



November 2010
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REVISED REPORT

GEOTECHNICAL INVESTIGATION

Highway 401 Undercrossing Trunk Sanitary Sewer 8th Concession Road Windsor, Ontario

Submitted to:
Mr. Tim Glos, P.Eng.
Glos Associates Inc.
3535 North Service Road
Windsor, Ontario
N8W 5R7

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GEOTECHNICAL INVESTIGATION HIGHWAY 401 UNDERCROSSING

December 2, 2010

Project No. 10-1140-0096-R01

Glos Associates Inc.
3535 North Service Road
Windsor, Ontario
N8W 5R7

Attention: Mr. Tim Glos, P.Eng.

**GEOTECHNICAL INVESTIGATION
HIGHWAY 401 UNDERCROSSING
TRUNK SANITARY SEWER
8TH CONCESSION ROAD
WINDSOR, ONTARIO**

Dear Mr. Glos

This report presents the results of a geotechnical investigation carried out for the design of the trunk sanitary sewer from the north side of Highway 401, beneath Highway 401, to County Road 46 in the City of Windsor and the Town of Tecumseh. The approximate location of the site is shown on the Key Plan, Figure 1.

The purpose of the investigation was to determine the subsurface soil and groundwater conditions at the site, and to provide geotechnical engineering recommendations for the design of the proposed sewer and road reconstruction works.

The field work was carried out, and this report prepared, in general accordance with our proposal P0-1140-0096, dated August 20, 2010. Authorization to proceed with the work was received from Mr. Tim Glos, P.Eng. of Glos Engineering Inc., on September 13, 2010.

1.0 BACKGROUND

It is proposed to extend the Sandwich South Sanitary Sewer on 8th Concession Road, from the north side of Highway 401 to County Road 46 in the City of Windsor, Ontario. The sewer will be about 750 metres in length and about 1 metre in diameter. The invert of the proposed sewer is expected to be at a depth of about 7.5 metres below the current ground surface. As part of the sewer work, it is proposed to install a 1500 millimetre diameter steel casing to carry the proposed trunk sewer beneath Highway 401. The installation will be carried out using jack and bore techniques with the casing invert being about 8 metres below the ground surface. Jacking and receiving pits will also be required.

It is understood that the geotechnical report prepared for this project will be used to support a Corridor Encroachment Permit Application to the Ministry of Transportation for the Highway 401 undercrossing work. As such we have reviewed the document "Guidelines for Foundation Engineering – Tunnelling Specialty, For



Corridor Encroachment Permit Application, Ministry of Transportation, Pavement and Foundation Section' last updated April 3, 2008 (Guideline). Based on that document, the following geotechnical investigation program was developed.

2.0 INVESTIGATIVE PROCEDURE

The field work for this investigation was carried out on October 7, 8 and 30, 2010 on which dates seven (7) boreholes were advanced to depths of between about 9.8 and 14.3 metres below the ground surface. The boreholes in the Highway 401 corridor were laid out generally consistent with the Guideline mentioned previously. Due to utility conflicts and site conditions, the relocation of several boreholes was required. The approximate location of the boreholes advanced for this project are shown on the Location Plan, Figure 1 and are identified on the Record of Borehole sheets. The boreholes were drilled using a truck mounted power auger equipped with solid stem augers, supplied and operated by BUD Environmental Services, a specialist drilling contractor.

During the drilling, standard penetration testing and soil sampling was carried out at 0.75 metre intervals to a depth of about 6.5 metres and 1.5 metres beyond that depth using conventional 35 millimetre inside diameter split spoon sampling equipment. In-situ vane testing was also carried out in the boreholes to determine the undrained shear strength of softer cohesive soils encountered. The soil samples obtained were examined in the field, placed in individually labelled containers and brought to our Windsor office for further examination, water content determination and representative classification testing. The boreholes were monitored for groundwater seepage during drilling.

The soil stratigraphy and groundwater conditions encountered in the boreholes, as well as the results of field and laboratory testing, are shown in detail on the Record of Borehole sheets following the text of this report and on the Inferred Section, Figure 2. The results of laboratory grain size distribution analyses carried out on selected samples of the native silty clay till encountered at the site are shown on Figure 3.

The field work for this investigation was supervised throughout by an experienced member of our geotechnical engineering staff who located the boreholes in the field, obtained underground utility locates, directed the drilling and sampling operations, logged the boreholes and cared for the soil samples obtained. On completion of drilling the boreholes were abandoned consistent with current regulatory requirements.

3.0 SUBSURFACE CONDITIONS

3.1 General

The subsurface soil and groundwater conditions encountered in the boreholes drilled for this investigation are shown on the attached Record of Borehole sheets. It should be noted that the soil boundaries indicated have



been inferred from non-continuous sampling and observations of drilling resistance. The boundaries typically represent a transition from one soil type to another and are not intended to define exact planes of geological change. Further, the subsurface conditions are established only at the borehole locations and may vary between and beyond the borehole locations.

The subsurface soil conditions encountered at the site generally consisted of topsoil, existing pavement structures, granular shoulder materials and surficial materials, overlying extensive strata of firm to hard, silty clay till.

3.2 Topsoil, Fill and Pavement Structures

From the ground surface in boreholes 1 to 5, inclusive, and 7, brown to black clayey to sandy topsoil fill was encountered to depths of 0.38 to 0.76 metres below the ground surface at the borehole locations. The water content of samples of the topsoil varied between about 13 and 25 per cent.

Underlying the topsoil fill in borehole 1, about 850 millimetres of silty clay fill containing topsoil and sand was encountered. In borehole 2, about 1 metre of silty sand and gravel fill was encountered underlying the topsoil fill. Measured 'N' values from standard penetration testing within the fill materials varied from 4 to 34 blows per 0.3 metres. The water content of samples of the fill materials varied between about 8 to 13 per cent.

Borehole 6 was drilled through the existing pavement structure of 8th Concession Road and encountered 180 millimetres of asphalt, 100 millimetres of concrete and 180 millimetres of granular base material from the road surface.

3.3 Silty Sand

Underlying the topsoil fill material in borehole 3, compact brown silty sand, about 610 millimetres in thickness was encountered. A single measured 'N' value in the sand was 14 blows per 0.3 metres. The water content of the sample of sand obtained was about 18 per cent.

3.4 Silty Clay Till

Beneath the topsoil materials in boreholes 4, 5 and 7, the fill materials in borehole 2 and the granular base materials in borehole 6, firm to stiff, mottled brown and grey silty clay till was encountered. The mottled brown and grey silty clay till ranged in thickness from about 0.6 to 1.3 metres at the borehole locations. Measured 'N' values obtained from standard penetration testing carried out in mottled silty clay till ranged from 6 to 20 blows per 0.3 metres. The water content of samples of mottled silty clay till obtained varied from about 16 to 26 per



cent. Atterberg limits determinations carried out on a sample of the mottled silty clay till yielded plastic and liquid limits of about 20 and 40 per cent, respectively.

Underlying the mottled brown and grey silty clay till in boreholes 2, 4, 5, 6 and 7, silty sand in borehole 3 and the silty clay fill material in borehole 1, stiff to hard brown silty clay till was encountered. The brown silty clay till ranged in thickness from about 1.5 to 3.2 metres at the borehole locations. Measured 'N' values obtained in the brown silty clay till ranged from 12 to 40 blows per 0.3 metres, but were more typically in excess of 30 blows per 0.3 metres. The water content of the samples of brown silty clay till obtained varied from about 10 to 17 per cent. Atterberg limit testing carried out on a sample of the brown silty clay till yielded a plastic limit of about 15 per cent and a liquid limit of about 30 per cent.

Beneath the brown silty clay till, very stiff grey silty clay till was encountered to the termination depths of the boreholes. Occasional thin sand and silt seams or partings were encountered within the grey silty clay till at depth. Measured 'N' values obtained in the grey silty clay till ranged from 6 to 24 blows per 0.3 metres. In-situ vane testing carried out in the grey silty clay till yielded undrained shear strengths varying from about 68 to greater than 96 kPa. The water content of the samples of grey silty clay till obtained varied from about 11 to 19 per cent. Atterberg limit testing carried out on samples of the grey silty clay till yielded an average plastic limit of about 15 per cent and a liquid limit of about 26 per cent.

The results of laboratory grain size distribution analyses carried out on samples of the silty clay till are presented in Figure 3. The results of Atterburg Limits testing are presented on the Plasticity Chart, Figure 4.

3.5 Groundwater Conditions

Boreholes 1, 6 and 7 remained dry during drilling. Slight groundwater seepage was observed in boreholes 4 and 5 at depths of between about 5.3 and 6.1 metres during drilling. Water seepage into the boreholes from the surficial granular materials was observed in boreholes 2 and 3 at depths of about 1.4 metres during drilling. Water seepage was also observed from a sand layer at a depth of about 12.4 metres in borehole 4. The water level in a standpipe installed in borehole 4 was at about 182.18 or some 7.8 metres below the ground surface on November 1, 2010, 2 days following drilling.

4.0 DISCUSSION

4.1 General

This section of the report presents our interpretation of the factual information obtained from the investigation and is intended only for use by the design engineer. Where comments are made on construction, they are provided only in order to highlight aspects of construction which could potentially affect the design of the project. Contractors bidding on or undertaking any work at the site should examine the factual results of the



investigation, satisfy themselves as to the adequacy of the information for construction and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, equipment capabilities, costs, sequencing and the like.

Our professional services for this assignment address only the geotechnical (physical) aspects of the subsurface conditions at this site. The geo-environmental (chemical) aspects, including the consequences of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this report and have not been investigated or addressed.

As indicated, it is proposed to extend the Sandwich South Sanitary Sewer on 8th Concession Road, from the north side of Highway 401 to County Road 46 in the City of Windsor, Ontario. The sewer will be about 750 metres in length and about 1 metre in diameter. The invert of the proposed sewer is expected to be at a depth of about 7.5 metres below the current ground surface. As part of the sewer work, it is proposed to install a 1500 millimetre diameter steel casing to carry the proposed trunk sewer beneath Highway 401. The installation will be carried out using jack and bore techniques with the casing invert being about 8 metres below the ground surface. Jacking and receiving pits will also be required.

5.0 OPEN CUT PORTIONS

5.1 Sewer Excavation

The depth of the invert of the proposed sanitary sewer is understood to be about 7 metres below the current grade. Based on this understanding and the results of this investigation, the base of the sanitary sewer excavations will generally be located in the very stiff, grey silty clay till. The silty clay till founding soil is considered to be competent for sewer pipe support.

All excavations should be carried out in general accordance with the current Occupational Health and Safety Act and Regulations for Construction Projects. For the purposes of the Act, the fill and native soils at the site may be classified as Type '3' soil.

Due to the depth of excavation proposed, it is anticipated that the sewer works will be carried out in a vertical excavation utilizing an engineered support system. The support system should be certified as being designed in accordance with the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The support system should be designed, installed and removed in such a manner that it not only provides protection for the workers, but also provides adequate support for the sides of the excavation.

A recommended earth pressure diagram for the design of the support system is shown on Figure 4.

Adequate provision should be made for the control of surface water adjacent to the open excavations. Assuming the foregoing is carried out, no major groundwater problems are anticipated during construction. Nevertheless, some water seepage into the open excavations should be anticipated from the surficial fill and granular materials



encountered at the site. The inflows can probably be suitably controlled by pumping from properly filtered sumps located within the excavation bottom.

It is recommended that a public dig be carried out during the tender stage to enable prospective contractors to view the soil and groundwater conditions for themselves and to assess the ground control and dewatering requirements. The locations of the test pits should cover the full extent of the project area.

5.2 Protection of Existing Structures

Adjacent to a vertically sided supported excavation, there are several zones in which movement of the surrounding soil may take place, as indicated on Figure 5. Within a zone defined by a line sloped at 2 vertical to 1 horizontal from about 0.6 metres below the base of the excavation, substantial movements may be anticipated. Structures within this zone should be protected. Within a zone bounded by lines sloping at 1 vertical to 1 horizontal and 2 vertical to 1 horizontal, upward and outward from a point located 0.6 metres below the base of the excavation, some settlements may be expected, and within a zone bounded by lines sloping at 1 vertical to 2 horizontal and 1 vertical to 1 horizontal, slight movements may be anticipated.

It is recommended that the alignment and depths of existing utilities be checked relative to the proposed sewer trench(s). In general, if movement of existing utilities and other settlement sensitive elements is to be minimized, it will be necessary to carry out sewer construction in a properly sheeted and braced excavation. If, however, some movement of the adjacent utilities can be tolerated, sewer installation within a prefabricated support system (trench liner box) is probably acceptable.

Longitudinal open sections of the trench(s) should be kept to a minimum and backfilling of the trench(s) should be carried out immediately behind the support system. Any utilities along the proposed route of the sewers that fall within Zones I and II should be continuously monitored during construction so that corrective action can be taken if significant ground movement is observed.

A number of existing utility lines will cross the proposed alignment. Where existing services are exposed during the excavation, suitable temporary or permanent support of these services should be provided consistent with the requirements of the respective utility company.

5.3 Pipe Bedding

The bedding material for the new sewer pipes should consist of an approved granular material, consistent with the type and class of pipe to be used. Granular 'A' is considered to be an appropriate bedding material for the site. The bedding should extend from 150 millimetres below the pipe to at least 300 millimetres above the pipe. The pipe bedding should be uniformly compacted to 95 per cent of the standard Proctor maximum dry density. Hand tamping around the pipe may be required to ensure that no voids are present below the spring line of the



pipe. It is also important to provide a well compacted granular bedding within the approach zone of the pipe(s) at the manholes.

Consideration could also be given to the use of a graded clear stone material known locally as “sewer stone” placed up to the spring line of the pipe. Should clear stone be used it would be prudent to provide seepage collars periodically along the alignment of the sewer pipe.

5.4 General Trench Backfill

The suitability of the backfill materials will be determined in part by the method of excavation. This factor should be recognized when considering the following comments.

The native silty clay till soils are expected to be acceptable for use as general trench backfill at the site. Further, the use of excavated native soils for sewer trench backfill will minimize the material disposal requirements on completion of the work.

The native silty clay till used for general trench backfill should be placed in maximum 300 millimetre thick loose lifts and be uniformly compacted as follows. Where the placement water contents of the silty clay backfill materials are at the optimum water content to 5 per cent wet of the optimum water content for mechanical compaction purposes, the trench backfill material should be uniformly compacted to at least 95 per cent of standard Proctor maximum dry density. If the water content of the backfill is greater than 5 per cent above the optimum water content for mechanical compaction purposes, the material should be uniformly compacted to at least 90 per cent of standard Proctor maximum dry density. Materials should not be considered acceptable as trench backfill when the placement water content exceeds the optimum water content (as determined by the standard Proctor compaction test ASTM D698) by more than 10 per cent. Further, material that is drier than the optimum water content should be wetted during compaction to minimize post construction settlement, or should not be used.

Where the upper one metre of the trench backfill forms a roadway subgrade, it should be uniformly compacted to at least 98 per cent of standard Proctor maximum dry density.

With the backfill recommendations outlined above and the maximum anticipated excavation depths, it is estimated that the long term settlement of the trench backfill may be in the order of about 60 millimetres. If lesser degrees of compaction are achieved, increased settlements will result. Further, if non-uniform compaction of the backfill is achieved, non-uniform settlement of the trench backfill material will result.

For general trench backfill within the roadway, the use of granular backfill such as OPSS Granular ‘B’, Type I could be considered for the upper metre of the trench for support of the pavement structure.



5.5 Pavement Restoration

It is understood that either restoration of disturbed sections of 8th Concession Road or roadway reconstruction will be carried out as part of the sewer work. In either case, the roadworks should be designed as a major collector roadway. For this classification, a pavement structure consisting of 100 millimetres of asphalt and 500 millimetres of Granular 'A' base or 140 millimetres of asphalt and 400 millimetres of Granular 'A' base may be considered. The asphalt materials should consist of HL-4 surface asphalt and HL-8 binder course asphaltic concrete.

Prior to reconstructing any pavement structures at the site, all softened, loosened and/or otherwise deleterious materials should be removed from within the limits of the roadway. The exposed subgrade should then be heavily proofrolled under the direction of the geotechnical engineer. Any softened areas identified during this operation should be subexcavated and backfilled with approved granular material. The Granular 'A' base materials should be placed in 250 millimetre thick loose lifts and be uniformly compacted to 100 per cent of standard Proctor maximum dry density.

5.6 Trenchless Crossing (Tunnelling)

The sanitary sewer work will include a crossing of Highway 401. It is expected that the sewer installation will be carried out within a steel casing installed using jack and bore techniques. The casing will have an obvert at about 6.5 metres below grade at about elevation 183.4 metres. The invert of the casing is expected to be at about elevation 181.9 metres.

Based on the subsurface conditions encountered in the boreholes, jack and bore techniques are considered suitable for this site. Hand mining of the soil associated with the pipe jacking is also considered suitable and may allow for better directional control of the casing and observations at the tunnel face during excavation. The use of a tunnel boring machine (TBM) could also be considered for the site.

Thin seams or parting of fine grained, granular materials were identified within the predominately silty clay till stratum in the boreholes. Care will have to be taken to minimize loss of ground should water bearing zones be encountered. With care, draining of these discontinuous layers should be possible with little or no loss of ground. Once the granular layers are drained, the operations can continue. On completion of the jacking, **all voids around the pipe** should be grouted to minimize settlement.

The local silty clay till soils are known to occasionally contain cobbles and boulders which could cause the pipe to go off line. Based on these various factors, jacking forces should be continually monitored and the level and alignment of the lead end of the pipe checked routinely.

The jack and bore operations should be carried out in accordance with Ontario Provincial Standard Specifications 416. The augerhead should be kept at least one quarter diameter within the lead end of the casing and should at no time extend beyond the lead end of the casings.



Significant difficulties are not anticipated with squeezing of the silty clay till around the pipe or into the advancing pipe. The skin friction developed around the pipe due to nominal squeezing of the very stiff silty clay till and the like, however, may be sufficient to restrict the size and length of the pipe which can be jacked. The feasibility of the operation should be assessed by the individual contractors tendering the project based on the capability of their equipment. For the initial analyses, it is recommended that an adhesion of 100 kilopascals be used for the disturbed silty clay in contact with the steel casing pipe. It may be possible to reduce the skin friction of the pipe by continuously injecting a bentonite slurry into the annular space outside the pipe as the pipe is advanced.

The undercrossing of Highway 401 must be constructed with the approval of the Ministry of Transportation Ontario (MTO) and in accordance with their regulations including the Guideline as mentioned previously. All trenchless work should be carried out by an experienced specialist contractor employing only qualified workers skilled in their trade under the direction of an experienced foreman. The contractor's work plan should include:

- A proposed course of action should the ground surface settlement review and alert levels discussed below be exceeded.
- A provision for compensation grouting should the need arise; and/or mud jacking of the highway pavement if required.

It is recommended that the geotechnical aspects of the contractor's work plan for the undercrossing be reviewed by this office prior to construction.

The trenchless contractor is advised to carefully expose any underground utilities which cross the bore path to confirm their elevations prior to commencement of drilling.

5.7 Settlement and Settlement Monitoring

The estimated ground surface/pavement settlement directly above the casing pipeline within the Highway 401 right-of-way area is 10 millimetres or less assuming appropriate control of the tunnelling operation is achieved. Settlement monitoring of the Highway 401 undercrossing should be carried out prior to, during and after the casing installation to assess any impacts on the highway. In addition, the undercrossing construction should be monitored by qualified personnel.

A monitoring program consisting of eighteen (18) surface settlement points is recommended. Ten (10) would be located behind the guardrails at the edges of the roadway embankment and seven (7) within the paved roadway and median. In addition, one deep monitoring point about midway between the sending pit and the roadway is recommended. The proposed locations of the settlement points are shown in plan on Figure 7.

The ten (10) surface settlement points consisting of two arrays of 5 points located on the outermost shoulders would be comprised of threaded rods and washers installed and concreted into augerholes to below the frost zone. Each row of five settlement points will include one located at the pipeline centreline and pairs offset 4 and 8 metres from the centerline of the pipeline crossing.

The transverse line of seven (7) settlement points would consist of nails spaced approximately 5 metres apart and embedded in the pavement and median wall and marked with flagging or paint. This line would be situated



directly above the pipeline centerline. The deep monitor should be installed above the pipe centreline at about one diameter above the pipe.

A condition survey to document the existing pavement condition should be carried out prior to the start of construction. A baseline survey of the monitoring array should be carried out at least twice, prior to construction, with the points referenced to two independent benchmarks. Anomalous readings should be rechecked and/or discarded, as necessary. Acceptance of the baseline survey by all parties should be acknowledged in writing.

Monitoring should be carried out at least three times daily during the construction period, including during temporary work stoppages, non-operational periods and weekends. More frequent readings will be required if anomalous conditions are encountered or alert levels are being approached or exceeded. Once construction has ceased, monitoring should continue weekly for the first month and subsequently monthly for at least three months after completion of the crossing. The monitoring data will be evaluated to see if the magnitude of any movements detected during construction warrant continued monitoring beyond a period of two months following the crossing installation. Anomalous reading should be rechecked and/or discarded, as necessary. The transverse line of monitors within the travelled roadway and median should be read at least twice prior to the start of construction, at the end of construction and at suitable intervals if the results of the monitors situated behind the guardrails suggest that such readings are necessary.

The monitoring frequencies recommended above should be increased if review or alert levels are exceeded. If a total recorded movement of 10 millimetres relative to the baseline readings is achieved, this will trigger a review of the contractor's methods including construction rate, sequence and ground stabilization methods with a view to arresting excessive movements. An alert level of 15 millimetres relative to the baseline movements requires cessations of construction. At this point, implementation of pre-planned settlement mitigation measures is required to assure public safety and maintain traffic flow.

5.8 Sending and Receiving Pits

The sending pit and receiving pit for the pipe jacking operations will be about 8 to 9 metres in depth. The sending and receiving pits will likely be comprised of braced and sheeted excavations. The soils anticipated at the pit locations may be classified as Type 3 soils under the Occupational Health and Safety Act. The sheeted excavation may be designed using the lateral earth pressure diagram shown on Figure 4. The shoring system should also be designed to support any surcharge loading from the construction operations and adjacent roadway embankments. Based on the anticipated excavation configuration the excavations are expected to have adequate factors of safety against basal instability.

If the pits are constructed in areas where post-construction settlements are a concern, they should be backfilled with OPSS Granular 'B', Type I material, placed in maximum 300 millimetre thick loose lifts and uniformly compacted to 98 per cent of standard Proctor maximum dry density. If post-construction settlement is not a concern, the excavated silty clay till from the pits could be used for subsequent backfilling of the pits. The silty clay backfill should be placed in maximum 300 millimetre thick loose lifts and uniformly compacted to at least 95 per cent of standard Proctor maximum dry density.



GEOTECHNICAL INVESTIGATION HIGHWAY 401 UNDERCROSSING

To ensure the recommendations outlined above are followed, it is recommended that on site inspection by the geotechnical engineer be carried out during the pipe jacking works.

6.0 GEOTECHNICAL INSPECTION AND TESTING

This office should be given an opportunity to review the final design drawings to ensure that they are consistent with the recommendations contained within this report.

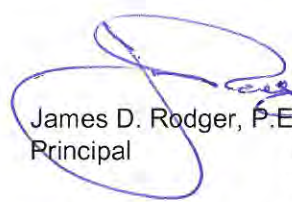
To ensure that construction is carried out in a manner consistent with the intent of the recommendations set forth in this report, a program of geotechnical inspection and testing should be developed and implemented throughout the construction phase. In addition, related laboratory testing should be carried out in conjunction with the field work to monitor compliance with the various material and project specifications.


The factual data, interpretation and recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location or elevation, or if the project is not initiated within twelve months of the date of the report, Golder should be given an opportunity to confirm that the recommendations are still valid.

Please refer to the "Important Information and Limitations of This Report", which follows the text, but forms an integral part of this document.

We trust that this report provides all of the geotechnical information required for you to proceed with the design of the undercrossing. Should any point require clarification, or if we can be of additional assistance, please contact this office.

GOLDER ASSOCIATES LTD.

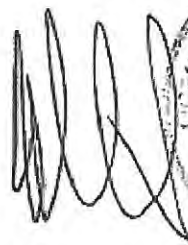

James D. Rodger, P.Eng.
Principal




JDR/JW/jdr/dw

Attachments

- Limitations
- List of Abbreviations
- List of Symbols
- Records of Boreholes 1 to 7, inclusive
- Figures 1 to 7


John Westland, P.Eng.
Principal



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Report No. 10-1140-0096-R01
MTO GEOCREC #40J2-117

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client can not rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT (cont'd)

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split spoon sampler for a distance of 300 mm (12 in.)

(b) Cohesive Soils

Consistency	c_u, s_u	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

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

I. General

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_L	liquid limit
w_p	plastic limit
I_p	plasticity index $= (w_L - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_L - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 + \sigma_3)/2$ or $(\sigma'_1 + \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 + \sigma_3)$
S_t	sensitivity

- Notes:**
- 1 $\tau = c' + \sigma' \tan \phi'$
 - 2 shear strength = (compressive strength)/2
 - * density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

SAMPLER HAMMER, 63.5kg; DROP, 760mm

BORING DATE: October 7, 2010 & October 30, 2010

DATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

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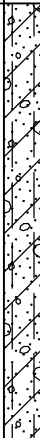
PROJECT: 10-1140-0096
 LOCATION: UTM 4678982.0 N, 339373.0 E
 SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE 1

BORING DATE: October 7, 2010 & October 30, 2010

SHEET 2 OF 2
 DATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m					HYDRAULIC CONDUCTIVITY, k, cm/s					ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m		20	40	60	80	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³				
									SHEAR STRENGTH Cu, kPa				WATER CONTENT PERCENT							
									nat V.	+	Q -	•								
									rem V.	•	U -	○								
									20	40	60	80	10	20	30	40				
10	POWER AUGER SOLID STEM	-- CONTINUED FROM PREVIOUS PAGE --																		
11		Very stiff, grey SILTY CLAY , some sand, trace gravel, occasional silt partings (TILL)			13	SS	12	179						○						
12								178												
12					14	SS	16						○							
13		END OF BOREHOLE		176.90 12.80				177												
14																				
15																				
16																				
17																				
18																				
19																				

DEPTH SCALE

1 : 50



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PROJECT: 10-1140-0096

RECORD OF BOREHOLE 2

SHEET 1 OF 2

LOCATION: UTM 4678948.2 N, 339380.5 E

BORING DATE: October 8, 2010 & October 30, 2010

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES			ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE		BLOWS/0.3m	20 40 60 80				10 ⁻⁶ 10 ⁻⁵ 10 ⁻⁴ 10 ⁻³					
									SHEAR STRENGTH Cu, kPa				WATER CONTENT PERCENT Wp — W — WI					
0	POWER AUGER SOLID STEM	GROUND SURFACE		190.00														
		Stiff, brown clayey topsoil (FILL)		0.00	1	AS												
				189.62	2	SS	11											
				0.38														
1		Compact to loose, brown silty sand, trace to some gravel (FILL)			3	SS	4											
				188.63														
				1.37	4	SS	10											
2		Stiff, brown and grey SILTY CLAY, some sand, trace gravel, fissures (TILL)		188.02														
				1.98														
					5	SS	38											
3		Hard, brown SILTY CLAY, some sand, trace gravel, occasional silt partings with oxidized fissures (TILL)			6	SS	40											
				186.34														
			3.66	7	SS	24												
4				8	SS	16												
5																		
				9	SS	19												
6																		
				10	SS	15												
7		Very stiff to stiff, grey SILTY CLAY, some sand, trace gravel, occasional silt partings (TILL)																
				11	SS	13												
8																		
9																		
				12	SS	10												
				180.25														
				9.75														
		--- CONTINUED NEXT PAGE ---																

Seepage
Oct. 8/10Groundwater seepage
into borehole at about
elevation 188.3m during
drilling on October 8,
2010.

MH

MH

DEPTH SCALE

1 : 50



LOGGED: TA

CHECKED:

LDN_BHS_02 1011400096.GPJ GLDR_LON.GDT 12/2/10 DATA INPUT: SJL

PROJECT: 10-1140-0096

RECORD OF BOREHOLE 2

SHEET 2 OF 2

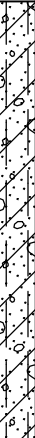
LOCATION: UTM 4678948.2 N, 339380.5 E


BORING DATE: October 8, 2010 & October 30, 2010

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m					HYDRAULIC CONDUCTIVITY, k, cm/s					ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m		SHEAR STRENGTH Cu, kPa					WATER CONTENT PERCENT						
									20	40	60	80	nat V. rem V.	+ Θ	Q - U -	● ○	10 ⁻⁶	10 ⁻⁵		
		--- CONTINUED FROM PREVIOUS PAGE ---																		
10	POWER AUGER SOLID STEM	Stiff to very stiff, grey SILTY CLAY , some sand, trace gravel, occasional silt partings, occasional sand and gravel pockets (TILL)					180													
11				13	SS	18	179													
12							178													
				14	SS	14														
13		END OF BOREHOLE		177.20 12.80																
14																				
15																				
16																				
17																				
18																				
19																				

Seepage
Oct. 30/10 Minor groundwater
seepage into borehole at
about elevation 177.5m
during drilling on October
30, 2010.

DEPTH SCALE

1 : 50



LOGGED: TA

CHECKED:

SAMPLER HAMMER, 63.5kg; DROP, 760mm

BORING DATE: October 7, 2010 & October 30, 2010

DATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

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1 : 50



LDN_BHS_02 1011400096.GPJ GLDR_LON.GDT 12/2/10 DATA INPUT: SJL

PROJECT: 10-1140-0096

RECORD OF BOREHOLE 3

SHEET 2 OF 2

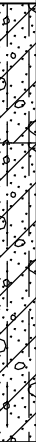
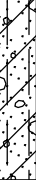
LOCATION: UTM 4678893.2 N, 339376.8 E

BORING DATE: October 7, 2010 & October 30, 2010

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS					
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m		20 40 60 80				10 ⁻⁶ 10 ⁻⁵ 10 ⁻⁴ 10 ⁻³										
									SHEAR STRENGTH Cu, kPa				WATER CONTENT PERCENT Wp — W — WI										
		--- CONTINUED FROM PREVIOUS PAGE ---																					
10		Very stiff, grey SILTY CLAY , some sand, trace gravel, some silt partings (TILL) (Coarse sand layer at a depth of about 10.8m)		178.78	13	SS	9	179															
				10.82																			
11																							
12																							
		Stiff, grey SILTY CLAY , some sand, trace gravel, occasional silty sand layers (TILL)			14	SS	5	177															
13		END OF BOREHOLE		176.80																			
				12.80																			
14																							
15																							
16																							
17																							
18																							
19																							

Seepage
Oct. 30/10

Groundwater seepage encountered at about elevation 178.9m during drilling on October 30, 2010.

DEPTH SCALE

1 : 50



LOGGED: TA

CHECKED:

SAMPLER HAMMER, 63.5kg; DROP, 760mm

BORING DATE: October 7, 2010 & October 30, 2010

DATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m					HYDRAULIC CONDUCTIVITY, k, cm/s					ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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									SHEAR STRENGTH Cu, kPa					nat V. rem V.					+ ⊕					Q - U -					● ○	WATER CONTENT PERCENT Wp ——— W ——— WI																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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0	POWER AUGER SOLID STEM	GROUND SURFACE		189.60 0.00	1	AS		189																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															

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PROJECT: 10-1140-0096

RECORD OF BOREHOLE 4

SHEET 2 OF 2

LOCATION: UTM 4678874.1 N, 339374.9 E

BORING DATE: October 7, 2010 & October 30, 2010

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m					HYDRAULIC CONDUCTIVITY, k, cm/s					ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE		BLOWS/0.3m	SHEAR STRENGTH Cu, kPa		nat V. rem V. + Q - U			WATER CONTENT PERCENT						
									20	40	60	80	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³	Wp			W
		--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80		10	20	30	40				
	POWER AUGER SOLID STEM	Very stiff to stiff, grey SILTY CLAY , some sand, trace gravel, some silt partings (TILL)		12	SS	8	180											<div>Bentonite</div> <div>Sand</div> <div>Screen</div> <div>Slight groundwater seepage encountered at about elevation 183.5m during drilling on October 7, 2010.</div> <div>Groundwater seepage encountered at about elevation 176.7m during drilling on October 31, 2010.</div> <div>Water level in standpipe at about elevation 181.9m on November 1, 2010.</div>		
10																				
			Compact, grey SAND , some silt, trace clay (TILL)		13	SS	8	179												
11																				
12		Stiff, grey SILTY CLAY to CLAYEY SILT , some sand, trace gravel, numerous silt pockets/partings (TILL)					178													
13		END OF BOREHOLE					177													
14							176													
15																				
16																				
17																				
18																				
19																				

DEPTH SCALE

1 : 50



LOGGED: TA

CHECKED:

LDN_BHS_02 1011400096.GPJ GLDR_LON.GDT 12/2/10 DATA INPUT: SJL

PROJECT: 10-1140-0096

RECORD OF BOREHOLE 5

SHEET 1 OF 1

LOCATION: UTM 4678691.5 N, 339373.8 E


BORING DATE: October 7, 2010

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m					HYDRAULIC CONDUCTIVITY, k, cm/s					ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m		SHEAR STRENGTH Cu, kPa					WATER CONTENT PERCENT						
									20	40	60	80	nat V. rem V.	+ ⊕	Q - U -	● ○	10 ⁻⁶	10 ⁻⁵		
									20	40	60	80		10	20	30	40			
0	POWER AUGER SOLID STEM	GROUND SURFACE		189.60 0.00	1	AS									○					
		Stiff, brown clayey topsoil (FILL)			2	SS	10									○				
				188.99 0.61												○				
1			Stiff to very stiff, mottled brown and grey SILTY CLAY, some sand, trace gravel, fissures (TILL)		3	SS	10									○				
				187.72 1.88	4	SS	20									○				
2																○				
			Very stiff to hard, brown SILTY CLAY, some sand, trace gravel, some silt partings and fissures (TILL)		5	SS	37									○				
						6	SS	36								○				
				185.94 3.66																
4					7	SS	24									○				
5				8	SS	16									○					
6				9	SS	13									○					
7				10	SS	9									○					
		Very stiff, grey SILTY CLAY, some sand, trace gravel, some silt partings and fissures (TILL)																		
8				11	SS	8									○					
9																				

Seepage Slight groundwater
seepage encountered at
about elevation 184.3m
during drilling on October
7, 2010.

DEPTH SCALE

1 : 50



LOGGED: TA

CHECKED:

LDN_BHS_02 1011400096.GPJ GLDR_LON.GDT 12/2/10 DATA INPUT: SJL

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE 6

BORING DATE: October 8, 2010

SHEET 1 OF 1

DATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

[illegible]

DN_BHS_02 1011400096.GPJ GLDR_LON.GDT 12/2/10 DATA INPUT: SJL

DEPTH SCALE

1 : 50

LOGGED: TA

CHECKED:

PROJECT: 10-1140-0096

RECORD OF BOREHOLE 7

SHEET 1 OF 1

LOCATION: UTM 4678390.3 N, 339367.6 E

BORING DATE: October 8, 2010

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m					HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m												
									SHEAR STRENGTH Cu, kPa					WATER CONTENT PERCENT Wp — W — WI					
									20	40	60	80		10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³		
0	POWER AUGER SOLID STEM	GROUND SURFACE		189.52															
		Loose, brown sandy topsoil (FILL)		0.00	1	AS													
				189.09	2	SS	7	189											
		Firm, mottled brown and grey SILTY CLAY, some sand, trace gravel (TILL)		0.43															
1					3	SS	7												
				188.15				188											
				1.37	4	SS	13												
2																			
					5	SS	38	187											
3			Stiff to hard, brown SILTY CLAY, some sand, trace gravel, some silt partings and fissures (TILL)																
					6	SS	39												
4								186											
					7	SS	32												
5				185.10				185											
				4.42	8	SS	15												
6																			
				9	SS	15	184												
7																			
8																			
9																			

LDN_BHS_02 1011400096.GPJ GLDR_LON.GDT 12/2/10 DATA INPUT: SJL

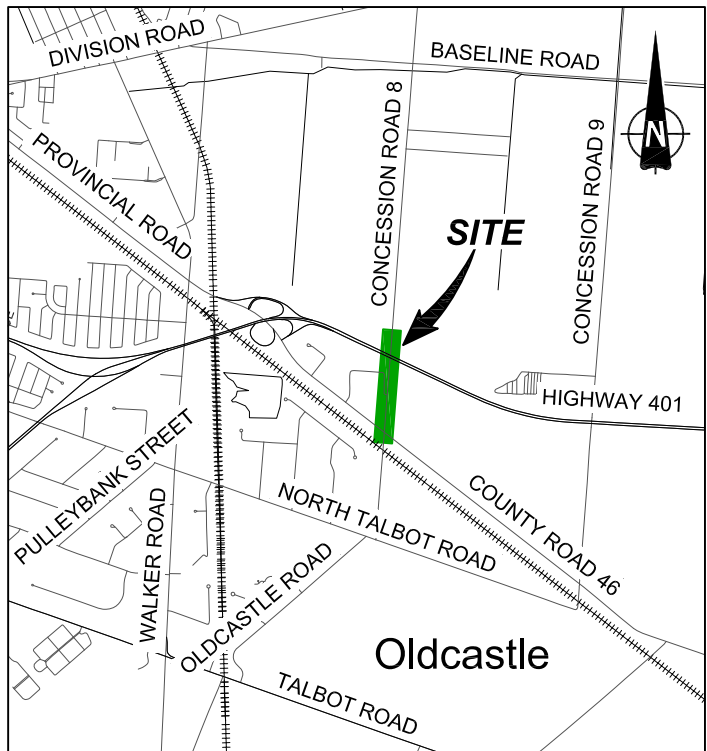
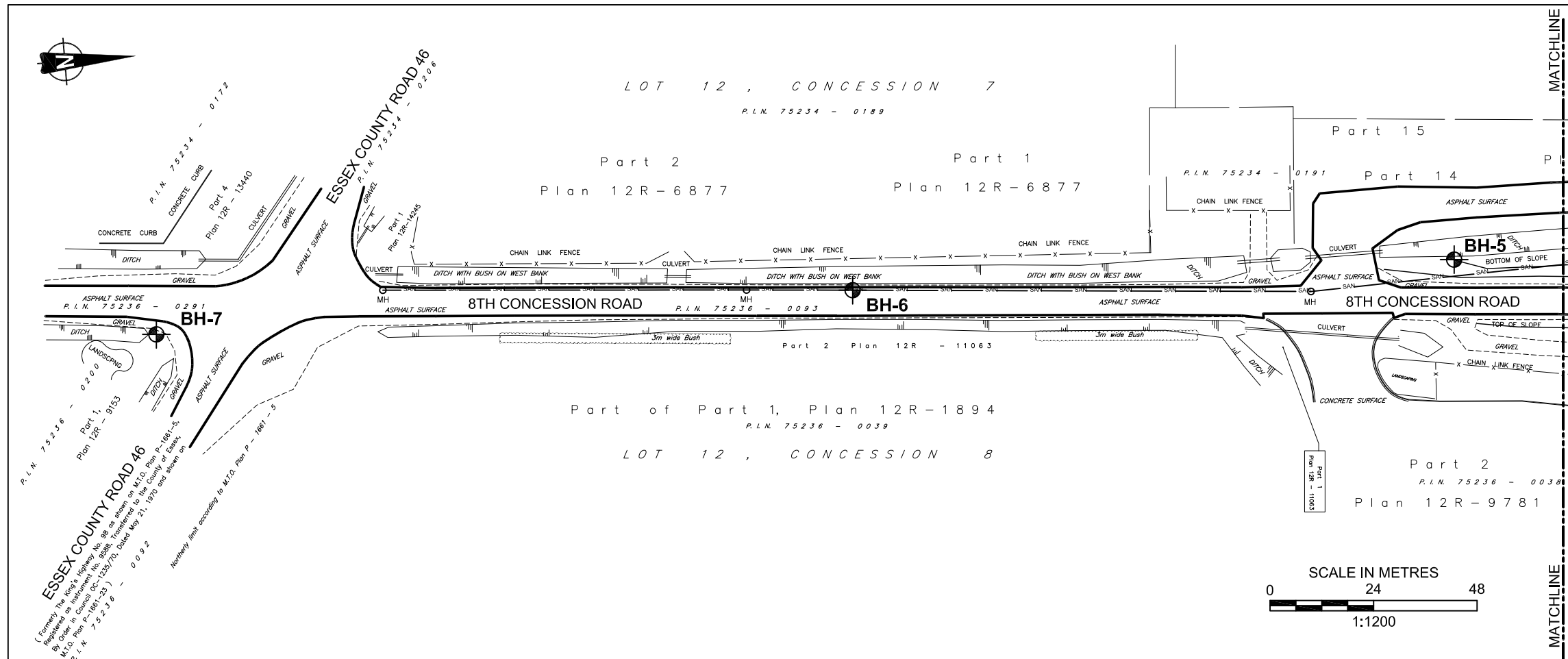
DEPTH SCALE

1 : 50



LOGGED: TA

CHECKED:



KEY PLAN

LEGEND

BOREHOLE

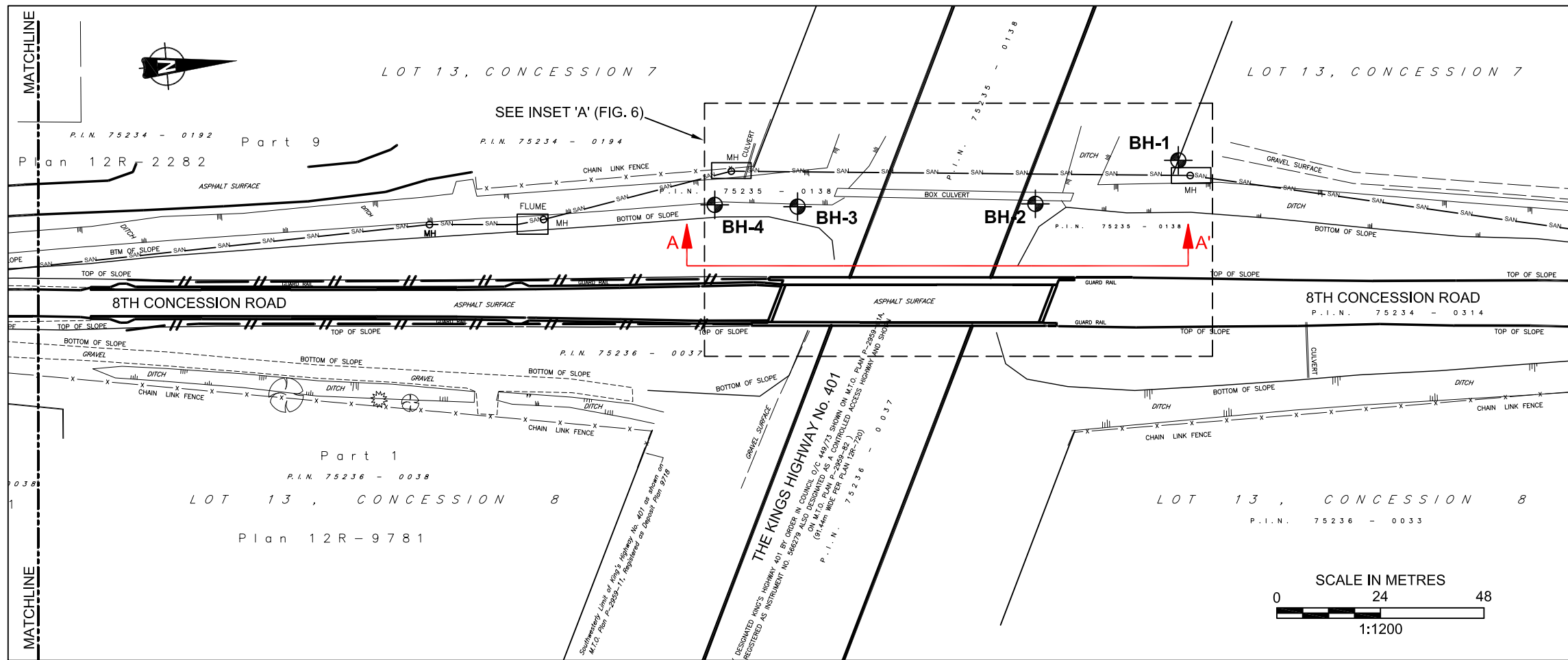
REFERENCE

DRAWING BASED ON PLAN PROVIDED BY VERHAEGEN, STUBBERFIELD, BREWER, BEZAIRE INC., "TOPOGRAPHIC SURVEY OF ORIGINAL ROAD ALLOWANCE BETWEEN CONCESSIONS 7 AND 8 BETWEEN HIGHWAY 46 AND HIGHWAY 401", PLAN FILE No. 111R-1, OCTOBER 8, 2010; CANMAP STREETFILES V2008.4

NOTES

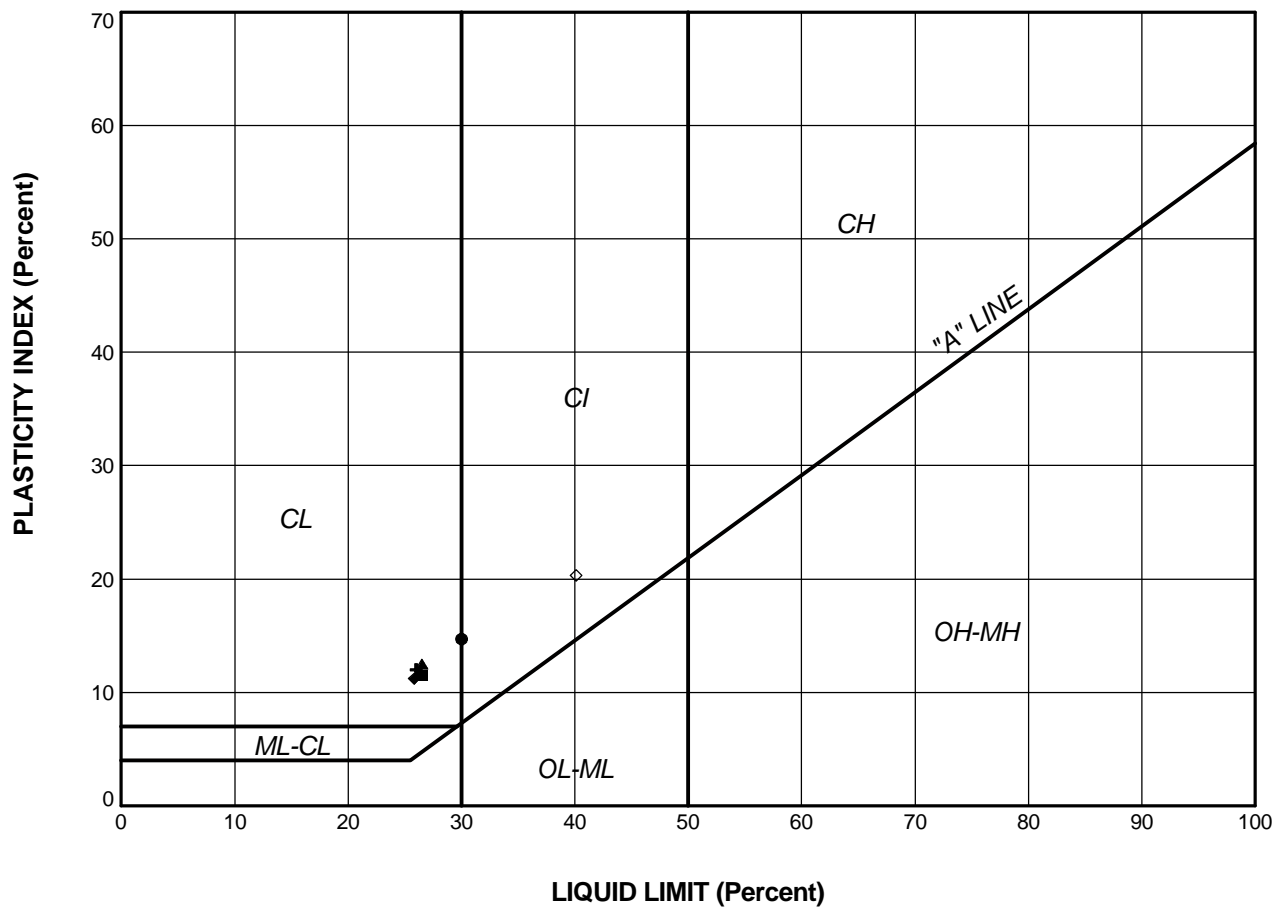
THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

ALL LOCATIONS ARE APPROXIMATE.



PROJECT		GEOTECHNICAL INVESTIGATION 8TH CONCESSION ROAD TOWN OF TECUMSEH, ONTARIO	
TITLE		LOCATION PLAN	
PROJECT No. 10-1140-0096		FILE No. 1011400096-R01001	
CADD		SCALE AS SHOWN	
CHECK		REV.	
OCT. 18/10		FIGURE 1	



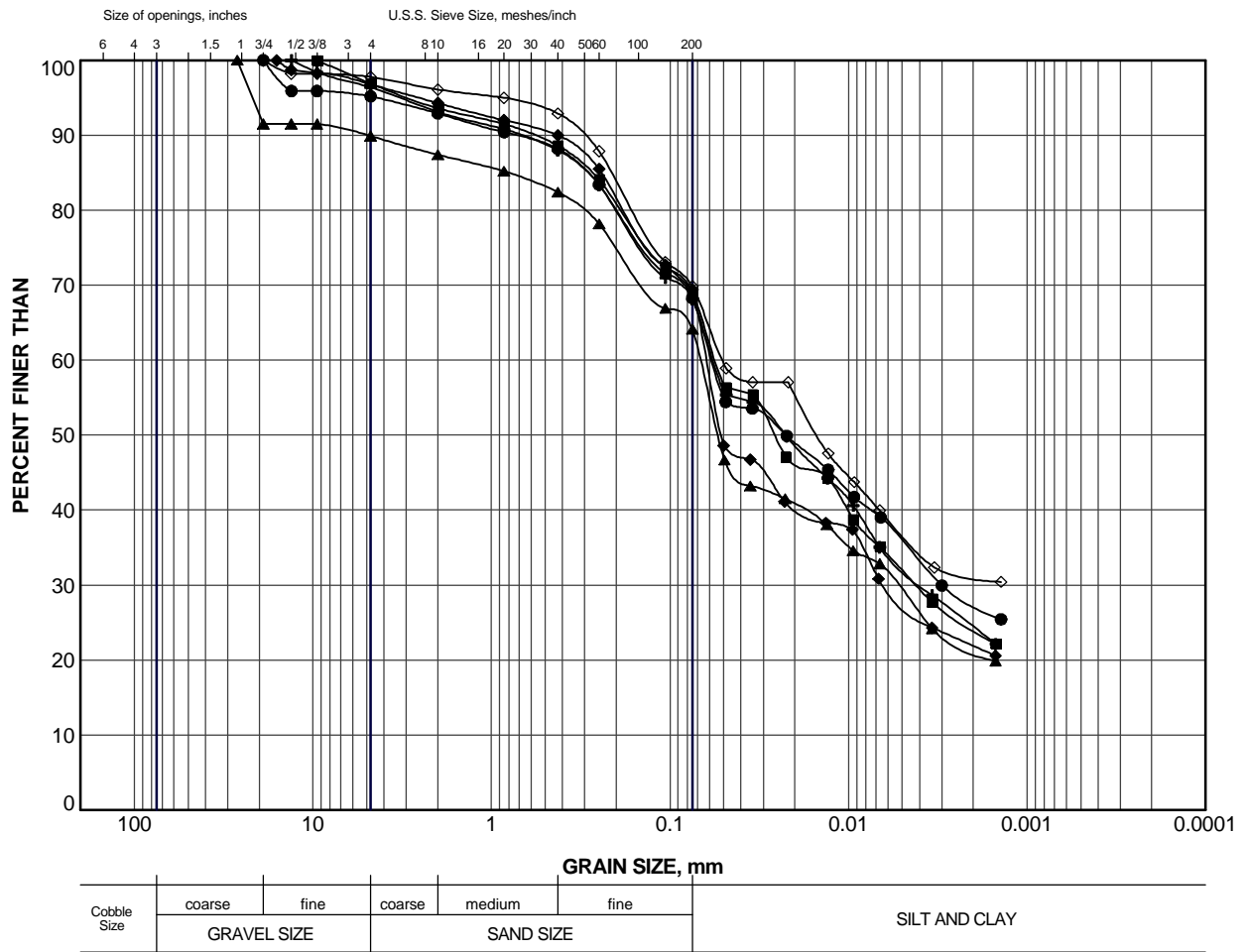


LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	1	5	30.0	15.3	14.7
■	2	8	26.5	15.0	11.5
▲	2	11	26.5	14.0	12.5
+	3	7	26.0	14.0	12.0
◆	3	10	25.8	14.6	11.2
◇	4	4	40.1	19.8	20.3


PROJECT		GEOTECHNICAL INVESTIGATION 8TH CONCESSION ROAD TOWN OF TECUMSEH, ONTARIO			
TITLE		PLASTICITY CHART			
PROJECT No.		10-1140-0096		FILE No. 1011400096.GPJ	
DRAWN	SJL	DEC. 2/10		SCALE	N/A
CHECK				REV.	
				FIGURE 3	

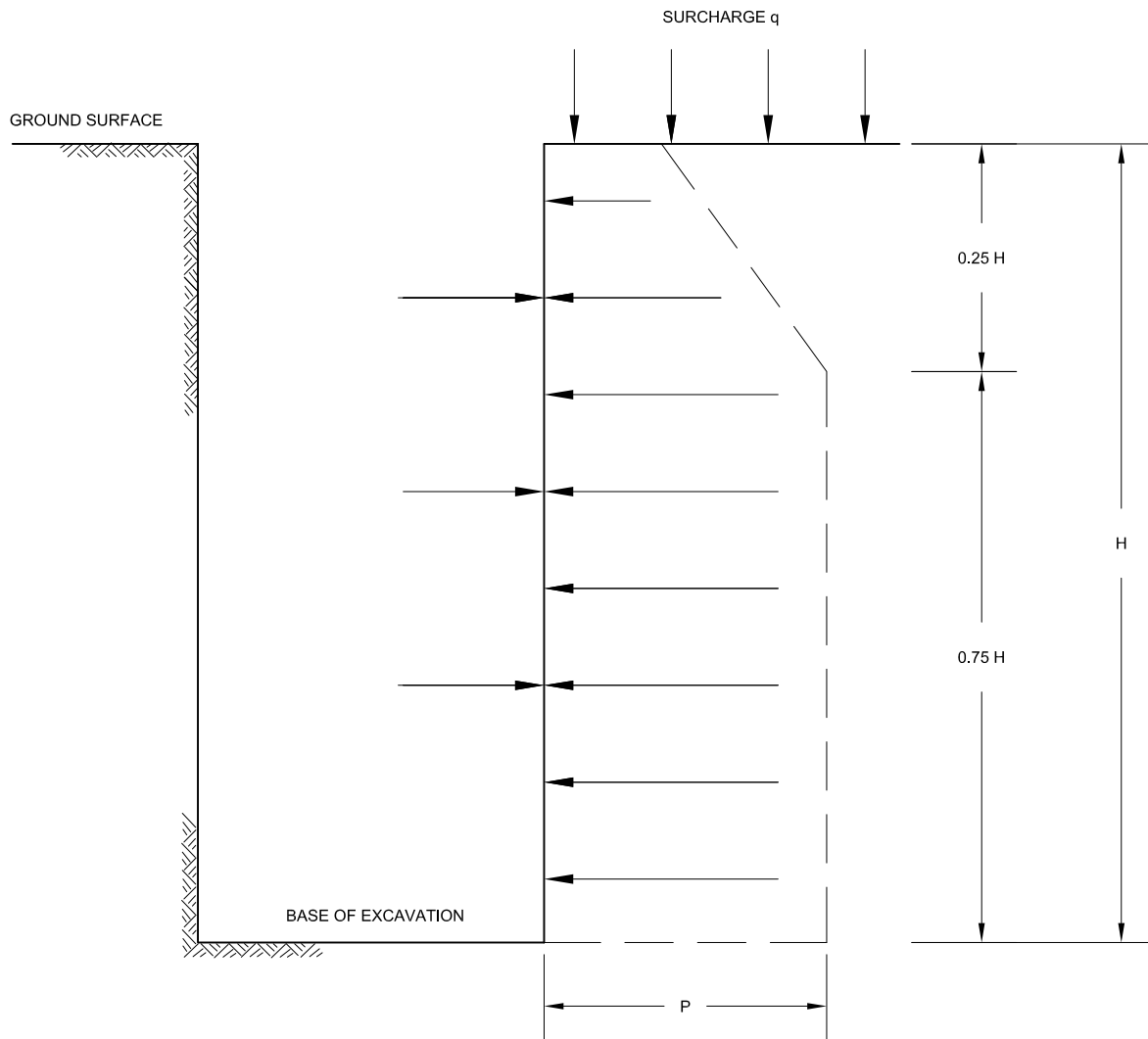




LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	1	5	187.2
■	2	8	185.2
▲	2	11	182.2
+	3	7	185.6
◆	3	10	183.3
◇	4	4	187.9

PROJECT				GEOTECHNICAL INVESTIGATION			
				8TH CONCESSION ROAD			
				TOWN OF TECUMSEH, ONTARIO			
TITLE				GRAIN SIZE DISTRIBUTION			
				SILTY CLAY, some sand, trace gravel (TILL)			
PROJECT No.		10-1140-0096		FILE No.		1011400096.GPJ	
DRAWN		S.J.L.		NOV. 1/10		SCALE N/A	
CHECK						REV.	
 Golder Associates WINDSOR, ONTARIO				FIGURE 4			




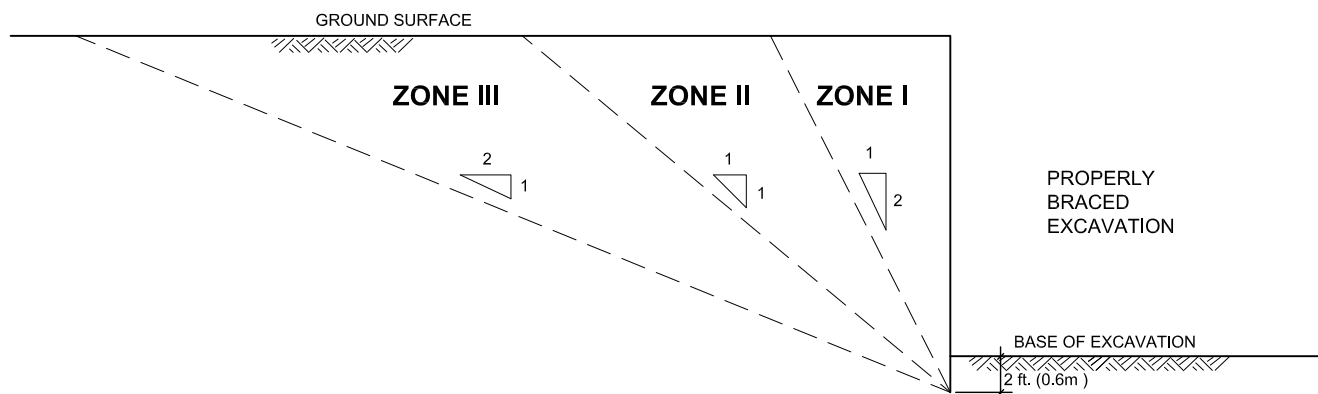
$$P = 0.3(\gamma H + q) \text{ WHERE } \gamma = 22 \text{ kN/m}^3$$

$$q = 15 \text{ kPa}$$

NOTES

- NUMBER & LOCATION OF STRUTS & WALES DEPENDANT ON DEPTH OF EXCAVATION.
- EARTH PRESSURE DIAGRAM BASED ON GENERALIZED SOIL STRATIGRAPHY.
- THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.

PROJECT		GEOTECHNICAL INVESTIGATION 8TH CONCESSION ROAD TOWN OF TECUMSEH, ONTARIO			
TITLE		EARTH PRESSURE DIAGRAM FOR BRACED EXCAVATION			
		PROJECT No. 10-1140-0096		FILE No. 1011400096-R01005	
		CADD SJL NOV. 1/10		SCALE N.T.S. REV. 0	
CHECK				FIGURE 5	



ZONE I

SUBSTANTIAL SETTLEMENT IN THIS ZONE SHOULD BE ANTICIPATED. STRUCTURES WITHIN THIS ZONE SHOULD BE PROTECTED OR UNDERPINNED.

ZONE II


SOME SETTLEMENT WITHIN THIS ZONE SHOULD BE ANTICIPATED.

ZONE III

SLIGHT MOVEMENTS WITHIN THIS ZONE MAY BE ANTICIPATED.

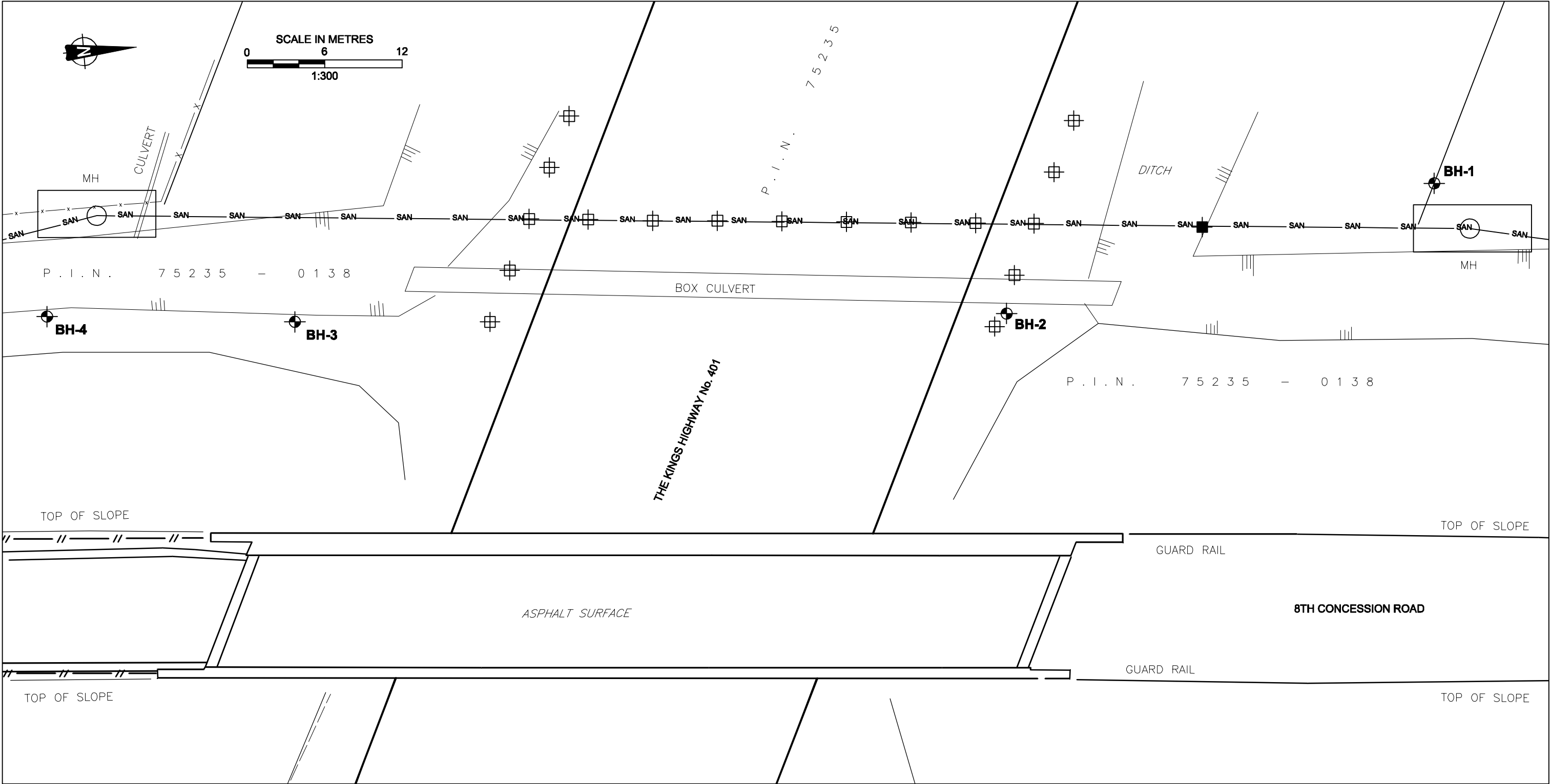
NOTES

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.




PROJECT		GEOTECHNICAL INVESTIGATION 8TH CONCESSION ROAD TOWN OF TECUMSEH, ONTARIO			
TITLE		ZONES OF POTENTIAL MOVEMENT (SUPPORTED EXCAVATION)			
		PROJECT No. 10-1140-0096		FILE No. 1011400096-R01006	
		SCALE		N.T.S.	REV. 0
CADD		SJL	NOV. 1/10	FIGURE 6	
CHECK					

Drawing file: 1011400096--R01001.dwg Dec 02, 2010 - 2:34pm

INSET 'A'



LEGEND


-  BOREHOLE
-  SHALLOW SETTLEMENT MONITOR
-  DEEP SETTLEMENT MONITOR

REFERENCE

DRAWING BASED ON PLAN PROVIDED BY VERHAEGEN, STUBBERFIELD, BREWER, BEZAIRE INC., "TOPOGRAPHIC SURVEY OF ORIGINAL ROAD ALLOWANCE BETWEEN CONCESSIONS 7 AND 8 BETWEEN HIGHWAY 46 AND HIGHWAY 401", PLAN FILE No. 111R-1, OCTOBER 8, 2010; CANMAP STREETFILES V2008.4

NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.
ALL LOCATIONS ARE APPROXIMATE.

PROJECT		GEOTECHNICAL INVESTIGATION 8TH CONCESSION ROAD TOWN OF TECUMSEH, ONTARIO	
TITLE		SETTLEMENT MONITORING PLAN	
		PROJECT No. 10-1140-0096	FILE No. 1011400096-R01001
CADD	SJL	OCT. 18/10	SCALE AS SHOWN
CHECK			REV.
		FIGURE 7	

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1825 Provincial Road
Windsor, Ontario, N8W 5V7
Canada
T: +1 (519) 250-3733
F: +1 (519) 250-6452

