



HYDROGEOLOGICAL INVESTIGATION AND DESIGN FINAL REPORT

**SITE 1
STATIONS 25+000 TO 25+500 MCNAB-BRAESIDE TOWNSHIP**

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

Geocres #31F-164

February 2008

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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 associated highway infrastructure improvements. In addition, the MTO has engaged MRC to carry out technical studies along Highway 17 between Scheel Drive and Bruce Street (north of Renfrew).

As part of these studies, Ecoplans recently completed 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

The purpose of these investigations, which are documented in the reports listed below, were 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) *Hydrogeological Screening Final Report – SITE 1 Stations 25+000 to 25+500 McNab-Braeside Township.* Highway 17 Twinning Campbell Drive to Scheel Drive GWP 4067-03-00. Geocres #31F-159. August 2007.
- 2) *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.

In addition to completing Hydrogeological Screening Investigations of the four sites, a follow-up Hydrogeological Investigation and Design study was completed for Site 1 to evaluate potential groundwater impacts from Highway 17 widening at this location which will require a significant rock cut to accommodate the construction of new westbound lanes. This study is documented in this report.

As per the Terms of Reference (ToR) for this project, this report is organized in three (3) main sections:

- Introduction, Site Description, Background Information Review, Site Inspection, and Water Well Testing (Sections 1 to 5) are general introductory sections to document the purpose of this study, scope of work, site description, detailed background information review, and site inspection;
- Hydrogeological Investigation Section (Section 6) presents and discusses the methodology and results of the subsurface investigation undertaken at the site; and
- Hydrogeological Design Section (Sections 7 to 9) discusses the site susceptibility to highway construction impacts, presents recommendations for the design and construction of the highway with respect to groundwater management, and presents a long term groundwater monitoring program for the site.

1.1 Purpose of Study

The purpose of the Hydrogeological Investigation and Design Study is to provide more detailed site specific information about Site 1; assess the potential impacts the proposed excavation cut may have on the surface and subsurface hydrology; and develop appropriate monitoring and mitigating measures for any identified impacts.

The specific objectives of the study are to:

- Define the local groundwater regime;
- Determine the physical, hydraulic and chemical properties of the soil and bedrock;
- Establish a long term monitoring network; and
- Provide feasible mitigation options to effectively manage any highway construction impacts to groundwater.

1.2 Scope of Study

The general scope of work included:

- Undertaking a site inspection to document and evaluate existing surface topography, and site access;
- Reviewing all available background information for the site;
- Carrying out a water well testing program of all water wells within the vicinity of the site;
- Completing boreholes and monitoring wells across the site to characterize soil and/or bedrock conditions;
- Measuring groundwater levels and pressure heads to define groundwater flow characteristics at all monitoring wells;

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- Collecting selected soil and groundwater samples to characterize soil and groundwater quality, respectively;
- Undertaking aquifer hydraulic tests to characterize the aquifers' hydraulic properties; interpreting all collected field and analytical data; determining the groundwater flow system at the site; and identifying any unstable soils or geological conditions;
- Identifying and comparing the various groundwater mitigation options available during construction;
- Designing the most feasible groundwater mitigation options that are to be coordinated with the overall detailed design of highway through this area; and
- Presenting a comprehensive long term monitoring program at the site to monitor the groundwater levels and potential highway construction impacts.

2.0 SITE DESCRIPTION

The site is located along Highway 17 extending from approximately 500 metres to 1 km west of Campbell Drive (approximate 500 metre stretch), i.e. Stations 25+000 to 25+500. It extends in the north-south direction for approximately 115 metres within the proposed MTO ROW. Figure 1 shows the site location and Figure 2 shows the approximate site limits and significant site features. A summary of significant site features is included below.

- The site is located on a large bedrock knoll/outcrop rising above the surrounding flat clay plains.
- The existing vertical profile of Highway 17 cuts through the bedrock rising moderately to the west from Station 25+475 to Station 25+000 (475 metre horizontal distance). The deepest part of the cut is approximately 5.6 metres from the base of the ditch to the top of the bedrock surface, and occurs at Station 25+260 on the north side of Highway 17.
- Open ditches flank the north and south sides of the highway between the road bed and bedrock. Flow in the ditches is to the east towards two culverts, one at Station 25+600 and the other at Station 25+760.
- At the time of the Hydrogeological Screening site inspection on May 10, 2007, two groundwater discharge zones (seeps) were observed on the north and south sides of the highway. Seep 1 occurred on the north side of Highway 17 at Station 25+370. It appears to be a discrete seep located at the base of the bedrock in the ditch. Water was observed to be pooling in the ditch and gently flowing along the north side of Highway 17 and into the culverts located east of the site, west of Campbell Drive. Seep 2 occurred on the south side of the highway at Station 25+400. It appears to be a discrete seep located at the base of a low bedrock cut in the ditch. Water was observed to be pooling in the ditch and gently flowing along the south side of Highway 17 and into the culverts located east of the site, west of Campbell Drive. The locations of the seeps are shown on Figure 2.
- The bedrock surface appears to be covered by a thin veneer of overburden vegetated with predominantly deciduous forest cover.
- There are shallow bedrock depressions scattered across the bedrock surface exhibiting poor drainage.
- The landscape surrounding the large forested bedrock outcrop is predominantly flat clay plains, especially to the north and east.

3.0 BACKGROUND INFORMATION REVIEW

A background information review was conducted by Ecoplans as part of the Hydrogeological Screening Investigation. The purpose of the review was to provide a general understanding of the local geology and hydrogeology found within the study area. Ecoplans reviewed existing geological maps, current and historical aerial photographs, and water well records. A summary of the findings from the report mentioned above has been provided in the following sections.

3.1 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 general topography of the site and surrounding area is variable. The site itself is located on a large bedrock outcrop gently dipping to the east, north and south. The outcrop extends for approximately 5 km in the east/west direction and 1.5 km in the north/south direction. The topography surrounding the bedrock outcrop is flat clay plains.

According to the Ontario Base Map (OBM) for the area, the approximate elevations of the Highway 17 road surface and the surrounding bedrock surface at the site are 119 and 125 metres above mean sea level (mAMSL), respectively. The outcrop rises to the west to an elevation of 137 mAMSL. The surrounding clay plain ranges in elevation between 116 and 118 mAMSL.

3.2 Drainage

Regional drainage is to the north into Dochart Creek, which is a tributary of the Madawaska River. Both watercourses flow in a general easterly direction to the Ottawa River. The Madawaska River is the largest of the Ontario drainage systems discharging to the Ottawa River, and covers an area of approximately 8,500 km² (Chapman and Putnam, 1984).

Site drainage is generally poor on the bedrock surface with wetland depressions scattered across the bedrock surface. Drainage along the highway is conveyed through drainage ditches flanking the north and south sides of the highway which flow to the east towards two culverts between the east site limits and Campbell Drive. Culvert discharge is via direct infiltration into the soil. The clay plains surrounding the bedrock are poorly drained.

3.3 Geology

3.3.1 Overburden Geology

The site consists of Precambrian bedrock surrounded 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.

3.3.2 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).

Overlying the Mazinaw Terrane are Palaeozoic deposits associated with the Gull River and Oxford Formations. The Gull River Formation is extremely complex and contains several different sedimentary sequences (Golder Associates Ltd, 2003). The lower portion of the formation consists mainly of limestone and silt dolostone, with shale and sandstone interbeds. The upper portion of the formation contains less dolostone. The Gull River Formation is limited to southeast trending bends in the vicinity of the site. The Oxford Formation is a dolomitic and sandstone unit occurring as two narrow isolated units northwest and southeast of the site.

3.4 Hydrogeology

The hydrogeology of the site and surrounding area 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 bedrock aquifer system consists of aquifers located in Palaeozoic and Precambrian rock deposits. The Oxford and Gull River Formations hydrogeological units associated with the Paleozoic bedrock are of adequate quality for domestic consumption (Golder Associates Ltd, 2003). The Oxford Formation is a dolostone aquifer and occurs as two narrow isolated units northwest and southeast of the site. The Gull River Formation is a dolostone, limestone, shale and sandstone aquifer and occurs to the north (north of the Oxford Formation) and further to the south and southeast of the site as a narrow band expanding further to the east. The groundwater yield of this formation typically decreases with depth, and the areal extent is small when compared to other bedrock aquifers.

The regionally extensive aquifer beneath the site, and to the south and west 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.

3.5 Water Well Records

Ecoplans completed a water well record search to within two (2) kilometers of the site. The results of the search identified a total of 105 water wells located in the vicinity of the site. The following relevant data from the records is included below:

- The earliest water well records available were from 1950 to as recent as 2006;
- All water wells are drilled into the bedrock aquifer, 106 wells in total (2 had no information recorded);
- Water wells drilled into the bedrock aquifer terminate between 7.3 metres to 99.0 metres below ground surface;
- Twenty-six (26) wells are drilled into granite deposits, and 73 wells are drilled into limestone deposits;
- The wells drilled into granite deposits are generally located south-southeast of the site, and wells drilled into limestone deposits are generally located north-northeast;
- The depth to water for water wells drilled into the bedrock aquifer range between 5.5 metres to 96.0 metres below ground surface;
- Twenty-eight (28) wells encounter water less than 15.0 metres below ground surface (i.e. shallow wells), 49 wells encounter water between 15.0 metres and 30.0 metres below ground surface (i.e. intermediate wells), and 25 wells encounter water greater than 30.0 metres below ground surface (i.e. deep wells);
- Shallow and intermediate wells are generally located southeast of the site in the vicinity of Pinegrove. Deep wells are generally located north-northeast and southeast of the site;
- Three (3) shallow wells (i.e. water less than 15.0 m from ground surface) are located close to the site. Two (2) wells (5510603 and 5510604) are approximately 250 metres south of the site, and one (1) well (5501316) is approximately 250 metres northeast of the site (based on the water well survey, Section 5.0, this well does not exist at the location identified in the well record);
- The groundwater elevations range from 38.1 m above sea level to 114.3 m above sea level;
- Two (2) wells are commercial water wells, 94 wells are domestic water wells, six (6) wells are stock water wells, and one (1) well is a public supply water well. The public supply well is located in Pinegrove, approximately 1.5 kilometres southeast of the site; and
- The general groundwater flow direction is north-northeast towards the Ottawa River.

Based on interpretation of the water well records, the site and immediate surrounding area to the north and west of the site is underlain by Precambrian bedrock and to the south and east by Paleozoic

limestone and dolostone bedrock. The thickest overburden (predominantly clays) occurs at and north of the Campbell Drive/Highway 17 intersection (12 – 17 metres thick). Water was encountered in the bedrock at elevations between 52 mAMSL (approximately 1.5 km east of the site) to 115 mAMSL (approximately 250 metres south of the site) with an average elevation of 87 mAMSL. This represents the regional bedrock aquifer system.

3.6 *Aerial Photographs*

As part of the Hydrogeological Screening investigation, Ecoplans conducted a review of historical aerial photographs (for the years 1946, 1959, 1978 and 1987) for the site and surrounding area to identify any surface features that are of potential hydrogeological significance (surface water bodies, vegetation cover and human development impacts). The following summarizes significant findings from the Screening Report:

- Forest cover had progressively increased on the site from at least 1959 to 1987. Prior to this part of the land may have been in limited agricultural production or could have been selectively logged; and
- The 1978 aerial photo shows the Highway 17 drainage ditches flanking the north and south sides of the highway immediately east of the site to contain significant water. This could be groundwater discharging from the bedrock cut seeps located on the north and south sides of the highway.

3.7 *Review of Previous Hydrogeological Reports*

The Hydrogeological Screening Report completed by Ecoplans in August 2007 was reviewed and relevant information from this report was incorporated into appropriate sections of this report, most notably Sections 1.0 and 2.1 to 2.6.

4.0 SITE INSPECTION

The purpose of the site inspection was to observe and document any significant features of hydrogeological concern such as surface water courses, seepage zones springs (groundwater discharge), topography and surficial geology. During the course of this study, a number of site inspections were completed. Figure 2 and Appendix A (site photographs) show some of the features identified during the site inspections. The results of the site inspections are summarized below.

- The site is located on the east flank of a large Precambrian bedrock knoll/outcrop which is surrounded by a flat clay plain.
- Highway 17 cuts through the bedrock with a moderate upslope to the west. The cut is deepest near Station 25+260 approaching 5 to 6 metres.
- The bedrock surface to the north and south of the highway is forested on thin soils and slopes to the north and south. Scattered wetland depressions were observed on the bedrock surface.
- Two discrete groundwater discharge zones (seeps) were observed (Seeps 1 and 2) both at an estimated elevation of 119 m amsl.
- Seep 1 was noted at the base of the bedrock cut on the north side of Highway 17 at Station 25+370. The discharge is likely at or below ground surface as no obvious channelized flow was observed discharging from the rock cut. However, there was cold water in the ditch collecting at this point and gently flowing along the highway ditch to the east downslope towards the culverts located east of the site limits.
- Seep 2 was noted at the base of a smaller bedrock cut on the south side of Highway 17 at Station 25+400. As with Seep 1, the discharge is likely at or below ground surface as no obvious channelized flow was observed discharging from the rock cut. However, there was water in the ditch collecting at this point and gently flowing along the highway ditch to the east downslope towards the culverts located east of the site limits. Seep 2 appeared to discharge less groundwater than Seep 1.
- Both Seeps 1 and 2 were noted to be dry at the time of groundwater sampling carried out in early July 2007.

5.0 WATER WELL TESTING PROGRAM

As part of the Hydrogeological Screening Investigation, a door-to-door water well survey of all wells within approximately 500 metres of the site was completed. The purpose of the door-to-door well survey was to confirm the presence, location, construction details and static water levels of each well, access permitting. The results of the survey identified three (3) residences using private water wells within 500 metres of the site. Of the three residents, two (2) were surveyed (762 and 767 Campbell Drive). There was no response at the third residence (664 Campbell Drive). As part of this investigation, a water sample was collected on July 5, 2007 from the potable water well located on 767 Campbell Drive. The sample was submitted to the laboratory for chemical and bacteriological analysis. Results are presented on Table 9. The water well located at 762 Campbell Drive was not sampled as the well was actually more than 500 metres from the site.

6.0 HYDROGEOLOGICAL INVESTIGATION

This section presents factual information detailing the methodology and results of the subsurface investigation completed during this study.

Ecoplans carried out a subsurface investigation at the site to provide a general physical and chemical assessment of the soil, bedrock and groundwater conditions across the site. The investigation included the drilling of boreholes, installation of groundwater monitoring wells, soil and groundwater chemical testing, and aquifer hydraulic testing. The overall field program was completed between June 18 and July 18, 2007.

The monitoring wells were spatially distributed to provide a characterization of the geology and hydrogeology of the site. Figure 3 shows the approximate locations of the monitoring wells.

All fieldwork was carried out with due regard to generally accepted environmental field protocols and in general accordance with applicable Ontario Ministry of the Environment (MOE) and Canadian Standards Association (CSA) guidelines.

6.1 Drilling Program

Under the direct supervision of Ecoplans field personnel, the drilling program was undertaken by Marathon Drilling Company Limited between June 18 and 22, 2007.

A total of six (6) monitoring wells were installed at the site at the locations shown on Figure 3.

6.1.1 Overburden Drilling

The overburden boreholes were advanced using a track-mounted drilling rig equipped with hollow stem augers (4 ¾" inch) to a maximum depth of 0.7 m. The augers were extended to the pre-determined sampling interval using conventional drilling methods, removed, and then a decontaminated split spoon sampler was driven to the depth of the borehole to collect a discrete soil sample. In areas where sampler and/or auger refusal was obtained, bedrock drilling techniques (Section 5.1.2) were used to facilitate sample submission and well installation.

6.1.2 Bedrock Drilling

The drilling of 0.11 m (4 inches) casing with clean water flushing was conducted down through a few feet into the bedrock. NQ size of 0.08 m (2.98 inch) diameter diamond bit rock drilling was used to advance the boreholes into the bedrock to a maximum depth of 13.6 m, and clean potable water was used to remove cuttings and lubricate the diamond bit during drilling.

Rock cores collected from the six (6) bedrock boreholes were logged for rock type/mineralogy, presence of fissures and fractures and water bearing zones. Rock cores were collected in 1.5 m (5 ft) sections, logged, and preserved in dedicated core-boxes with proper labeling of borehole name and depth interval. All relevant bedrock logging information is presented in the borehole logs found in Appendix B.

6.2 Soil Sampling Program

In an effort to establish the existing chemical and physical conditions of the very shallow soil across the site, selected soil samples were collected and submitted for chemical analysis to AGAT Laboratories Ltd. (AGAT), a full service analytical laboratory certified by the Canadian Association of Environmental Analytical Laboratories for chemical analyses. Soil samples were also collected and submitted for physical analysis (grain-size analysis and moisture content) to Thurber Engineering Ltd. (Thurber).

Representative soil samples were collected from the overburden boreholes using a 0.6 m (2 ft) split-spoon sampler, which was driven by use of a 63.5 kg (140 lb) hammer. The number of blows applied per each 0.15 m (6 inches) was recorded, where possible. Split-spoon soil samples were generally collected at 0.75 m (2.5 foot) intervals and were either composited over the 0.6 m (2 ft) spoon, or were composited to represent each different geological unit encountered.

All soil samples were named and labeled indicating the borehole number followed by the sample interval number. A total of three (3) soil samples were collected and submitted to AGAT for chemical analyses. All soil samples were inspected for the presence of gross impact (i.e. odours and/or staining), and logged for colour, texture and consistency before being placed in Ziploc bags and sample jars. Soil samples were logged in general accordance with the MTO Soil Classification System. In general, no more than 0.6 m (2 feet) of overburden was encountered and the vast majority of the samples collected were in the form of rock cores (Section 5.3). Table 1 presents the soil sampling locations and analytical schedule provided at the end of this report

A total of two (2) soil samples were submitted to Thurber for grain size analysis and moisture content.

6.2.1 Soil Sample Screening and Collection

All soil samples collected were immediately placed into laboratory supplied containers for the parameters listed in Table 1. Due to the limited amount of soil available overlying the bedrock, field screening for the presence of total organic vapors (TOVs) in soil was not completed. The limited amount of soil was required for laboratory analysis.

6.2.2 Soil Sample Transfer

All soil samples were collected using dedicated, disposable nitril butyl gloves and placed directly into laboratory supplied containers. All collected soil samples were immediately placed into coolers and brought to temperatures compliant with laboratory requirements (between 1 and 10°C) using freezer packs and/or ice. Field chain of custody forms were completed on-site and sent together with the samples inside of a sealed cooler to the analytical laboratory via courier.

6.2.3 Equipment Decontamination

All equipment in contact with soil samples was decontaminated after each use to prevent the cross-contamination of individual samples and to ensure reliable, representative, and unbiased chemical test results. Decontamination of sampling equipment was typically achieved using tap water/lab detergent wash, followed by clean water rinse, methyl hydrate rinse, and de-ionized water rinse.

6.3 Monitoring Well Installations

A total of six (6) monitoring wells were installed at the site. Scaled diagrams of the monitoring wells installed are included in the borehole logs provided in Appendix B.

6.3.1 Monitoring Well Construction

All monitoring wells were completed in the bedrock unconfined aquifer. The bedrock monitoring wells were constructed using a 0.11 m (4 inch) diameter steel casing that was advanced through the overburden to approximately 0.3 m (1 ft) into the bedrock. The casing was secured in the overburden using bentonite. The borehole from the overburden/bedrock interface to the well bottom was left open.

No PVC cement or any chemical or solvent was used during the construction of the wells. All monitoring wells were capped using lockable J-plugs and high-density steel weather resistant locks. Based on the surrounding environment, all wells were equipped with above ground 4"x 5' lockable protective steel casing. The top 0.3 m of the well bore (above the bentonite seal) was filled with cold-patch cement to ensure stability to both the well and protective casing.

6.3.2 Monitoring Well Development

The water levels were measured in all wells a few hours following installation. If water was present in the well, the well was 'developed' by pumping. The objectives of well development are to pump any non-representative groundwater introduced during drilling activities so that the natural hydraulic properties of the water-bearing formation are restored; and to create agitation in the groundwater in order to remove particulate matter from the well, thereby collecting a groundwater sample that is representative of natural groundwater. Well development was

continued until the water was free from suspended particulates or until it was impractical to continue due to low water yields.

Well development was achieved by continuous pumping, using a submersible gas powered pump. Well development was continued until at least 10 casing volumes of water were removed. The total volume of purge water pumped from the well was measured based upon the pump's flow rate. The flow rate was determined by measuring the time required for the pump at a specified power level to fill a 20 L bucket.

6.4 *Groundwater Level Monitoring Program*

A groundwater level monitoring program was implemented by Ecoplans staff at all installed wells. Groundwater levels were recorded during two (2) monitoring events; July 3rd and 19th, 2007. A third round of groundwater levels is scheduled for the spring of 2008. All monitoring wells were surveyed for both horizontal and vertical control to a geodetic site datum. The above information allowed for the determination of vertical and horizontal gradients as well as groundwater flow direction.

6.5 *Groundwater Quality Program*

Subsequent to monitoring well development, all wells were purged before sampling. Purging involves the removal of standing/stagnant water from inside the well casing. This ensures that any chemical analyses performed are representative of actual groundwater conditions. As a minimum, three (3) casing volumes are removed from the well prior to sample collection.

Prior to sampling, clean plastic sheeting was placed on the ground surface adjacent to the well being sampled, which was used for storage of equipment and supplies. Clean disposable latex gloves were used throughout the sampling process to ensure reliable and representative sample collection.

Following collection, all groundwater samples were placed immediately into an insulated cooler complete with ice and/or freezer packs. Field chain-of-custody records completed at the time of sample collection, accompanied the samples inside the cooler for delivery to the laboratory. All coolers were couriered or hand delivered to the analytical laboratory within 24 hours of sampling time.

All equipment in contact with groundwater samples was either discarded or otherwise decontaminated after each use to prevent the cross-contamination of the monitoring wells and to ensure reliable, representative, and unbiased chemical test results. Decontamination of groundwater sampling equipment was typically achieved using methyl hydrate rinse followed by de-ionized water rinse.

6.6 *Quality Assurance/Quality Control*

AGAT completed a variety of quality assurance/quality control (QA/QC) measures on the soil and groundwater samples submitted as part of the sampling program. These included: sample replicates, which are identical analysis carried out on the same sample multiple times used to measure laboratory analytical precision; matrix spiked laboratory blanks, which are solvent or reagent blanks spiked with the analytes of interest used to measure and detect any analytical method errors; and process blanks, which are matrices without the analytes of interest that are carried through all steps of the analytical procedure used to measure contamination when stirring, blending, digesting, or sub-sampling and to prepare sampling prior to analysis. The results of the laboratory QA/QC program for this project are included in the laboratory Certificates of Analysis, presented in Appendix D.

The procedures used by the laboratory for each of the analytical packages (both soil and groundwater) were in accordance with industry-accepted laboratory protocols and the MOE Standards. The specific procedures used by AGAT for each analysis are documented in the laboratory Certificates of Analysis, included in Appendix D.

In addition to the laboratory QA/QC, a groundwater field duplicate was collected. The results of the duplicate analysis are shown in the respective analytical tables (Table 10). Most of the parameters analysed in the field duplicate were observed to be within acceptable limits of variance (<10%). Parameters with large variances between the duplicate and actual sample are considered to be estimates only and are to be interpreted with caution for the site.

6.7 *Hydraulic Testing*

In order to define the groundwater flow system of the site, Ecoplans undertook a Hydraulic Testing program on July 18, 2007 on selected wells (MW1 and MW2) located adjacent to Seep 1 as identified in the Hydrogeological Screening Report.

A total of four (4) Single Well Response Tests (SWRTs) were conducted on MW1 and MW2 in order to determine if there is a hydraulic connection between the bedrock aquifer and groundwater seeps (Seeps 1 and 2). SWRTs were conducted either through Falling/Rising Head testing, Constant Head Testing and/or Pump Testing. Results from the testing performed are presented in Section 7.2.2.

6.7.1 Pumping Test

A pumping test was undertaken at the MW2 to obtain information on the hydraulic properties of the bedrock formation underlying the site. An application for a Permit to Take Water (PTTW) from the Ministry of Environment (MOE) for the temporary taking of water during the pumping

test was not needed based on the proposed pumping rate and duration (i.e. <50,000 L/day). MW2 was scheduled to be pumped for twenty-four (24) hours at a maximum attainable rate of 22L/min and water levels were recorded both manually and automatically (with the use of a Solinst water level meter as well as pressure transducers) for the duration of the pump test. No observable impact was seen at any of the monitoring wells other than MW2 (which had a total drawdown of 0.57m from initial static level). Due to this fact the pump test only lasted a total of six (6) hours. Results for all water levels collected during the pump test are provided in Appendix C.

6.7.2 Constant Head Testing

Since no observable influence was seen during the above pumping test, Ecoplans conducted a Constant Head Test on MW2 in order to obtain further data regarding the bedrock formations' hydraulic conductivity. A Constant Head Test consists of pumping the well at three different steady states and measuring the flow rate at these three states. From this information a linear response curve can be plotted and hydraulic conductivity can be determined using the Hvorslev method (Hvorslev, 1951). Results from the Constant Head Testing are presented in Appendix C.

6.7.3 Falling and Rising Head Tests

Falling and rising head tests were conducted on MW2 and MW1 to provide further accuracy with respect to hydraulic conductivity values. A falling head test consists of inducing an increase in the static level of a well through the addition of a known volume (either water or a solid column). The time taken to recover to the static water level is then used to calculate the hydraulic conductivity. A rising head test consists of removing a known volume from the well and lowering the water level. Time taken to recover to static is measured and then used to determine the hydraulic conductivity. Results from the Falling and Rising Head Tests are presented in Appendix C.

7.0 RESULTS OF HYDROGEOLOGICAL INVESTIGATION

7.1 *Site Geology*

Based on the observations and interpretation of samples collected during the drilling investigation, the site geology consists of light grey granite (Precambrian) with small quartz crystals and mica, which is overlain with dark brown topsoil ranging in depths from 0.1m at MW2, MW3 and MW4 to 0.4m at MW1. A shallow (0.7 m) surficial sandy silt and silt till was present at MW5. In general, fractures are numerous in the shallower portion of the bedrock and decrease slightly with depth across the site. This confirms previously reported data indicating that the seepage zones observed on-site likely discharge from a localized perched groundwater system (i.e. unconfined aquifer).

MW2, which was advanced in the area adjacent to Seep 1, encountered boulders and cobbles for the first 0.3m of drilling (119.0 to 118.7m amsl). These boulders and cobbles may be resultant from previous work performed during road construction in the early 1970's. Below 118.7m amsl, highly fractured granite was encountered to a depth of approximately 2.2 m below ground surface (116.5 m amsl).

7.2 *Site Hydrogeology*

A total of six (6) monitoring wells were installed into the local unconfined bedrock aquifer. All wells were then surveyed for horizontal and vertical control (i.e. top of riser and ground elevation). Top of riser elevations are used to determine groundwater elevations based on the recorded depth to water. Table 2 summarizes the monitoring well details for the site and Table 3 summarizes the relative groundwater elevations for each monitoring well at the site during monitoring events (July 3rd and July 18th, 2007). Figure 5 shows a cross section of groundwater elevations (using MW4, MW3 and MW1), ground surface and the proposed westbound lane (WBL) road surface for the Highway 17 project.

7.2.1 Groundwater Flow

Based on the observations noted during the drilling and monitoring program, the shallow unconfined aquifer is present within the bedrock. Horizontal groundwater flow generally follows the local topography and flows from west to east with a shift to the northeast at the east end of the site in the vicinity of MW1, MW2 and MW6. Figure 4 shows the inferred groundwater elevation contours based on the groundwater elevations recorded July 18, 2007 monitoring event. The bedrock aquifer horizontal gradients are approximately 0.004 metres per metre (m/m). Based on the hydraulic gradient of 0.004, bedrock fracture porosity of 0.40, and a K-value of 1.1×10^{-4} m/s (Section 6.2.2), the estimated horizontal shallow bedrock groundwater velocity would be 0.1 metres/day or 34.7 metres/year.

7.2.2 Aquifer Hydraulic Properties

Single Well Response Tests were conducted on MW1 and MW2 in order to determine the properties of the unconfined aquifer. Testing on MW2 consisted of a pump test, a constant head test, and a falling/rising head test (the results of these tests can be seen in Appendix C) Performing these three tests ensured for an accurate prediction of the hydraulic conductivity (K-value) of the area in and around Seep 1. K-values ranged from 1.4×10^{-4} m/s to 6.1×10^{-4} m/s at MW2 and 4.1×10^{-5} m/s to 3.0×10^{-5} m/s at MW1. A geometric mean of 1.1×10^{-4} m/s was calculated based on results from all tested wells. The estimated hydraulic conductivity observed on-site is within typical K-values for fractured bedrock. Due to the fact that the order of magnitude of the K-value remains unchanged regardless of the type of test performed on each well, it can be stated that the values obtained are highly representative of actual hydraulic conditions. It should be noted that no K-values were determined during the attempted pump test due to the fact that no influence was seen in surrounding wells during pumping. This is indicative of high secondary permeability throughout the unconfined aquifer.

The Transmissivity (T) value which is calculated based on the hydraulic conductivity and the results of the aquifer hydraulic testing is in the order of $0.006 \text{ m}^2/\text{s}$ ($518 \text{ m}^2/\text{day}$). Transmissivity is defined as the rate at which water flows through a 1 metre wide vertical strip of the aquifer which extends through the full saturated thickness under a hydraulic gradient of 1. The estimated transmissivity for the shallow bedrock aquifer is considered to be fair to good.

7.3 Analytical Results

At the time of this investigation, the following applicable environmental standards were used to assess the environmental quality of the soil and groundwater at the site:

Ontario Regulation 153/04

In October 2004, the MOE introduced “Ontario Regulation 153/04” (Part XV.1 of the Environmental Protection Act), hereafter referred to as “Regulation 153/04”. Regulation 153/04 details the requirements that property owners must meet in order to file a Record of Site Condition in addition to providing the Guideline for Use at Contaminated Sites in Ontario assessment procedures.

Two supporting technical documents, the “Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act (MOE Standard), and the “Protocol for Analytical Methods Used in the Assessment of Properties Under Part XV.1 of the Environmental Protection Act” (MOE Protocol) were also released as part of the Regulation 153/04 requirements. The MOE Standard and the MOE Protocol, provide applicable site condition standards, and laboratory analytical protocols for the analysis of soil, sediment and groundwater,

respectively. These documents replace the “Guideline for Use at Contaminated Sites in Ontario”, (December 1996) hereafter referred to as the MOE Standard.

The Regulation 153/04 clean-up approach for contaminated sites utilizes generic site assessment/remediation criteria based on the effects the criteria may have on human health and the natural environment. It incorporates risk assessment through the provision of two clean-up scenarios: 1) Full Depth - restoration of soil quality to the full extent of the contamination; and 2) Stratified Depth - restoration of soil quality of the top 1.5 m following the full depth criteria; however, soil quality deeper than 1.5 m must be restored to stratified depth criteria. Each of these clean-up scenarios follows particular criteria for both soil and groundwater separated into three different land use designations (i.e. agricultural, residential/parkland, and industrial/commercial) in either a potable or non-potable groundwater situation.

The site is situated in rural forested area along the Highway 17 corridor. The source of potable water for the surrounding area and is through groundwater. To this end, applicable analytical results from the soil and groundwater samples collected from the site were compared against Full Depth Generic Site Criteria for industrial/commercial land use in a potable groundwater situation (Table 2 of the MOE Standards).

Ontario Drinking Water Standards

The Ontario Drinking Water Standards (ODWS) are a set of chemical and physical standards for drinking water implemented by the MOE and adopted from the Canadian Drinking Water Guidelines (CDWG). The objectives are either health-related or not health-related (aesthetic or operational guidelines). To this end, applicable analytical results from all of the groundwater samples (including the monitoring wells and water well at 767 Campbell Drive) were compared against the ODWS as a general indicator of the groundwater quality for drinking purposes for the site.

7.3.1 Results of Soil Analysis (Chemical)

The chemical results of the selected soil samples submitted for analysis were compared to the industrial/commercial land use remediation criteria outlined in Table 2 of the MOE Standards, assuming coarse-textured soils. The results of the chemical analysis for all of the soil samples submitted are presented in Tables 4 and 5 at the end of this report.

All soil samples collected and submitted for analysis met the applicable MOE Standards. The full analytical soil results as prepared by AGAT are included in Appendix D.

7.3.2 Results of Soil Analysis (Physical)

Ecoplans submitted two (2) soil samples for physical analysis of grain-size analysis to Thurber Engineering Ltd (Thurber). Based on the results of the grain-size analyses, most of the overburden is sandy silt to silt. The results are presented in the borehole logs provided in Appendix B

Based on the results of the soil moisture analyses, the moisture content range of the overburden deposits is between 9.6% and 15.22%. The reported soil moisture contents and grain size analyses were typical for the nature of the soils encountered. These reported results are also consistent to what was observed in the field and as reported in the background information (i.e. geological maps and previous hydrogeological reports).

The results of the physical analysis for all of the soil samples are included in Appendix E.

7.3.3 Results of Groundwater Analysis

The chemical results of groundwater samples collected from the six (6) monitoring wells on July 3rd, 2007 were compared to Table 2 of the MOE Standards. For comparative purposes, the analytical results were also compared to the Ontario Drinking Water Standards (ODWS). The results of groundwater analysis are summarized in Tables 6, 7, and 8. The residential water well quality collected at 767 Campbell Drive is provided in Table 9.

Groundwater sampling results indicated exceedences for the Table 2 criteria for chloride at MW2 and MW3 (290mg/L and 338mg/L respectively) and for sodium at MW3 and MW4 (316mg/L and 405mg/L respectively). Due to their proximity to Highway 17, these exceedences can be attributed to road salting during winter conditions and are likely typical of monitoring wells installed within highway right-of-ways. Sample results for MW4 indicated an exceedance for chromium (152mg/L). This monitoring well also exhibited a significantly elevated pH of 12.1 and elevated levels of iron, hardness and sulphate (much higher than the other monitoring wells). It is unknown as to the source of the poor groundwater chemistry at this location. A follow-up round of monitoring (scheduled for spring 2008) will provide confirmation as to whether or not this is an anomalous reading or is in fact the true groundwater chemistry at this location. Regardless, at this time, no remedial action is required for the identified exceedences of pH, hardness, sodium, chloride, iron, chromium, and sulphate.

All other groundwater sample parameters collected from the site are well below the applicable MOE Standards. In addition, all groundwater sample parameters collected from the site and from the water well located at 767 Campbell Drive are well below the applicable ODWS for the parameters analysed, with the exception of the following:

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Location	Parameter	Result (µg/L)	ODWS (µg/L)
MW1	Manganese	52	50
767 Campbell Drive	Manganese	55.6	50
MW2	Iron	358	300
MW4	Iron	998	300
MW6	Iron	702	300
767 Campbell Drive	Iron	588	300
MW1	Total Hardness	270	80-100
MW2	Total Hardness	273	80-100
MW3	Total Hardness	260	80-100
MW4	Total Hardness	774	80-100
MW5	Total Hardness	247	80-100
MW6	Total Hardness	236	80-100
MW4	Sulphate	602	500
MW4	pH	12.1	6.5-8.5

Overall, the noted ODWS exceedances are common in Ontario natural groundwater and are not believed to be as a result of any contamination. These exceedances are regulated under the aesthetic and operational objectives of ODWS and are not health-related parameters of concern. However, the source of the exceedances at MW4 (as previously discussed) is unknown and will require confirmation sampling in early 2008.

The full analytical groundwater results as prepared by AGAT are included in Appendix D

8.0 HYDROGEOLOGICAL DESIGN

As per the Terms of Reference, this section interprets the findings of the hydrogeological investigation and discusses the site susceptibility to highway construction impacts, presents recommendations for the design and construction of the highway with respect to groundwater management, and presents a long-term groundwater monitoring program for the site.

8.1 *Summary of Site Geology and Hydrogeology*

The surficial geology of the site and surrounding area is dominated by a large Precambrian bedrock outcrop extending approximately 5 km in the east/west direction and 1.5 km in the north/south direction and rising more than 20 metres above the surrounding flat clay plains. Highway 17 cuts through the bedrock generally following the east-west axis of the outcrop. The bedrock surface is covered with a thin veneer of soil. Dolostone and limestone rocks lie to the east of the site and predominantly igneous rocks to the south. These rocks are covered with marine clays ranging in thickness from 10 to 30 metres.

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 km of the site, the bedrock aquifer system is found at depths between 5.5 and 96 m bgs (elevations of between 115 and 52 mAMSL), the deepest being approximately 1.5 km east of the site. All of the water wells servicing the 2-km radius area exploit the bedrock aquifer as a potable source with the majority of the wells drawing their water from the limestone aquifer, generally located to the north-northeast of the site. Based on the water well records and well survey, there are shallow wells to the northeast and south of the site. Groundwater flow in the bedrock aquifer system is generally to the north-northeast towards the Ottawa River.

At the time of site inspections in late spring/early summer, two groundwater discharge zones (seeps) were identified on the north (Seep 1) and south (Seep 2) sides of Highway 17 approximately 600 metres west of Campbell Drive. Both seeps discharge groundwater at the base of the bedrock cut at which point the water pools and gently flows along the highway ditches to the east and downgradient towards the flatter clay plains. Most, if not all, of the water is lost through direct infiltration into the overburden and bedrock before reaching the Highway 17 culverts located between the east site limits and Campbell Drive. These seeps likely discharge groundwater from a localized perched bedrock aquifer system that was the focus of this study's field investigations. This aquifer was breached during the construction of Highway 17 in the early 1970's, and was backfilled with gravel and rocks. The areal extent of the aquifer is unknown but is likely localized. It appears that the discharge is not significant but does sustain flow in the ditches which is then lost to the subsurface through infiltration. It is likely that both

seeps are hydraulically connected with the main groundwater discharge from the bedrock occurring at Seep 1 and an appreciable portion of the discharge contributes to Seep 2 by flowing under the highway through the highway bedding material. These seeps were noted to be dry in July at the time of the well monitoring.

Based on the field investigations completed by Ecoplans which included the installation and monitoring of six bedrock monitoring wells and aquifer hydraulic tests, the geology of the site consists of light grey granite (Precambrian) with small quartz crystals and mica, which is overlain with a thin layer of topsoil sandy silt and silt till. In general, fractures were noted to be numerous in the shallower portion of the bedrock, decreasing slightly with depth across the site. This confirms previously reported data indicating that the seepage zones observed on-site likely discharge from a localized perched groundwater system (i.e. unconfined aquifer). The bedrock fractures are the primary water bearing zone (aquifer) with bulk storage of the water in the upper fracture zone. As there is no overlying confining layer (i.e. dense soil or competent bedrock), the aquifer is unconfined (i.e. not under artesian conditions) and is subject to seasonal fluctuations. This is confirmed by the fact that the groundwater seeps along the highway ditch were not present during the well monitoring in July. The results of the aquifer hydraulic tests demonstrate that the fractures can transmit appreciable quantities of groundwater with no significant drop in the water table during the tests.

The water table was encountered at elevation depths between 120.41 mAMSL at MW4 to 117.91 mAMSL at MW1 (location of the seep) on July 3, 2007. Groundwater flow is to the east with a shift to the northeast at the east end of the site in the vicinity of MW1, MW2 and MW6. The estimated horizontal shallow bedrock groundwater velocity would be approximately 0.1 metres/day or 34.7 metres/year. It should be noted that the line of monitoring wells (i.e. MW1, MW3 and MW4) along the north MTO fenceline were completed approximately 25 metres south of the proposed Highway 17 WBL, and therefore it is reasonable to extrapolate the subsurface and groundwater conditions encountered at these boreholes to those conditions expected to be encountered along the proposed WBL.

8.2 Site Susceptibility

The proposed twinning of Highway 17 through the site will involve a significant cut (could be approximately 6 metres or more) into the bedrock to the north of the existing highway to accommodate construction of the westbound lanes. Overall, the site susceptibility to construction impacts resulting from excavation work would be considered low with respect to potential physical impacts (i.e. groundwater quantity/supply) due to the following reasons:

- The proposed bedrock cut through the site will not intercept the shallow bedrock aquifer identified during this study. According to the preliminary design drawings, the proposed elevation of the WBL at MW4 and MW1 will be 123.2 and 119.3 mAMSL, respectively.

Based on the field investigations, the bedrock aquifer was encountered at elevations of 120.41 mAMSL at MW4 and 117.91 mAMSL at MW1. Therefore, there will be at least a 1.4 metre separation between the highway grade and aquifer. Figure 5 shows a cross-section of the site.

- The aquifer is not the regionally extensive bedrock aquifer supplying potable water to the residential wells in the area. It is likely confined to the bedrock outcrop.
- The aquifer's discharge appears not to be significant and may only contribute minimal recharge into the regional bedrock aquifer system.
- The only sensitive receptors in the area are the water wells associated with the residences to the north and northeast (groundwater flow in the regional bedrock aquifer system is the north-northeast). The closest well is located approximately 250 metres north of the site.

The potential chemical impacts (i.e. groundwater quality) to the groundwater systems would represent a moderate concern due to winter maintenance (road salting) activities and potential spills. The addition of new westbound lanes will inherently increase potential salt losses to the environment.

8.3 Mitigation

Although the proposed Highway 17 westbound lanes will likely not intercept the shallow bedrock aquifer, it would be prudent to consider the mitigation alternatives summarized in Table 11 to minimize the potential for highway construction and operation impacts to the local and regional groundwater system. Option A is a "Do Nothing" alternative. Options B and C focus on the design and construction of the highway drainage ditches along the rock cut.

It is important that regardless of the design, the final vertical profile elevation of the westbound lanes through the bedrock cut should be at or above 119 mAMSL at MW1 (Station 25+410) to 122 mAMSL at MW4 (Station 25+100) in order to minimize the potential for groundwater interception.

Preferred Mitigation Option

Although both mitigation options are relatively similar from a physical groundwater impact perspective, i.e. low potential for groundwater interception, Option C (lining the ditches with a geosynthetic clay liner) represents the least potential impact to the shallow bedrock aquifer from a chemical groundwater impact perspective, especially relating to road salt losses and spills. As such Option C is the preferred mitigation option.

The geosynthetic clay liner should consist of a thin layer of clay sandwiched within geotextile fabrics. Upon hydration, the clay will swell and provide a seal having a permeability in the order of 10^{-9} to 10^{-10} cm/sec. The total liner thickness is in the order of 4 to 7 millimetres and it can be placed on a very thin layer of earth borrow (meeting the requirements of OPSS Earth Borrow) to smooth out the roughness of the blasted bedrock surface. The liner must be covered with a minimum of 300 millimetres of soil to make sure that there is sufficient confining force to prevent uncontrolled expansion of the hydrating clay and also to prevent excessive drying. Compared to a natural silty clay liner, the amount of bedrock removal to accommodate this liner and cover material is considerably less. The liner must be placed under the direction of the manufacturer. The placement procedures are, however, easy to carry out and there are only a few "must do" procedures to make sure that the laps are properly constructed. This liner can also be placed on slopes that are consistent with normal ditching side slopes.

Contingency

In the event that the highway construction work intercepts the shallow bedrock aquifer, it is recommended that appropriate dewatering of the excavation be carried out to minimize interference with construction activities. The dewatering activity will not require a Permit To Take Water (PTTW) as it is considered "passive dewatering" and is exempt from the permit requirements as specified in the PTTW Memorandum of Understanding between the MOE and MTO dated September 13, 2006. Due to the unconfined nature (i.e. not under artesian conditions) of the bedrock aquifer, it is anticipated that any dewatering activities will not be significant.

8.4 *Proposed Long Term Monitoring Program*

An integral component of highway design, construction and operation is to develop and implement a long-term groundwater monitoring program to assess any groundwater impacts (both physical and chemical).

The groundwater monitoring program should include three monitoring events; pre-construction, during construction and post construction. The existing six monitoring wells and the private water well located at 767 Campbell Drive should be used as the monitoring network. Each event should include chemical testing of groundwater for metals and chloride; and measuring water levels. The program should be administered as part of Contract Administration for the project.

If at any time, any of the wells are either damaged or are no longer required, they will have to be appropriately decommissioned in accordance with O.Reg 903.

In addition to the long-term groundwater monitoring program, and as part of the scope of work for this study, Ecoplans will complete another groundwater monitoring event in early spring of 2008 during high flow conditions.

9.0 QUALIFICATIONS OF THE CONSULTANT

Ecoplans Limited, established in 1970, provides consulting services in the biological and physical sciences, environmental planning, landscape architecture, environmental impact assessment, and environmental site assessment and remediation. Ecoplans' staff includes specialists in all facets of the environmental field. The Environmental Site Assessment and Remediation Division of Ecoplans Limited specializes in Phase I, II and III Environmental Site Assessments, electromagnetic surveys, aboveground and underground storage tank removals/assessments, groundwater investigations and site remediation/restoration. Ecoplans has completed numerous Phase I and Phase II Environmental Site Assessments for both the public and private sector. Some of the more significant clients include the Ministry of Transportation, GO Transit, Ontario Realty Corporation, Regional Municipality of Peel, Greater Toronto Airports Authority, Medallion Properties Inc., and Marshall-Barwick Inc.

Mr. Derek Stewart, M.Sc., P.Geo., as Senior Hydrogeologist, is the head of Ecoplans' Environmental Site Assessment & Remediation Division. Mr. Stewart has 16 years experience carrying out site assessments and remediation projects working for a number of environmental consulting firms. He has been with Ecoplans since 1996. At the project level, Mr. Stewart provides technical and editorial support to his staff, and peer reviews all draft and final reports prior to being sent to the client.

Mr. Martin Gedeon, M.Sc., P.Geo., is a Hydrogeologist working with Ecoplans' Environmental Site Assessment & Remediation Division. Mr. Gedeon is licensed as a professional geoscientist in the Province of Ontario. Mr. Gedeon has over ten (11) years of experience as an environmental/hydrogeological consultant in the areas of groundwater monitoring, environmental impact assessment, due diligence and remediation. Mr. Gedeon has significant experience in physical and contaminant hydrogeology across Canada and overseas and provides hydrogeological/environmental technical support to various projects with Ecoplans.

Mr. Mark Misko, B.Sc., is an environmental scientist working with Ecoplans Environmental Site Assessment & Remediation Division. Mr. Misko has an extensive academic and applied background in hydrogeology, groundwater sciences and groundwater transport mechanisms. Mr. Misko has experience conducting Phase II Environmental Site Assessments, Environmental Inspection and Environmental Monitoring for Dewatering Projects.

10.0 CLOSURE

There is no warranty, expressed or implied, by Ecoplans Limited that the foregoing subsurface investigation portion of the hydrogeological study has uncovered all potential contaminants, sources of contaminants or construction impacts due to groundwater discharge on the site.

All conclusions are based on design drawings provided to Ecoplans Limited at the time of this report. Ecoplans Limited cannot guarantee the absence of groundwater impacts related to construction activities with respect to the Highway 17 Twinning project should the design and/or scope of work change.

The results of the subsurface investigation are based upon the total number of sampling points and the depth of investigation. These are considered to be fairly representative of the soil and groundwater conditions within each area tested. This assessment cannot guarantee that isolated pockets of contaminated soil and groundwater are not located on the site within areas not addressed by this project. The overall chemical and physical parameters tested have been chosen to reflect the potential contamination sources identified and therefore, conclusions regarding site environmental compliance are limited to those areas and parameters tested.

The distribution of this report is intended solely for the client. Ecoplans does not assume any third-party liability based on the unauthorized distribution of this report.

We trust the information outlined in this report meets with your requirements.

Yours truly,

Ecoplans Limited



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TABLES

TABLE 1
SOIL AND GROUNDWATER ANALYTICAL SCHEDULE
Highway 17 Twinning - Campbell Drive to Scheel Drive

Sample ID	Soil Sample Depth Interval (m)	Sampling Date	Analysis							
			Petroleum Hydrocarbons (F1-F4)	BTEX	Reg. 153 Metals	Grain Size Analysis	Moisture Contant (%)	Nutrients ⁽¹⁾	General Chemistry ⁽²⁾	Major Anions ⁽³⁾
SOIL										
BH1/MW1	0 - 0.2	18-Jun-07	√	√	√					
BH5/MW5	0 - 0.61	21-Jun-07	√	√	√					
	0.8 - 1.4					√	√			
	1.5 - 2.1					√	√			
BH6/MW6	0 - 0.61	21-Jun-07	√	√	√					
GROUNDWATER										
MW1		5-Jul-07	√	√	√			√	√	√
MW2		5-Jul-07	√	√	√			√	√	√
MW3		18-Jul-07	√	√	√			√	√	√
MW4		5-Jul-07	√	√	√			√	√	√
MW5		5-Jul-07	√	√	√			√	√	√
MW6		5-Jul-07	√	√	√			√	√	√

BTEX - Benzene, Toluene, Ethylbenzene, Xylenes

(1) Nutrients - Phosphorous, TKN, Ammonia

(2) General Chemistry - Hardness, TOC, TSS, pH

(3) Major Anions - Cl, F, Br, NO₂, NO₃, SO₄

TABLE 2
MONITORING WELL DETAILS
Highway 17 Twnning - Campbell Drive to Scheel Drive

Monitoring Well ID	Monitoring Well Depth (mbgs) ⁽¹⁾	Screened Interval (mbgs)	Reference Ground Surface Elevation (mAMSL)	Screened Lithology	Hydraulic Conductivity (m/s)
MW1	10.0	0.22 - 10.0	120.42	Granite	N/A
MW2	9.8	0.35 - 9.8	119.04	Granite	6.1x 10 ⁻⁴
MW3	13.6	0.22 - 13.6	125.62	Granite	N/A
MW4	8.9	0.45 - 8.9	123.96	Granite	N/A
MW5	5.3	0.81 - 5.3	123.46	Granite	N/A
MW6	9.3	0.32 - 9.3	119.26	Granite	N/A

Notes:

- (1) mbgs: metres below ground surface
- (2) mAMSL: metres above mean sea level
- (3) N/A: Not Available

TABLE 3
GROUNDWATER ELEVATIONS
Highway 17 Cambell Drive to Scheel Drive

Well ID	GPS Co-ordinates		Station Location	Well Details			Water Level	
	Northing	Easting		Top of Riser	Bottom of Well	Ground Surface	3-Jul-07	18-Jul-07
MW1	389467	5032326	25+423.00	121.34	110.42	120.42	117.57	117.91
MW2	389459	5032313	25+430.80	119.62	109.24	119.04	118.45	118.33
MW3	389297	5032341	25+243.65	126.04	112.02	125.62	118.63	118.66
MW4	389170	5032437	25+110.54	124.66	115.06	123.96	120.57	120.41
MW5	389165	5032373	25+135.40	124.11	118.16	123.46	120.49	120.45
MW6	389491	5032287	25+465.57	119.26	109.64	118.94	118.00	118.24

TABLE 4
SOIL ANALYTICAL RESULTS - METALS AND GENERAL CHEMISTRY
Highway 17 Twinning -Campbell Drive to Scheel Drive

Parameter	MOE Soil Standards ⁽¹⁾	Sample Results ⁽²⁾		
		18-Jun-07	21-Jun-07	
		MW1 0-8"	MW5 0-2'	MW6 0-2'
Sampling Depth (m)		0 - 0.2	0 - 0.61	0 - 0.61
METALS & GENERAL CHEMISTRY				
Antimony	40	<1.6	<1.6	<1.6
Arsenic	40	3.9	1.4	1.8
Barium	1500	220	65.3	182
Beryllium	1.2	0.6	<0.4	0.5
Cadmium	12	1.5	<0.4	0.5
Chromium (Total)	750	33.2	15.9	30.8
Cobalt	80	9.8	7.1	10.5
Copper	225	26.6	10.1	27.3
Lead	1000	82.9	17.7	38.7
Molybdenum	40	1.2	<0.5	0.6
Nickel	150	18.9	10.4	24
Selenium	10	<0.8	<0.8	<0.8
Silver	40	<0.4	<0.4	<0.4
Thallium	32	0.5	<0.4	0.7
Vanadium	200	35.8	25.7	43.4
Zinc	600	380	47.3	126
Electrical Conductivity (2:1) mS/cm	1.4	0.494	0.381	0.57
Sodium Adsorption Ratio ⁽³⁾	12	0.236	0.512	5.15
pH 2:1 Water:Soil Extraction ⁽³⁾	NV	7.63	7.07	7.4

Notes:

- | | |
|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>(1)</p> <p>(2)</p> <p>(3)</p> <p><</p> <p>NV</p> <p>mS/cm</p> | <p>MOE Soil Standards, Ontario Regulation 153/04</p> <p>Table 2; Full Depth Generic Site Condition Standards in a Potable Water Condition (Industrial/Commercial/Community Property Uses)</p> <p>All results reported in micrograms per gram (µg/g) unless otherwise noted.</p> <p>Parameter has no unit of measurement</p> <p>Parameter not detected above value specified</p> <p>No Value (Parameter not included in MOE Standard)</p> <p>Millisiemens per centimetre</p> |
|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

TABLE 5
SOIL ANALYTICAL RESULTS - PETROLEUM HYDROCARBON FRACTIONS AND BTEX
Highway 17 Twinning - Campbell Drive to Scheel Drive

Parameter	MOE Soil Standards ⁽¹⁾	Sample Results ⁽²⁾		
		18-Jun-07	21-Jun-07	
		MW1 0-8"	MW5 0-2'	MW6 0-2'
	Sampling Depth (m)	0 - 0.2	0 - 0.61	0 - 0.61
PETROLEUM HYDROCARBONS				
F1 (C6-C10)	230	<5	<5	<5
F2 (>C10-C16)	150	<10	<10	<10
F3 (>C16-C34)	1700	<50	<50	<50
F4 (<C34)	3300	<50	<50	<50
BTEX				
Benzene	5.3	<0.10	<0.10	<0.10
Toluene	34	<0.08	<0.08	<0.08
Ethylbenzene	290	<0.05	<0.05	<0.05
Xylenes (Total)	34	<0.07	<0.07	<0.07

Notes:

- (1) MOE Soil Standards, Ontario Regulation 153/04
Table 2; Full Depth Generic Site Condition Standards in a Potable Water Condition
(Industrial/Commercial/Community Property Uses)
- (2) All results reported in micrograms per gram (µg/g) unless otherwise noted.
< Parameter not detected above value specified

TABLE 6
GROUNDWATER ANALYTICAL RESULTS - METALS
Highway 17 Twinning - Campbell Drive to Scheel Drive

Parameter	MOE Groundwater Standards ⁽¹⁾	ODWS ⁽²⁾	Unit	Sample Results					
				5-Jul-07					18-Jul-07
				MW1	MW2	MW4	MW5	MW6	MW3
METALS									
Aluminum	NV	100(OG)	ug/L	5.3	5.18	10.5	3.99	3.2	4.09
Antimony	6	6 (IMAC)	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Arsenic	25	25 (IMAC)	ug/L	<0.60	<0.60	2.07	<0.60	<0.60	<0.60
Barium	1000	1000 (MAC)	ug/L	46.6	68.7	113	60.1	45.8	64.7
Beryllium	4	NV	ug/L	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50
Bismuth	NV	NV	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Boron	5000	5000 (IMAC)	ug/L	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Cadmium	5	5 (MAC)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Calcium	NV	NV	mg/L	89.4	86.3	310	82.5	75.5	84.5
Chromium	50	50(MAC)	ug/L	2.92	2.88	152	1.58	1.78	21.4
Cobalt	100	NV	ug/L	<0.50	0.5	<0.50	<0.50	<0.50	<0.50
Copper	23	1000 (AO)	ug/L	1.85	3.76	6.48	1.96	1.49	4.13
Iron	NV	300 (AO)	ug/L	242	358	998	207	702	<10.0
Lead	10	10(MAC)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Lithium	NV	NV	ug/L	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Magnesium	NV	NV	mg/L	11.3	14	<0.05	10	11.6	3.25
Manganese	NV	50 (AO)	ug/L	52	15.7	<0.60	2.02	38.4	3.25
Molybdenum	7300	NV	ug/L	1.71	1.89	55.9	<0.50	20.2	0.67
Nickel	100	NV	ug/L	1.08	3.06	<1.00	<1.00	1.52	1.67
Phosphorus	NV	NV	mg/L	<20.0	<20.0	<20.0	<20.0	<20.0	<0.02
Potassium	NV	NV	mg/L	1.14	2.38	135	0.83	1.35	1.69
Selenium	10	100(MAC)	ug/L	<0.80	<0.80	3.37	<0.80	1.18	<0.80
Silicon	NV	NV	mg/L	2.95	2.99	1.56	4.78	3.19	4.41
Silver	1.2	NV	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Strontium	NV	NV	ug/L	255	360	2090	211	366	353
Sulphur	NV	NV	mg/L	3.75	6.27	226	3.16	3.36	12.7
Thallium	2	NV	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Tin	NV	NV	ug/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Titanium	NV	NV	ug/L	<1.00	<1.00	6.66	<1.00	<1.00	1.03
Uranium	NV	20 (MAC)	ug/L	<0.20	<0.20	<0.20	<0.20	<0.20	0.3
Vanadium	200	NV	ug/L	2.33	4.31	4.7	2.36	1.58	4.75
Zinc	1100	5000 (AO)	ug/L	6.7	17.7	9.2	9.1	8.4	6.8

Notes:

(1) MOE Groundwater Standards, Ontario Regulation 153/04, Table 2; Full-depth Generic Site Conditions in a Potable Ground Water Condition (All Types of Property Uses)

(2) Ontario Drinking Water Standards (June 2003)

MAC Maximum acceptable concentration (health-related)

IMAC Interim maximum acceptable concentration (health-related)

AO Aesthetic objective (non-health related, i.e. colour, taste, smell)

OG Operational guideline (non-health related: water treatment and distribution)

NV No Value (Parameter not included in Standard)

< Parameter not detected above value specified

152 Indicates exceedance of MOE and/or ODWS Standards; health-related

358 Indicates exceedance of MOE and/or ODWS Standard; non-health related

TABLE 7
GROUNDWATER ANALYTICAL RESULTS - GENERAL CHEMISTRY
Highway 17 Twinning - Campbell Drive to Scheel Drive

Parameter	MOE Groundwater Standards ⁽¹⁾	ODWS ⁽²⁾	Unit	Sample Results					
				5-Jul-07					18-Jul-07
				MW1	MW2	MW4	MW5	MW6	MW3
GENERAL CHEMISTRY									
Fluoride	NV	1.5 (MAC)	mg/L	0.13	0.38	0.35	0.12	0.12	0.13
Chloride	250	250 (AO)	mg/L	52.9	290	238	14.5	2.96	338
Bromide	NV	NV	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrate as N	10	10 (MAC)	mg/L	<0.05	0.06	0.46	<0.05	<0.05	0.64
Nitrite as N	1	1 (MAC)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphate	NV	500(AO)	mg/L	10.5	17.7	602	9.09	9.69	31.5
Sodium	200	200 (AO)	mg/L	47	176	405	8.89	4.87	316
Ammonia as N	NV	NV	mg/L	<0.02	<0.02	3.96	<0.02	<0.02	<0.02
Total Kjeldahl Nitrogen	NV	NV	mg/L	0.41	0.61	8.19	0.34	0.51	<0.10
Total Phosphorus	NV	NV	mg/L	0.07	0.93	0.15	0.07	<0.05	0.27
Total Organic Carbon	NV	NV	mg/L	2.6	6.3	6.8	1.6	1.8	7.9
pH	NV	6.5-8.5 (OG)	N/A	8.17	8.07	12.1	7.94	8.1	7.56
Total Hardness	NV	80-100 (OG)	mg/L	270	273	774	247	236	260
Total Suspended Solids	NV	NV	mg/L	834	26	394	153	75	1360
Electrical Conductivity	NV	NV	uS/cm	649	1160	4480	468	410	1740

Notes:

- | | |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (1) | MOE Groundwater Standards, Ontario Regulation 153/04, Table 2; Full-depth Generic Site Conditions in a Potable Ground Water Condition (All Types of Property Uses) |
| (2) | Ontario Drinking Water Standards (June 2003) |
| MAC | Maximum acceptable concentration (health-related) |
| IMAC | Interim maximum acceptable concentration (health-related) |
| AO | Aesthetic objective (non-health related, i.e. colour, taste, smell) |
| OG | Operational guideline (non-health related: water treatment and distribution) |
| NV | No Value (Parameter not included in Standard) |
| < | Parameter not detected above value specified |
| mg/L | Milligrams per litre |
| uS/cm | micro Siemens per centimeter |
| 290 | Indicates exceedance of MOE and/or ODWS Standard; non-health related |

TABLE 8
GROUNDWATER ANALYTICAL RESULTS - PETROLEUM HYDROCARBON FRACTIONS AND BTEX
Highway 17 Twinning - Campbell Drive to Scheel Drive

Parameter	MOE Groundwater Standards ⁽¹⁾	ODWS ⁽²⁾	Sample Results					
			5-Jul-07					18-Jul-07
			MW1	MW2	MW4	MW5	MW6	MW3
PETROLEUM HYDROCARBONS								
F1 (6<C<10)	1000	NV	<100	<100	<100	<100	<100	<100
F2 (10<C<16)								
F3 (16<C<34)	1000	NV	<500	<500	<500	<500	<500	<500
F4 (34<C<50)								
BTEX								
Benzene	5	5 (MAC)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	24	24 (AO)	<0.2	<0.2	0.32	<0.2	<0.2	<0.2
Ethylbenzene	2.4	2.4 (AO)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Xylenes (Total)	300	300 (AO)	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14

Notes:

- (1) MOE Groundwater Standards, Ontario Regulation 153/04, Table 2; Full Depth Generic Site Condition Standards in a Potable Ground Water Condition (All Types of Property Uses)
- (2) Ontario Drinking Water Standards (June 2003)
- (3) All results reported in micrograms per litre (µg/L) unless otherwise noted.
- < Parameter not detected above value specified
- MAC Maximum acceptable concentration (health-related)
- AO Aesthetic objective (non-health related, i.e. colour, taste, smell)
- NV No Value (Parameter not included in Standard)

TABLE 9
DRINKING WATER ANALYTICAL RESULTS - METALS AND GENERAL CHEMISTRY
Highway 17 Twinning -Campbell Drive to Scheel Drive

Parameter	ODWS ⁽¹⁾	Sample Results ⁽²⁾
		5-Jul-07
		767 Campbell Dr
METALS (µg/L)		
Aluminum	100(OG)	1.16
Antimony	6 (IMAC)	<1.00
Arsenic	25 (IMAC)	2.37
Barium	1000 (MAC)	201
Beryllium	NV	<1.50
Bismuth	NV	<0.50
Boron	5000 (IMAC)	57.4
Cadmium	5 (MAC)	<0.50
Calcium (mg/L)	NV	2.46
Chromium	50(MAC)	37.7
Cobalt	NV	0.76
Copper	1000 (AO)	0.96
Iron	300 (AO)	588
Lead	10(MAC)	<0.50
Lithium	NV	<10.0
Magnesium (mg/L)	NV	25.9
Manganese	50 (AO)	55.6
Molybdenum	NV	0.78
Nickel	NV	<1.00
Phosphorus (mg/L)	NV	<20.0
Potassium	NV	9.5
Selenium	100(MAC)	<0.80
Silicon (mg/L)	NV	8.18
Silver	NV	<0.50
Strontium	NV	2990
Sulphur (mg/L)	NV	5.44
Thallium	NV	<0.50
Tin	NV	<1.00
Titanium	NV	<1.00
Uranium	20 (MAC)	0.32
Vanadium	NV	1.66
Zinc	5000 (AO)	6.1

Parameter	ODWS	Sample Results
		5-Jul-07
		767 Campbell Dr
GENERAL CHEMISTRY (mg/L)		
Fluoride	1.5 (MAC)	1.49
Chloride	250 (AO)	26.8
Bromide	NV	<0.05
Nitrate as N	10 (MAC)	<0.05
Nitrite as N	1 (MAC)	<0.05
Sulphate	500(AO)	14
Sodium	200 (AO)	46.5
Ammonia as N	NV	0.07
Total Kjeldahl Nitrogen	NV	0.49
Total Phosphorus	NV	<0.05
Total Organic Carbon	NV	1.1
pH**	6.5-8.5 (OG)	8.48
Total Hardness	80-100 (OG)	201
Total Dissolved Solids	500 (AO)	306
Electrical Conductivity (uS/cm)	NV	519

Notes:

- (1) Ontario Drinking Water Standards (June 2003)
- (2) All results reported in micrograms per litre (µg/L) unless otherwise noted.
- MAC Maximum acceptable concentration (health related)
- IMAC Interim maximum acceptable concentration (health related)
- AO Aesthetic objective (non-health related, i.e. colour, taste, smell)
- OG Operational guideline (non-health related: water treatment and distribution)
- NV No Value (Parameter not included in Standard)
- < Parameter not detected above value specified
- mg/L Milligrams per litre
- * uS/cm: Micro siemens per centimeter
- ** No unit of measurement
- 588** Exceedance of ODWS; non-health related

TABLE 10
GROUDNWATER ANALYTICAL RESULTS - QA/QC
Highway 17 Twinning - Campbell Drive to Scheel Drive

Parameter	5-Jul-07		% Difference
	Sample MW6	Duplicate MW7	
METALS			
Aluminum	3.2	2.42	27.8%
Antimony	<1.00	<1.00	0.0%
Arsenic	<0.60	<0.60	0.0%
Barium	45.8	46.5	1.5%
Beryllium	<1.50	<1.50	0.0%
Bismuth	<0.50	<0.50	0.0%
Boron	<10.0	<10.0	0.0%
Cadmium	<0.50	<0.50	0.0%
Calcium	75.5	77.8	3.0%
Chromium	1.78	2.21	21.6%
Cobalt	<0.50	<0.50	0.0%
Copper	1.49	1.64	9.6%
Iron	702	745	5.9%
Lead	<0.50	<0.50	0.0%
Lithium	<10.0	<10.0	0.0%
Magnesium	11.6	12.1	4.2%
Manganese	38.4	40.2	4.6%
Molybdenum	20.2	20.1	0.5%
Nickel	1.52	1.51	6.6%
Phosphorus	<20.0	<20.0	0.0%
Potassium	1.35	1.42	5.1%
Selenium	1.18	<0.80	98.7%
Silicon	3.19	3.36	5.2%
Silver	<0.50	<0.50	0.0%
Strontium	366	370	1.1%
Sulphur	3.36	3.37	0.3%
Thallium	<0.50	<0.50	0.0%
Tin	<1.00	<1.00	0.0%
Titanium	<1.00	<1.00	0.0%
Uranium	<0.20	<0.20	0.0%
Vanadium	1.58	1.49	5.9%
Zinc	8.4	6.3	28.6%

Parameter	5-Jul-07		% Difference
	Sample MW6	Duplicate MW7	
GENERAL CHEMISTRY			
Fluoride	0.12	0.14	15.4%
Chloride	2.96	2.92	1.4%
Bromide	<0.05	<0.05	0.0%
Nitrate as N	<0.05	<0.05	0.0%
Nitrite as N	<0.05	<0.05	0.0%
Sulphate	9.69	9.51	1.9%
Sodium	4.87	4.92	1.0%
Ammonia as N	<0.02	<0.02	0.0%
Total Kjeldahl Nitrogen	0.51	0.28	62.2%
Total Phosphorus	<0.05	<0.05	0.0%
Total Organic Carbon	1.8	1.8	0.0%
pH	8.1	8.09	0.2%
Total Hardness	236	244	3.3%
Total Suspended Solids	75	72	4.1%
Electrical Conductivity	410	411	0.2%
PETROLEUM HYDROCARBONS			
F1 (6<C<10)	<100	<100	0.0%
F2 (10<C<16)			
F3 (16<C<34)	<500	<500	0.0%
F4 (34<C<50)			
BTX			
Benzene	<0.2	<0.2	0.0%
Toluene	<0.2	<0.2	0.0%
Ethylbenzene	<0.1	<0.1	0.0%
Xylenes (Total)	<0.14	<0.14	0.0%

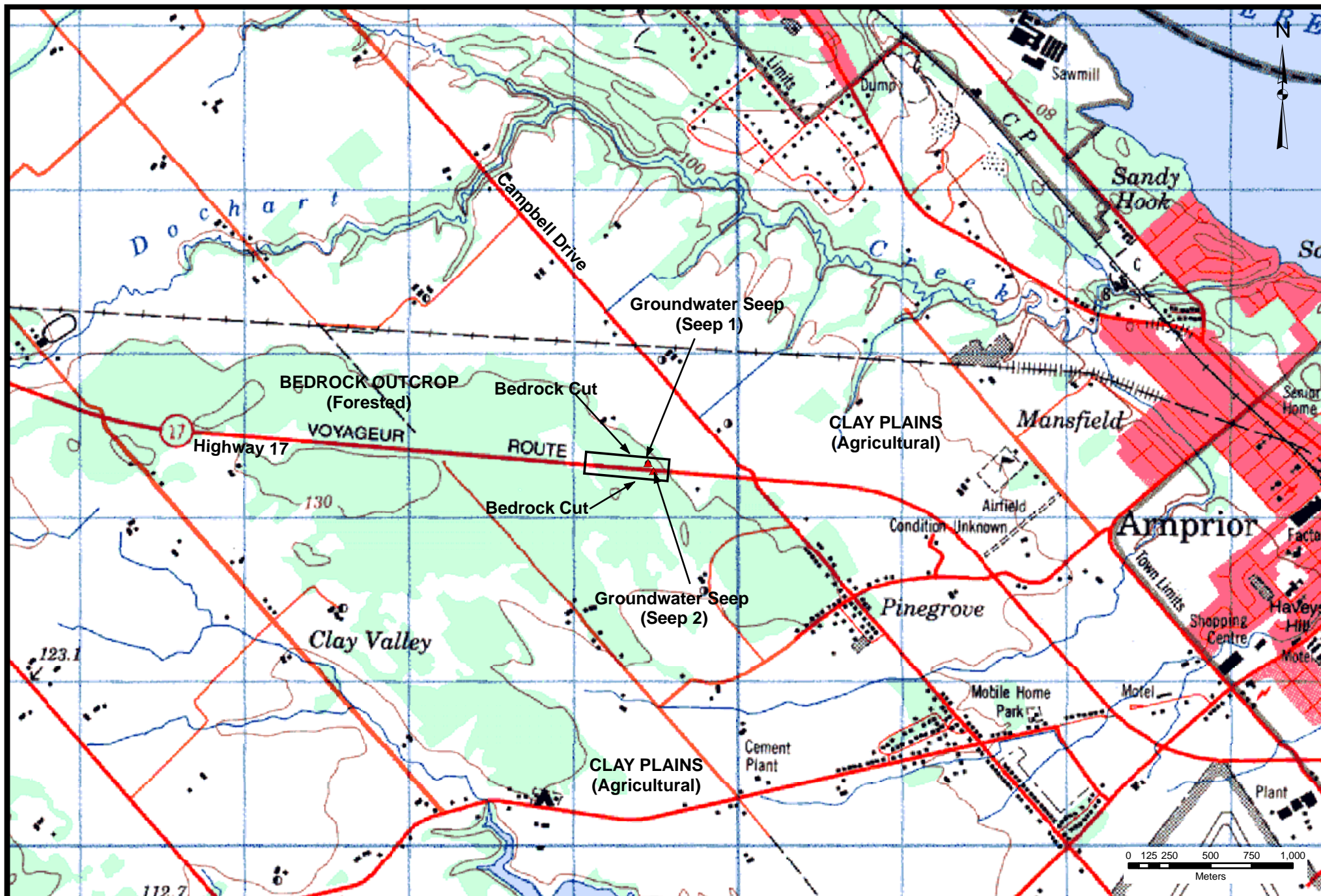
Notes:

< Parameter not detected above value specified
 % Difference Relative Percent Difference = $\frac{|(X-Y)|}{\text{Average}(X,Y)} \times 100\%$ where X is the sample and Y is the duplicate

TABLE 11
SUMMARY OF MITIGATION ALTERNATIVES
SITE 1 - STATIONS 25+000 TO 25+500 MCNAB-BRAESIDE TOWNSHIP
Highway 17 Campbell Drive to Scheel Drive

Mitigation Option	Advantages	Disadvantages	Costs
<u>Option B</u> Do Nothing	<ul style="list-style-type: none"> - No cost - Does not require any design, construction, or maintenance 	<ul style="list-style-type: none"> - High vulnerability of salt and hydrocarbon-related impact into the shallow local and regional aquifer 	None
<u>Option B</u> <ul style="list-style-type: none"> - construct conventional bedrock highway drainage ditches with no base liner - consider using highway deicing alternatives such as liquid potassium acetate or “Geomelt” (organic pre-wetting agent) and calcium magnesium acetate (CMA) to avoid using more conventional road salt and thus eliminating sodium chloride impacts to the groundwater. 	<ul style="list-style-type: none"> - alternative road deicing agents are environmentally friendly and do not include either sodium or chloride - relatively low cost for designing and constructing ditches 	<ul style="list-style-type: none"> - potentially creates an “open window” to the shallow bedrock aquifer – aquifer is then susceptible to road salt impacts and spills; however road salt impacts would be eliminated if using alternative deicers. - alternative road de-icing agents are much more expensive than road salt. 	Equipment costs generally remain the same for all deicers. Material costs - alternative de-icing liquid can range from \$0.2/lit to \$1/lit compared to an average of \$0.05/lit for regular brine i.e. 4 to 20 times more expensive. Material costs for conventional road salt is approximately \$60/tn
<u>Option C</u> <ul style="list-style-type: none"> - incorporate a geosynthetic clay liner as base material for the highway drainage ditches to minimize salt losses to the shallow bedrock aquifer - ditch should be lined through the full extent of the bedrock cut from approximately Station 25+050 to 25+400 (approximately 350 metres) - continue using road salt as a highway deicing agent 	<ul style="list-style-type: none"> - significantly minimizes potential road salt losses to the shallow bedrock aquifer; therefore can continue to use road salt as a deicer - may be able to use clay excavate from road construction of the Campbell Drive overpass (no importing of fill) - low erosion potential 	<ul style="list-style-type: none"> - requires more design and construction than Option A - construction more costly than Option A; however, long-term winter road maintenance costs using road salt will be less than Option A 	\$7 per sq. meter for liner Material bulk cost for 350 m length lined ditch at widths ranging from 4.3 m to 5.9 m on both sides of the east and westbound lanes = \$40,000 Additional contractor’s cost to install

FIGURES



Source: National Topographic System (NTS)

Scale: 1:30,000

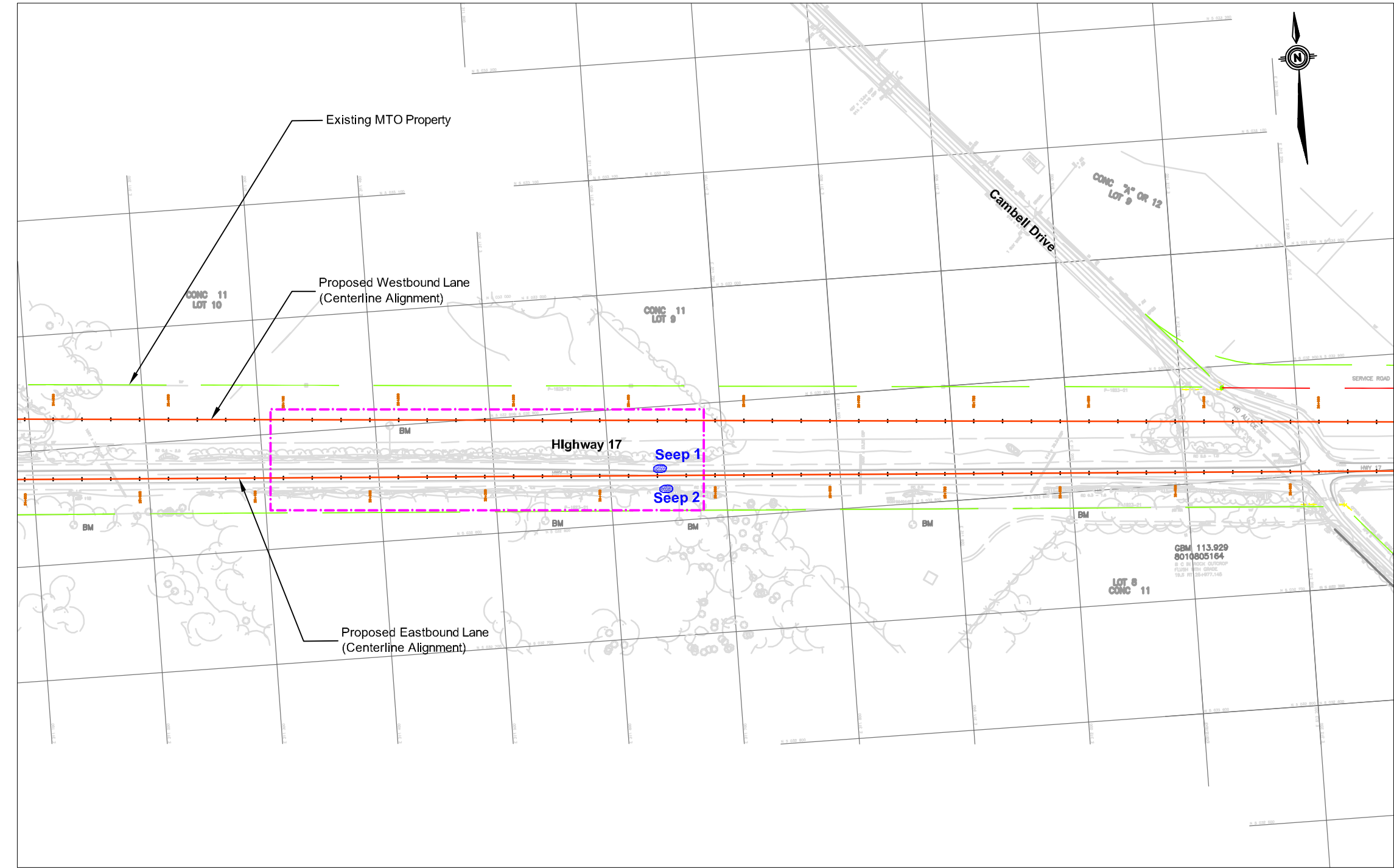


HYDROGEOLOGICAL INVESTIGATION AND DESIGN REPORT
 HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
 GWP 4067-03-00
SITE LOCATION PLAN

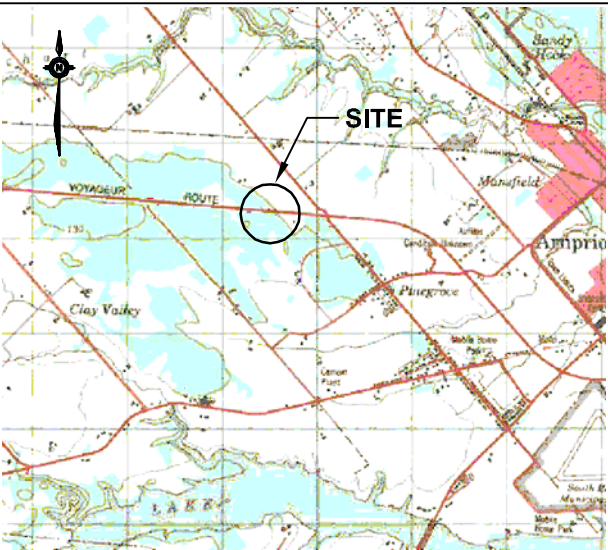
DATE:
Feb. 2008
 PROJECT:
R07-0261

FIGURE
1

\\ecoplans\03 - REMEDIATION\PROJECTS\R07-0261 17 Twinning - Campbell to Scheel\0261-700 Drawings
DRAWING NAME: ProposedBH.DWG
DRAWN BY: G. Yang
MODIFIED: 07/05/20 12:06:16 Revised



KEY PLAN



Source:
National Topographic System (NTS) - Department of Energy, Mines and Resource.
Map 31F/8, Arnprior, Ontario-Quebec, 1991

Approximate Scale: 1:83,000

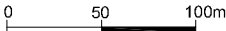
LEGEND:

- Approximate Site Limits
- Groundwater Seep Location
- Proposed Highway 17 Alignment
- Existing MTO Property

SOURCES:

Basemap from McCormick Rankin Corp.

SCALE: 1:4,000





ecoplans
Limited
Environmental Consultants

2655 North Sheridan Way
Suite 280
Mississauga, Ontario
L5K2P6

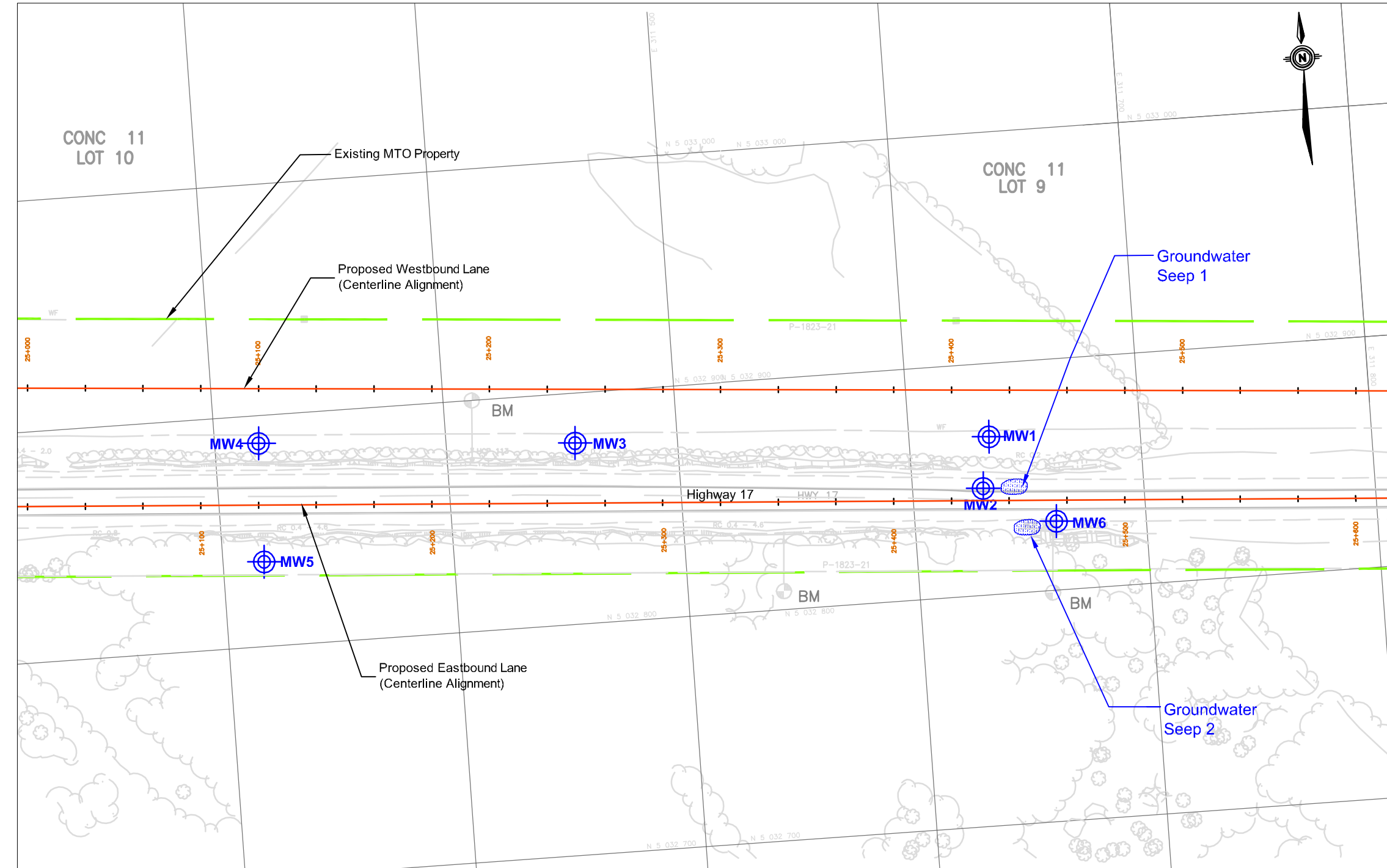
Phone: (905) 823-4888
Fax: (905) 823-2699
ecoplans@ecoplans.com

SITE PLAN

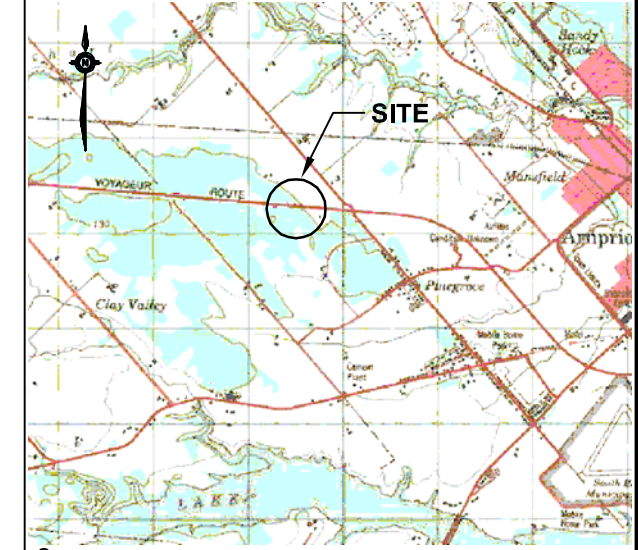
HYDROGEOLOGICAL INVESTIGATION AND DESIGN REPORT
HIGHWAY 17 TWINNING CAMPBELL DRIVE TO SCHEEL DRIVE

DATE: February 2008	DRAWN BY: G. Yang	FIGURE NO.: 2
PROJECT NO.: R07-0261	CHECKED BY: D. Stewart	

\\ecoplans\03 - REMEDIATION\PROJECTS\R07-0261 17 Trinning - Campbell to Scheel\0261-700 Drawings
DRAWING NAME: ProposedBH.DWG
DRAWN BY: G. Yang
MODIFIED: 07/05/20 12:06:16
Revised



KEY PLAN



Source:
National Topographic System (NTS) - Department of Energy, Mines and Resource.
Map 31F/8, Amprior, Ontario-Quebec, 1991

Approximate Scale: 1:83,000

LEGEND:

- Monitoring Well Location
- Groundwater Seep Location
- Proposed Highway 17 Alignment
- Existing MTO Property

SOURCES:

Basemap from McCormick Rankin Corp.

SCALE: 1:2,000



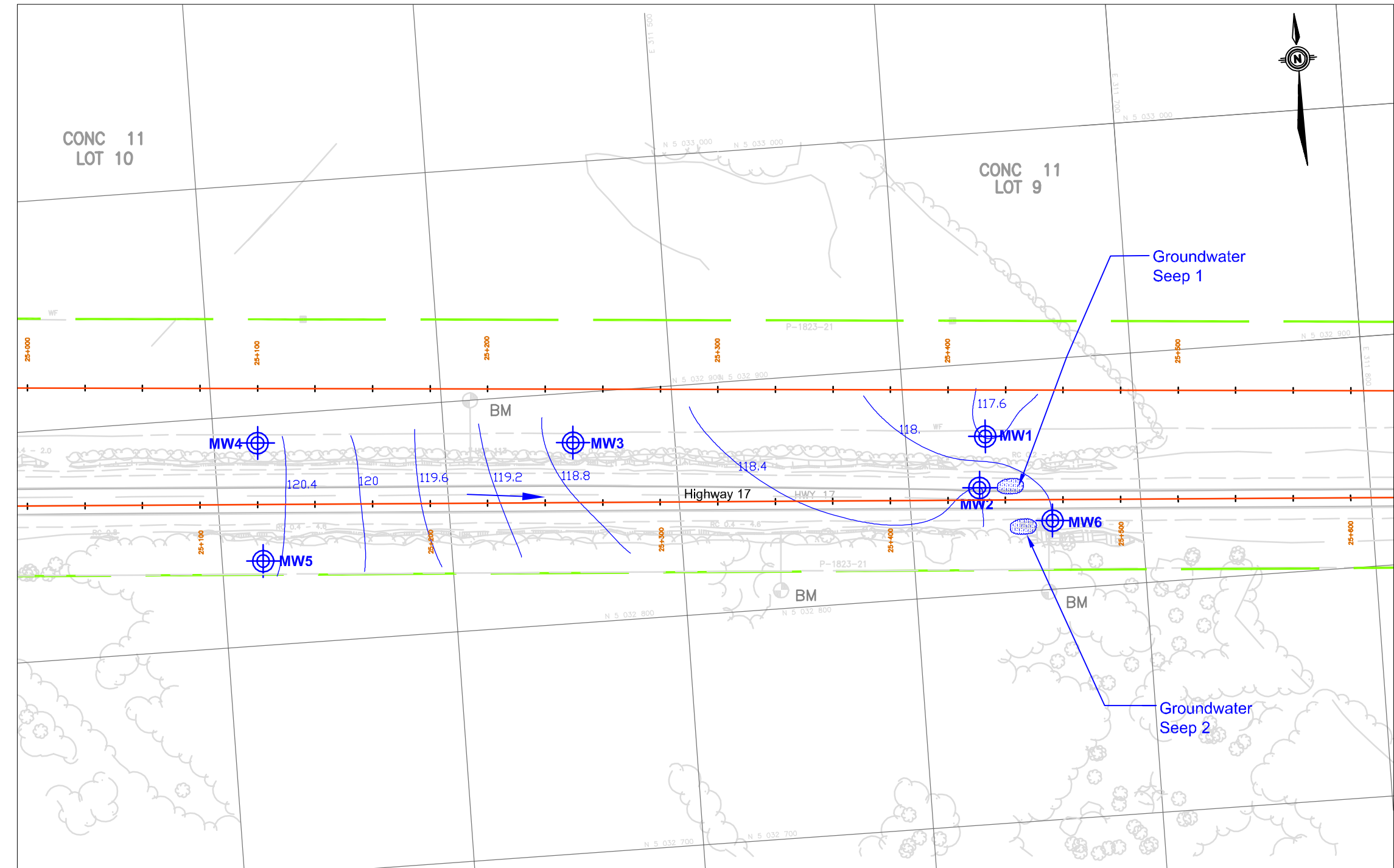
ecoplans Limited
Environmental Consultants
2655 North Sheridan Way Suite 280
Mississauga, Ontario L5K2P6
Phone: (905) 823-4888
Fax: (905) 823-2669
ecoplans@ecoplans.com

MONITORING WELL LOCATION PLAN

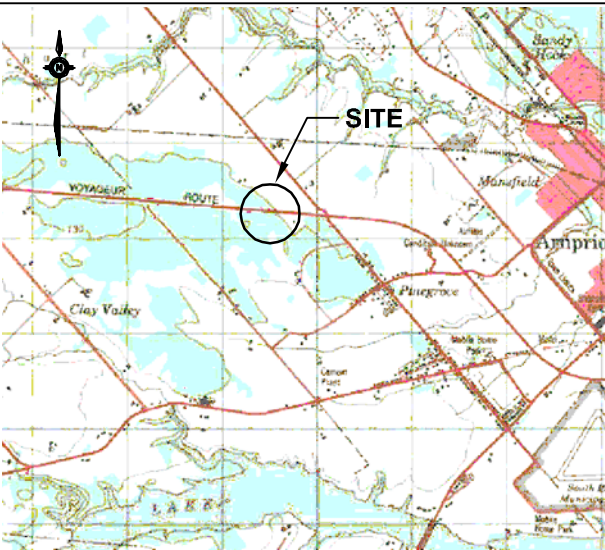
HYDROGEOLOGICAL INVESTIGATION AND DESIGN REPORT HIGHWAY 17 TWINNING CAMPBELL DRIVE TO SCHEEL DRIVE

DATE: February 2008	DRAWN BY: G. Yang	FIGURE NO.: 3
PROJECT NO.: R07-0261	CHECKED BY: D. Stewart	

\\ecoplans\03 - REMEDIATION\PROJECTS\R07-0261 17 Twinning - Campbell to Scheel\0261-700 Drawings
DRAWING NAME: ProposedBH.DWG
DRAWN BY: G. Yang
MODIFIED: 07/05/20 12:06:16
Revised



KEY PLAN



Source:
National Topographic System (NTS) - Department of Energy, Mines and Resource.
Map 31F/8, Amprior, Ontario-Quebec, 1991

Approximate Scale: 1:83,000

LEGEND:

- Monitoring Well Location
- Groundwater Seep Location
- Inferred Direction of Groundwater Flow
- (118m) Groundwater Elevation
July 3, 2007
- Groundwater Elevation Contour

SOURCES:

Basemap from McCormick Rankin Corp.

SCALE: 1:2,000

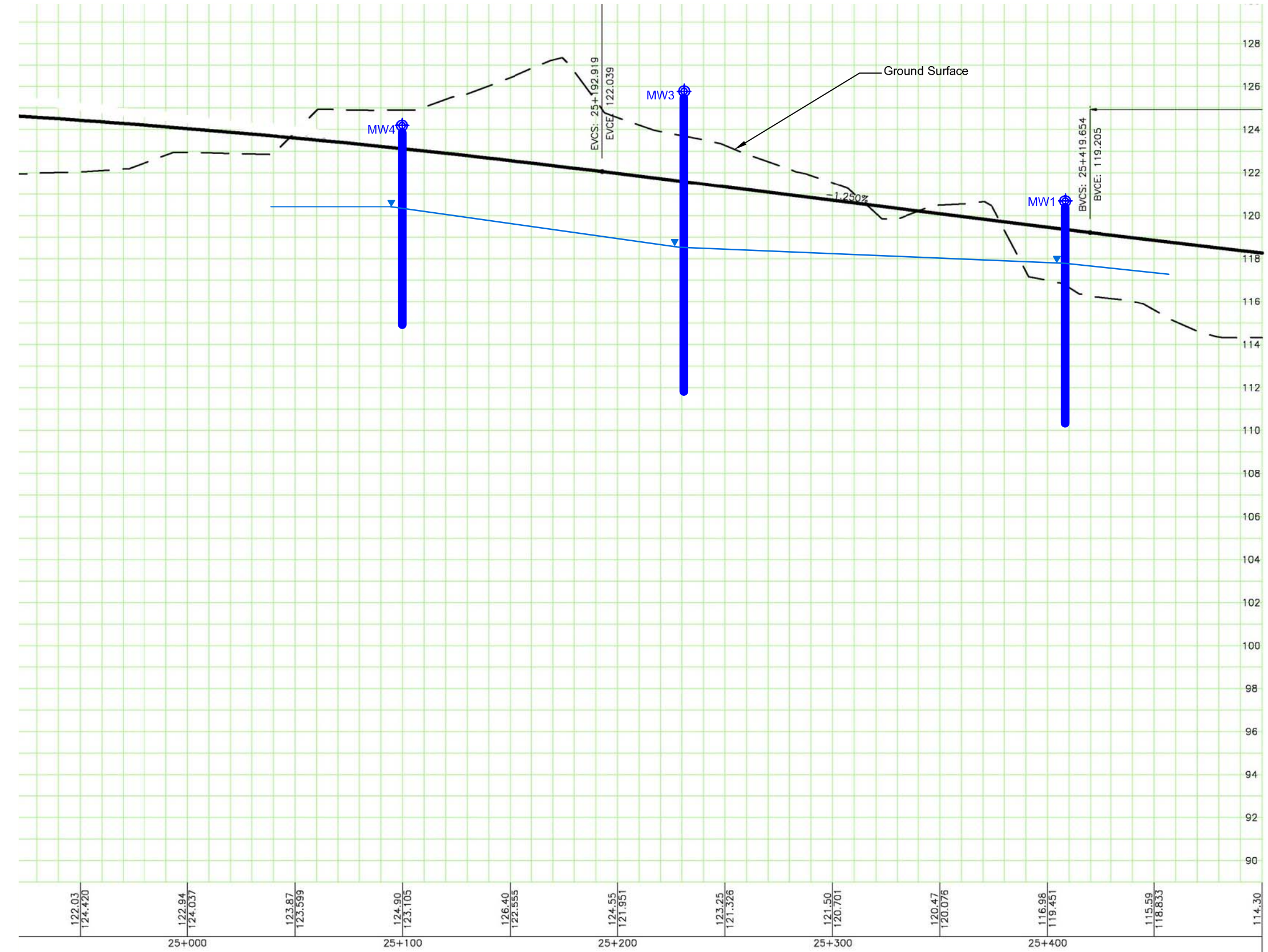


GROUNDWATER ELEVATION CONTOURS

HYDROGEOLOGICAL INVESTIGATION AND DESIGN REPORT
HIGHWAY 17 TWINNING CAMPBELL DRIVE TO SCHEEL DRIVE

DATE: February 2008	DRAWN BY: G. Yang	FIGURE NO.: 4
PROJECT NO.: R07-0261	CHECKED BY: D. Stewart	

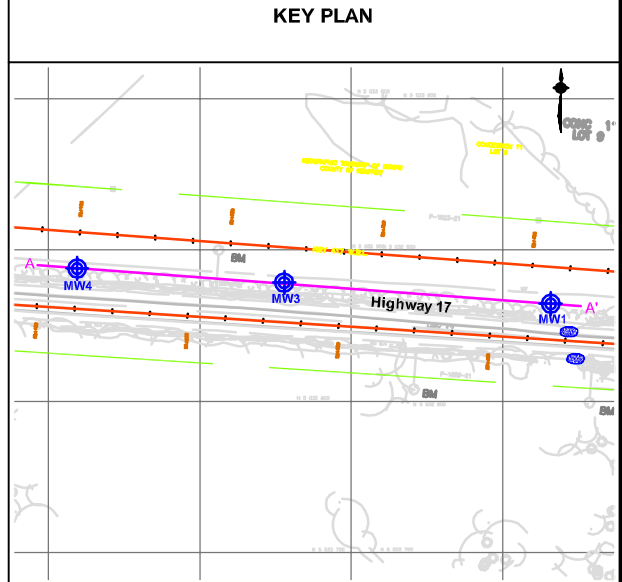
\\ecoplans\03 - REMEDIATION\PROJECTS\R07-0261 17 Twinning - Campbell to Scheel\0261-700 Drawings
DRAWING NAME: ProposedBH.DWG
DRAWN BY: G. Yang
MODIFIED: 07/05/20 12:06:16 Revised



CROSS-SECTION A - A'




HYDROGEOLOGICAL INVESTIGATION AND DESIGN REPORT
HIGHWAY 17 TWINNING CAMPBELL DRIVE TO SCHEEL DRIVE


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Fax: (905) 823-2669
ecoplans@ecoplans.com



Scale: 1:5,000

LEGEND:

-  Monitoring Well Location
-  Groundwater Level
-  Proposed Vertical Profile of Highway 17 Westbound Lanes (Centerline)

MW ID	Coordinates	Elevation(m)	GW Elevation(m)
MW1	389467, 5032326	120.4	117.57
MW3	389297, 5032341	125.6	118.63
MW4	389170, 5032437	124.0	120.57

SOURCES:

Basemap from Ministry of Transportation

Vertical Scale: 1:200

Horizontal Scale: 1:2,000

DATE: February 2008	DRAWN BY: G. Yang	FIGURE NO.: 5
PROJECT NO.: R07-0261	CHECKED BY: D. Stewart	

APPENDIX A
SITE PHOTOGRAPHS



← Photo 1
 Highway 17 bedrock cut through site.
 Photo taken facing east.



Photo 2 →
 Highway 17 bedrock cut through site.
 Photo taken facing west.



← Photo 3
 Bedrock cut on north side of Highway 17
 noting pool of water generated from
 groundwater seep (Seep 1).
 Photo taken facing west.



2655 North Sheridan Way, Mississauga, Ont L5K 2P6
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Hydrogeological Investigation and Design Report
Highway 17 Twinning Campbell Drive to Scheel Drive
 GWP 4067-03-00
Site Photographs

Date:
 Feb. 2008

Project No.:
 R07-0261

Figure No.

A-1



← Photo 4
Close up of bedrock groundwater discharge seep (Seep 1).
Photo taken facing northeast.



Photo 5 →
Seep 1 discharge location noting flow and pooling to the east along the ditch.
Photo taken facing east.



← Photo 6
Close up of groundwater discharge seep (Seep 2) located on the south side of Highway 17.
Photo taken facing east.



← Photo 7
MW1.
Photo taken facing east.



Photo 8 →
MW1.
Photo taken facing south towards Highway 17.



← Photo 9
Location of Seep 1 and MW2.
Photo taken facing east.



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Hydrogeological Investigation and Design Report
Highway 17 Twinning Campbell Drive to Scheel Drive
GWP 4067-03-00
Site Photographs

Date:
Feb. 2008

Project No.:
R07-0261

Figure No.

A-3



← Photo 10
MW2.
Photo taken facing west.

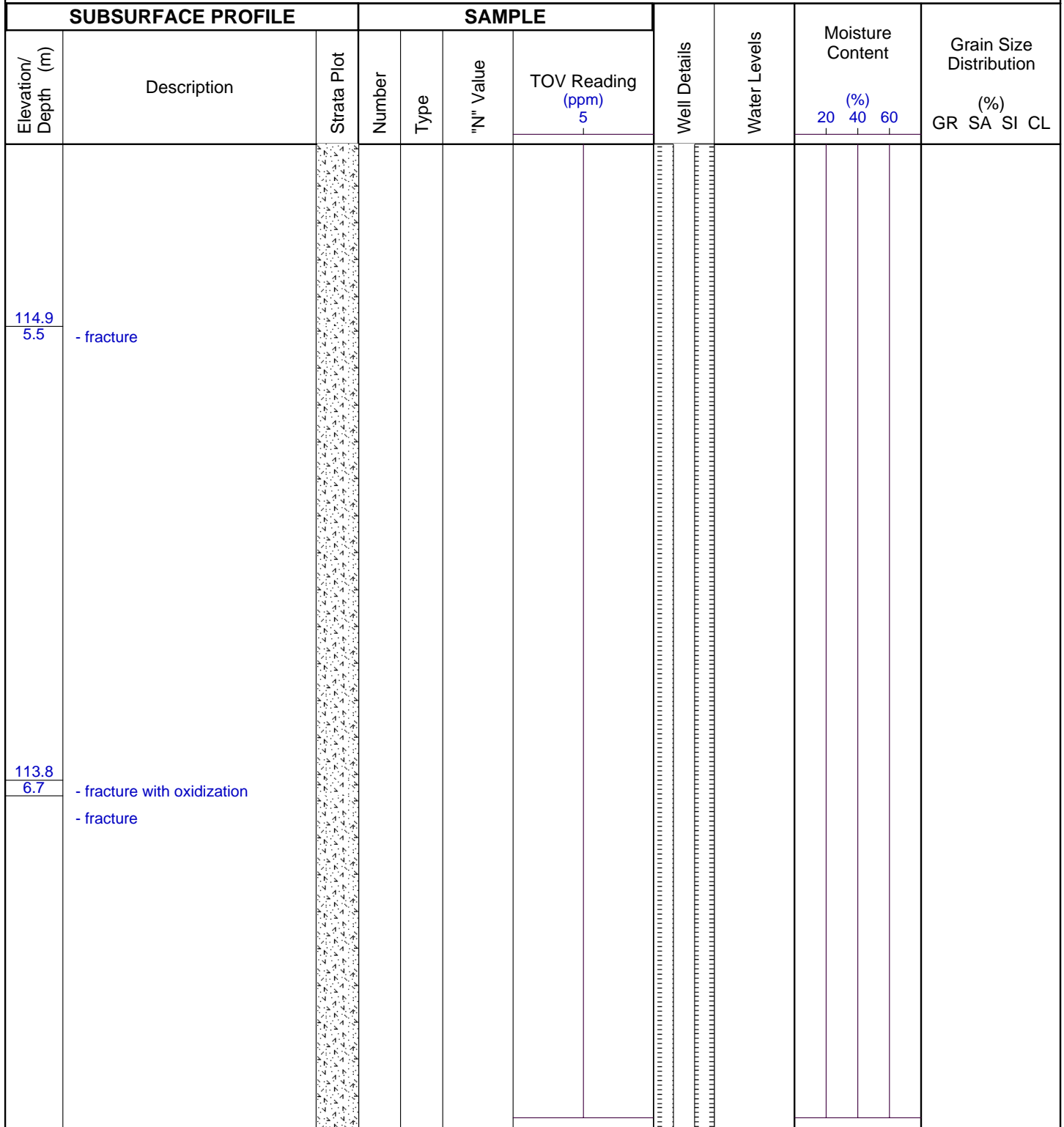


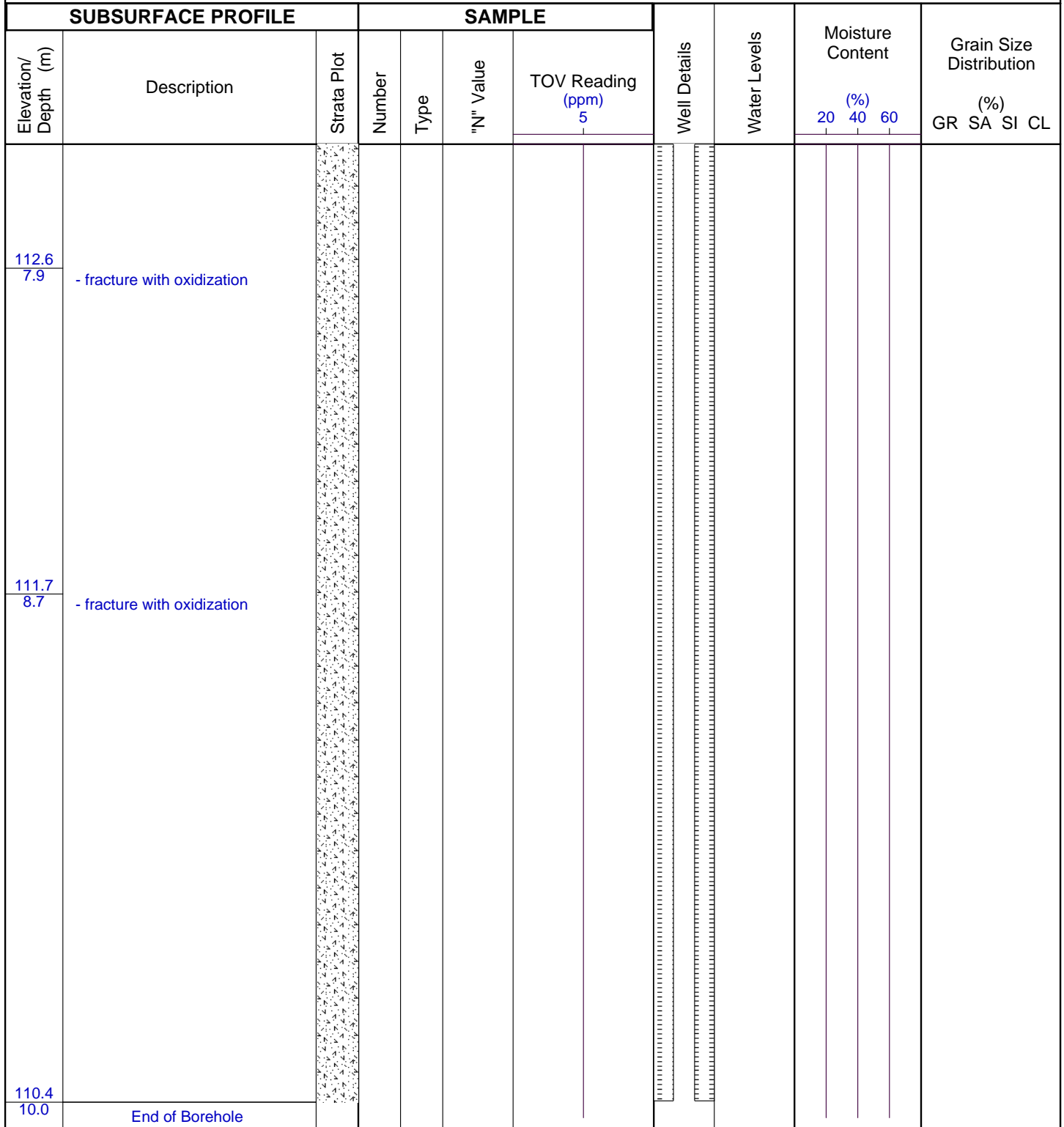
Photo 11 →
MW4.
Photo taken facing south towards Highway 17.



← Photo 12
Mw6.
Photo taken facing west.

APPENDIX B
BOREHOLE LOGS





Log of Borehole: MW2

Sheet: 1 of 4

WP: 4067-03-001

Co-ordinates: 389459, 5032313

Originated By: L. Roberts

Project: Highway 17 Twinning


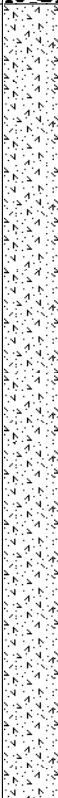
Borehole Type: NQ Diamond Drilling

Contractor: Marathon Drilling


Datum: Geodetic

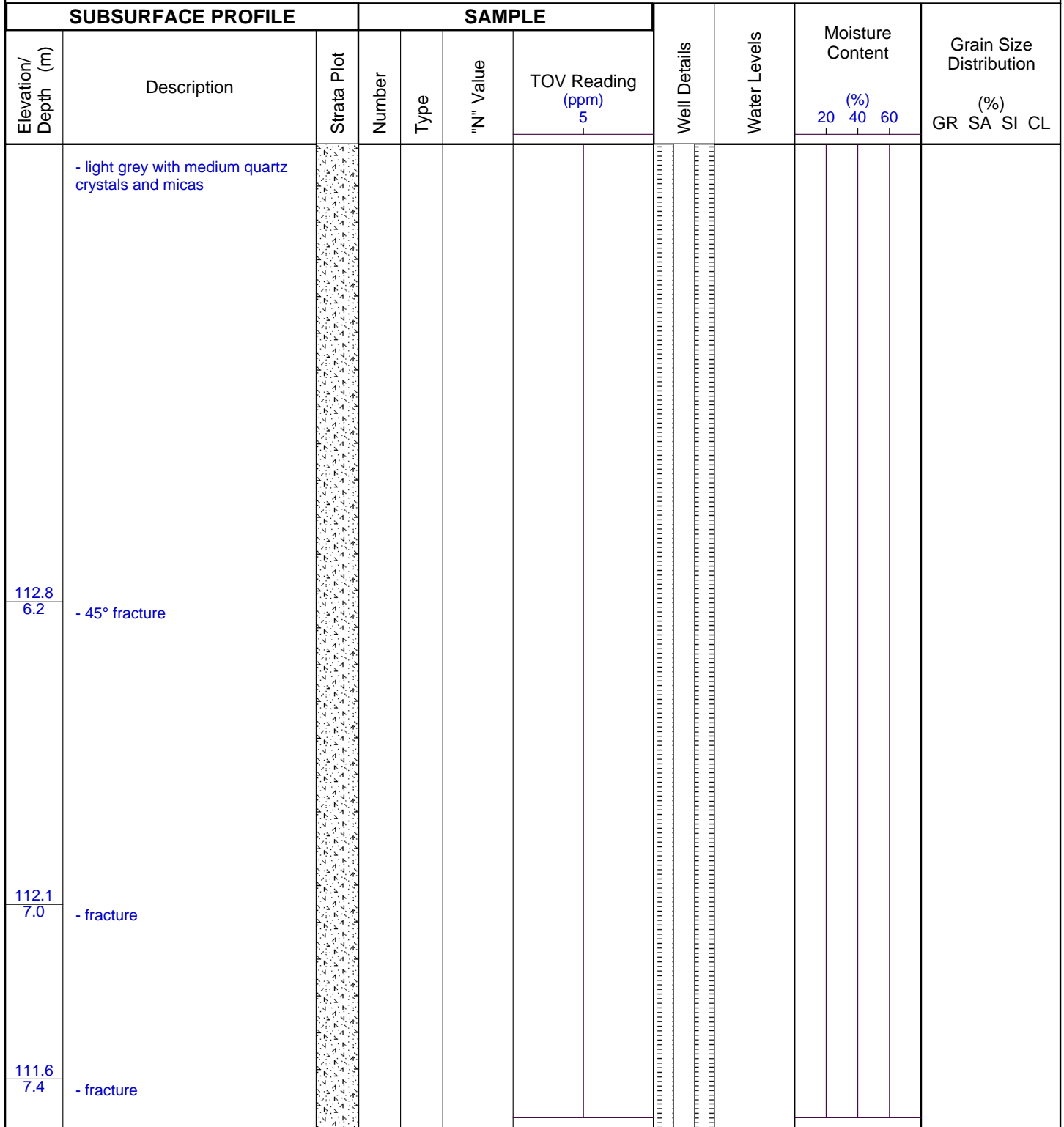
Date: June 2007

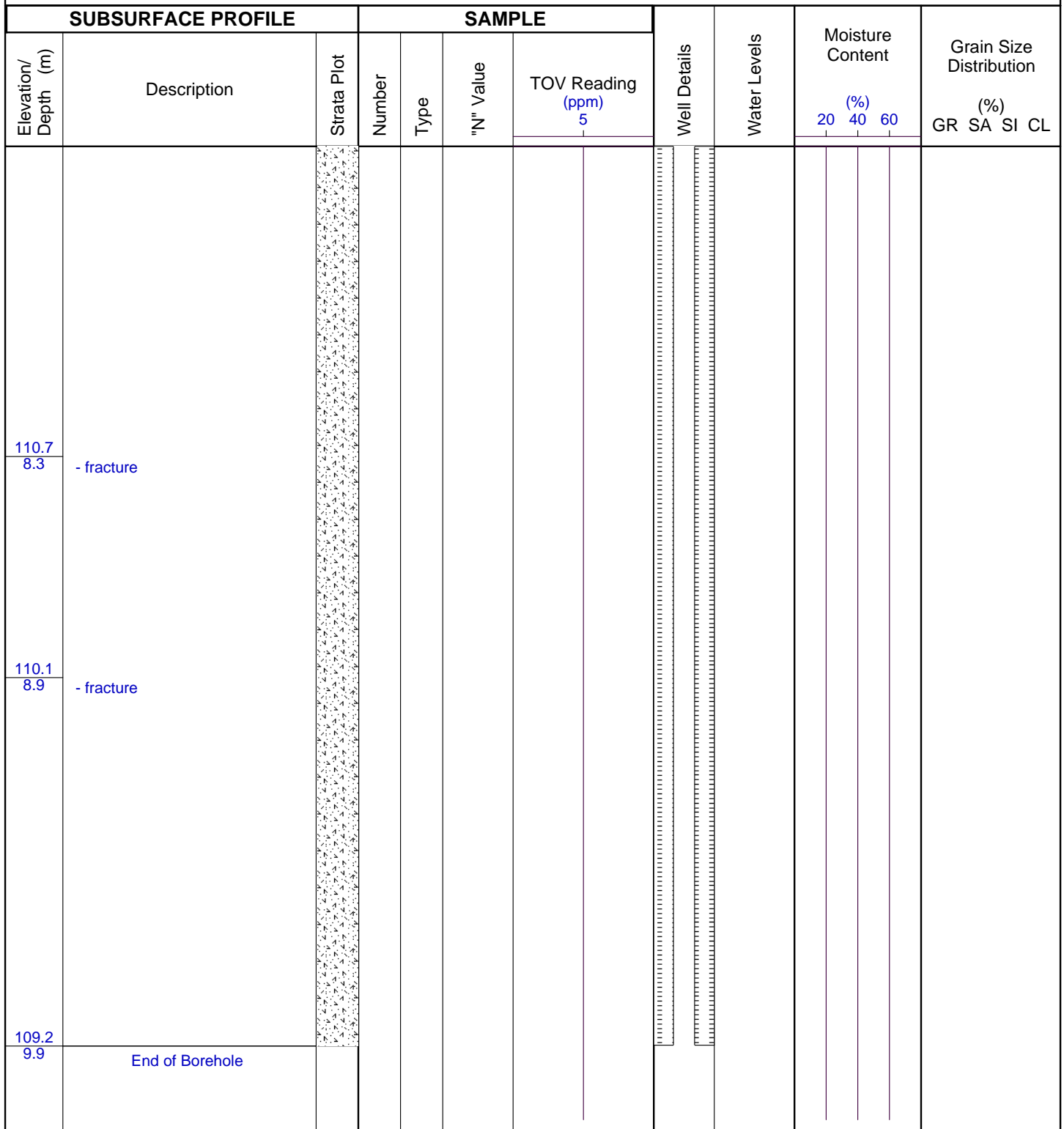
Checked By: D. Stewart

SUBSURFACE PROFILE			SAMPLE					Well Details	Water Levels	Moisture Content			Grain Size Distribution						
Elevation/ Depth (m)	Description	Strata Plot	Number	Type	"N" Value	TOV Reading (ppm)					Moisture Content			Grain Size Distribution					
						0.5	1.5			2.5	3.5	4.5	20	40	60	GR	SA	SI	CL
119.0 0.0	Ground Surface Boulders and cobbles																		
118.7 0.3	Granite																		
118.7 0.3	- light grey with medium quartz crystals and micas																		
	- fracture																		
118.6 0.4	- fracture																		
	- fracture																		
118.6 0.4	- many fractures																		
118.5 0.5	- many fractures																		

July 3 /07

SUBSURFACE PROFILE			SAMPLE				Well Details	Water Levels	Moisture Content			Grain Size Distribution				
Elevation/ Depth (m)	Description	Strata Plot	Number	Type	"N" Value	TOV Reading (ppm)			20	40	60	GR	SA	SI	CL	
116.5 2.6	- 45° fracture with orthoclase															
115.8 3.3	- fracture															
115.4 3.7	- fracture															
114.9 4.2	- fracture with oxidization															
114.7 4.3	- dark grey with very small micas, fracture															
114.6 4.5	- fracture															
114.5 4.6	- fracture															
114.4 4.7	- 45° fracture															
114.2 4.8	- fracture															
114.0																





Sheet: 2 of 7

Originated By: L. Roberts

Contractor: Marathon Drilling

Checked By: D. Stewart

[illegible]

Log of Borehole: MW3

Sheet: 4 of 7

WP: 4067-03-001

Co-ordinates: 389297, 5032341

Originated By: L. Roberts

Project: Highway 17 Twinning


Borehole Type: Hollow Stem/NQ Diamond Drilling

Contractor: Marathon Drilling

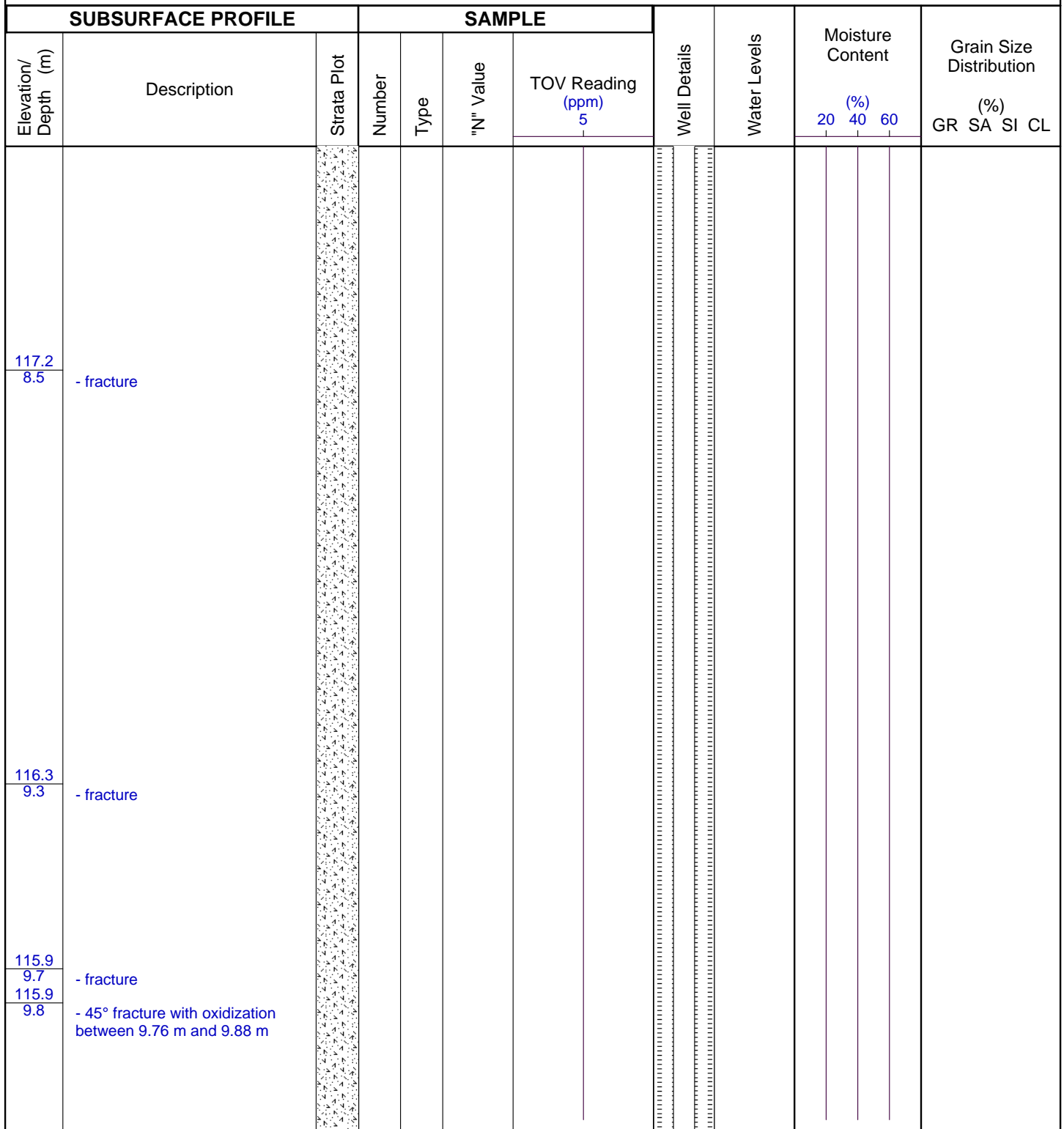
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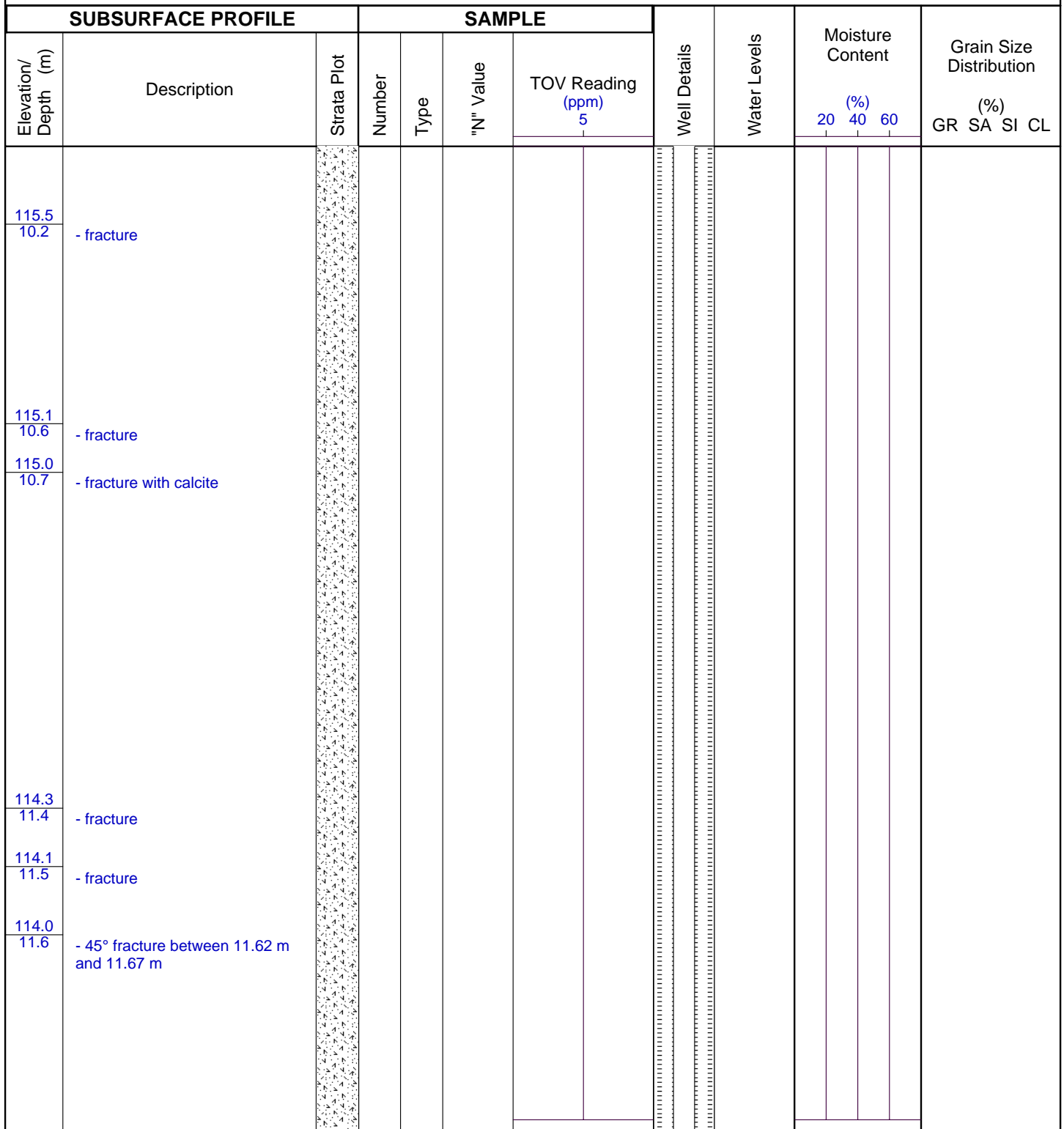
Date: June 2007

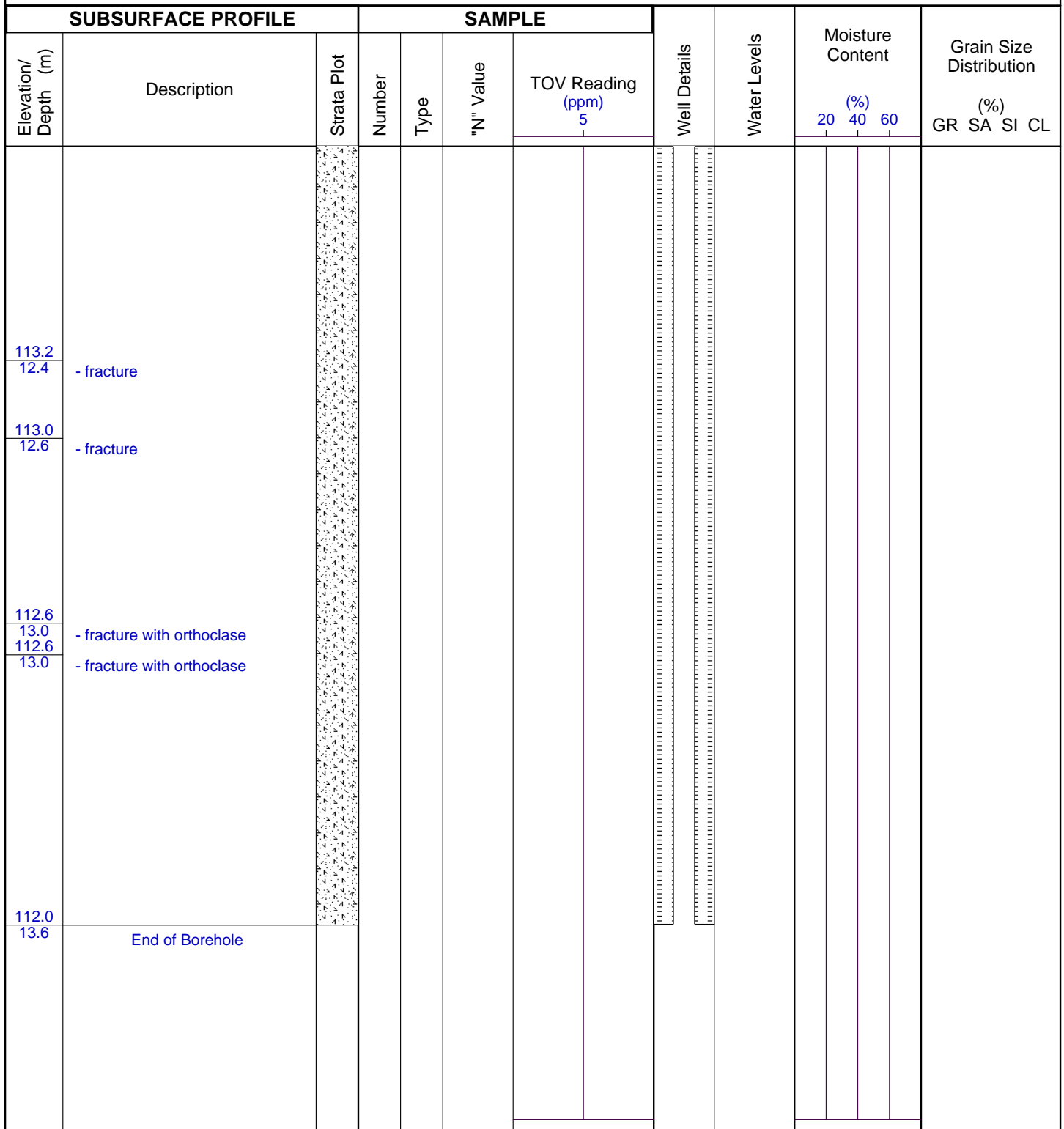
Checked By: D. Stewart

SUBSURFACE PROFILE			SAMPLE				Well Details	Water Levels	Moisture Content			Grain Size Distribution				
Elevation/ Depth (m)	Description	Strata Plot	Number	Type	"N" Value	TOV Reading (ppm)			20	40	60	GR	SA	SI	CL	
						5										
119.5 6.2	- fracture with calcite															
119.3 6.3	- fracture															
119.1 6.5	- fracture															
119.0 6.7	- fracture with calcite															
118.7 7.0	- fracture															
118.6 7.1	- vertical quartz vein 2.5 cm wide between 7.06 m and 7.14 m															
118.4 7.2	- fracture															
118.3 7.3	- fracture															
117.9 7.7	- fracture															
117.7 8.0	- fracture															

July 3 /07







Log of Borehole: MW4

Sheet: 2 of 4

WP: 4067-03-001

Co-ordinates: 389170, 5032437

Originated By: L. Roberts

Project: Highway 17 Twinning

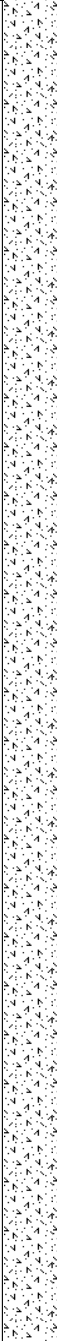
Borehole Type: Hollow Stem/NQ Diamond Drilling

Contractor: Marathon Drilling

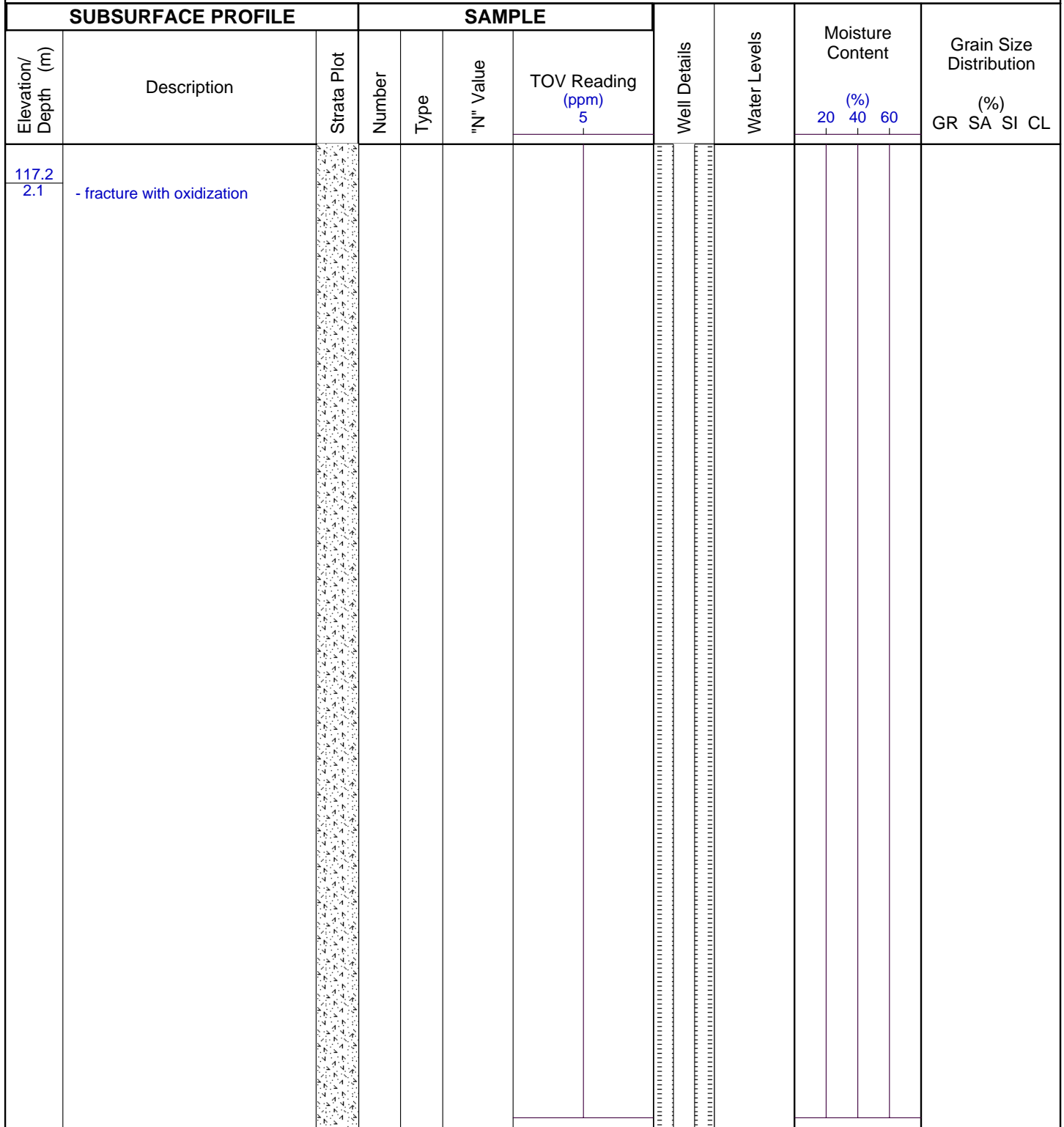
Datum: Geodetic

Date: June 2007

Checked By: D. Stewart

SUBSURFACE PROFILE			SAMPLE				Well Details	Water Levels	Moisture Content			Grain Size Distribution			
Elevation/ Depth (m)	Description	Strata Plot	Number	Type	"N" Value	TOV Reading			(%) 20 40 60	(%) GR SA SI CL					
						(ppm) 5									
	- fracture with medium brown sand, some grey clay														
121.2															
2.8	- fracture														
121.1															
2.9	- fracture														
	- fracture with calcite														
120.9															
3.1	- fracture														
120.4	- fracture														
3.6															
120.2	- fracture														
3.8															
120.0	- 45° fracture with orthoclase, calcite and oxidization between 3.94 m and 4.01 m														
3.9															
119.7	- fracture														
4.3															
										</					

July 3 /07




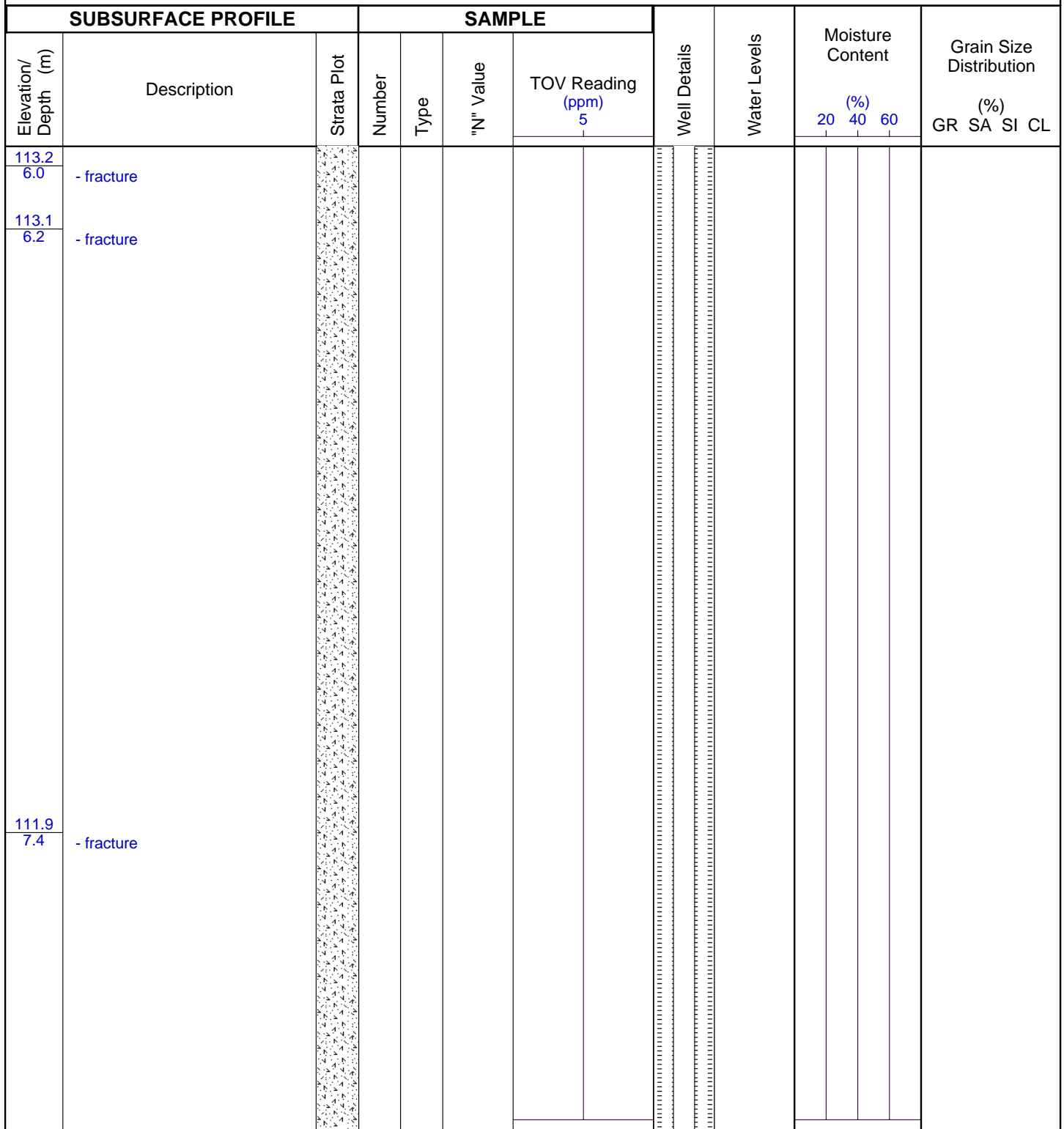
Sheet: 3 of 5

Originated By: L. Roberts

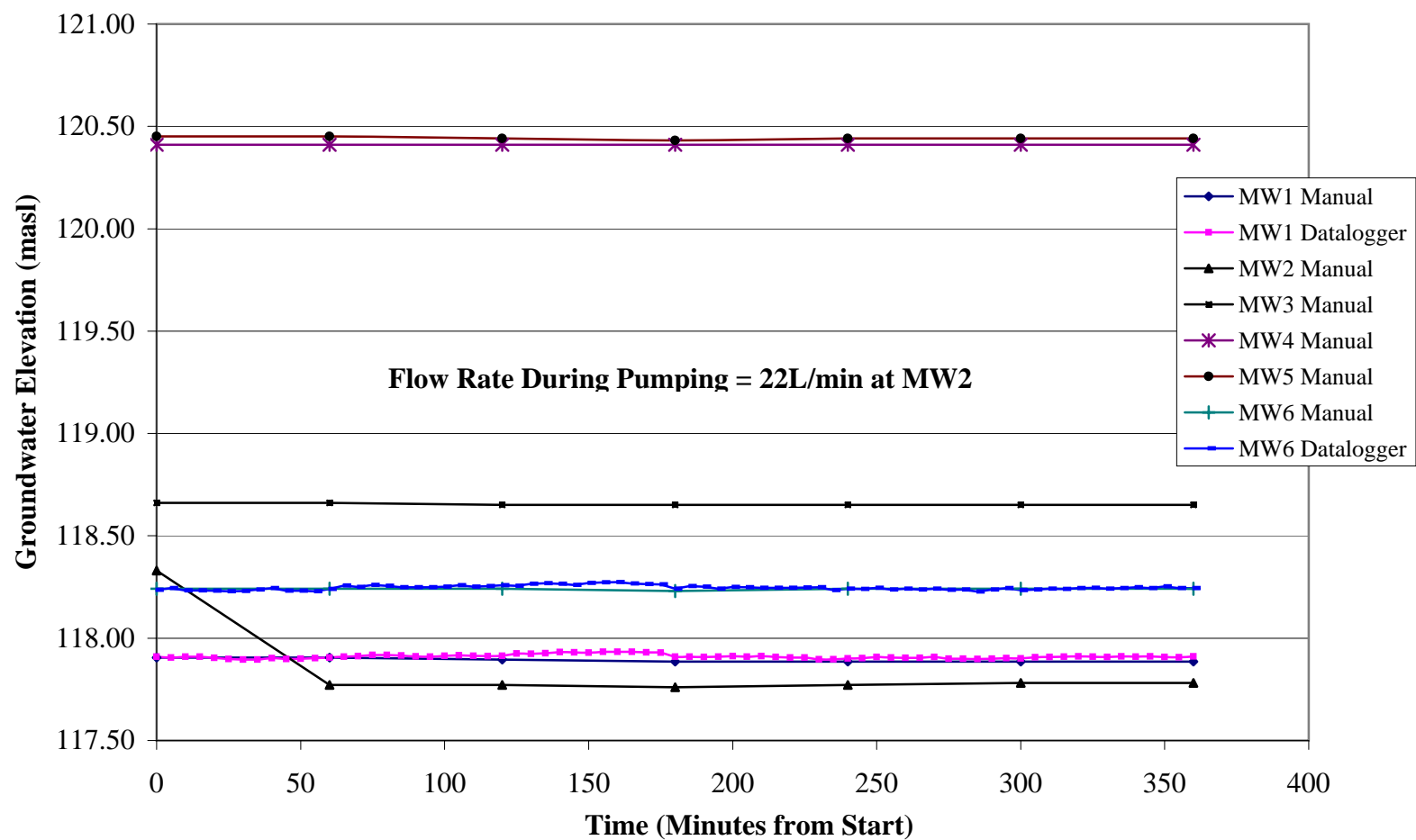
Contractor: Marathon Drilling

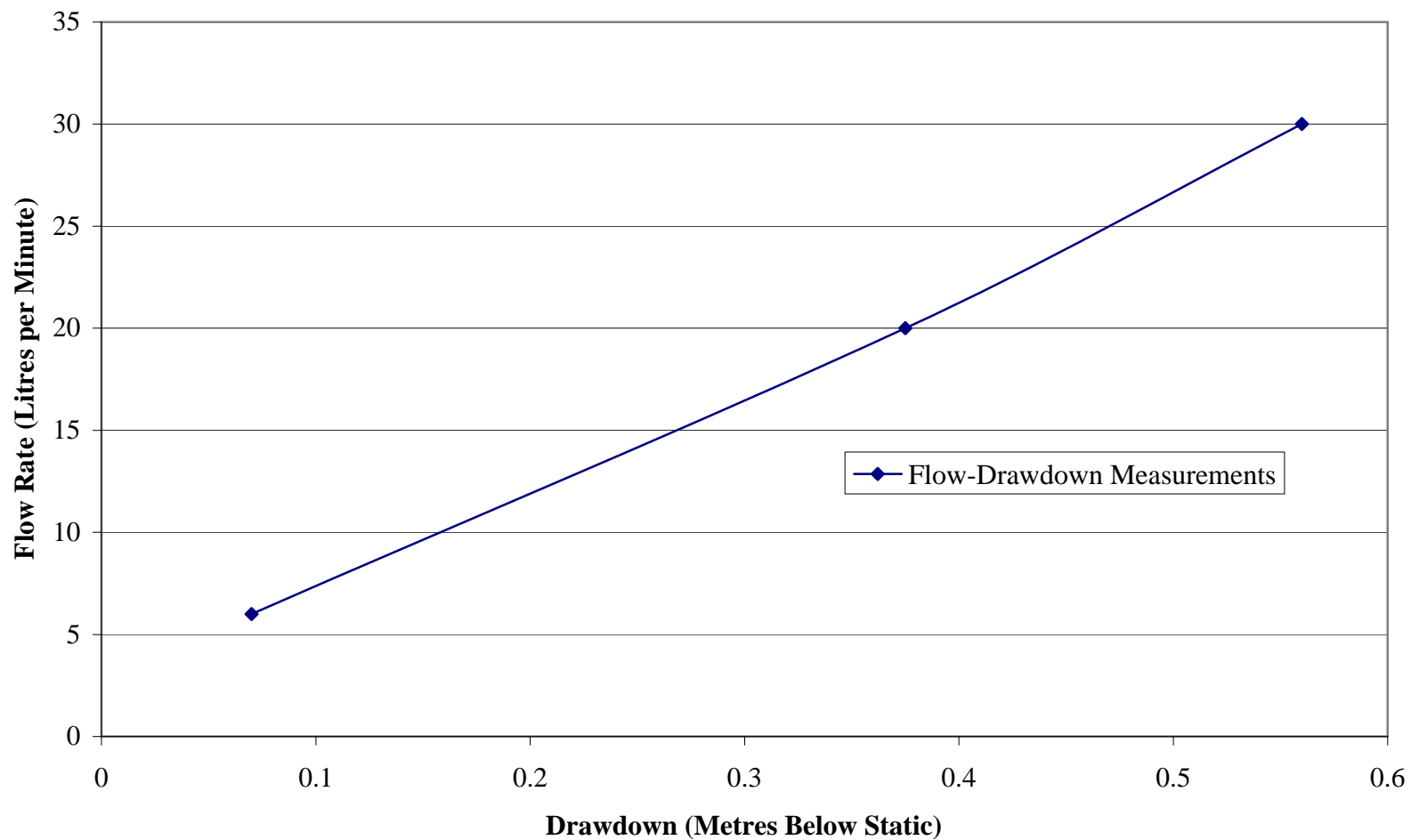
Checked By: D. Stewart

SUBSURFACE PROFILE			SAMPLE				Well Details	Water Levels	Moisture Content			Grain Size Distribution				
Elevation/ Depth (m)	Description	Strata Plot	Number	Type	"N" Value	TOV Reading (ppm)			20	40	60	GR	SA	SI	CL	
						5										
114.9 4.3	- fracture															
114.6 4.6	- fracture															
114.3 5.0	- fracture with oxidization															
	- fracture with oxidization															
	- fracture with oxidization															
114.1 5.2	- fracture															
113.5 5.7	- fracture															
113.3 6.0	- fracture															



APPENDIX C
HYDRAULIC TESTING RESULTS



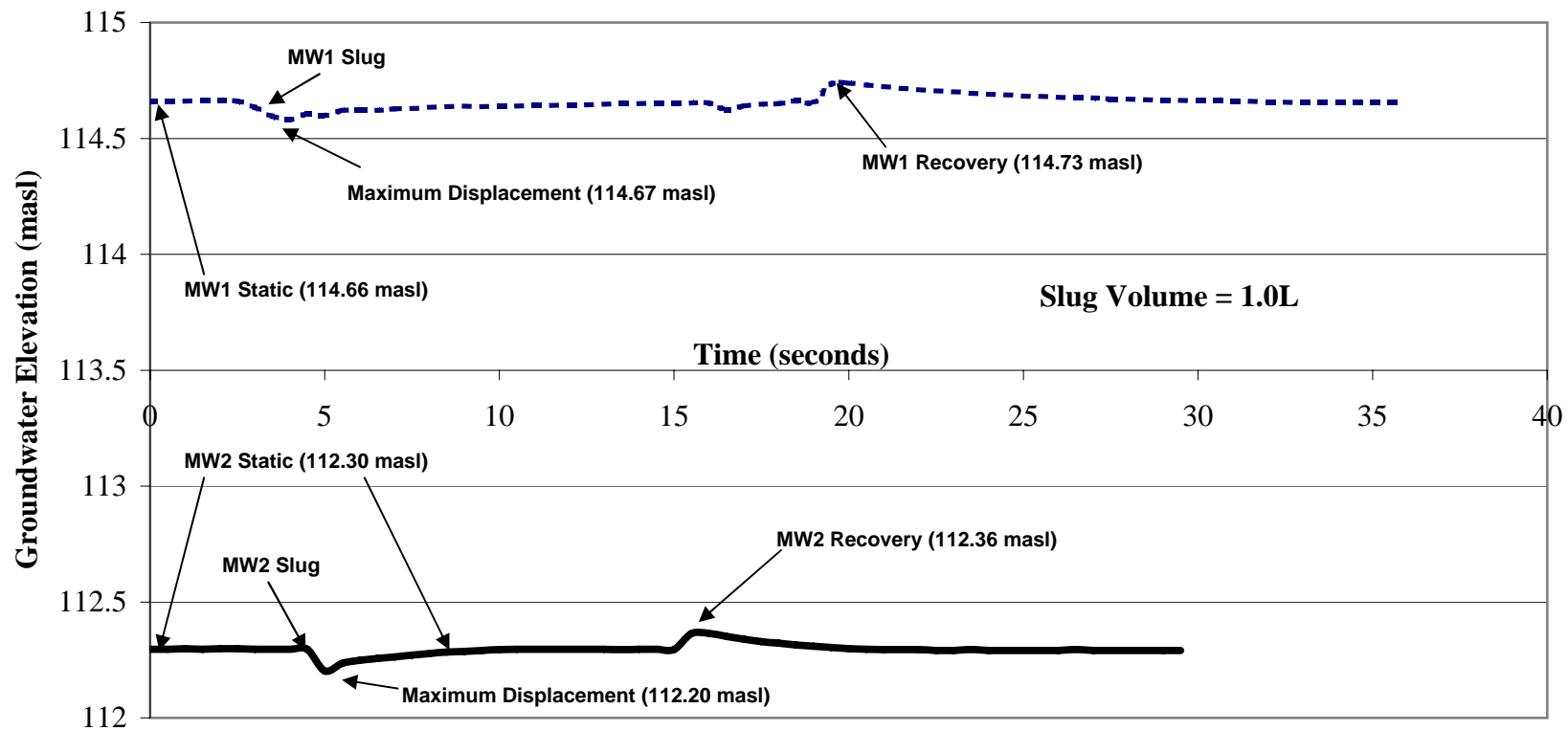


**HYDROGEOLOGICAL INVESTIGATION AND DESIGN REPORT
HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
GWP 4067-03-00
Constant Head Test Results**

DATE:
Feb. 2008

PROJECT:
R07-0261

**FIGURE
C-2**



HYDROGEOLOGICAL INVESTIGATION AND DESIGN REPORT
HIGHWAY 17 TWINNING CAMBELL DRIVE TO SCHEEL DRIVE, ONTARIO
GWP 4067-03-00
Falling and Rising Head Test Results

DATE:
 Feb. 2008
PROJECT:
 R07-0261

FIGURE
C-3

APPENDIX D
LABORATORY CERTIFICATES OF ANALYSIS



Certificate of Analysis

AGAT WORK ORDER: 07T231877
PROJECT NO: R07-0261

5623 McADAM ROAD
MISSISSAUGA, ON
CANADA L4Z 1N9

PH: (905)501-9998
FAX: (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: ECOPLANS LTD.

ATTENTION TO: DEREK STEWART

O. Reg 153 Petroleum Hydrocarbon F1 - F4 in Water

DATE SAMPLED: Jul 05, 2007

DATE RECEIVED: Jul 06, 2007

DATE REPORTED: Jul 13, 2007

SAMPLE TYPE: Water

	Unit	G / S	M.D.L	MW1 750090	MW2 750093	MW4 750103	MW5 750113	MW6 750123	MW7 750133
Benzene	µg/L	5.0	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	µg/L	24	0.2	<0.2	<0.2	0.32	<0.2	<0.2	<0.2
Ethylbenzene	µg/L	2.4	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Xylenes (Total)	µg/L	300	0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14
C6 - C10 (F1)	µg/L		100	<100	<100	<100	<100	<100	<100
C6 - C10 (F1 minus BTEX)	µg/L		100	<100	<100	<100	<100	<100	<100
C>10 - C16 (F2)	µg/L		100	<100	<100	<100	<100	<100	<100
C6 - C16 (F1 + F2)	µg/L	1000	100	<100	<100	<100	<100	<100	<100
C>16 - C34 (F3)	µg/L		500	<500	<500	<500	<500	<500	<500
C>34 - C50	µg/L		500	<500	<500	<500	<500	<500	<500
C>16 - C50 (F3 + F4)	µg/L	1000	500	<500	<500	<500	<500	<500	<500
Gravimetric Heavy Hydrocarbons	µg/L		500	NA	NA	NA	NA	NA	NA

Comments: M.D.L - Method Detection Limit; G / S - Guideline / Standard: Refers to T2(PGW)

750090-750133

The C6-C10 fraction is calculated using Toluene response factor.

The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and n-C34.

Gravimetric Heavy Hydrocarbons are not included in the Total C16 - C50 and are only determined if the chromatogram of the C34 - C50 Hydrocarbons indicated that hydrocarbons >C50 are present.

Total C6-C50 results are corrected for BTEX contributions.

This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.

nC6 and nC10 response factors are within 30% of Toluene response factor.

nC10, nC16 and nC34 response factors are within 10% of their average.

C50 response factor is within 70% of nC10 + nC16 nC34 average.

Linearity is within 15%.

Extraction and holding times were met for this sample.

Fractions 1-4 are quantified with the contribution of PAHs. Under Ontario Regulation 153, results are considered valid without determining the PAH contribution if not requested by the client.

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 07T231877
PROJECT NO: R07-0261

5623 McADAM ROAD
MISSISSAUGA, ON
CANADA L4Z 1N9

PH: (905)501-9998
FAX: (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: ECOPLANS LTD.

ATTENTION TO: DEREK STEWART

Ground Water Custom Package (Project # R07-0261)

DATE SAMPLED: Jul 05, 2007

DATE RECEIVED: Jul 06, 2007

DATE REPORTED: Jul 13, 2007

SAMPLE TYPE: Water

	Unit	G / S	M.D.L	MW1 750090	MW2 750093	MW4 750103	MW5 750113	MW6 750123	MW7 750133	767 Campbell 750159
Fluoride	mg/L		0.05	0.13	0.38	0.35	0.12	0.12	0.14	1.49
Chloride	mg/L	250	0.10	52.9	290	238	14.5	2.96	2.92	26.8
Bromide	mg/L		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrate as N	mg/L	10	0.05	<0.05	0.06	0.46	<0.05	<0.05	<0.05	<0.05
Nitrite as N	mg/L	1	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphate	mg/L		0.10	10.5	17.7	602	9.09	9.69	9.51	14.0
pH	N/A		N/A	8.17	8.07	12.1	7.94	8.10	8.09	8.48
Electrical Conductivity	uS/cm		2	649	1160	4480	468	410	411	519
Aluminum	µg/L		1.00	5.30	5.18	10.5	3.99	3.20	2.42	1.16
Antimony	µg/L	6.0	1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Arsenic	µg/L	25	0.60	<0.60	<0.60	2.07	<0.60	<0.60	<0.60	2.37
Barium	µg/L	1000	0.50	46.6	68.7	113	60.1	45.8	46.5	201
Beryllium	µg/L	4.0	1.50	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50	<1.50
Bismuth	µg/L		0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Boron	µg/L	5000	10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	57.4
Cadmium	µg/L	5.0	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chromium	µg/L	50	1.00	2.92	2.88	152	1.58	1.78	2.21	2.46
Cobalt	µg/L	100	0.50	<0.50	0.50	<0.50	<0.50	<0.50	<0.50	0.76
Copper	µg/L	23	0.80	1.85	3.76	6.48	1.96	1.49	1.64	0.96
Iron	µg/L		10.0	242	358	998	207	702	745	588
Lead	µg/L	10	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Lithium	ug/L		10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Manganese	µg/L		0.60	52.0	15.7	<0.60	2.02	38.4	40.2	55.6
Molybdenum	µg/L	7300	0.50	1.71	1.89	55.9	<0.50	20.2	20.1	0.78
Nickel	µg/L	100	1.00	1.08	3.06	<1.00	<1.00	1.52	1.51	<1.00
Phosphorus	µg/L		20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
Selenium	µg/L	10	0.80	<0.80	<0.80	3.37	<0.80	1.18	<0.80	<0.80
Silicon	mg/L		0.10	2.95	2.99	1.56	4.78	3.19	3.36	8.18
Silver	µg/L	1.2	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Strontium	µg/L		0.50	255	360	2090	211	366	370	2990
Sulfur	mg/L		0.20	3.75	6.27	226	3.16	3.36	3.37	5.44

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 07T231877
PROJECT NO: R07-0261

5623 McADAM ROAD
MISSISSAUGA, ON
CANADA L4Z 1N9

PH: (905)501-9998
FAX: (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: ECOPLANS LTD.

ATTENTION TO: DEREK STEWART

Ground Water Custom Package (Project # R07-0261)

DATE SAMPLED: Jul 05, 2007

DATE RECEIVED: Jul 06, 2007

DATE REPORTED: Jul 13, 2007

SAMPLE TYPE: Water

	Unit	G / S	M.D.L	MW1 750090	MW2 750093	MW4 750103	MW5 750113	MW6 750123	MW7 750133	767 Campbell 750159
Thallium	µg/L	2.0	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Tin	µg/L		1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Titanium	µg/L		1.00	<1.00	<1.00	6.66	<1.00	<1.00	<1.00	<1.00
Uranium	µg/L		0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.32
Vanadium	µg/L	200	0.40	2.33	4.31	4.70	2.36	1.58	1.49	1.66
Zinc	µg/L		5.0	6.7	17.7	9.2	9.1	8.4	6.3	6.1
Calcium	mg/L		0.05	89.4	86.3	310	82.5	75.5	77.8	37.7
Magnesium	mg/L		0.05	11.3	14.0	<0.05	10.0	11.6	12.1	25.9
Sodium	mg/L	200	0.05	47.0	176	405	8.89	4.87	4.92	46.5
Potassium	mg/L		0.05	1.14	2.38	135	0.83	1.35	1.42	9.50
Total Kjeldahl Nitrogen	mg/L		0.10	0.41	0.61	8.19	0.34	0.51	0.28	0.49
Ammonia as N	mg/L		0.02	<0.02	<0.02	3.96	<0.02	<0.02	<0.02	0.07
Total Hardness	mg CaCO3/L			270	273	774	247	236	244	201
Total Organic Carbon	mg/L		0.5	2.6	6.3	6.8	1.6	1.8	1.8	1.1
Total Dissolved Solids	mg/L		20	364	600	1870	268	244	244	306
Total Suspended Solids	mg/L		10	834	26	394	153	75	72	<10
Total Phosphorus	mg/L		0.05	0.07	0.93	0.15	0.07	<0.05	<0.05	<0.05

Comments: M.D.L - Method Detection Limit; G / S - Guideline / Standard: Refers to T2(PGW)

750090-750159 < - Values refer to Method Detection Limits.

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 07T233620
PROJECT NO: R07-0261

5623 McADAM ROAD
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<http://www.agatlabs.com>

CLIENT NAME: ECOPLANS LTD.

ATTENTION TO: DEREK STEWART

O. Reg 153 Petroleum Hydrocarbon F1 - F4 in Water

DATE SAMPLED: Jul 18, 2007

DATE RECEIVED: Jul 19, 2007

DATE REPORTED: Jul 30, 2007

SAMPLE TYPE: Water

	Unit	G / S	M.D.L	mw 3 758682
Benzene	µg/L	5.0	0.2	<0.2
Toluene	µg/L	24	0.2	<0.2
Ethylbenzene	µg/L	2.4	0.1	<0.1
Xylenes (Total)	µg/L	300	0.14	<0.14
C6 - C10 (F1)	µg/L		100	<100
C6 - C10 (F1 minus BTEX)	µg/L		100	<100
C>10 - C16 (F2)	µg/L		100	<100
C6 - C16 (F1 + F2)	µg/L	1000	100	<100
C>16 - C34 (F3)	µg/L		500	<500
C>34 - C50	µg/L		500	<500
C>16 - C50 (F3 + F4)	µg/L	1000	500	<500
Gravimetric Heavy Hydrocarbons	µg/L		500	NA

Comments: M.D.L - Method Detection Limit; G / S - Guideline / Standard: Refers to T2(PGW)

758682

The C6-C10 fraction is calculated using Toluene response factor.

The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and n-C34.

Gravimetric Heavy Hydrocarbons are not included in the Total C16 - C50 and are only determined if the chromatogram of the C34 - C50 Hydrocarbons indicated that hydrocarbons >C50 are present.

Total C6-C50 results are corrected for BTEX contributions.

This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.

nC6 and nC10 response factors are within 30% of Toluene response factor.

nC10, nC16 and nC34 response factors are within 10% of their average.

C50 response factor is within 70% of nC10 + nC16 nC34 average.

Linearity is within 15%.

Extraction and holding times were met for this sample.

Fractions 1-4 are quantified with the contribution of PAHs. Under Ontario Regulation 153, results are considered valid without determining the PAH contribution if not requested by the client.

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 07T233620
PROJECT NO: R07-0261

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PH: (905)501-9998
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CLIENT NAME: ECOPLANS LTD.

ATTENTION TO: DEREK STEWART

Ground Water Custom Package (Project # R07-0261)

DATE SAMPLED: Jul 18, 2007

DATE RECEIVED: Jul 19, 2007

DATE REPORTED: Jul 30, 2007

SAMPLE TYPE: Water

	Unit	G / S	M.D.L	mw 3 758682
Fluoride	mg/L		0.05	0.13
Chloride	mg/L	250	0.10	338
Bromide	mg/L		0.05	<0.05
Nitrate as N	mg/L	10	0.05	0.64
Nitrite as N	mg/L	1	0.05	<0.05
Sulphate	mg/L		0.10	31.5
pH	N/A		N/A	7.56
Electrical Conductivity	uS/cm		2	1740
Aluminum	µg/L		1.00	4.09
Antimony	µg/L	6.0	1.00	<1.00
Arsenic	µg/L	25	0.60	<0.60
Barium	µg/L	1000	0.50	64.7
Beryllium	µg/L	4.0	1.50	<1.50
Bismuth	µg/L		0.50	<0.50
Boron	µg/L	5000	10.0	<10.0
Cadmium	µg/L	5.0	0.50	<0.50
Chromium	µg/L	50	1.00	21.4
Cobalt	µg/L	100	0.50	<0.50
Copper	µg/L	23	0.80	4.13
Iron	µg/L		10.0	<10.0
Lead	µg/L	10	0.50	<0.50
Lithium	ug/L		10.0	<10.0
Manganese	µg/L		0.60	3.25
Molybdenum	µg/L	7300	0.50	0.67
Nickel	µg/L	100	1.00	1.67
Phosphorus	mg/L		0.02	<0.02
Selenium	µg/L	10	0.80	<0.80
Silicon	mg/L		0.10	4.41
Silver	µg/L	1.2	0.50	<0.50
Strontium	µg/L		0.50	353
Sulfur	mg/L		0.20	12.7

Certified By:



Certificate of Analysis

AGAT WORK ORDER: 07T233620
PROJECT NO: R07-0261

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CLIENT NAME: ECOPLANS LTD.

ATTENTION TO: DEREK STEWART

Ground Water Custom Package (Project # R07-0261)

DATE SAMPLED: Jul 18, 2007

DATE RECEIVED: Jul 19, 2007

DATE REPORTED: Jul 30, 2007

SAMPLE TYPE: Water

	Unit	G / S	M.D.L	mw 3 758682
Thallium	µg/L	2.0	0.50	<0.50
Tin	µg/L		1.00	<1.00
Titanium	µg/L		1.00	1.03
Uranium	µg/L		0.20	0.30
Vanadium	µg/L	200	0.40	4.75
Zinc	µg/L		5.0	6.8
Calcium	mg/L		0.05	84.5
Magnesium	mg/L		0.05	11.9
Sodium	mg/L	200	0.05	316
Potassium	mg/L		0.05	1.69
Total Kjeldahl Nitrogen	mg/L		0.10	<0.10
Ammonia as N	mg/L		0.02	<0.02
Total Hardness	mg CaCO3/L			260
Total Organic Carbon	mg/L		0.5	7.9
Total Dissolved Solids	mg/L		20	920
Total Suspended Solids	mg/L		10	1360
Total Phosphorus	mg/L		0.05	0.27

Comments: M.D.L - Method Detection Limit; G / S - Guideline / Standard: Refers to T2(PGW)
758682 < - Values refer to Method Detection Limits.

Certified By:

APPENDIX E
LABORATORY GRAIN SIZE AND MOISTURE CONTENT
ANALYSIS



Project No. 19-5038-2

Laboratory Test Results**Hydrometer Test Results:**

Particle Size (mm)	BH-5 2.5-4.5'	Particle Size (mm)	BH-5 5-7'
12.5	100	12.5	100
9.5	95.4	9.5	100
4.75	89.6	4.75	99.6
2.0	81.5	2.0	94.4
0.85	76.6	0.85	89.3
0.425	70.8	0.425	82.8
0.25	63.4	0.25	75.6
0.15	52.7	0.15	66.8
0.075	40.3	0.075	55.9
0.0483	29.2	0.0471	41.4
0.0348	24.4	0.0340	35.8
0.0223	21.1	0.0220	29.2
0.0129	19.5	0.0129	24.5
0.0092	17.1	0.0093	18.9
0.0066	13.0	0.0066	16.1
0.0047	11.4	0.0047	13.3
0.0033	10.6	0.0033	11.4
0.0025	9.8	0.0025	9.5
0.0014	7.4	0.0014	7.6

Moisture Content Results:

Sample ID	% Moisture
BH-5 at 2.5-4.5'	15.22
BH-5 at 5-7'	9.60

Laboratory Testing GRAIN SIZE DISTRIBUTION

FIGURE 1

