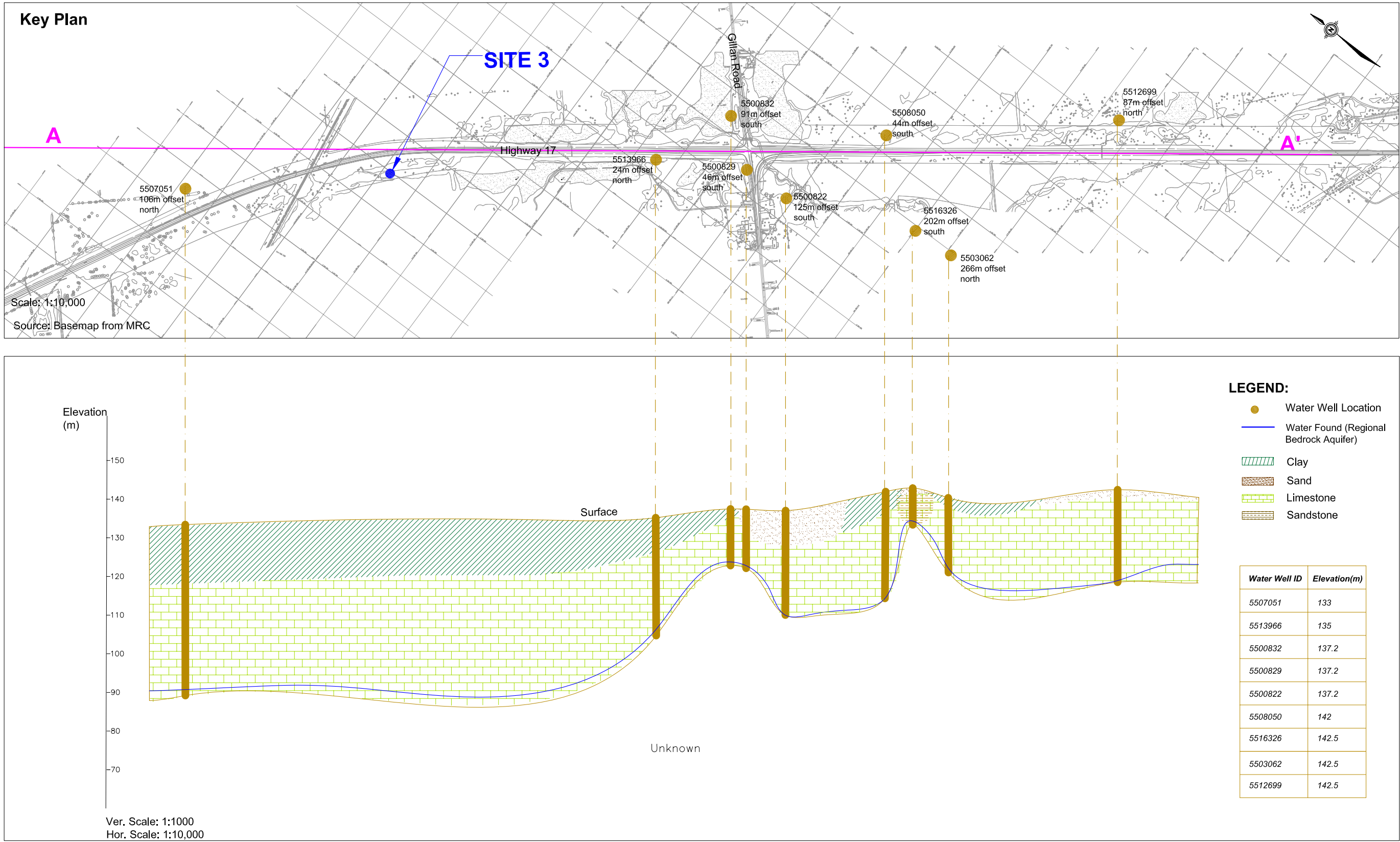
PROJECT NO.:
R07-0261

DRAWN BY:
G. Yang

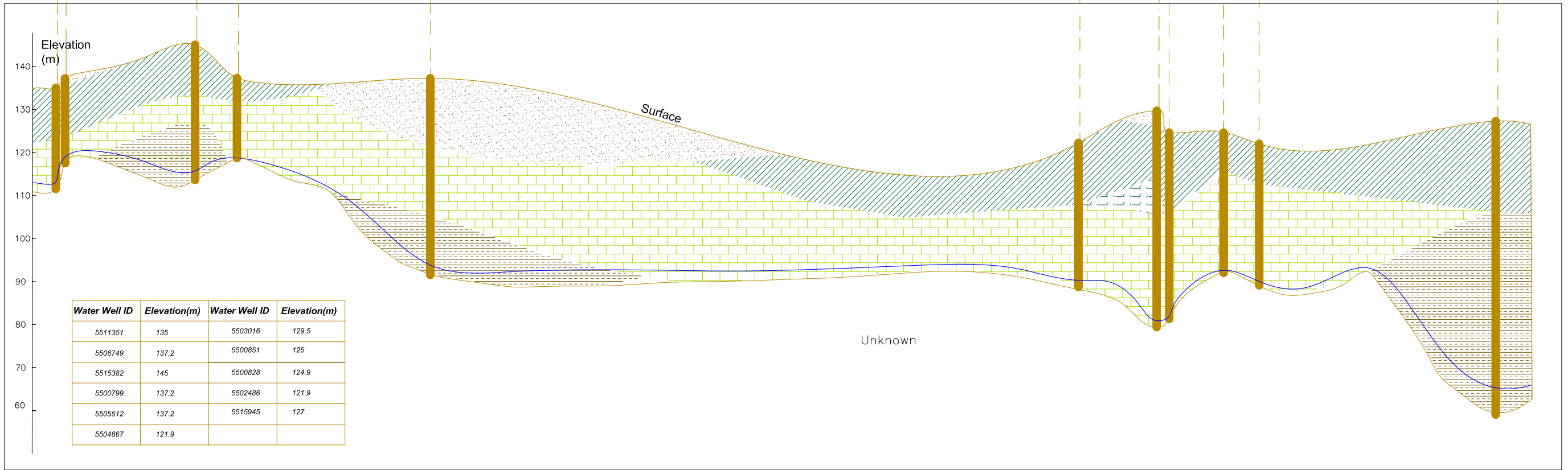
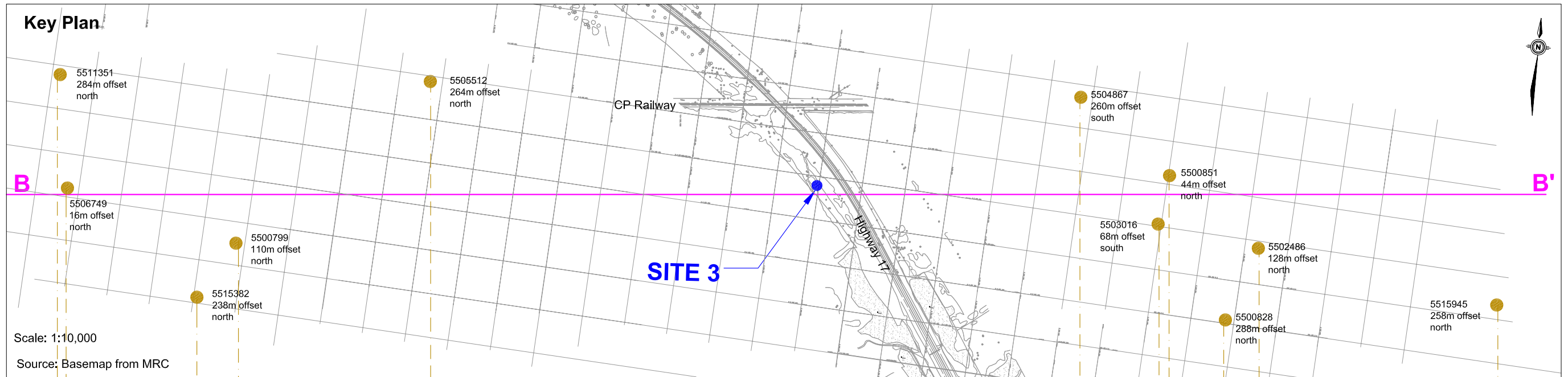
CHECKED BY:
D. Stewart

FIGURE NO.:

3-5a



FILE LOCATION-I:\ECOPLANS\03 - REMEDIATION\PROJECTS\R07-0261 17 Twinning - Campbell to Scheel\0261-700 Drawings
DRAWING NAME: R07-0261 Cross Section.DWG
DRAWN BY: G. Yang
12:06:16
12/06/16
Revised



LEGEND:

- Water Well Location
- Water Found (Regional Bedrock Aquifer)
- Clay
- Sand
- Limestone
- Granite
- Sandstone



Geological Cross-Section B - B' of Site 3

Highway 17 Twinning from Campbell Drive to Scheel Drive
GWP 4067-03-00

DATE:
August 2007
PROJECT NO.:
R07-0261

DRAWN BY:
G. Yang
CHECKED BY:
D. Stewart

FIGURE NO.:
3-5b

APPENDIX 3-A

Site 3 – Site Photographs



← Photo 1
Wetland between Highway 17 (right side of photo) and gravel pits (beyond left side of photo). Photo taken facing west.

Photo 2 →
Groundwater seep discharging groundwater from bedrock face (bottom right corner of photo) and into wetland.
Photo taken facing south.



← Photo 3
Location of groundwater seep at base of bedrock terrace (in front of person). Photo taken facing east.



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Hydrogeological Screening Report
Highway 17 Twinning Campbell Drive to Scheel Drive
GWP 4067-03-00
SITE 3: Site Photographs

Date:
August 2007

Project No.:
R07-0261

Figure No.

3-A1



← Photo 4
West end of wetland showing drainage culvert and CPR Overpass. Photo taken facing west.



Photo 5 →
West end of wetlands showing standing water and CPR tracks. Photo taken facing southwest.



← Photo 6
East end of wetland showing small stream (in the few trees at the left side of the photo) flowing to the east towards Deil's Creek. Photo taken facing west.



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Hydrogeological Screening Report
Highway 17 Twinning Campbell Drive to Scheel Drive
GWP 4067-03-00
SITE 3: Site Photographs

Date:
August 2007

Project No.:
R07-0261

Figure No.

3-A2

APPENDIX 3-B

Site 3 – Ministry of the Environment (MOE) Water Well Records

Summary of Water Well Records Within 2 km of Site 3

Hydrogeological Screening Report
Highway 17 Twinning Campbell Drive to Scheel Drive
GWP 4067-03-00

<i>MOE</i>	<i>UTM Coordinates</i>		<i>Ground Surface</i>	<i>Depth</i>	<i>Depth</i>	<i>Depth</i>	<i>Groundwater</i>	<i>Date</i>	<i>Water</i>	<i>Well Type</i>	<i>Bedrock</i>
<i>Well ID</i>	<i>Easting</i>	<i>Northing</i>	<i>Elevation</i>	<i>of Well</i>	<i>to Bedrock</i>	<i>to Water</i>	<i>Elevation</i>	<i>Constructed</i>	<i>Supply Type</i>		<i>Unit</i>
			<i>(m ASL)</i>	<i>(m bgs)</i>	<i>(m)</i>	<i>(m bgs)</i>	<i>(m ASL)</i>				
5506749	370799	5036599	137.2	19.5	1.5	18.3	118.9	10/27/1981	Commercial	Bedrock	Limestone
5500851	373325	5036950	125.0	43.3	19.8	42.7	82.3	9/25/1963	Domestic	Bedrock	Limestone
5503658	373250	5036050	137.2	56.7	3.4	54.6	82.6	11/2/1974	Domestic	Bedrock	Limestone
5504867	373100	5037100	121.9	35.1	14.3	33.5	88.4	8/23/1976	Domestic	Bedrock	Limestone
5506385	374299	5037499	121.9	35.1	14.9	33.5	88.4	10/31/1980	Domestic	Bedrock	Limestone
5505512	371600	5036950	137.2	47.2	16.2	45.7	91.4	5/5/1978	Domestic	Bedrock	Limestone
5506381	373399	5036399	129.5	38.1	12.8	36.6	93.0	11/18/1980	Domestic	Bedrock	Limestone
5500834	371125	5037475	129.5	36.6	19.8	36.0	93.6	6/6/1964	Domestic	Bedrock	Limestone
5500824	373390	5036240	129.5	24.4	0.9	23.8	105.8	1/12/1961	Domestic	Bedrock	Limestone
5502239	371150	5037070	131.1	30.8	15.2	23.2	107.9	4/30/1969	Domestic	Bedrock	Limestone
5503845	373550	5036550	121.9	13.7	7.9	13.4	108.5	8/23/1975	Domestic	Bedrock	Dolomite
5500797	371200	5036525	137.2	27.4	4.6	27.4	109.7	3/23/1955	Domestic	Bedrock	Limestone
5500822	373060	5035950	137.2	27.7	9.1	27.1	110.0	9/20/1958	Domestic	Bedrock	Limestone
5500819	373780	5036410	132.6	22.3	4.0	19.8	112.8	3/24/1956	Domestic	Bedrock	Limestone
5503179	373661	5036307	128.6	16.2	4.9	14.3	114.3	8/23/1973	Domestic	Bedrock	Limestone
5503061	374085	5035903	134.1	17.1	1.2	16.2	118.0	5/16/1973	Domestic	Bedrock	Limestone
5500798	371197	5036525	137.2	19.2	15.5	19.2	118.0	3/24/1955	Domestic	Bedrock	Limestone
5500796	371125	5035525	137.2	25.9	10.7	19.2	118.0	7/21/1960	Domestic	Bedrock	Limestone
5502638	372865	5035900	143.3	31.4	14.0	25.3	118.0	5/14/1971	Domestic	Bedrock	Limestone
5500799	371203	5036525	137.2	18.6	12.2	18.6	118.6	3/25/1955	Domestic	Bedrock	Limestone
5500820	372950	5035850	140.2	22.3	5.5	21.3	118.9	8/8/1958	Domestic	Bedrock	Limestone
5503062	373185	5035521	140.2	19.5	2.4	18.3	121.9	5/22/1973	Domestic	Bedrock	Limestone
5500829	373060	5036075	137.2	15.2	6.1	14.6	122.5	9/11/1961	Domestic	Bedrock	Limestone
5503383	371050	5035860	144.8	23.2	12.5	21.9	122.8	6/6/1973	Domestic	Bedrock	Limestone
5500832	373150	5036190	137.2	14.3	2.4	13.7	123.4	10/9/1965	Domestic	Bedrock	Limestone
5502916	372990	5035860	141.7	18.3	4.6	16.8	125.0	9/5/1972	Domestic	Bedrock	Limestone
5503049	370949	5035698	144.8	20.1	7.0	19.5	125.3	9/5/1972	Domestic	Bedrock	Limestone
5503344	372879	5035898	144.8	19.2	6.7	18.3	126.5	12/12/1973	Domestic	Bedrock	Limestone
5500803	370875	5035850	144.8	28.3	14.9	18.3	126.5	8/14/1967	Domestic	Bedrock	Limestone
5502496	372900	5035400	144.8	18.3	3.7	17.4	127.4	8/11/1970	Domestic	Bedrock	Limestone
5500794	372500	5035450	147.8	20.4	1.2	19.8	128.0	4/29/1959	Domestic	Bedrock	Limestone

Summary of Water Well Records Within 2 km of Site 3

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<i>MOE</i>	<i>UTM Coordinates</i>		<i>Ground Surface</i>	<i>Depth</i>	<i>Depth</i>	<i>Depth</i>	<i>Groundwater</i>	<i>Date</i>	<i>Water</i>	<i>Well Type</i>	<i>Bedrock</i>
<i>Well ID</i>	<i>Easting</i>	<i>Northing</i>	<i>Elevation</i>	<i>of Well</i>	<i>to Bedrock</i>	<i>to Water</i>	<i>Elevation</i>	<i>Constructed</i>	<i>Supply Type</i>		<i>Unit</i>
			<i>(m ASL)</i>	<i>(m bgs)</i>	<i>(m)</i>	<i>(m bgs)</i>	<i>(m ASL)</i>				
5502144	372890	5035680	144.8	17.4	6.1	16.5	128.3	6/27/1968	Domestic	Bedrock	Limestone
5500821	372850	5035400	144.8	16.8	4.9	16.2	128.6	8/13/1958	Domestic	Bedrock	Limestone
5503182	372956	5035989	143.3	29.9	5.5	12.8	130.5	8/20/1973	Domestic	Bedrock	Limestone
5500823	372910	5035320	144.8	14.3	4.3	13.7	131.1	5/2/1959	Domestic	Bedrock	Limestone
5500816	373125	5035125	144.8	12.8	4.6	12.8	132.0	12/12/1958	Domestic	Bedrock	Limestone
5503345	371993	5035540	147.8	15.8	NA	15.8	132.0	12/14/1973	Domestic	Overburden	NA
5503072	372200	5036030	149.4	18.3	8.2	16.2	133.2	5/10/1972	Domestic	Bedrock	Granite
5502715	372750	5035500	145.7	12.5	5.2	11.6	134.1	9/7/1971	Domestic	Bedrock	Limestone
5500793	372625	5035550	147.8	15.2	4.6	13.7	134.1	11/16/1957	Domestic	Bedrock	Limestone
5503079	372159	5036100	155.4	29.9	6.4	21.0	134.4	5/2/1973	Domestic	Bedrock	Granite
5500830	372575	5035705	149.4	15.2	12.2	14.6	134.7	7/10/1964	Domestic	Bedrock	Limestone
5500827	372700	5035750	149.4	15.2	1.5	14.0	135.3	5/3/1957	Domestic	Bedrock	Limestone
5505211	373100	5035100	144.8	19.5	2.1	9.1	135.6	8/20/1978	Domestic	Bedrock	Limestone
5502632	372020	5035250	147.8	12.5	1.8	12.2	135.6	4/20/1971	Domestic	Bedrock	Limestone
5500825	372700	5035575	147.8	12.2	5.5	11.6	136.2	9/19/1963	Domestic	Bedrock	Limestone
5500826	372750	5035500	147.8	12.2	3.7	11.6	136.2	9/27/1963	Domestic	Bedrock	Limestone
5500791	373310	5037400	147.8	11.3	1.8	10.7	137.2	7/26/1965	Domestic	Bedrock	Limestone
5505990	372799	5035199	152.4	11.6	NA	11.6	140.8	11/29/1979	Domestic	Overburden	NA
5516326	373183	5035631	NA	9.4	1.5	8.5	NA	12/19/2005	Domestic	Bedrock	Sandstone
5507918	373340	5035831	NA	12.2	6.7	11.3	NA	7/3/1985	Domestic	Bedrock	Limestone
5508050	373340	5035831	NA	28.3	5.5	12.2	NA	9/26/1985	Domestic	Bedrock	Limestone
5514062	373340	5035831	NA	34.7	0.6	12.2	NA	7/4/2000	Domestic	Bedrock	Limestone
5513311	371526	5035941	NA	29.0	1.5	13.4	NA	6/26/1998	Domestic	Bedrock	Limestone
5507590	372315	5034992	NA	42.7	1.2	14.3	NA	6/30/1984	Domestic	Bedrock	Limestone
5513966	372948	5036283	NA	30.5	10.4	15.2	NA	5/25/2000	Domestic	Bedrock	Limestone
5513864	374363	5036714	NA	18.9	9.8	16.8	NA	11/22/1999	Domestic	Bedrock	Dolomite
5515382	371124	5036390	NA	31.4	11.9	17.1	NA	9/15/2003	Domestic	Bedrock	Sandstone
5512699	373720	5035368	NA	24.4	1.8	18.9	NA	7/29/1996	Domestic	Bedrock	Limestone
5507819	372948	5036284	NA	47.5	14.3	22.9	NA	5/21/1985	Domestic	Bedrock	Limestone
5511351	370749	5036860	NA	25.0	13.1	23.5	NA	6/2/1992	Domestic	Bedrock	Limestone
5508427	372315	5034992	NA	32.3	15.2	23.5	NA	11/20/1986	Domestic	Bedrock	Limestone

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<i>MOE</i>	<i>UTM Coordinates</i>		<i>Ground Surface</i>	<i>Depth</i>	<i>Depth</i>	<i>Depth</i>	<i>Groundwater</i>	<i>Date</i>	<i>Water</i>	<i>Well Type</i>	<i>Bedrock</i>
<i>Well ID</i>	<i>Easting</i>	<i>Northing</i>	<i>Elevation</i>	<i>of Well</i>	<i>to Bedrock</i>	<i>to Water</i>	<i>Elevation</i>	<i>Constructed</i>	<i>Supply Type</i>		<i>Unit</i>
			<i>(m ASL)</i>	<i>(m bgs)</i>	<i>(m)</i>	<i>(m bgs)</i>	<i>(m ASL)</i>				
5511542	373720	5035368	NA	44.2	1.5	25.9	NA	5/12/1993	Domestic	Bedrock	Limestone
5511459	374363	5036714	NA	44.2	0.9	29.6	NA	5/8/1993	Domestic	Bedrock	Limestone
5513882	373721	5035368	NA	42.7	0.0	32.6	NA	10/22/1999	Domestic	Bedrock	Limestone
5510270	374363	5036714	NA	34.4	25.9	32.9	NA	8/30/1990	Domestic	Bedrock	Limestone
5511912	371526	5035941	NA	42.7	12.2	41.1	NA	5/31/1994	Domestic	Bedrock	Limestone
5507051	372182	5037229	NA	44.2	15.2	42.7	NA	9/8/1982	Domestic	Bedrock	Limestone
5508360	374363	5036714	NA	46.3	18.9	43.3	NA	10/15/1986	Domestic	Bedrock	Limestone
5515945	374117	5036740	NA	68.3	21.6	61.9	NA	3/12/2005	Domestic	Bedrock	Sandstone
5505055	371800	5035600	144.8	15.2	NA	NA	NA	6/6/1978	Domestic	Overburden	NA
5503379	373200	5036000	137.2	18.3	NA	NA	NA	5/3/1974	Domestic	Overburden	NA
5500833	372640	5035700	149.4	42.4	7.0	24.7	124.7	4/25/1966	Industrial	Bedrock	Limestone
5500795	372290	5035400	144.8	13.7	8.5	13.7	131.1	3/19/1962	Industrial	Bedrock	Limestone
5500828	373500	5036625	121.9	32.6	8.8	24.4	97.5	7/11/1959	Public Supply	Bedrock	Limestone
5508426	372315	5034992	NA	19.5	2.4	11.3	NA	11/11/1986	Public Supply	Bedrock	Limestone
5508424	372315	5034992	NA	19.5	7.6	12.5	NA	11/10/1986	Public Supply	Bedrock	Limestone
5508546	372315	5034992	NA	44.5	9.8	12.8	NA	11/8/1986	Public Supply	Bedrock	Limestone
5500850	373650	5036580	125.0	30.5	10.1	NA	NA	1/15/1949	Public Supply	Bedrock	Limestone
5506606	371099	5035499	144.8	53.3	14.9	51.5	93.3	10/5/1981	Stock	Bedrock	Limestone
5502486	373550	5036800	121.9	32.9	9.4	22.9	99.1	8/21/1970	Stock	Bedrock	Limestone
5503016	373312	5036839	129.5	50.3	15.5	24.4	105.2	2/20/1973	Stock	Bedrock	Granite
5500831	372790	5035810	144.8	18.6	5.5	17.7	127.1	6/29/1965	Stock	Bedrock	Limestone

Notes:

UTM - Universal Transverse Mercator

m ASL - metres above sea level

m bgs - metres below ground surface

NA - No information recorded in the well record

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SITE 4

Station 19+080 Horton Twp.

4.0 SITE 4 - Station 19+080 Horton Twp.

4.1 Site Description

The site is located on the west side of Highway 17 approximately 500 metres south of Bruce Street, i.e. Station 19+080. Figure 4-1 shows the site location and Figure 4-2 shows the significant site features plotted on a 2005 aerial photograph. Site photographs have been included in Appendix 4-A. These features are described below:

- Highway 17 rises to the north from the Bonnechere River valley and cuts through the bedrock escarpment and then levels out on the tablelands.
- The site is located close to the crest of the escarpment. At this location the highway cuts through the bedrock. The tableland runs in a west-east direction following the Bonnechere River Valley. The predominantly south facing slope of the tableland is forested with a number of residences nestled in the forest. Agricultural land dominates the tableland and the river valley. The most significant features of the area are the large bedrock knoll located to the east and a smaller one to the west of the site. There are two residences perched atop the large knoll, and one on the smaller knoll.
- The site consists of a discrete groundwater discharge zone (seep) discharging from a culvert (Culvert 1) located on the west side of Highway 17 (Seep 1). The discharge water flows along the ditch flanking the west side of the highway and collects and pools approximately 120 metres south of the site on relatively flat terrain. At this pool location, another culvert (Culvert 2) running beneath the highway conveys drainage water from the east side of the highway. The pool, which is vegetated with tall grasses and cattails, likely collects both storm water and groundwater from both sides of the highway and slowly infiltrates into the shallow aquifer system.
- On the east side of the highway at Station 19+000 (immediately upgradient of a bedrock cut), a passive groundwater discharge zone (seep) exists on the side of the steep slope rising up to the surrounding bedrock tableland (Seep 2). The soil covering the localized seep area which measures approximately 10 metres in length by 5 metres high was noted to be wet and vegetated with grasses and horsetails (indicative of wet conditions). At the base of the seep, groundwater pools and then flows along the drainage ditch flanking the east side of the highway and downslope into the culvert (Culvert 2) running beneath the highway and into the pool located on the west side of the highway as noted above.
- Another culvert (Culvert 3) exists on the east side of the highway at Station 19+030 (between Seep 2 and Culvert 2). The culvert is on an approximate 45⁰ angle with the ditch and discharges groundwater into the ditch. Both flow from this culvert and Seep 2 contribute to the receiving pool at the Culvert 2 discharge area.
- The landscape surrounding the site is a mixture of forest, agricultural and residential.

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Current Land Use

According to the Renfrew County Official Plan describes the following land designations for the site:

- *Rural* – found along both sides of Highway 17 corridor between McNab/Braeside Township and Bruce Street, except for the Town of Renfrew and Mineral Aggregate designations. The permitted uses include rural residential, agriculture, and rural-related commercial, industries and recreation.

Ecoplans also completed a ground survey of the surrounding area to document current land use and any significant structures and water courses within 500 metres of the site. Figure 4-2 shows the approximate site limits and significant structures documented during the survey. The following relevant data from the ground survey is included below:

- The site is surrounded by agricultural land to the north, east, south and southwest; and forested to the northwest and southeast (following the bedrock escarpment);
- There are 8 residences within 500 metres of the site, 7 to the east of the highway along Dugald Road and one to the northwest of the site on top of the bedrock knoll.
- There are no significant surface water courses within 500 metres of the site.
- Bonnechere River is located approximately 800 metres to the south of the site.
- The Bruce Street/Highway 17 intersection is located approximately 500 metres north of the site.

Current Municipal and Private Servicing

Ecoplans completed a request for information from the County of Renfrew for existing water and sanitary sewer systems. The information was used to identify and confirm the presence of municipal servicing of areas within two (2) kilometers of the site. Based on the information obtained from the County, the closest municipal servicing is approximately 1.5 km to the south of the site servicing an area on the north side of Highway 60 west of Highway 17.

In addition to completing a request for information from the County, Ecoplans also carried out a ground survey to confirm the presence of private servicing of the site and the immediate surrounding area. At the time of inspection, Ecoplans did not identify any private servicing to the site. Ecoplans did confirm that the surrounding area is serviced privately, with each residence serviced by a septic system and associated weeping tile bed; and water well (See Section 4.4).

There are no municipal and communal wells within 2 km of the site.

4.2 Background Information Review

Ecoplans completed a background information review for the site. The purpose of the review was to gain a general understanding of the regional and local geology and hydrogeology of the site. This was achieved by reviewing topographic and geological maps, water well records, current and historical aerial photographs, local and regional groundwater studies, and background geotechnical and environmental studies.

4.2.1 Topography

The site is located within the physiographic region known as the Ottawa Valley Clay Plains (Chapman and Putnam, 1984). This region is characterized by flat-lying tracts of clayey soils ranging from 10 to 30 km wide. The average topography of the area surrounding the site can range from approximately 120 to 140 m above sea level (asl), due to the presence of ridges of rock or sand interspersed through the region.

The site itself is located close to the crest of an east-west trending bedrock escarpment rising from the Bonnechere River valley to the south and flattening out on tablelands to the north of the site.

4.2.2 Drainage

The site is located north of the Bonnechere River, and south of the Little Halliday Creek (a tributary of the Bonnechere River). The Bonnechere River takes a general southeasterly course largely controlled by major bedrock faults in the region (Chapman and Putnam, 1984). In the vicinity of Renfrew there are waterfalls below which the river has cut a trench over 30 m deep in the Pleistocene deposits, and there is a succession of deep lateral gullies.

Site drainage is to the south along Highway 17 ditches.

4.2.3 Geology

Surficial Geology

According to the groundwater report completed by Golder Associates Ltd (2003) for the Mississippi Valley Conservation Authority (MVCA), the site is overlain by surficial deposits of marine clay. The fine-grained deposits were laid down in quiet water environments, such as bedrock valleys or in depressions between drumlinized terrain. The thickness of the clay varies, and depends on the depth of depressions in which the clay was deposited. On average, the overburden surrounding the site is approximately 10-30 m thick.

According to the Geological Survey of Canada (Quinn, 1956), the site is located on limestone and dolomite bedrock. Glacial drift deposits of gravel, sand and clay occur to the north and east of the site, and marine clays to the south and southwest.

Figure 4-3 shows the surficial geology of the site and surrounding area.

Bedrock Geology

The bedrock geology of the site and surrounding area is composed of Precambrian igneous rock associated with the Bancroft Terrane (OGS, 1991). The Bancroft Terrane is the largest of the four terranes in the Central Metasedimentary Belt, and is composed of highly-metamorphosed, continental shelf sediments (Golder Associates et al. 2003). The terrane shows an abundance of marble, clastic sediments, gneiss, and felsic plutonic rocks.

4.2.4 Hydrogeology

Preamble

Groundwater is found in water bearing zones below the ground. Less permeable or impermeable layers called aquitards may separate these water bearing zones or aquifers. The aquitards restrict groundwater movement typically between the shallow groundwater zone and the deeper groundwater zone. The shallow groundwater zone is usually perched, unconfined (i.e. not under hydrostatic pressure), limited in areal extent, and generally reflects the surface topography. On the other hand, the deeper groundwater zone is usually at depth, confined (i.e. under hydrostatic pressure/artesian conditions), regional in extent, and does not generally reflect the surface topography. The regional aquifer, or groundwater system, is usually the potable water supply source for human and agricultural consumption.

Site

The hydrogeology of the site is predominantly characterized by the bedrock (regional) aquifer system. Since the overburden is largely composed of silt and clay, the overburden across the site would be considered a major confining unit (aquitard), and not an adequate source of potable groundwater. Hydraulic conductivities in the weathered clay deposits (top 3.0 to 5.0 m) have been measured by Dillon Consulting (1997) at 10^{-4} to 10^{-5} cm/s.

The regionally extensive aquifer beneath the site is the Precambrian bedrock. In general, fracture zones in the Precambrian aquifer yield marginal to adequate quantities of water for individual wells (Golder Associates Ltd, 2003). Groundwater flow is through secondary porosity from these fractures, while primary porosity will only account for approximately 2% of all flow (Freeze and Cherry, 1979). Near the bedrock surface stress releases can cause bedrock sheeting that result in the development of horizontal fractures parallel to the topographic surface. Vertical fractures can also form which may

result in unconfined aquifer conditions where the bedrock is exposed at ground surface without adequate overburden cover, increasing the potential for surface contamination. Freeze and Cherry (1979) estimate the hydraulic conductivity of fractured igneous and metamorphic rocks at 10^{-6} to 10^{-2} cm/s.

4.2.5 Water Well Records

Preamble

The Ministry of the Environment's Water Well Database is a compilation of water wells drilled in the Province of Ontario for the purpose of human, agricultural and industrial consumption. Pursuant to the Ontario Water Resources Act, any well drilled for these purposes must be drilled by an MOE licensed well drilling contractor and documented on a Water Well Record. The record is then filed with the MOE. Examples of data recorded on a water well record include: location of well, date drilled, depth to water, static water level and subsurface stratigraphy. Since well records have been completed by many different drillers during the past 50 or so years, data accuracy and consistency is sometimes questionable. The most important data recorded on a record are the depth of the water supply aquifer and the subsurface stratigraphy. This information helps in determining whether the aquifer is hydraulically connected to the surface hydrology of an area through groundwater recharge and discharge. It is also important to realize that water wells are drilled into aquifers that can yield appreciable quantities of water for their intended purpose. The majority of these aquifers are normally found at depth in the deep groundwater zones. Therefore, shallow perched aquifers are rarely exploited as a resource due to high susceptibility to contamination, low yields, and potential impacts to surface water baseflow. Water well records seldom identify shallow perched aquifers.

However, given their limitations, water well records still provide a very useful source of both local and regional geological and hydrogeological information.

Site and Surrounding Area

Ecoplans completed a water well record search to within two (2) kilometers of the site. The results of the search identified a total of 55 water wells located in the vicinity of the site. The well locations are shown in Figure 4-4. However, it should be noted that the well locations are approximate and based on coordinate information provided within the water well records database, which are all subject to some margin of error. Documentation of the water well records has been included in Appendix 4-B. The following relevant data from the records is included below:

- The earliest water well records available were from 1953 to as recent as 2006;
- Five (5) water wells are drilled into the overburden aquifer, and 50 water wells are drilled into the

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bedrock aquifer;

- Water wells drilled into the overburden aquifer terminate between 18 and 56 metres below ground surface (m bgs), and wells drilled into the bedrock aquifer terminate between 8.5 metres to 91.4 metres bgs;
- Sixteen (16) wells are drilled into granite deposits, 20 wells are drilled into limestone deposits, eight (8) wells are drilled into dolomite deposits, and four (4) wells are drilled into sandstone deposits;
- The wells drilled into granite deposits are generally located east of the site, and wells drilled into limestone deposits are generally located northeast of the site. There are four (4) wells drilled into granite bedrock within 500 metres of the site, and two (2) wells drilled into limestone bedrock;
- The depth to water for water wells drilled into the overburden aquifer range between 18 metres to 53 metres bgs, and the depth to water for wells drilled into the bedrock aquifer range between 7.9 metres to 90 metres bgs;
- Five (5) wells encounter water less than 15 metres below ground surface (i.e. shallow wells), 22 wells encounter water between 15 metres and 30 metres bgs (i.e. intermediate wells), and 25 wells encounter water greater than 30 metres bgs (i.e. deep wells);
- Shallow wells are generally located south and east of the site. Intermediate wells are located north and south and northeast of the site. Deep wells are largely present north and west of the site, with seven (7) wells located within 500 metres;
- The groundwater elevations range from 51 metres above sea level (amsl) to 137.5 metres ASL;
- Five (5) wells are stock water wells, 48 wells are domestic water wells, and one (1) well is a public supply water well. The public supply well is located approximately 1.8 kilometres northeast of the site; and
- The general groundwater flow direction is south-southeast towards the Bonnechere River.

Figures 4-5a and 4-5b show the geological interpretation of the site and surrounding area (geological cross-sections) based on those well records within 300 metres of a two-kilometre transect through the site. Figure 4-5a shows a geological cross-section based on 6 well records through the site and along Highway 17 while Figure 6b shows a cross-section based on 9 well records through the site and roughly perpendicular to Highway 17. It should be noted that some of the well records did not show surface elevations and therefore surface elevations were estimated based on OBM maps.

Based on interpretation of the cross-sections, the site and area to the east is covered by Precambrian bedrock and to the north, south and west by Paleozoic limestone and dolostone bedrock. According to well record 5508309, there is an isolated occurrence of Precambrian bedrock in this well located approximately 800 metres northwest of the site. Based on the surrounding wells which encounter limestone bedrock, it is possible this isolated well is in limestone (error in the record). The bedrock is generally covered with a thin layer of overburden (topsoil, sand and clay). However, the area north of the site (north of Bruce Street) is covered with over 30 metres of clays. Water was encountered in the

bedrock at elevations between 141.1 m amsl (approximately 1.1 km southeast of the site) to 73.1 m amsl (approximately 800 metres northwest of the site) with an average elevation of 114.2 m amsl. This represents the regional bedrock aquifer system.

4.2.6 Aerial Photographs

Current (2005) and historical aerial photographs (for the years 1946, 1959, 1978 and 1987) for the site and surrounding area were reviewed by Ecoplans to identify any surface features that are of potential hydrogeological significance (surface water bodies, vegetation cover and human development impacts). A description of the notable features for each aerial photo is summarized in Table 4-1.

Table 4-1
Review of Aerial Photographs – Significant Site Features

Year	Significant Site Features
1931	<ul style="list-style-type: none">- Hwy. 17 not present- Site is agricultural land- Three prominent forested bedrock knolls rise above the surrounding flat agricultural land. One of the knolls flanks the east side of the site, and a smaller one is to the west of the site. This east knoll appears to exhibit the most significant topographic relief.
1959	<ul style="list-style-type: none">- Hwy 17 not present- No significant changes since the 1931 aerial photo.
1966	<ul style="list-style-type: none">- Hwy. 17 not present- An area west of the larger bedrock knoll (i.e. the knoll flanking the east side of the site) appears to show some wet soil conditions extending from a small bedrock outcrop southwards for approximately 750 metres. This could represent a groundwater discharge area and could be associated with the seep discussed in this report.- No significant changes since the 1959 aerial photo.
1969	<ul style="list-style-type: none">- Hwy. 17 not present- No significant changes since the 1966 aerial photo.
1987	<ul style="list-style-type: none">- Hwy. 17 present.- The possible groundwater discharge area to the east of the larger bedrock knoll noted in the 1966 and 1969 aerial photos is not present.- Residences appear to the east and northeast of the site.- No significant changes since the 1966 aerial photo.
2005	<ul style="list-style-type: none">- No significant changes since the 1987 aerial photo.

The most significant observations noted on the aerial photos are:

- The site and surrounding area predominantly consists of large forested bedrock knolls and ridges and flat agricultural tablelands.
- Based on the 1966 and 1969 aerial photos, a significant groundwater discharge area appears on the agricultural landscape to the west of the larger bedrock knoll. It appears to discharge from a small bedrock cut and flows to the south for approximately 750 metres. This groundwater discharge may be associated with the seep observed in this study.

4.2.7 Background Studies

This section summarizes the background studies that were reviewed noting significant relevant information.

- Existing Conditions Report- Volume 3, Appendix F. Highway 17 Twinning Arnprior to Renfrew WP 647-92-00. Prepared by Totten Sims Hubicki Associates (TSH) and National Capital Engineering (NCE). November 2002.*

Significant relevant information included:

- Based on the MOE Water Well Data Set, approximately 10 water wells were identified within 1 km of the site.
- The Towns of Arnprior and Renfrew are on municipal water systems.
- The bedrock along Highway 17 between Renfrew and Arnprior is Precambrian including granite, gneiss and carbonate rocks and crystalline limestone outcrops in certain areas (the site itself).
- The soils at the site are predominantly Renfrew soils (sand complex). These soils are the best agricultural soils in Renfrew County. There is a localized deposit of Tweed Soils (sandy loams) to the immediate north of the site on top of the bedrock tableland. These soils, which are associated with surface outcrops of crystalline limestone, exhibit good drainage and high base status making them suitable for forest cover.
- The physiography along Highway 17 between Arnprior and Renfrew consists mainly of clay plains (Ottawa Valley Clay Plains Physiographic Region) interrupted by shallow till and rock ridges (the site itself), sand plains and a small area of kame moraines at County Road 6. The clay plains are extremely susceptible to surface erosion and are underlain with very soft blue-grey silt, silty clay and clay referred to as “leda clay”. Leda clay is extremely unstable and vulnerable to slope failure.

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- Land use within and surrounding the site consists predominantly of agricultural (to the north, south and southwest), natural areas/woodlots (to the northwest and east), and institutional (to the north).
- Renfrew County Official Plan describes the following land designations for the site:
 - *Rural* – found along both sides of Highway 17 corridor between McNab/Braeside Township and Bruce Street, except for the Town of Renfrew and Mineral Aggregate designations. The permitted uses include rural residential, agriculture, and rural-related commercial, industries and recreation.
- The existing highway drainage system at the site is typical of many current provincial highway drainage systems, i.e. open ditch and culverts. Ditches flank each side of the highway and flow to the south and into a small pool located on the west side of the highway approximately 120 metres south of the site. Water from the east ditch is piped through a culvert beneath the highway and into the pool. The water then infiltrates into the subsurface.
- The site lies along the south facing escarpment of the bedrock tableland. The escarpment is surrounded by young upland deciduous and mixed forest with red Oak, White Ash, Basswood, Ironwood, White Birch and White Pine with small open areas containing Common Juniper. The lower slopes at the base of the escarpment contain White Elm, Sugar Maple and White Pine.

ii) *Renfrew County-Mississippi-Rideau Groundwater Study, Volume 1 and 2, Summary Report and Technical Appendices.* Prepared by Golder Associates Limited. September 2003.

Significant relevant information has been incorporated into Section 4.2.3 and Section 4.2.4.

iii) *Hydrogeology of Southern Ontario, Second Edition.* Prepared by S.N. Singer, C.K. Cheng and M.K. Scafe; Ministry of the Environment. 2003.

Significant relevant information has been incorporated into Section 4.2.3 and Section 4.2.4.

4.3 Site Inspection

A site inspection was carried out on May 10, 2007. The purpose of the site inspections was to observe and document any significant features of hydrogeologic concern such as surface water courses, seepage zones and springs (groundwater discharge), topography and surficial geology. Site photographs have been included in Appendix 4-A. The results of the inspections are summarized below.

- The site consists of a discrete groundwater discharge zone (seep) discharging from a culvert (Culvert 1) located on the west side of Highway 17 (Seep 1). The discharge water flows along the ditch flanking the west side of the highway and collects and pools approximately 120 metres south of the site on relatively flat terrain. At this pool location, another culvert (Culvert 2) running beneath the highway conveys drainage water from the east side of the highway. The pool, which is vegetated with tall grasses and cattails, likely collects both storm water and groundwater from both sides of the highway and slowly infiltrates into the shallow aquifer system.
- On the east side of the highway at Station 19+000 (immediately upgradient of a bedrock cut), a passive groundwater discharge zone (seep) exists on the side of the steep slope rising up to the surrounding bedrock tableland (Seep 2). The soil covering the localized seep area which measures approximately 10 metres in length by 5 metres high was noted to be wet and vegetated with grasses and horsetails (indicative of wet conditions). At the base of the seep, groundwater pools and then flows along the drainage ditch flanking the east side of the highway and downslope into the culvert (Culvert 2) running beneath the highway and into the pool located on the west side of the highway as noted above.
- Another culvert (Culvert 3) exists on the east side of the highway at Station 19+030 (between Seep 2 and Culvert 2). The culvert is on an approximate 45⁰ angle with the ditch and discharges groundwater into the ditch. Both flow from this culvert and Seep 2 contribute to the receiving pool at the Culvert 2 discharge area.
- The landscape surrounding the site is a mixture of forest, agricultural and residential.

4.4 Water Well Survey

Ecoplans completed a door-to-door water well survey of all wells within 500 metres of the site. The purpose of the door-to-door well survey was to confirm the presence, location and construction details of each well, access permitting. The results of the survey identified nine (9) residences using private water wells within 500 metres of the site. Of the nine (9) residents, five (5) were surveyed. There was no response at four (4) residences. All surveyed wells are shown on Figure 4-4.

Surveyed wells tap into both the overburden and bedrock aquifers of the area with well depths ranging from 1.7 to 86 m below ground surface. At accessible wells, groundwater levels in the overburden aquifer are relatively shallow and are flowing at one location (1185 Dugald Drive). Groundwater levels in the bedrock aquifer are relatively deeper ranging from 2.1 to 24.6 m below ground surface. All residents reported overall good water quality and quantity with the exception of one property (1156 Dugald Drive) reporting water shortages during high demand periods.

Table 4-2 summarizes the well survey results for the water wells within 500 metres of the site.

Table 4-2
Water Wells Within 500 Metres of the Site

Address	GPS Coordinates	Date Installed *	Well Diameter (cm)	Well Type	Well Depth (m)	Static Water Level (m bgs)	Notes
1067 Dugald Drive	I	I	I	I	I	I	No one home
1075 Dugald Drive	369785E 5039333N	2006*	0.15	Drilled	I	12.2	Good water quality and quantity*
1082 Dugald Drive	369666E 5039172N	I	I	I	I	I	No one home
1095 Dugald Drive	369843E 5039265N	I	I	I	I	I	No one home
1107 Dugald Drive	369908E 5039208N	2006*	0.15	Drilled	73*	11.3	Good water quality and quantity*

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Table 4-2
Water Wells Within 500 Metres of the Site

Address	GPS Coordinates	Date Installed *	Well Diameter (cm)	Well Type	Well Depth (m)	Static Water Level (m bgs)	Notes
1120 Dugald Drive	369812E 5039053N	I	0.91	Dug	I	I	No one home
1156 Dugald Drive	370207E 5038691N	1989*	0.15	Drilled	86*	24.62	- Good water quality - Water supply problems during high demand
1185 Dugald Drive	370182E 5039020N	1972*	0.91	Dug	1.65	Flowing	- Good water quality and quantity - Artesian (flowing) well
1025 Bruce Street	369406E 5039213N	U	0.91*	Drilled*	52*	2.13*	- Buried well - Good water quality and quantity

Notes:

* = Well information based on information obtained through occupant interview.

U = Unknown

I = Inaccessible

4.5 Evaluation of Groundwater Resources and Vulnerability

The surficial geology of the site and surrounding area consists of overburden overlying predominantly Paleozoic bedrock (limestone and dolomite). The overburden consist of glacial drift deposits of gravel, sand and clay (to the north and east of the site), and marine clays (to the south and southwest of the site). The site itself is located close to the crest of an east-west trending bedrock escarpment rising from the Bonnechere River valley to the south and flattening out on tablelands to the north of the site.

The hydrogeology of the site and surrounding area is dominated by bedrock driven groundwater systems found in the fractures and bedding planes of the Paleozoic (predominantly dolostone and limestone) rock. Within two kilometres of the site, five (5) water wells are drilled into the overburden aquifer, and 50 water wells are drilled into the bedrock aquifer. The depth to water for water wells drilled into the overburden aquifer range between 18 metres to 53 metres bgs, and the depth to water for wells drilled into the bedrock aquifer range between 7.9 metres to 90 metres bgs. Based on the water well records and well survey, there are shallow wells (i.e. aquifer is <15 m bgs) approximately 1 km to the northeast and 1.6 km to the south of the site (well records 55511069 and 5511734, respectively). Groundwater flow in the bedrock aquifer system is generally to the south-southeast towards the Bonnechere River .

The site inspection identified a discrete groundwater discharge zone (Seep 1) discharging from a culvert (Culvert 1) located on the west side of Highway 17. The discharge water flows along the ditch flanking the west side of the highway and collects and pools approximately 120 metres south of the site on relatively flat terrain. At this pool location, another culvert (Culvert 2) running beneath the highway conveys drainage water from the east side of the highway. The pool likely collects both storm water and groundwater from both sides of the highway and slowly infiltrates into the shallow aquifer system. On the east side of the highway (approximately 80 metres to the northeast of Seep 1), immediately upgradient of a bedrock cut, a passive groundwater discharge zone (Seep 2) exists on the side of the steep slope rising up to the surrounding bedrock tableland (Seep 2). At the base of the seep, groundwater pools and then flows along the drainage ditch flanking the east side of the highway and downslope into Culvert 2 running beneath the highway and into the pool located on the west side of the highway as noted above. Another culvert (Culvert 3) exists on the east side of the highway, approximately 50 metres south of Seep 2. The culvert is on an approximate 45⁰ angle with the ditch and discharges groundwater into the ditch. Both flow from this culvert and Seep 2 contribute to the receiving pool at the Culvert 2 discharge area.

Based on the site inspection and historical aerial photographs as noted in Table 4-1, it appears that there are groundwater discharge zones along the bedrock escarpment face between the bedrock knolls to the east and west of the site. The 1966 and 1969 aerial photos showed a possible significant

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groundwater discharge area west of the larger bedrock knoll (i.e. the knoll flanking the east side of the site) and extending from a small bedrock outcrop southwards for approximately 750 metres. At this time Highway 17 was not constructed. However, in the 1987 aerial photo, the discharge area disappears. It is possible that the discharge area was impacted by the highway resulting in the groundwater seeps that are present today. Seep 1 could be discharging groundwater from the passive seep located on the east side of the highway and other potential seeps located upgradient of the site flowing within the highway sub-grade. Additional groundwater flow beneath the highway is discharged into the ditch flanking the east side of the highway through Culvert 3. The groundwater discharging from Seep 1 (Culvert 1), Seep 2 and Culvert 3 is conveyed to Culvert 2 on the west side of the highway through the highway ditches (a proportion of the flow is lost through ditch infiltration) where it pools and slowly infiltrates into the soil and bedrock.

Groundwater Impacts and Vulnerability

The proposed twinning of Highway 17 at Site 4 will involve the construction of southbound lanes to the west of the existing highway. This will involve significant fill from the Bonnechere River valley to the bedrock escarpment and a bedrock cut into the bedrock knoll to the immediate northwest of the site to accommodate construction of the southbound lanes. This will impact the groundwater discharge system by both intercepting and impeding groundwater flow. Due to the proximity of the water wells associated with the one residence located approximately 260 metres northwest of the site (1025 Bruce Street), and the two residences located approximately 100 metres northeast of the site above Seep 2 (1082 and 1120 Dugald Drive) it is possible that any bedrock cuts into escarpment could impact the wells both from a chemical (road salt and spills) and physical (supply) perspective.

Based on the above, the overall vulnerability of the local and regional groundwater systems to highway construction activities would be considered high with respect to groundwater quantity and quality issues. Provided adequate mitigation measures are implemented, any potential construction related groundwater impacts could be minimized.

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Sites 2, 3 and 4 – McNab-Braeside and Horton Twp. – GWP 4067-03-00

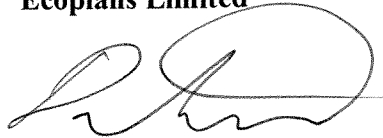
August 2007

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We trust the information outlined in this report meets with your requirements. Should you have any questions, please do not hesitate to contact our office.

Sincerely,

Ecoplans Limited

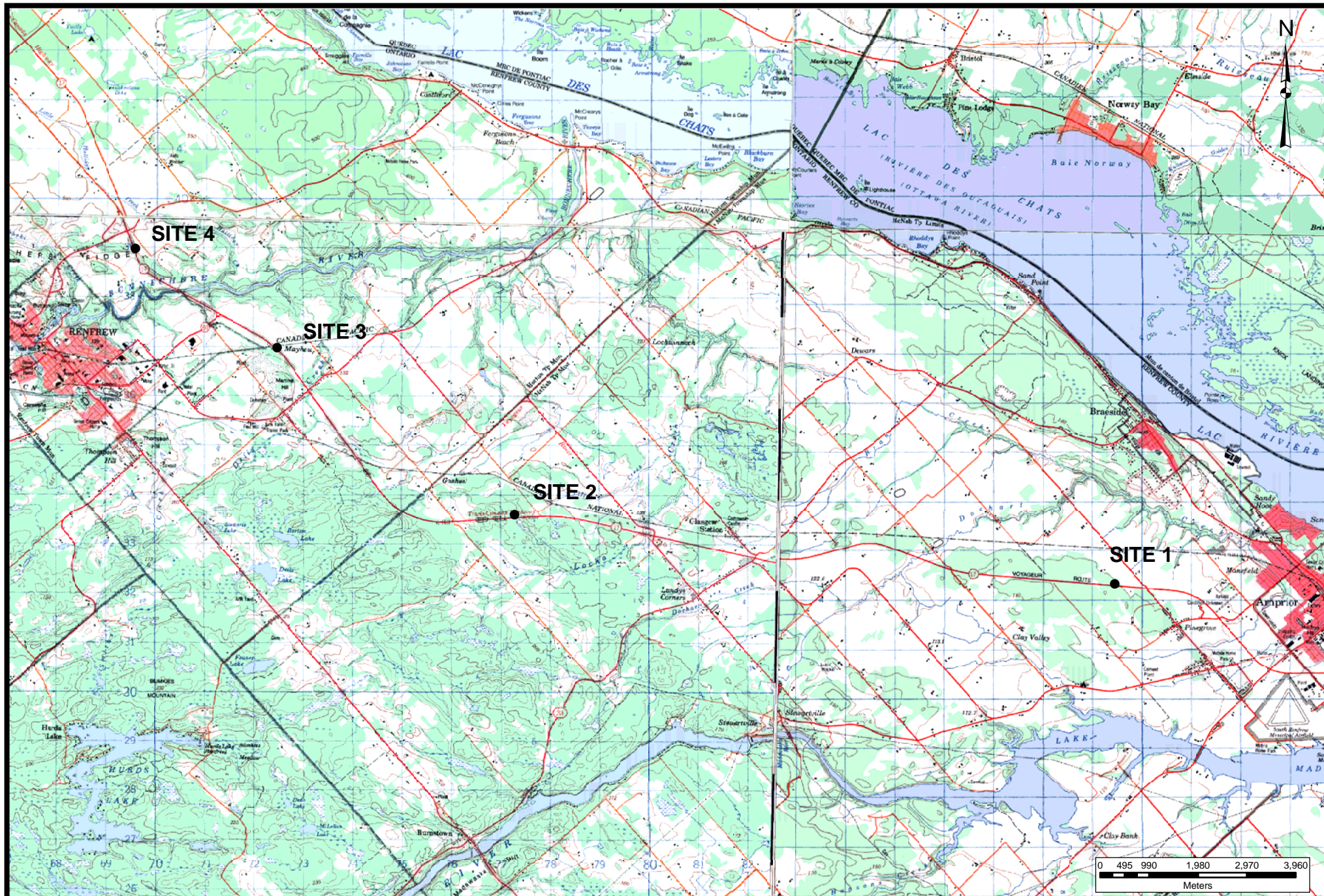


Derek A. Stewart, B.Sc., P.Geo
Senior Hydrogeologist



cc. Tony Sangiuliano, MTO
Manny Goetz, MRC

FIGURES
Site 4 – Station 19-080 Horton Twp.



Source: National Topographic System (NTS)

Scale: 1:100,000



HYDROGEOLOGICAL SCREENING REPORT
HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
 GWP 4067-03-00
SITE LOCATION PLAN - SITE 4

DATE:
AUGUST 2007
PROJECT:
R07-0261

FIGURE
4-1



Source: 2005 Aerial Photograph (Provided by the Ministry of Transportation)



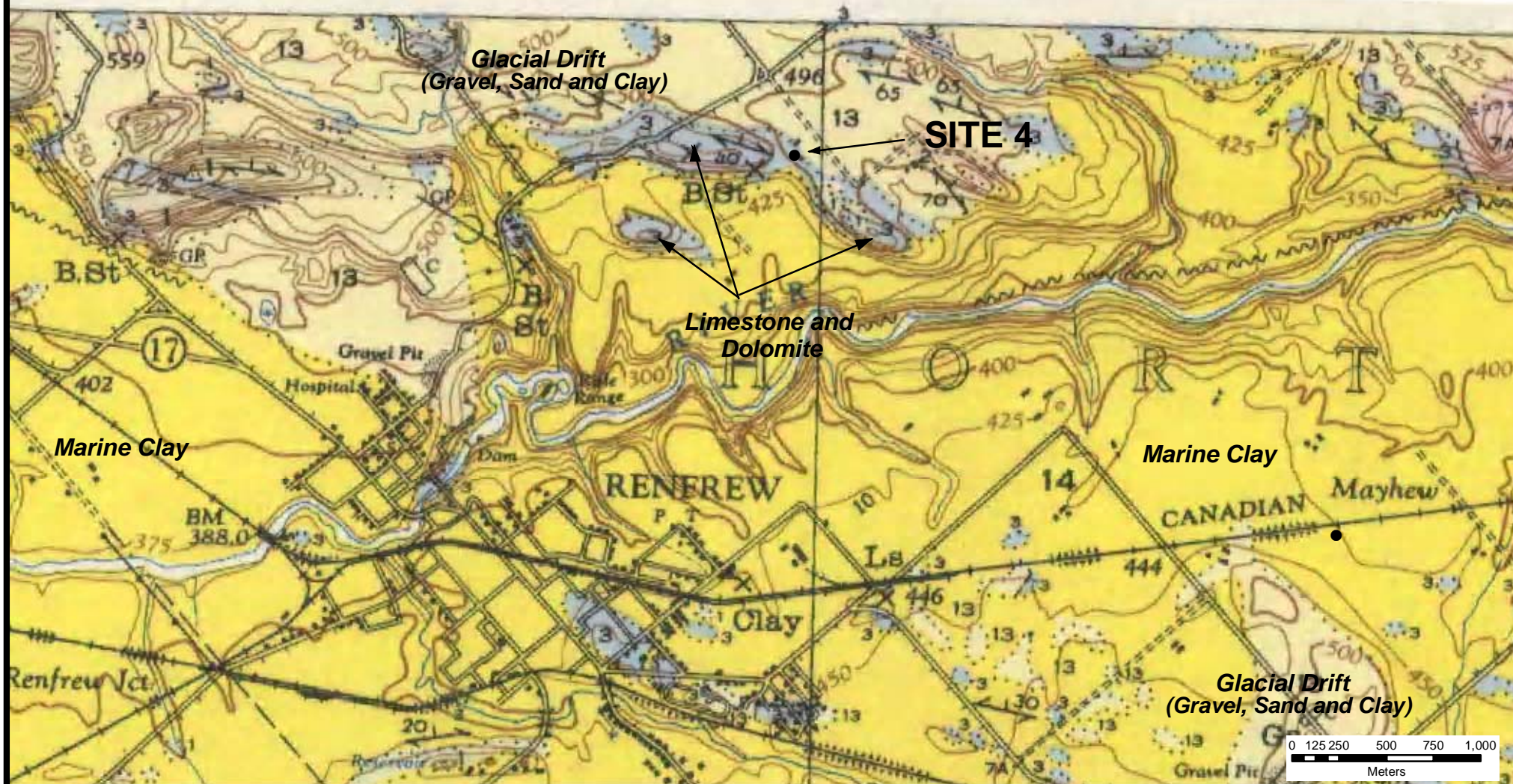
HYDROGEOLOGICAL SCREENING REPORT
HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
GWP 4067-03-00
SITE PLAN - SITE 4

DATE:
AUGUST 2007
PROJECT:
R07-0261

FIGURE
4-2



NO MAP AVAILABLE



Source: Geological Survey of Canada, 2003

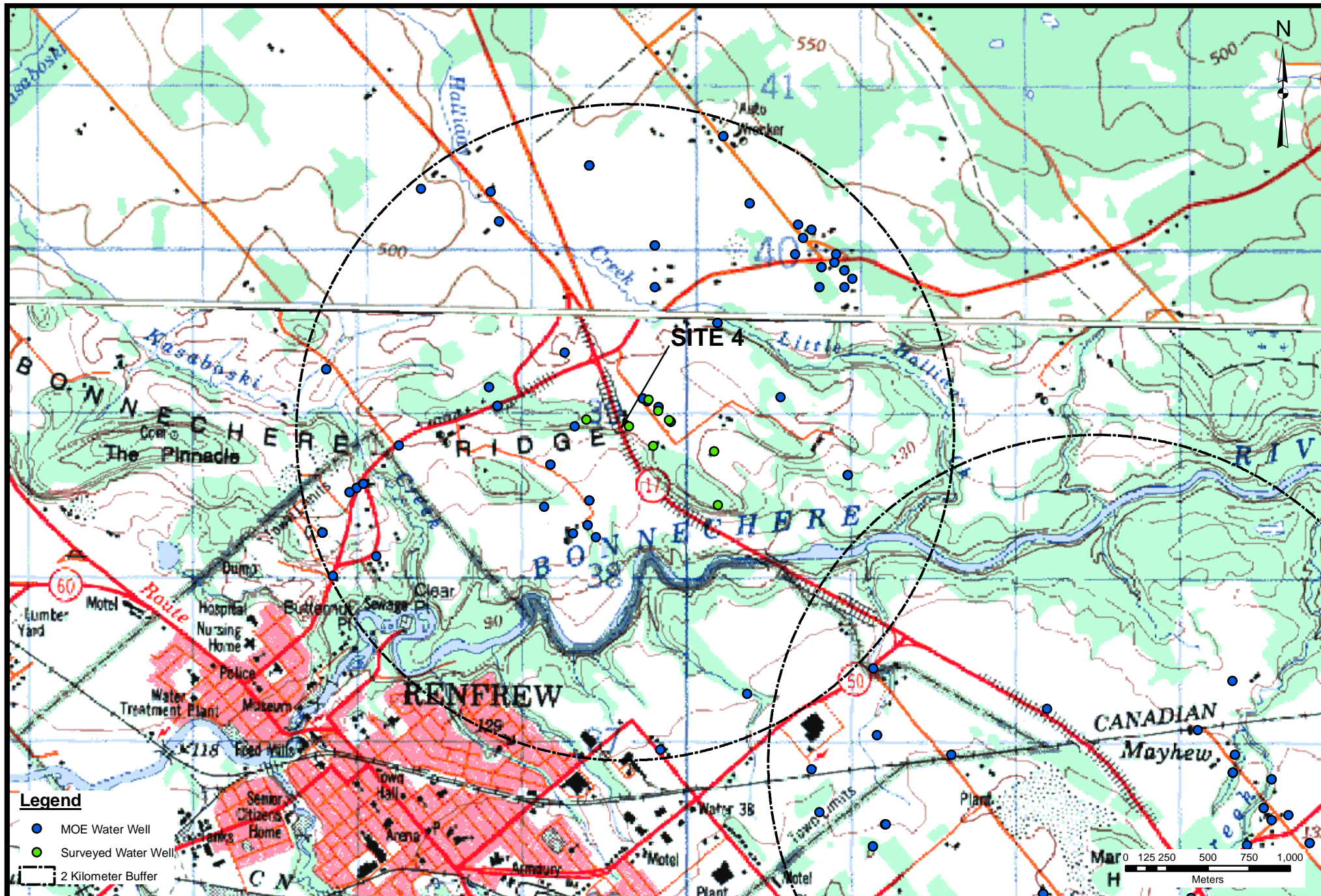
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HYDROGEOLOGICAL SCREENING REPORT
HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
GWP 4067-03-00
SURFICIAL GEOLOGY OF THE SITE AND SURROUNDING AREA - SITE 4

DATE:
AUGUST 2007
PROJECT:
R07-0261

FIGURE
4-3



Source: National Topographic System (NTS)

Scale: 1:30,000



HYDROGEOLOGICAL SCREENING REPORT
 HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
 GWP 4067-03-00
WATER WELL LOCATION PLAN - SITE 4

DATE:
AUGUST 2007
 PROJECT:
R07-0261

FIGURE
4-4

FILE LOCATION-I:\ECOPLANS\03 - REMEDIATION\PROJECTS\R07-0261 17 Twinning - Campbell to Scheel\0261-700 Drawings
DRAWING NAME: R07-0261 Cross Section.DWG
DRAWN BY: G. Yang
MODIFIED: 07/05/30
12:06:16
Revised

Geological Cross-Section A - A' of Site 4

Highway 17 Twinning from Campbell Drive to Scheel Drive
GWP 4067-03-00

DATE:
August 2007

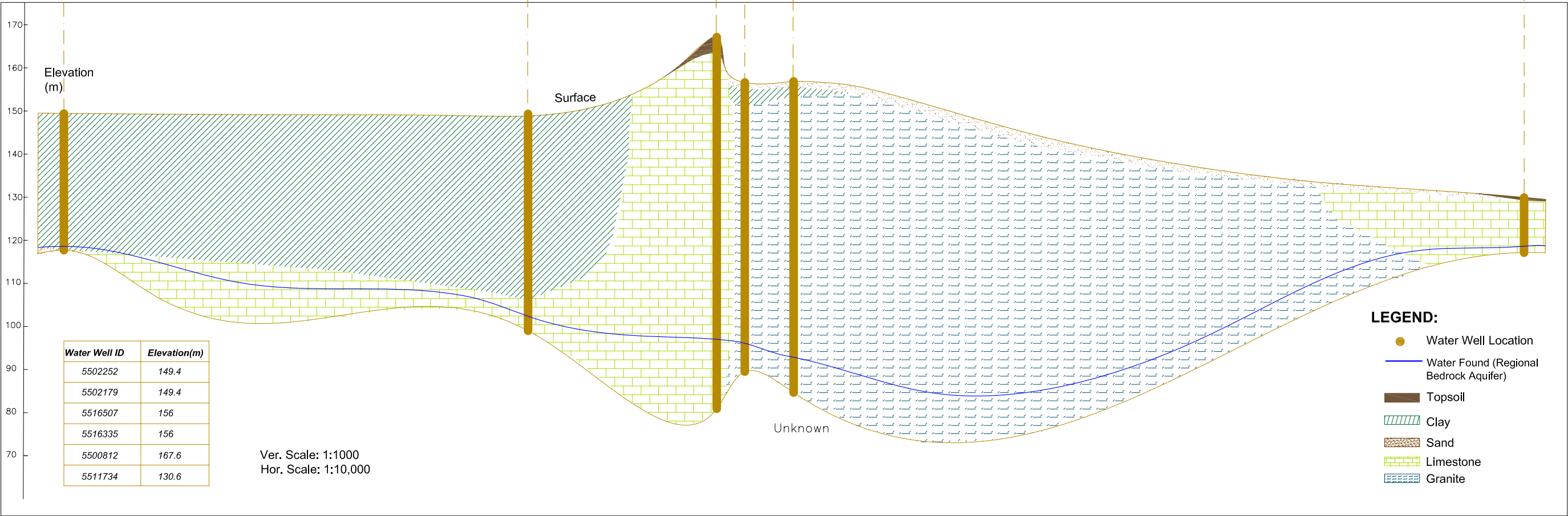
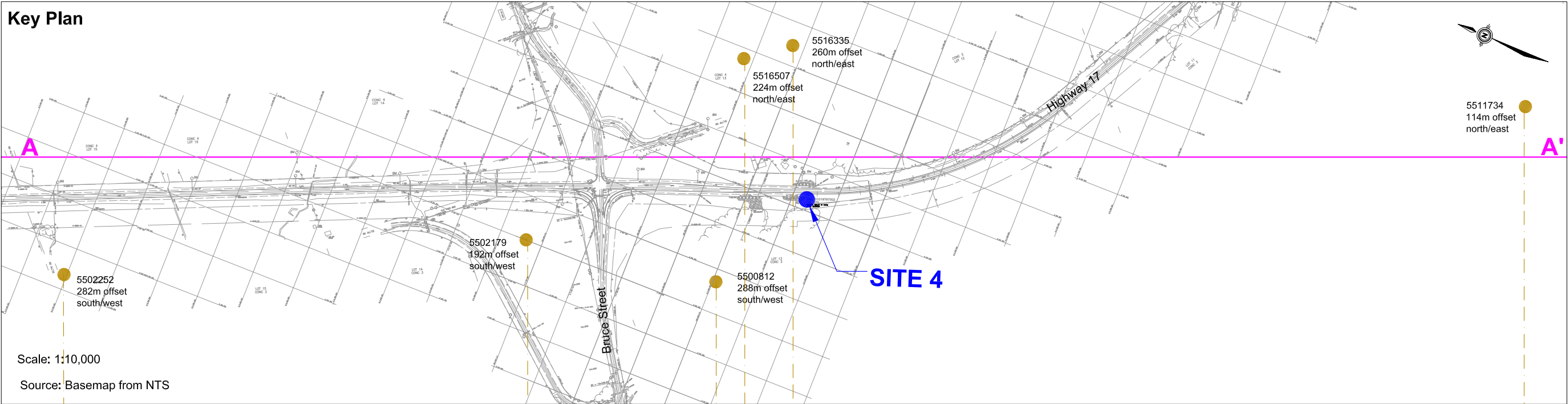
PROJECT NO.:
R07-0261

DRAWN BY:
G. Yang

CHECKED BY:
D. Stewart

FIGURE NO.:

4-5a



FILE LOCATION-I:\Ecoplans\03 - Remediation\PROJECTS\R07-0261 17 Twinning - Campbell to Scheel\0261-700 Drawings
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DRAWN BY: G. Yang
MODIFIED: 07/05/30 12:06:16 Revised

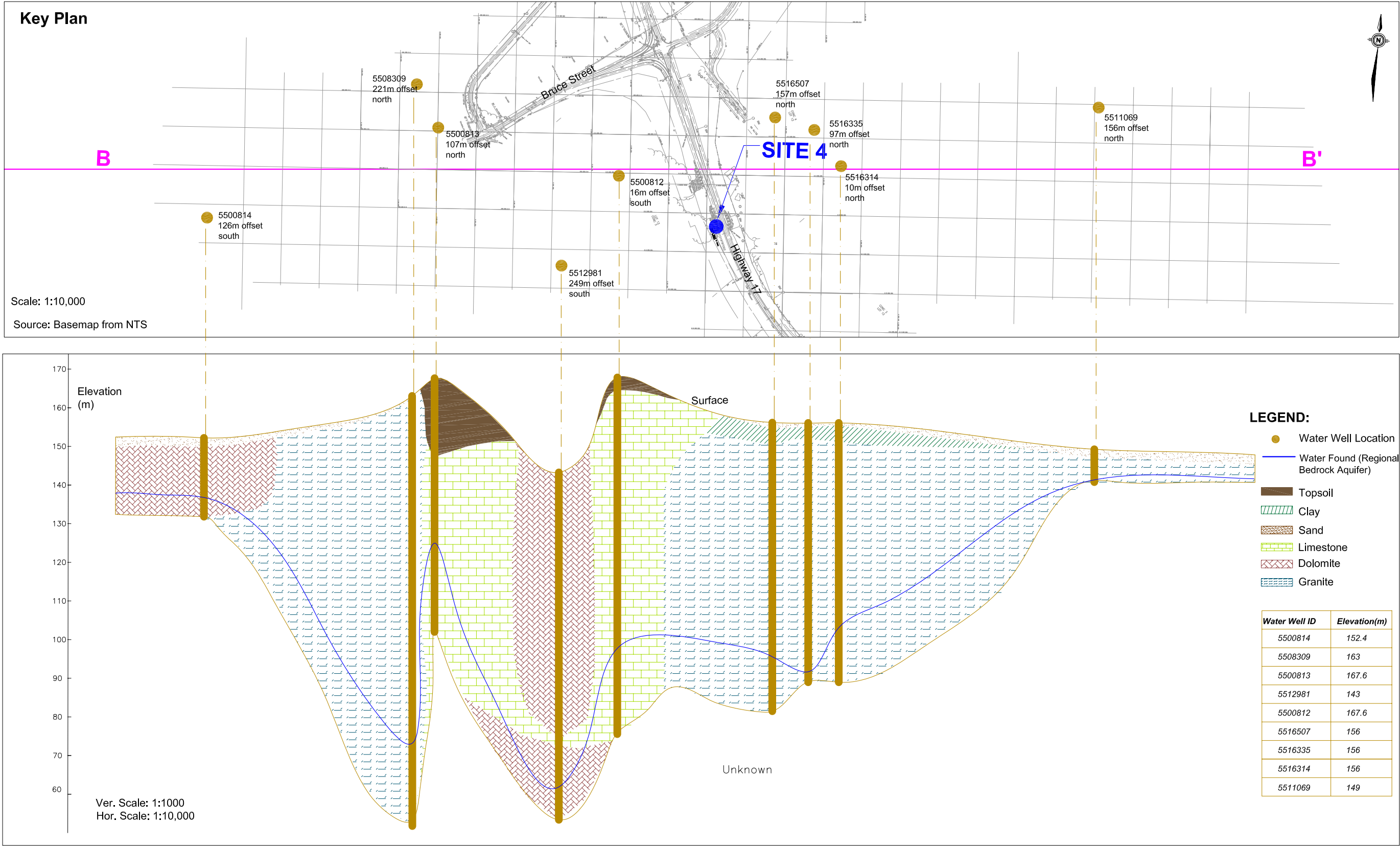
Geological Cross-Section B - B' of Site 4

Highway 17 Twinning from Campbell Drive to Scheel Drive
GWP 4067-03-00

DATE:
August 2007
PROJECT NO.:
R07-0261

DRAWN BY:
G. Yang
CHECKED BY:
D. Stewart

FIGURE NO.:
4-5b



APPENDIX 4-A

Site 4 – Site Photographs



← Photo 1
Photo showing groundwater seep (Seep 2). The seep area is the patch of brown vegetation (horsetail) to the left of the bedrock outcrop. Photo taken facing northeast.



Photo 2 →
Photo showing a close-up of Seep 1 with water flowing from the culvert (Culvert 1), pooling and flowing into a south flowing ditch along the west side of Highway 17. Photo taken facing east.



← Photo 3
Seep 1 drainage ditch following the base of the west highway embankment conveying discharge water from Culvert 1 towards a pool of water south of the site. Photo taken facing southwest.



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Highway 17 Twinning Campbell Drive to Scheel Drive
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SITE 4: Site Photographs

Date:
August 2007

Project No.:
R07-0261

Figure No.

4-A1



← Photo 4
Photo showing Culvert 3 discharging water into the drainage ditch on the east side of Highway 17 which then flows to the south of the site and into Culvert 2. Photo taken facing north.



Photo 5 →
Photo showing Culvert 3 located south of the site on the west side of Highway 17. Photo taken facing east.



← Photo 6
Drainage ditch flanking the east side of the highway between Culverts 2 and 3. Photo taken facing south.



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SITE 4: Site Photographs

Date:
August 2007

Project No.:
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Figure No.

4-A2

APPENDIX 4-B

Site 4 – Ministry of the Environment (MOE) Water Well Records

Summary of Water Well Records Within 2 km of Site 4

Hydrogeological Screening Report
Highway 17 Twinning Campbell Drive to Scheel Drive
GWP 4067-03-00

<i>MOE</i>	<i>UTM Coordinates</i>		<i>Ground Surface</i>	<i>Depth</i>	<i>Depth</i>	<i>Depth</i>	<i>Groundwater</i>	<i>Date</i>	<i>Water</i>	<i>Well Type</i>	<i>Bedrock</i>
<i>Well ID</i>	<i>Easting</i>	<i>Northing</i>	<i>Elevation</i>	<i>of Well</i>	<i>to Bedrock</i>	<i>to Water</i>	<i>Elevation</i>	<i>Constructed</i>	<i>Supply Type</i>		<i>Unit</i>
			<i>(m ASL)</i>	<i>(m bgs)</i>	<i>(m)</i>	<i>(m bgs)</i>	<i>(m ASL)</i>				
5503440	371000	5039850	144.8	86.9	1.5	83.8	61.0	5/1/1974	Domestic	Bedrock	Limestone
5506492	369299	5038299	126.5	61.0	NA	60.4	66.1	7/3/1981	Domestic	Bedrock	Limestone
5501639	367840	5038040	118.9	41.8	27.1	41.1	77.7	9/29/1958	Domestic	Bedrock	Granite
5500812	369310	5038950	167.6	72.2	3.4	70.1	97.5	9/12/1966	Domestic	Bedrock	Limestone
5506027	370900	5040000	152.4	54.9	8.5	53.6	98.8	11/21/1979	Domestic	Bedrock	Dolomite
5506230	369399	5038499	121.9	37.8	3.0	21.3	100.6	9/10/1980	Domestic	Bedrock	Limestone
5502179	369250	5039400	149.4	50.3	42.7	46.6	102.7	10/1/1968	Domestic	Bedrock	Limestone
5502089	369830	5036980	129.5	40.5	5.2	25.3	104.2	5/11/1968	Domestic	Bedrock	Granite
5501645	368025	5038600	137.2	38.4	16.2	22.9	114.3	4/11/1963	Domestic	Bedrock	Granite
5506754	369799	5039799	152.4	35.7	20.7	34.1	118.3	7/23/1981	Domestic	Bedrock	Limestone
5502252	368800	5040380	149.4	31.7	NA	30.8	118.6	5/2/1969	Domestic	Overburden	NA
5503627	370750	5040150	146.3	29.0	1.2	27.4	118.9	6/5/1974	Domestic	Bedrock	Limestone
5502143	370890	5039950	147.8	32.0	2.4	27.1	120.7	6/25/1968	Domestic	Bedrock	Limestone
5501634	367985	5038575	144.8	33.8	5.2	22.9	121.9	9/24/1953	Domestic	Bedrock	Granite
5500813	368840	5039075	167.6	45.7	20.4	42.7	125.0	8/6/1959	Domestic	Bedrock	Limestone
5503053	370700	5040100	146.3	22.3	3.4	21.3	125.0	8/25/1972	Domestic	Bedrock	Limestone
5506667	367799	5039299	137.2	61.0	8.8	10.7	126.5	11/20/1981	Domestic	Bedrock	NA
5504542	370950	5039800	152.4	24.4	1.2	23.5	128.9	6/14/1977	Domestic	Bedrock	Sandstone
5502145	370670	5040180	149.4	21.3	6.1	19.8	129.5	10/2/1968	Domestic	Bedrock	Dolomite
5505097	370950	5039900	152.4	35.4	NA	15.8	136.6	6/20/1978	Domestic	Bedrock	Limestone
5500814	368240	5038835	152.4	20.4	2.4	15.2	137.2	1/3/1966	Domestic	Bedrock	Dolomite
5505884	370799	5039799	152.4	25.6	0.3	15.2	137.2	6/19/1979	Domestic	Bedrock	Sandstone
5502142	370810	5039920	147.8	30.2	10.4	10.4	137.5	7/6/1968	Domestic	Bedrock	Limestone
5503683	370650	5040000	149.4	26.8	1.2	NA	NA	5/23/1975	Domestic	Bedrock	Granite
5503546	368850	5040200	149.4	54.9	41.8	NA	NA	12/9/1974	Domestic	Bedrock	Limestone
5511069	370563	5039128	NA	8.5	2.4	7.9	NA	9/20/1992	Domestic	Bedrock	Granite
5507589	369400	5040540	NA	21.6	1.5	9.1	NA	6/21/1984	Domestic	Bedrock	Limestone
5511734	370359	5037321	NA	12.8	0.6	11.3	NA	10/7/1993	Domestic	Bedrock	Limestone
5516314	369894	5038978	NA	67.1	6.4	16.2	NA	12/10/2005	Domestic	Bedrock	Granite
5510645	370178	5039581	NA	21.3	12.8	16.8	NA	8/23/1991	Domestic	Bedrock	Sandstone
5511353	369797	5040054	NA	30.5	4.6	17.4	NA	11/24/1992	Domestic	Bedrock	Limestone

Summary of Water Well Records Within 2 km of Site 4

Hydrogeological Screening Report
Highway 17 Twinning Campbell Drive to Scheel Drive
GWP 4067-03-00

<i>MOE</i>	<i>UTM Coordinates</i>		<i>Ground Surface</i>	<i>Depth</i>	<i>Depth</i>	<i>Depth</i>	<i>Groundwater</i>	<i>Date</i>	<i>Water</i>	<i>Well Type</i>	<i>Bedrock</i>
<i>Well ID</i>	<i>Easting</i>	<i>Northing</i>	<i>Elevation</i>	<i>of Well</i>	<i>to Bedrock</i>	<i>to Water</i>	<i>Elevation</i>	<i>Constructed</i>	<i>Supply Type</i>		<i>Unit</i>
			<i>(m ASL)</i>	<i>(m bgs)</i>	<i>(m)</i>	<i>(m bgs)</i>	<i>(m ASL)</i>				
5509445	367775	5038303	NA	25.9	19.8	18.3	NA	4/28/1989	Domestic	Bedrock	Dolomite
5511148	370178	5039581	NA	21.0	18.3	19.8	NA	12/1/1992	Domestic	Bedrock	Dolomite
5516335	369820	5039069	NA	67.1	2.1	20.7	NA	2/16/2006	Domestic	Bedrock	Granite
5512582	370971	5038654	NA	44.2	2.7	24.1	NA	4/28/1996	Domestic	Bedrock	Granite
5508008	369400	5040540	NA	32.0	1.2	30.5	NA	5/31/1984	Domestic	Bedrock	Limestone
5507658	369797	5040054	NA	32.0	5.2	30.5	NA	11/21/1984	Domestic	Bedrock	Limestone
5516422	369753	5039104	NA	59.4	44.8	41.1	NA	5/15/2006	Domestic	Bedrock	Granite
5513965	368789	5039189	NA	41.1	NA	41.1	NA	5/19/2000	Domestic	Overburden	NA
5511246	370178	5039581	NA	44.2	0.6	42.7	NA	4/14/1988	Domestic	Bedrock	Limestone
5516507	369724	5039122	NA	74.7	19.8	48.2	NA	8/10/2006	Domestic	Bedrock	Granite
5511329**	367775	5038303	NA	68.6	40.8	50.3	NA	NA	Domestic	Bedrock	Granite
5516294	368104	5038158	NA	56.1	NA	53.0	NA	11/3/2005	Domestic	Overburden	NA
5508385	367775	5038303	NA	79.2	57.0	65.5	NA	10/19/1986	Domestic	Bedrock	Dolomite
5508575	367775	5038303	NA	68.6	21.3	67.1	NA	3/13/1987	Domestic	Bedrock	NA
5512981	369163	5038718	NA	89.9	NA	69.8	NA	7/3/1997	Domestic	Bedrock	Dolomite
5512736	367775	5038303	NA	86.9	35.1	74.7	NA	8/28/1996	Domestic	Bedrock	Dolomite
5508309	368789	5039189	NA	91.4	0.6	89.9	NA	7/24/1985	Domestic	Bedrock	Granite
5512098	367775	5038303	NA	33.8	NA	NA	NA	10/13/1994	Not Used	Overburden	NA
5500835	370375	5040310	132.6	30.5	7.3	19.8	112.8	4/16/1957	Public Supply	Bedrock	Limestone
5500810	369440	5038275	121.9	79.2	56.4	70.1	51.8	1/4/1963	Stock	Bedrock	Granite
5500809	369390	5038350	125.0	66.4	6.1	46.6	78.3	5/26/1962	Stock	Bedrock	Sandstone
5501641	367940	5038550	146.3	61.0	7.0	42.7	103.6	4/22/1961	Stock	Bedrock	Granite
5500811	369125	5038460	137.2	18.3	NA	18.3	118.9	9/23/1965	Stock	Overburden	NA
5500856	370215	5040720	152.4	38.1	2.1	18.3	134.1	3/10/1962	Stock	Bedrock	Granite

Notes:

UTM - Universal Transverse Mercator

m ASL - metres above sea level

m bgs - metres below ground surface

NA - No information recorded in the well record

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