GEI Consultants

Consulting
Engineers and
Scientists

Geotechnical Investigation

40 Wilson Avenue

Belleville, Ontario

Submitted to:
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May 19, 2022, Revision 1
Project No. 2102519

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1. Introduction

GEI Consultants (GEI) was retained by RIC (Midland Land) Inc. to complete a subsurface investigation and provide a geotechnical engineering report for the proposed residential subdivision to be located at 40 Wilson Avenue and along an extension of Wilson Avenue, in Belleville, Ontario. A site location plan is enclosed as Figure 1. Revision 1 of this report was prepared to reflect the newest site plan, which now only includes the western half of the original property. The new subject site boundary is shown on Figures 2A and 2B.

The existing site is generally rectangular in shape and consists of industrial lands that are bounded by Wilson Avenue and industrial lands to the south, Palmer Road and residential lands to the west, residential lands to the north, and industrial lands to the east. A large industrial building formerly existed at 40 Wilson Avenue just east of the subject site but was recently demolished, and a large stockpile of concrete rubble and construction debris (assumed to be from the demolition) is in the northern part of the site. The site mainly consists of vacant fields with intermittent trees, stockpiles of soil and rubble, and concrete debris. A cell tower is located in the northwestern corner of the property near Palmer Road. An aerial image of the site from 2018 is provided on Figure 2A.

GEI was provided with the following drawing for review in preparation of this report: *"Draft Plan of Subdivision, Part of Lots 15, 16, 17, 2 & 27, Plan 135, Part of Lots 6 & 7, Plan 1819, Part of Wilson Avenue, Plan 6, In the City of Belleville, County of Hastings,"* dated November 6, 2020, by Innovative Planning Solutions.

The drawing shows that the subject site has an area of 7.78 ha. Proposed site conditions are shown on Figure 2B and the development will generally consist of the following:

- A variety of single detached residential lots and street townhouse units.
- A SWM facility in the southwestern corner.
- An extension to Wilson Avenue and new Streets B, C and D.

The purpose of the geotechnical investigation was to assess the subsurface conditions at the site by advancing eight (8) exploratory boreholes at the subject site to provide geotechnical engineering recommendations in support of the proposed development. Monitoring wells were installed in three (3) of the boreholes. It is noted that the original investigation included the eastern part of the 40 Wilson Avenue property and an additional five boreholes (two which recovered rock core) with three monitoring well installations were advanced in the eastern area. These boreholes, rock coring and monitoring well results are not included within Revision 1 of this report.

This report summarizes the borehole findings, provides design recommendations for foundations, slabs on grade, earth pressures, site servicing, and pavements, and provides considerations for constructability such as soil excavation, compaction, and temporary groundwater control for the subject site. GEI provided a hydrogeological study under a separate cover.

2. Procedures and Methodology

Prior to the commencement of drilling activities, the locations of underground utilities including natural gas, electrical, telephone, water, etc. were marked out by public and private utility locating companies. The fieldwork for the drilling program was carried out on August 4 to 6, 2021. A total of eight boreholes (Boreholes 6 to 13) were advanced on the subject site using a track-mounted drill rig. To advance the boreholes, continuous flight solid stem augers and standard soil sampling equipment was utilized. All samples were collected as per ASTM D1586 *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils* to assess the strength characteristics of the substrate.

It is noted that the original investigation also included the eastern part of the 40 Wilson Avenue property and an additional five boreholes (Boreholes 1 to 5) with three monitoring well installations were advanced in the eastern area. Boreholes 1 and 4 also recovered rock core. The logs and results from Boreholes 1 to 5 are not included within Revision 1 of this report as they were advanced beyond the subject site boundary.

The boreholes were advanced to auger refusal at depths of 1.5 to 4.6 metres below existing grade. The horizontal locations were laid out in the field by GEI prior to the drilling operations and the locations are shown on Figures 2A (2018 aerial image) and 2B (proposed site plan). Ground surface elevations of the boreholes were measured using survey equipment in reference to a local site benchmark (top nut of the fire hydrant located north of Wilson Avenue to the east of the subject site) with an assumed elevation of 100.0 metres. The GPS coordinates of the borehole locations were measured with a handheld GPS unit and were referenced to the NAD 83 geodetic datum.

The field staff examined and classified characteristics of the soils encountered in the boreholes, made groundwater observations during and upon completion of the drilling, recorded observations of borehole construction, and processed the recovered samples. Soil sampling was conducted at regular intervals for the full depth of the borehole. The boreholes were backfilled upon completion. All recovered soil samples were logged in the field, carefully packaged and transported to the laboratory for more detailed examination and classification. In the laboratory, the samples were classified as to their visual and textural characteristics and geotechnical laboratory testing was carried out with the results included in Appendix B. Three (3) monitoring wells were installed to facilitate long-term groundwater monitoring. Monitoring well construction is shown on the borehole logs in Appendix A.

3. Subsurface Conditions

3.1 General Overview

The detailed soil profiles encountered in the boreholes are indicated on the attached borehole logs in Appendix A and the geotechnical laboratory results are included in Appendix B. The borehole locations are shown on Figures 2A and 2B and subsurface profiles are provided as Figures 3A and 3B.

It should be noted that the conditions indicated on the borehole logs and subsurface profiles are for specific locations only and can vary beyond and between the borehole locations. It should be noted that the soil boundaries indicated on the borehole logs and profiles are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones and should not be interpreted as exact planes of geological change.

In addition, the descriptions provided in the borehole logs are inferred from a variety of factors, including visual observations of the soil samples retrieved, laboratory testing, measurements prior to and after drilling, and the drilling process itself (speed of drilling, shaking/grinding of the augers, etc.). The passage of time also may result in changes in conditions interpreted to exist at locations where sampling was conducted.

3.2 Stratigraphy

3.2.1 Earth Fill

Earth fill was encountered at the ground surface in Boreholes 6 to 11, and 13. The earth fill extended to depths of 0.8 to 1.5 metres below grade (local Elev. 99.9 to 96.8 metres) in Boreholes 6 to 8, 10, 11 and 13. Borehole 9 encountered auger refusal in the earth fill at 2.1 metres below grade (local Elev. 97.4 metres) due to an obstruction (possibly a buried concrete slab). The earth fill consisted of silty sand, to sandy and silt, to sand and gravel, to sand and limestone fragments. Deleterious material including concrete, bricks, plastic, and fabric was encountered within the fill in Boreholes 9 to 11 and 13. The earth fill was typically brown and moist. Standard Penetration Test (SPT) results ("N" Values) measured in the earth fill ranged from 9 to greater than 100 blows per 300 mm of penetration, indicating a loose to very dense relative density.

3.2.2 Native Soils

A native cohesionless deposit consisting of sand and limestone fragments, with trace to some silt, and trace to some gravel was predominantly encountered beneath the site above the bedrock surface. The deposit was encountered at the ground surface in Borehole 12 and underlying the earth fill in Boreholes 6 to 8, 11 and 13. The deposit extended from depths of 0 to 1.5 metres below grade (local Elev. 99.9 to 96.8 metres) to the inferred bedrock surface at depths of 1.5 to 4.6 metres below grade (local Elev. 98.5 to 95.2 metres) in the boreholes. The sand with limestone fragments was typically damp to moist and brown, and the measured SPT "N" Values ranged from 9 to greater than 100 blows per 300 mm of penetration, indicating a loose to very dense (but typically dense to very dense) relative density.

In Borehole 10, clayey and silty sand with trace gravel and trace to some limestone fragments was encountered underlying the earth fill at 1.5 metres below grade (local Elev. 97.8 metres). The brown and wet clayey and silty sand extended to the inferred bedrock surface at 2.4 metres below grade (local Elev. 96.9 metres). The SPT "N" Values were greater than 100, indicating a hard consistency.

The augers were constantly grinding as they advanced through the overburden soils due to the amount of limestone fragments. Cobbles, boulders, and limestone slabs are expected to be encountered in the overburden across the site.

3.2.3 Inferred Weathered Bedrock

Inferred weathered bedrock was encountered in the boreholes underlying the soil overburden, at depths of 1.5 to 4.6 metres below grade (local Elev. 98.5 to 95.2). The bedrock was inferred by drilling observations, auger grinding, auger refusal, and samples recovered in the split spoon or by auger samples.

The depths of inferred bedrock and method of identification are summarized below. The bedrock surface undulates across the site but generally slopes down from north to south.

Borehole Location	Local Elev. (m) of Ground Surface	Depth / Local Elev. (m) of Inferred Weathered Bedrock Surface	Method of Bedrock Identification
6	100.63	2.1 / 98.5	Inferred by auger grinding, auger refusal, auger sample
7	99.91	4.6 / 95.3	
8	99.63	3.5 / 96.1	
9	99.51	Not encountered – refusal on obstruction in earth fill	Not encountered
10	99.32	2.4 / 96.9	Inferred by auger grinding, auger refusal, auger sample, split spoon sample
11	98.35	3.2 / 95.2	
12	96.69	1.5 / 95.2	
13	97.95	1.7 / 96.3	

It is noted that rock core was recovered from two boreholes advanced by GEI approximately 110 and 320 metres east of the current subject site as part of the original investigation.

Weathered limestone bedrock of the Verulam Formation was encountered. The Total Core Recovery (TCR), Solid Core Recovery (SCR) and Rock Quality Designation (RQD) values were recorded in accordance with the conventions used by the International Society for Rock Mechanics (ISRM). TCR ranged from 33 to 67%, SCR ranged from 0 to 32%, and RQD was 0%. The TCR was low due to the amount of weathering, rubblized zones and fractures which resulted in core loss. RQD was 0% in all core runs due to the number of fractures and rubblized zones. Sound (unweathered) bedrock was not encountered in the cored holes, and the weathered zone may be thicker than 3 metres in some locations based on the recovered core.

3.3 Groundwater

Unstabilized groundwater level measurements and cave measurements were taken upon completion of drilling of each borehole as shown on the borehole logs in Appendix A. These measurements provide a rough estimate of the possible excavation and temporary groundwater control constructability considerations that may arise. The boreholes remained open and dry upon completion.

Monitoring wells were installed in Boreholes 7, 12 and 13 to facilitate the measurements of long-term, stabilized groundwater levels. The 50 mm diameter PVC wells had 0.6 to 1.5-metre-long screens as required based on the depth of soil overburden. An existing monitoring well was encountered on site near Borehole 13, as shown on Figures 2A and 2B. The purpose of this well is unknown but was measured to be 8.5 metres deep and the groundwater level was measured to be 5.31 to 5.56 metres below grade. The well is screened within the limestone bedrock based on the results of nearby Borehole 13.

A summary of the groundwater level measurements is presented below:

<table>
<tr><th rowspan="2">Monitoring Well</th><th colspan="2">Screened Location</th><th rowspan="2">Strata Screened</th><th colspan="3">Depth / Local Elevation (m) of Groundwater Table</th></tr>
<tr><th>Depth (m)</th><th>Local Elev. (m)</th><th>August 31, 2021</th><th>October 8, 2021</th><th>March 26, 2022</th></tr>
<tr><td>7</td><td>3.1 to 4.6</td><td>96.8 to 95.3</td><td rowspan="3">Sand & Limestone Fragments</td><td colspan="3" rowspan="3">Dry</td></tr>
<tr><td>12</td><td>0.9 to 1.5</td><td>95.8 to 95.2</td></tr>
<tr><td>13</td><td>1.1 to 1.7</td><td>96.9 to 96.3</td></tr>
<tr><td>Existing Well near BH 13</td><td colspan="2">Bottom of Well at 8.5 m / 89.5 m</td><td>Limestone Bedrock</td><td>5.31 / 92.64</td><td>5.56 / 92.39</td><td>3.6 / 94.4</td></tr>
</table>

The highest groundwater level measured at the site to date is 3.6 metres below grade, within the limestone bedrock at the south end of the site. The site grades generally slope from a higher elevation in the north to a lower elevation in the south. Some perched water may be present at the overburn-bedrock interface following precipitation events or the spring freshet, however the other monitoring wells remained dry on site during each reading. The groundwater level will change based on seasonal fluctuations. The overburden soils are cohesionless and will allow for the free flow of water when wet. It is expected that the highly fractured bedrock will also allow for the free flow of water.

GEI is measuring the water levels once per month for a year to determine the seasonally high groundwater elevation, with the results provided in a separate letter report. Additional groundwater considerations are provided in GEI's hydrogeological report under a separate cover.

3.4 Karst Topography

Karst topography is defined as an irregular landscape characterized by streamless valleys, sinkholes, and streams that disappear underground, all developed by the action of surface and underground water in soluble rocks such as limestone and dolomite. Limestone is composed primarily of the mineral calcite; while dolomite rock has a significant amount of the mineral dolomite, as well as calcite (Adams, et. al., 1984).

Karst geology mapping from the Ontario Geological Survey (OGS) was reviewed for the site. There are no potential or known karst areas near 40 Wilson Avenue.

4. Engineering Design Parameters

GEI was provided with the following drawing for review in preparation of this report: *"Draft Plan of Subdivision, Part of Lots 15, 16, 17, 2 & 27, Plan 135, Part of Lots 6 & 7, Plan 1819, Part of Wilson Avenue, Plan 6, In the City of Belleville, County of Hastings,"* dated November 6, 2020, by Innovative Planning Solutions.

The drawing shows that the subject site has an area of 7.78 ha. Proposed site conditions are shown on Figure 2B and the development will generally consist of the following:

- A variety of single detached residential lots and street townhouse units.
- A SWM facility in the southwestern corner.
- An extension to Wilson Avenue and new Streets B, C and D.

In conjunction with the geotechnical design advice provided in the subsequent sections, all minimum requirements within the most recent version of the Ontario Building Code must be followed.

4.1 Foundation Design Parameters

Existing topsoil, concrete slabs, asphalt pavements, and any zones of earth fill are not suitable for the support of new foundations. The undisturbed native soils typically consisted of compact to very dense sands with limestone fragments and were typically encountered at depths of 0 to 1.5 metres below grade. Fractured and weathered limestone bedrock was inferred / confirmed at depths of 1.5 to 4.6 metres below grade across the site. The undisturbed native soils and weathered limestone bedrock are suitable for the support of conventional shallow foundations, as follows:

- New spread or strip footing foundations made uniformly on the undisturbed native soils typically encountered at 0 to 1.5 metres below grade across most of the site (or deeper than 2.1 metres below grade at Borehole 9), can be designed using a geotechnical reaction at SLS of 150 kPa, for 25 mm or less of total settlement. The maximum factored geotechnical resistance at ULS is 225 kPa.
- If the spread or strip footings are made uniformly on the weathered and fractured limestone bedrock, they can be designed using a geotechnical reaction at SLS of 300 kPa, for 25 mm or less of total settlement. The maximum factored geotechnical resistance at ULS is 500 kPa.
- It is important to note that these foundation design parameters are applicable for foundations set onto undisturbed native soils or bedrock. If any filling occurs at the site, the foundations must extend through the additional fill to reach the underlying competent bearing strata.

- In addition, it is recommended that buildings be either wholly founded on native soils or wholly founded on bedrock, as if foundations straddle two different types of founding strata there is a higher potential for differential settlement to occur.

All footings exposed to ambient air temperature throughout the year must be provided with a minimum of 1.4 metres of earth cover or equivalent insulation for frost protection. This is applicable to foundations made on soil or weathered and fractured bedrock, which is also frost susceptible. The minimum strip and spread footing widths to be used shall be dictated as per the Ontario Building Code, regardless of loading considerations. Footings stepped from one level to another must be at a slope not exceeding 7 vertical to 10 horizontal. This concept should also be applied to excavations for new foundations in relation to existing footings or underground services unless rigid shoring is provided.

The foundation design parameters provided above are predicated on the assumption that the foundation subgrade surface is undisturbed, and that all deleterious, softened, disturbed, organic, and caved material is removed. For foundations on bedrock, any excessive bedrock fracturing, rubblized or weathered zones should be removed to reach a uniform bedrock subgrade. The foundation excavation must be done in such a way that groundwater is controlled to prevent any disturbance to the foundation base. Temporary groundwater control during construction is discussed in Section 5.2.

The foundation subgrade for the single residential dwellings and townhouses may be reviewed by the geotechnical engineer as required by the local municipal authority. For any foundations designed on weathered bedrock, they must be inspected by the geotechnical engineer prior to concrete placement to ensure the foundation design parameters described above are applicable, and to provide remedial recommendations if necessary. If the foundation excavation will be open for a prolonged period of time, the foundation subgrade should be protected with a skim coat of lean mix concrete (after the subgrade inspection), to ensure that no deterioration will occur due to weather effects.

4.2 Earth Pressure Design Parameters

Underground levels, basements, retaining walls and cantilevered shoring walls all must be designed to resist unbalanced lateral earth pressures imparted from the weight of adjacent soils. Lateral earth pressures are calculated using the following equation:

$$\boldsymbol{P = K[\gamma h + q]}$$

where,

P = the horizontal pressure at depth, **h** (m)
K = the earth pressure coefficient (dimensionless)
h = depth below ground surface (m)
$\boldsymbol{\gamma}$ = the bulk unit weight of soil, (kN/m^3)
q = surcharge loading (kPa)

The above equation assumes that a drainage system is present which prevents the build-up of any hydrostatic pressure behind the structure subjected to the unbalanced lateral earth pressures. If this is not the case, the equation must be revised to also incorporate the submerged unit weight of the soil multiplied by the earth pressure coefficient, in addition to the water pressure itself.

The values for use in the design of structures subjected to unbalanced lateral earth pressures at this site are as follows.

Soil Type	γ - Bulk Unit Weight (kN/m^3)	φ - Friction Angle (degrees)	Earth Pressure Coefficient (dimensionless)		
			K_a - Active	K_o – At-Rest	K_p - Passive
Imported Granular Material	20.0	32	0.31	0.47	3.25
Existing Earth Fill	19.0	30	0.33	0.50	3.00
Sand & Limestone Fragments, Silty Sand	20.0	35	0.27	0.43	3.69

The calculation of the earth pressure coefficients is based on Rankine theory, which provides a conservative estimate as no friction between the soil and the structure is accounted for. The earth pressure coefficients provided above are applicable for flat ground surfaces beyond the structure and must be revised for sloping ground surfaces.

The earth pressure coefficients referenced within the above table are a function of the friction angle of the adjacent soil, and both the degree and direction of movement of the structure subjected to unbalanced lateral earth pressures. For structures that are restrained at the top (such as basement walls), the at-rest earth pressure coefficient will apply. For structures that allow for 0.1 to 1% of movement away from the soil (such as unrestrained retaining walls), the full active earth pressure coefficient will apply. For structures that allow for 1 to 10% of movement into the soil, the full passive earth pressure coefficient will apply. The percentage movement is based on the height of the structure.

Other types of structures such as shoring walls with multiple rows of tiebacks and soil nail walls are subject to different loading conditions and must be analyzed separately.

Bedrock typically does not exert lateral pressures onto a foundation wall, but a common design approach is to assume a uniform pressure distribution below the bedrock surface equal to the maximum earth pressure for the soil overburden at the bedrock surface. This is conservative but ensures a consistent design for the foundation wall. If the basement levels will extend deeper than 2 metres into sound bedrock, rock swelling can occur over time due to locked-in horizontal stresses. This scenario is not expected for the site but GEI can be contacted to provide additional recommendations for basement levels deeper than 2 metres into sound bedrock.

4.3 Slab-on-Grade Design

Topsoil, existing pavements or slabs, vegetation, and existing earth fill containing excessive organics or deleterious materials are not suitable for the support of a slab on grade and must be removed. Existing earth fill and the undisturbed native sand with limestone fragments are suitable for the support of a lightly loaded and unreinforced slab-on-grade provided the soils are proof-rolled with large compaction equipment or a loaded tandem axle dump truck, inspected and approved by the geotechnical engineer.

If any soft or weak subgrade areas are identified, or if there are areas containing excessive amounts of deleterious/organic material, they must be locally sub-excavated and backfilled with approved clean earth fill or imported granular material and compacted to a minimum of 98% SPMDD. The modulus of subgrade reaction appropriate for design of a slab-on-grade on the above-noted soils is 20,000 kPa/m.

If the structures will have basement levels, the slab could be made on weathered bedrock depending on the location at the site. The weathered bedrock is suitable for the support of a slab-on-grade provided the bedrock surface is inspected and approved by the geotechnical engineer. The modulus of subgrade reaction appropriate for design of a slab-on-grade made uniformly on the weathered bedrock is 40,000 kPa/m.

All building floor slabs must be provided with a capillary moisture barrier and drainage layer. This is made by placing the concrete slab on a minimum 200 mm layer of 19 mm clear stone (OPSS.MUNI 1004) compacted by vibration to a dense state. The upper 50 mm of clear stone can be replaced with 19 mm crusher run limestone for a working surface.

4.4 Basement Drainage

For new structures that will be slab-on-grade with no basement levels, perimeter and under-slab drainage at the foundation level is not required, provided that the underside of concrete slab is at least 200 mm above the prevailing grade of the site and the surrounding surfaces slope away from the building at a gradient of at least 2% to promote surface water run-off and to reduce groundwater infiltration adjacent to foundations. To minimize infiltration of surface water, the upper 150 mm of backfill could consist of less permeable, compacted clayey soil.

Where basements are constructed, all basement foundation walls must be provided with damp-proofing provisions in conformance to the Ontario Building Code. Backfill along the foundation wall must consist of Granular ‘B’ Type 1 (OPSS 1010) for a minimum lateral distance of 600 mm out from the foundation wall. Alternatively, if a filtered cellular drainage media is provided adjacent to the foundation wall, the backfill may consist of common earth fill.

A perimeter drainage system must be installed that will remove any water that infiltrates into the building backfill, to ensure that any water does not infiltrate into the basement. The perimeter drains must consist of minimum 100 mm diameter perforated pipes wrapped in filter socks, sufficiently covered on all sides by 19 mm clear stone. Perimeter drains should be directed to the sump underneath the basement floor in solid pipes so as not to surcharge the underfloor drainage layer with water. One run of subfloor drainage pipe trenched below the slab granular drainage layer is recommended for the single residential dwellings, and 6 metre on-centre spacing is recommended for the townhouses. All sump pumps should be on emergency power for redundancy in case of a power outage. A typical basement drainage detail is included in Appendix C.

It is common practice to set the basement level a minimum of 0.5 metres above the seasonally high groundwater level. If the basement level is set near or within the prevailing groundwater level, it is possible that perimeter drainage issues may occur in the future (e.g. sump pump failure, blockage of drainage pipes, etc.), which would lead to potential foundation cracking and basement flooding. Basements can be set below the groundwater table provided these risks are fully acknowledged and all obligations set by the governing bodies in the jurisdiction are met which stipulate minimum clearance distances between basement slab elevation and seasonal high groundwater table.

The water level is expected to be 3.6 metres or deeper below grade, and basements are not expected to extend below the groundwater table. GEI is measuring groundwater levels each month for a year to determine the seasonally high groundwater level, and the results will be included in a future letter report.

4.5 Site Servicing

4.5.1 Bedding

The type of material and depth of granular bedding below the pipe will, to some extent, depend on the method of construction used by the contractor. Pipe bedding for flexible pipes should follow the requirements in Ontario Provincial Standard Drawing (OPSD) 802.010 or 802.013 or applicable municipal standards. Pipe bedding for rigid pipes should follow the requirements in OPSD 802.030 to 802.033 or applicable municipal standards.

A subgrade consisting of the native soils, weathered bedrock or earth fill on site will provide adequate support for pipes with the bedding requirements as laid out in the above referenced OPS drawings. Where disturbance of the trench base has occurred from groundwater seepage, construction traffic, etc., the disturbed soils should be sub-excavated and replaced with suitably compacted granular fill. If weak zones are encountered, additional bedding materials and differing construction practices may be required and should be determined during construction.

Regardless of whether flexible or rigid pipes are implemented, granular bedding and cover material should consist of a well graded, free draining material, such as Granular “A” (OPSS.MUNI 1010). All granular bedding must be compacted to a minimum of 98% SPMDD.

4.5.2 Backfill

Excavated soil from the site can be used as backfill in trenches provided the moisture content is within 2% of optimum (see Section 5.3 for more details on soil compaction). As noted in Section 5.3, a high percentage of the in-situ sands are dry of optimum and moisture conditioning will be required. Any backfill that is frozen, contains a high percentage of organic material (topsoil, peat, etc.) or moisture, or has otherwise unsuitable deleterious inclusion should not be used as backfill. The maximum cobble or boulder size should not exceed half of the loose lift thickness (i.e. all particles with a diameter greater than 100 mm should be removed). The backfill should be compacted to a minimum of 98% SPMDD. In confined areas the layer thickness will have to be reduced to utilize smaller compaction equipment efficiently or by using granular material instead of locally sourced fill.

Excavated bedrock cannot be re-used as backfill in settlement sensitive areas, as it cannot be compacted properly and often contains voids.

Where trenches are within the traveled portions of a roadway, backfill within the frost penetration depth of 1.4 metres should consist of native, non-organic, excavated material consistent with the soils surrounding the trench. If this technique is not undertaken, then frequently problems arise with yearly differential frost heave movements between the trench backfill and the adjacent native soil. This could occur, for example, if imported granular fill was used to backfill the trenches which is less susceptible to frost compared to some of the existing soils at the site with higher silt content. Alternatively, if different soil is used as the backfill due to issues with achieving compaction, a frost taper of 5H:1V can be implemented to help mitigate the potential for differential settlement and frost heave.

4.6 Pavement Design

As part of the proposed development, Wilson Avenue will be extended to connect with Palmer Road and new Streets B, C and D will be constructed within the development.

4.6.1 Subgrade Preparation

Topsoil, existing pavements or slabs, vegetation, and existing earth fill containing excessive organics or deleterious materials are not suitable for the support of a pavement structure and must be removed. Existing earth fill and the undisturbed native sand with limestone fragments are suitable for the support of a pavement structure provided the soils are proof-rolled with large compaction equipment or a loaded tandem axle dump truck, inspected and approved by the geotechnical engineer.

If any soft or weak subgrade areas are identified, or if there are areas containing excessive amounts of deleterious/organic material, they must be locally sub-excavated and backfilled with approved clean earth fill or imported granular material and compacted to a minimum of 98% SPMDD.

The long-term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures must be maintained to ensure that uniform subgrade moisture and density conditions are achieved as much as possible when fill is placed, and the natural subgrade is not disturbed or weakened after it is exposed.

4.6.2 Drainage

Control of surface water is an important factor in achieving a good pavement life. The need for adequate subgrade drainage cannot be over-emphasized. The subgrade must be free of depressions and sloped at a minimum grade of 2 percent to provide effective drainage toward perimeter subgrade drains, catch basins, or roadside ditches. Grading adjacent to pavement areas should be designed to ensure that water is not allowed to pond adjacent to the outside edges of the pavement.

Continuous pavement subdrains should be provided along both sides of the roadways and drained into respective catch basins to facilitate drainage of the subgrade and the granular materials. The subdrain invert should be maintained at least 0.3 metres below subgrade level. To minimize the problems of differential movement between the pavement and catchbasins / manhole due to frost action, the backfill around the structures should consist of free-draining granular material. Alternatively, the granular material can slope and drain into roadside ditches. Typical pavement drainage details are included in Appendix C.

4.6.3 Pavement Structure

The projected traffic volumes for the proposed development were unknown at the time of writing of this report. There are two different types of pavements that need to be designed for:

- Light duty: Includes roadways and parking lots which will not see frequent heavy traffic loads such as buses, delivery or fire trucks, etc., and will mostly service small vehicles such as cars or pickup trucks.
- Heavy Duty: Includes roadways and parking lots which are designated fire truck routes, or will see frequent heavy traffic loads such as buses, delivery or garbage trucks, etc.

The industry pavement design methods are based on a design life of 15 to 20 years for typical weather conditions depending on actual traffic volumes. The following pavement thickness designs are provided on the above noted considerations and subgrade basis.

Pavement Layer	**Compaction Requirements**	**Minimum Component Thickness**	
		Light Duty	**Heavy Duty**
Surface Course Asphaltic Concrete: HL3 (OPSS.MUNI 1150) with PG 58-28 Asphalt Cement (OPSS.MUNI 1101)	OPSS.MUNI 310	40 mm	40 mm
Binder Course Asphaltic Concrete: HL8 (OPSS 1150) with PG 58-28 Asphalt Cement (OPSS.MUNI 1101)		50 mm	70 mm
Base Course: Granular A (OPSS.MUNI 1010)	100% Standard Proctor Maximum Dry Density (ASTM-D698)	150 mm	150 mm
Subbase Course: Granular B Type I or II (OPSS.MUNI 1010)		300 mm	450 mm

The granular materials should be placed in lifts 200 mm thick or less and must be compacted to a minimum of 100% SPMDD for both granular base and granular subbase. Asphalt materials should be rolled and compacted as per OPSS.MUNI 310. The granular and asphalt pavement materials and their placement should conform to OPSS.MUNI 310, 501, 1010, 1150 and/or 1151.

If the pavement construction occurs in wet, winter or inclement weather, it may be necessary to provide additional subgrade support for heavy construction traffic by increasing the thickness of the granular subbase, base or both. Further, traffic areas for construction equipment may experience unstable subgrade conditions. These areas may be stabilized utilizing additional thickness of granular materials.

It should be noted that in addition to adherence of the above pavement design recommendations, a close control on the pavement construction process will also be required in order to obtain the desired pavement life. Therefore, it is recommended that regular inspection and testing should be conducted during the pavement construction to confirm material quality, thickness, and to ensure adequate compaction.

5. Constructability Recommendations

5.1 Excavations

Excavations must be carried out in accordance with the Occupational Health and Safety Act, Ontario Regulation 213/91 (as amended), Construction Projects, Part III - Excavations, Section 222 through 242.

Where workers must enter a trench or excavation the soil must be suitably sloped and/or braced in accordance with the OHSA. These regulations designate four (4) broad classifications of soils to stipulate appropriate measures for excavation safety. The regulation stipulates safe slopes of excavation as follows based on the soils encountered at this site:

- *Type 3 Soils – All Site Soils Above Water Table:* Trench sidewalls to be constructed no steeper than 1 horizontal to 1 vertical from the base of the excavation.
- *Type 4 Soils – All Site Soils Below Water Table:* Trench sidewalls to be constructed no steeper than 3 horizontal to 1 vertical from the base of the excavation.

Where more than one soil type is encountered in an excavation, the most conservative soil type must be followed. It is expected that most excavations made on site will follow Type 3 soils.

Minimum support system requirements for steeper excavations are stipulated in Sections 235 through 238 and 241 of the OHSA and include provisions for timbering, shoring and moveable trench boxes. In order to reduce the potential for instability of the trench excavations, materials excavated from the service trenches and/or other fill materials or heavy equipment should not be placed near the crest of the trench excavations.

Bedrock is not classified as soil under the OHSA, and vertical bedrock cuts are typically stable and self-supporting for construction purposes. Due to the weathering and fractures of the bedrock encountered below the site, excavations extending into the bedrock should be inspected by the geotechnical engineer to verify vertical cuts are acceptable or if other support systems are required to protect workers from loose bedrock fragments (e.g. wire meshing, rock bolts, etc.). Zones of the weathered and fractured limestone may be rippable with conventional excavator teeth, but it should be assumed that techniques such as hydraulic breaking, line drilling and blasting, or similar methods will be required for most excavations made into bedrock. If a large, intact limestone bed is encountered above the founding elevation, the entire thickness of the bed may need to be removed. The contract documents should address that over-excavation and excess bedrock removal may be required for foundations on bedrock, coupled with additional concrete below the founding elevation.

The boreholes encountered inferred limestone slabs or boulders within the sand deposit above the bedrock surface, and buried obstructions were embedded within the earth fill. The possibility for encountering these obstructions and their removal (if encountered) should be addressed within the construction contracts.

It is important to note that soils and weathered bedrock encountered in the construction excavations may vary significantly across the site. Our preliminary soil classifications are based solely on the materials encountered in widely spaced boreholes advanced on site. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, we recommend that GEI be contacted immediately to evaluate the conditions encountered.

5.2 Temporary Groundwater Control

It is expected that the groundwater table is located at a depth of 3.6 metres below grade during wet seasons and 5 metres below grade during summer months, based on the groundwater levels measured to date. The groundwater table appears to be located within the limestone bedrock. Some perched water may be present at the soil overburden-bedrock interface following precipitation events or the spring freshet. The groundwater level will change based on seasonal fluctuations. The overburden soils are cohesionless and will allow for the free flow of water when wet. It is expected that the highly fractured bedrock will also allow for the free flow of water. GEI is measuring the water levels once per month for a year to determine the seasonally high groundwater elevation, with the results provided in a separate letter report.

On a preliminary basis, excavations are not expected to extend below the groundwater table. Any seepage from the overburden or runoff from precipitation events can be controlled using a conventional sump pump system. Additional groundwater control details are provided in GEI's hydrogeological study under a separate cover.

5.3 Compaction Specifications

Standard Proctor Maximum Dry Density (SPMDD) is the level to which a soil or aggregate is compacted. To achieve the specified SPMDD as indicated in this report, all soils or aggregates must be placed in lift thicknesses no greater than 200 mm. If this is not the case, only the upper portion of the lift will be adequately compacted, and the lower portion of the lift has a high probability of not meeting compaction specifications. In addition, industry standard equipment used to determine the degree of compaction consists of nuclear densometers. These devices have an inherent limitation in that they cannot test beyond 300 mm in depth, and so the degree of compaction beyond this depth cannot be quantitatively determined.

Along with lift thickness, ensuring that the soil or aggregate is within 2% of its optimum moisture content ensures that the specified compaction can be reached. If the soil or aggregate is too dry/wet, it is either very difficult or impossible to reach the specified compaction. This is especially true for when higher compaction specifications such as 98% and 100% SPMDD are required. The following conditions are expected for the in-situ soil based on the moisture contents of the soil samples recovered in the boreholes:

- One-quarter of the soil is at optimum moisture content.
- Three-quarters of the soil is below optimum moisture content.

The soil will likely require moisture conditioning (addition of water) prior to re-use in order to achieve the compaction specifications. It must be noted that the in-situ moisture contents can change based on the time of year in which construction occurs, as the prevailing weather can have a significant effect on the moisture content of stockpiled and in-situ soil.

Excavated bedrock cannot be re-used as backfill in settlement sensitive areas, as it cannot be compacted properly and often contains voids.

In addition to the above compaction specifications, in any areas where compacted fill will be placed over the exposed native soil subgrade, any loose, soft, wet or unstable areas should be sub-excavated, and backfilled with clean earth fill or Granular ‘B’ (OPSS.MUNI 1010) compacted to a minimum of 98% SPMDD. This recommendation applies to site servicing, slab-on-grade, and pavement subgrades.

5.4 Quality Verification Services

On-site quality verification services are an integral part of the geotechnical design function, and for foundations, retaining walls, and engineered fill, are required under the Ontario Building Code (OBC). Quality verification services are used to confirm that construction is being conducted in general conformance with the requirements as outlined in the drawings, reports and specifications prepared for the proposed development.

GEI can provide all the on-site quality verification services outlined below:

- The subgrade for the single dwelling or townhouse shallow foundations may be field reviewed by the geotechnical engineer as required by the municipal regulating authority.
- Installation of retaining structures over 1.0 metres high and related backfilling operations must be field reviewed on a continuous basis by the geotechnical engineer as required in the OBC.
- Part-time monitoring of the subgrade support capabilities (i.e. proof-roll, inspection), material quality, lift thickness, moisture content, degree of compaction, etc. is recommended for the following areas to ensure the recommendations within this report are followed and they perform adequately in the long-term:
  - Slab-on-grades;
  - Pavement structures (granular and asphalt); and
  - Bedding/backfilling of site servicing.

- Testing of the concrete (compressive strength, slump, air content, etc.) and testing of the asphalt (asphalt content and gradation) are recommended to ensure that the quality of the materials being brought to site meet the requirements of the project.

5.5 Site Work

The soils found at this site may become weakened when subjected to traffic, particularly when wet. If there is site work carried out during periods of wet weather, then it can be expected that the subgrade will be disturbed unless an adequate granular working surface is provided to protect the integrity of the subgrade soils from construction traffic. Subgrade preparation works cannot be adequately accomplished during wet weather and the project must be scheduled accordingly. The disturbance caused by the traffic can result in the removal of disturbed soil and use of granular fill material for site restoration or underfloor fill that is not intrinsic to the project requirements.

The most severe loading conditions on the subgrade may occur during construction. Consequently, special provisions such as end dumping and forward spreading of earth and aggregate fills, restricted construction lanes, and half-loads during paving and other work may be required, especially if construction is carried out during unfavourable weather.

If construction proceeds during freezing weather conditions, adequate temporary frost protection for the founding subgrade and concrete must be provided. The soil at this site is susceptible to frost damage. Consideration must be given to frost effects, such as heave or softening, on exposed soil surfaces in the context of this particular project development.

6. Limitations and Conclusions

6.1 Limitations

The recommendations and comments provided are necessarily on-going as new information of underground conditions becomes available. More specific information with respect to the conditions between samples, or the lateral and vertical extent of materials may become apparent during excavation operations. The interpretation of the borehole information must, therefore, be validated during excavation operations. Consequently, conditions not observed during this investigation may become apparent. Should this occur, GEI should be contacted to assess the situation and additional testing and reporting may be required.

GEI should be retained for a general review of the final design drawings and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, GEI will assume no responsibility for interpretation of the recommendations in the report.

The comments given in this report are intended only for the guidance of the design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. could be greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

This report was prepared by GEI for the account of RIC (Midland Land) Inc. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. GEI accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this project.

6.2 Conclusion

It is recognized that municipal/regional governing bodies, in their capacity as the planning and building authority under Provincial statues, will make use of and rely upon this report, cognizant of the limitations thereof, both as are expressed and implied.

We trust this report is complete within our terms of reference, and the information presented is sufficient for your present purposes. If you have any questions, or when we may be of further assistance, please do not hesitate to contact our office.

Yours Truly,

GEI Consultants

Prepared By:

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R. M. WIGINTON
100193069
May 19, 2022
PROVINCE OF ONTARIO

Reviewed By:

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May 19, 2022
PROVINCE OF ONTARIO

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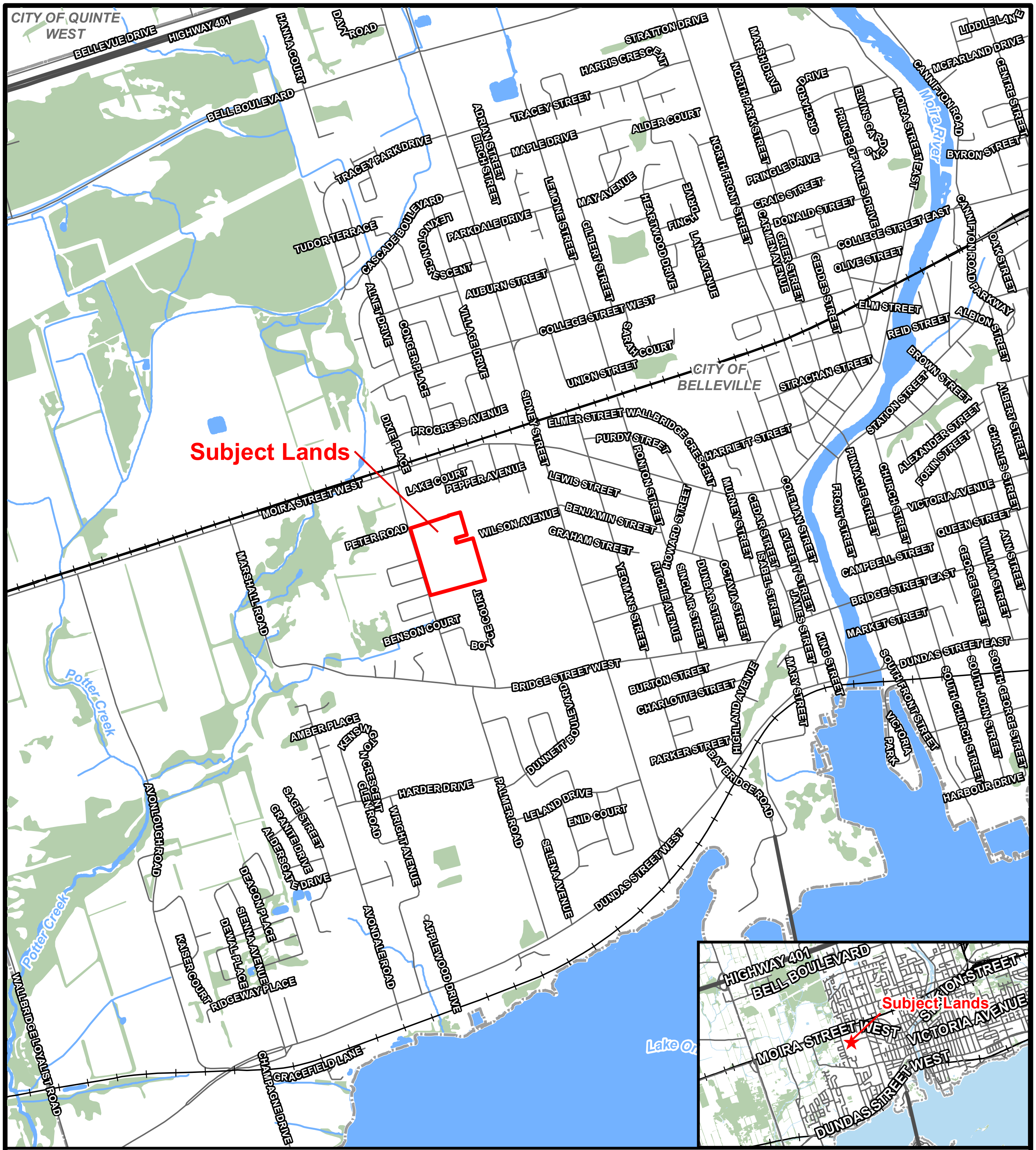
Geotechnical and Earth Sciences Manager

Figures

Site Location Plan

Borehole Location Plans

Geological Cross-Section A-A’



NOTES:
1. Coordinate System: NAD 1983 UTM Zone 18N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2022.

Legend

🟥 Subject Lands	— Road
▭ Municipal Boundary, Lower/Single Tier	— Watercourse
▭ Municipal Boundary, Upper Tier	🟦 Waterbody
┼ Railway	🟩 Wooded Area
— Highway	

N

0 310 620 m

1:25,000

Wilson Avenue Extension,
Belleville, ON

RIC (Midland Land) Inc.

GEI Consultants

Project: 2102519

SITE LOCATION PLAN

May 2022

Fig. 1

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 18N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2022.
3. Orthoimagery © First Base Solutions, 2022. Imagery taken in 2008.

Legend

- ▭ Subject Lands
- ↔ Cross Section Location
- ⊕ Approximate Borehole Location
- ⊕ Approximate Borehole and Monitoring Well Location
- ⊕ Approximate Monitoring Well Location (From Others, Unknown Details)

N

0 25 50 m

1:2,000

Wilson Avenue Extension,
Belleville, ON

RIC (Midland Land) Inc.

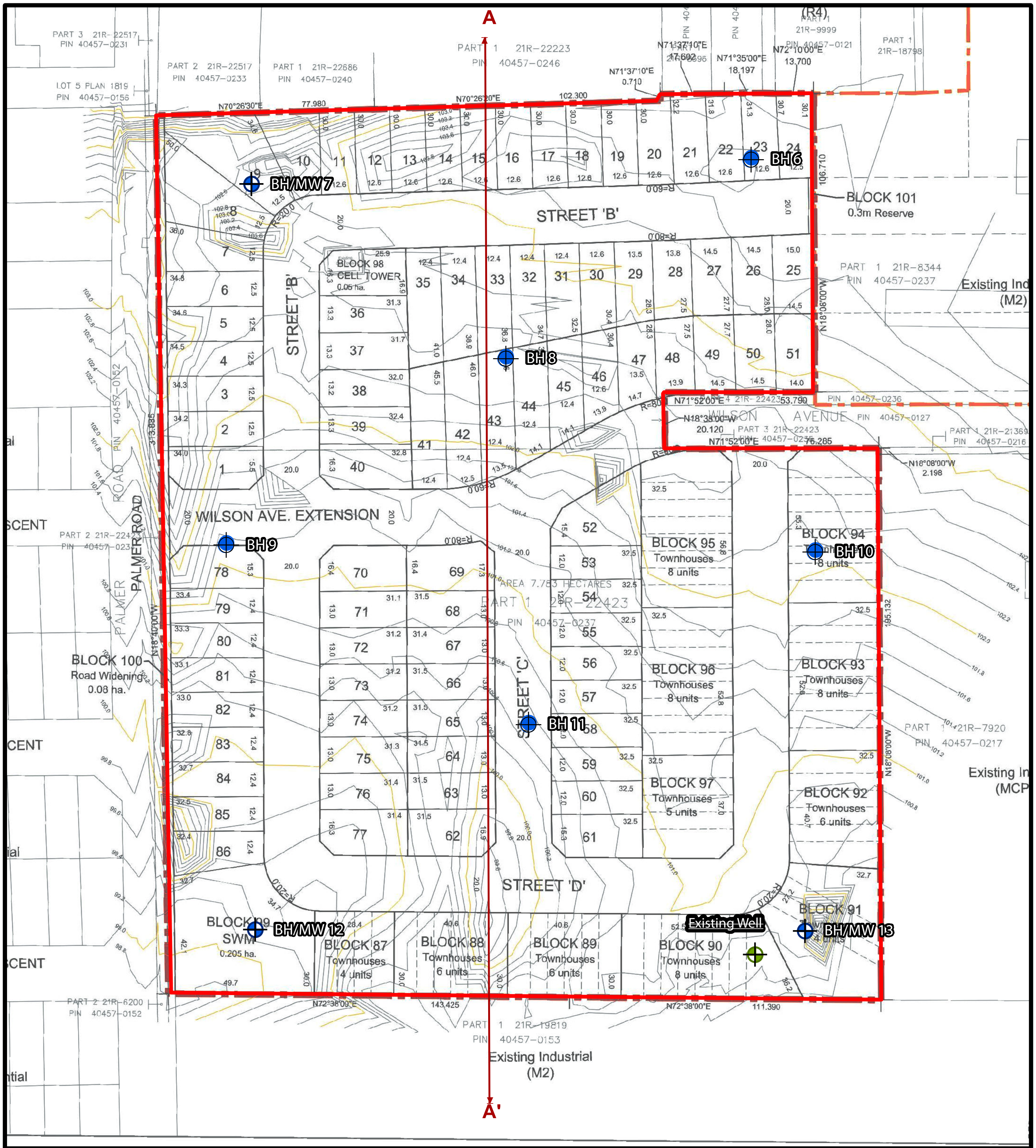
GEI Consultants

Project: 2102519

BOREHOLE LOCATION PLAN
(AERIAL)

May 2022

Fig. 2A



<BOL><UND><ITA>NOTES:</ITA></UND></BOL>
1. Coordinate System: NAD 1983 UTM Zone 18N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2022.
3. "Draft Plan of Subdivision, Part of Lots 15, 16, 17, 26 & 27, Plan 135, Part of Lots 6 & 7, Plan 1819, Part of Wilson Avenue, Plan 6, in the City of Belleville, County of Hastings" dated November 06, 2020, by Innovative Planning Solutions.

Legend

- 🟥 Subject Lands
- ↔ Cross Section Location
- ⊕ Approximate Borehole Location
- ⊕ Approximate Borehole and Monitoring Well Location
- ⊕ Approximate Monitoring Well Location (From Others, Unknown Details)

N

0 25 50
m
1:2,000

Wilson Avenue Extension,
Belleville, ON

RIC (Midland Land) Inc.

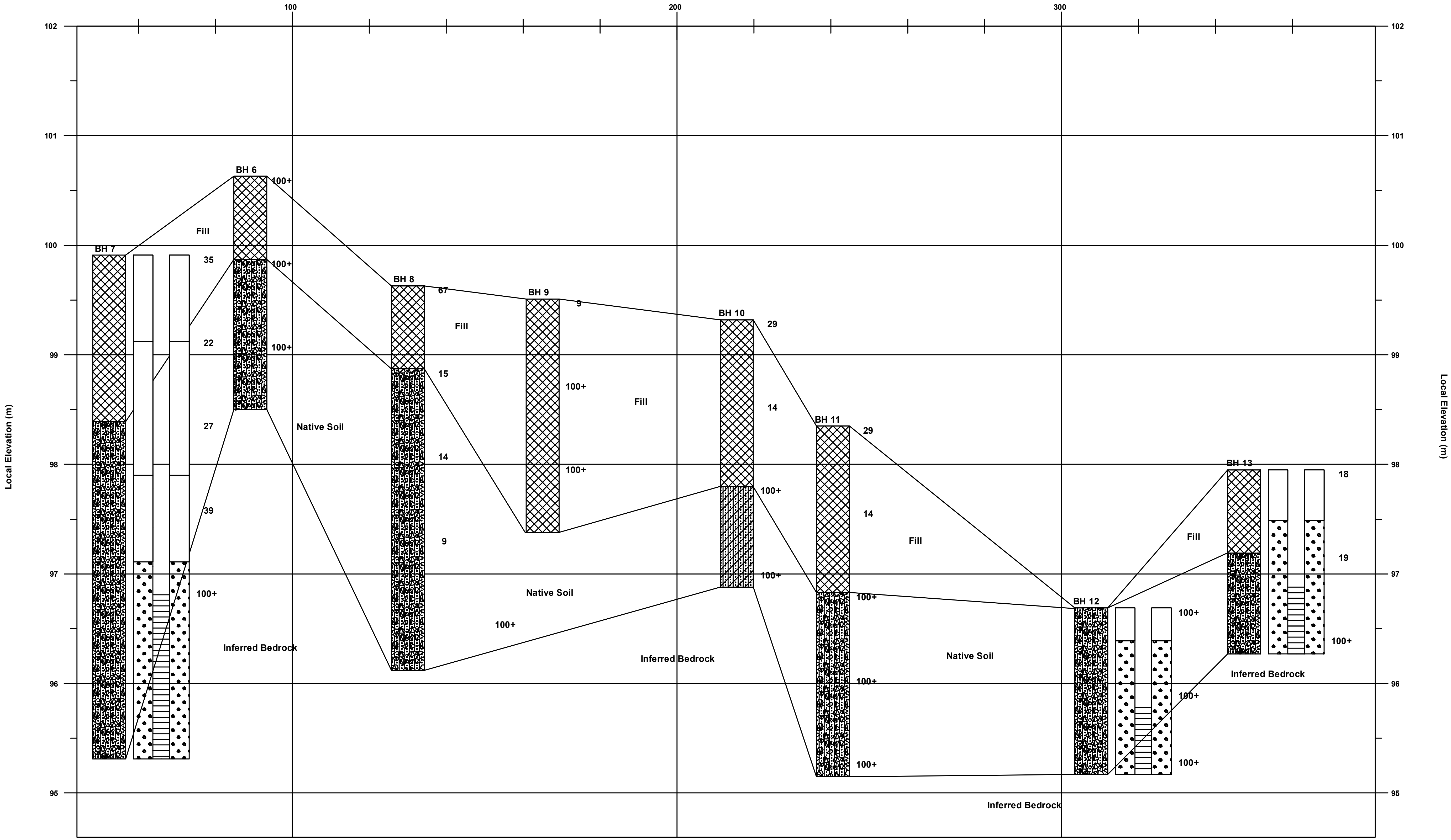
GEI
Consultants

Project: 2102519

BOREHOLE LOCATION PLAN
(PROPOSED SITE PLAN)

May 2022

Fig. 2B



1. Numbers shown next to boreholes are SPT "N" Values.
2. Subsurface conditions known only at borehole locations.
3. Horizontal distance between boreholes is not to scale.

Strata symbols

▨ **Fill**

▨ **Sand & Limestone Fragments**

▨ **Clayey & Silty Sand**

Wilson Avenue Extension,
Belleville, ON

RIC (Midland Land) Inc.

GEI Consultants

Project: 2102519

GEOLOGICAL CROSS
SECTION A-A'

May 2022

Fig. 3

Appendix A

Borehole Logs

RECORD OF BOREHOLE No. 6

GEI Consultants

Project Number: **2102519**
Project Client: **RIC (Midland Land) Inc.**
Project Name: **40 Wilson Avenue**
Project Location: **Belleville, Ontario**
Drilling Location: **See Figure 2**

Drilling Method: **Solid Stem Augers**
Drilling Machine: **Track Mount**
Logged By: **MH**
Northing: **4893168**
Date Started: **Aug. 4, 2021**
Reviewed By: **AW**
Easting: **307551**
Date Completed: **Aug. 4, 2021**

FIELD TESTING
Shear Strength Testing (kPa)
× Other Test
+ Pocket Penetrometer
▲ Field Vane (Intact)
△ Field Vane (Remolded)
40 80 120 160
Penetration Testing
○ SPT ● DCPT
10 20 30 40

LAB TESTING
△ Combustible Organic Vapour (ppm)
▲ Combustible Organic Vapour (%LEL)
✳ Total Organic Vapour (ppm)
100 200 300 400
Atterberg Limits
PL ├──┤ LL
○ Water Content (%)
10 20 30 40

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)			
Lithology Plot	DESCRIPTION Local 100.63m	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	DEPTH (m)	ELEVATION (m)			Instrumentation Installation	GR	SA	SI	CL
▨	FILL: Sand & Gravel, Trace Limestone Fragments, Very Dense, Brown, Damp	SS	1	25	100+	0		100+	3		Auger Grinding			
	0.8 99.9						100							
▨	SAND & LIMESTONE FRAGMENTS, Some Silt, Very Dense, Brown, Damp	SS	2	100	100+	1		100+	1					
		SS	3	100	100+		99	100+	3		Auger Grinding			
	2.1 98.5					2								
	Auger Refusal on Inferred Bedrock at 2.1m													

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647 Welham Road, Unit 14
Barrie, Ontario L4N 0B8
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www.geiconsultants.com

Groundwater depth encountered on completion of drilling: **Dry**

Cave depth after auger removal: **Open**

Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :50**

RECORD OF BOREHOLE No. 7

Project Number:	**2102519**				
Project Client:	**RIC (Midland Land) Inc.**				
Project Name:	**40 Wilson Avenue**	Drilling Method:	**Solid Stem Augers**	Drilling Machine:	**Track Mount**
Project Location:	**Belleville, Ontario**	Logged By:	**MH**	Northing:	**4893106**
				Date Started:	**Aug. 5, 2021**
Drilling Location:	**See Figure 2**	Reviewed By:	**AW**	Easting:	**307399**
				Date Completed:	**Aug. 5, 2021**

LITHOLOGY PROFILE / SOIL SAMPLING

Local **99.91m**

Depth (m) / Elevation (m)	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	Water Content (%)	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
0 / 99.91	FILL: Silty Sand, Some Gravel, Some Limestone Fragments, Dense to Compact, Brown, Moist	SS	1	100	35		
		SS	2	100	22	7	
1.5 / 98.4	SAND & LIMESTONE FRAGMENTS, Some Silt, Trace Clay, Compact to Dense, Brown, Moist	SS	3	100	27	4	GR 43, SA 35, SI 14, CL 8
		SS	4	100	39	7	Auger Grinding
	--- Very Dense ---	SS	5	100	100+	7	Auger Grinding and Spoon Bouncing
		AS	6	100		5	
4.6 / 95.3	Auger Refusal on Inferred Bedrock at 4.6m						

FIELD TESTING

Shear Strength Testing (kPa)

- × Other Test
- + Pocket Penetrometer
- ▲ Field Vane (Intact)
- △ Field Vane (Remolded)

40 80 120 160

Penetration Testing

○ SPT ● DCPT

10 20 30 40

LAB TESTING

- △ Combustible Organic Vapour (ppm)
- ▲ Combustible Organic Vapour (%LEL)
- ✳ Total Organic Vapour (ppm)

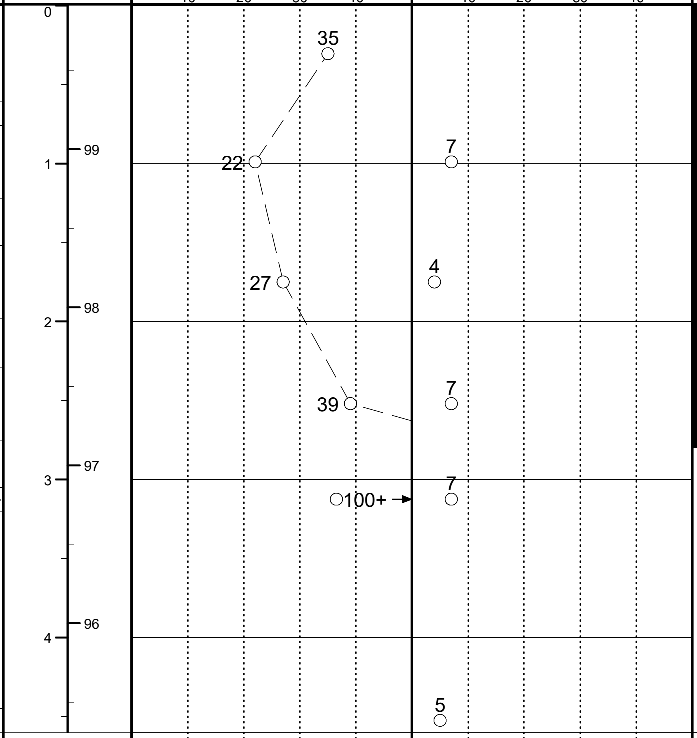
100 200 300 400

Atterberg Limits

PL ├──┤ LL

○ Water Content (%)

10 20 30 40



Instrumentation Installation

GR	SA	SI	CL
43	35	14	8

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Groundwater depth encountered on completion of drilling: **Dry**

Cave depth after auger removal: **Open**

Groundwater depth observed on **Aug. 31/21** at a depth of: **Dry**

Observed on **Oct. 8/21** at a depth of: **Dry**

Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :50**

Page: **1 of 1**

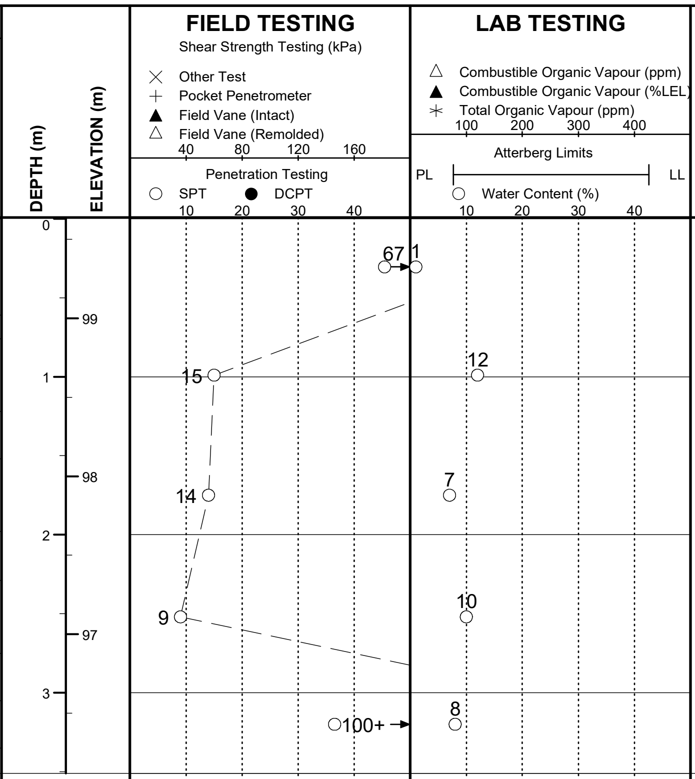
RECORD OF BOREHOLE No. 8

GEI Consultants

Project Number: **2102519**
Project Client: **RIC (Midland Land) Inc.**
Project Name: **40 Wilson Avenue**
Project Location: **Belleville, Ontario**
Drilling Location: **See Figure 2**

Drilling Method: **Solid Stem Augers**
Drilling Machine: **Track Mount**
Logged By: **MH**
Reviewed By: **AW**
Northing: **4893066**
Easting: **307487**
Date Started: **Aug. 4, 2021**
Date Completed: **Aug. 4, 2021**

Lithology Plot	DESCRIPTION (Local 99.63m)	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
▨	FILL: Sand & Limestone Fragments, Silty, Very Dense, Grey, Damp	SS	1	100	67	
	0.8 98.9					
▨	SAND, Some Silt, Some Limestone Fragments, Some Gravel, Compact, Brown, Moist	SS	2	100	15	
		SS	3	100	14	Auger Grinding
	--- Loose ---	SS	4	100	9	
	--- With Limestone Fragments, Very Dense ---	SS	5	100	100+	
	3.5 96.1					
	Auger Refusal on Inferred Bedrock at 3.5m	AS				



Instrumentation Installation

GR SA SI CL

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Groundwater depth encountered on completion of drilling: **Dry**

Cave depth after auger removal: **Open**

Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :50**

Page: **1 of 1**

RECORD OF BOREHOLE No. 9

GEI Consultants

Project Number: **2102519**
Project Client: **RIC (Midland Land) Inc.**
Project Name: **40 Wilson Avenue**
Project Location: **Belleville, Ontario**
Drilling Location: **See Figure 2**

Drilling Method: **Solid Stem Augers**
Drilling Machine: **Track Mount**
Logged By: **MH**
Northing: **4892980**
Date Started: **Aug. 5, 2021**
Reviewed By: **AW**
Easting: **307404**
Date Completed: **Aug. 5, 2021**

FIELD TESTING

Shear Strength Testing (kPa)
- × Other Test
- + Pocket Penetrometer
- ▲ Field Vane (Intact)
- △ Field Vane (Remolded)

40 80 120 160

Penetration Testing
- ○ SPT
- ● DCPT

10 20 30 40

LAB TESTING

- △ Combustible Organic Vapour (ppm)
- ▲ Combustible Organic Vapour (%LEL)
- ✳ Total Organic Vapour (ppm)

100 200 300 400

Atterberg Limits: PL ├──┤ LL

○ Water Content (%)

10 20 30 40

COMMENTS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

Local 99.51m

LITHOLOGY PROFILE: DESCRIPTION	SOIL SAMPLING: Sample Type	Sample Number	Recovery (%)	SPT "N" Value	FIELD TESTING: SPT	LAB TESTING: Water Content (%)	Instrumentation Installation	COMMENTS
FILL: Sand & Gravel, Some Concrete Fragments, Trace Silt, Loose, Brown, Moist	SS	1	100	9	9	13		
--- Trace Brick Fragments & Fabric, Very Dense ---	SS	2	100	100+	100+ →	10		Auger Grinding on Obstruction at 0.6m
	SS	3	100	100+	100+ →	6		Auger Grinding
2.1 97.4								
Auger Refusal on Burried Obstruction (Possible Concrete Slab) at 2.1m								

DEPTH (m): 0, 1, 2
ELEVATION (m): 99, 98

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Groundwater depth encountered on completion of drilling: **Dry**

Cave depth after auger removal: **Open**

Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :50**

Page: **1 of 1**

RECORD OF BOREHOLE No. 10

Project Number: **2102519**
Project Client: **RIC (Midland Land) Inc.**
Project Name: **40 Wilson Avenue**
Project Location: **Belleville, Ontario**
Drilling Location: **See Figure 2**

Drilling Method: **Solid Stem Augers**
Drilling Machine: **Track Mount**
Logged By: **MH**
Northing: **4893037**
Date Started: **Aug. 5, 2021**
Reviewed By: **AW**
Easting: **307611**
Date Completed: **Aug. 5, 2021**

FIELD TESTING
Shear Strength Testing (kPa): × Other Test; + Pocket Penetrometer; ▲ Field Vane (Intact); △ Field Vane (Remolded) — 40, 80, 120, 160
Penetration Testing: ○ SPT; ● DCPT — 10, 20, 30, 40

LAB TESTING
△ Combustible Organic Vapour (ppm); ▲ Combustible Organic Vapour (%LEL); ✳ Total Organic Vapour (ppm) — 100, 200, 300, 400
Atterberg Limits: PL ├─┤ LL; ○ Water Content (%) — 10, 20, 30, 40

LITHOLOGY PROFILE: DESCRIPTION (Local 99.32m)	SOIL SAMPLING: Sample Type	Sample Number	Recovery (%)	SPT "N" Value	DEPTH (m)	ELEVATION (m)	FIELD TESTING: SPT	LAB TESTING: Water Content (%)	Instrumentation Installation	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
FILL: Sand & Gravel, Some Limestone Fragments, Compact, Brown, Moist	SS	1	100	29	0	99	29	10		Auger Grinding
0.8 — 98.6 FILL: Silty Sand, Some Concrete Fragments, Trace Plastic, Compact, Dark Brown, Moist	SS	2	100	14	1	98	14	25		
1.5 — 97.8 CLAYEY & SILTY SAND, Trace Gravel, Trace Limestone Fragments, Hard, Brown, Wet	SS	3	100	100+	2		100+ →	42		
2.4 --- Some Limestone Fragments --- 96.9	SS	4	100	100+		97	100+ →	5		Auger Gridning & Spoon Bouncing
Auger Refusal on Inferred Bedrock at 2.4m										

GR | SA | SI | CL

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Groundwater depth encountered on completion of drilling: **Dry**

Cave depth after auger removal: **Open**

Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :50**
Page: **1 of 1**

RECORD OF BOREHOLE No. 11

GEI Consultants

Project Number: **2102519**
Project Client: **RIC (Midland Land) Inc.**
Project Name: **40 Wilson Avenue**
Project Location: **Belleville, Ontario**
Drilling Location: **See Figure 2**

Drilling Method: **Solid Stem Augers**
Drilling Machine: **Track Mount**
Logged By: **MH**
Northing: **4892958**
Date Started: **Aug. 5, 2021**
Reviewed By: **AW**
Easting: **307520**
Date Completed: **Aug. 5, 2021**

LITHOLOGY PROFILE · **SOIL SAMPLING** · **FIELD TESTING** · **LAB TESTING** · **COMMENTS & GRAIN SIZE DISTRIBUTION (%)**

FIELD TESTING – Shear Strength Testing (kPa): × Other Test; + Pocket Penetrometer; ▲ Field Vane (Intact); △ Field Vane (Remolded); scale 40, 80, 120, 160. Penetration Testing: ○ SPT; ● DCPT; scale 10, 20, 30, 40.

LAB TESTING – △ Combustible Organic Vapour (ppm); ▲ Combustible Organic Vapour (%LEL); ✳ Total Organic Vapour (ppm); scale 100, 200, 300, 400. Atterberg Limits: PL ├─┤ LL; ○ Water Content (%); scale 10, 20, 30, 40.

Description (Local 98.35m)	Depth (m)	Elevation (m)	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	Water Content (%)	GR	SA	SI	CL	Comments
FILL: Silty Sand, Some Gravel, Some Concrete Fragments, Compact, Brown, Moist	0	98.35	SS	1	100	29	6					
--- Gravelly ---			SS	2	100	14	8					
SAND & LIMESTONE FRAGMENTS, Trace Silt, Very Dense, Brown, Moist	1.5	96.8	SS	3	100	100+	4	54	39	(7)		Auger Grinding
			SS	4	100	100+	10					
			SS	5	100	100+	5					Auger Grinding & Spoon Bouncing
Auger Refusal in Inferred Bedrock at 3.2m	3.2	95.2										

Instrumentation Installation

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Groundwater depth encountered on completion of drilling: **Dry**

Cave depth after auger removal: **Open**

Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :50**

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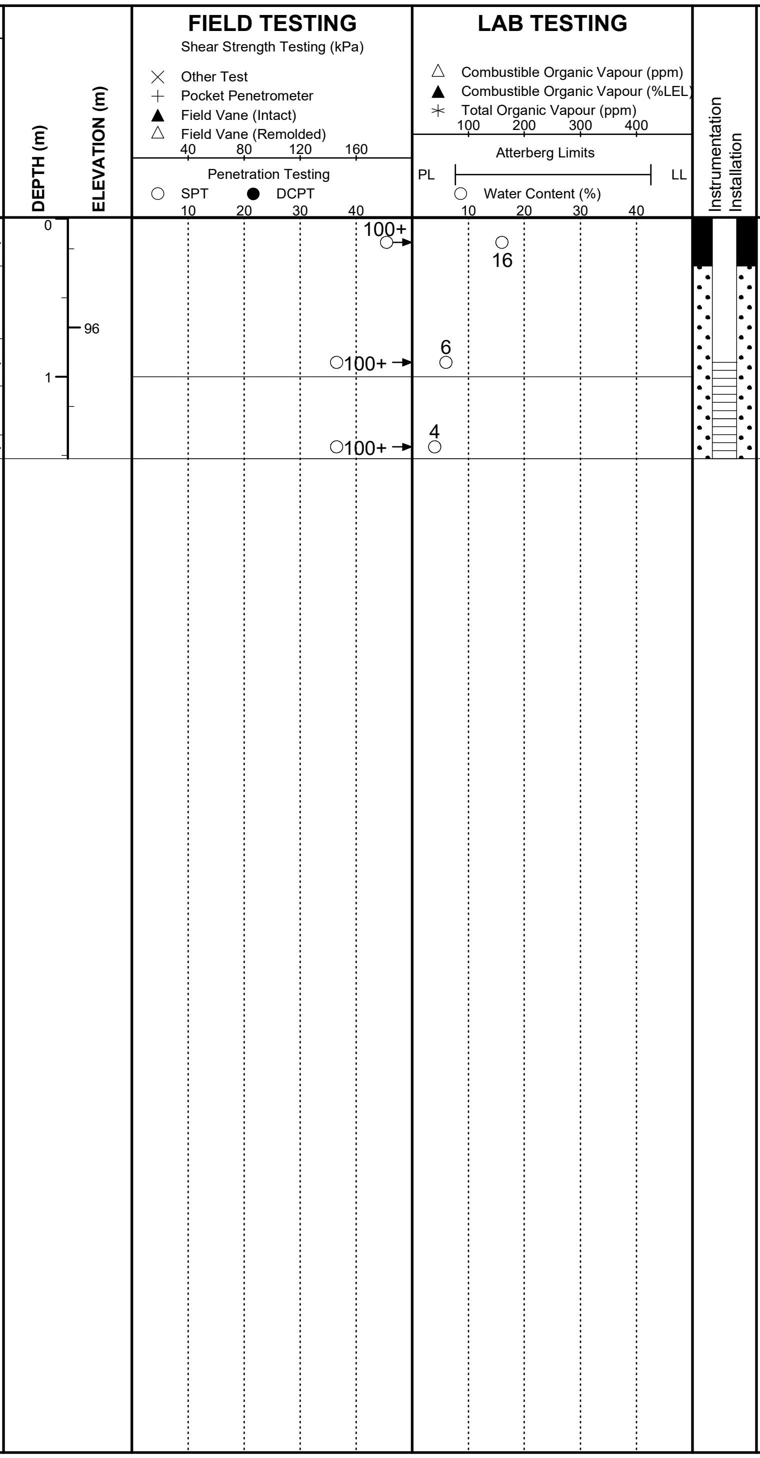
RECORD OF BOREHOLE No. 12

GEI Consultants

Project Number: **2102519**
Project Client: **RIC (Midland Land) Inc.**
Project Name: **40 Wilson Avenue**
Project Location: **Belleville, Ontario**
Drilling Location: **See Figure 2**

Drilling Method: **Solid Stem Augers**
Drilling Machine: **Track Mount**
Logged By: **MH**
Northing: **4892850**
Date Started: **Aug. 5, 2021**
Reviewed By: **AW**
Easting: **307477**
Date Completed: **Aug. 5, 2021**

LITHOLOGY PROFILE		SOIL SAMPLING					COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION Local 96.69m	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	Instrumentation Installation	GR / SA / SI / CL
▨	SAND & LIMESTONE FRAGMENTS, Trace Silt, Very Dense, Brown, Moist	SS	1	100	100+		Auger Grinding
▨	--- Grey, Damp ---	SS	2	100	100+		
▨	1.5 95.2	AS	3	100	100+		Auger Grinding
	Auger Refusal on Inferred Bedrock at 1.5m						



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Groundwater depth encountered on completion of drilling: **Dry**

Cave depth after auger removal: **Open**

Groundwater depth observed on **Aug. 31/21** at a depth of: **Dry**

Observed on **Oct. 8/21** at a depth of: **Dry**

Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :50**

Page: **1 of 1**

RECORD OF BOREHOLE No. 13

GEI Consultants

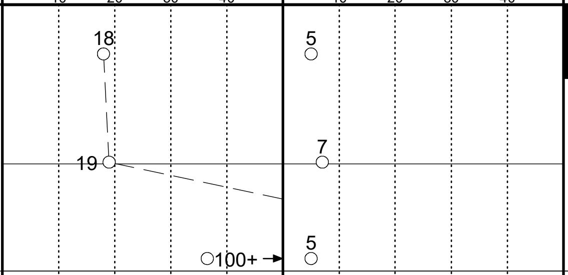
Project Number:	**2102519**				
Project Client:	**RIC (Midland Land) Inc.**				
Project Name:	**40 Wilson Avenue**	Drilling Method:	**Solid Stem Augers**	Drilling Machine:	**Track Mount**
Project Location:	**Belleville, Ontario**	Logged By:	**MH**	Northing:	**4892905**
Drilling Location:	**See Figure 2**	Reviewed By:	**AW**	Easting:	**307645**

Date Started: **Aug. 5, 2021**

Date Completed: **Aug. 5, 2021**

LITHOLOGY PROFILE / SOIL SAMPLING / FIELD TESTING / LAB TESTING / COMMENTS & GRAIN SIZE DISTRIBUTION (%)

Depth (m)	Elevation (m)	DESCRIPTION (Local 97.95m)	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	Water Content (%)	COMMENTS	GR	SA	SI	CL
0	97.95	FILL: Sand & Gravel, Some Concrete & Limestone Fragments, Compact, Brownn, Moist	SS	1	100	18	5	Auger Grinding				
0.8	97.2	SAND & LIMESTONE FRAGMENTS, Trace Silt, Compact, Brown, Moist	SS	2	100	19	7		37	55	(8)	
		--- Very Dense ---	SS	3	100	100+	5	Auger Grinding & Spoon Bouncing				
1.7	96.3	Auger Refusal on Inferred Bedrock at 1.7m										



FIELD TESTING
Shear Strength Testing (kPa)
× Other Test
+ Pocket Penetrometer
▲ Field Vane (Intact)
△ Field Vane (Remolded)
40 80 120 160
Penetration Testing
○ SPT ● DCPT
10 20 30 40

LAB TESTING
△ Combustible Organic Vapour (ppm)
▲ Combustible Organic Vapour (%LEL)
✳ Total Organic Vapour (ppm)
100 200 300 400
Atterberg Limits
PL LL
○ Water Content (%)
10 20 30 40

Instrumentation Installation

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Groundwater depth encountered on completion of drilling: **Dry**

Cave depth after auger removal: **Open**

Groundwater depth observed on **Aug. 31/21** at a depth of: **Dry**

Observed on **Oct. 8/21** at a depth of: **Dry**

Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :50**

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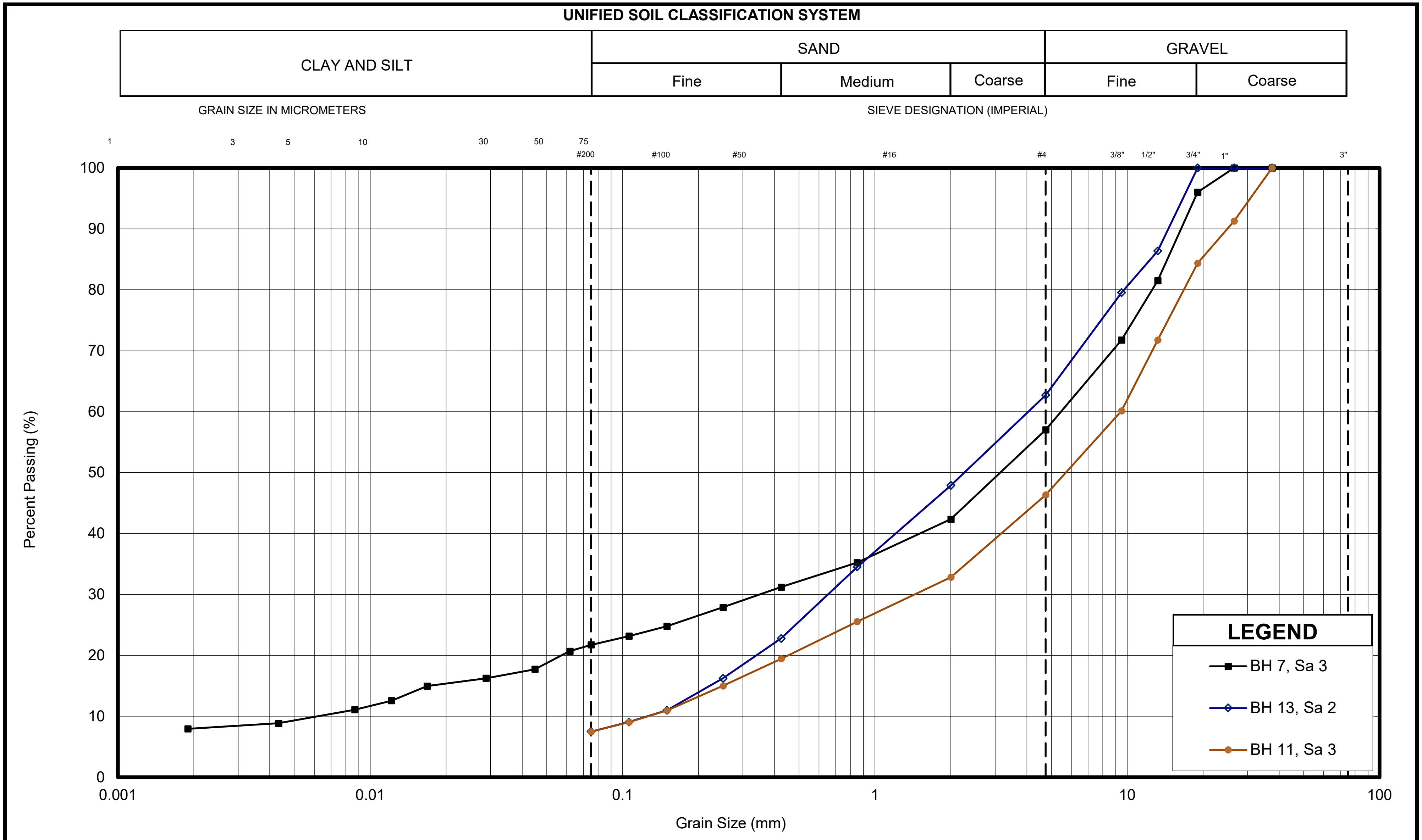
Appendix B

Geotechnical Laboratory Data



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
BH 7, Sa 3	SAND & LIMESTONE FRAGMENTS, Some Silt, Trace Clay	43	35	14	8	0.006	0.35	5.469	883	3.62
BH 13, Sa 2	SAND & LIMESTONE FRAGMENTS, Trace Silt	37	55	8		0.126	0.651	4.058	32.28	0.83
BH 11, Sa 3	SAND & LIMESTONE FRAGMENTS, Trace Silt	54	39	7		0.126	1.438	9.436	74.66	1.73

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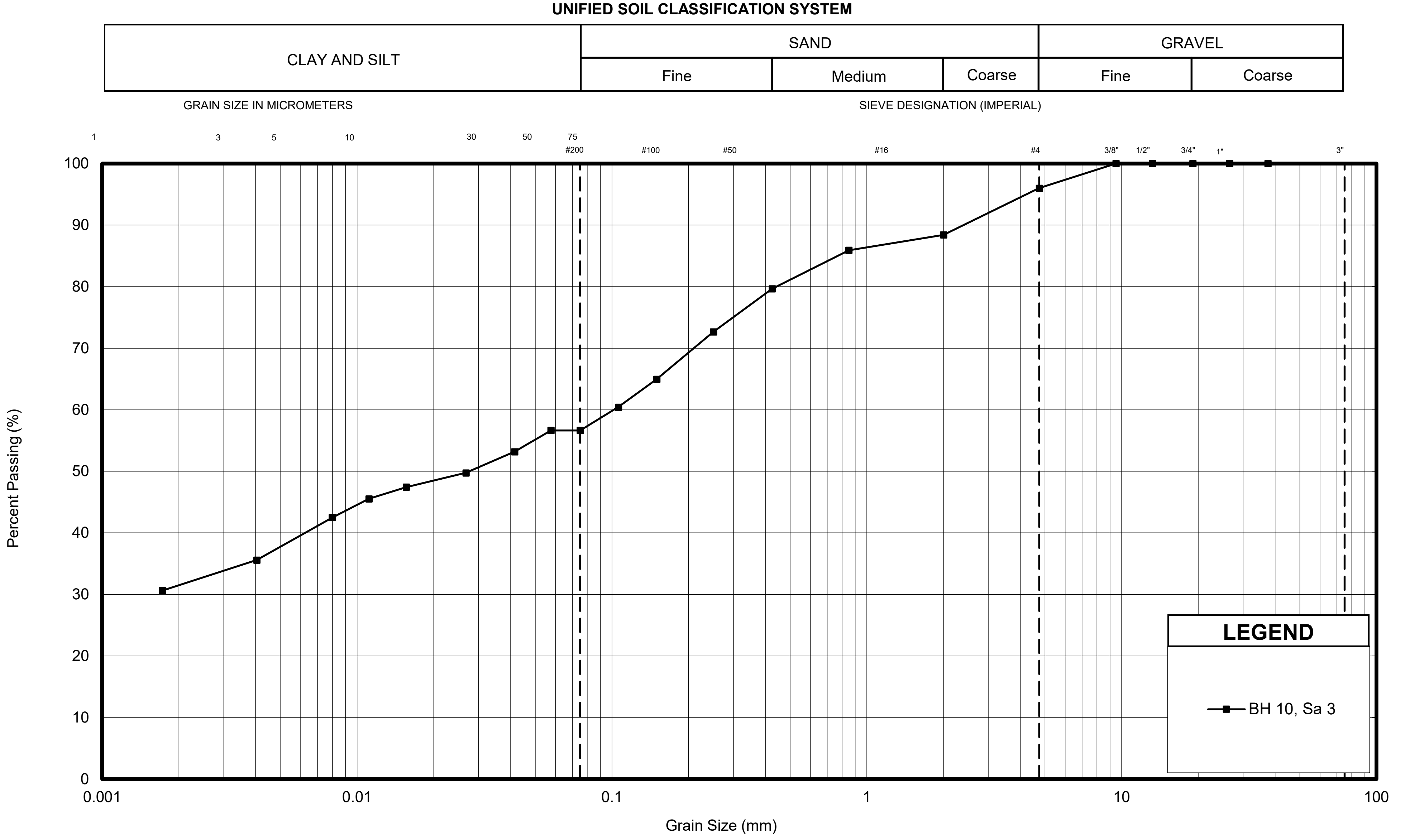
GRAIN SIZE DISTRIBUTION

SAND & LIMESTONE FRAGMENTS

APP. No.	B
REF. No.	2102519
DATE	September 2021



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
BH 10, Sa 3	CLAYEY & SILTY SAND, Trace Gravel	4	39	26	31	-	-	0.102	-	-

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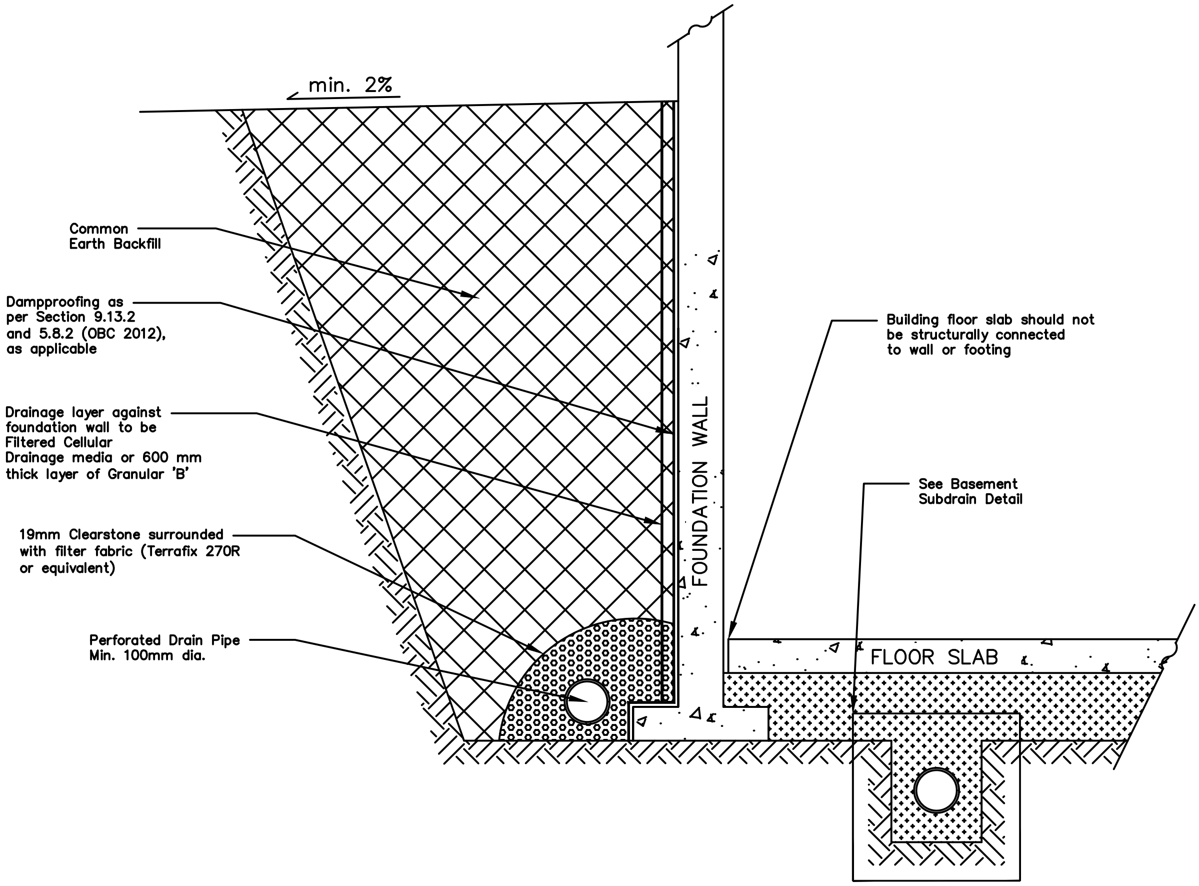
GRAIN SIZE DISTRIBUTION

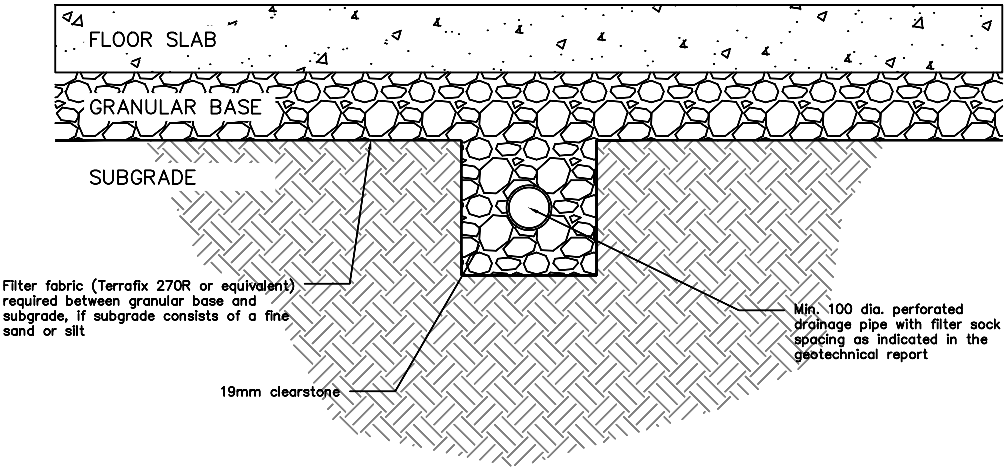
CLAYEY & SILTY SAND

APP. No.	B
REF. No.	2102519
DATE	September 2021

Appendix C

Typical Details





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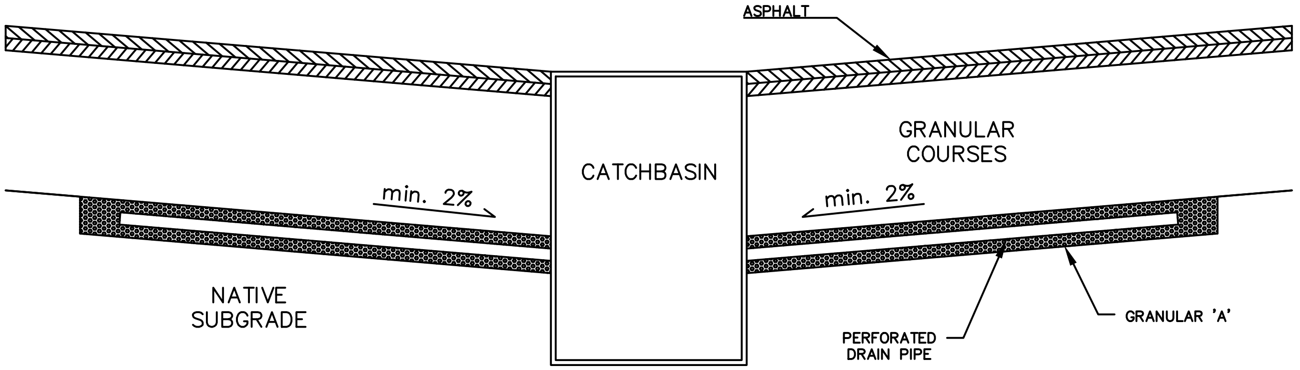
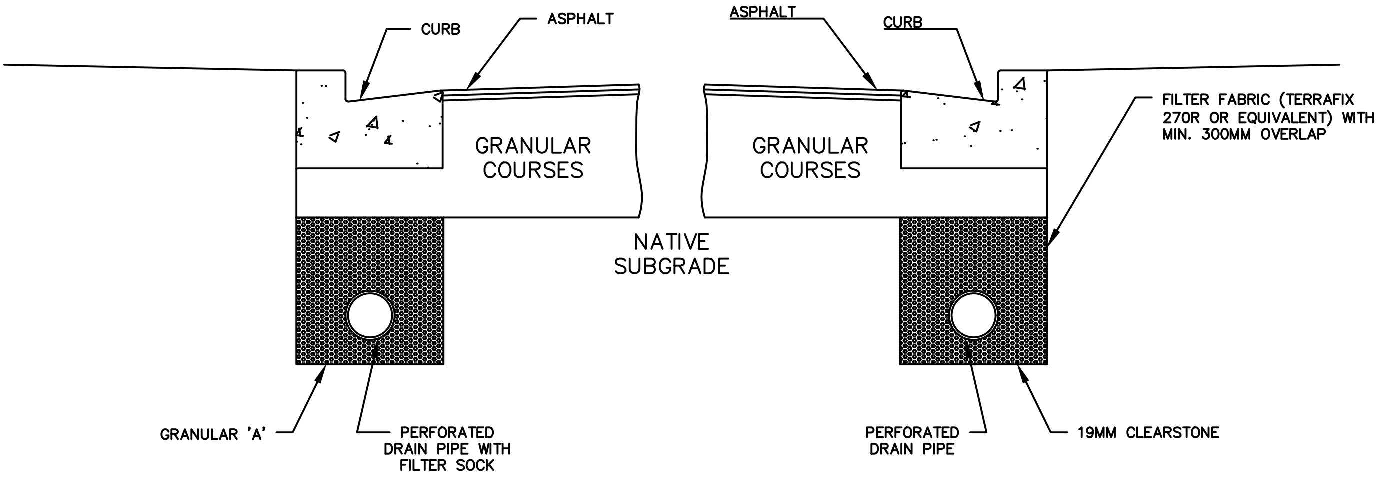
BASEMENT FOUNDATION WALL & SUBFLOOR DRAINAGE TYPICAL DETAIL

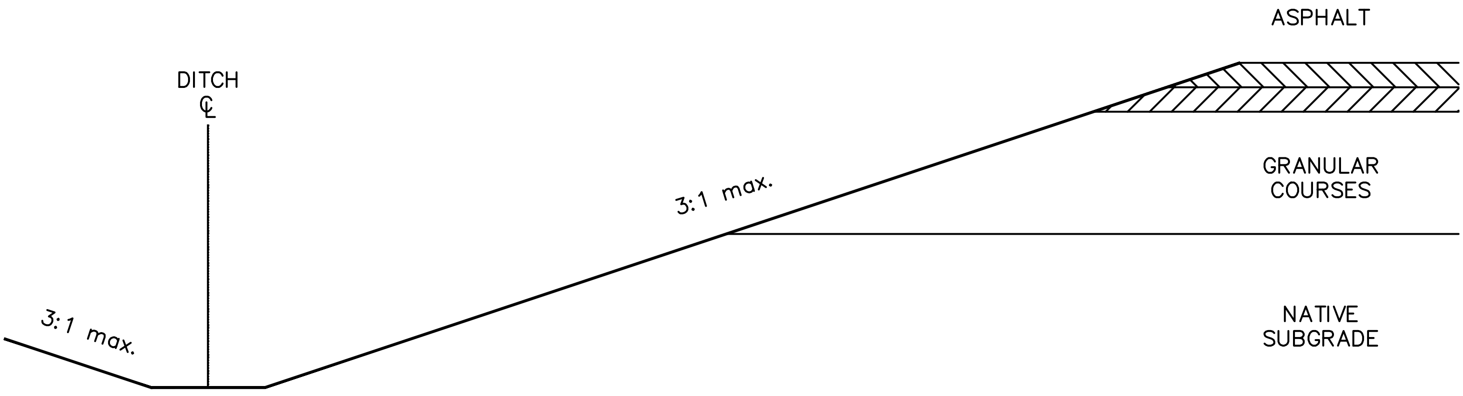




Unwrapped Trench

Wrapped Trench

Urban Cross Sections



Rural Cross Section

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PAVEMENT DRAINAGE ALTERNATIVES TYPICAL DETAILS