Final Environmental Study Report (ESR)
Volume 4 - Technical Appendices

City of Kitchener
Biehn Drive Municipal Class Environmental Assessment

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Submitted by:
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Appendix J

Dewatering Assessment

BT ENGINEERING

Dewatering Assessment, Biehn Drive Extension, City of Kitchener, Ontario

March 14, 2024

Prepared for:
BT Engineering

Cambium Reference: 1969-002

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1.0 Introduction

Cambium Inc. (Cambium) is pleased to provide BT Engineering (the client) with dewatering assessment to present the background review, groundwater levels, and dewatering estimates in support of the proposed roadway extension of Biehn Drive. The extension is from Biehn Drive's current terminus, approximately 60 m west of Spencer Court, south to the future Robert Ferrie Drive Extension located in the City of Kitchener Ontario (referred to herein as the Site).

It is understood that the works will also include a trunk sanitary sewer, storm sewers and a watermain, in addition to the roadway extension. Groundwater levels and a dewatering assessment is required for the construction and placement of linear infrastructure such as storm and sanitary sewer along the roadway at the proposed Biehn Drive Extension. Due to the presence of the Strasburg Creek Wetland Complex across the linear infrastructure alignment, some of the installation will be completed using trenchless horizontal directional drilling (HDD). A site location plan is included in Figure 1 and the construction alignment and profile is included in Appendix A.

The purpose of the dewatering investigation was to obtain information about the subsurface conditions by means of a number of boreholes and based on the findings provide recommendations pertaining to the geotechnical design of the new features.

1.1 Scope of Work

The scope of work for the dewatering assessment included the following tasks:

- **Well Installation and Water Level Measurement:** Seven boreholes which were advanced at the Site as part of the geotechnical investigation and four of the boreholes were completed as monitoring wells to allow for measurement of stabilized groundwater levels and to facilitate hydrogeological testing.
- **Single Well Hydraulic Tests (SWHT) and Analysis:** SWHTs were completed at each monitoring wells to provide estimates of hydraulic conductivity of the native soils for dewatering calculations.

- **Estimation of Dewatering Requirements:** The volume of water required for dewatering at the Site was estimated using borehole information, results obtained from SWHT analysis, and watermain excavation design parameters.
- **Assessment of Water Taking Registration Requirements:** An assessment of Permit to Take Water (PTTW) and/or Environmental Activity Sector Registry (EASR) registration requirements was completed based on the dewatering volume estimated for the Site.
- **Groundwater Sampling and Analysis for Discharge Characterization:** One groundwater quality sample was collected and submitted for laboratory analysis and compared against Provincial Water Quality Objective (PWQO) Standards for overland discharge flow.
- **Report preparation:** A dewatering assessment report was prepared presenting the results, findings, and recommendations of this investigation.

2.0 Well Installation and Testing

2.1 Past Investigation

2.1.1 Peto MacCallum Geotechnical Investigations

Previous geotechnical investigations were completed by Peto MacCallum Ltd. during December 1986 and November 2020. One shallow monitoring well was installed to a depth of 4.6 m below ground surface (mbgs) during December 1986. The soils encountered were mainly topsoil consisting of silt and trace gravel up to a maximum depth of 1.6 mbgs, followed by sand and gravel to installed depth. Depth to water level ranged between 2.40 mbgs and 2.90 mbgs.

Two monitoring wells MW108-20 and MW109-20 were installed closer to the Biehn Drive Extension during the November 2020 geotechnical investigation; however, a detailed geotechnical report or monitoring well logs were not available at the time of this report's preparation. Available borehole logs and a borehole location plan are provided in Appendix B.

It should be noted that Peto MacCallum completed the investigation for the entire proposed development at the Site. The focus of the current dewatering assessment is confined to the Biehn Drive Extension roadway only.

2.1.2 MTE Consultants Geotechnical Investigation

MTE Consultants completed a geotechnical investigation during December 2019 and January 2020 for the entire development at the Site. During the investigation, a total of eleven monitoring wells were installed on the entire development area. Monitoring wells MW104-20, MW105-20, MW108-20, and MW109-20 were installed closer to and along the alignment of Biehn Drive Extension. Detailed geotechnical report was not made available at the time of this report's preparation. Only borehole logs and a site location plan were provided by the client.

Based on the sub-surface soils encountered at the Site, silty sand to sand was the predominant soil type across the Site. All the borehole logs and the site location plan are included in Appendix C.

A long-term, 12-months monitoring was completed at the Site and based on the water level data provided by MTE (Appendix C), depth to water levels ranged between 4.64 mbgs and 6.72 mbgs at all the monitoring wells, except monitoring well MW105-20. As this monitoring well was situated within a wetland area, the water levels ranged from 0.61 mbgs to 0.95 mbgs.

2.1.3 Previous Cambium Geotechnical Investigation

Cambium completed a geotechnical investigation on this property in 2022 to determine the subsurface and groundwater conditions. This previous investigation consisted of 6 boreholes at the Site to a maximum depth of 8.2 m below ground surface (mbgs), cumulating in our report entitled "*Geotechnical Investigation Report – Biehn Drive Extension, Kitchener, ON*" dated April 14, 2022. Three of these boreholes were outfitted with monitoring wells (BH101-22, BH104-22, and BH106-22) and were monitored as part of this hydrogeological investigation. The previous borehole locations and the previous borehole logs are included in Appendix D.

Based on the results of this borehole investigation, subsurface conditions at the Site generally consist of a layer topsoil, overlying a native deposit consisting of silty sand to sand. Groundwater measurements were taken from the monitoring wells two weeks after completion of drilling on February 4, 2022, and groundwater levels ranged from 0.41 mbgs to 4.10 mbgs, and BH106-22 was dry during the monitoring event.

2.2 Results of Current Subsurface Investigations

Cambium completed a supplemental borehole investigation at the Site on September 28, 29, 30 and August 1, 2023, in order to understand the groundwater and hydrogeologic conditions across the wetland feature. A total of six boreholes, designated as BH201-23 through BH206-23, were advanced into the subsurface at predetermined locations. These boreholes were terminated at depths of 6.7 to 9.8 m below ground surface. Three of these boreholes were outfitted with monitoring wells (BH202-23, BH203-23, and BH205-23) and were monitored as part of this hydrogeological investigation. The borehole locations are shown on Figure 2 of this report and the borehole logs are included in Appendix D.

The locations and elevations of the boreholes were obtained using a Realtime Kinematic Unit (RTK) using a site benchmark (BM). The BM is recognized as the top of the southeast corner concrete pad for a generator found just south of the hydrant at the south end at Cobbledick Road, which has elevation of 85.44 m based on the existing topographic survey provided by the client.

In summary, the subsurface conditions consist of a peat or pavement buildup underlain predominantly by a sand to silty sand deposits.

2.3 Groundwater Levels

Cambium completed on-site water level monitoring for the well that they installed on three occasions: February 4, 2022, October 10, 2023, and March 11, 2024. Well construction details and water levels are summarized in Table 1.

Table 1 Well Details and Water Levels

Well		BH101-22	BH104-22	BH106-22	BH202-23	BH203-23	BH206-23
Top of Pipe Elevation (masl)		314.51	322.18	325.83	312.43	314.19	313.70
Ground Surface Elevation (masl)		313.42	320.99	324.77	312.58	312.95	312.57
Stick-up (m)		1.09[1]	1.19	1.06	-0.15	0.91	1.02
February 4, 2022	Water Level (mbgs)	0.41	4.10	Dry	-	-	-
	Groundwater Elev.(masl)	313.01	316.89	-	-	-	-
October 10, 2023	Water Level (mbgs)	0.60	In-accessible	In-accessible	0.95	0.26	0.19
	Groundwater Elev.(masl)	312.82	-	-	311.63	312.69	312.38
March 11, 2024	Water Level (mbgs)	0.38	4.04	5.66	0.67	0.15	-0.14
	Groundwater Elev.(masl)	313.04	316.95	319.11	311.91	312.80	312.71

1. *Stick-up value was measured at 1.04 m on October 13, 2023, due to minor subsidence of the monitoring well.*

Groundwater levels ranged between -0.14 mbgs to 5.66 mbgs, with equivalent elevations of 311.63 masl and 319.11 masl. It is noted that the deeper water levels measured at BH104-22

and BH106-22 are interpreted to be due to elevational difference between the boreholes and is situated farther away from the low-lying Strasburg Creek Wetland Complex. The other four wells monitor water levels within the wetland complex or immediately adjacent to and reported water levels are much closer to the ground surface; the water level reported from BH206-23 (within the wetland complex) was reported at 0.14 metres above ground surface, indicating that the shallow water table has risen up to the surface water levels within the wetland complex during the spring months.

Water levels are expected to fluctuate with seasonal variation. As discussed above, MTE consultants conducted a long-term water level monitoring program for the entire development (not just the extension area); the water levels from their two closest monitoring wells to the extension area (MW104-20 and MW109-20) reported peak water levels in late April/early May and that the seasonal fluctuation from spring high to summer/fall low was approximately 1 m to 1.5 m (Appendix C).

The water elevations measured on October 10, 2023 and March 11, 2024, from the monitoring wells installed within the wetland (BH101-22, BH203-23, and BH206-23) reported similar elevations that are higher than the elevation at the adjacent monitoring well, BH202-23. This indicates that the groundwater within the shallow unconfined aquifer in the wetland complex has slight upward gradients as indicated by the high water levels.

2.4 Single Well Hydraulic Tests

The hydraulic conductivity (k-value) of the soils were estimated based on the results obtained from the single well response tests (slug tests). Aquifer response test (slug tests/single well response tests) was conducted on February 4, 2022, for the old Cambium well and on October 11, 2023, for the newly installed Cambium wells. Either falling head test or rising head tests were performed in the monitoring wells BH101-22, BH104-22, BH202-23, BH203-23, and BH206-23. Results of hydraulic conductivity tests are presented below in Table 2 and analytical data is included in Appendix E.

Table 2 Results of Estimated Hydraulic Conductivity as per Slug Test

Monitoring well	Estimated Hydraulic Conductivity (m/sec)	Tested Soil Type
BH101-22	3.59×10^{-6}	Sand, Silty Sand and trace Clay
BH104-22	3.08×10^{-6}	Sand, trace Silt and Clay
BH202-23	1.10×10^{-5}	Sand, trace to some Silt, trace Clay
BH203-23	8.65×10^{-6}	Silty Sand
BH206-23	1.55×10^{-6}	Sand, some Clay

The hydraulic conductivity was estimated utilizing Aquifer Test Pro slug test software using the Hvorslev method. The estimated hydraulic conductivities ranged between 1.15×10^{-6} m/sec and 1.10×10^{-5} m/sec and the geometric mean of hydraulic conductivity was calculated at 4.39×10^{-6} m/sec.

2.5 Open Cut and Trenchless Construction Methods

A hydrogeologic cross section (Figure 3) was prepared depicting the existing ground surface profile, lithology, water levels, and the alignment of the proposed new 525 mm trunk sewer across the wetland complex.

The alignment on either side of the wetland complex will use traditional open cut excavation and the sewer alignment across the creek would entirely be a trenchless construction method using either by a microtunnelling or horizontal directional drilling (HDD) method of installation (see Section 3.5 for more details).

Microtunnelling is a pit launched technique with extreme accuracy and low risk, but however, has a high upfront costs. On the other hand, the HDD is surface launched making it a cost effective technique.

Based on Figure 3, the proposed trunk sewer alignment will intercept soils that range from silt to silty sand, with trace to some clay. The ground surface elevation varies somewhat across the alignment, but the average ground surface elevation within the wetland area is approximately 313.25 masl.

The dewatering estimates for both open-cut and trenchless construction and an evaluation of excavation methods are described below in Section 3.0.

3.0 Dewatering Assessment – Open Cut Excavation

Construction dewatering is intended to lower the groundwater levels in the excavation area in order to ensure a dry working condition for the placement of linear infrastructure such as storm and sanitary sewers and watermains.

The requirements for construction dewatering generally depend on the Site's soil and groundwater conditions including soil type, soil permeability or hydraulic conductivity, local groundwater levels, and the design of the proposed works, such as the foundation and/or excavation elevation, as well as the size of proposed structure / excavation.

3.1 Excavation Design Parameters

The proposed development works include the installation of linear infrastructure along the proposed road extension. The proposed alignment and profile of linear excavation was included in Appendix A.

3.1.1 Trench Segments

Traditional open cut trench excavation methods will be used for the installation of linear infrastructure from 10+000 to 10+320. For this dewatering calculation, it is assumed that all trench excavations will be 2 m wide, and that the linear infrastructure installation will be conducted in 50 m segments. Based off the alignment drawings provided, the bottom of the linear infrastructure elevation at 10+000 is approximately 312.00 masl, and it dips down to approximately 310.50 masl by 10+320.

As determined through the water levels recorded by Cambium on February 4, 2022, October 10, 2023, and March 11, 2024, the water levels within the area of the wetland complex are very shallow; however, the water levels dropped to 316.95 masl at BH104-22 on March 11, 2024, which is located about 100 m south of the wetland complex. This water elevation is representative of spring water elevations and was used for this dewatering assessment. This water elevation is also similar to the elevations recorded at MW109-20 within MTE Consultants long-term water level monitoring program. The water elevation of 316.95 masl be used for the dewatering assessment for the open cut excavation from 10+000 to 10+320.

To facilitate safe working conditions, water levels will be lowered to 1 m below the invert of proposed sewer line at each excavation. To be conservative, it is assumed that water levels will be lowered to 309.50 masl for each trench segment; therefore, a drawdown of 7.45 m was used for this dewatering assessment.

The thickness of the aquifer within this area is unknown. For the purposes of this dewatering assessment, it was assumed that the aquifer extends several metres below the base of the construction excavation, and an aquifer thickness of 12 m was used.

3.1.2 Pilot Holes or Entry & Exit Shafts

Due to the presence of the wetland, it is proposed that microtunnelling methods will be used from approximately 10+320 to 10+500. However, to initiate the microtunnelling, two receiving pits (one on each side of the wetland) will need to be excavated. It is assumed that each receiving pit will have a radius of 6 m or have a length and width of 6 m and will extend to 6 mbgs. Therefore, to ensure safe working conditions, groundwater levels will be lowered to 7 mbgs (1 m below the base of the excavation).

The shallowest water level measured at the Site were on March 11, 2024, at -0.14 mbgs. Therefore, it is known that the spring groundwater levels are above, at, or just below the ground surface and therefore, groundwater level is considered at ground surface and was used for this dewatering assessment. A total of 7 m of drawdown is anticipated at the Site.

The thickness of the aquifer within the wetland complex area is considered as the same aquifer thickness of 12 m that was used for this dewatering assessment.

3.2 Estimated Construction Dewatering Rates (50 m Trench Segment)

A modified Dupuit-Forchheimer equation was used to estimate the dewatering rate required for the proposed linear trench excavation (Powers, 2007):

$$Q = \frac{\pi K(H^2 - h^2)}{\ln(R_0/r_s)} + 2\left[\frac{xK(H^2 - h^2)}{2L}\right]$$

$Where$:

$Q = dewatering\ rate\ (m^3/s)$

$K = hydraulic\ conductivity\ (m/s)$

$H = initial\ hydraulic\ head\ in\ aquifer\ (m)$

$h = target\ hydraulic\ head\ (initial\ hydraulic\ head - target\ drawdown)\ (m)$

$R_0 = zone\ of\ influence\ (from\ excavation\ center) = 3000(H-h)\sqrt{K}\ (m)$

$r_s = equivalent\ single\ well\ radius = width\ of\ trench/2\ (m)$

$x = unit\ length\ of\ trench\ (m)$

$L = distance\ to\ line\ source\ = R_0/2(m)$

The radius of influence for each excavation was estimated from soil hydraulic conductivity using the method of Sichardt (1930). In conditions of low hydraulic conductivity, where R_0 is calculated to be less than r_s , the denominator of the first right hand term of the above equation is amended to be $\ln((R_0 + r_s)/r_s)$.

A summary of calculated dewatering rates, given a target depth to water of 309.50 masl and a unit trench length of 50 m, is provided in Table 3. Detailed calculations are provided in Appendix F.

Table 3 Calculated Construction Dewatering Rates – 50 m Trench Segment

	Hydraulic Conductivity (K)	Zone of Influence (R_0)	Dewatering Rate (Q)	
	(m/s)	(m)	L/day	L/s
Minimum	1.15 x10^{-6}	24	32,400	0.37
Maximum	1.10 x10^{-5}	74	124,700	1.44
Geom. Mean	4.39 x10^{-6}	47	70,700	0.82

Given a maximum estimated hydraulic conductivity of 1.10 x10^{-5} m/s, the estimated R_0 for dewatering is 75 m and the estimated construction dewatering rate is 124,700 L/day or 1.44 L/s.

It is noted that the above equation is designed to represent steady state pumping conditions. In general, at the beginning of the pumping, the pumping rate required to lower Site water levels to acceptable levels may be greater than the rate estimated for steady state conditions as incoming water replaces the volume of excavated soils. Additionally, the above equation does

not account for any precipitation that may occur during the construction process. To account for these factors and the uncertainty of the aquifer thickness, a safety factor of 2 was applied and the estimated dewatering rate per unit trench length is estimated at 249,300 L/day or 2.89 L/sec.

3.3 Estimated Construction Dewatering Rates (Receiving Pit)

A modified Dupuit-Forchheimer equation was used to estimate the dewatering rate required for the proposed square excavation (Powers, 2007):

$$Q = \frac{\pi K(H^2 - h^2)}{\ln(R_0/r_s)}$$

$Where$:

$Q = dewatering\ rate\ (m^3/s)$

$K = hydraulic\ conductivity\ (m/s)$

$H = initial\ hydraulic\ head\ in\ aquifer\ (m)$

$h = target\ hydraulic\ head\ (initial\ hydraulic\ head - target\ drawdown)\ (m)$

$R_0 = zone\ of\ influence\ (from\ excavation\ center) = 3000(H - h)\sqrt{K}\ (m)$

$r_s = equivalent\ single\ well\ radius$

For square excavations, the equivalent radius (r_s)can be determined as the radius of a circle with the same area as the excavation, or with the same perimeter as the excavation.

Here, the equivalent area method was used such that

$$r_s = \sqrt{\frac{ab}{\pi}}$$

A summary of calculated dewatering rates, given a target depth to water of 7.0 mbgs, and a length and width of 6.0 m, is provided in Table 4. Detailed calculations are provided in Appendix F.

Table 4 Calculated Construction Dewatering Rates – Per Receiving Pit

	Hydraulic Conductivity (K)	Zone of Influence (R_0)	Dewatering Rate (Q)	
	(m/s)	(m)	L/day	L/s
Minimum	1.15×10^{-6}	23	19,600	0.23
Maximum	1.10×10^{-5}	70	117,500	1.36
Geom. Mean	4.39×10^{-6}	44	55,300	0.64

Given a maximum estimated hydraulic conductivity of 1.10×10^{-5} m/s, the estimated R_0 for dewatering is 70 m and the estimated construction dewatering rate is 117,500 L/day or 1.36 L/s.

It is noted that the above equation is designed to represent steady state pumping conditions. In general, at the beginning of the pumping, the pumping rate required to lower Site water levels to acceptable levels may be greater than the rate estimated for steady state conditions as incoming water replaces the volume of excavated soils. Additionally, the above equation does not account for any precipitation that may occur during the construction process. To account for these factors and the uncertainty of the aquifer thickness, a safety factor of 2 was applied and the estimated dewatering rate per each receiving pit is estimated at 235,000 L/day or 2.72 L/sec.

3.4 Assessment of Required Regulatory Permits or Registration

Any construction dewatering or other water taking in Ontario is governed by the Ontario Water Resources Act (OWRA) (Ontario Regulation 387/04 and/or Ontario Regulation 63/16) and/or the Environmental Protection Act (Registrations under Part II.2).

Where construction dewatering is required in amounts in excess of 400,000 L/day, a Permit To Take Water (PTTW) must be obtained. For temporary construction dewatering (six months or less) greater than 50,000 L/day but less than 400,000 L/day, registration through Environmental Activity and Sector Registry (EASR) is required.

Based on the estimated dewatering rate for each 50 m trench segment of 249,300 L/day (including a safety factor) and the estimated dewatering rate for each receiving pit of 235,000 L/day (including a safety factor), an EASR registration will be required as dewatering rates

exceed 50,000 L/day. Additionally, if multiple excavations are dewatering simultaneously, dewatering rates could exceed 400,000 L/day and a PTTW may be required.

It is imperative that daily dewatering rates be monitored (or the dewatering of stagnant water in the construction excavation estimated) to ensure that the short-term dewatering rates are less than 400,000 L/day. If the rates are greater than 400,000 L/day, operations would be required to cease until a Permit to Take Water (PTTW) was acquired.

3.1.4 Zone of Influence

The dewatering calculations include estimates of the horizontal distance away from the walls of each excavation where the influence of water withdrawal will be negligible (i.e., the length to zero drawdown).

The length to zero drawdown from the construction excavation to accommodate each 50 m linear infrastructure was calculated at about 74 m from the walls of the construction excavations and at about 70 m from the walls of the construction excavation for each receiving pit (Appendix F). The area included within the length to zero drawdown from the excavation is the zone of influence (ZOI).

The ZOI predominantly encompasses open land with no known structure or infrastructure; however, there are existing houses within the calculated ZOI within the northern end of the road extension. During construction dewatering activities, the areas adjacent to the construction excavations should be monitored regularly for land settlement and stability.

3.5 Trenchless Horizontal Directional Drilling (HDD)

Trenchless construction consists of installing pipes such as sewer lines and watermains via tunneling under a highway, a waterbody, a wetland etc. Trenchless construction should be considered in areas where conventional open-trench construction methods are undesirable. Trenchless construction usually includes tunneling using a jacked, non man-entry microtunnel boring machine (MTBM), (usually referred to as “microtunnelling), and horizontal directional drilling (HDD) also known as directional boring. Open trenching, as in this case, will be done all the way up to the point where horizontal drilling started. The crossing of the wetland complex

using HDD primarily consists of drilling a small diameter pilot hole (~ 6 inch to 8 inch) along the drilling path and then enlarging / reaming the pilot hole up to a diameter which can facilitate the pipe string pull-back (generally 1.5 times pipe diameter). Microtunnelling boring machine can usually create tunnels from 0.5 m to 4 m in diameter and includes a vacuum extraction system which promotes a cleaner environment and little to no dewatering along the path.

Microtunnelling will be launched from receiving pits on either side of the wetland complex (dewatering for each receiving pit calculated in Section 3.3).

Directional drilling is best suited for clays. Soft to hard clays are the preferred soils for HDD applications, although its use in cohesionless fine sands and silts is also acceptable (Gokhale & Iseley, 1997). Soils containing more than 50% gravel or loose soils are generally unsuitable (Hair, 1994). Directional boring should not be conducted in soils that contain material with particle diameters greater than 3”, since these particles are too large to be suspended in the drilling fluid (Gelinas, et al., 2010). HDD can be used successfully underwater, in saturated soils, under permafrost, and in a soil that is likely to erode (Hashash, 2011).

The following hydrogeologic information is required for the selection of the trenchless method:

- The presence and depth of gravels, cobbles, boulders, loose sand, soft clay etc.,
- Soil and rock stratigraphy and depth to bedrock,
- Groundwater levels and elevations, groundwater conditions such as unconfined or confined, and
- The presence of expansive or collapsible materials.

Accordingly, a cross section was prepared (Figure 3) to depict the existing geologic and hydrogeologic conditions across the proposed trenchless alignment. The length of trenchless excavation extends approximately 120 m (from 10+340 to 10+460) between the boreholes BH201-23, BH203-23 through BH206-23, and BH101-22 and the lithology along the alignment predominantly consists of silt to silty sand with trace clay throughout.

A length of about 120 m of the sewer and waterman installation will be below the water table. Groundwater is being discharged to the wetland complex at an approximate elevation of 312.6

to 313.0 masl. The deepest point of alignment will be at an elevation of approximately 309.62 masl under the Creek, and therefore, the maximum height of water column above the deepest part of sewer line will be about 3.38 m.

It should be noted that trenchless construction would normally require less or no dewatering than traditional open cut installations. Drilling fluid is used to suspend and remove the soil cuttings and also to stabilize the hole, reduce friction and control soil pressure below the surface.

4.0 Water Quality Assessment

Groundwater samples were collected from the monitoring well BH101-22 on February 4, 2022, and were submitted for chemical analysis in order to identify compliance issues (if any) when compared to Provincial Water Quality Objective (PWQO) parameters. Groundwater sample was collected in unfiltered form and submitted to SGS Laboratories for chemical analysis. SGS has been accredited by Canadian Association for Laboratory Accreditation (CALA). The laboratory analytical results are presented in Appendix G.

The chemical results were tabulated in Table 5 indicating parameter exceedances in comparison to the guideline values.

Table 5 Guideline Violation of Groundwater Samples Compared to PWQO (µg/L)

Sample ID	Filtration	Parameter	Measured Concentration	Guideline Value
BH101-22	Unfiltered	Zinc	**856**	30
BH101-22	Unfiltered	Thallium	**0.80**	0.3
BH101-22	Unfiltered	Lead	**153**	5
BH101-22	Unfiltered	Nickel	**127**	25
BH101-22	Unfiltered	Iron	**130000**	300
BH101-22	Unfiltered	Cadmium	**1.64**	0.2
BH101-22	Unfiltered	Arsenic	**26.6**	5
BH101-22	Unfiltered	Silver	**0.4**	0.1

Note: Bolded values exceeding the applicable standard.

Based on the results of the chemical analysis, the following comments on the groundwater quality are provided.

- The concentrations of most metals, including zinc, thallium, lead, nickel, iron, cadmium, arsenic, and silver in the unfiltered groundwater sample, exceeded the PWQO guideline values.
- The groundwater dewatering contractor should verify the quality of the filtered sample before being discharged as over land flow to the nearby wetland.

- If discharged as overland flow, the concentration of total suspended solids (TSS) should not exceed 25 mg/L concentrations. Standard discharge mitigation BMP for TSS (discharge running through fine mesh filter bags) must be utilized during construction as TSS is expected to be very high due to the type of construction activities at the site.

5.0 Recommendations

Cambium recommends the following as part of this assessment.

- As EASR registration will be required prior to the initiation of any dewatering activities. A dewatering and discharge plan should be prepared to support the EASR registration.
- If simultaneous excavations are planned (multiple trench segments and/or receiving pits), a PTTW registration will be required.
- Regardless, is imperative that daily dewatering rates be monitored (or the dewatering of stagnant water in the construction excavation estimated) to ensure that the short-term dewatering rates are less than 400,000 L/day. If the rates are greater than 400,000 L/day, operations would be required to cease until a Permit to Take Water (PTTW) was acquired.
- If possible, during the period of active dewatering, water levels should be monitored within the excavation footprints and in the existing monitoring wells to confirm the estimated zone of influence.
- All daily water takings and discharge rates shall be recorded both manually once a day and using continuous data logging devices (continuously recording flow meters with totalizing function) and maintained for the purpose of the mandatory water taking reporting.
- If dewatered groundwater is to be discharged as overland flow, the concentration of total suspended solids (TSS) should not exceed 25 mg/L concentrations. Standard discharge mitigation plan for TSS (discharge running through fine mesh filter bags) must be utilized during construction as TSS is expected to be very high due to the type of construction activities at the site.
- During construction dewatering activities, the areas adjacent to the construction excavations should be monitored regularly for land settlement and stability issues.
- The proposed trenchless installation method is suitable for the placement of sewer and watermain infrastructure beneath the Strasburg Creek Wetland Complex, based on hydrogeologic conditions assessed across the area.

6.0 Closing

We trust that the information in this submission meets your current requirements. If you have any questions regarding the contents of this report, please contact the undersigned.

All information received from the Client in the preparation of the report has been assumed correct and Cambium assumes no responsibility for the accuracy, completeness, or workmanship of any such information.

Respectfully submitted,

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8.0 Standard Limitations

Limited Warranty

In performing work on behalf of a client, Cambium relies on its client to provide instructions on the scope of its retainer and, on that basis, Cambium determines the precise nature of the work to be performed. Cambium undertakes all work in accordance with applicable accepted industry practices and standards. Unless required under local laws, other than as expressly stated herein, no other warranties or conditions, either expressed or implied, are made regarding the services, work or reports provided.

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The findings and results presented in reports prepared by Cambium are based on the materials and information provided by the client to Cambium and on the facts, conditions and circumstances encountered by Cambium during the performance of the work requested by the client. In formulating its findings and results into a report, Cambium assumes that the information and materials provided by the client or obtained by Cambium from the client or otherwise are factual, accurate and represent a true depiction of the circumstances that exist. Cambium relies on its client to inform Cambium if there are changes to any such information and materials. Cambium does not review, analyze, or attempt to verify the accuracy or completeness of the information or materials provided, or circumstances encountered, other than in accordance with applicable accepted industry practice. Cambium will not be responsible for matters arising from incomplete, incorrect, or misleading information or from facts or circumstances that are not fully disclosed to or that are concealed from Cambium during the provision of services, work, or reports.

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When preparing reports, Cambium considers applicable legislation, regulations, governmental guidelines, and policies to the extent they are within its knowledge, but Cambium is not qualified to advise with respect to legal matters. The presentation of information regarding applicable legislation, regulations, governmental guidelines, and policies is for information only and is not intended to and should not be interpreted as constituting a legal opinion concerning the work completed or conditions outlined in a report. All legal matters should be reviewed and considered by an appropriately qualified legal practitioner.

Site Assessments

A site assessment is created using data and information collected during the investigation of a site and based on conditions encountered at the time and particular locations at which fieldwork is conducted. The information, sample results and data collected represent the conditions only at the specific times at which and at those specific locations from which the information, samples and data were obtained and the information, sample results and data may vary at other locations and times. To the extent that Cambium's work or report considers any locations or times other than those from which information, sample results and data was specifically received, the work or report is based on a reasonable extrapolation from such information, sample results and data but the actual conditions encountered may vary from those extrapolations.

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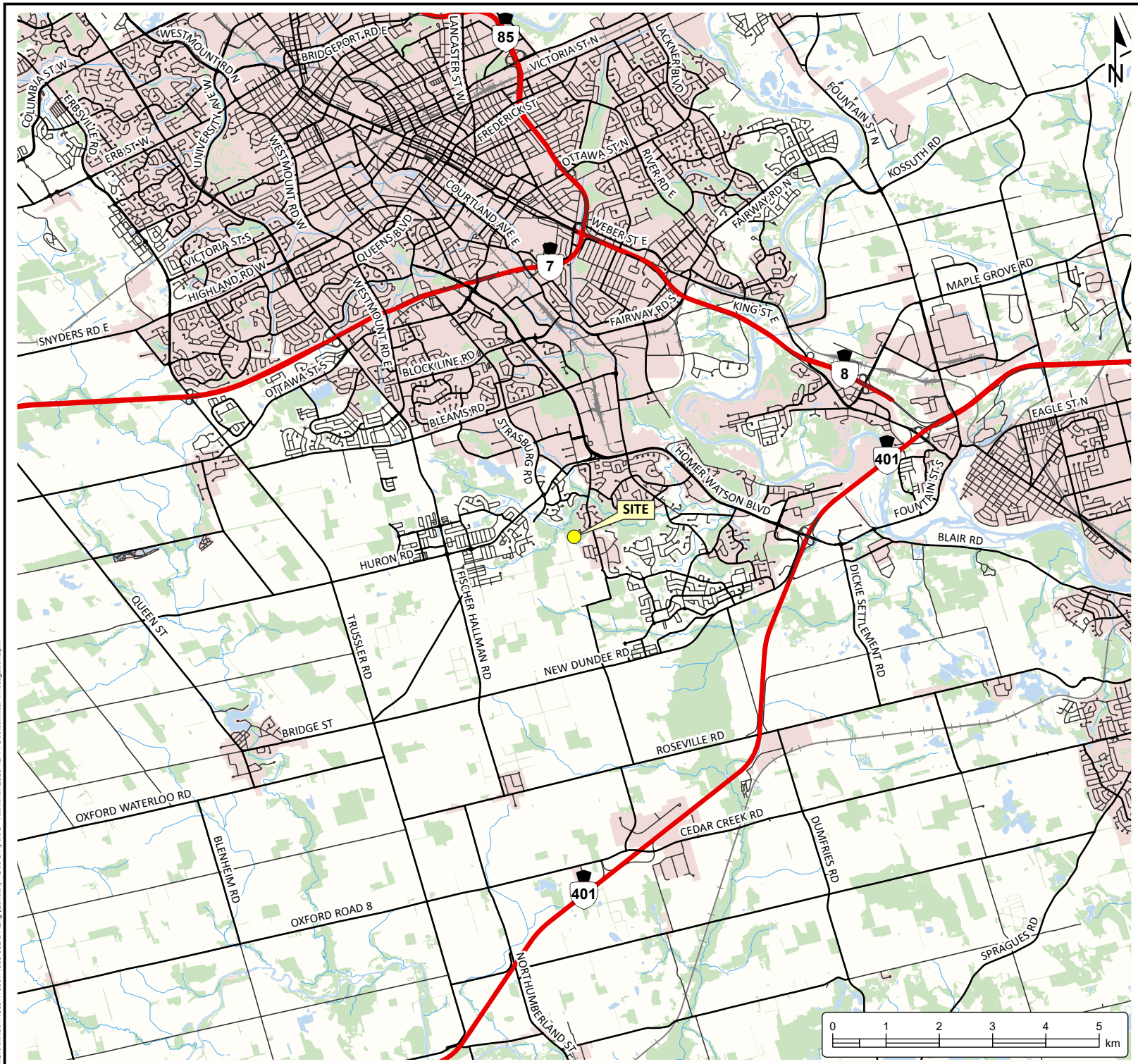
Appended Figures



DEWATERING ASSESSMENT

BT ENGINEERING
Biehn Drive
Kitchener, Ontario

LEGEND

- Highway
- Major Road
- Minor Road
- Railway
- Watercourse
- First Nations Reserve
- Provincial Park
- Water Area
- Wooded Area
- Built Up Area

Notes:
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- Distances on this plan are in metres and can be converted to feet by dividing by 0.3048.
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SITE LOCATION PLAN

Project No.: 11969-002		Date: December 2023 Rev.:	
Scale: 1:100,000		Projection: NAD 1983 UTM Zone 17N	
Created by: MAT	Checked by: SK	Figure:	1

O:\GIS\MXDs\11900-11999\11969-002 BT Eng (London) - Geo & HydroG - Kitchener\2023-12-14 Geotechnical Investigation.aprx

DEWATERING ASSESSMENT

BT ENGINEERING
Biehn Drive
Kitchener, Ontario

LEGEND

- Benchmark
- Borehole
- Monitoring Well
- Contours (5m Interval)
- Provincially Significant Wetlands
- Section Profile

Notes:
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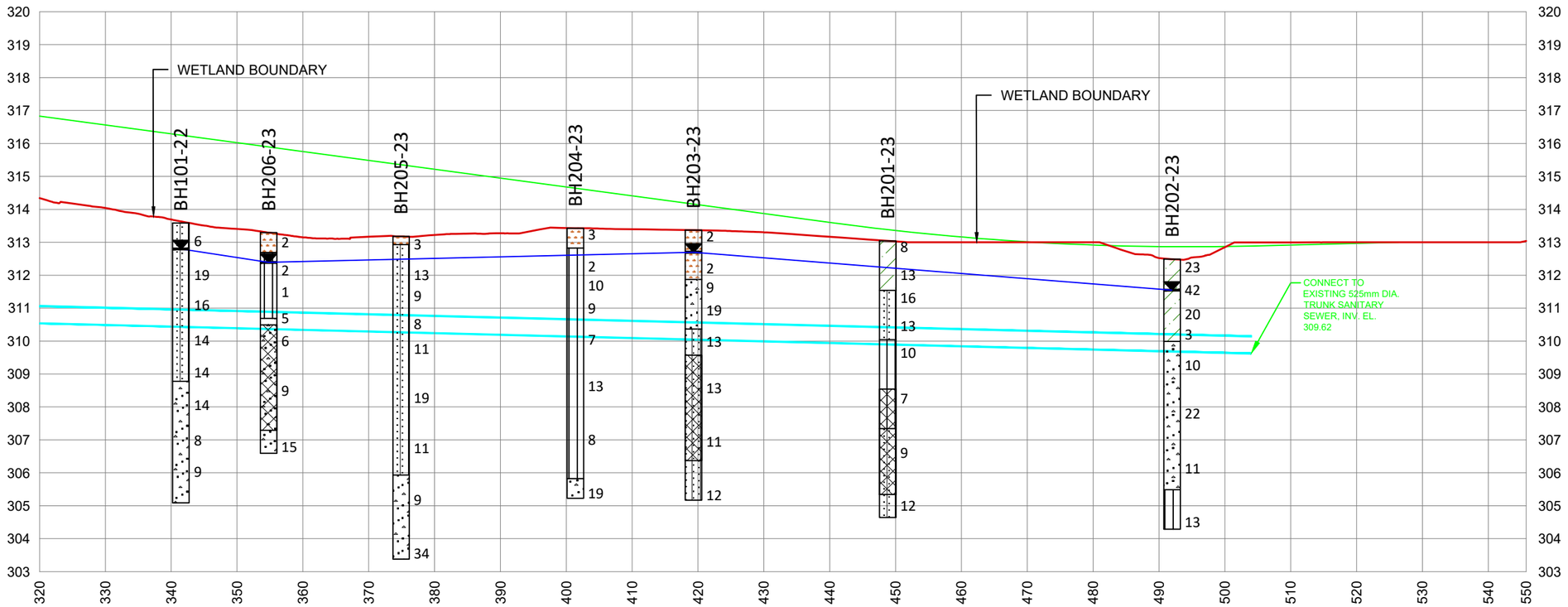
BOREHOLE LOCATION PLAN

Project No.: 11969-002		Date: December 2023	Rev.:
Scale: 1:1,500		Projection: NAD 1983 UTM Zone 17N	
Created by: MAT	Checked by: SK	Figure: 2	

O:\GIS\MXDs\11900-11999\11969-002 BT Eng (London) - Geo & HydroG - Kitchener\2023-12-14 Geotechnical Investigation.aprx



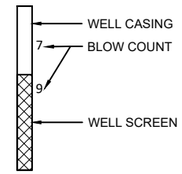
DEWATERING ASSESSMENT

BT ENGINEERING

Biehn Drive Kitchener, Ontario

LEGEND

- WATER LEVEL INDICATOR
- FILL
- PEAT
- SILT
- SILTY SAND
- SAND
- WATER LEVEL
- GROUND SURFACE
- PROPOSED SURFACE GRADING
- PROPOSED SEWER



Notes:
1. Survey completed by Cambium Inc. December 6, 2023
2. Distances on this plan are in metres and can be converted to feet by dividing by 0.3048.

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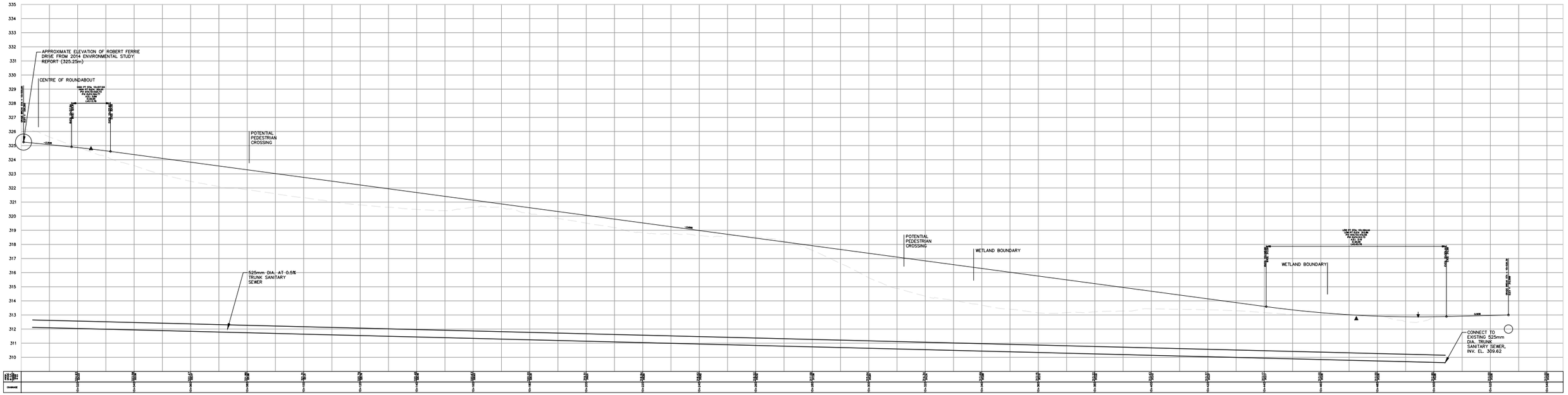
PROFILE CROSS SECTION

Project No.:	Date:
11969-002	December 2023
	Rev.:
Horizontal Scale:	Vertical Scale:
N/A	N/A
Drawn By:	Checked By:
MAT	SK
Figure:	
3	

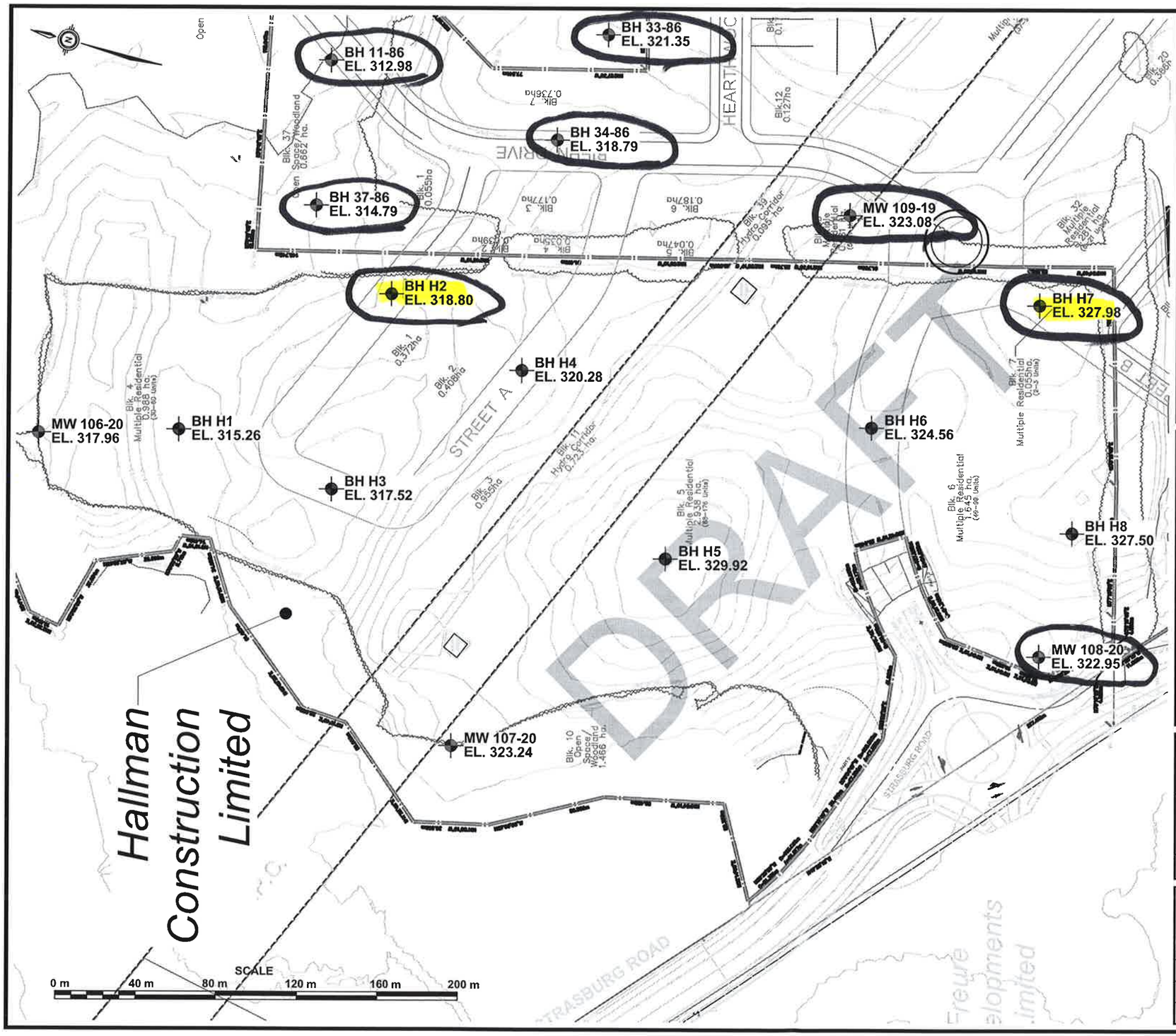
Appendix A

Linear Alignment and Profile



Appendix B

Borehole Logs (Peto MacCallum)



KEY PLAN

LEGEND:

- BOREHOLE LOCATION
- PREVIOUS INVESTIGATION BOREHOLE / MONITORING WELL
  PML REF: 86F423

REFERENCE:

BOREHOLE LOCATION PLAN REPRODUCED FROM DRAWING SUPPLIED BY CLIENT.

NOTES:

THE INFERRED STRATIGRAPHY REFERRED TO IN THE REPORT IS BASED ON THE DATA FROM THESE BOREHOLES SUPPLEMENTED BY GEOLOGICAL EVIDENCE. THE ACTUAL STRATIGRAPHY BETWEEN THE BOREHOLES MAY VARY.

THE BOREHOLE LOCATIONS AND GEODETIC ELEVATIONS WERE SURVEYED WITH A SOKKIA GCX3 REAL TIME KINEMATIC RECEIVER CONNECTED TO THE GLOBAL NAVIGATION SATELLITE SYSTEM.

HALLMAN CONSTRUCTION LIMITED

BRIGADOON SOUTH SUBDIVISION

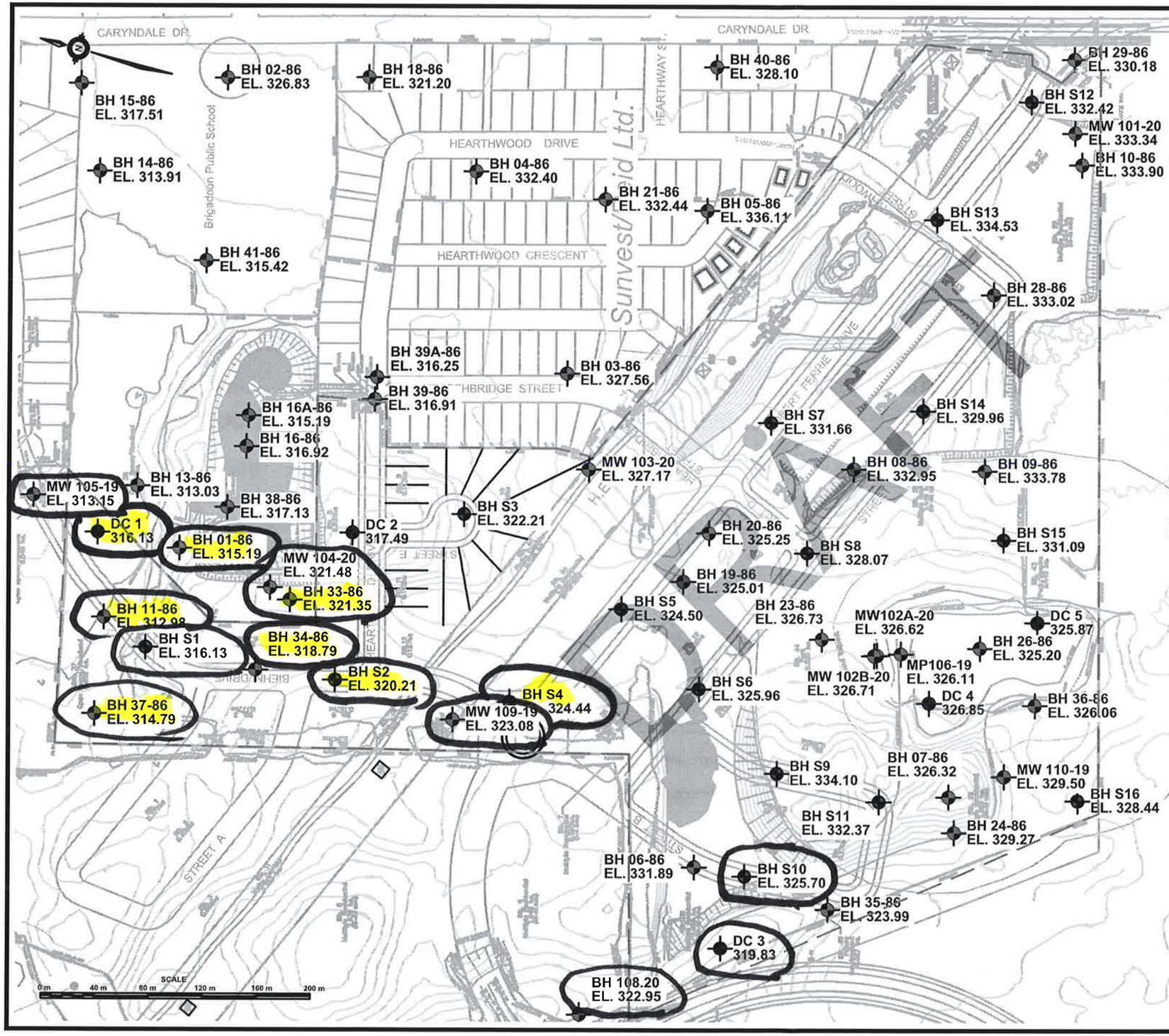
HALLMAN LANDS

KITCHENER, ONTARIO

BOREHOLE LOCATION PLAN

PML Peto MacCallum Ltd.
CONSULTING ENGINEERS

DRAWN	D. BRICE	DATE	SCALE	PML REF.	DWG. NO.
CHECKED	W. LOGHRIN	FEBRUARY 2021	AS SHOWN	20KF063A	1
APPROVED	G. MITCHELL				



KEY PLAN

LEGEND:

- BOREHOLE LOCATION
- DYNAMIC CONE PENETRATION TEST
- PREVIOUS INVESTIGATION BOREHOLES / MONITORING WELLS
  PML REF: 86F423

REFERENCE:

TEST HOLE LOCATION PLAN REPRODUCED FROM DRAWING SUPPLIED BY CLIENT.

NOTES:

THE INFERRED STRATIGRAPHY REFERRED TO IN THE REPORT IS BASED ON THE DATA FROM THESE TEST HOLES SUPPLEMENTED BY GEOLOGICAL EVIDENCE. THE ACTUAL STRATIGRAPHY BETWEEN THE TEST HOLES MAY VARY.

THE TEST HOLE LOCATIONS AND GEODETIC ELEVATIONS WERE SURVEYED WITH A SOKKIA GCX3 REAL TIME KINEMATIC RECEIVER CONNECTED TO THE GLOBAL NAVIGATION SATELLITE SYSTEM.

SUNVEST CONSTRUCTION LIMITED

BRIGADOON SOUTH SUBDIVISION
SUNVEST LANDS
KITCHENER, ONTARIO

TEST HOLE LOCATION PLAN

Peto MacCallum Ltd.
CONSULTING ENGINEERS

DRAWN	D. BRICE	DATE	SCALE	PML REF.	DWG. NO.
CHECKED	W. LOGHRIN	APRIL 2021	AS SHOWN	20KF063B	1
APPROVED	W. LOGHRIN				

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. DC-1

PROJECT Brigadoon South Subdivision - Sunvest Reid Lands
LOCATION Kitchener, Ontario
BORING METHOD
BORING DATE
PML REF. 20KF063B
ENGINEER W. Loghrin
TECHNICIAN

SOIL PROFILE			SAMPLES				SHEAR STRENGTH (kPa)			GROUND WATER OBSERVATIONS AND REMARKS
DEPTH / ELEV (metres)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	+FIELD VANE △TORVANE ○ Qu ▲POCKET PENETROMETER ○ Q; 50 100 150 200; DYNAMIC CONE PENETRATION × STANDARD PENETRATION TEST ●; 20 40 60 80	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT; w_P w w_L; WATER CONTENT (%) 10 20 30 40	UNIT WEIGHT kN/m³	GRAIN SIZE DISTRIBUTION (%) GR SA SI&CL
SURFACE ELEVATION										

0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0

NOTES

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. DC-3

PROJECT Brigadoon South Subdivision - Sunvest Reid Lands
LOCATION Kitchener, Ontario
BORING METHOD Dynamic Cone Penetration Test
BORING DATE
PML REF. 20KF063B
ENGINEER W. Loghrin
TECHNICIAN R. Bhavsar

DEPTH ELEV (metres)	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	ELEVATION SCALE	SHEAR STRENGTH (kPa): +FIELD VANE △TORVANE ○ Qu ▲POCKET PENETROMETER ○ Q; 50 100 150 200; DYNAMIC CONE PENETRATION STANDARD PENETRATION TEST ×●; 20 40 60 80	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30 40	UNIT WEIGHT kN/m³	GROUND WATER OBSERVATIONS AND REMARKS; GRAIN SIZE DISTRIBUTION (%) GR SA SI&CL
0.0	SURFACE ELEVATION 319.83 See BH 35-86 for soil stratigraphy					319				
1.0										
2.0						318				
3.0										
4.0						317				
5.0										
6.0						316				
7.0										
8.0						315				
9.0										
10.0						314				
11.0										
12.0						313				
13.0										
14.0						312				
15.0	CONTINUED									
						311				
						310				
						309				
						308				
						307				
						306				
						305				

NOTES

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. DC-3

PROJECT Brigadoon South Subdivision - Sunvest Reid Lands
LOCATION Kitchener, Ontario
BORING METHOD Dynamic Cone Penetration Test
BORING DATE
PML REF. 20KF063B
ENGINEER W. Loghrin
TECHNICIAN R. Bhavsar

DEPTH ELEV (metres)	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	ELEVATION SCALE	SHEAR STRENGTH (kPa): +FIELD VANE △TORVANE ○ Qu ▲POCKET PENETROMETER ○ Q; DYNAMIC CONE PENETRATION × STANDARD PENETRATION TEST ●	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%)	UNIT WEIGHT kN/m³	GROUND WATER OBSERVATIONS AND REMARKS; GRAIN SIZE DISTRIBUTION (%) GR SA SI&CL
15.0	CONTINUED FROM PREVIOUS PAGE						50 100 150 200; 20 40 60 80	10 20 30 40		
16.1	DYNAMIC CONE TERMINATED AT 16.1 m					304				

NOTES

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. S-2

PROJECT Brigadoon South Subdivision - Sunvest Reid Lands
LOCATION Kitchener, Ontario
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE 11/24/20
PML REF. 20KF063B
ENGINEER W. Loghrin
TECHNICIAN R. Bhavsar

DEPTH (metres)	ELEV	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES
		SURFACE ELEVATION 320.21				
0.0	320.21	TOPSOIL: Dark brown silt, some sand, trace clay, rootlets, moist		1	SS	3
0.51	319.70	SILTY SAND: Loose brown silty sand, trace gravel, trace clay, moist		2	SS	6
1.0				3	SS	5
2.0						
2.2	318.0	becoming compact		4	SS	29
3.0						
3.0	317.2	becoming wet		5	SS	30
4.0						
4.1	316.1	SAND: Compact to dense brown sand, some silt, trace to some gravel, wet		6	SS	30
5.0						
6.0				7	SS	35
7.0						
8.0				8	SS	17
8.7	311.5	becoming very dense, occasional wet silt layers		9	SS	56
9.0						
10.0						
10.2	310.0	becoming loose		10	SS	5
11.0						
11.3	308.9	BOREHOLE TERMINATED at 11.3 m				
12.0						
13.0						
14.0						
15.0						

ELEVATION SCALE: 320, 319, 318, 317, 316, 315, 314, 313, 312, 311, 310, 309

SHEAR STRENGTH (kPa)
+FIELD VANE △TORVANE ○ Qu
▲POCKET PENETROMETER ○ Q
50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
20 40 60 80

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30 40

UNIT WEIGHT kN/m³

GROUND WATER OBSERVATIONS AND REMARKS
GRAIN SIZE DISTRIBUTION (%) GR SA SI&CL

Sampler wet from 4.6 m to completion.

Upon Completion of augering, Cave @ 4.9 m, Free water @ 3.1 m.

NOTES

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. S-4

PROJECT Brigadoon South Subdivision - Sunvest Reid Lands
LOCATION Kitchener, Ontario
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE 11/24/20
PML REF. 20KF063B
ENGINEER W. Loghrin
TECHNICIAN R. Bhavsar

DEPTH (metres)	ELEV	DESCRIPTION	NUMBER	TYPE	"N" VALUES
		SURFACE ELEVATION 324.44			
0.0	324.44	TOPSOIL: Dark brown silt, some sand, trace gravel, rootlets, moist	1A	SS	4
0.31	324.13	SANDY SILT: Loose brown sandy silt, trace gravel, moist	1B		
1.00	323.44	SAND: Compact brown sand, trace to some gravel, trace silt, moist	2	SS	6
			3	SS	15
2.2	322.2	becoming dense	4	SS	34
			5	SS	48
			6	SS	34
			7	SS	38
			8	SS	33
8.7	315.7	GRAVELLY SAND: Dense to very dense brown gravelly sand, trace silt, wet	9	SS	38
			10	SS	72/280mm
11.3	313.1	BOREHOLE TERMINATED at 11.3 m			

SHEAR STRENGTH (kPa)
+FIELD VANE △TORVANE ○ Qu
▲POCKET PENETROMETER ○ Q
50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
20 40 60 80

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30 40

UNIT WEIGHT kN/m³

GROUND WATER OBSERVATIONS AND REMARKS
GRAIN SIZE DISTRIBUTION (%) GR SA SI&CL

Sampler wet from 9.1 m to completion.

Upon Completion of augering, Cave @ 7.9 m, Free water @ 7.7 m.

NOTES

Peto MacCallum Ltd
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. S-10

PROJECT Brigadoon South Subdivision - Sunvest Reid Lands
LOCATION Kitchener, Ontario
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE 11/27/20
PML REF. 20KF063B
ENGINEER W. Loghrin
TECHNICIAN R. Bhavsar

DEPTH (metres)	ELEV	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES
		SURFACE ELEVATION 325.70				
0.15	325.55	TOPSOIL: Dark brown silt, trace sand, trace clay, rootlets, moist		1	SS	6
0.97		CLAYEY SILT: Stiff brown clayey silt, trace gravel, trace sand, DTPL				
	324.73	SILT: Compact brown silt, some sand, trace gravel, trace clay, moist		2	SS	12
				3	SS	13
2.2	323.5	CLAYEY SILT: Stiff to very stiff brown clayey silt, trace gravel, trace sand, DTPL to APL		4	SS	13
				5	SS	20
4.1	321.6	becoming grey, very stiff to hard				
				6	SS	22
				7	SS	35
7.8	317.9	SILTY SAND: Dense brown silty sand, trace gravel, trace clay, wet		8	SS	34
8.2	317.5	BOREHOLE TERMINATED at 8.2 m				

ELEVATION SCALE: 325, 324, 323, 322, 321, 320, 319, 318

SHEAR STRENGTH (kPa)
+FIELD VANE △TORVANE ○ Qu
▲POCKET PENETROMETER ○ Q
50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
20 40 60 80

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30 40

UNIT WEIGHT kN/m³

GROUND WATER OBSERVATIONS AND REMARKS
GRAIN SIZE DISTRIBUTION (%)
GR SA SI&CL

Upon Completion of augering,
No cave,
No free water.

NOTES

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. H-7

PROJECT Brigadoon South Subdivision - Hallman Lands
LOCATION Kitchener, Ontario
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE 11/26/20
PML REF. 20KF063A
ENGINEER W. Loghrin
TECHNICIAN R. Bhavsar

DEPTH ELEV (metres)	DESCRIPTION	NUMBER	TYPE	"N" VALUES
	SURFACE ELEVATION 327.98			
0.20 / 327.78	TOPSOIL: Dark brown clayey silt, trace sand, rootlets, moist	1	SS	2
0.69 / 327.29	CLAYEY SILT: Soft brown clayey silt, trace sand, APL			
	SILTY SAND: Loose brown silty sand, trace gravel, trace clay, moist	2	SS	7
1.5 / 326.5	becoming compact	3	SS	20
		4	SS	20
3.0 / 325.0	becoming dense	5	SS	40
4.1 / 323.9	becoming very dense	6	SS	56
		7	SS	59
		8	SS	50
8.2 / 319.8	BOREHOLE TERMINATED at 8.2 m			

SHEAR STRENGTH (kPa): +FIELD VANE △TORVANE ○ Qu ▲POCKET PENETROMETER ○ Q; 50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
20 40 60 80

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%): 10 20 30 40

UNIT WEIGHT kN/m³

GROUND WATER OBSERVATIONS AND REMARKS
GRAIN SIZE DISTRIBUTION (%) GR SA SI&CL

Upon Completion of augering,
No cave,
No free water.

NOTES

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. H-2

PROJECT Brigadoon South Subdivision - Hallman Lands
LOCATION Kitchener, Ontario
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE 11/25/20
PML REF. 20KF063A
ENGINEER W. Loghrin
TECHNICIAN R. Bhavsar

DEPTH (metres) / ELEV	DESCRIPTION	NUMBER	TYPE	"N" VALUES
	SURFACE ELEVATION 318.80			
0.20 / 318.60	TOPSOIL: Brown silt, some sand, trace clay, rootlets, moist	1A / 1B	SS	1
0.69 / 318.11	SILT: Very loose brown silt, trace sand, trace clay, moist to wet			
1.5 / 317.3	CLAYEY SILT: Very stiff brown clayey silt, trace sand, trace gravel, DTPL to APL becoming soft to stiff, some sand, APL	2	SS	28
		3	SS	8
		4	SS	2
3.6 / 315.2		5	SS	10
4.1 / 314.7	SAND: Brown sand, some silt, trace clay, trace gravel, wet			
	CLAYEY SILT: Stiff grey clayey silt, some sand, trace gravel, APL to WTPL	6	SS	11
		7	SS	11
8.2 / 310.6		8	SS	8
	BOREHOLE TERMINATED at 8.2 m			

SHEAR STRENGTH (kPa): +FIELD VANE △TORVANE ○ Qu ▲POCKET PENETROMETER ○ Q; 50 100 150 200
DYNAMIC CONE PENETRATION / STANDARD PENETRATION TEST ×/●: 20 40 60 80
ELEVATION SCALE: 318 317 316 315 314 313 312 311
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%): 10 20 30 40
UNIT WEIGHT kN/m³

GROUND WATER OBSERVATIONS AND REMARKS
GRAIN SIZE DISTRIBUTION (%) GR SA SI&CL

Sampler wet from 3.1 m to completion.

Upon Completion of augering, Cave @ 6.1 m, Free water @ 4.7 m.

NOTES

PETO MacCALLUM LTD.
CONSULTING ENGINEERS

LOG OF BOREHOLE No. 1 & 2

JOB NAME: PROPOSED RESIDENTIAL SUBDIVISION — JOB No.: 86 F 423
LOCATION: Biehn Drive, Kitchener, Ontario — BORING DATE: 1986 12 11 & 12 — ENGINEER: G. Mitchell
BORING METHOD: Continuous Flight Solid Stem Augers — TECHNICIAN: D. Kelly

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES	GROUNDWATER OBSERVATIONS AND REMARKS
	BOREHOLE 1 GROUND ELEVATION: 315.19						
0.45	TOPSOIL: Dark brown silt, organics, very moist		315	1	SS	6	
1.20	SAND AND GRAVEL: Compact brown fine to medium sand and gravel, little silt, moist		314	2	SS	11	
1.5	SAND: Compact to dense brown fine sand, numerous sandy silt seams, wet to saturated		313	3	SS	21	
				4	SS	44	
3.0			312	5	SS	38	
			311				
4.5 4.55	BOREHOLE TERMINATED AT 4.55 m			6	SS	25	Upon completion of drilling, borehole caved to 0.75 m with no free water
	BOREHOLE 2 GROUND ELEVATION: 326.83						
0.0							
0.60	TOPSOIL: Dark brown silt, organics, moist		326				
	SILT: Very loose brown silt, trace sand, wet			1	SS	2	
1.5 1.55			325	2	SS	6	
2.75	SAND: Loose to compact brown silty fine sand, moist						
	Occasional gravel seams		324	3	SS	21	
3.0				4	SS	26	
			323				
4.5 4.55	Becoming dense to very dense		322	5	SS	53*	
			321				
6.0 6.10	Occasional silt seams			6	SS	54	Following Sample 6, sampler wet
			320				
7.5			319	7	SS	42	
			318				
9.0 9.15	BOREHOLE TERMINATED AT 9.15 m			8	SS	35	Upon completion of drilling, borehole open with no free water

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3m: 20 40 60 80

LIQUID LIMIT W_L
PLASTIC LIMIT W_P
WATER CONTENT W
W_P W W_L
WATER CONTENT %: 10 20 30

NOTES:
* Sampler overfilled.
Borehole 2: Bulk sample taken from 1.65 to 3.00 m

CHECKED BY:

PETO MacCALLUM LTD.
CONSULTING ENGINEERS

LOG OF BOREHOLE No. 6

JOB NAME PROPOSED RESIDENTIAL SUBDIVISION — JOB No. 86 F 423

LOCATION Biehn Drive, Kitchener, Ontario — BORING DATE 1986 12 15 — ENGINEER G. Mitchell

BORING METHOD Continuous Flight Solid Stem Augers — TECHNICIAN D. Kelly

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m N VALUES
	BOREHOLE 6					
	GROUND ELEVATION: 331.89					
0.10	TOPSOIL: Dark brown sandy silt, organics, moist			1	SS	2
	SAND: Loose to compact brown fine to medium sand, little silt, moist		331	2	SS	7
1.5			330	3	SS	12
			329	4	SS	18
3.0				5	SS	16
			328			
4.5			327	6	SS	15
			326			
6.10	Occasional sandy silt seams and coarse sand seams			7	SS	24
			325			
7.5			324	8	SS	23
			323			
9.15	BOREHOLE TERMINATED AT 9.15 m			9	SS	15
10.5						
12.0						
13.5						
15.0						
16.5						
18.0						

SHEAR STRENGTH C_u ▲

DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●

BLOWS/0.3m 20 40 60 80

LIQUID LIMIT W_L
PLASTIC LIMIT W_P
WATER CONTENT W
W_P — W — W_L

WATER CONTENT % 10 20 30

GROUNDWATER OBSERVATIONS AND REMARKS

Upon completion of drilling, borehole open with no free water

NOTES: Bulk sample taken from 1.50 to 4.50 m

CHECKED BY gh

PML/504A

PETO MacCALLUM LTD.
CONSULTING ENGINEERS

LOG OF BOREHOLE No. 11 & 12

JOB NAME: PROPOSED RESIDENTIAL SUBDIVISION — JOB No.: 86 F 423
LOCATION: Biehn Drive, Kitchener, Ontario — BORING DATE: 1986 12 12 — ENGINEER: G. Mitchell
BORING METHOD: Continuous Flight Solid Stem Augers — TECHNICIAN: D. Kelly

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	SAMPLES: NUMBER	SAMPLES: TYPE	BLOWS/0.3m N VALUES	GROUNDWATER OBSERVATIONS AND REMARKS
	BOREHOLE 11 GROUND ELEVATION: 312.98						
0.55	TOPSOIL: Black silt, organics, very moist			1	SS	2	43%
	SAND: Loose to compact brown fine sand, little silt, occasional silt seams, saturated		312	2	SS	18	Water level at surface
1.5			311	3	SS	20	
			310	4	SS	12	
3.0				5	SS	19	
			309				
4.5 4.55				6	SS	9	
	BOREHOLE TERMINATED AT 4.55 m						Upon completion of drilling, borehole caved to 0.55 m with water level at surface
6.0							
	BOREHOLE 12 GROUND ELEVATION: 313.18						
0.0	PEAT: Black fibrous peat, saturated		313	1	SS	1	385%
1.10	MARL: Grey marl, saturated		312	2	SS	2	172%
1.5 1.60	SAND: Loose to compact brown fine to medium sand, little silt, saturated			3	SS	18	56%
			311	4	SS	13	Water level at surface
3.0			310	5	SS	26	
			309				
4.5 4.55				6	SS	9	
	BOREHOLE TERMINATED AT 4.55 m						Upon completion of drilling, borehole caved to 0.30 m with water level at surface
6.0							

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3m: 20 40 60 80

LIQUID LIMIT W_L
PLASTIC LIMIT W_P
WATER CONTENT W
W_P W W_L
WATER CONTENT %: 10 20 30

NOTES:
Water samples taken in Borehole 11.

CHECKED BY

PETO MacCALLUM LTD.
CONSULTING ENGINEERS

LOG OF BOREHOLE No. 33 & 34

JOB NAME PROPOSED RESIDENTIAL SUBDIVISION — JOB No. 86 F 423
LOCATION Biehn Drive, Kitchener, Ontario — BORING DATE 1986 12 14 — ENGINEER G. Mitchell
BORING METHOD Continuous Flight Solid Stem Augers — TECHNICIAN D. Kelly

BOREHOLE 33

GROUND ELEVATION: 321.35

DEPTH in METRES	DESCRIPTION	ELEVATION	SAMPLE NUMBER	SAMPLE TYPE	BLOWS/0.3m N VALUES
0.45	TOPSOIL: Dark brown sandy silt, organics, moist	321	1	SS	7
	SAND: Compact to dense brown fine sand, little silt, very moist to moist	320	2	SS	12
1.5			3	SS	28
		319			
2.75			4	SS	43
3.0	Becoming very dense fine to medium sand, damp	318	5	SS	67*
4.00					
4.5 4.55	SILT TILL: Very hard brown clayey silt, little sand and gravel, D.T.P.L.	317	6	SS	65*
	BOREHOLE TERMINATED AT 4.55 m				
6.0					

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION •
STANDARD PENETRATION TEST •
BLOWS/0.3m: 20 40 60 80

LIQUID LIMIT W_L
PLASTIC LIMIT W_P
WATER CONTENT W
W_P W W_L
WATER CONTENT %: 10 20 30

GROUNDWATER OBSERVATIONS AND REMARKS

Upon completion of drilling, borehole open with no free water

BOREHOLE 34

GROUND ELEVATION: 318.79

DEPTH in METRES	DESCRIPTION	ELEVATION	SAMPLE NUMBER	SAMPLE TYPE	BLOWS/0.3m N VALUES
0.0	TOPSOIL: Dark brown silt, organics, very moist		1	SS	3
0.60	SILT: Loose brown silt, little clay, trace sand, wet	318	2	SS	8
1.20	SAND AND GRAVEL: Compact to dense brown fine to coarse sand and gravel, moist to wet	317	3	SS	44
1.5					
2.70		316	4	SS	42
3.0	Becoming saturated				
3.25	SAND: Compact to dense grey medium to coarse sand, saturated	315	5	SS	27
4.5 4.55			6	SS	41
	BOREHOLE TERMINATED AT 4.55 m	314			
6.0					

Bentonite Seal
Native Backfill
12 mm PVC Pipe
Piezometer Tip

Upon completion of drilling, borehole caved to 2.55 m with no free water

PIEZOMETER READINGS:

1987 01 11: 2.40 m
1987 02 19: 2.90 m

NOTES: * Sampler overfilled.

CHECKED BY gk

PML/504A

PETO MacCALLUM LTD.
CONSULTING ENGINEERS

LOG OF BOREHOLE No. 35 & 36

JOB NAME PROPOSED RESIDENTIAL SUBDIVISON — JOB No. 86 F 423
LOCATION Biehn Drive, Kitchener, Ontario — BORING DATE 1986 12 15 — ENGINEER G. Mitchell
BORING METHOD Continuous Flight Solid Stem Augers — TECHNICIAN D. Kelly

DEPTH in METRES	DESCRIPTION	ELEVATION	SAMPLE NUMBER	SAMPLE TYPE	BLOWS/0.3m N VALUES	GROUNDWATER OBSERVATIONS AND REMARKS
	BOREHOLE 35 GROUND ELEVATION: 323.99					
0.45	TOPSOIL: Dark brown sandy silt, organics, moist		1	SS	5	
	SAND: Loose to compact brown fine to medium sand, little gravel, moist to damp	323	2	SS	5	
		322	3	SS	11	
		321	4	SS	9	
			5	SS	27	
4.00		320				
4.55	Becoming very dense		6	SS	65	
	BOREHOLE TERMINATED AT 4.55 m					Upon completion of drilling, borehole caved to 4.00 m with no free water
	BOREHOLE 36 GROUND ELEVATION: 326.06					
0.42	TOPSOIL: Black sandy silt, organics, very moist		1	SS	7	
	SAND: Very loose to compact brown fine sand, little silt, saturated	325	2	SS	2	
		324	3	SS	8	
2.10	Becoming grey with occasional cobbles		4	SS	54*	
		323	5	SS	24	
3.35	SILT: Very stiff grey clayey silt, trace sand, D.T.P.L.	322				
4.55	BOREHOLE TERMINATED AT 4.55 m		6	SS	20	Upon completion of drilling, borehole caved to 1.15 m and wet

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION ○
STANDARD PENETRATION TEST ●
BLOWS/0.3m — 20 40 60 80

LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT ——— W
W_P W W_L
WATER CONTENT % — 10 20 30

NOTES: * Driving on cobble.

CHECKED BY: gh

PETO MacCALLUM LTD.
CONSULTING ENGINEERS

LOG OF BOREHOLE No. 37 & 38

JOB NAME: PROPOSED RESIDENTIAL SUBDIVISION — JOB No.: 86 F 423
LOCATION: Biehn Drive, Kitchener, Ontario — BORING DATE: 1986 12 12 — ENGINEER: G. Mitchell
BORING METHOD: Continuous Flight Solid Stem Augers — TECHNICIAN: D. Kelly

DEPTH in METRES	DESCRIPTION	GRAPHIC	ELEVATION	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m N VALUES	GROUNDWATER OBSERVATIONS AND REMARKS
	BOREHOLE 37 GROUND ELEVATION: 314.79						
0.45	TOPSOIL: Dark brown silt, organics, very moist			1	SS	2	Water level at surface
	SILT: Compact brown sandy silt, saturated		314	2	SS	12	
1.50							
	SAND: Compact to dense brown fine sand, occasional coarse sand seams, saturated		313	3	SS	26	
			312	4	SS	33	
				5	SS	28	
3.65			311				
	Becoming grey fine to coarse sand			6	SS	27	
4.55	BOREHOLE TERMINATED AT 4.55 m		310				Upon completion of drilling, borehole caved to 1.35 m with no free water
	BOREHOLE 38 GROUND ELEVATION: 317.13						
0.60	TOPSOIL: Dark brown to black silt, organics, very moist			1	SS	4	
	SILT: Loose to compact brown sandy silt, trace clay, very moist to saturated		316	2	SS	12	
				3	SS	8	
			315	4	SS	3	
3.00							
	SAND: Loose brown fine sand, little silt, saturated		314	5	SS	2	
			313				
4.55				6	SS	10	
	BOREHOLE TERMINATED AT 4.55 m						Upon completion of drilling, borehole caved to 3.00 m with no free water Wet at 3.00 m

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION +
STANDARD PENETRATION TEST •
BLOWS/0.3m 20 40 60 80

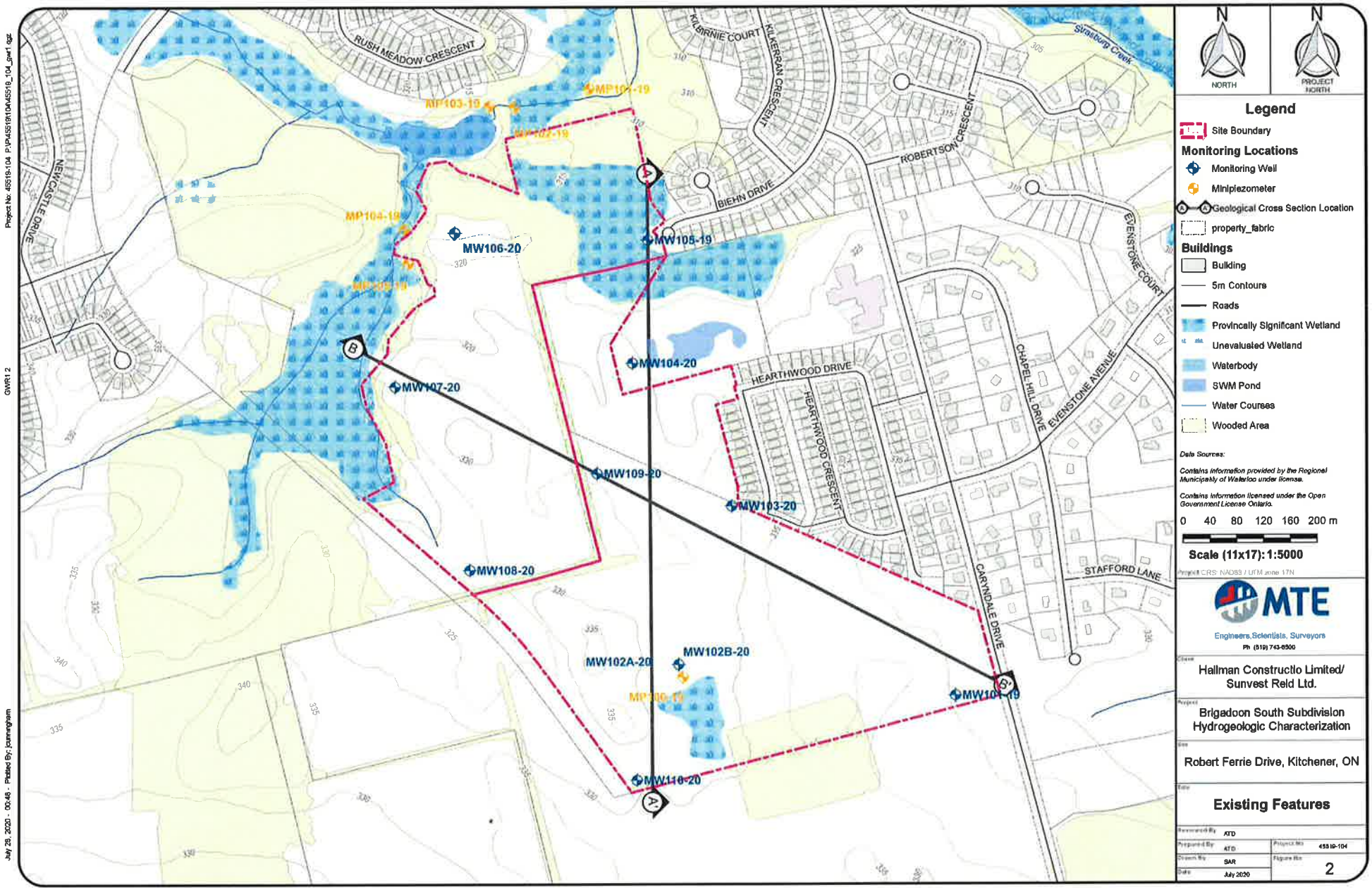
LIQUID LIMIT W_L
PLASTIC LIMIT W_P
WATER CONTENT W
W_P W W_L
WATER CONTENT % 10 20 30

NOTES

CHECKED BY: gk

Appendix C

Borehole Logs (MTE Consultants)



N
NORTH

N
PROJECT NORTH

Legend

- Site Boundary

Monitoring Locations

- Monitoring Well
- Minipiezometer
- Geological Cross Section Location
- property_fabric

Buildings

- Building
- 5m Contours
- Roads
- Provincially Significant Wetland
- Unevaluated Wetland
- Waterbody
- SWM Pond
- Water Courses
- Wooded Area

Data Sources:

Contains information provided by the Regional Municipality of Waterloo under license.

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0 40 80 120 160 200 m

Scale (11x17): 1:5000

Project CRS: NAD83 / UTM zone 17N

MTE
Engineers, Scientists, Surveyors
Ph (519) 743-6500

Client: Hallman Constructio Limited/ Sunvest Reid Ltd.

Project: Brigadoon South Subdivision Hydrogeologic Characterization

Site: Robert Ferrie Drive, Kitchener, ON

Title: **Existing Features**

Reviewed By	ATD		
Prepared By	ATD	Project No.	45519-104
Drawn By	SAR	Figure No.	2
Date	July 2020		

Project No: 45519-104 P:\P45519\104\45519_104_gwr1.tgz
GWR1 2
July 28, 2020 - 00:48 - Plotted By: jcunningham

Table 1: Manual Water Levels

ID	MW101-19		MW102A-20		MW102B-20		MW103-20		MW104-20		MW105-19	
TOC Elevation (mAMSL)	334.27		327.65		327.66		328.17		322.56		314.09	
GS Elevation (mAMSL)	333.34		326.62		326.71		327.17		321.48		313.15	
Date	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs
10-Dec-19	16.57	15.64	NI	-	NI	-	NI	-	NI	-	NI	#VALUE!
4-Feb-20	16.61	15.68	9.79	8.76	2.96	2.02	10.60	9.60	6.09	5.01	1.55	0.61
11-Feb-20	16.51	15.58	9.80	8.77	2.96	2.02	10.57	9.57	6.09	5.01	1.60	0.66
2-Jun-20	16.27	15.34	9.67	8.63	2.94	2.00	10.46	9.46	6.09	5.01	1.67	0.73
1-Sep-20	16.68	15.75	10.04	9.01	4.60	3.65	10.77	9.77	6.44	5.36	1.89	0.95
27-Nov-20	17.03	16.10	10.40	9.37	5.09	4.15	11.14	10.14	6.68	5.60	1.59	0.65
5-Mar-21	17.28	16.35	10.61	9.58	4.55	3.60	11.34	10.34	6.80	5.72	1.64	0.70
3-Jun-21	17.26	16.33	10.60	9.57	4.04	3.10	11.36	10.36	6.80	5.72	1.79	0.85
10-Sep-21	17.55	16.62	10.81	9.78	dry		11.57	10.57	7.02	5.94	1.82	0.88
17-Nov-21	17.48	16.55	10.81	9.78	4.66	3.72	11.55	10.55	6.93	5.85	1.65	0.71

ID	MW106-20		MW107-20		MW108-20		MW109-20		MW110-20	
TOC Elevation (mAMSL)	319.08		324.32		324.02		324.08		330.32	
GS Elevation (mAMSL)	317.90		323.25		322.95		323.09		329.50	
Date	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs
10-Dec-19	NI	-	NI	-	NI	-	NI	-	NI	-
4-Feb-20	5.46	4.28	7.51	6.43	5.71	4.64	6.77	5.78	5.13	4.31
11-Feb-20	5.48	4.30	7.50	6.42	damaged		6.76	5.77	5.12	4.30
2-Jun-20	5.50	4.32	7.48	6.40	5.98	4.91	6.70	5.71	5.24	4.42
1-Sep-20	5.62	4.44	7.78	6.70	6.40	5.33	7.03	6.04	5.84	5.02
27-Nov-20	5.53	4.35	8.05	6.97	6.80	5.73	7.35	6.36	6.24	5.42
5-Mar-21	5.55	4.37	8.19	7.11	6.93	5.86	7.51	6.52	6.28	5.46
3-Jun-21	5.59	4.41	8.18	7.10	6.86	5.79	7.50	6.51	6.07	5.25
10-Sep-21	5.65	4.47	8.37	7.29	7.16	6.09	7.71	6.72	6.50	5.68
17-Nov-21	5.59	4.41	8.33	7.25	7.09	6.02	7.69	6.70	6.34	5.52

ID	MP101-19 - in		MP101-19 - out		MP102-19		MP102-19 - out		MP103-19		MP103-19 - out	
TOC Elevation (mAMSL)	-		-		310.43		310.43		313.16		313.16	
GS Elevation (mAMSL)	-		-		309.27		-		311.89		-	
Date	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs
10-Dec-19	1.09	-0.01	1.04	-0.06	1.51	0.35	0.93	-0.23	1.56	0.29	0.91	-0.36
4-Feb-20	-	-	-	-	-	-	-	-	-	-	-	-
11-Feb-20	1.10	0.00	1.10	0.00	0.90	-0.26	0.97	-0.19	1.07	-0.20	frozen	-
2-Jun-20	destroyed		destroyed		0.92	-0.25	0.98	-0.18	1.11	-0.16	0.92	-0.36
1-Sep-20	destroyed		destroyed		0.98	-0.18	1.00	-0.16	1.41	0.13	0.92	-0.35
27-Nov-20	destroyed		destroyed		0.86	-0.30	0.95	-0.21	1.15	-0.12	0.91	-0.36
5-Mar-21	destroyed		destroyed		0.91	-0.25	0.95	-0.21	1.05	-0.22	frozen	
3-Jun-21	destroyed		destroyed		0.95	-0.21	0.99	-0.17	1.13	-0.14	0.90	-0.37
10-Sep-21	destroyed		destroyed		0.93	-0.23	0.97	-0.19	0.78	-0.49	0.47	-0.80
17-Nov-21	destroyed		destroyed		0.84	-0.32	0.94	-0.22	0.78	-0.49	0.55	-0.72

ID	MP104-19		MP104-19 - out		MP105-19		MP105-19 - out		MP106-19		MP106-19 - out	
TOC Elevation (mAMSL)	314.27		314.27		314.91		314.91		327.19		327.19	
GS Elevation (mAMSL)	313.05		-		313.67		-		326.09		-	
Date	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs
10-Dec-19	0.82	-0.40	1.02	-0.20	2.00	0.76	1.13	-0.11	1.72	0.62	0.98	-0.12
4-Feb-20	-	-	-	-	-	-	-	-	-	-	-	-
11-Feb-20	0.84	-0.38	1.10	-0.12	frozen		frozen		frozen		frozen	
2-Jun-20	0.84	-0.39	1.07	-0.15	1.30	0.06	1.18	-0.06	0.82	-0.29	0.82	-0.28
1-Sep-20	0.88	-0.34	1.09	-0.13	1.45	0.21	dry	-	1.75	0.65	dry	
27-Nov-20	0.82	-0.40	1.01	-0.21	1.14	-0.10	1.16	-0.08	1.66	0.56	dry	
5-Mar-21	frozen		1.06	-0.16	frozen		dry		1.71	0.61	dry	
3-Jun-21	0.86	-0.36	1.07	-0.15	1.25	0.01	dry		1.69	0.59	dry	
10-Sep-21	0.89	-0.33	1.08	-0.14	1.24	0.00	dry		1.76	0.66	dry	
17-Nov-21	0.85	-0.37	1.06	-0.16	1.15	-0.09	1.16	-	dry		dry	

Notes:
NM = not measured
NI = not installed
TOC = top of casing
GS = ground surface
N/A = not applicable
- in = groundwater level measured inside mini-piezometer
- out = surface water level measured outside mini-piezometer
mAMSL = meters above mean sea level
mbtoc = meters below top of casing
Monitoring well TOC and Ground Surface elevations surveyed May, 2020

Table 2: Manual Water Elevations

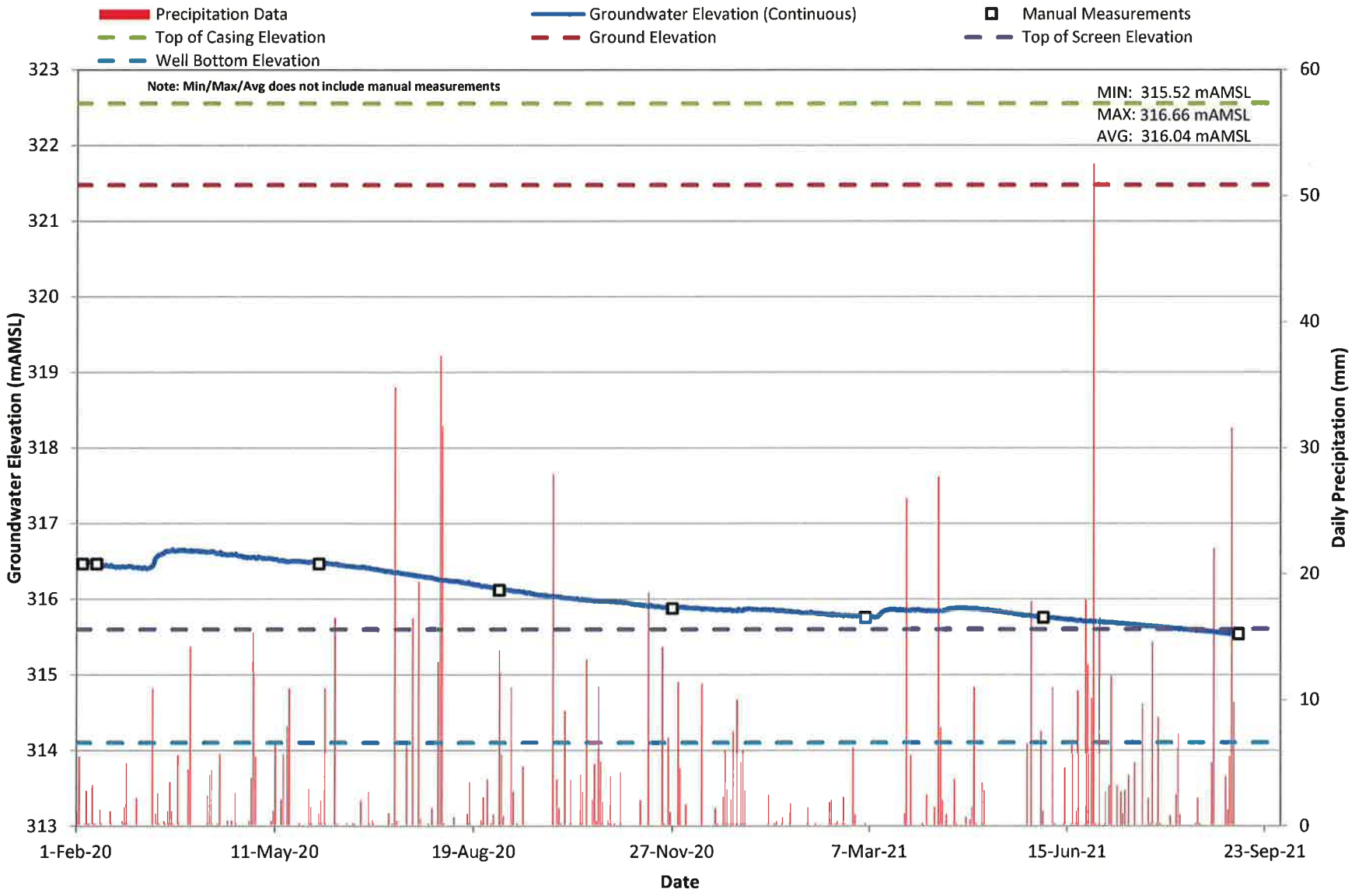
ID	MW101-19	MW102A-20	MW102B-20	MW103-20	MW104-20	MW105-19	MW106-20	MW107-20	MW108-20	MW109-20	MW110-20
TOC Elevation (mAMSL)	334.27	327.65	327.66	328.17	322.56	314.09	319.08	324.32	324.02	324.08	330.32
GS Elevation (mAMSL)	333.34	326.62	326.71	327.17	321.48	313.15	317.90	323.25	322.95	323.09	329.50
10-Dec-19	317.70	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI
4-Feb-20	317.66	317.86	324.70	317.57	316.47	312.54	313.62	316.81	318.31	317.31	325.19
11-Feb-20	317.76	317.85	324.70	317.60	316.47	312.49	313.60	316.82	NM	317.32	325.20
2-Jun-20	318.00	317.98	324.72	317.71	316.47	312.42	313.58	316.84	318.04	317.38	325.08
1-Sep-20	317.59	317.61	323.06	317.40	316.12	312.20	313.46	316.55	317.62	317.05	324.48
27-Nov-20	317.24	317.25	322.57	317.03	315.88	312.50	313.55	316.27	317.22	316.73	324.08
5-Mar-21	316.99	317.04	323.11	316.83	315.76	312.45	313.53	316.13	317.09	316.57	324.04
3-Jun-21	317.01	317.05	323.62	316.81	315.76	312.30	313.49	316.14	317.16	316.58	324.25
10-Sep-21	316.72	316.84	dry	316.60	315.54	312.27	313.43	315.95	316.86	316.37	323.82
17-Nov-21	316.79	316.84	323.00	316.62	315.63	312.44	313.49	315.99	316.93	316.39	323.98

ID	MP101-19-in	MP101-19-out	MP102-19-in	MP102-20-out	MP103-19-in	MP103-19-out	MP104-19-in	MP104-19-out	MP105-19-in	MP105-19-out	MP106-19-in	MP106-19-out
TOC Elevation (mAMSL)	0.00	0.00	310.43	310.43	313.16	313.16	314.27	314.27	314.91	314.91	327.19	327.19
GS Elevation (mAMSL)	0.00	-	309.27	-	311.89	-	313.05	-	313.67	-	326.09	-
10-Dec-19	-1.09	-1.04	308.92	309.50	311.60	312.25	313.45	313.25	312.91	313.78	325.47	326.21
4-Feb-20	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
11-Feb-20	-1.10	-1.10	309.53	309.46	312.09	Frozen	313.43	313.17	Frozen	Frozen	Frozen	Frozen
2-Jun-20	Destroyed		309.52	309.45	312.05	312.25	313.43	313.20	313.61	313.73	326.38	326.37
10-Sep-21	Destroyed		309.45	309.43	311.76	312.24	313.39	313.18	313.46	dry	325.44	dry
27-Nov-20	Destroyed		309.57	309.48	312.01	312.25	313.45	313.26	313.77	313.75	325.53	dry
5-Mar-21	Destroyed		309.52	309.48	312.11	frozen	frozen	313.21	frozen	dry	325.48	dry
3-Jun-21	Destroyed		309.48	309.44	312.03	312.26	313.41	313.20	313.66	dry	325.50	dry
10-Sep-21	Destroyed		309.50	309.46	312.38	312.69	313.38	313.19	313.67	dry	325.43	dry
17-Nov-21	Destroyed		309.57	309.48	312.01	312.25	313.45	313.26	313.77	313.75	325.53	dry

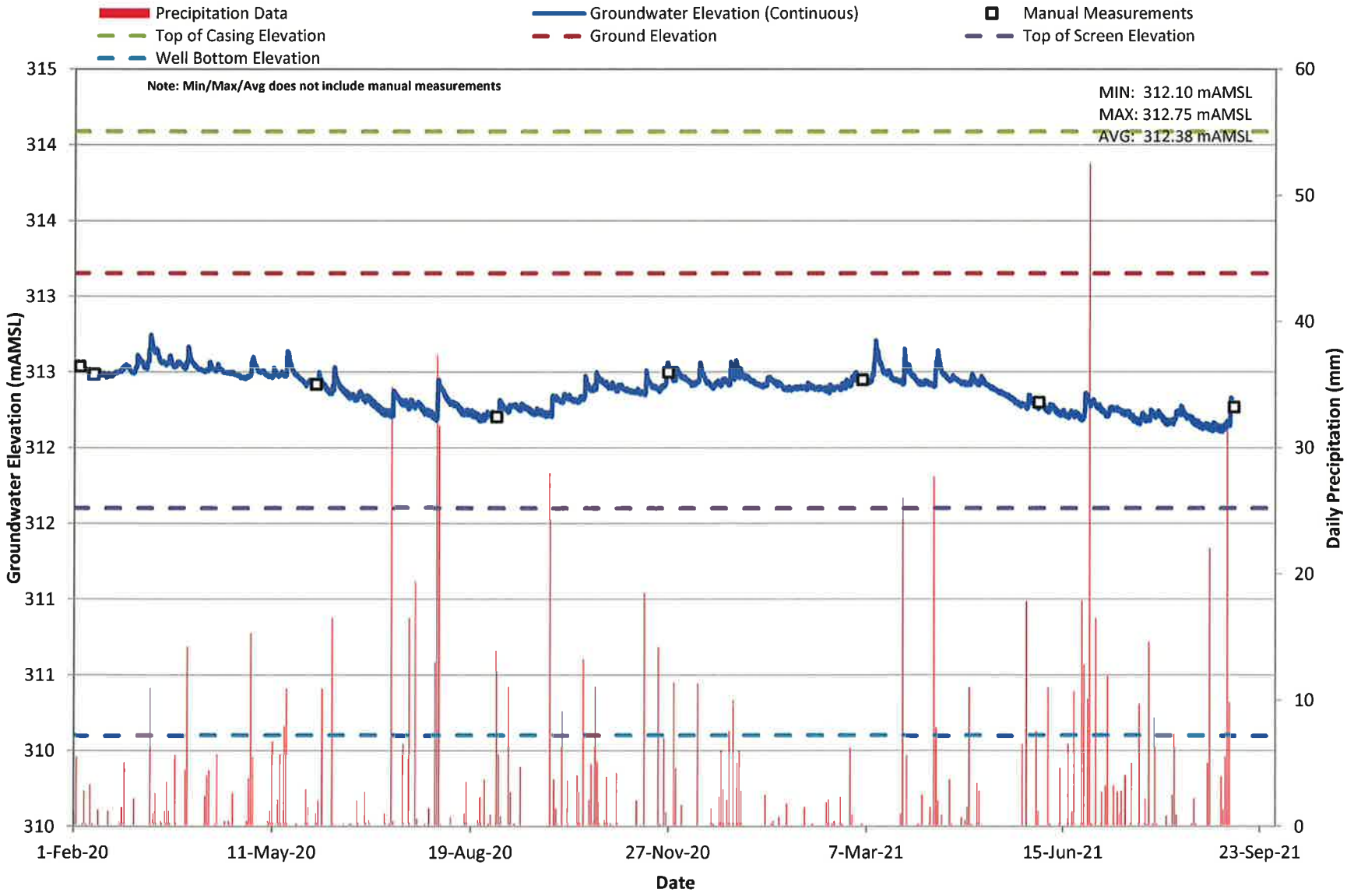
Notes:
NM = not measured
NI = not installed
TOC = top of casing
GS = ground surface
- in = groundwater level measured inside mini-piezometer
- out = surface water level measured outside mini-piezometer

mAMSL = meters above mean sea level
mbtoc = meters below top of casing
Monitoring well TOC and Ground Surface elevations surveyed May, 2020

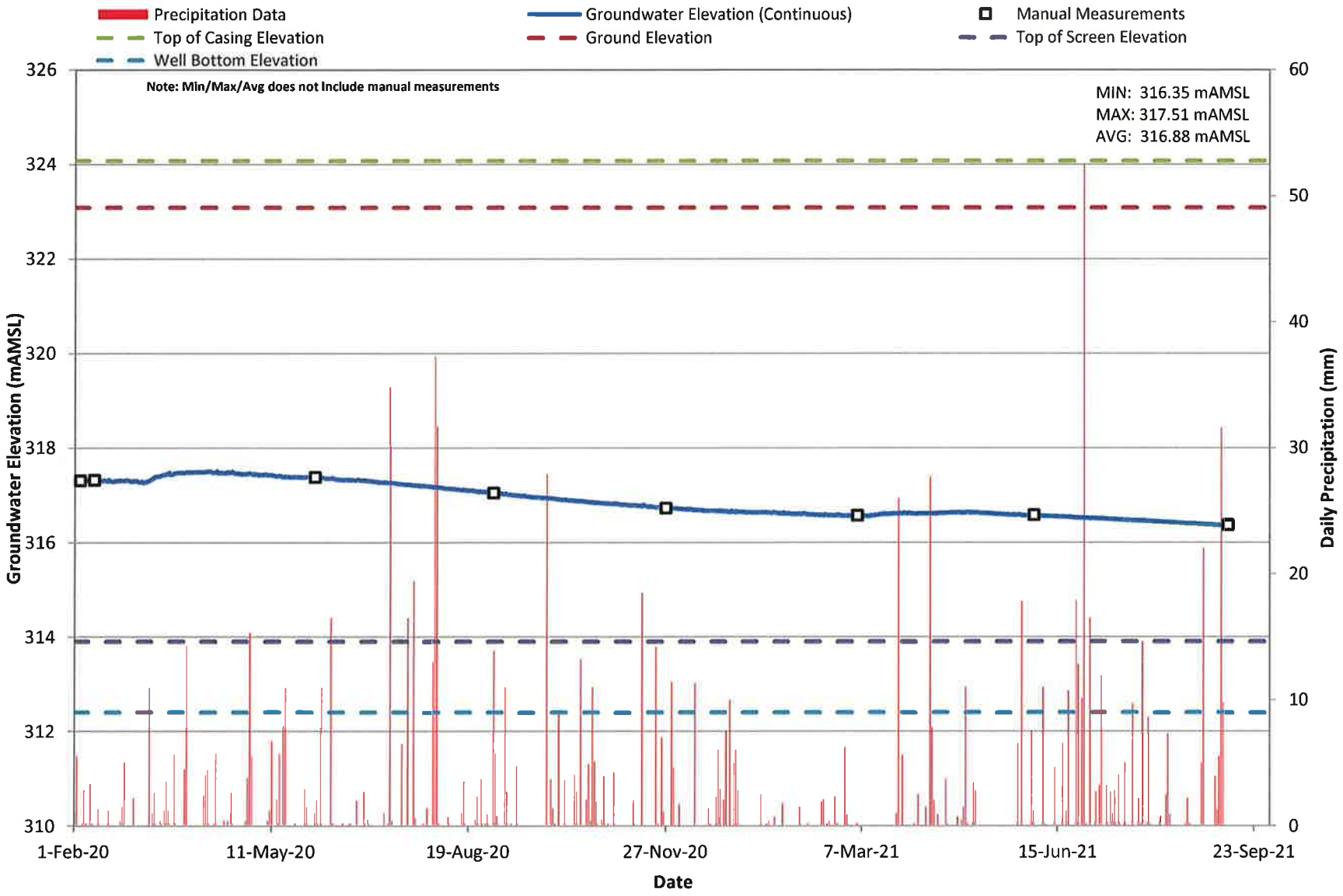
Hydrograph 5: Groundwater Elevations (mAMSL) - MW104-20



Hydrograph 6: Groundwater Elevations (mAMSL) - MW105-19



Hydrograph 10: Groundwater Elevations (mAMSL) - MW109-20



ID Number: MW104-20

Project Name: Brigadoon South

Project No: 45519-104

Client: Sunvest/Reid Ltd.

Site Location: Kitchener, Ontario

Date Completed: 1/27/2020

Drilling Contractor: Geo-Environmental

Drill Rig: CME M75-3

Drill Method: Hollow Stem Auger

Protective Cover: Monument

Depth Scale (ft / m)	Soil Description	Elevation (masl) / Depth (m)	Sample Number	Type	Recovery (%)	SPT N-Value (Blows/305mm)	Moisture Content (%)	Well Completion Details
0 / 0	Ground Surface	321.5						Concrete
	TOPSOIL Silty sand, organics, dark brown, soft, moist	0.0 / 321.2						
	SILTY SAND Brown, loose, moist	0.3 / 320.4	1	SS	80	4		
			2	SS	100	7		
2 / 4	**SAND** Trace silt and clay, brown, loose, moist	1.1	3	SS	50	20		Bentonite
6 / 2			4	SS	50	18		51 mm PVC Riser
8 / 10			5	SS	60	7		
12 / 4								Jan 27, 2020
14 / 16	Wet at approximately 5 m	316.4 / 5.0	6	SS	50	9		Feb 4, 2020

Field Technician: KNR

Drafted by: KNR

Reviewed by:

MTE

MOE Well Tag: A287241
Easting: 543796
Northing: 4803568

ID Number: MW104-20

Project Name: Brigadoon South

Project No: 45519-104

Client: Sunvest/Reid Ltd.

Site Location: Kitchener, Ontario

Date Completed: 1/27/2020

Drilling Contractor: Geo-Environmental

Drill Rig: CME M75-3

Drill Method: Hollow Stem Auger

Protective Cover: Monument

Depth Scale	Symbol	Soil Description	Elevation (masl) / Depth (m)	Sample Number	Sample Type	Recovery (%)	SPT N-Value (Blows/305mm)	Moisture Content %	Well Completion Details
18									
20	6								
				7	SS	100	31		
22									
24									
26	8			8	SS	100	38		
			313.2 / 8.2						
28		Drilling Terminated							
30									
32	10								
34									
36									

Well Completion Details: Sand Pack; 51mm Slotted Screen

Field Technician: KNR

Drafted by: KNR

Reviewed by:

MTE

MOE Well Tag: A287241
Easting: 543796
Northing: 4803568

ID Number: MW105-19

Project Name: Brigadoon South

Project No: 45519-104

Client: Hallman Construction Ltd.

Site Location: Kitchener, Ontario

Date Completed: 12/2/2019

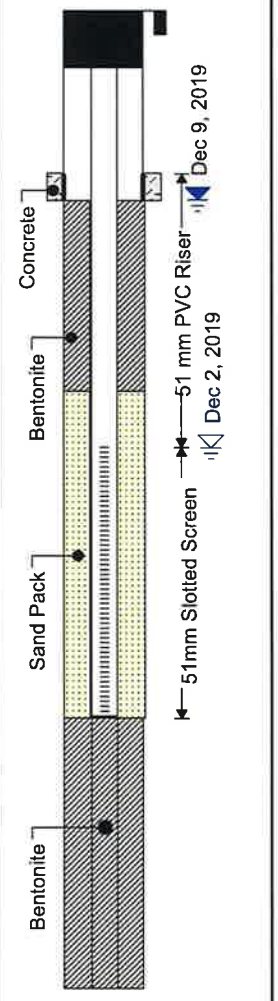
Drilling Contractor: Geo-Environmental

Drill Rig: CME M75-3

Drill Method: Hollow Stem Auger

Protective Cover: Monument

Depth Scale (ft / m)	Soil Description	Elevation (masl) / Depth (m)	Sample Number	Type	Recovery (%)	SPT N-Value (Blows/305mm)	Moisture Content (%)
0 / 0	Ground Surface	313.2 / 0.0					
	TOPSOIL Silty sand, dark brown, loose, moist						
	SAND Brown, loose, moist		1	SS	25	8	
		312.2 / 0.9					
	SILTY SAND Trace clay, brown, moist, loose		2	SS	50	17	
		311.6 / 1.5					
	Wet at approximately 1.5 m		3	SS	90	12	
			4	SS	100	7	
		309.8 / 3.4	5	SS	100	7	
	CLAYEY SILT Trace sand, brown, soft, moist						
		309.3 / 3.8					
	SAND Brown, loose, wet		6	SS	25	0	
		308.6 / 4.6					
	Drilling Terminated						



Field Technician: KNR

Drafted by: KNR

Reviewed by:

MTE

MOE Well Tag #A279204
Easting: 543819
Northing: 4803753

Sheet: 1 of 1

ID Number: MW108-20

Project Name: Brigadoon South

Project No: 45519-104

Client: Hallman Construction Ltd.

Site Location: Kitchener, Ontario

Date Completed: 2/27/2020

Drilling Contractor: Geo-Environmental

Drill Rig: CME M75-3

Drill Method: Hollow Stem Auger

Protective Cover: Monument

Depth Scale (ft / m)	Soil Description	Elevation (masl) / Depth (m)	Sample Number	Type	Recovery (%)	SPT N-Value (Blows/305mm)	Moisture Content (%)	Well Completion Details
0 / 0	Ground Surface	323.0						
	TOPSOIL Silty sand, organics, black, loose, moist	0.0						
	SILTY SAND Trace clay, brown, loose, moist		1	SS	50	7		
2			2	SS	50	6		
4								
6 / 2			3	SS	75	15		
8			4	SS	75	14		
10			5	SS	75	15		
12 / 4								
14	Wet at approximately 4.6 m	318.4 / 4.6						
16			6	SS	75	16		

Moisture Content (%): 10 20 30

Well Completion Details: Concrete; Bentonite; 51 mm PVC Riser; Feb 27, 2020

Field Technician: KNR

Drafted by: KNR

Reviewed by:

MTE

MOE Well Tag: A287234
Easting: 543553
Northing: 4803257

ID Number: MW108-20

Project Name: Brigadoon South

Project No: 45519-104

Client: Hallman Construction Ltd.

Site Location: Kitchener, Ontario

Date Completed: 2/27/2020

Drilling Contractor: Geo-Environmental

Drill Rig: CME M75-3

Drill Method: Hollow Stem Auger

Protective Cover: Monument

Depth Scale	Symbol	Soil Description	Elevation (masl) / Depth (m)	Sample Number	Sample Type	Recovery (%)	SPT N-Value (Blows/305mm)	Moisture Content %	Well Completion Details
18									
20	6			7	SS	80	19		
22									
24									
26	8			8	SS	90	9		
28									
30		**SAND** Some silt, brown, loose, saturated	313.8 9.1	9	SS	100	10		
32	10	Drilling Terminated	313.2 9.8						
34									
36									

Well Completion Details: Sand Pack; Bentonite; 51mm Slotted Screen

Field Technician: KNR

Drafted by: KNR

Reviewed by:

MTE

MOE Well Tag: A287234
Easting: 543553
Northing: 4803257

ID Number: MW109-20

Project Name: Brigadoon South

Project No: 45519-104

Client: Sunvest/Reid Ltd.

Site Location: Kitchener, Ontario

Date Completed: 1/27/2020

Drilling Contractor: Geo-Environmental

Drill Rig: CME M75-3

Drill Method: Hollow Stem Auger

Protective Cover: Monument

Depth Scale (ft / m)	Symbol	Soil Description	Elevation (masl) / Depth (m)	Sample Number	Sample Type	Recovery (%)	SPT N-Value (Blows/305mm)	Moisture Content (%)	Well Completion Details
0 / 0		Ground Surface	323.1						
		TOPSOIL Silty sand, black, loose, moist	0.0	1	SS	25	7		Concrete
2		**SILTY SAND** Some clay, brown, soft, moist		2	SS	80	6		
4			321.6						
6 / 2		**CLAYEY SILT** Trace sand, brown, soft, loose, wet	1.5	3	SS	90	18		
			320.8						
8		**SILTY SAND** Trace clay, brown, compact, moist	2.3	4	SS	100	18		
10				5	SS	100	21		Bentonite
12 / 4									
14			318.5						
		CLAYEY SILT Trace sand, grey, compact, moist	4.6	6	SS	80	18		51 mm PVC Riser Jan 27, 2020
16									
18									

Field Technician: KNR

Drafted by: KNR

Reviewed by:

MTE

MOE Well Tag: A246045
Easting: 543743
Northing: 4803402

ID Number: MW109-20

Project Name: Brigadoon South

Project No: 45519-104

Client: Sunvest/Reid Ltd.

Site Location: Kitchener, Ontario

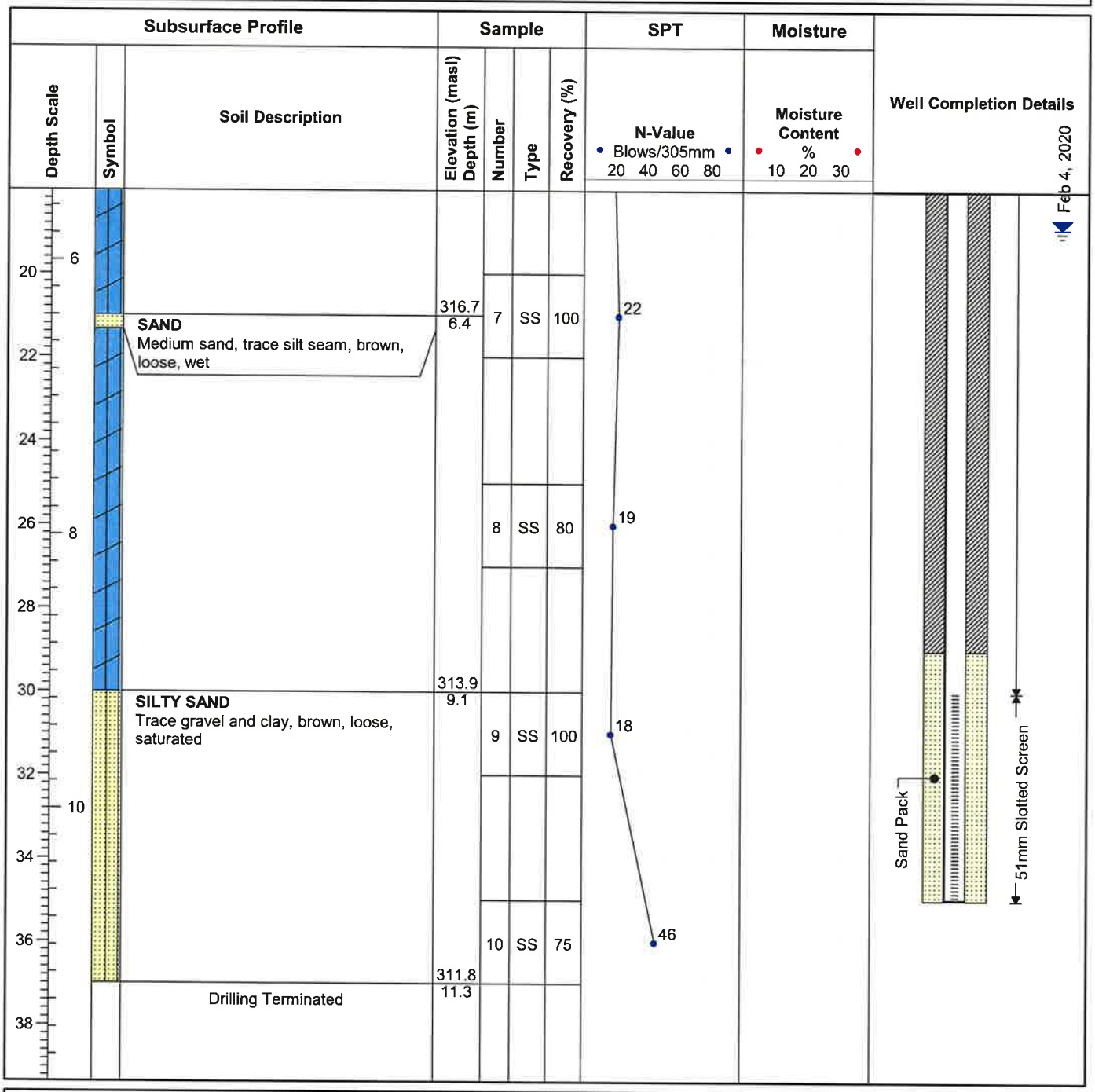
Date Completed: 1/27/2020

Drilling Contractor: Geo-Environmental

Drill Rig: CME M75-3

Drill Method: Hollow Stem Auger

Protective Cover: Monument



Field Technician: KNR

Drafted by: KNR

Reviewed by:

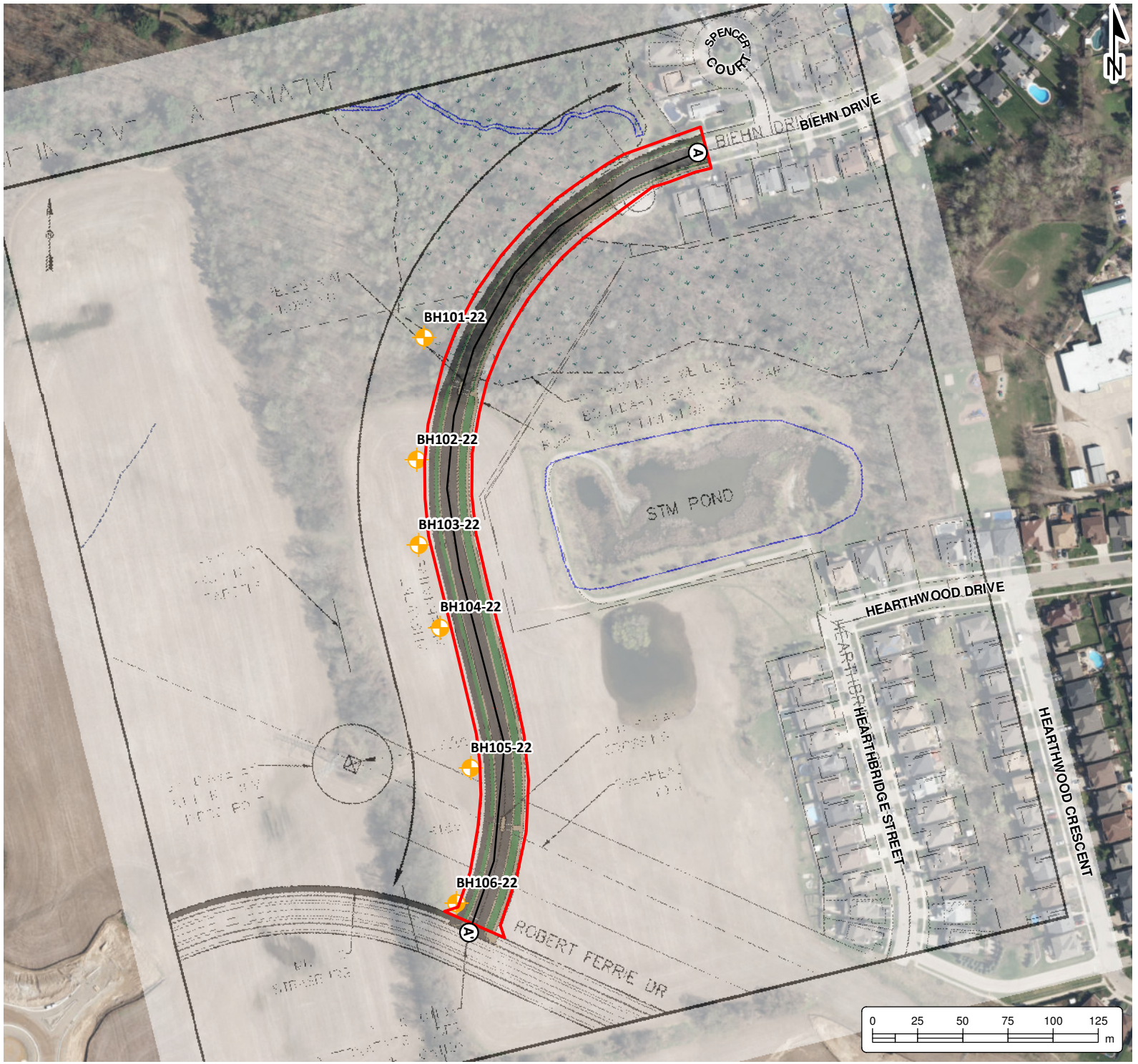
MTE

MOE Well Tag: A246045
Easting: 543743
Northing: 4803402

Sheet: 2 of 2

Appendix D

Borehole Logs (Cambium)



HYDROGEOLOGICAL ASSESSMENT

CITY OF KITCHENER
Biehn Drive
Kitchener, Ontario

LEGEND

- Borehole
- Cross Section
- Site (approximate)

Notes:
- Base mapping features are © Queen's Printer of Ontario, 2019 (this does not constitute an endorsement by the Ministry of Natural Resources or the Ontario Government).
- Distances on this plan are in metres and can be converted to feet by dividing by 0.3048.
- Cambium Inc. makes every effort to ensure this map is free from errors but cannot be held responsible for any damages due to error or omissions. This map should not be used for navigation or legal purposes. It is intended for general reference use only.

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LINEAR INFRASTRUCTURE EXCAVATION AREA

Project No.: 11969-001		Date: February 2022 Rev.:	
Scale: 1:3,000		Projection: NAD 1983 UTM Zone 17N	
Created by: ACS	Checked by: SK	Figure:	4

O:\GIS\MXDs\11900-11999\11969-001 City of Kitchener - Hydrogeological Assessment - geological Assessment, Kitchener\2022-01-31 FIG 4 - Linear Infrastructure Excavation Area.mxd

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Log of Borehole: BH101-22

Client:	BT Engineering, London	**Project Name:**	Geotechnical Investigation	**Project No.:**	11969-001
Contractor:	Drilltech	**Method:**	Solid Stem Auger	**Date Completed:**	January 20, 2022
Location:	Biehn Drive Extension	**UTM:**	17T 543732 E, 4803683 N	**Elevation:**	313.42 mASL

Elevation (m)	Depth	Description	Number	Type	% Recovery	SPT (N) / DCPT	Well Installation	Remarks
314	-1						Cap	
							Monument	
313	0	TOPSOIL: Dark brown silt topsoil, some organics, moist, loose	1A	SS	50	6	Water level at 0.41 mbgs on on Feb 04, 2022	
			1B	SS				
	1	SILTY SAND: Brown silty sand, moist, loose						
312		SAND: Brown sand, some silt, trace gravel, wet, compact	2	SS	65	19		
		SILTY SAND: Brown silty sand, some gravel, trace clay, APL, stiff	3	SS	35	16	PVC Riser	GSA SS3: 19% Gravel 52% Sand 26% Silt 3% Clay
311	2						Bentonite Plug	
			4	SS	50	14		
	3							
310			5	SS	80	14		
	4							
309		SAND: Reddish brown sand, moist, compact	6	SS	100	14		
	5							
308								
	6	-Wet, loose					Sand Pack	
307			7	SS	80	8	PVC Screen	
	7							
306							Cap	
	8		8	SS	50	9		Water level at 2.1 mbgs upon completion
305		Borehole terminated at 8.2 mbgs in SAND						

% Moisture: 25 50 75
SPT (N) / DCPT: 10 20 30 40

Logged By: TA **Input By:** KL

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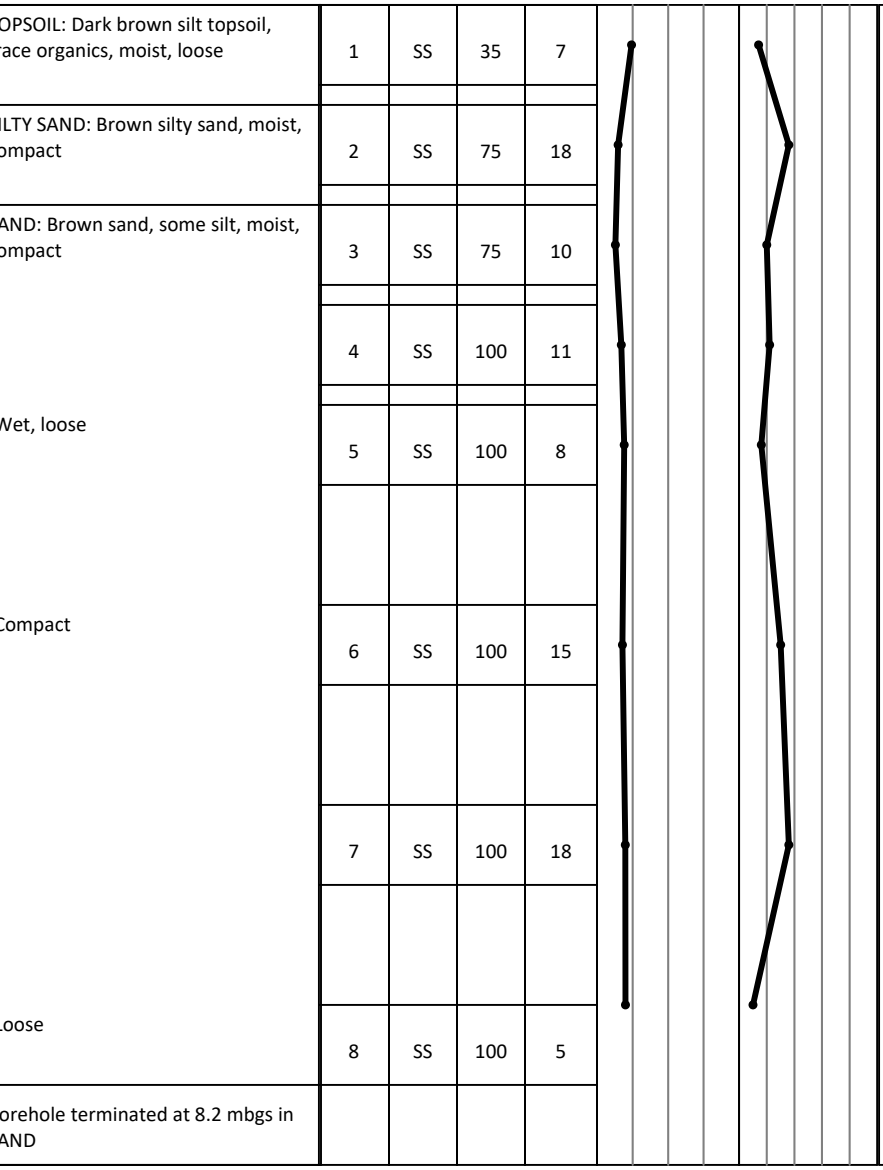
Log of Borehole: BH102-22

Client:	BT Engineering, London	**Project Name:**	Geotechnical Investigation	**Project No.:**	11969-001
Contractor:	Drilltech	**Method:**	Solid Stem Auger	**Date Completed:**	January 20, 2022
Location:	Biehn Drive Extension	**UTM:**	17T 543728 E, 4803615 N	**Elevation:**	318.09 mASL

Elevation (m)	Depth	Description	Number	Type	% Recovery	SPT (N) / DCPT	Well Installation	Remarks
318	0	TOPSOIL: Dark brown silt topsoil, trace organics, moist, loose	1	SS	35	7		
317	1	SILTY SAND: Brown silty sand, moist, compact	2	SS	75	18		
		SAND: Brown sand, some silt, moist, compact	3	SS	75	10		
316	2		4	SS	100	11		
315	3	-Wet, loose	5	SS	100	8		
314	4							
		-Compact	6	SS	100	15		
313	5							
312	6		7	SS	100	18		
311	7							
		-Loose	8	SS	100	5		Water level at 3.0 mbgs upon completion
310	8	Borehole terminated at 8.2 mbgs in SAND						



Logged By: TA **Input By:** KL

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Log of Borehole: BH103-22

Client:	BT Engineering, London	**Project Name:**	Geotechnical Investigation	**Project No.:**	11969-001
Contractor:	Drilltech	**Method:**	Solid Stem Auger	**Date Completed:**	January 21, 2022
Location:	Biehn Drive Extension	**UTM:**	17T 543729 E, 4803568 N	**Elevation:**	318.67 mASL

Elevation (m) / Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
318 / 0		TOPSOIL: Dark brown silty topsoil, some organics, moist, loose	1	SS	100	8				
			2A	SS	75	7				
317 / 1		SAND: Light brown sand, moist, loose	2B	SS						
		-Trace gravel, compact	3	SS	100	30				
316 / 2		-some gravel, dense	4	SS	75	44				
		-Wet, compact	5	SS	50	29				
315 / 3										
314 / 4		-trace gravel	6	SS	100	29				
313 / 5										
312 / 6		-Saturated, dense	7	SS	100	44				
311 / 7										
310 / 8		-Grey	8	SS	100	33				Water level at 4.6 mbgs upon completion
		Borehole terminated at 8.2 mbgs in SAND								

Logged By: TA **Input By:** KL

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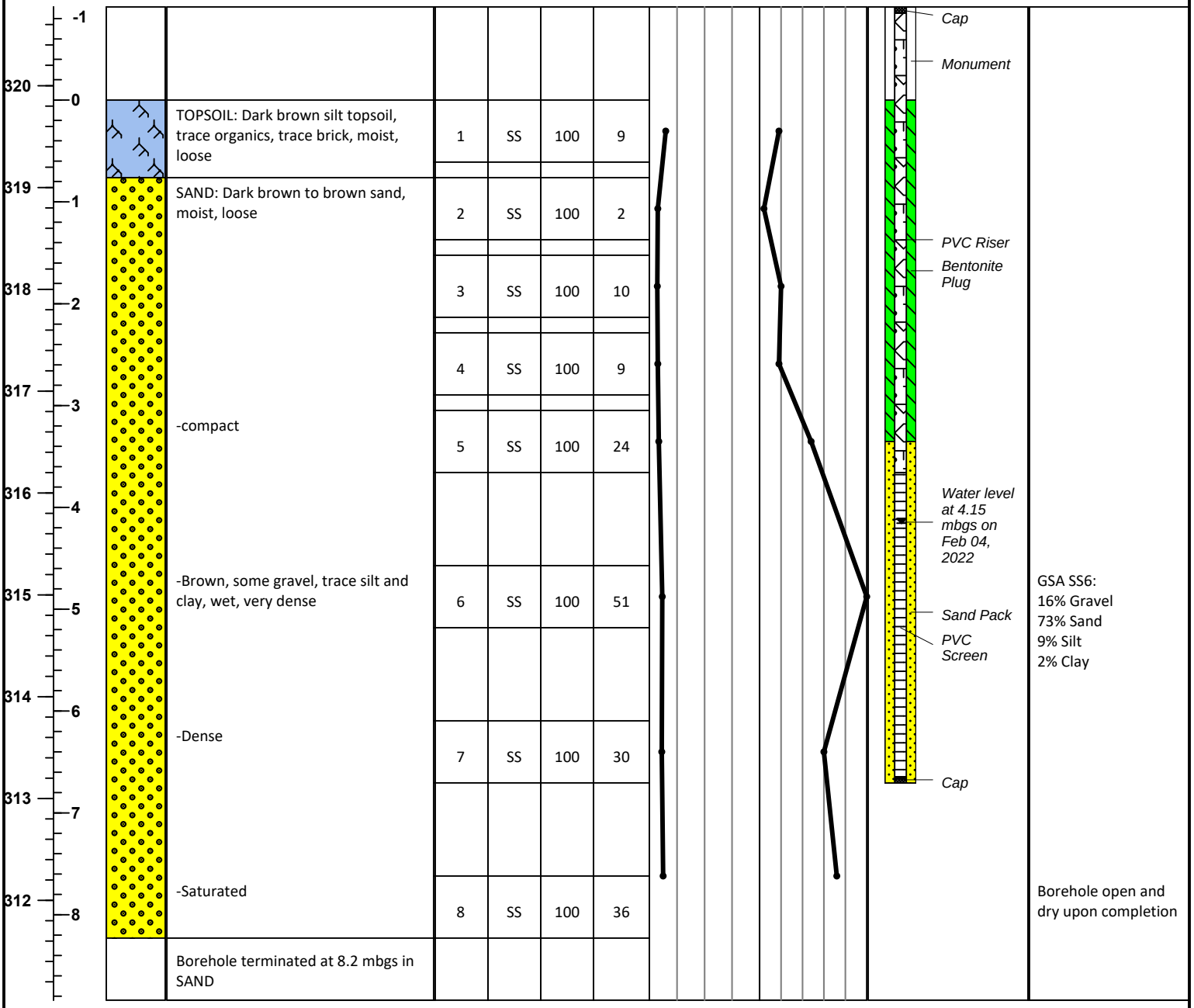
Log of Borehole: BH104-22

Client:	BT Engineering, London	**Project Name:**	Geotechnical Investigation	**Project No.:**	11969-001
Contractor:	Drilltech	**Method:**	Solid Stem Auger	**Date Completed:**	January 20, 2022
Location:	Biehn Drive Extension	**UTM:**	17T 543741 E, 4803522 N	**Elevation:**	319.86 mASL

Elevation (m)	Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	Well Installation	Remarks
320	0		TOPSOIL: Dark brown silt topsoil, trace organics, trace brick, moist, loose	1	SS	100	9	Cap	
319	1		SAND: Dark brown to brown sand, moist, loose	2	SS	100	2	Monument	
318	2			3	SS	100	10	PVC Riser	
317	3		-compact	4	SS	100	9	Bentonite Plug	
316	4			5	SS	100	24		
315	5		-Brown, some gravel, trace silt and clay, wet, very dense	6	SS	100	51	Water level at 4.15 mbgs on Feb 04, 2022	GSA SS6: 16% Gravel 73% Sand 9% Silt 2% Clay
314	6		-Dense	7	SS	100	30	Sand Pack	
313	7							PVC Screen	
312	8		-Saturated	8	SS	100	36	Cap	Borehole open and dry upon completion
			Borehole terminated at 8.2 mbgs in SAND						



Logged By: TA **Input By:** KL

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Log of Borehole: BH105-22

Client:	BT Engineering, London	**Project Name:**	Geotechnical Investigation	**Project No.:**	11969-001
Contractor:	Drilltech	**Method:**	Solid Stem Auger	**Date Completed:**	January 21, 2022
Location:	Biehn Drive Extension	**UTM:**	17T 543758 E, 4803444 N	**Elevation:**	321.11 mASL

Elevation (m)	Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
321	0		TOPSOIL: Dark brown clayey silt topsoil, APL, stiff	1	SS	100	16				
320	1		CLAYEY SILT: Brown clayey silt, APL, stiff	2	SS	100	13				
			-Very stiff	3	SS	100	19				
319	2		-WTPL, hard	4	SS	100	32				
			SAND: Brown sand, wet, dense								
318	3		CLAYEY SILT: Brown clayey silt, WTPL, hard	5	SS	100	41				
317	4										
			SILTY SAND: Brown silty sand, wet, dense	6	SS	100	34				
316	5										
315	6		SAND: Brown sand, some gravel, saturated, compact	7	SS	100	20				
314	7										
			-Light brown, very dense	8	SS	100	70				Water level at 4.6 mbgs upon completion
313	8		Borehole terminated at 8.2 mbgs in SAND								

Logged By: TA **Input By:** KL

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Log of Borehole: BH106-22

Client:	BT Engineering, London	**Project Name:**	Geotechnical Investigation	**Project No.:**	11969-001
Contractor:	Drilltech	**Method:**	Solid Stem Auger	**Date Completed:**	January 21, 2022
Location:	Biehn Drive Extension	**UTM:**	17T 543750 E, 4803369 N	**Elevation:**	324.77 mASL

Elevation (m)	Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
	-1									Cap; Monument	
325	0		TOPSOIL: Dark brown silt topsoil, some organics, moist, compact	1	SS	100	13				
324	1		SAND: Brown sand, some silt, trace gravel, trace clay, moist, compact	2	SS	100	20				
323	2			3	SS	100	19			PVC Riser; Bentonite Plug	
322	3		-Dense	4	SS	100	27				GSA SS4: 3% Gravel 76% Sand 18% Silt 3% Clay
321	4			5	SS	100	39				
320	5		-No gravel, wet, compact	6	SS	100	19				
319	6			7	SS	100	29			Sand Pack; PVC Screen	
318	7										
317	8		-Trace gravel	8	SS	100	23			Cap; Well is dry on Feb 04, 2022	Borehole open and dry upon completion
316			Borehole terminated at 8.2 mbgs in SAND								

Logged By: TA **Input By:** KL

Client: BT Engineering
Contractor: DrillTech Drilling
Project No.: 11969-002
Location: Biehn Drive, Kitchener

Project Name: Biehn Drive Trunk Sewer, Kitchener
Method: Track Mounted Solid Stem Auger
Elevation: 312.8 mASL
UTM: 17T **N:** 4803760 **E:** 543814

Log of Borehole: BH201-23
Page: 1 of 2
Date Completed September 29, 2023

Elevation (m) / Depth	Lithology	Description	Elevation / Depth	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) LL PL PI 25 50 75 / % Moisture 25 50 75	Shear Strength Cu, kPa nat V. rem V. 20 40 60 80 / SPT (N) 20 40 60 80	Well Installation	Log Notes
312.8 — 0		**FILL:** (SP) SAND, some gravel; brown (FILL); non-cohesive, moist, loose		1	SS	50	8	4.9%	8		
312.3 — 0.5											
311.8 — 1				2	SS	0	13		13		Borehole caved to ~0.9 mbgs upon completion of drilling
			311.35								
311.3 — 1.5		**(SM) SILTY SAND:** (SM) SILTY SAND; brown; non-cohesive, wet, compact	1.45	3	SS	100	16	14.2%	16		Borehole caved multiple times at ~1.5 mbgs during drilling.
310.8 — 2											
310.3 — 2.5				4	SS	75	13	16.9%	13		Groundwater level first encountered at ~2.3 mbgs during drilling
			309.83								
309.8 — 3		**(ML) sandy SILT:** (ML) Sandy SILT, trace clay; brown; non-cohesive, wet, compact	2.97	5	SS	75	10	20.5%	10		
			309.29								
309.3 — 3.5		**(ML) SILT:** (CL/ML) CLAY and SILT, trace sand, trace gravel; grey; cohesive, W~PL, stiff to firm	3.51								
308.8 — 4											
308.3 — 4.5		Cobbles removed during augering		6	SS	10	7	26.0%	7		
307.8 — 5											
307.3 — 5.5			307.16								
		(SM) SILTY SAND: (SM) SILTY SAND, some clay; grey; non-cohesive, saturated to wet, loose to compact	5.64								
306.8 — 6											
306.3 — 6.5				7	SS	50	9	15.5%	9		
		Cobbles removed during augering									
305.8 — 7											
305.3			305.3								
			7.5								

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY
SS 6	1	6	46	47

1m = 24 units

Logged By: EC **Input By:** EC

CAMBIUM

Client: BT Engineering
Contractor: DrillTech Drilling
Project No.: 11969-002
Location: Biehn Drive, Kitchener

Project Name: Biehn Drive Trunk Sewer, Kitchener
Method: Track Mounted Solid Stem Auger
Elevation: 312.8 mASL
UTM: 17T **N:** 4803760 **E:** 543814

Log of Borehole: BH201-23
Page: 2 of 2
Date Completed September 29, 2023

SUBSURFACE PROFILE			SAMPLE							
Elevation (m) / Depth	Lithology	Description (Elevation / Depth)	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) LL PL PI; 25 50 75; % Moisture 25 50 75	Shear Strength Cu, kPa (nat V., rem V.); 20 40 60 80; SPT (N) 20 40 60 80	Well Installation	Log Notes
305.3 / 7.5		**(SM) SILTY SAND:** (SM) SILTY SAND, some clay; grey; non-cohesive, saturated to wet, loose to compact	8	SS	0	12	16.9%	12		
304.8 / 8		304.57								
304.3 / 8.5		Borehole terminated @ 8.2 mbgs due to target depth achieved. 8.23								
303.8 / 9										
303.3 / 9.5										
302.8 / 10										
302.3 / 10.5										
301.8 / 11										
301.3 / 11.5										
300.8 / 12										
300.3 / 12.5										
299.8 / 13										
299.3 / 13.5										
298.8 / 14										
298.3 / 14.5										
297.8										

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY
SS 6	1	6	46	47

1m = 24 units

Logged By: EC **Input By:** EC

CAMBIUM

Client: BT Engineering
Contractor: DrillTech Drilling
Project No.: 11969-002
Location: Biehn Drive, Kitchener

Project Name: Biehn Drive Trunk Sewer, Kitchener
Method: Tricone
Elevation: 312.6 mASL
UTM: 17T **N:** 4803766 **E:** 543859

Log of Borehole: BH202-23
Page: 1 of 2
Date Completed: August 1, 2023

Elevation (m)	Depth	Description	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) / % Moisture	Shear Strength Cu, kPa / SPT (N)	Well Installation	Log Notes
312.6	0	**ASPHALT:** ~70 mm thick (312.52 / 0.08)							Cap	
		FILL: (SP/GP) SAND and GRAVEL; brown (Granular Fill); non-cohesive, moist, compact to very loose	1	SS	45	25	4.9%	25		
312.1	0.5									
311.6	1		2	SS	90	42	5.4%	42	Bentonite Plug	Groundwater level measured in monitoring well at a depth of ~0.95 mbgs on October 13, 2023
311.1	1.5									
			3	SS	45	20	6.8%	20		
310.6	2									
310.1	2.5	(310.16) **(SM) SILTY SAND:** (SM) SILTY SAND; light brown; non-cohesive, wet, very loose (2.44 / 309.7)	4	SS	90	3	34.5%	3	Riser	Groundwater level first encountered at a depth of ~2.3 mbgs during drilling
309.6	3	**(SW) SAND:** (SP) SAND, trace to some silt, trace clay, none to trace gravel/cobble; brown to light brown; non-cohesive, wet, loose to compact (2.9)	5	SS	35	10	18.9%	10		
309.1	3.5									
308.6	4									
308.1	4.5		6	SS	65	22	15.4%	22	Sand Pack	
307.6	5									
307.1	5.5									
306.6	6								PVC Screen	
306.1	6.5		7	SS	100	11	16.8%	11		
305.6	7	(305.51) **(ML) SILT:** (ML) SILT, some sand; brown; non-cohesive, wet, compact (7.09 / 305.1)								
305.1		(7.5)								

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY
SS 5	0	80	17	3

1m = 24 units

Logged By: SN **Input By:** EC

Client: BT Engineering
Contractor: DrillTech Drilling
Project No.: 11969-002
Location: Biehn Drive, Kitchener

Project Name: Biehn Drive Trunk Sewer, Kitchener
Method: Tricone
Elevation: 312.6 mASL
UTM: 17T **N:** 4803766 **E:** 543859

Log of Borehole: BH202-23
Page: 2 of 2
Date Completed: August 1, 2023

Elevation (m)	Depth	Lithology	Description	Elevation / Depth	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) LL PL PI / % Moisture (25 50 75)	Shear Strength Cu, kPa nat V. rem V. (20 40 60 80) / SPT (N) (20 40 60 80)	Well Installation	Log Notes
305.1	7.5		**(ML) SILT:** (ML) SILT, some sand; brown; non-cohesive, wet, compact	304.52	8	SS	100	13	23.8%	13	Sand Pack, PVC Screen	
304.6	8		Borehole terminated @ 8.1 mbgs due to target depth achieved.	8.08								
304.1	8.5											
303.6	9											
303.1	9.5											
302.6	10											
302.1	10.5											
301.6	11											
301.1	11.5											
300.6	12											
300.1	12.5											
299.6	13											
299.1	13.5											
298.6	14											
298.1	14.5											
297.6												

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY
SS 5	0	80	17	3

1m = 24 units

Logged By: SN **Input By:** EC

CAMBIUM

Client: BT Engineering
Contractor: DrillTech Drilling
Project No.: 11969-002
Location: Biehn Drive, Kitchener

Project Name: Biehn Drive Trunk Sewer, Kitchener
Method: Track Mounted Solid Stem Auger
Elevation: 313 mASL
UTM: 17T **N:** 4803744 **E:** 543791

Log of Borehole: BH203-23
Page: 1 of 2
Date Completed September 29, 2023

Elevation (m)	Depth	Lithology	Description	Elevation / Depth	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) LL PL PI 25 50 75 / % Moisture 25 50 75	Shear Strength Cu, kPa nat V. rem V. 20 40 60 80 / SPT (N) 20 40 60 80	Well Installation	Log Notes
313	0		**(PT) PEAT:** PEAT, none to trace sand; black; non-cohesive, moist, very loose		1	SS	5	2	31.8%	2	Cap	Groundwater level measured in monitoring well at a depth of ~0.26 mbgs on October 13, 2023
312.5	0.5											
312	1				2	SS	40	2	33%	2		Groundwater level measured at a depth of ~0.6 mbgs upon completion of drilling
				311.55								
311.5	1.5		**(SW) SAND:** (SP) SAND, trace silt; brown; non-cohesive, wet, loose to compact	1.45	3	SS	60	9	16.9%	9	Bentonite Plug	
311	2										Riser	
310.5	2.5				4	SS	60	19	14.6%	19		Borehole caved to a depth of ~2.1 mbgs upon completion of drilling
				310.03								
310	3		**(SM) SILTY SAND:** (SM) SILTY SAND; brown; non-cohesive, wet, compact	2.97	5	SS	50	13	15.2%	13		Groundwater first encountered at a depth of ~3.0 mbgs during drilling
309.5	3.5											
309	4											
308.5	4.5				6	SS	60	13	16.9%	13	Sand Pack	
308	5											
307.5	5.5										PVC Screen	
307	6											
306.5	6.5				7	SS	50	11	17.7%	11		
306	7											
305.5				305.5							Cap	
	7.5											

GRAINSIZE DISTRIBUTION: SAMPLE | GRAVEL | SAND | SILT | CLAY

1m = 24 units

Logged By: EC **Input By:** EC

Peterborough, Barrie, Oshawa, Kingston, Ottawa

CAMBIUM

Client: BT Engineering
Contractor: DrillTech Drilling
Project No.: 11969-002
Location: Biehn Drive, Kitchener

Project Name: Biehn Drive Trunk Sewer, Kitchener
Method: Track Mounted Solid Stem Auger
Elevation: 313 mASL
UTM: 17T **N:** 4803744 **E:** 543791

Log of Borehole: BH203-23
Page: 2 of 2
Date Completed September 29, 2023

SUBSURFACE PROFILE			SAMPLE							
Elevation (m) / Depth	Lithology	Description (Elevation / Depth)	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) LL PL PI — 25 50 75 / % Moisture 25 50 75	Shear Strength Cu, kPa (nat V., rem V.) 20 40 60 80 / SPT (N) 20 40 60 80	Well Installation	Log Notes
305.5 / 7.5										
305 / 8		**(SM) SILTY SAND:** (SM) SILTY SAND; brown; non-cohesive, wet, compact — 304.77	8	SS	60	12	15.6%	12		
		Borehole terminated @ 8.23 mbgs due to target depth achieved. — 8.23								
304.5 / 8.5										
304 / 9										
303.5 / 9.5										
303 / 10										
302.5 / 10.5										
302 / 11										
301.5 / 11.5										
301 / 12										
300.5 / 12.5										
300 / 13										
299.5 / 13.5										
299 / 14										
298.5 / 14.5										
298										

GRAINSIZE DISTRIBUTION: SAMPLE | GRAVEL | SAND | SILT | CLAY

1m = 24 units

Logged By: EC **Input By:** EC

CAMBIUM

Client: BT Engineering
Contractor: DrillTech Drilling
Project No.: 11969-002
Location: Biehn Drive, Kitchener

Project Name: Biehn Drive Trunk Sewer, Kitchener
Method: Track Mounted Solid Stem Auger
Elevation: 312.6 mASL
UTM: 17T **N:** 4803730 **E:** 543781

Log of Borehole: BH204-23
Page: 1 of 2
Date Completed September 28, 2023

Elevation (m)	Depth	Description	Elevation / Depth	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) LL PL PI — 25 50 75 / % Moisture 25 50 75	Shear Strength Cu, kPa (nat V. rem V.) 20 40 60 80 / SPT (N) 20 40 60 80	Well Installation	Log Notes
312.6	0	**(PT) PEAT:** PEAT; black; non-cohesive, moist, very loose	311.91 / 0.69	1	SS	5	3	21%	3		Groundwater level measured at a depth of ~0.6 mbgs upon completion of drilling
312.1	0.5	**(ML) SILT:** (ML) SILT and ASH; white to light grey, trace organic matter; cohesive, W~PL, very soft	311.58 / 1.02	2	SS	60	2	50.4%	2		
311.6	1	**(SW) SAND:** (SP) SAND, trace silt; grey; non-cohesive, wet, very loose	311.15 / 1.45	3	SS	65	10	17.6%	10		
311.1	1.5	**(SM) SILTY SAND:** (SM) SILTY SAND; brown, trace organics, oxidation stains; non-cohesive, moist, stiff	310.39 / 2.21	4	SS	75	9	17.6%	9		
310.6	2	**(CL) sandy SILTY CLAY:** (CL) Sandy SILTY CLAY; grey; cohesive, W<PL, stiff	309.86 / 2.74	5	SS	75	7	19.8%	7		Groundwater first encountered at a depth of ~3.0 mbgs during drilling
310.1	2.5	**(ML) sandy SILT:** (ML) Sandy SILT, some clay; brown; non-cohesive, wet, loose		6	SS	60	13	20.3%	13		Borehole caved to a depth of ~4.6 mbgs upon completion of drilling
309.6	3			7	SS	50	8	14.5%	8		
309.1	3.5										
308.6	4										
308.1	4.5										
307.6	5										
307.1	5.5										
306.6	6										
306.1	6.5										
305.6	7		305.44								
305.1		**(SW) SAND:** (SP) SAND, trace silt; brown; non-cohesive, moist, compact	305.1 / 7.16 / 7.5								

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY
SS 6	0	24	62	14

1m = 24 units

Logged By: EC **Input By:** EC

Peterborough, Barrie, Oshawa, Kingston, Ottawa

Client: BT Engineering
Contractor: DrillTech Drilling
Project No.: 11969-002
Location: Biehn Drive, Kitchener

Project Name: Biehn Drive Trunk Sewer, Kitchener
Method: Track Mounted Solid Stem Auger
Elevation: 312.6 mASL
UTM: 17T **N:** 4803730 **E:** 543781

Log of Borehole: BH204-23
Page: 2 of 2
Date Completed September 28, 2023

Elevation (m)	Depth	Lithology	Description	Elevation / Depth	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) LL PL PI 25 50 75 / % Moisture 25 50 75	Shear Strength Cu, kPa nat V. rem V. 20 40 60 80 / SPT (N) 20 40 60 80	Well Installation	Log Notes
305.1	7.5		**(SW) SAND:** (SP) SAND, trace silt; brown; non-cohesive, moist, compact	304.37	8	SS	25	19	15.3%	19		
304.6	8											
304.1	8.5		Borehole terminated @ 8.2 mbgs due to target depth achieved.	8.23								
303.6	9											
303.1	9.5											
302.6	10											
302.1	10.5											
301.6	11											
301.1	11.5											
300.6	12											
300.1	12.5											
299.6	13											
299.1	13.5											
298.6	14											
298.1	14.5											
297.6												

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY
SS 6	0	24	62	14

1m = 24 units

Logged By: EC **Input By:** EC

CAMBIUM

Client: BT Engineering
Contractor: DrillTech Drilling
Project No.: 11969-002
Location: Biehn Drive, Kitchener

Project Name: Biehn Drive Trunk Sewer, Kitchener
Method: Track Mounted Solid Stem Auger
Elevation: 312.7 mASL
UTM: 17T **N:** 4803712 **E:** 543759

Log of Borehole: BH205-23
Page: 1 of 2
Date Completed September 28, 2023

Elevation (m)	Depth	Lithology	Description	Elevation / Depth	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) LL PL PI — 25 50 75 / % Moisture 25 50 75	Shear Strength Cu, kPa (nat V. rem V.) 20 40 60 80 / SPT (N) 20 40 60 80	Well Installation	Log Notes
312.7	0		**(PT) PEAT:** PEAT; black; non-cohesive, moist, loose	312.4 / 0.3	1	SS	10	3	77.8%	3		
312.2	0.5		**(CL) sandy SILTY CLAY:** (CL) Sandy SILTY CLAY; grey to dark grey, some organic matter; cohesive, W<PL, very soft	312.01 / 0.69								
311.7	1		**(SM) SILTY SAND:** (SM) SILTY SAND, trace clay, trace gravel; brown; non-cohesive, wet compact to loose		2	SS	70	13	14.5%	13		Groundwater level at ~0.9 mbgs upon completion of drilling
311.2	1.5			310.92 / 1.78	3	SS	50	9	13.4%	9		
310.7	2		**(ML) SILT:** (ML/SP) SILT and SAND, some clay; brown to light brown; non-cohesive, moist, stiff									Borehole caved to ~2.1 mbgs upon completion of drilling
310.2	2.5				4	SS	60	8	16.9%	8		
309.7	3			309.73 / 2.97								Groundwater first encountered at a depth of ~3.0 mbgs during drilling
309.2	3.5		**(SM) SILTY SAND:** (SM) SILTY SAND, trace to some clay; light brown to brown; non-cohesive, wet, compact		5	SS	85	11	17.9%	11		
308.7	4											
308.2	4.5				6	SS	50	19	19.5%	19		
307.7	5											
307.2	5.5											
306.7	6				7	SS	50	11	21%	11		
306.2	6.5											
305.7	7			305.54 / 7.16								
305.2			**(SW) SAND:** (SP) SAND, trace silt; brown; non-cohesive, wet to moist, loose to dense	305.2 / 7.5								

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY
SS 4	0	38	44	18

1m = 24 units

Logged By: EC **Input By:** EC

Client: BT Engineering
Contractor: DrillTech Drilling
Project No.: 11969-002
Location: Biehn Drive, Kitchener

Project Name: Biehn Drive Trunk Sewer, Kitchener
Method: Track Mounted Solid Stem Auger
Elevation: 312.7 mASL
UTM: 17T **N:** 4803712 **E:** 543759

Log of Borehole: BH205-23
Page: 2 of 2
Date Completed September 28, 2023

SUBSURFACE PROFILE				SAMPLE							
Elevation (m) / Depth	Lithology	Description (Elevation / Depth)	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) LL PL PI; % Moisture 25 50 75	Shear Strength Cu, kPa (nat V., rem V.); SPT (N) 20 40 60 80	Well Installation	Log Notes
305.2 / 7.5		**(SW) SAND:** (SP) SAND, trace silt; brown; non-cohesive, wet to moist, loose to dense								
304.7 / 8			8	SS	50	9	14.6%	9		
304.2 / 8.5										
303.7 / 9										
303.2 / 9.5			9	SS	0	34	14.8%	34		Second spoon completed in this sample depth due to low recovery
302.95 / 9.75		Borehole terminated @ 9.8 mbgs due to target depth achieved.								
302.7 / 10										
302.2 / 10.5										
301.7 / 11										
301.2 / 11.5										
300.7 / 12										
300.2 / 12.5										
299.7 / 13										
299.2 / 13.5										
298.7 / 14										
298.2 / 14.5										
297.7										

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY
SS 4	0	38	44	18

1m = 24 units

Logged By: EC **Input By:** EC

CAMBIUM

Client: BT Engineering
Contractor: DrillTech Drilling
Project No.: 11969-002
Location: Biehn Drive, Kitchener

Project Name: Biehn Drive Trunk Sewer, Kitchener
Method: Track Mounted Solid Stem Auger
Elevation: 312.6 mASL
UTM: 17T **N:** 4803696 **E:** 543750

Log of Borehole: BH206-23
Page: 1 of 1
Date Completed September 30, 2023

Elevation (m)	Depth	Description	Elevation / Depth	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) LL PL PI / % Moisture (25 50 75)	Shear Strength Cu, kPa (nat V. rem V.) / SPT (N) (20 40 60 80)	Well Installation	Log Notes
312.6	0	**(PT) PEAT:** PEAT; black; non-cohesive, moist, very loose	311.99 / 0.61	1	SS	5	2	65%	2	Cap	Groundwater level measured in monitoring well at a depth of ~0.19 mbgs on October 13, 2023
312.1	0.5										
311.6	1	**(ML) SILT:** (ML) SILT, some clay, some sand; dark grey to grey, trace to no organics; cohesive, W~PL to W>PL, very soft to firm		2	SS	10	2	18.9%	2	Bentonite Plug	Groundwater level at a depth of ~0.6 mbgs upon completion of drilling
311.1	1.5									Riser	
310.6	2			3	SS	20	1	27.7%	1		
310.1	2.5		309.91 / 2.69	4	SS	50	5	15.8%	5		Groundwater level at a depth of ~2.3 mbgs during drilling
309.6	3	**(SM) SILTY SAND:** (SM) SILTY SAND, some clay; brown; non-cohesive, wet, loose	309.63 / 2.97								
309.1	3.5	**(SW) SAND:** (SP) SAND, some clay; brown; non-cohesive, very saturated, loose		5	SS	20	6	12%	6		Borehole caved to a depth of ~3.0 mbgs upon completion of drilling
308.6	4									Sand Pack	
308.1	4.5									PVC Screen	
307.6	5			6	SS	0	9	18.1%	9		
307.1	5.5		306.96 / 5.64								
306.6	6	**(SW) SAND:** (SP/ML) SAND and SILT, trace clay, trace gravel; brown; non-cohesive, wet, compact									
306.1	6.5		305.89	7	SS	50	15	19%	15		
305.6	7	Borehole terminated @ 6.7 mbgs due to target depth achieved.	6.71							Cap	
305.1											

1m = 24 units

GRAINSIZE DISTRIBUTION

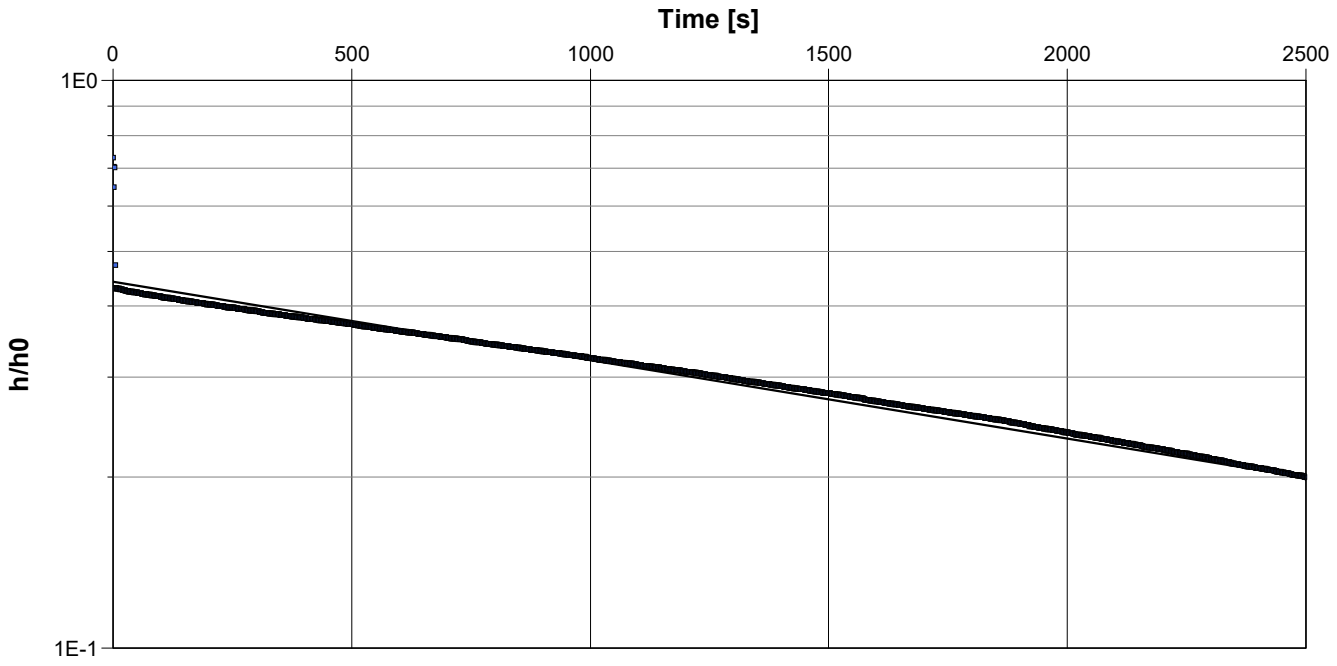
SAMPLE	GRAVEL	SAND	SILT	CLAY
SS 7	5	45	41	9
SS3	0	11	75	14

Logged By: EC **Input By:** EC

Appendix E
SWHT Results

Cambium Inc. 135 Bayfield St #102, Barrie, ON L4M 3B3	**Slug Test Analysis Report**
	Project: Dewatering Assessment- Biehn Dr. Ext.
	Number: 11969-001
	Client: BT Engineering

Location: Biehn Drive, City of Kitchener	Slug Test: MW101-22	Test Well: MW101-22
Test Conducted by: Chris Malliaros		Test Date: 2/4/2022
Analysis Performed by:	Hvorslev	Analysis Date: 2/9/2022
Aquifer Thickness: 7.04 m		

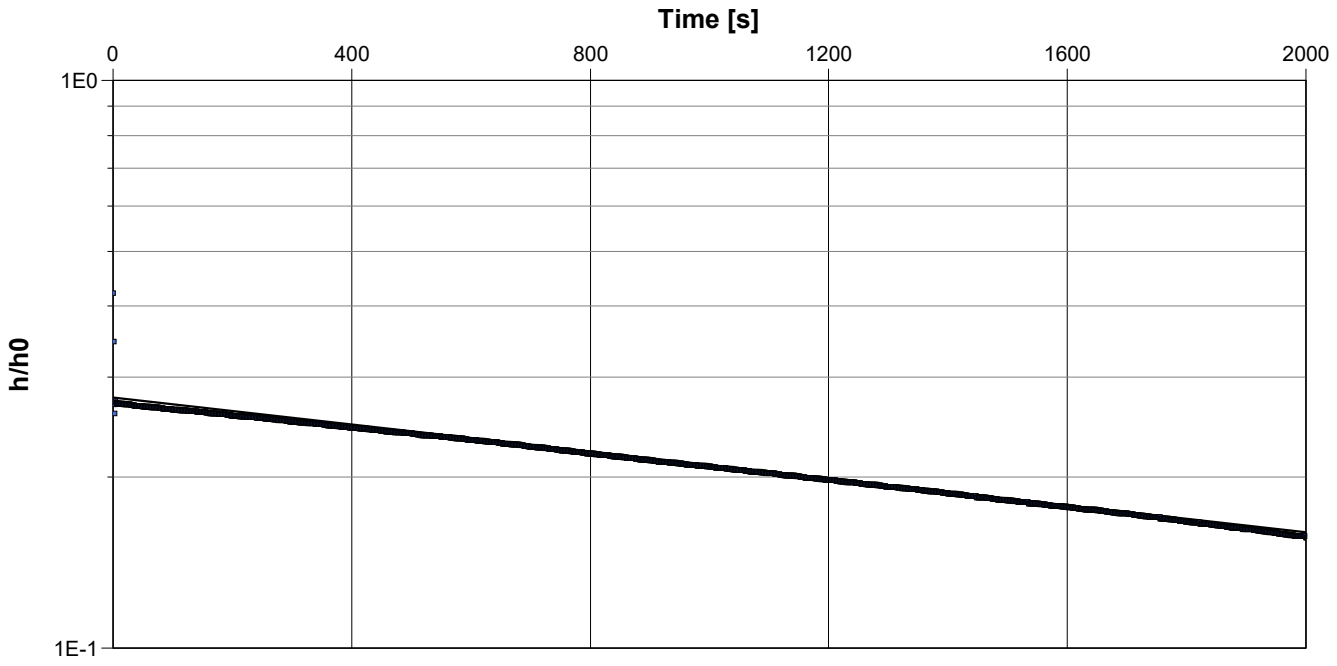


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW101-22	3.59×10^{-6}	

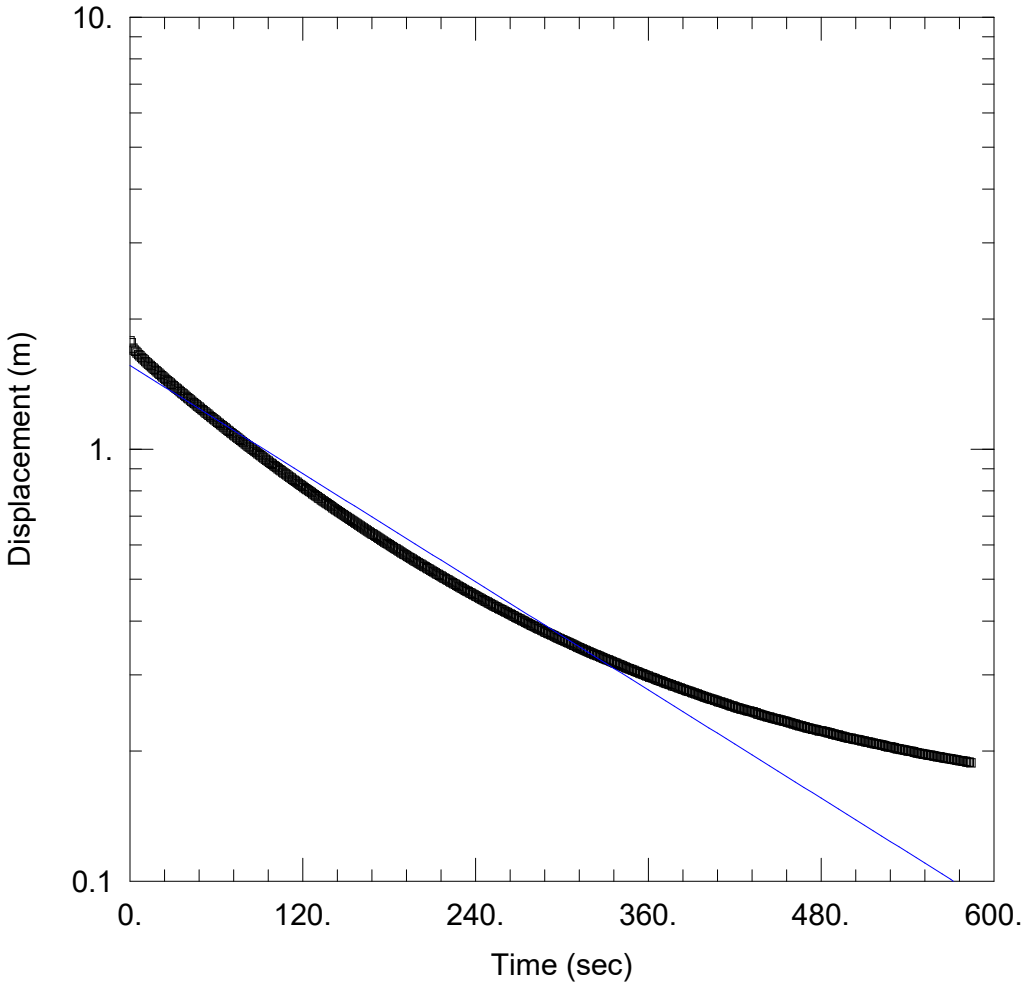
Cambium Inc. 135 Bayfield St #102, Barrie, ON L4M 3B3	**Slug Test Analysis Report**
	Project: Dewatering Assessment- Biehn Dr. Ext.
	Number: 11969-001
	Client: BT Engineering

Location: Biehn Drive, City of Kitchener	Slug Test: MW104-22	Test Well: MW104-22
Test Conducted by: Chris Malliaros		Test Date: 2/4/2022
Analysis Performed by: Sudhakar Kurli	Hvorslev	Analysis Date: 2/9/2022
Aquifer Thickness: 2.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW104-22	3.08×10^{-6}	



RISING HEAD TEST

Data Set:
Date: 10/23/23 Time: 13:11:09

PROJECT INFORMATION

Company: BT Engineering
Client: City of Kirchener
Project: 11969-002
Location: Biehn Dr, South Extension
Test Well: BH202-23
Test Date: 2023-10-11

AQUIFER DATA

Saturated Thickness: 7.06 m Anisotropy Ratio (Kz/Kr): 1.

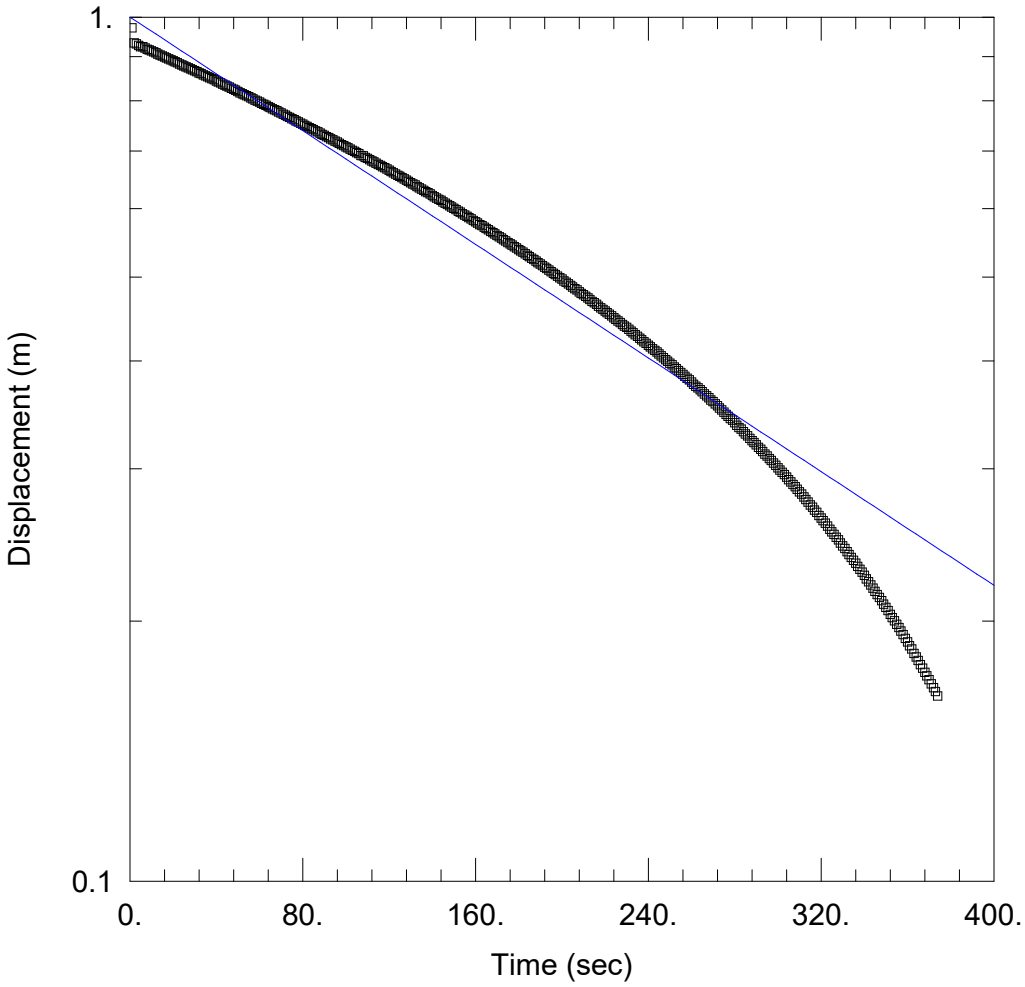
WELL DATA (BH202-23)

Initial Displacement: 1.78 m
Total Well Penetration Depth: 7.06 m
Casing Radius: 0.05 m
Static Water Column Height: 7.06 m
Screen Length: 3. m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 1.097E-5 m/sec y0 = 1.562 m



WELL TEST ANALYSIS

Data Set:
Date: 10/23/23 Time: 13:19:43

PROJECT INFORMATION

Company: BT Engineering
Client: City of Kirchener
Project: 11969-002
Location: Biehn Dr, South Extension
Test Well: BH203-23
Test Date: 2023-10-11

AQUIFER DATA

Saturated Thickness: 6.23 m Anisotropy Ratio (Kz/Kr): 1.

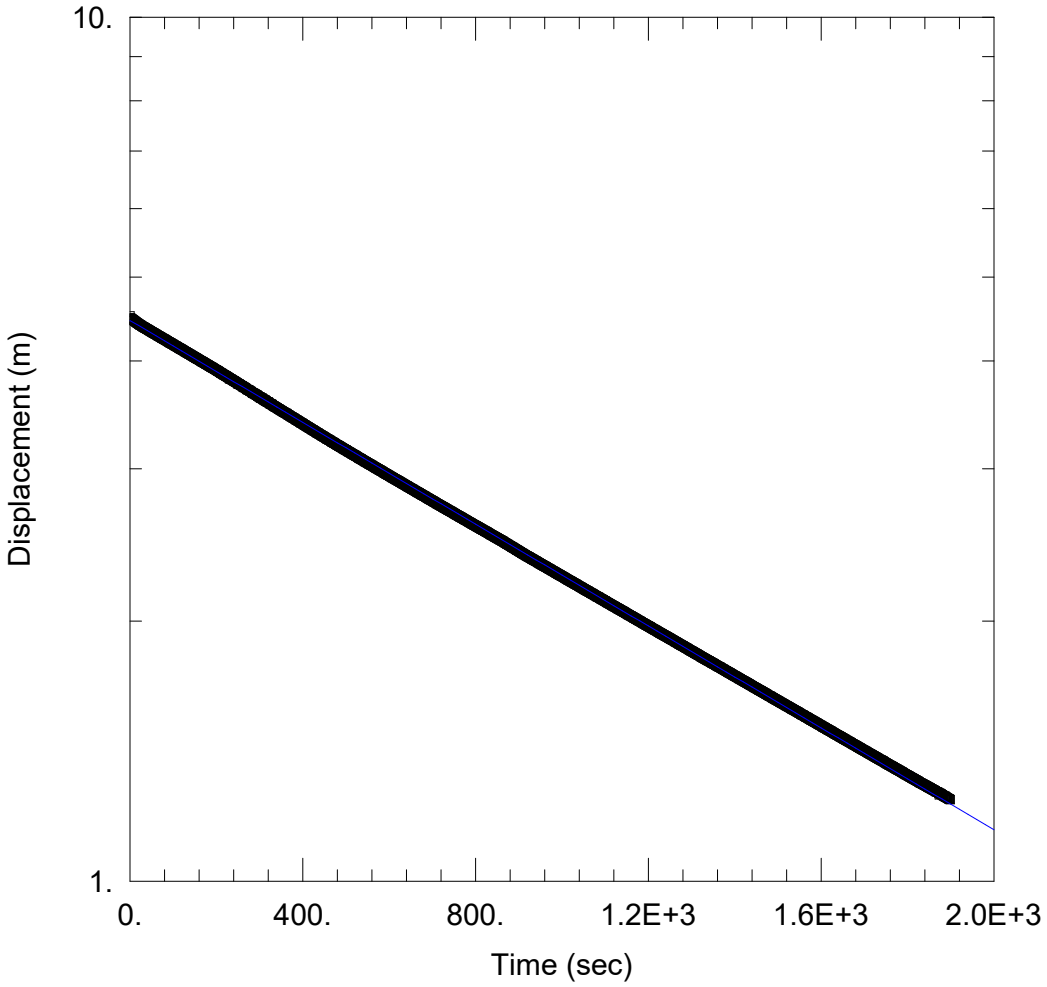
WELL DATA (BH203-23)

Initial Displacement: 1.36 m
Total Well Penetration Depth: 7.4 m
Casing Radius: 0.05 m
Static Water Column Height: 6.23 m
Screen Length: 3. m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 8.647E-6 m/sec y0 = 1. m



RISING HEAD TEST

Data Set:
Date: 10/23/23 Time: 13:43:13

PROJECT INFORMATION

Company: BT Engineering
Client: City of Kirchener
Project: 11969-002
Location: Biehn Dr, South Extension
Test Well: BH206-23
Test Date: 2023-10-11

AQUIFER DATA

Saturated Thickness: 5.59 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH206-23)

Initial Displacement: 4.51 m
Total Well Penetration Depth: 5.59 m
Casing Radius: 0.05 m
Static Water Column Height: 5.59 m
Screen Length: 3. m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 1.55E-6 m/sec y0 = 4.455 m

Appendix F
Dewatering Estimates

DEWATERING CALCULATIONS - 50 m TRENCH SEGMENT

Modified Dupuit-Forchheimer Equation: unconfined flow into a linear excavation.
Calculations assume no flow boundary at aquifer base

Excavation Area		Initial depth to groundwater	Target Depth to groundwater	Depth to Base of Aquifer	Unit length of trench (a)	Width of Trench (b)	Hydraulic Conductivity (K)	s	R_o	$L = R_o/2$	$r_s = b/2$	$\ln(R_o/r_s)$ [If $r_s<R_o$] or $\ln((R_o+r_s)/r_s)$ [If $r_s>=R_o$]	H	h = H-s	Q_{ends}	Q_{trench}	Q_{total}		
		mbgs	mbgs	mbgs	m	m	m/s	m	m	m	m	-	m	m	m^3/s	m^3/s	m^3/s	L/s	L/d
Elongated Trench @ 50 m Increments	Min	4.04	11.5	12.0	50	2	1.15E-06	7.45	23.97	11.98	1.00	3.18	7.96	0.51	0.000072	0.000303	**0.000375**	**0.37**	**32,360**
	Max	4.04	11.5	12.0	50	2	1.10E-05	7.45	74.13	37.06	1.00	4.31	7.96	0.51	0.000506	0.000936	**0.001443**	**1.44**	**124,661**
	Avg	4.04	11.5	12.0	50	2	4.39E-06	7.45	46.83	23.41	1.00	3.85	7.96	0.51	0.000226	0.000592	**0.000818**	**0.82**	**70,658**

s = target drawdown (initial - target depth to groundwater) (m)
R_o = radius of influence of construction dewatering/pumping (m)
L = distance to line source (m)
r_s = equivalent single well radius (m)
H = Initial hydraulic head in aquifer (m)
h = hydraulic head at radius of well (m)
Q = construction dewatering rate (m^3/s)

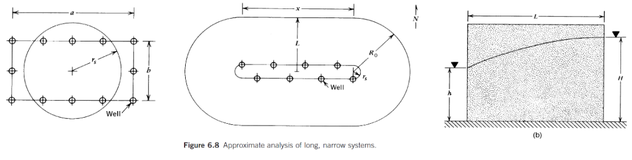


Figure 6.8 Approximate analysis of long, narrow systems.

$$Q = \frac{\pi K(H^2 - h^2)}{\ln R_0/r_s} + 2\left[\frac{xK(H^2 - h^2)}{2L}\right] \quad (6.10b)$$

x = unit length of trench

$R_o = 3000*s*\sqrt{K}$

Source: Kyrieleis, W. and Sichardt, W. "Grundwasserabsenkung bei Fundierungsarbeiten" Springer, Berlin, 1930

Source: Powers, J. Patrick, et al. "Construction dewatering and groundwater control." (2007)

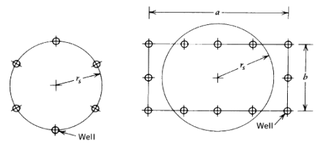
Dewatering Assessment, Biegn Drive Extension, City of Kitchener, Ontario
BT Engineering
Cambium Reference: 11929-002

DEWATERING CALCULATIONS - RECEIVING PIT

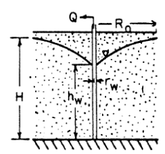
Modified Dupuit-Forchheimer Equation: unconfined flow into a rectangular excavation.
Calculations assume no flow boundary at aquifer base

Excavation Area		Initial depth to groundwater	Target Depth to groundwater	Depth to Base of Aquifer	Trench Length (a)	Trench Width (b)	Hydraulic Conductivity (K)	s	R_o	$r_s = \sqrt{(ab/\pi)}$	$\ln(R_o/r_s)$ [If $r_s<R_o$] or $\ln((R_o+r_s)/r_s)$ [If $r_s>=R_o$]	H	h_w = H-s	Q_{total}		
		mbgs	mbgs	mbgs	m	m	m/s	m	m	m	-	m	m	m^3/s	L/s	L/d
Rectangular trench with dimensions 6 m x 6 m	Minimum K	0	7.0	12.0	6	6	1.15E-06	7.00	22.52	3.39	1.90	12.00	5.00	**0.000227**	**0.23**	**19,602**
	Maximum K	0	7.0	12.0	6	6	1.10E-05	7.00	69.65	3.39	3.02	12.00	5.00	**0.001360**	**1.36**	**117,493**
	Geometric mean K	0	7.0	12.0	6	6	4.39E-06	7.00	44.00	3.39	2.56	12.00	5.00	**0.000640**	**0.64**	**55,287**

s = target drawdown (initial - target depth to groundwater) (m)
R_o = radius of influence of construction dewatering/pumping (m)
r_s = equivalent single well radius (m)
H = Initial hydraulic head in aquifer (m)
h = hydraulic head at radius of well (m)
Q = construction dewatering rate (m^3/s)



$$r_s = \sqrt{\frac{ab}{\pi}}$$



Radial flow, water table aquifer

$$Q_w = \frac{\pi K(H^2 - h_w^2)}{\ln R_o / r_w}$$

(from Table 6.1, pg 67)

*Use $r_w = r_s$ for rectangular excavations

R_o = 3000*s*sqrt(K)

Source: Kyrieleis, W. and Sichardt, W. "Grundwasserabsenkung bei Fundierungsarbeiten" Springer, Berlin, 1930

Source: Powers, J. Patrick, et al. "Construction dewatering and groundwater control." (2007)

Appendix G

Laboratory Certificate of Analysis

CADUCEON™ ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B22-03453

Report To:

Cambium Environmental
135 Bayfield Street, Unit 102
Barrie ON L4M 3B3
Attention: Sudhakar Kurli

Caduceon Environmental Laboratories
112 Commerce Park Drive
Barrie ON L4N 8W8
Tel: 705-252-5743
Fax: 705-252-5746

DATE RECEIVED: 04-Feb-22
DATE REPORTED: 14-Feb-22
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:

P.O. NUMBER: 11969-001
WATERWORKS NO.

Parameter	Qty	Site Analyzed	Analyst Initials	Date Analyzed	Lab Method	Reference Method
Alkalinity (as CaCO3)	1	Holly Lane	SYL	07-Feb-22	A-ALK-03 (o)	SM 2320B
Anions	1	Holly Lane	VK	08-Feb-22	A-IC-01 (o)	SM4110C
pH	1	Holly Lane	SYL	07-Feb-22	A-PH-01 (o)	SM 4500H
A - Wet Chem	1	Kingston	ach	07-Feb-22	A-TPTKN-001 (P)(k)	E3516.2
BOD	1	Kingston	bbr	07-Feb-22	C-BOD-001 (k)	SM 5210B
Metals - ICP-OES	1	Holly Lane	AHM	09-Feb-22	D-ICP-01 (o)	SM 3120
Metals - ICP-MS	1	Holly Lane	TPR	08-Feb-22	D-ICPMS-01 (o)	EPA 200.8

PWQO - Provincial Water Quality Objectives
Interim PWQO - Interim PWQO
PWQO - Provincial Water Quality Objectives

Christine Burke
Lab Manager

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

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DATE RECEIVED: 04-Feb-22
DATE REPORTED: 14-Feb-22
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 11969-001
WATERWORKS NO.

	Client I.D.		BH101-22				PWQO	
	Sample I.D.		B22-03453-1				Interim PWQO	PWQO
	Date Collected		04-Feb-22					
Parameter	**Units**	**R.L.**						
pH @25°C	pH Units		7.94					8.5
Alkalinity(CaCO3) to pH4.5	mg/L	5	241					
Hardness (as CaCO3)	mg/L	1	2990					
BOD(5 day)	mg/L	3	< 3					
Chloride	µg/L	500	11700					
Nitrite (N)	µg/L	50	320					
Nitrate (N)	µg/L	50	2610					
Nitrate + Nitrite (N)	µg/L	50	2900					
Phosphorus-Total	µg/L	10	**4890**				10	
Arsenic	µg/L	0.1	**26.6**				5	5
Cadmium	µg/L	0.015	**1.64**				0.1	0.2
Calcium	µg/L	20	976000					
Cobalt	µg/L	0.1	**66.5**				0.9	
Copper	µg/L	0.1	**207**				5	
Iron	µg/L	5	**130000**					300
Lead	µg/L	0.02	**153**				1	5
Magnesium	µg/L	20	135000					
Nickel	µg/L	0.2	**127**					25
Silver	µg/L	0.1	**0.4**					0.1
Sodium	µg/L	200	7200					
Thallium	µg/L	0.05	**0.80**				0.3	0.3
Uranium	µg/L	0.05	4.24				5	
Vanadium	µg/L	0.1	**120**				6	

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DATE RECEIVED: 04-Feb-22
DATE REPORTED: 14-Feb-22
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 11969-001
WATERWORKS NO.

	Client I.D.		BH101-22				PWQO	
	Sample I.D.		B22-03453-1				Interim PWQO	PWQO
	Date Collected		04-Feb-22					
Parameter	**Units**	**R.L.**						
Zinc	µg/L	5	**856**				20	30
Zirconium	µg/L	3	**19**				4	

PWQO - Provincial Water Quality Objectives
Interim PWQO - Interim PWQO
PWQO - Provincial Water Quality Objectives

Christine Burke
Lab Manager

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DATE RECEIVED: 04-Feb-22
DATE REPORTED: 14-Feb-22
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 11969-001
WATERWORKS NO.

Summary of Exceedances

Interim PWQO

BH101-22	Found Value	Limit
Zirconium (µg/L)	19	4
Zinc (µg/L)	856	20
Vanadium (µg/L)	120	6
Thallium (µg/L)	0.80	0.3
Phosphorus-Total (µg/L)	4890	10
Lead (µg/L)	153	1
Copper (µg/L)	207	5
Cobalt (µg/L)	66.5	0.9
Cadmium (µg/L)	1.64	0.1
Arsenic (µg/L)	26.6	5

Provincial Water Quality Objectives

BH101-22	Found Value	Limit
Zinc (µg/L)	856	30
Thallium (µg/L)	0.80	0.3
Lead (µg/L)	153	5
Nickel (µg/L)	127	25
Iron (µg/L)	130000	300
Cadmium (µg/L)	1.64	0.2
Arsenic (µg/L)	26.6	5
Silver (µg/L)	0.4	0.1

PWQO - Provincial Water Quality Objectives
Interim PWQO - Interim PWQO
PWQO - Provincial Water Quality Objectives

Christine Burke
Lab Manager

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Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Appendix K

Biehn Drive Trunk Sanitary Sewer Extension
Technical Memorandum

BT ENGINEERING

TECHNICAL MEMORANDUM

TO:	Steve Taylor, P.Eng.	**OUR REF.:**	SN0447
FROM:	Leonardo Sanchez, P.Eng.	**DATE:**	March 31, 2022
COPY:	Katherine Scott, P.Eng.		

RE: **City of Kitchener**
Biehn Drive Trunk Sanitary Sewer Extension

The purpose of this Technical Memorandum is to present the initial design of the proposed trunk sanitary sewer extension of the existing sanitary trunk sewer on Biehn Drive.

Existing Sanitary Sewer

The original drainage area for the entire system was defined in the City's GIS system and is shown on Figure 1. The Strasburg-Biehn drainage area is part of the Schneider sanitary system and includes 209.1 ha. The undeveloped portion of the drainage area that is denoted as tributary to the existing sanitary trunk sewer at the proposed extension covers 128.9 ha.

The existing Biehn Drive trunk sanitary sewer is a 525 mm diameter pipe at the current end of the system. The existing pipe has capacity for 186 litres per second (l/s) flowing half-full, which corresponds to the peak flow that would be produced by the undeveloped tributary area if it was developed as low density residential.

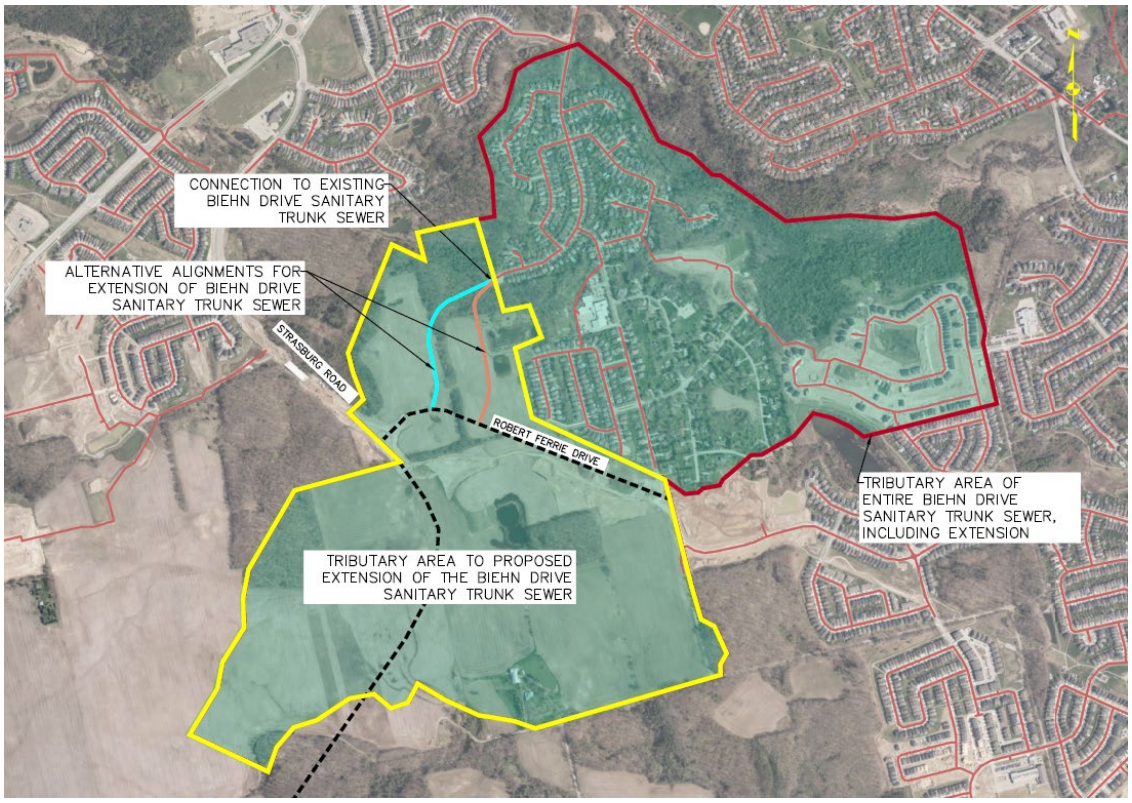

Figure 1 - Original Sanitary Sewer Tributary Area

The City's Official Plan designates the lands within the original drainage area as shown on Figure 2. The lands designated as Rural and Agricultural drain naturally to the adjacent watershed and will not be connected to the sanitary trunk sewer. Therefore, these lands can be considered to be non-tributary.

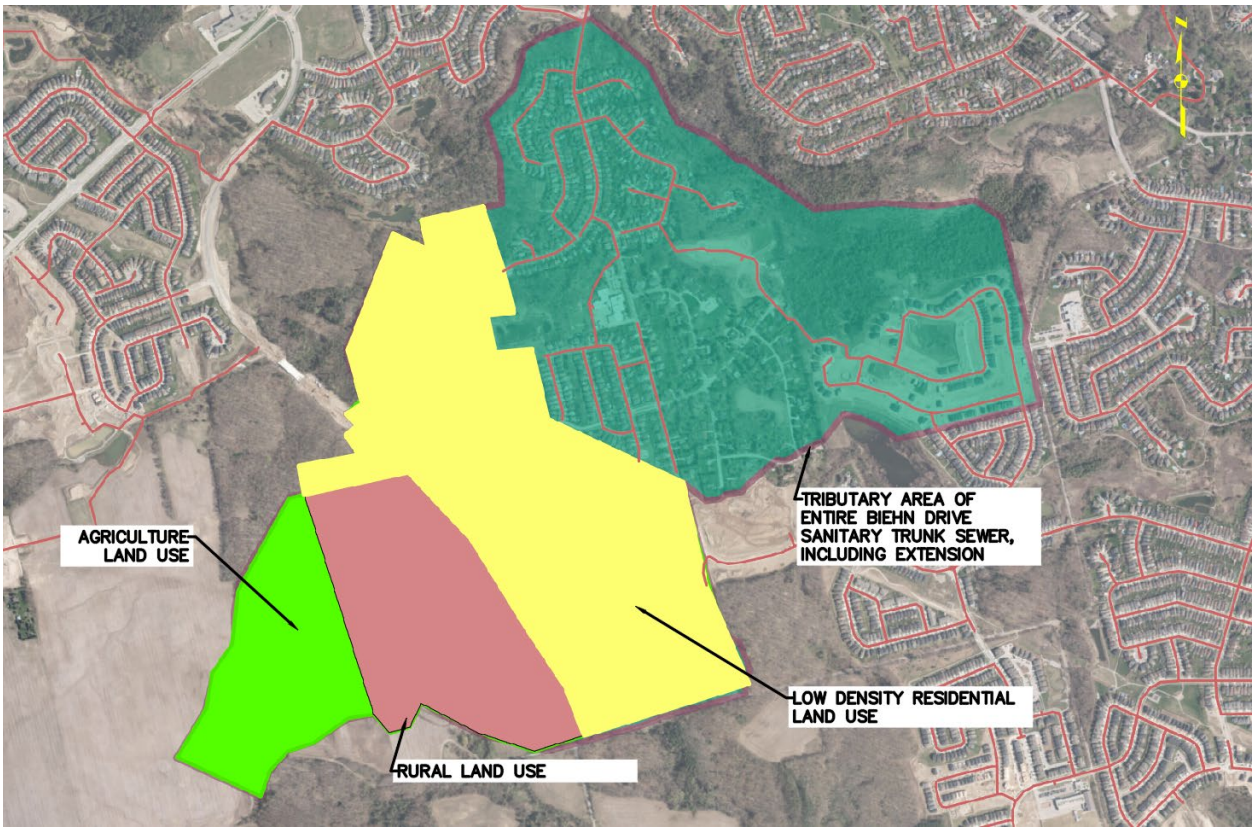

Figure 2 - Land Uses per Official Plan

Therefore, the revised sanitary drainage area was modified to include only the lands that are designated for urban development. The revised sanitary trunk sewer drainage area, shown on Figure 3, includes 72.0 ha.

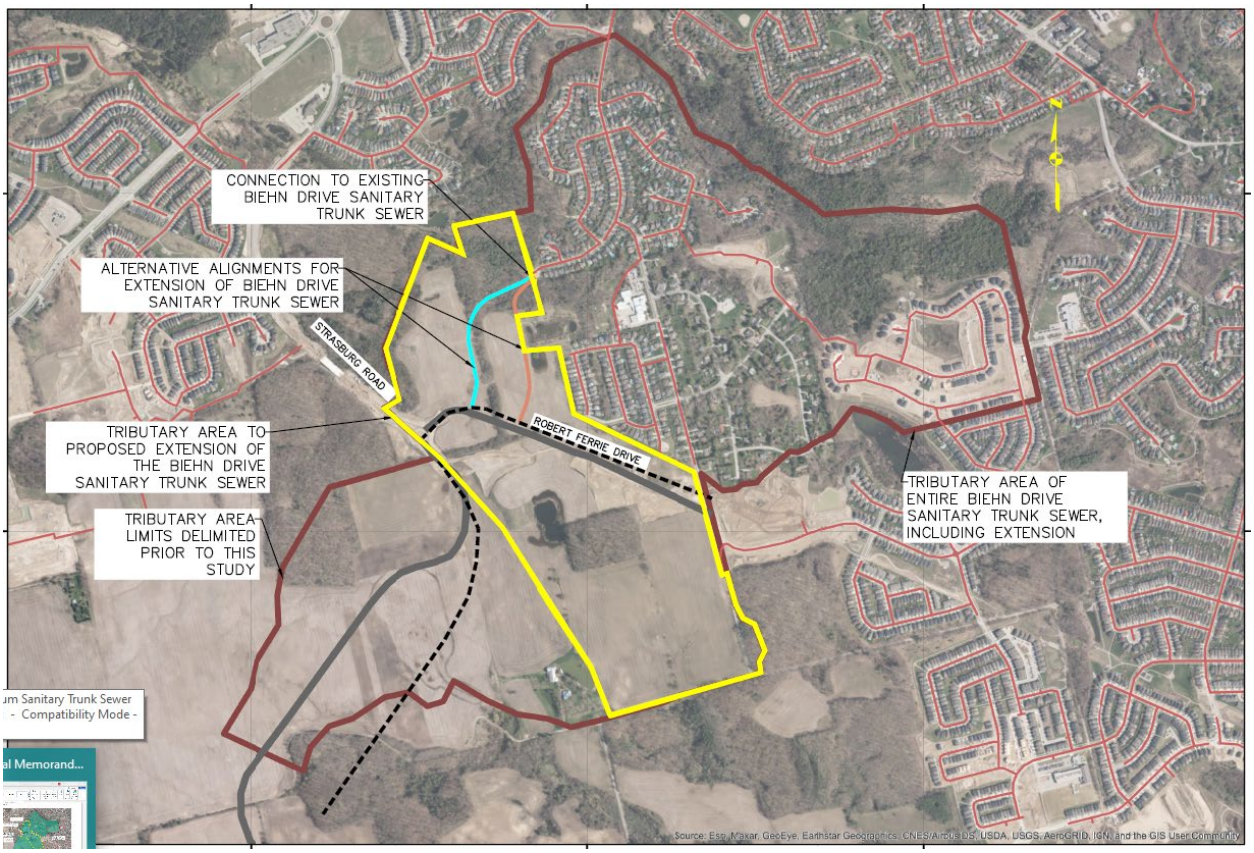

Figure 3 - Revised Sanitary Trunk Sewer Drainage Area

Population Estimate

The Official Plan designates the urban areas within the sanitary trunk sewer drainage area as Low Density Residential, which allows for a maximum of 30 dwellings per hectare. Based on the drainage area of 72.0 ha, the total number of dwellings is 1920. This is a conservative estimate, given that it does not subtract the area required for roadways, parks, and schools. However, given that the proposed development is not fully defined, it represents a reasonable estimate.

Statistics Canada 2016 Census data show that the average number of persons per dwelling in the Region is 2.6 persons. On this basis, the population of the revised drainage area is 5016 persons.

Estimated Sanitary Sewage Flow

The 2021 Development Manual of the City of Kitchener provides the design criteria for sanitary servicing. Based on the Kitchener Development Manual, the average flow per capita for new sanitary sewers is 305 litres per day (305 l/cap/day). The peak flow in the sanitary sewer must be calculated using a Peaking Factor Formula (the Harmon Formula) related to the serviced population.

In addition to the average sewage flow, the sanitary sewer must have hydraulic capacity to accommodate a minimum flow resulting from inflow and infiltration (I/I flow). The required I/I flow is 0.15 l/s/ha.

On this basis, the peak flowrate at the junction of the trunk sewer extension and the existing sewer is 67 l/s.

It should be noted that the existing sanitary trunk sewer has a hydraulic capacity of 168 l/s, which is appropriate for the larger drainage area of 127.3 ha.

Alternative Sanitary Trunk Sewer Alignments

Two Sanitary Sewer Alignment Alternatives were considered, as shown on Figure 4.

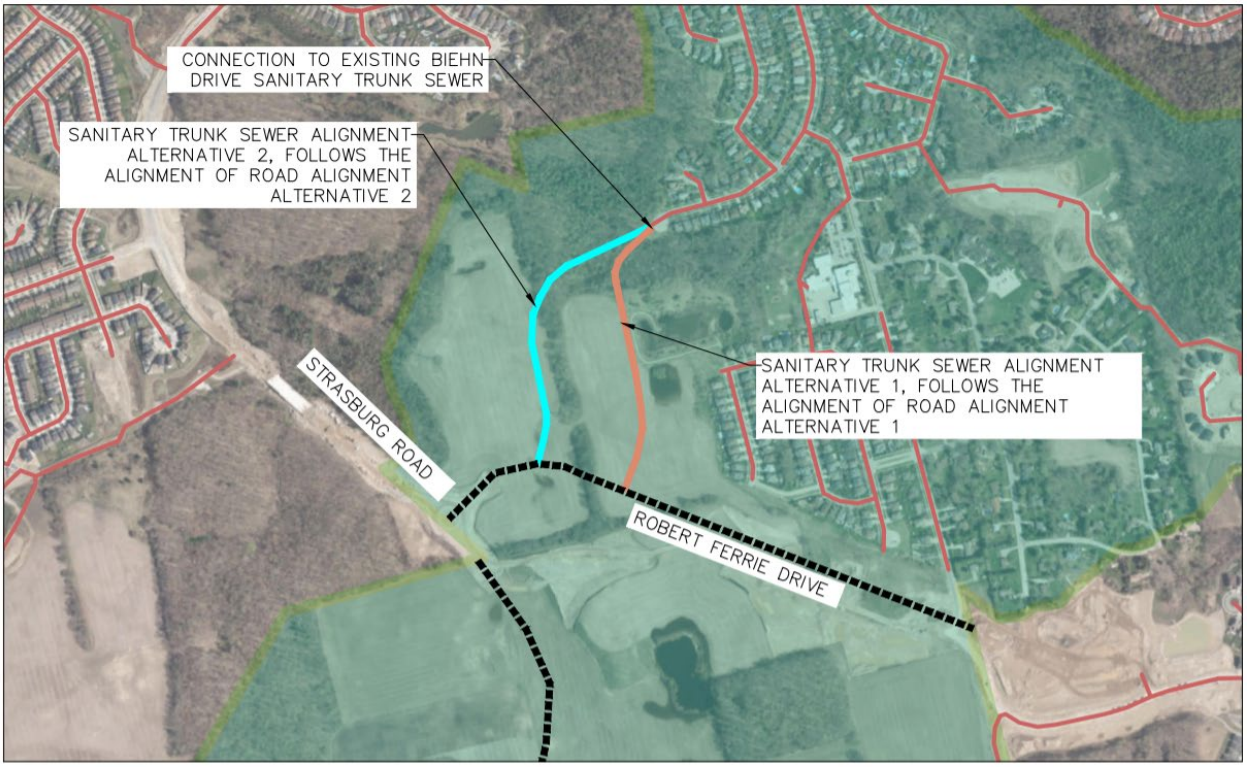

Figure 4 - Sanitary Sewer Alignment Alternatives

The two alternative alignments were evaluated in conjunction with the analysis and evaluation of the road alignment alternatives, as discussed in the Environmental Study Report. Based on the evaluation of alternatives, the Technically Preferred Sanitary Sewer Alignment Alternative is Sanitary Sewer Alignment 1.

New Sanitary Trunk Sewer

The new trunk sanitary sewer will follow the alignment of the Biehn Drive extension to Robert

Ferrie Drive. Based on the sanitary drainage area, the new trunk sewer will be designed for a peak flow of 67 l/s, and will be installed at a grade of 0.50% to allow connection of the areas of the sewershed located south of Robert Ferrie Drive. The required trunk sanitary sewer pipe will be a 500 mm diameter HDPE pipe or a 525 mm diameter pipe. The type of pipe will be confirmed in the preliminary design.

Figure 5 shows an approximate alignment of a future sanitary sewer that would serve the southern portion of the sewershed. Figure 6 shows the ground and sewer profiles along the same alignment. The maximum depths could be up to 21 m.

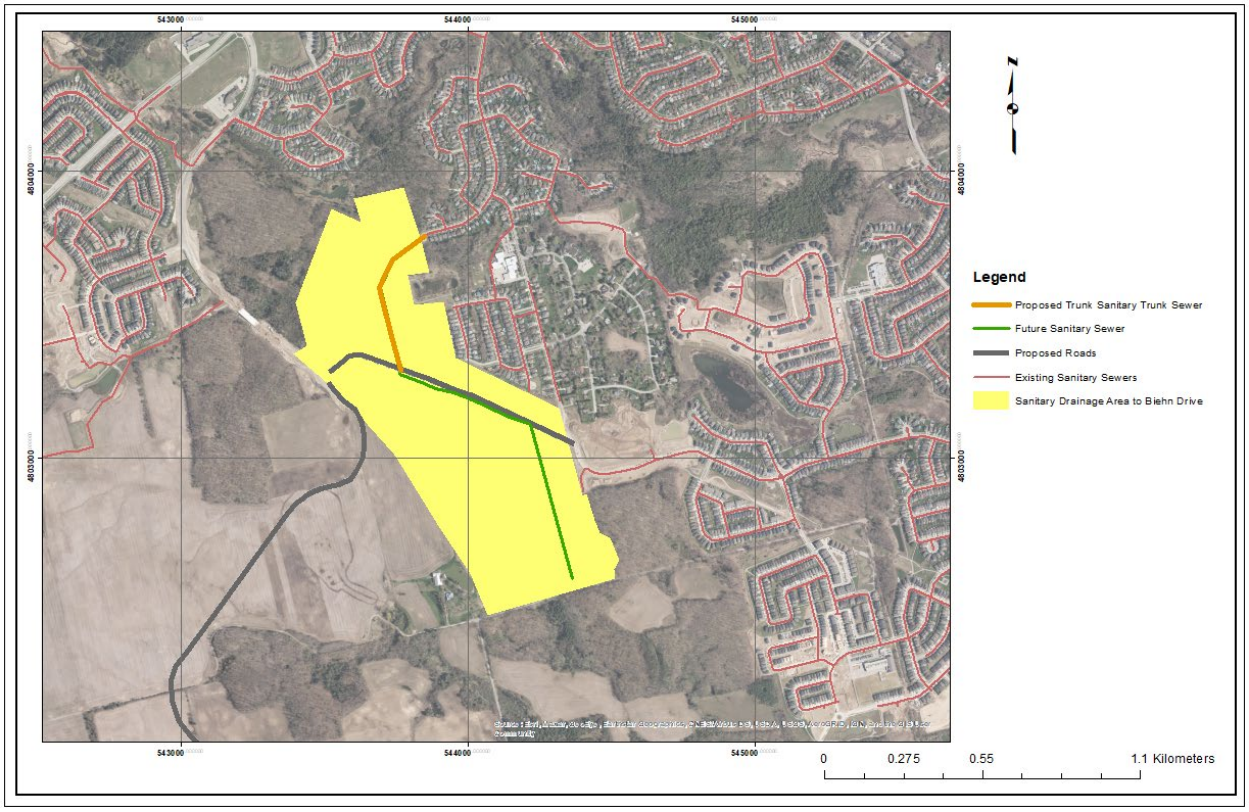

Figure 5 - Future Sanitary Sewer

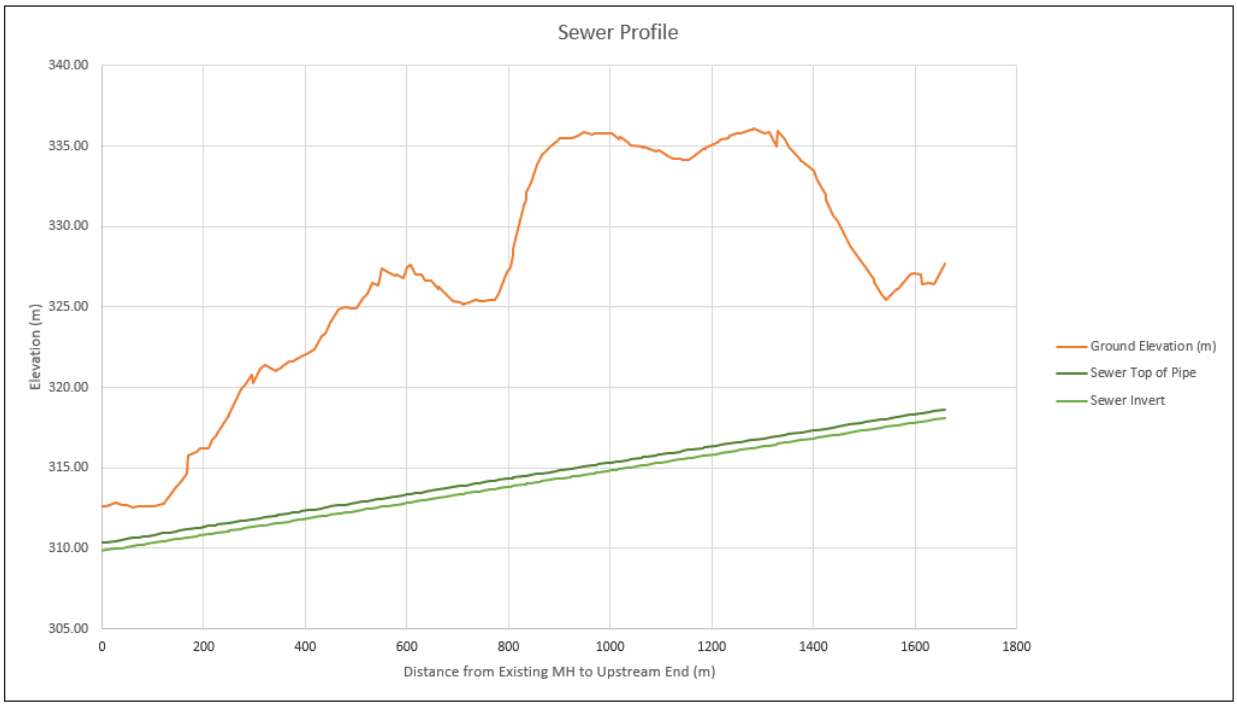

Figure 6 - Future Sewer Profile

Although it is possible to install the pipe at the depth shown, other options may be more appropriate to serve this area in the future. For example, the southern half of the tributary area may require a pumping station and forcemain. Alternatively, the City may wish to consider draining the southern portion to the adjacent New Dundee sewershed, if the hydraulic capacity of that system permits. However, to provide for the possibility that the entire system connects to the proposed Biehn Drive trunk sanitary sewer extension, the sewer needs to set at the lowest feasible grade.

Additional details will be provided in the preliminary design.

Prepared by

Leonardo Sanchez, P.Eng.

Appendix L

Analysis and Evaluation Report

BT ENGINEERING

Updated Analysis and Evaluation Report

City of Kitchener
Biehn Drive Extension Environmental Assessment Study
Municipal Class Environmental Assessment

August 2024, Revision 1

Submitted by:
BT Engineering Inc.
509 Talbot Street
London, ON N6A 2S5
519-672-2222

Table of Contents

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1.0 INTRODUCTION

This report supersedes the original Analysis and Evaluation Report REV. 3 February 28, 2023.

The City of Kitchener (City) is undertaking a Class Environmental Assessment (EA) Study of the extension of Biehn Drive southerly to the proposed extension of Robert Ferrie Drive. The extension of Biehn Drive will include a trunk sanitary sewer and a watermain. The Study involves evaluation of alternatives for the alignment of the Biehn Drive extension, the location and design of intersections, and municipal services, while minimizing natural, social, cultural and land use impacts. This report describes the revised evaluation of the Preliminary Alignment Alternatives carried forward following Public Information Centre (PIC) No. 2 and the additional studies carried out by the City of Kitchener.

1.1 Problem and Opportunity Statement

The planned extensions of Strasburg Road and Robert Ferrie Drive combined with new development will result in changes to the traffic demands and patterns within the Doon South and Brigadoon communities. To address those changes, the City of Kitchener Transportation Master Plan and Official Plan have identified an extension of Biehn Drive from its current terminus to Robert Ferrie Drive. The Study has revisited the need for an extension of Biehn Drive and evaluated potential alignment alternatives if an extension of Biehn Drive is still recommended. The Study has considered the natural, social environments and the future land use in the Study Area. The study is assessing the road network to provide safe, reliable transportation access to communities within Doon South and Brigadoon considering vehicular, pedestrian, cycling and truck routes. The road project is being completed as a Schedule C undertaking.

The Project provides the opportunity to:

- Improve accessibility to the local community by providing additional network links;
- Define a multi-modal transportation plan to support travel within the local neighbourhoods; and
- Allow development to proceed on lands that currently require the infrastructure requirements to be defined prior to developing the land use plan.

In parallel, the City is planning for new municipal services that are required to serve future development to the south. The future watermain and sanitary trunk sewer crossing of the Provincially Significant Wetland (PSW) from the existing services at the end of Biehn Drive are being completed as a Schedule B project.

1.2 Study Area

The Local Study Area extends from the current terminus of Biehn Drive, approximately 60 m west of Spencer Court, southerly to the future Robert Ferrie Drive Extension.

Comments received from the public at the combined Community Café and PIC No. 1, indicated that the Study Area should be expanded to include a Broader Study Area and consider traffic effects in adjacent neighbourhoods. The Study Area is illustrated in **Figure 1.**

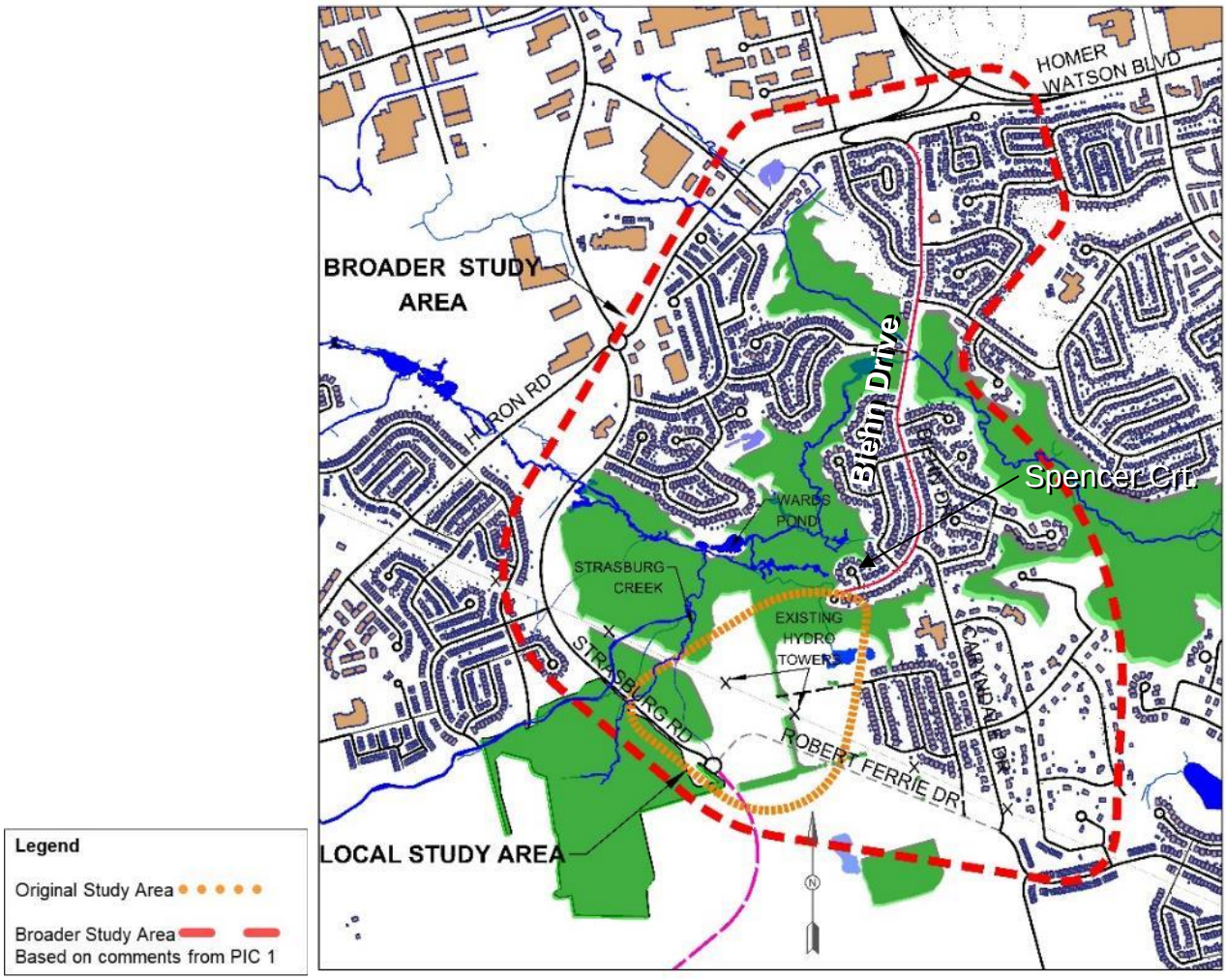


Figure 1: Study Area

1.3 Study Introduction

This study was initiated as a Municipal Schedule C project as defined by the Municipal Class Environmental Assessment (MCEA). The Study involves evaluating alternative alignments for Biehn Drive to serve the Brigadoon Community located in the southwest portion of the City of Kitchener. The extension of Biehn Drive has long been a part of the integrated land use and transportation plan for the larger community. The City of Kitchener Official Plan (November 2014) identifies Biehn Drive as a Major Community Collector Street, shown in orange, refer to **Figure 2**. Collector streets function to collect traffic from local streets and provide access to arterial streets, shown in orange.

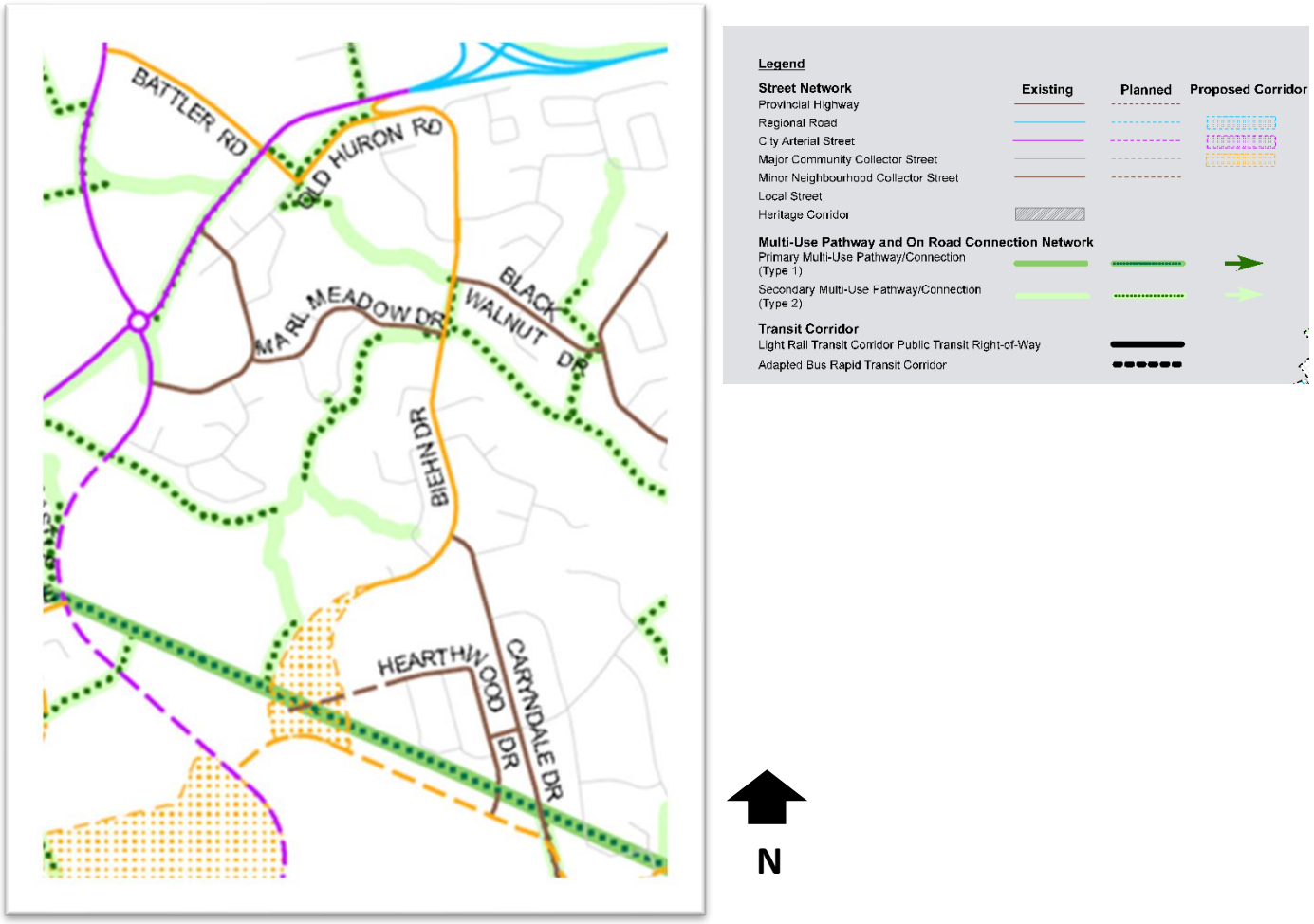


Figure 2: Future Road Network

Source: City of Kitchener Official Plan: A Complete & Healthy Kitchener November 19, 2014 OP Map 11 - Integrated Transportation System.

1.4 Background

Since the mid-2000's, the road network and municipal servicing for the Doon South and Brigadoon areas in the City of Kitchener involved plans for area development and evolving transportation needs. The 2014 Official Plan and the (add date) Transportation Master Plan (TMP) identified the need to extend Biehn Drive westerly to the Robert Ferrie Drive extension and ultimately to Strasburg Road. The Biehn Drive Extension would be a major collector road, as identified in Schedule B of the City of Kitchener's Official Plan Amendment. This link would accommodate vehicles to and from the Brigadoon community and would help mitigate cut-through traffic on local streets within the community. A collector road would collect traffic from local roads within the community and provide connectivity to high tier arterial roads including Strasburg Road.

1.5 Additional Studies

Following PIC 2 in November 15 to 29, 2021, three additional studies were carried out to fully understand the traffic and natural heritage impacts anticipated with the extension of Biehn Drive. These studies included an updated traffic analysis of the Doon South and Brigadoon communities, a survey for Black Ash trees which were listed as a Species at Risk in January 2024 and a dewatering assessment for constructing municipal services beneath the Strasburg Creek Wetland. These three studies significantly altered the evaluation methodology and added significant criteria which was not considered in the original evaluation of road alignments carried out in October 2021. The Analysis and Evaluation Report has been updated to reflect the recent findings. This report documents the revised evaluation of the Preliminary Design Alternatives.

1.5.1 City of Kitchener Doon South Community Area Transportation Study

The purpose of this study was to confirm the need and justification for the Biehn Drive extension and the implications of not proceeding with this project.[1] The findings and conclusion are briefly listed as follows:

- Caryndale Drive functions as a major neighborhood community collector. It provides the only westerly connection between Biehn Drive and Robert Ferrie Drive.
- Caryndale Drive in combination with Biehn Drive and Robert Ferrie Drive provides the only continuous route through the western area of the Doon South neighbourhood between New Dundee Road and Huron Road.
- The future extension of Robert Ferrie Drive west to Strasburg Road, and the extension of Strasburg Road south to New Dundee Road is likely to redistribute (and increase) traffic volumes on Caryndale Drive by providing a new link to Caryndale Drive from Strasburg Road (if Biehn Drive is not connected to Robert Ferrie Drive).
- The extension of Biehn Drive to Robert Ferrie Drive will ensure Carnydale Dive functions as a minor neighbourhood collector street, as described in the City of Kitchener Official Plan and will provides an alternate route to the Caryndale Drive corridor.

The Doon South Community Area is shown in **Figure 3.**

[1] City of Kitchener Doon South Community Area Transportation Study, by Paradigm Transportation Solutions Limited 02/2024.

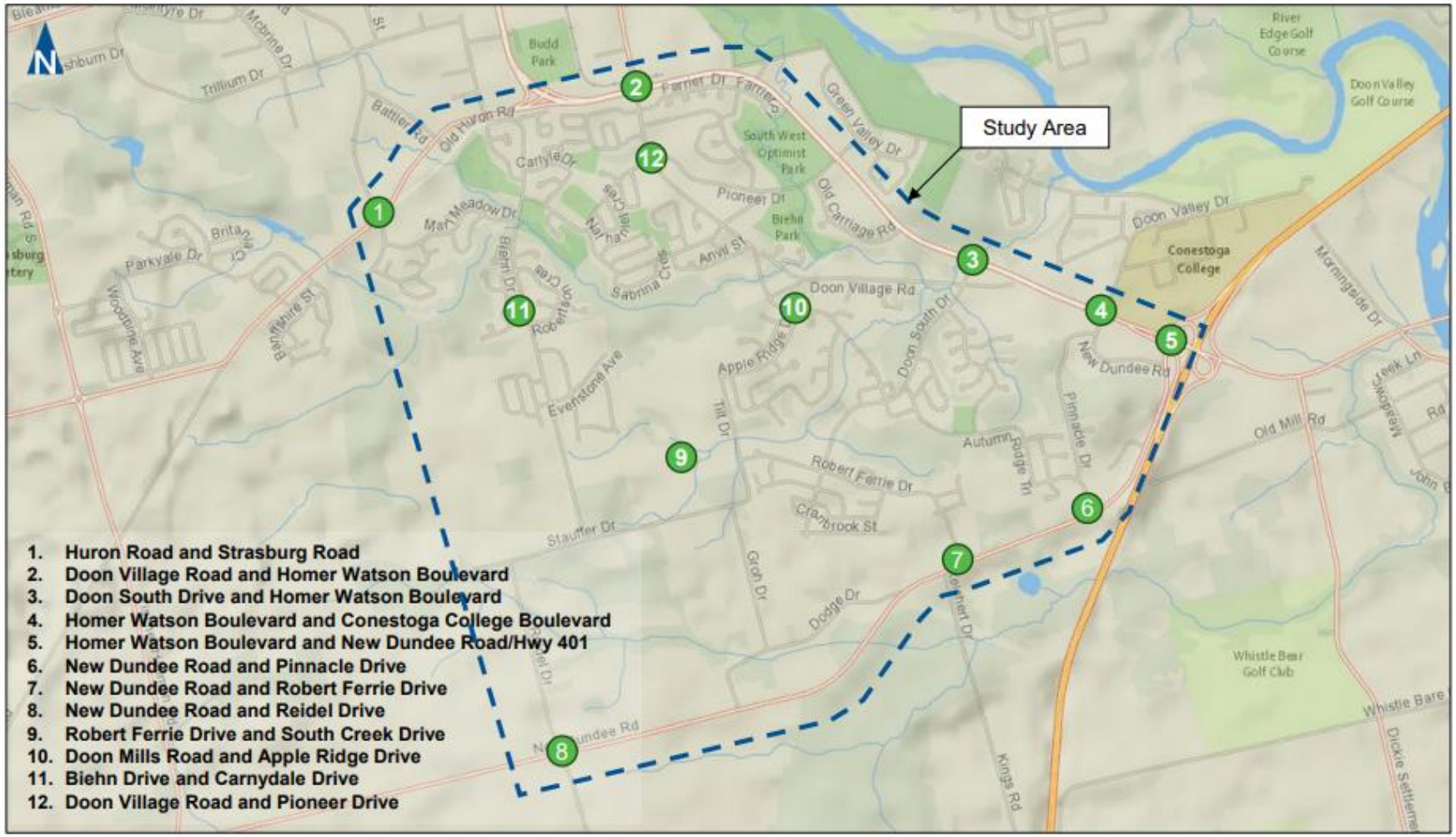


Image Source: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Figure 3: City of Kitchener Doon South Study Area and Intersections

1.5.2 Black Ash Tree Identification

A Site Reconnaissance of the portion of the Strasburg Creek Provincially Significant Wetland (PSW) within the Study Area was undertaken on October 23, 2024, to identify Black Ash trees.[2] Six trees are considered potential Black Ash within the preferred road alignment, four were classified as potential Black Ash due to the absence of leaves, which limits identification, and two exhibit stronger potential based on distinct bark characteristics. .

The *Endangered Species Act*, 2007 (ESA) protections for Black Ash came into force on January 26, 2024. Ontario's new regulations apply to healthy Black Ash that appear to have survived exposure to the Emerald Ash Borer (EAB). These regions encompass various municipalities, counties, townships, and cities, including Kitchener in the region of Waterloo. Ontario's habitat protection prohibitions are applicable to a radial distance of 30 metres around Black Ash.

1.5.3 Hydrogeology Assessment

A trenchless installation method is suitable for the placement of sewer and watermain infrastructure beneath the Strasburg Creek Wetland, based on hydrogeologic conditions assessed across the area.[3]

[2] Black Ash Tree Identification Update - October 23, 2024

[3] Geotechnical Investigation – Proposed Trunk Sewer, Biehn Drive South Extension, Kitchener, by Cambium December 20, 2023

2.0 ALTERNATIVES TO THE UNDERTAKING – PLANNING ALTERNATIVES

2.1 Description of Planning Alternatives

Planning Alternatives represent alternative ways or methods of addressing the Problem and Opportunity Statement specific to this study. These reflect different strategies and include the "Do Nothing" approach (maintaining the status quo, i.e. not addressing the Problem and Opportunity Statement). The consideration of all reasonable alternatives is a guiding principle for EA studies.

The analysis and evaluation process involves a 2-step decision-making process. Initially the evaluation of Planning Alternatives (alternative project types or alternative strategies to address the problem) are identified followed by the subsequent evaluation of preliminary design alternatives. The preliminary design alternatives include the Biehn Drive extension alignment, sanitary sewer alignment, cross section, and intersection alternatives.

The Planning alternatives were previously considered in the City of Kitchener Transportation Master Plan, 2013, which identified the extension of Biehn Drive as a City Street Capacity Improvement. The TMP was developed following Phases 1 and 2 of the Class EA process, including the evaluation of Alternative Planning Solutions. The TMP includes recommendations for the "implementation of new streets in southwest Kitchener Urban Areas Study Community Master Plan, including the extension of Biehn Drive between Biehn Drive and Robert Ferrie Drive".

In reviewing the TMP recommendations, the following Planning Alternatives were assessed:

- Do Nothing: This alternative would maintain the existing road network and would not extend Biehn Drive and not provide a bundled sanitary and municipal service corridor.
- Transportation Demand Management (TDM): Reduces vehicular traffic demand (encourages alternative work hours, work at home and active modes of transportation). Does not address the need for a municipal service corridor. TDM will be accomplished by the inclusion of a multi-use path adjacent to the roadway.
- Use of Local Roads: Encourage the use of other local roads to reduce the need to extend Biehn Drive. Local roads are generally not designed or maintained to accommodate high traffic volumes. This alternative does not address the parallel requirement for a municipal services corridor.
- Limit Land Use Development: Limit any new residential, commercial or industrial development and therefore reduce the generation of new trips. This does not achieve the Provincial mandate of the Places to Grow Act which directs the Region and City to create future development lands with specific targets to be achieved.
- Extend Biehn Drive: Provides a long-term solution for improved traffic operations for all modes of travel (pedestrians, cyclists, transit and local community traffic) and safety. It allows a bundling of municipal services in a common corridor which is required to service the expansion areas to the south to meet the Provincial Places to Grow Act mandate.

Based on the preliminary review of Alternative Planning Solutions, "Transportation Demand Management" and "Extend Biehn Drive" (including the bundling of the proposed trunk sanitary

sewer, maintenance roadway/multi-use path and watermain from Biehn Drive to Robert Ferrie Drive) are recommended. The Use of Local Roads was not a standalone solution but based on community input was carried forward as a modified approach of using two corridors (Alternative 4 carried forward using Caryndale Drive for traffic and using a municipal servicing corridor across the PSW). This approach validates and supports the previous TMP recommendations.

The evaluation of the Alternatives to the Undertaking (Planning Alternatives) for this Study is shown in **Table 1.**

The long list of alternatives and the coarse screening evaluation of alternatives was presented to the public at PIC No. 1 in early 2021. Following PIC No. 1 and the public's opportunity to comment, the Preliminary Alignment Alternatives were coarse screened, and the recommended alternatives were carried forward for a detailed evaluation. The coarse screening of the long list of alternatives and a description of the evaluation results will be documented in the final Environmental Study Report (ESR).

The Preliminary Alignment Alternatives (Alternative Methods of implementing the Preferred Planning Alternative) that are proposed to be considered for the recommended Planning Solution are: TDM; Use Existing Roads; and Extend Biehn Drive.

Table 1: Planning Alternatives

Screening Criteria	Do Nothing	TDM	Use of Existing Local Roads	Limit Development	Extend Biehn Drive (Road and servicing corridor)
Transportation	Does not address forecast traffic demand. Results in increased volumes on local roads.	May reduce vehicular demand by mode shift or work at home but will not eliminate need for new or improved infrastructure.	Local roads not designed to accommodate increased volumes. Caryndale Drive is not designated as a major collector and as such should not be expected to carry additional traffic.	May reduce vehicular demand by reducing the number of trips generated by development but does not address existing demands and/or background growth.	Accommodates all modes of transportation.
Municipal Services (Water and Trunk Sanitary Sewer for future development)	Does not accommodate future development.	Does not accommodate future development.	Does not accommodate future development.	Does not accommodate future development.	Accommodates future development.
Environmental	No impacts.	No or low impacts. Low impacts may be associated with active transportation projects/ improvements (i.e. sidewalks, bike lanes).	Low impacts. Creates disruption to properties on local roads that would experience an increase in traffic.	No impacts.	Low to High Servicing: Low Roadway: High environmental effect possible with new corridor. Magnitude of effects will depend impact on PSW and SAR tree species.

Screening Criteria	Do Nothing	TDM	Use of Existing Local Roads	Limit Development	Extend Biehn Drive (Road and servicing corridor)
City Planning Objectives	Does not meet objectives/ recommendations in City Planning document or support the Provincial *Places to Grow Act* requirement to create additional development areas (including municipal services).	Supports objective to encourage active transportation and alternate modes. Does not support the Provincial *Places to Grow Act* requirement to create additional development areas (including municipal services).	Does not meet objectives/ recommendations in City Planning documents. Does not support the Provincial *Places to Grow Act* requirement to create additional development areas (including municipal services).	Does not meet objectives/ recommendations in City Planning documents. Does not support the Provincial *Places to Grow Act* requirement to create additional development areas (including municipal services).	Supports the recommendations for the extension of Biehn Drive in OP and TMP. Supports the Provincial *Places to Grow Act* requirement to create additional development areas (including municipal services).
Recommendations	Not recommended but carried forward as a baseline to compare other alternatives. ✓	Recommended as a complementary solution. This is not a standalone solution. ✓	Following PIC No. 1 there was public support to carry forward this alternative. This is not a standalone solution. See Extend Biehn Drive which is a combination of Use of Local Roads and a New Municipal Servicing Corridor. ✓	Not recommended. ✗	Recommended to be carried forward for further study, for both municipal services and a transportation connection. ✓

✓ **Recommended Planning Solutions for further evaluation**

3.0 EVALUATION METHODOLOGY

3.1 Alignment Alternatives Evaluation Methodology

For the evaluation of the alignment alternatives, the study utilized a formal quantitative evaluation methodology described as the Multi Attribute Trade-off System (MATS). The use of this multi-criteria decision analysis involves establishing utility scores for each alternative on each criterion. The utility scores allow a translation of units of measure to a non-dimensional number that allows scores to be added between factor groups/sub-factors. The scores are then totalled using a system of weights to determine an overall ranking for each alternative.

A detailed description of the evaluation methodology used in this study for selecting the Technically Preferred Alignment is provided in **Appendix A**.

The quantitative approach for the evaluation of Alignment Alternatives is consistent with the Ministry of Environment, Conservation and Parks (MECP) practices for the evaluation of numerous and complex alternatives. This approach uses an analytical approach that measures scores based on a mathematical relationship, i.e., the degree of subjectivity by the evaluation team is minimized. This traceable process allows the evaluation team and the opportunity to assess trade-offs involved in the evaluation and use this information to support the decision-making process. The evaluation criteria include:

- Factor Groups: Traffic and Transportation; Natural Environment; Cultural Environment; Social Environment; Economic Environment; Land Use and Property; and Cost.
- Sub-factor Criteria (under each Factor Group) may include temporary or permanent property impacts; loss of fish habitat; noise; built heritage resource impacts; emergency response; and capital cost.

4.0 EVALUATION OF ALTERNATIVES

4.1 Coarse Screening Alignment Evaluation

4.1.1 Preliminary Alignment Alternatives

The Preliminary Alignment Alternatives presented to the public at PIC No. 1 are shown in **Figure 4**. An additional Alignment, Alternative 4 using existing roadways, was added following input from PIC No. 2. All the alternatives were carried forward to the detailed evaluation were considered by the Study Team to be reasonable alternatives to the Planning Solution and are listed in **Table 2**.

Table 2: Preliminary Alignment Alternatives

Alternative	Description
Do Nothing	Existing - Caryndale Drive
Alternative 1	Connect Biehn Drive to Robert Ferrie Drive - East Alignment
Alternative 2	Connect Biehn Drive to Robert Ferrie Drive - Central Alignment
Alternative 3	Connect Biehn Drive to Strasburg Road - West Alignment
Alternative 4	Existing - Caryndale Drive Provide an Active Transportation Link Municipal Trunk Sewer to follow Alternative 1

The coarse screening of Alignment Alternatives is shown in **Table 3.**

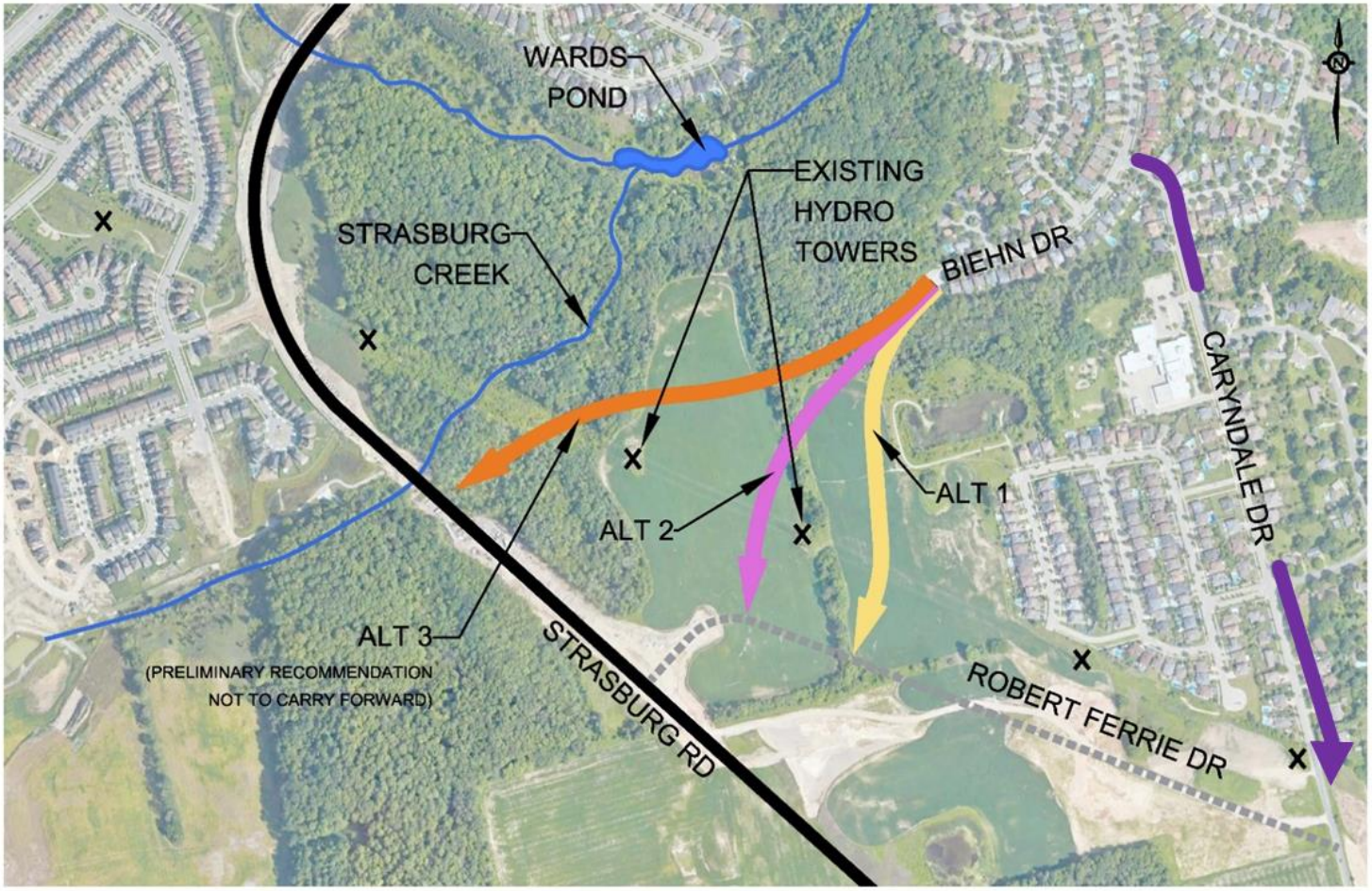
The preliminary alignment alternatives will include a trunk sanitary sewer in conjunction with the alternative road extension alternatives. It is noted that some of the alternative alignments for the trunk sewer may diverge from the road alignment alternatives. The Class EA process for extension of the sanitary sewer is a Schedule B process. However, the EA for the road and sanitary sewer will be combined into a single document and will be documented in an ESR. This EA is being undertaken concurrently with the Sanitary Sewer Master Plan.

In addition, following PIC No. 2, Alternative 4 was revised and no longer had a proposed Multi Use Pathway linking Biehn Drive to Robert Ferrie Drive to limit impacts to the PSW.

4.1.2 Short Listed Alignment Alternatives Evaluation

Figure 5 illustrates the three (3) alignment alternatives that were carried forward following the coarse screening. The short-listed Alignment Corridor Alternatives are shown in **Appendix B**. Alternative 4 was added following public comments received at PIC No.1 and the Do Nothing was included as a baseline to compare other alternatives.

Figure 4: Preliminary Alignment Alternatives



NTS

Legend

Future Roadway Alignment

Table 3: Coarse Screening of Alignment Alternatives

Screening Criteria	Do Nothing	Alternative 1: Extend Biehn Dr. to Robert Ferrie Drive east of Hydro Tower	Alternative 2: Extend Biehn Dr. to Robert Ferrie Drive west of Hydro Tower	Alternative 3: Strasburg Road Connection	Alternative 4: Existing - Caryndale Drive
Does this alternative satisfy forecast traffic demand, improve safety, and address all modes of transportation?	Does not meet forecast traffic demand, improve safety nor address all modes of transportation.	Provides a north-south connection to Robert Ferrie Drive. Accommodates all modes. Reduces cut-through traffic on Biehn Drive.	Provides a north-south connection to Robert Ferrie Drive. Accommodates all modes. Reduces cut-through traffic on Biehn Drive.	Provides a north-south connection to Strasburg Road. Accommodates all modes.	Provides a north-south connection to Strasburg Road. Accommodates all modes. However, there are increased levels of traffic on local roads.
Does the approach result in significant impacts to the natural environment?	No impacts.	Minor impacts to the woodlot/PSW (~0.3 ha).	Minor impacts to the woodlot/PSW (~0.3 ha).	Significant impacts to the woodlot/PSW (~1.3 ha).	No impacts.
Is the approach affordable for the City to implement?	Affordable alternative.	No significant difference.	No significant difference.	Higher cost - requires an intersection onto Strasburg Road (arterial).	Affordable alternative.
Does this alternative comply with the recommendations of the City's planning documents (I.e., TMP, OP, KGMP)	This alternative does not comply with the recommendations of the City's planning documents.	This alternative complies with the recommendations of the City's planning documents.	This alternative complies with the recommendations of the City's planning documents.	Does not comply with the recommendations of the Official Plan or Growth Management Plan. Based on the previous design and construction of the Strasburg Road and roundabout within the Study Area, this previous alternative is no longer considered feasible.	This alternative does not comply with the recommendations of the City's planning documents.
Recommendation:	Carry forward as a base line to compare alternatives. ✓	Carry forward for further evaluation. ✓	Carry forward for further evaluation ✓	Do not carry forward ✗	Carry forward for further evaluation ✓

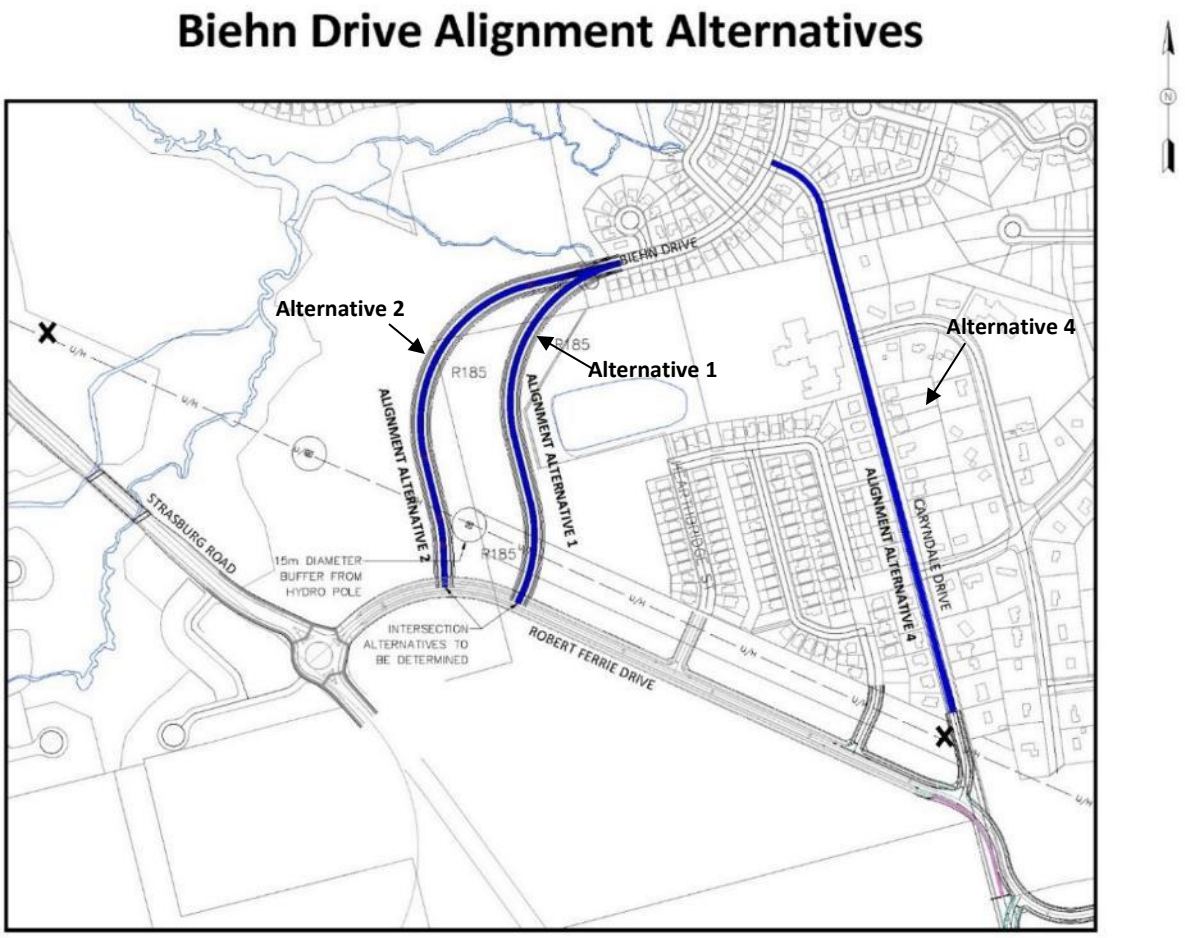


Figure 5: Short Listed Alignment Alternatives

4.1.3 Long List of Criteria - Alignment

A long list of sub-factors was established for each of the main factor categories to allow for the identification of all potential benefits and impacts. The relative measured effect of each criterion is also defined to ensure that the significance of each criterion (factor group or sub-factor) is recognized in the evaluation process.

Sub-factors are measurable criteria under a factor group. For example, under the category/factor group "Transportation", sub-factors relate to measurable transportation differences among alternatives. Using the Transportation factor group as an example, sub-factors may relate to safety or traffic operations measures for the identification of benefits and impacts.

Six categories or factors were selected which were used for each evaluation. Within each of these factor groups are sub-criteria, described as sub-factors, which define the measure and the relative differences of magnitude of impact or benefit. The factor groups include:

- Traffic and Transportation
- Natural Environment
- Cultural Environment

- Socio-Economic Environment
- Land Use and Property
- Cost

Within each of these categories (factor groups) are sub-factors which define the measure and the relative differences of magnitude of impact. The sub-factors were developed from a long list created by the Study Team (Consultants and City Staff). Where there were no measurable or meaningful differences between alternatives, and it is agreed that the alternatives are generally equal with respect to this criterion, then the sub-factor is not carried forward. When the Evaluation Team (Consultants and City Staff) considered the impacts were double counted among one or more criteria, then only one criterion was selected to be carried forward.

The long list of evaluation criteria that will not be carried forward are found in **Appendix C**. For a sub-factor to be carried forward, the sub-factor must:

- Be a measure of a meaningful difference among alternatives.
- Capture a measurable difference among alternatives.
- Not "double count" the effect that was measured under another sub-factor.
- Describe a difference in performance or an effect on the natural or social environment that the Technical Advisory Committee (Consultants and City Staff) considered necessary to be included in the decision-making process.

The selection of the sub-factors to address the goal of the study, are comprehensive enough to describe all aspects of the effects of the project, and do not double-count sub-factors.

4.1.4 Short Listed Criteria

Sub-factors selected to evaluate the alternatives including their definitions and scores are described in **Appendix D**.

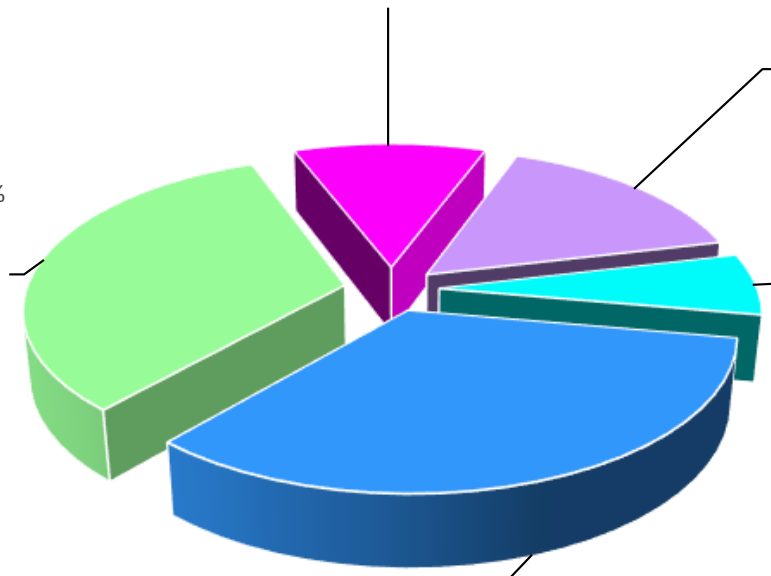
4.1.5 Preferred Alignment Alternatives

The Evaluation Team members were responsible for completing separate weighting exercises which provided independent perspectives of the relative importance of factor groups and sub-factors for each specific evaluation. The results of the weighting exercise are illustrated in **Figure 6** and **Figure 7.**

4.2 Technically Recommended Plan

Alternative 1 is the best-balanced solution, refer to **Table 4**. It provides the best transportation performance while minimizing natural and social environmental impacts. A limited number of Black Ash trees have been identified along the corridor however the city's best efforts to combat the Emerald Ash Borer has had limited success. The crossing of a PSW is accepted by the Provincial Policy Statement for transportation and utility corridors.

Alternative 1 is recommended as the Technically Preferred Plan and is shown in **Figure 8**. This recommendation minimizes the impacts to the PSW and provides a direct connection to Robert Farrie Drive. The trunk sewer and municipal water services will be extended southerly from Biehn Drive.



Socio - Economic Environment 10.3%
- Community Disruption to Biehn Drive North 21.0%
- Community Disruption to Biehn Drive South 50.0%
- Community Disruption to Caryndale 29.0%

Land Use and Property 14.2%
- Supports the City of Kitchener's Official Plan 56.0%
- Efficient Utilization of Land 29.5%
- Crossing of the Hydro Corridor 14.5%

Natural Environment 29.7%
- Wildlife Habitat 15.1%
- Accommodating Wildlife Movement 11.9%
- Provincially Significant Wetlands (PSW) Removed 24.8%
- Potential Black Ash Impacted 24.8%
- Groundwater Infiltration 23.5%

Cost 5.9%
- Capital Costs 100.0%

Transportation 30.5%
- Supports Urban Transit Service 8.5%
- Improved Emergency Response 7.1%
- Roadway Safety – Supports Area Traffic Calming Measures 17.5%
- Efficiency of Travel 19.9%
- Compatibility with Integrated Transportation Master Plan 8.3%
- Safety of School Zone 14.7%
- Personal Security of Pedestrians and Cyclists 7.3%
- Intersection Spacing/Safety 16.6%

Note:

Weights have been adjusted to account for updates to sub-factors.

Figure 6: Global Factor and Sub-factor Weights

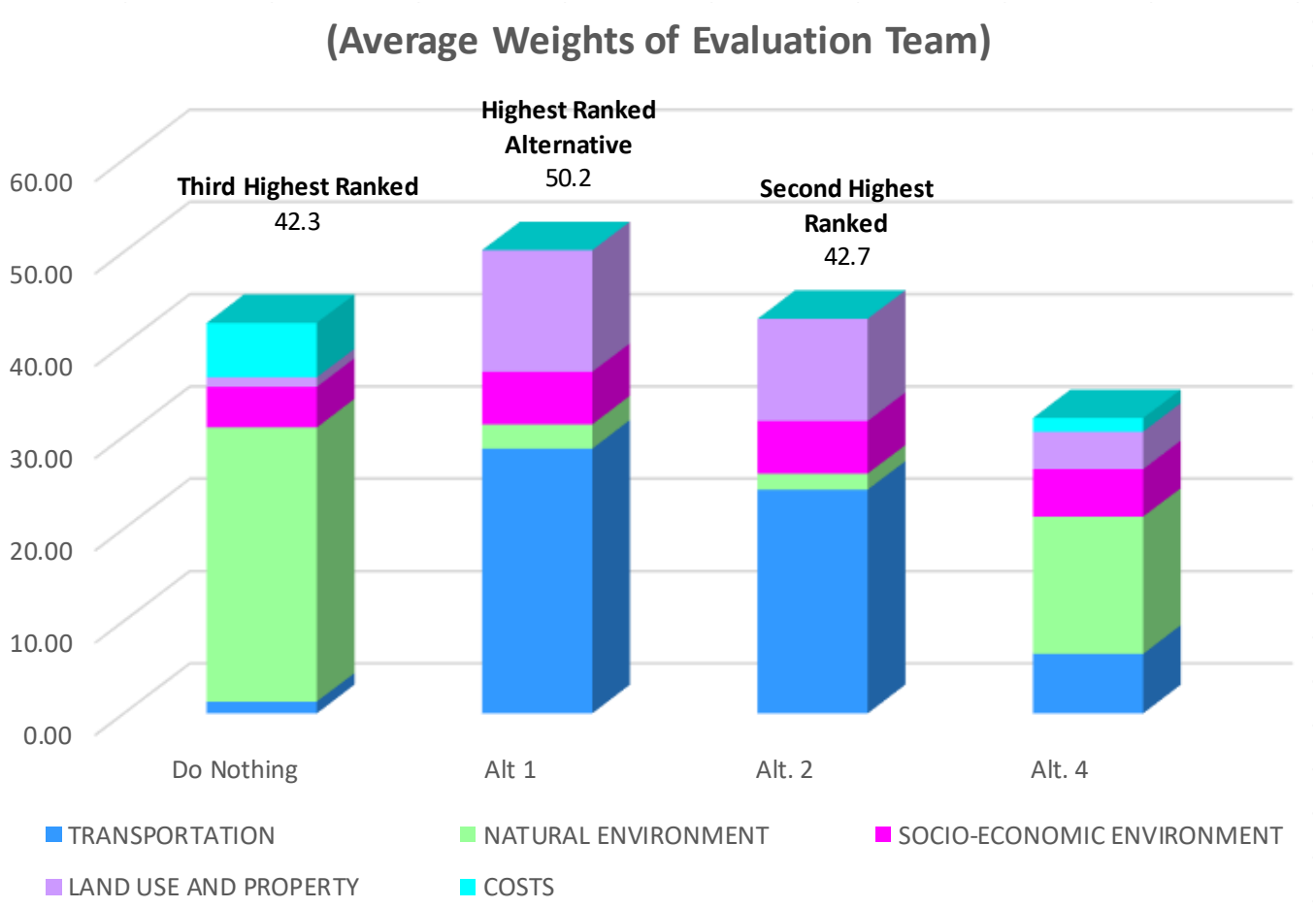


Figure 7: Alternative Totals

Table 4: Summary of Technical Recommendations

Do Nothing	Alternative 1: Extend Biehn Drive to Robert Ferrie Drive east of Hydro Tower	Alternative 2: Extend Biehn Drive to Robert Ferrie Drive west of Hydro Tower	Alternative 4: Existing Caryndale Drive and a Multi-Use Path crossing the PSW
Not recommended. The Do Nothing alternative fails to address the traffic volume and safety concerns along Caryndale Drive which should be expected to increase when the extension of Strasburg Road to New Dundee Road provides an alternative access to Highway 401. Caryndale Drive will continue to accommodate a higher volume of traffic and forced to function as a major collector street. The limited number of Black Ash trees in the PSW will continue to decline due to the Emerald Ash Borer. ✗	Recommended as the **Preferred Transportation Solution**. Alternative 1 is the best-balanced solution. It provides the best transportation performance while minimizing natural and social environmental impacts. A limited number of Black Ash trees have been identified along the corridor however the city's best efforts to combat the Emerald Ash Borer has had limited success. The crossing of a PSW is accepted by the Provincial Policy Statement for transportation and utility corridors. ✓	Not recommended. Although this alternative provides comparable transportation performance to Alternative 1 the environmental impacts are much greater. ✗	Not recommended. Caryndale Drive, classified as a minor neighbourhood collector street, will be forced to function as a major collector street. The neighbourhood was not designed for Caryndale Drive to continue to carry increasing volumes of vehicle traffic. ✗

4.2.1 Corridor Sensitivity Testing

To validate the weighting exercise, a sensitivity testing program was undertaken to determine whether the Technically Preferred Alternative (TPA) would have changed if a particular factor group was assigned a higher or lower importance than the group average. This ensures greater confidence in the selection process. The results of the sensitivity testing are shown in **Table 5**.

Table 5: Summary of Sensitivity Tests

Summary of Sensitivity Tests

Alternatives			Do Nothing	Alt 1	Alt. 2	Alt 4
	WEIGHT	Score:	42.3	50.2	42.7	32.0
Ranking			3	1	2	4
TRANSPORTATION	High	45.00%	3	1	2	4
	Low	20.00%	1	2	3	4
NATURAL ENVIRONMENT	High	40.00%	1	2	3	4
	Low	20.00%	3	1	2	4
SOCIO-ECONOMIC ENVIRONMENT	High	15.00%	2	1	3	4
	Low	10.00%	2	1	3	4
LAND USE AND PROPERTY	High	20.00%	3	1	2	4
	Low	10.00%	2	1	3	4
COST	High	10.00%	2	1	3	4
	Low	2.00%	3	1	2	4

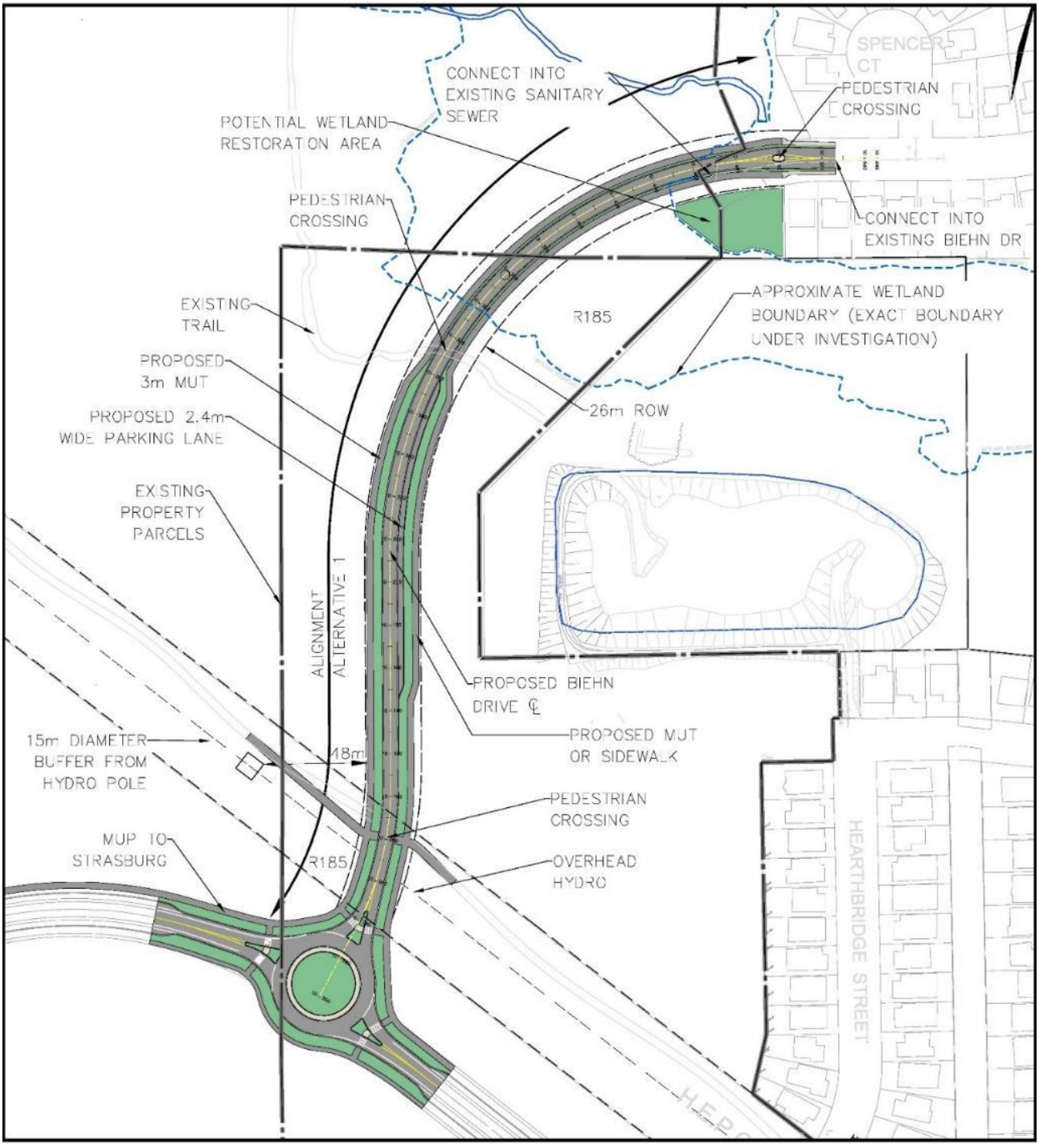


Figure 8: Technically Preferred Alternative

4.3 Cross Section Alternatives

Two (2) cross section alternatives were considered for Biehn Drive outside the limits of the wetland.

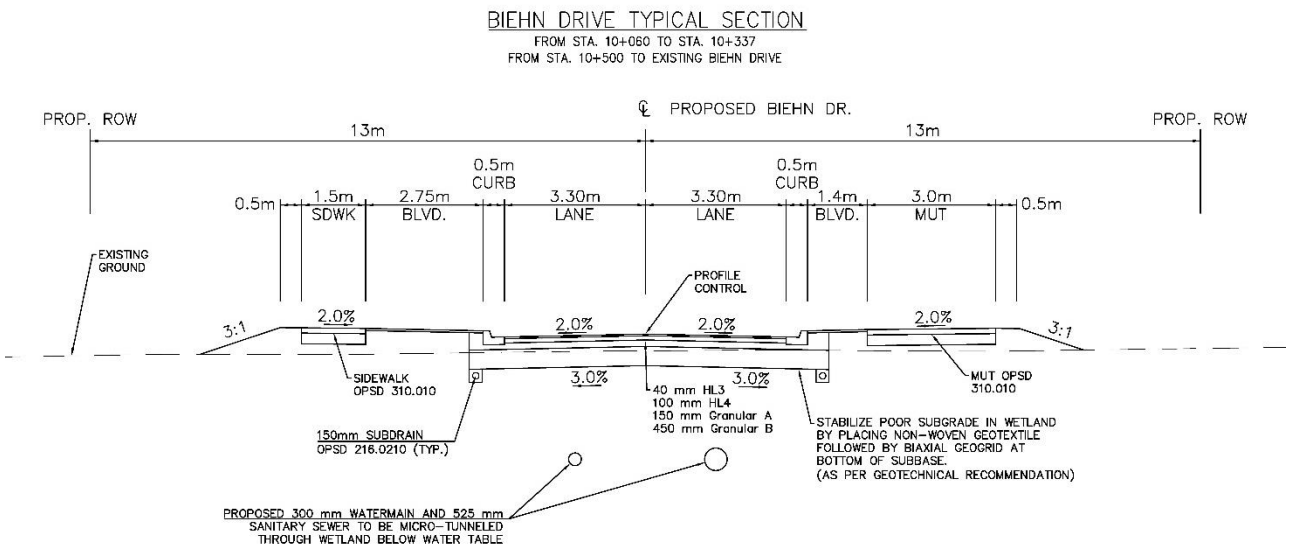
1. Alternative 1 – 26 m Major Collector with In-boulevard Cycling Facilities; and
2. Alternative 2 - 26 m Major Collector with Bike Lanes.

4.4 Technically Recommended Cross Section

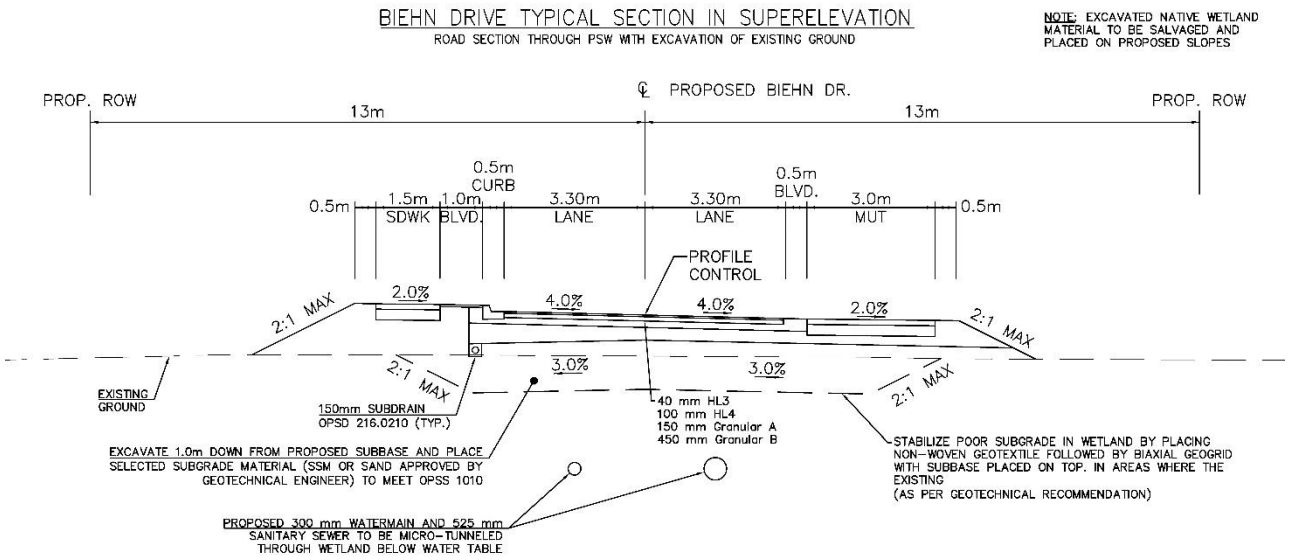
The preliminary evaluation of the cross section alternatives is shown in **Table 6**. Alternatives were developed to reflect the City of Kitchener's Complete Streets guidelines. The recommended cross section is Alternative 1 with multi-use trails as shown in **Figure 9**.

Table 6: Cross Section Evaluation

Evaluation Criteria	Alternative 1 – 26 m ROW with Multi-use Trail	Alternative 2 – 26 m ROW with Bike Lanes
Active Transportation	MUTs are preferred by the greatest proportion of cyclists (interested but concerned). Greater network continuity for cyclists with the future MUT along the Hydro corridor and potential to connect to the MUTs along Strasburg Road. ✓	Better accommodates pedestrians by separating pedestrians and cyclists. Increased conflict between cyclists and access to/from parked vehicles. ✗
Traffic Calming	The reduced pavement width would better promote lower travel speeds. ✓	Wider asphalt surface would be less effective in reducing travel speeds. ✗
Impacts to Natural Environment / Storm Water Quality	All alternatives considered equal.	All alternatives considered equal.
Impacts to Developable Lands	All alternatives considered equal.	All alternatives considered equal.
Cost	MUTs are more cost effective to construct with reduced pavement thickness and granulars. ✓	Wider roadway pavement structure increases construction cost. ✗
Recommendation:	Carry Forward **Alternative 1** ✓	



Typical Cross Section Outside the Wetland



Typical Cross Section Through Wetland

Figure 9: Recommended Cross Sections

4.5 Conclusions and Recommendations

The following are updated 2024 preliminary recommendations from the EA based on new data sources that included, the geotechnical investigation, the 2023 field inventory of ash trees, an analysis of the long-term Emerald Ash borer impacts on ash tree mortality in North America and City of Kitchener as well as the 2024 Doon South Community Area Transportation Study.

- Based on the 2023 geotechnical investigations it is feasible for the sanitary sewer and watermain without surficial construction to cross the PSW.
- The 2024 Doon South Community Area Transportation Study confirmed the recommendations of the current Transportation Master Plan, 2013 reflected in the Official Plan, 2019, for the long-term use of Biehn Drive and its extension as a major collector in the City.
- The 2024 provincial designation of the Black Ash trees as a Species at Risk (SAR) is now reflected in the recommendations.

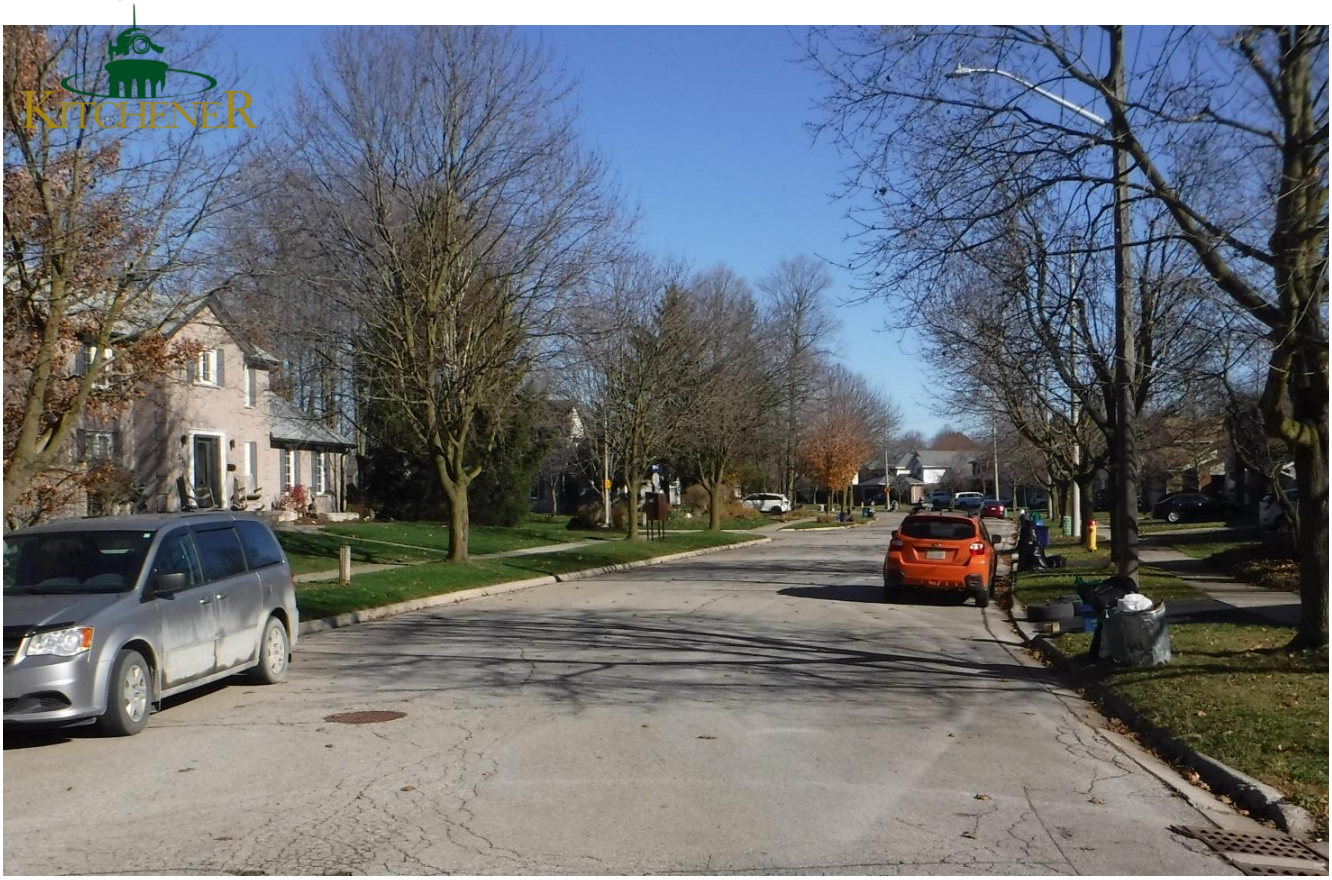
The following is the preferred approach for the planned improvements:

- Caryndale Drive will continue to be utilized until the extension of the Biehn Drive link is constructed.
- The health of the Black Ash trees are to be monitored.
- Development south of the PSW be permitted to proceed.
- That a right-of-way continue to be protected at the intersection of Biehn Drive and Robert Ferrie Drive for a future roundabout.
- The land acquisition should include the Right-of-Way required for municipal services and a road corridor.
- The alignment of the servicing corridor for the trunk sanitary sewer and watermain to follow the alignment for the road corridor.
- If Black Ash trees are impacted due to construction, the City will compensate for the loss. Compensation to be determined by Ministry of Environment Conservation and Parks.

Appendix A

Evaluation Methodology

BT ENGINEERING



Evaluation Methodology Report

Biehn Drive Municipal Class Environmental Assessment Study

August 2024, Revision 3

Submitted by:
BT Engineering Inc.
509 Talbot Street
London, ON N6A 2S5

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1.0 INTRODUCTION

The City of Kitchener (City) has initiated a Class Environmental Assessment (EA) Study to develop a transportation plan for the extension of Biehn Drive westerly to the Robert Ferrie Drive extension. The Biehn Drive extension will include municipal services including a trunk sanitary sewer, storm sewer/ditches and watermain. The focus of the Study will be to consider alternatives for the alignment of the Biehn Drive extension, intersection locations and designs and municipal services while minimizing environmental, social, and cultural impacts of the project.

1.0 STUDY PROCESS

This Study will complete the remaining phases of the Municipal Schedule C Class EA Study which was initiated by the TMP. The Study will meet all requirements of the Municipal Class EA by establishing the need and justification for the project, considering all reasonable alternatives with acceptable effects on the natural, social and cultural environments, and proactively involving the public in defining a Recommended Plan. The study will culminate in the filing of an Environmental Study Report (ESR) and provide environmental clearance to the City to proceed with the project, subject to permits and approvals that will occur during the future detail design stage of the project.

The Analysis and Evaluation process is a requirement of the EA process, based on the Ministry of the Environment, Conservation and Park's (MECP) Evaluation Methods in Environmental Assessment. [1]

This document describes the qualitative and quantitative methods of evaluation and which approaches will be utilized for different groups of alternatives for this study.

An evaluation method may be defined as a formal procedure for establishing an order of preference among alternatives. The use of a formal evaluation method has two main advantages: it provides a better basis for decision-making than would otherwise exist and it results in reasons for decisions that, on examination, can be traced.

The selection of an evaluation method should consider the following generic factors:

- Various evaluation methods have different capabilities which support different planning processes that may be better suited to a particular project or stage of the EA.
- With any particular planning process, all the steps (such as identifying alternatives, selecting criteria, consulting and involving interested parties, as well as evaluating) must be reasonable and provide a systematic assessment of the net effects of the project.

[1] Evaluation Methods in Environmental Assessment, Ministry of Environment, 1990.

The selection of the appropriate evaluation methodology depends upon the:

- Complexity of the decision-making;
- Number of alternatives;
- Number of criteria; and
- Sensitivity of the decision.

These issues are described in the following sections which explain the rationale for utilizing the most appropriate evaluation methodology in each stage of the EA study.

2.0 STUDY AREA

The Study Area is located in the City of Kitchener and is illustrated on **Figure 1**.

The Local Study Area extends from the current terminus of Biehn Drive, approximately 60 m west of Spencer Court, southerly to the future Robert Ferrie Drive Extension.

Based on comments from the public at the Community Café and Public Information Centre No. 1, the Study Area was expanded to a Broader Study Area to consider traffic effects in adjacent neighbourhoods.

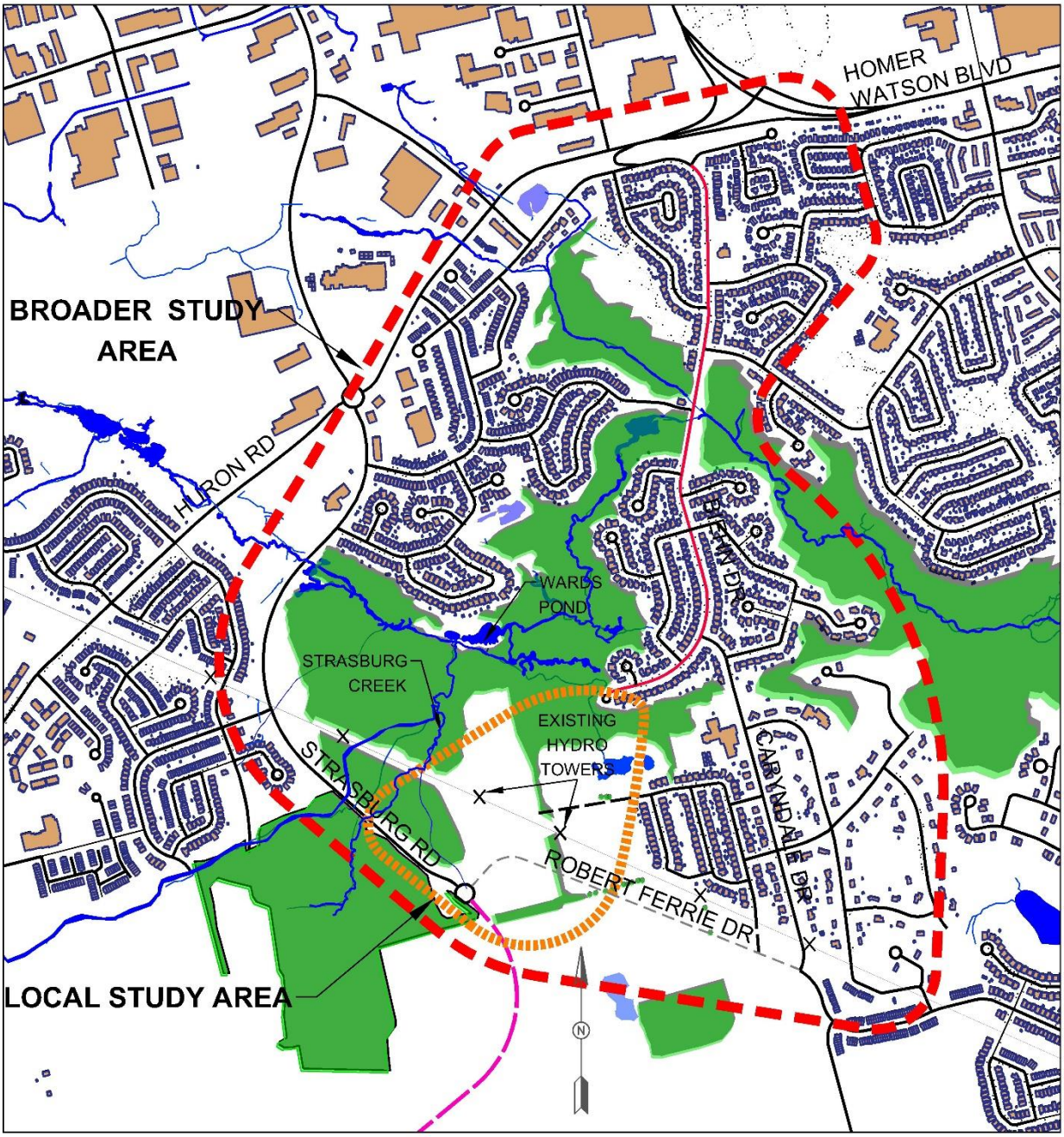


Figure 1: Study Area

3.0 PARTICIPATION

Public participation is a key component to the success of this project. Early public involvement is encouraged to establish a sound understanding of the public's concerns and views, to identify areas of concern and major study issues, and to establish a working relationship with the public that is amicable and cooperative rather than adversarial.

The City of Kitchener has a constitutional duty to consult with Indigenous Communities with traditional land use or interests within the Study Area. Clear, effective and timely consultation with Indigenous Communities is essential to ensure the success of the project.

3.1 Public, Property Owner, and Stakeholder Consultation

The public will be engaged through the use of three Public Information Centres (PIC) meetings and one-on-one meetings with directly affected property owners. This includes meetings and consultation with utilities, businesses and stakeholders that have an interest in providing comments on the design.

3.2 Indigenous Peoples Consultation

MECP has identified the Indigenous Peoples communities to be consulted during this study. Indigenous Peoples will be sent invitations by way of a notice to all public events such as the Community Café and PICs and will also be extended the offer to be met separately, if desired.

4.0 QUALITATIVE EVALUATION METHODOLOGY

A qualitative evaluation method involves describing impacts in narrative terms, or through qualitative measures, without the explicit specification of criteria, ratings or weights. This method, also known as “professional judgment” is widely used in EA’s to assess “Alternative Planning Solutions”. For example, an EA involving the selection of a corridor might evaluate alternative routes in considerable detail using a formal quantitative evaluation, but the evaluation of “Alternatives To” might be done using a simpler qualitative approach. See Error! Reference source not found. for a sample qualitative evaluation.

A challenge of the qualitative approach is the difficulty in recognizing when a comparison will have intuitive choice or universal support (public), i.e. a simple decision easily accepted. A qualitative approach may also be less defensible and could be subject to criticism. Should the public or stakeholders question these early decisions, additional information may be required to substantiate or detail the rationale for the early decisions. When alternatives are not systematically compared against a specified set of criteria, it may be difficult to follow how the decision was made and what evidence supports it.

Some advantages of using a qualitative approach over a quantitative approach include greater simplicity, reduced time and cost, and ease of presentation to the public. A qualitative approach is often used to evaluate alternatives where there is a straightforward conclusion and low public concern. The qualitative approach is also suitable where there are few alternatives and few criteria where there are measurable and meaningful differences between alternatives being considered.

Table 1: Planning Alternatives

Screening Criteria	Do Nothing	TDM	Use of Existing Local Roads	Limit Development	Extend Biehn Drive
Transportation	Does not address forecast traffic demand. Results in increased volumes on local roads.	May reduce vehicular demand by mode shift or work at home but will not eliminate need for new or improved infrastructure.	Local roads not designed to accommodate increased volumes. Caryndale Drive is not designated as a major collector and as such should not be expected to carry additional traffic.	May reduce vehicular demand by reducing the number of trips generated by development but does not address existing demands and/or background growth.	Accommodates all modes of transportation.
Environmental	No impacts.	No or low impacts. Low impacts may be associated with active transportation projects/ improvements (i.e. sidewalks, bike lanes).	Low impacts. Creates disruption to properties on local roads that would experience an increase in traffic.	No impacts.	Low to medium Environmental effect possible with new corridor. Magnitude of effects will depend on environmental mitigation.
City Planning Objectives	Does not meet objectives/ recommendations in City Planning document or support the Provincial *Places to Grow Act*	Supports objective to encourage active transportation and alternate modes. Does not support the Provincial *Places to Grow Act* requirement to create	Does not meet objectives/ recommendations in City Planning documents. Does not support the Provincial *Places to Grow Act*	Does not meet objectives/ recommendations in City Planning documents. Does not support the Provincial *Places to Grow Act*	Supports the recommendations for the extension of Biehn Drive in OP and TMP. Supports the Provincial *Places to Grow Act*

Screening Criteria	Do Nothing	TDM	Use of Existing Local Roads	Limit Development	Extend Biehn Drive
	requirement to create additional development areas (incuding municipal services).	additional development areas (including municipal services).	requirement to create additional development areas (including municipal services).	requirement to create additional development areas (including municipal services).	requirement to create additional development areas (including municipal services).
Recommendations	Not recommended but carried forward as a baseline to compare other alternatives. ✓	Recommended as a complementary solution. This is not a standalone solution. ✓	Following PIC No. 1 there was public support to carry forward this alternative. This is not a standalone solution. See Extend Biehn Drive which is a combination of Use of Local Roads and a New Municipal Servicing Corridor. ✓	Not recommended. ✗	Recommended to be carried forward for further study. ✓

✓ **Recommended Planning Solutions for further evaluation**

Where there are few criteria, such as in Error! Reference source not found., it is generally a cceptable to use a qualitative analysis because the trade-offs are clear and understandable. The more rigorous definition of the attributes of each alternative, as would be possible using a quantitative approach, is not required because there are a limited number of evaluation factors.

For this study, the qualitative approach will be used to assess Alternatives to the Undertaking and for the Coarse Screening of the initial long list of Preliminary Design Alternatives.

The use of a more comprehensive evaluation technique becomes necessary as the complexity increases (i.e. number of alternatives and number of criteria). In these situations, as described in **Section 5.0**, this study will utilize a quantitative approach.

5.0 QUANTITATIVE EVALUATION METHODOLOGY

Key principles of the EA Act and MECP's Guidelines on Environmental Assessment Planning and Approval are that there be accountability and traceability. A quantitative evaluation method allows both of these key principles to be addressed. A quantitative method based on the "Weighted Additive Method" utilizing utility measurements based on the "Likert Scale" will be used for this study and is also referred to as the "Multi-Attribute Trade-off System" (MATS).

The Weighted Additive Method has proven to be well suited for the evaluation of complex groups of alternatives. The methodology allows for sensitivity testing and the ability to answer "what if" questions. It is used on projects where the decision-making process is faced with either a large number of alternatives or a large number of competing criteria for the alternatives being evaluated.

The Weighted Additive Method is consistent with MECP practices for the evaluation of alternatives. It avoids many of the pitfalls associated with qualitative assessments by using an analytical approach that measures scores based on a mathematical relationship, i.e. the degree of subjectivity by the evaluators (i.e. the Technical Advisory Committee (TAC)) is minimized. A traceable process allows the TAC and public an opportunity to assess trade-offs involved in the evaluation and use this information in the decision-making process. In addition, this quantitative method allows sensitivity tests to be performed to determine if the highest ranked alternative is affected by changing the weights (perspective of importance) of the assessment factors.

For this study, preliminary design alternatives will be compared and scores assigned to each of the various assessment factors, and a sensitivity-testing program will be completed in consultation with the public and external agency interaction.

When using the Weighted Additive Method, each member of the TAC assigns a weight to the global factors and sub-factors. The Average TAC Weight is assigned to each of the

alternatives. The alternative with the highest score is selected as the Technically Preferred Alternative (TPA). The steps followed to arrive at an overall score for each alternative are shown in **Figure 2**.

This systematic approach includes the following steps:

- Collection of data/environmental inventories
- Development of a long list of reasonable alternatives (including coarse screening alternatives that are not feasible or unreasonable in comparison to those being carried forward)
- Public Information Centre (PIC) / Community Café No. 1
- Development of a long list of global evaluation criteria/performance sub-factors
- Short listing of sub-factors to those where there are meaningful differences among the alternatives to be compared
- Establishing Social Utility Functions (Performance Factors or Function Forms) for the short-listed sub-factors
- Weighting of Evaluation Criteria (assigning importance based on the specific set of alternatives)
- Rating of Alternatives
- Sensitivity Testing
- Selection of TPAs
- Public Information Centre No. 2
- Preliminary Design Alternatives for the Preferred Corridor Alternative
- Quantitative evaluation of the Preliminary Design Alternatives
- Public Information Centre No. 3
- Refinements to the Technically Preferred Plan (TPP)
- Recommended Plan

These steps, as they relate to this project, are briefly described in the following sections.

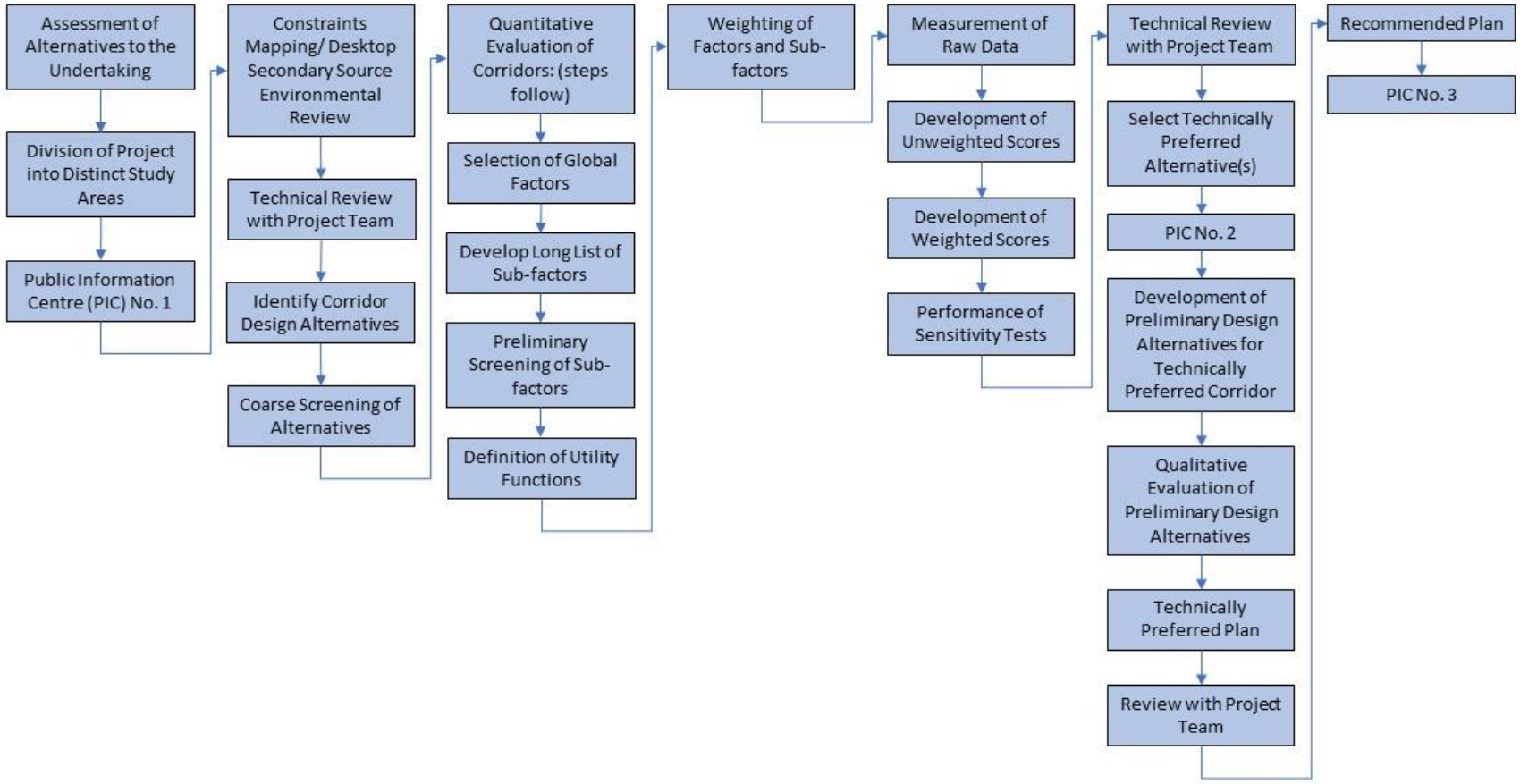


Figure 2: Study Evaluation Process

5.1 Evaluation Criteria – Factors

The initial step in the evaluation is to develop evaluation criteria from which alternatives will be assessed. This is a two-step process that involves the selection of a "global" group of factors and a number of "local" sub-factors under the global groups.

The global factors groups will be presented to the public and, following this consultation, will be accepted as describing the broad definition of the environment to be evaluated. Global factors considered for this study may include:

- Traffic and Transportation;
- Natural Environment;
- Cultural Environment;
- Socio-Economic Environment;
- Land Use and Property; and
- Cost.

While these factor groups are the starting point for the evaluation, one or more factors may be removed if it is determined that there is no sub-factor in this category i.e. there is not a meaningful and measurable difference between the alternatives being assessed in this category. When a particular factor is carried forward, then one or more sub-factors are considered under this group. These sub-factors are the individual descriptors for the evaluation. The selection of the sub-factors is very important to the decision-making process because they must adequately describe the issue to be evaluated and the alternatives being compared. See **Table 2** for a sample preliminary listing of sub-factors for Transportation. Any information regarding an alternative, where there are differences among alternatives, is incorporated into the decision-making process by including it as a sub-factor. The benefit to incorporating two levels of evaluation criteria (global factors and local sub-factors) is the prevention of the unbalancing of the evaluation (that could occur by adding more criteria under one group). Weights are assigned to the global factors to eliminate any possibility of skewing the results by selecting a large number of sub-factors in one particular factor group.

Table 2: Long List of Sub-factors

Factors and Sub-Factors	Carried Forward?
Transportation	
Delays (during construction)	✗
Supports Urban Transit Service	✓
Improved Emergency Response	✓
Fuel Consumption	✗
Road User Costs	✗

Factors and Sub-Factors	Carried Forward?
Roadway Operation and Safety – Supports Area Traffic Calming Measures	✓
Roadway Safety - Collision Potential at Intersections	✗
Active Transportation Connectivity – Conflicts through Communities	✗
Active Transportation – Proximity to Community Facilities	✗
Bicycle – Conflicts with Existing Bicycle Routes	✗
Flexibility for Future Expansion	✗
Horizontal Curvature	✗
Vertical Curves	✗
Minimum Radius of Curves	✗
Skewed Intersections / Angle of Skewed Intersections	✗
Level of Service on Local Roads	✗
Efficiency of Travel	✓
Compatibility with Integrated Transportation Master Plan	✓
Safety of School Zone	✓
Ability to Maintain Existing Roadway Classification	✗
Bicycle and Pedestrian Safety – Conflicts with Planned Hydro Corridor Multi-Use Trail	✓
Personal Security of Pedestrians and Cyclists	✓
Intersection Spacing	✗
Robert Ferrie Drive Intersection Location to Accommodate Future Development	✓

Generally, the process begins by establishing a long list of potential sub-factors through discussions with the public, community associations, the TAC and interest groups or from previous studies of the same nature. Then, for each group of alternatives being evaluated, the sub-factors are reviewed and screened by eliminating those that are considered equal

among alternatives being considered as well as those that do not apply to the Study Area, based on the site inventories carried out.

Table 3 provides a sample of a typical Global Factor, Sub-Factor, Unit and Utility Function Type from a Transportation Study. Similar Global Factor, Sub-factor and Utility functions will be developed for this study.

Table 3: Typical Evaluation Factor and Sub-Factors

Global Factor	Sub-Factor	Unit	Utility Function Type
Natural Environment	Wildlife Habitat	ha	Linear
	Accommodating Wildlife Movement	Preferred/Not Preferred	Stepped Function
	Provincially Significant Wetlands (PSW) Removed	ha	Linear
	Groundwater Infiltration	ha	Linear

5.2 Factor and Sub-factor Weights

The selection of weights for the factors and the sub-factors is based on assessments by the TAC of their relative importance. Within a group of factors, inevitably there is an ordering, with some factors having more importance than others. This is accounted for by each individual assigning a weight to each factor, which is reflected in the "Factor Weight" and "Sub-Factor Weight" columns. An example of typical results is shown in **Table 4**.

Table 4: Sample TAC Average Weights for a Factor Group and Sub-Factors in that Group

Factors	TAC	
	Factor Weight	Sub-Factor Weight
Traffic and Transportation	30.50%	
Supports Urban Transit Service		7.90%
Improved Emergency Response		6.50%
Roadway Safety – Supports Area Traffic Calming Measures		16.90%
Efficiency of Travel		19.30%

Table 4: Sample TAC Average Weights for a Factor Group and Sub-Factors in that Group		
Factors	**TAC**	
	Factor Weight	**Sub-Factor Weight**
Compatibility with Integrated Transportation Master Plan		7.70%
Safety of School Zone		14.10%
Bicycle and Pedestrian Safety - Conflicts with Planned Hydro Corridor Multi-Use Trail		4.90%
Personal Security of Pedestrians and Cyclists		6.70%
Intersection Spacing		16.00%
	Total	**100%**

As shown in **Table 4**, the group of evaluators judged the Traffic and Transportation Factor Group to be valued at 30.5% of the overall importance of the decision between the alternatives being considered.

Within each Factor Group the sum of the percentage weights of all sub-factors listed under each factor totals 100%. As shown in **Table 4** several of the sub-factors were judged to be more important/less important when compared to each other for this specific evaluation of alternatives being considered.

The weights for each factor and sub-factor are determined by averaging the weights assigned by the TAC (Evaluation Committee). Each member gives a judgement of the importance of each global factor and local sub-factor (a percentage value) based on his or her personal assessment and professional judgement, considering the net effects and input of stakeholders and the public.

There is usually a range of perspectives in deciding the weights (importance) of factors and sub-factors. Every person assigning weights has a personal perspective and understanding of the scope of the project. Hence, there is an advantage to having a diversified team of professionals with varied backgrounds performing the evaluation.

The weighting of each of the global factors is shown in **Figure 3**. The weighting of sub-factors within each factor group would be a similar distribution among the available sub-factors.

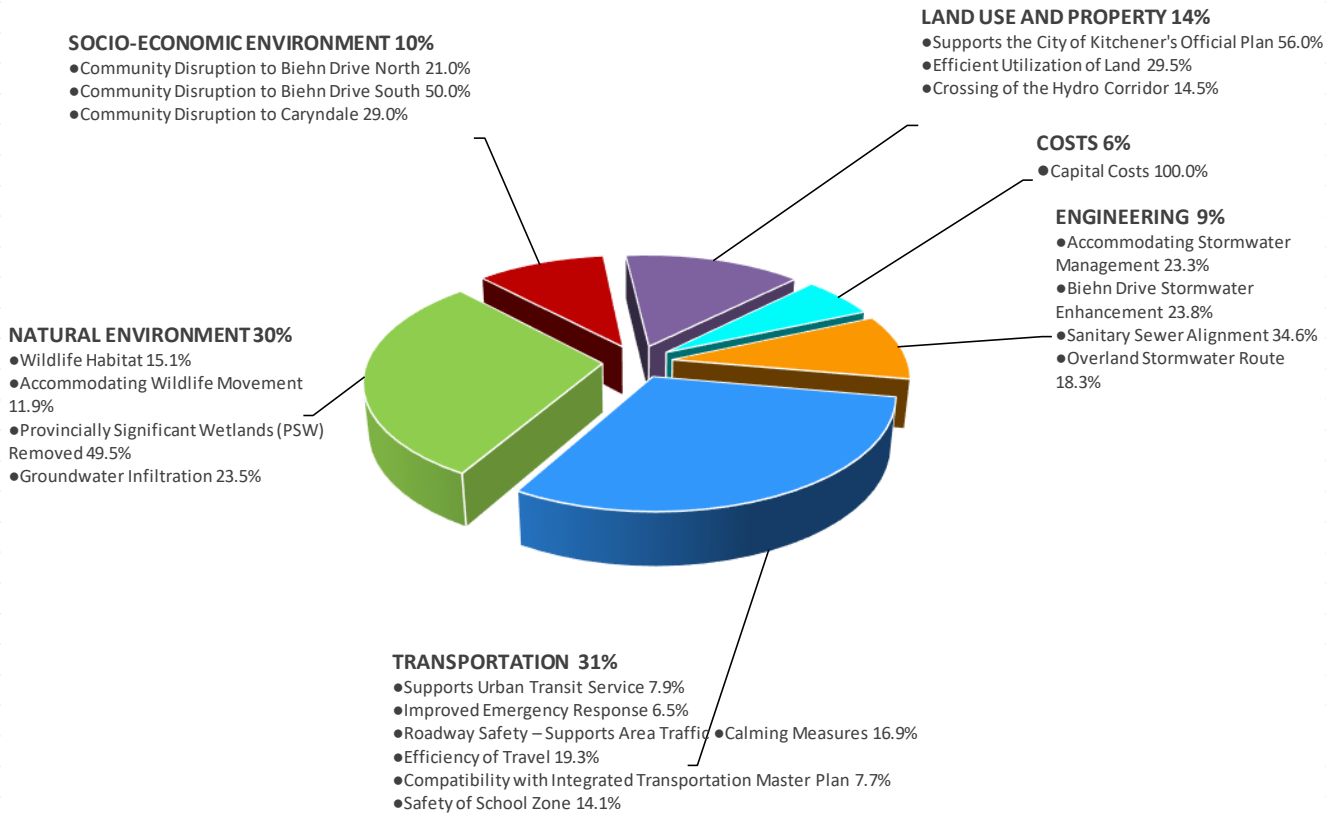


Figure 3: Sample Weighting of Global Factors

5.3 Social Utility Functions

The Weighted Additive Method used to evaluate alternatives relates the performance or attractiveness of alternatives using a mathematical relationship. This includes two variables: the first is the raw data or measured or modelled data, and the second is the utility or utility score, which is the measure of attractiveness of the alternative.

For this project, the relationship between these two variables is described, as shown in **Figure 4**, by either a dichotomous, stepped, or linear social utility function. A dimensionless utility score between zero (0) and 1 is assigned to an alternative for each sub-factor. The shape of this function can vary from linear to stepped or exponential and is defined by a subject area specialist.

The use of utility curves or functions is a step that transforms each of the measured effects to a dimensionless number and measure of utility. This step is required because the effects of each sub-factor are measured in different units (length, area, time, volume, dollars etc.). To produce a mathematical measure of the performance, each effect is translated to a measure of utility. The combined effect or performance of each alternative is a measure of utility (attractiveness) which is a dimensionless measure. The utility function (also commonly described as performance factor or function form) defines the relationship of effect to the

attractiveness (utility). These utility functions are defined by subject area specialists in their field of study.

Examples of Social Utility Functions for the “Community Disruption to Biehn Drive North” and “Improved Emergency Response“ sub-factor definitions are shown in **Figure 5.**

A dichotomous utility function enables the decision-maker to establish criteria that presents an “either–or” situation (desirable or undesirable, negative or positive, present or absent). If it is decided beforehand that a “yes” answer is desirable, then a utility score of one would be assigned to this criterion, otherwise zero would be assigned. One or zero are the available alternatives; no other utility score is available.

A linear function is used to convert scores for sub-factors that have varying measurements. Given a measurement, a unique utility score between zero and one can be assigned to a sub-factor. The slope of the linear utility function can be negative or positive depending on the desirability of the impact.

Figure 4: Sample Utility Functions

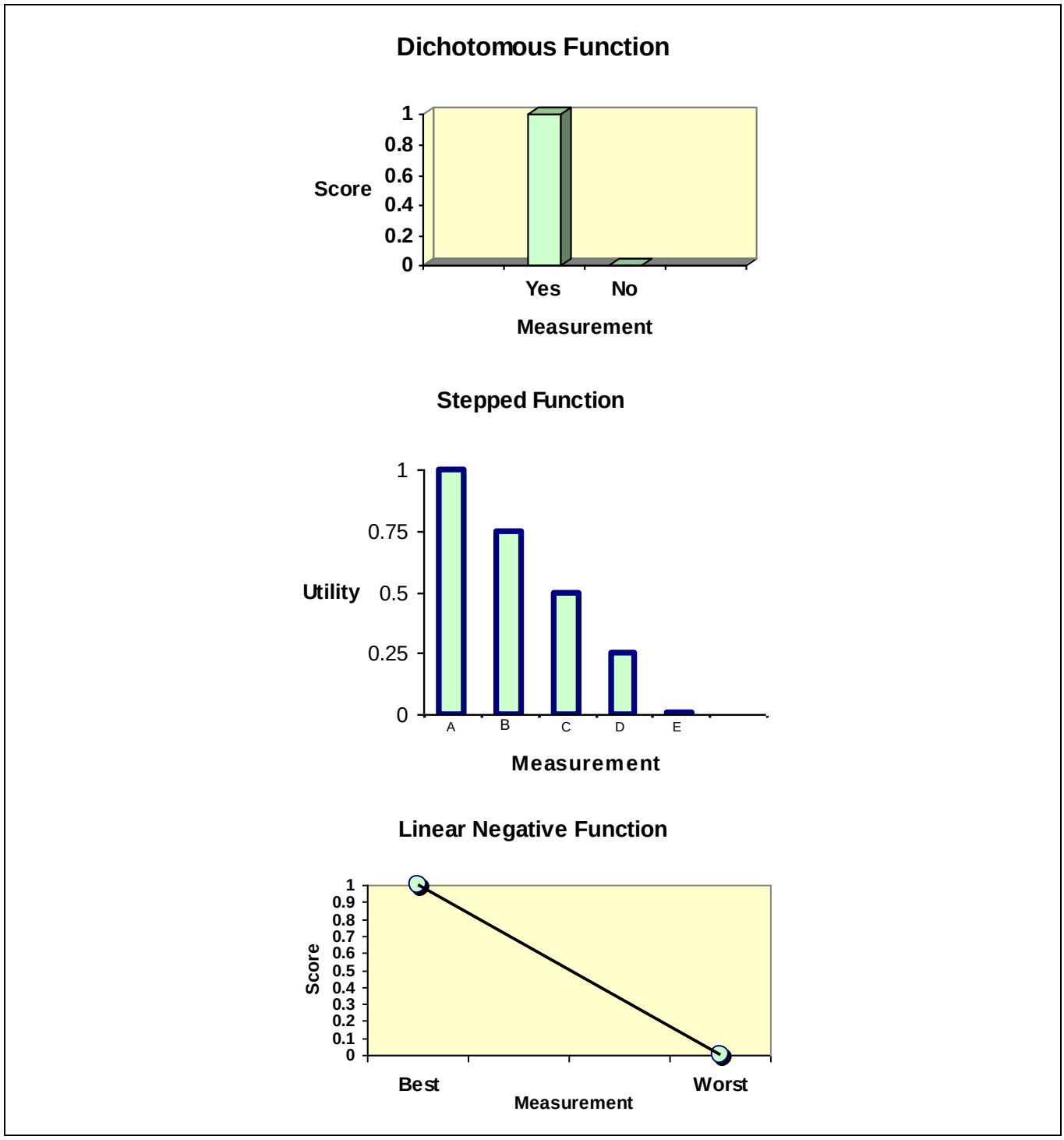
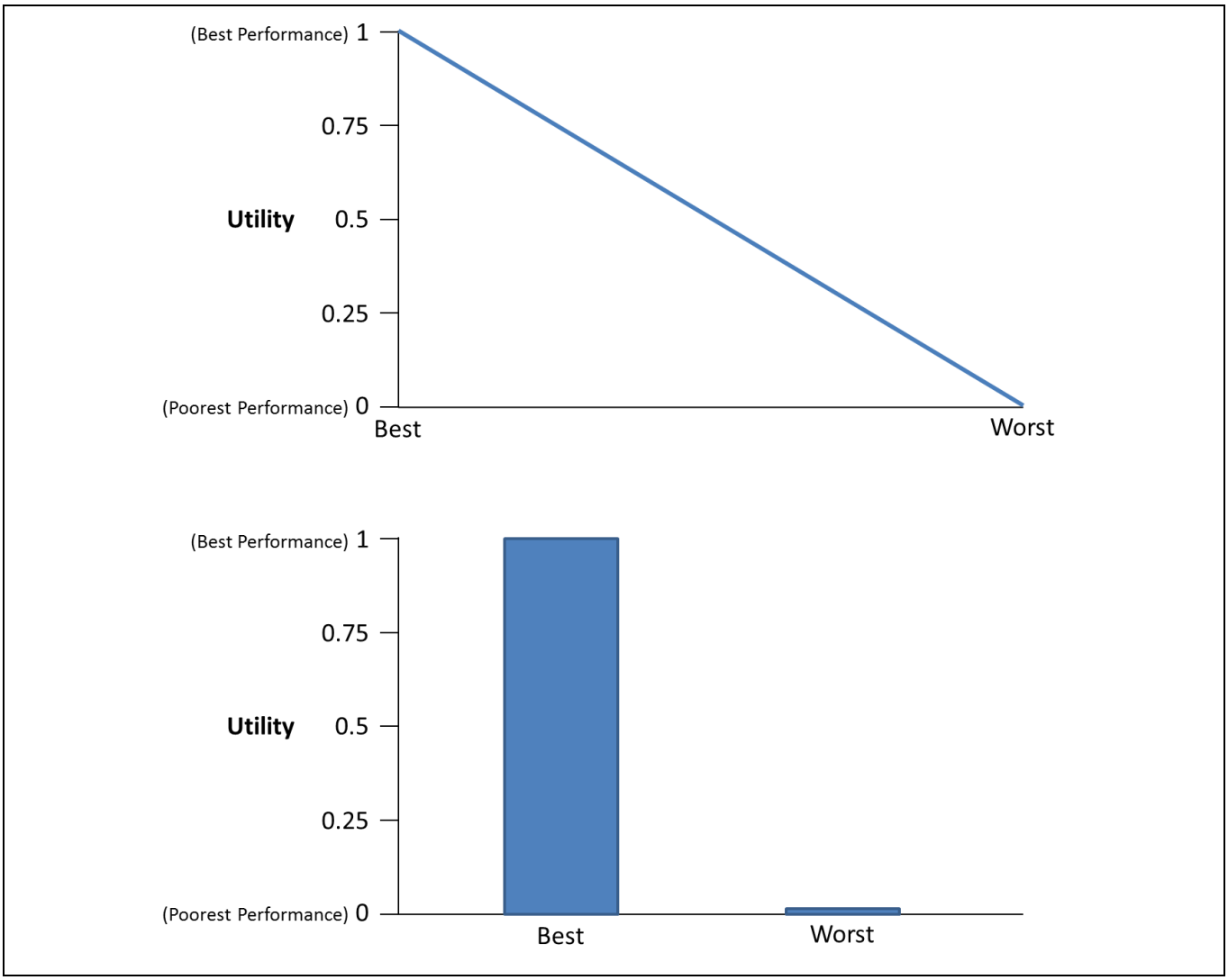


Figure 5: Social Utility Function



5.4 Weighted Score

The total un-weighted utility score of a given alternative can be expressed as:

U (Alternative A) = $\varnothing_1 X_1 + \varnothing_2 X_2 \ldots\ldots + \varnothing_n X_n$, where

U (A) = Total un-weighted utility score for Alternative A

$\varnothing_1$ = attractiveness with respect to parameters

X_1 = measurement of parameter X

Weighted scores are computed using the weights selected by the TAC. The weighted score for each alternative under a specific sub-factor is calculated as follows:

(weighted score) = (utility score x [(factor weight) x (sub-factor weight)])

Using this approach, a generic weighted attractiveness function can be expressed as:

U_w (Alternative A) = $U_1W_1 + U_2W_2 + \ldots. + U_nW_n$

OR

U_w (Alternative A) = $W_1\varnothing_1X_1 + W_2\varnothing_2X_2 \ldots. + W_n\varnothing_nX_n$

Where: U = Total un-weighted utility score for Alternative A

U_w (A) = Total weighted utility score for Alternative A

W_1= Weighted parameter (factor weight x sub-factor weight)

$\varnothing_1$ = Attractiveness with respect to parameter 1

X_1 = Measurement of parameter

The weighted scores of all the sub-factors are then added to give total score for each alternative.

$$U_w(A) = \sum_{X=1}^{n} W_n\varnothing_nX_n$$

5.5 Rating Alternatives

Following the selection of evaluation factors and sub-factors, measurements of the impacts are made using topographic plans, field surveys, and numerical modelling. These

measurements result in data being available under each of the evaluation criteria from which ratings are made for each alternative.

The Weighted Additive Method focuses on the differences of the alternative, addresses the complexity of the base data collected and provides a traceable and defensible decision-making process. This process is a numerical calculation where alternative scores are determined through the use of a mathematical relationship to equate impacts to scores. It eliminates any possible subjective opinions of scores for alternatives because the team does not estimate the score for an alternative.

The scores for each alternative under each of the respective sub-factors are normalized based on measured impacts. Social utility functions are defined to relate impacts to the attractiveness of an alternative. This means that under each sub-factor, the alternative receives an un-weighted rating of between zero and one based on these measurements. The mathematical relationships for calculating scores are developed in consultation with the TAC.

5.6 Sensitivity Testing Program

It should be recognized that the scope of the evaluation and determination of weights for the evaluation criteria are a matter of personal and professional judgement. Accordingly, it is considered essential to conduct sensitivity testing to determine the effect of changing weights assigned to each criterion.

To test how sensitive the outcome of the evaluation is with respect to the assigned weights (i.e. would the result have changed if different weights were used), a sensitivity testing program is undertaken. This results in greater confidence in the selection process and reduces the potential that the average weights bias the outcome of the evaluation.

Often, there is a diversity of opinion in the group as to what weight is appropriate for a factor or sub-factor. When an average weight is used to capture the preferences of the group it loses valuable information on the range of values of the group. To test the range of perspective of the TAC, the highest and lowest weights suggested by anyone in the group are defined as a reasonable range of weights to test. A series of sensitivity tests are performed for the evaluation of alternatives. This allows the team an opportunity to assess the outcome of the evaluation if different weights (different perspectives of importance) are assigned to the factors and sub-factors from the average weights defined by the TAC members. In this way, trade-offs can be identified, credibility can be achieved with the public, and “what if” questions can be answered quickly. See **Figure 6** for an example of the typical range of project team weights and **Table 5** for the ranking of alternatives.

Following the above methodology, a series of tests can be performed varying the weights for each global factor. These tests include:

- Average TAC Team Weight
- Highest Weight by any Team Member
- Lowest Weight by any Team Member

Following this series of tests, the results can be reviewed to assess whether the preferred alternative changes when the weights are varied.

Using this information alone is not the only justification for selecting a particular alternative, but it does provide a level of confidence in the selection. This information is used in the decision-making process before the TPAs are recommended to be carried forward.

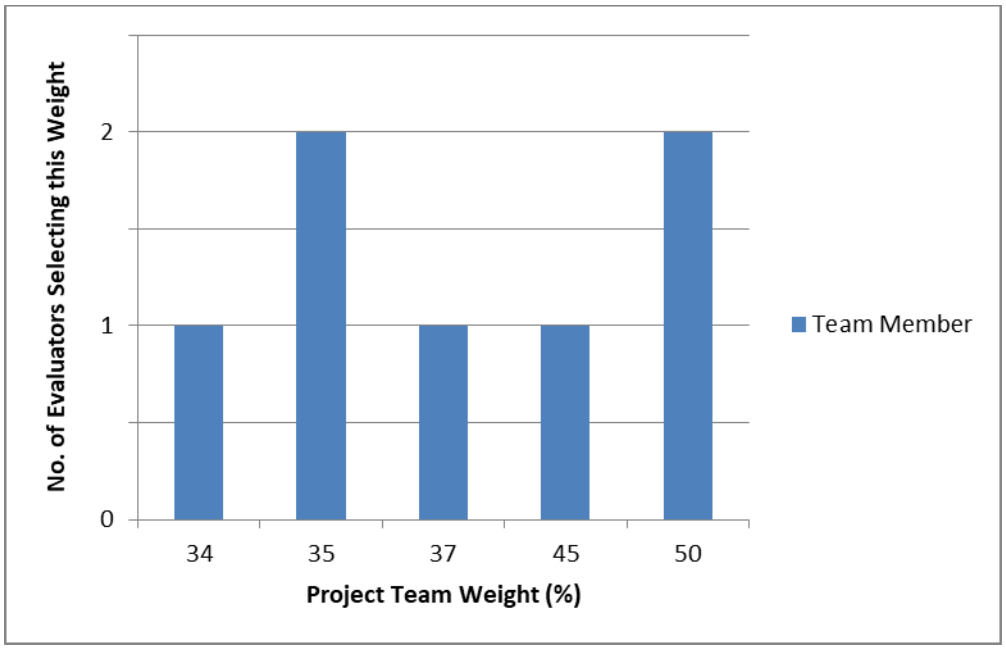


Figure 6: Sample Range of Weights for Traffic and Transportation

Table 5: Sensitivity Test Results

Alternatives			**Alt 1**	**Alt. 2**	**Alt. 4**
FACTORS	WEIGHT	Score:	76.40	45.02	48.88
Ranking			**1**	**3**	**2**
TRANSPORTATION	High	45.00%	1	2	3
	Low	20.00%	1	3	2
NATURAL ENVIRONMENT	High	40.00%	1	3	2
	Low	20.00%	1	2	3
SOCIO-ECONOMIC ENVIRONMENT	High	15.00%	1	3	2
	Low	10.00%	1	3	2
LAND USE AND PROPERTY	High	20.00%	1	2	3
	Low	10.00%	1	3	2
COST	High	10.00%	1	3	2
	Low	2.00%	1	2	3
ENGINEERING	High	15.00%	1	3	2
	Low	5.00%	1	3	2

5.7 Selection of Technically Preferred Alternative (TPA)

The TPA identifies the preferred solution by considering the technical analysis, environmental considerations and comments of all study participants.

The TPA is then presented to the public and external stakeholders. This allows for any comments or questions regarding the proposed design.

It should be recognized that the information and conclusions obtained using the evaluation method are only tools used to assist in the evaluation process and identifying trade-offs. In the end, it is the TAC (Evaluation Committee) which makes the final decision on the selection of the TPA, using both the information obtained throughout the evaluation process and their individual experience and expertise, and through additional input from senior management on funding availability or other program constraints.

The findings of the analysis and evaluation process will be included as a component of the EA Process and documented in the Environmental Study Report. The principles and methodology of the EA process assist the TAC in the analysis and evaluation of alternatives and the selection of the TPA. The public and government agencies have the opportunity to provide input throughout the course of the study.

Glossary of Terms

AASHTO	American Association of State and Highway Transportation Officials
Adjacent	Adjacent indicates lying near MTO or Municipal roadway rights-of-way, although not necessarily contiguous to them.
Aesthetics	Methods of providing visual relief and appealing characteristics to planned noise barriers thorough the application of landscaping designs.
Alternative	Well-defined and distinct course of action that fulfils a given set of requirements. The EA Act distinguishes between "Alternatives to the Undertaking" and "Alternative Methods of Carrying out the Undertaking".
Coarse Screening	Initial screening of a group of alternatives. Also see Screening.
COH	Community Open House
Criterion (Criteria)	Explicit feature or consideration used for comparison of alternatives.
Dichotomous Utility Function	A utility function that represents a desirable or undesirable response from a criterion (yes/no, present/absent, true/false).
Dimensionless Number	A number that does not have a unit of measurement, such as length (m), time (s), mass (kg) associated with it. Examples include Utility Score and Overall Score.
Do Nothing Alternative	This alternative is a mandatory requirement of the Class EA. This alternative is the null or no action alternative and it becomes the baseline to which all alternatives are compared.
Double Counting	Unintentional accounting for a particular factor or attribute more than once in the evaluation.
EA	Environmental Assessment
Environmental Study Report (ESR)	This report is prepared in compliance with the EA Act requirements and the Ministry of the Environment and Climate Change for acceptance, approval, informational or monitoring purposes and the public record.
Evaluation	The outcome of a process that appraises the advantages and disadvantages of alternatives.
Evaluation Criteria	See Criteria.

Evaluation Process	The process involving the identification of criteria, rating of predicted impacts, assignment of weights to criteria, aggregation of weights, and rating to produce an ordering of preference of alternatives.
Factor	See Global Factors.
Function Form	See Utility Function
Global Factors	The main categories of factors, (i.e. Transportation, Economic Environment, Natural Environment, Social and Cultural, Land Use and Property and Cost). All sub-factors are components or a subset of global factors.
Linear Utility Function	A function that can be defined using a linear equation of the form: y = a + bx, where y is the dependent variable (raw score) x is the independent variable (measurement) b is the slope of the function, and a is the y intercept, normalized in this study to be equal to one or zero
Matrix	A rectangular array of criteria and values.
MATS	Multi-Attribute Trade-off System
MECP	Ministry of the Environment, Conservation and Parks
Mitigation	Taking actions that either remove or alleviate to some degree the negative impacts associated with the implementation of alternatives.
MTO	Ministry of Transportation of Ontario
Overall Score	The final value of an alternative's score derived by summing all of the weighted scores.
Performance Factor	See Utility Function
Ranking	The ordering of alternatives from first to last for comparison purposes.
Raw Data	The measurement of the impact, or measured data, under each criterion.
Risk	Probability that a given outcome will or will not materialize. Distinct from uncertainty in that the alternative outcomes are known or defined and that the probability of each is measureable.

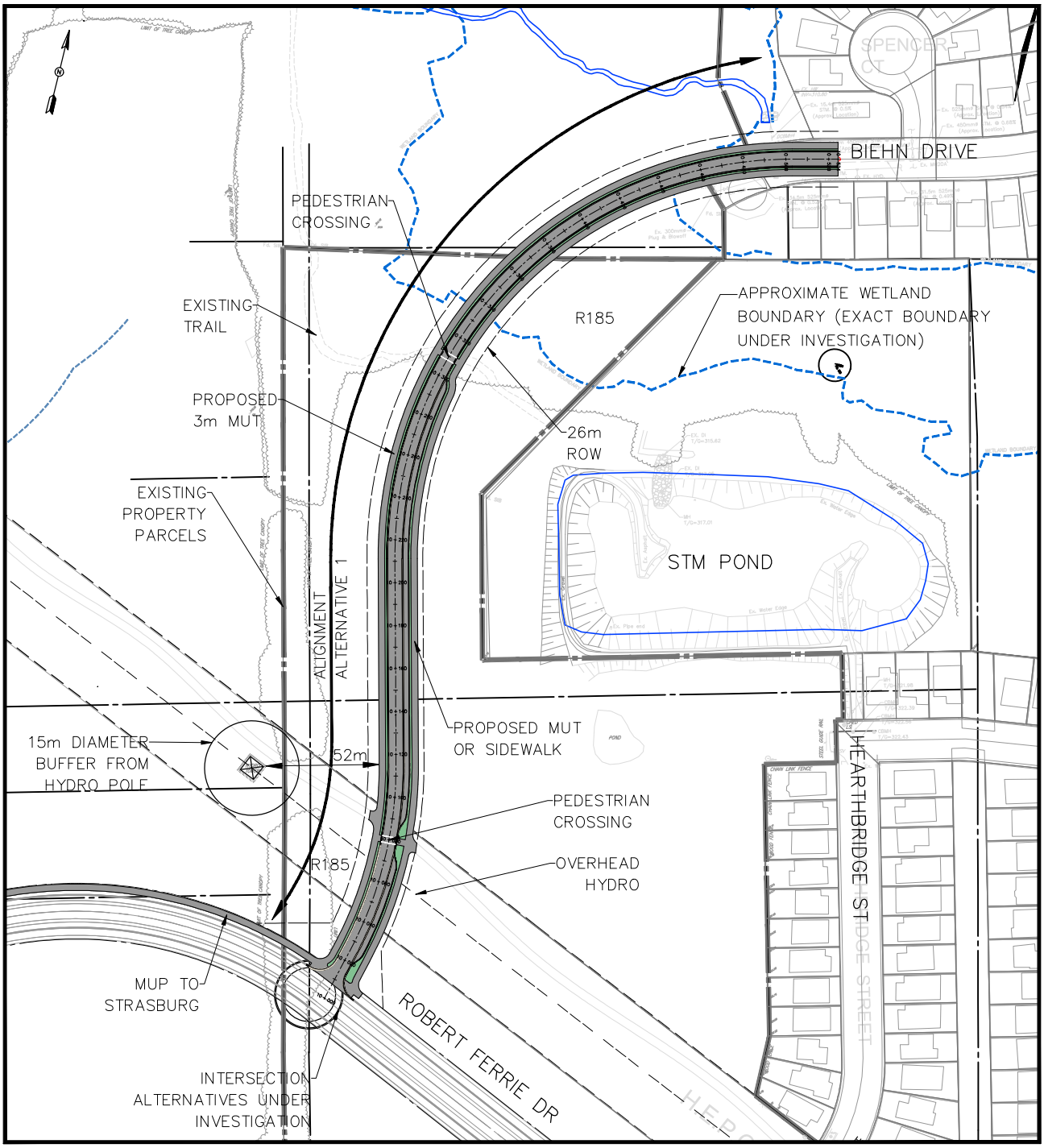
Screening	Process of eliminating alternatives from further consideration, which do not meet minimum conditions or categorical requirements.
Sensitivity Tests	A series of tests to assess the robustness of the evaluation and alternative scores.
Step Function	A utility function can be defined by several linear functions within separate ranges that have a slope equal to zero. For this study, two step functions are used: Case A: y = 1, for x = desirable and y = 0, for x = undesirable Case B: y = 1 for x = desirable, y = 0.5 for x = medium performance and y = o for x = undesirable
Sub-factor	A single criterion used for the evaluation. Each sub-factor is grouped under one of the factors.
TAC	Technical Advisory Committee
TPA	Technically Preferred Alternative
Traceability	Characteristic of an evaluation process which enables its development and implementation to be followed with ease.
Utility Function	A function (linear, step, dichotomous) that represents the Utility Score versus the criterion measurement or desirableness.
Utility Score	The “y” value derived from the Utility Function of the measurement of the impact induced by a particular alternative’s criterion. A measurement of the usefulness or attractiveness of an alternative with respect to an individual evaluation criterion based on its measured effect (a number between 0 and 1). The utility score is dimensionless.
Weight	The importance attributed to a criterion relative to other criterion. The value of the weight is expressed in a percentage and the sum of all criterion weights is equal to 100%.
Weighted Additive Method	The method used in the quantitative evaluation of alternatives, which reduces the project’s numerous criteria into a dimensionless number for each alternative suitable for comparison.
Weighted Score	A raw score that has been multiplied by the criterion weights. The weighted scores reflect the social value or importance of the specific group providing weights.

Appendix B

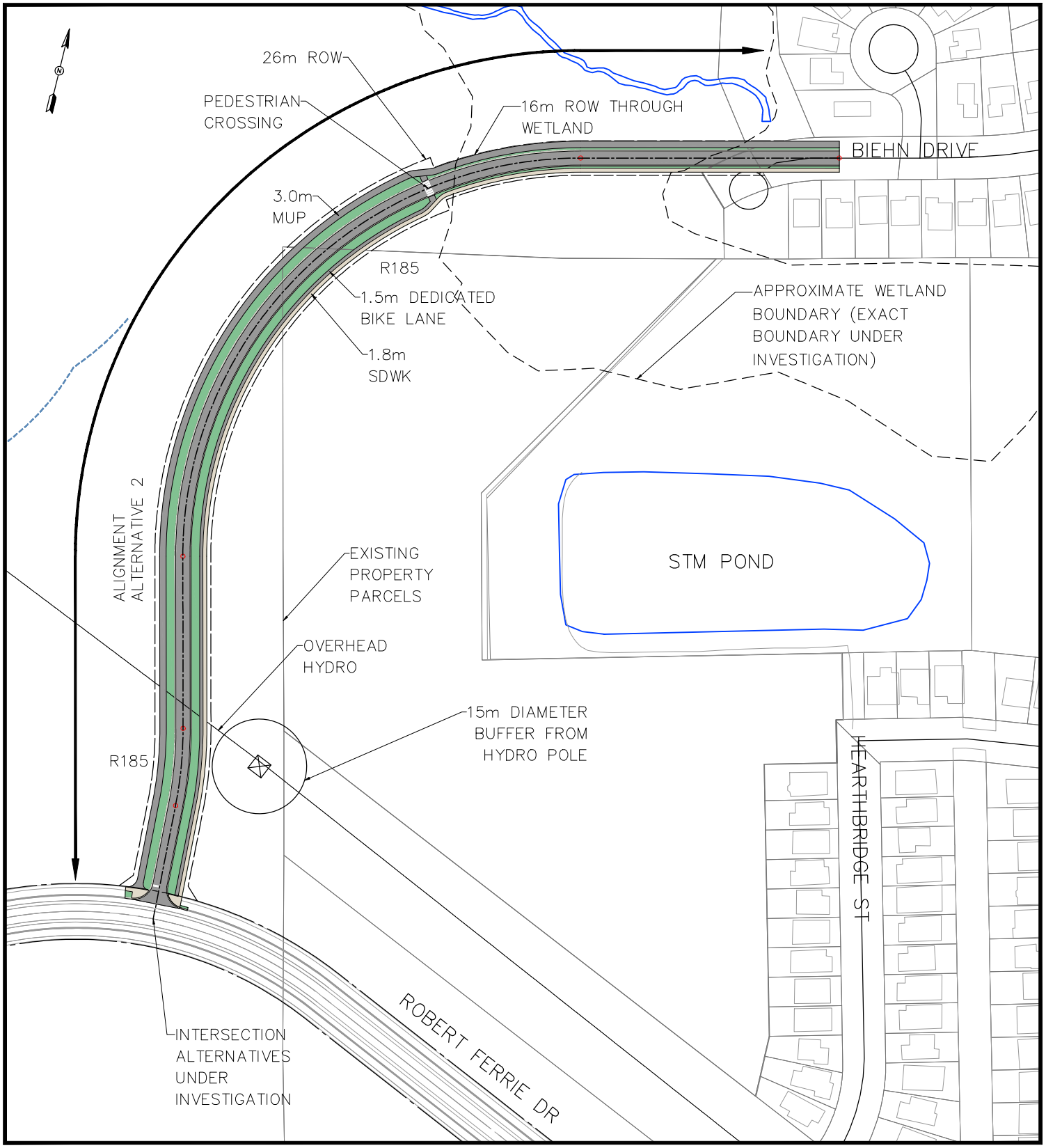
Short-Listed Alignment Corridor Alternatives

BT ENGINEERING

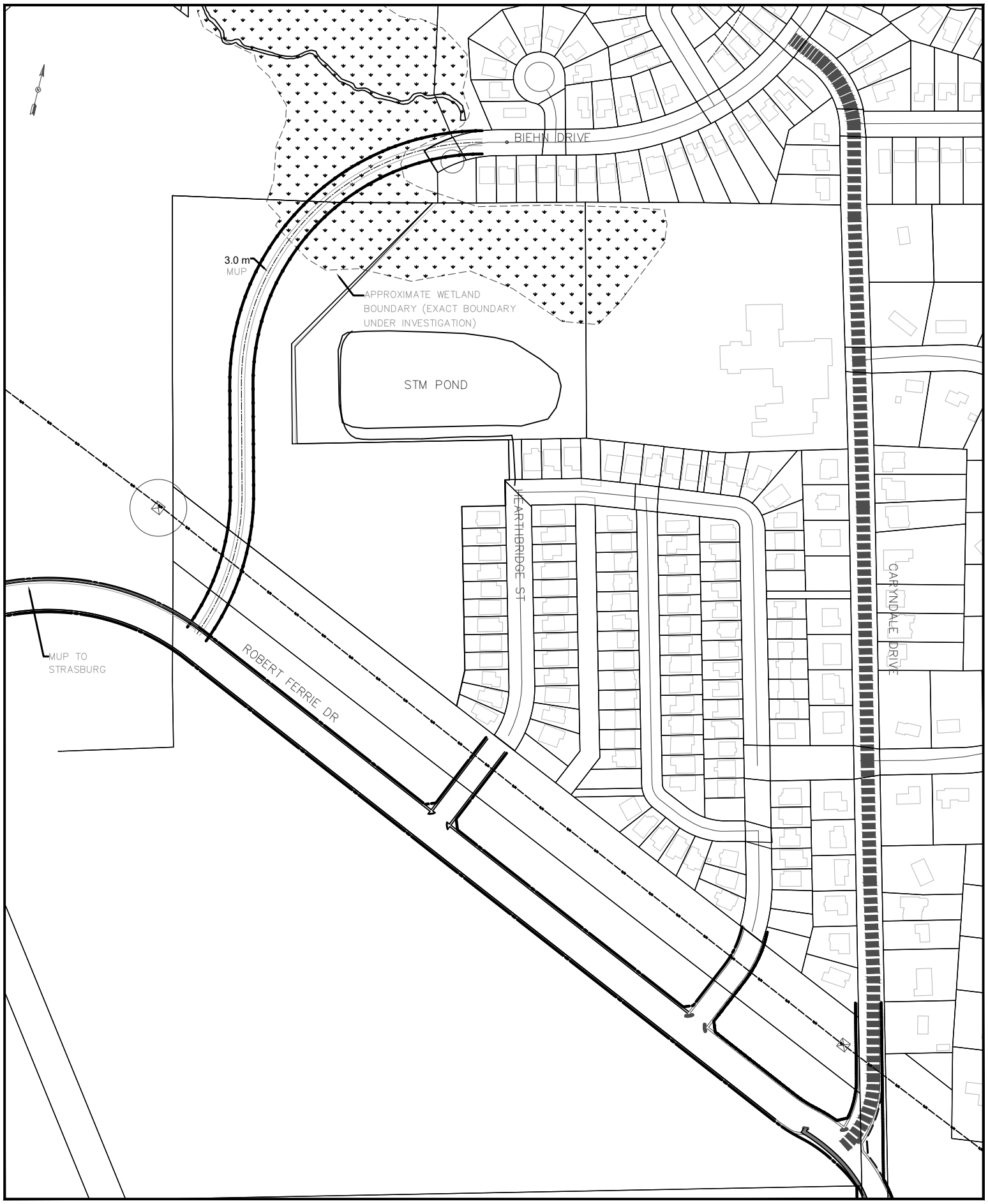
BIEHN DRIVE – ALTERNATIVE 1 – TPA



BIEHN DRIVE – ALTERNATIVE 2



BIEHN DRIVE – ALTERNATIVE 4



Appendix C

Long List of Evaluation Criteria

BT ENGINEERING

Alignment Alternatives
Long List of Evaluation Criteria

Factors and Sub-Factors	Unit of Measure	Carried Forward ?	Remarks
Transportation			
Delays (during construction)	veh-h	✗	All equal
Supports Urban Transit Service	High/Medium / Low	✓	
Improved Emergency Response	Yes/No	✓	
Fuel Consumption	l (litres)	✗	Measured under travel time
Road User Costs	$	✗	Measured under travel time
Roadway Safety	Length (m)	✓	
Roadway Safety - Collision Potential at Intersections	Number	✗	
Active Transportation Connectivity - Conflicts through Communities	Length (km)	✗	All equal. All alternatives provide an active transportation link extension from Biehn Drive westerly.
Active Transportation - Proximity to Community Facilities	number	✗	Covered above
Bicycle - Conflicts with Existing Bicycle Routes	Length (km)	✗	See Active Transportation criterion
Flexibility for Future Expansion	Yes/No	✗	
Horizontal Curvature	degrees of deflection	✗	
Vertical Curves	Number	✗	Meets City standards
Minimum Radius of Curves	m	✗	Meets City standards
Skewed Intersections / Angle of Skewed Intersections	Number	✗	
Level of Service on Local Roads	High/Low	✗	Measured under Efficiency of Travel
Efficiency of Travel	High/Medium /Low	✓	
Compatibility with Integrated Transportation Master Plan	Yes/No	✓	
Safety of School Zone	Yes/No	✓	
Ability to Maintain Existing Roadway Classification	Yes/No	✗	

Factors and Sub-Factors	Unit of Measure	Carried Forward ?	Remarks
Bicycle and Pedestrian Safety - Conflicts with Planned Hydro Corridor Multi-Use Trail	No. of Crossings	✗	
Personal Security of Pedestrians and Cyclists	Yes/No	✓	
Intersection Spacing	m	✓	
Robert Ferrie Drive Intersection Location to Accommodate Future Development	Length (m)	✗	
Natural Environment			
Climate Change - Change in Greenhouse Gas Emissions	Tonnes/year	✗	
Sustainability - Use of Natural Resources to Construct Project	ha	✗	
Aquatic Species at Risk Potential Habitat Impacted	Number of Occurrences	✗	Confirmed by field inventories and mapping.
Potential Species at Risk Potential Habitat Impacted	Number	✗	Potential for Butternut, Black Ash and Myotis species.
Significant Woodlands Removed	ha	✗	
Other Woodlands and Woodlots Removed (does not include significant woodlands)	ha	✗	
Warm / Cool Water Fish Habitat Impacted	m^2	✗	Potential for ephemeral or intermittent watercourses in PSW.
Cold Water Fish Habitat Impacted	m^2	✗	Downstream impacts to Strasburg Creek cold water fish habitat. Confirmed in field that all are equal.
Loss of Fish Habitat	m^2	✗	Measured above.
Water Quality (Stormwater Surface Runoff)	ha	✗	All equal.
Drainage Courses Crossed	Number	✗	Included under Cool/Cold and Warm Water Fish Habitat Impacted and Warm water Fish Habitat Impacted above.

Factors and Sub-Factors	Unit of Measure	Carried Forward ?	Remarks
Stormwater Management Measures (Quantity and Quality Control)	Developed/ undeveloped	✗	All equal. Mitigation for stormwater (road and land development) will include temporal and LID technology.
Type of Soil for Stormwater Management	Type	✗	All equal
Drainage: Road Grades (Slope)	%	✗	All equal. Meets standards.
Wildlife Habitat	ha	✓	
Accommodating Wildlife Movement	Preferred/Not Preferred	✓	
Migratory Bird Nesting Impact	Yes/No	✗	Mitigation measures applied.
Area of Natural and Scientific Interest Removed	ha	✗	No ANSIs.
Provincially Significant Wetland (PSW) Removed	ha	✓	Strasburg Creek PSW
Potential Black Ash Impacted	ha	✓	
Groundwater Infiltration	ha	✓	Strasburg Creek PSW
Conservation of Tree Canopy	ha	✗	Measured under Provincially Significant Wetland Removed
Adjacent Lands Removed	ha	✗	
Fragmentation of PSW	ha	✗	All equal. Each of the alternatives will cross the PSW in the approximate same location. As such, the resultant fragmentation will be nearly identical. Alternative 3 was not carried forward, in part, because it had a larger fragmentation and multiple wetland crossings.
Wetlands Removed	ha	✗	See above.
Unevaluated Wetlands Removed	ha	✗	
Aggregate Resource Area Removed	ha	✗	
Groundwater – Wellhead Protection Sensitivity Areas (WHPA) Vulnerability (GRCA) Area 4	ha	✗	All equal. Sanitary sewer trench to include mitigation (clay seals) to avoid groundwater flow.

Factors and Sub-Factors	Unit of Measure	Carried Forward ?	Remarks
Loss of Flood Plain Storage - Regulated Areas	ha	X	Outside the floodplain.
Kitchener Core Natural Heritage Features/Region Core Environmental Features Impacted, Map 6 Natural Heritage System City of Kitchener Official Plan	ha	X	Included in the PSW criteria.
Specimen Trees	Number	X	All equal
Cultural Environment			
Designated Heritage Property Impacted	ha	X	Not Applicable
Heritage Property Listed in Register Impacted	ha	X	Not Applicable
Heritage Property Impacted (not Designated or Listed)	ha	X	Not Applicable
Heritage Buildings Impacted	Number	X	Not Applicable
Impact to Heritage Landscape Features (fence rows, tree lines, etc.)	High/ Medium/ Low	X	Not Applicable
Cemeteries Impacted	Number	X	See Registered Archaeological Sites
Pre-contact Sites	Number	X	See Registered Archaeological Sites
Post-contact Sites	Number	X	See Registered Archaeological Sites
Mapped 19th Century Structures (no longer standing)	Number	X	Double counted with Post contact sites
Cultural Landscape Features Impacted (not Designated or Registered Historical Properties)	Number of Settlement Areas	X	Not Applicable
Area of Archaeological Potential	ha	X	All equal.
Socio-Economic Environment			
Air Quality (Sensitive Receptors)	Number of Sensitive Receptors	X	All equal.
Sound Level Increases (greater than 55 dBA)	Number	X	No increase.
Sound Level Increases (less than 55 dBA)	Number	X	No increase.

Factors and Sub-Factors	Unit of Measure	Carried Forward ?	Remarks
Vibration Impacts	Number	✗	Measured under Sound Level Increases
Proximity to Hearthwood Park	Number	✗	All equal, avoided.
Emergency Response	Yes/No	✗	Refer to Transportation
Community Festivals Impacted	Yes/No	✗	Avoided
Potential School Pick-up/Drop-off Locations	Number of schools	✗	See Community Disruption.
Community Disruption - Biehn Drive North	Distance (km) through Neighbour-hoods	✓	
Community Disruption - Biehn Drive South	Distance (km) through Neighbour-hoods	✓	
Community Disruption - Caryndale Drive	Distance (km) through Neighbour-hoods	✓	
Institutions Impacted	Number	✗	Brigadoon Public School Considered under Transportation subfactors.
Visual Intrusion to Adjacent Residents	Number	✗	Considered under community disruption.
Pits and Quarries Impacted	Number	✗	
Farming Activity Impacted	hectares	✗	Interim use only. To be redeveloped
Businesses Impacted	Number	✗	
Land Use and Property			
Supports City of Kitchener's Official Plan	Yes/No	✓	
Residences Partially Impacted	Number	✗	
Residential Buyouts	Number	✗	
Low Rise Residential Property Required	ha	✗	All equal. City of Kitchener Official Plan, supported by landowner.
Institutional Property Required	ha	✗	City of Kitchener Official Plan

Factors and Sub-Factors	Unit of Measure	Carried Forward ?	Remarks
Natural Heritage Conservation Property Required	ha	✗	City of Kitchener Official Plan, Measured under Natural Environment
Park Property (Hearthwood Park) Required	ha	✗	City of Kitchener Official Plan
Mineral Aggregate Resource Areas	ha	✗	City of Kitchener Official Plan
Commercial Property Required	ha	✗	Employment Areas are avoided. City of Kitchener Official Plan
Rural Property Required	ha	✗	City of Kitchener Official Plan
New Utility Corridor Crossing Required	Number	✗	Considered under Cost
Communication Towers Impacted	Number	✗	Communication towers are avoided.
Natural Heritage System/Major Open Space Required	ha	✗	Measured under Natural Environment
Hydrology/Hydraulics: Land Uses Upstream of Road	ha	✗	To be determined at a later date
Former Landfill Sites/Potential Site of Environmental Concern Impacted	Number	✗	To be determined at a later date.
Planned Primary Multi-Use Pathway/Connection (Type 1) Impacted, Map 11 Integrated Transportation System City of Kitchener OP	Number	✗	All equal. Trail system is accommodated.
Planned Secondary Multi-Use Pathway/Connection (Type 2) Impacted, Map 11 Integrated Transportation System City of Kitchener OP	Number	✗	All equal. Trail system is accommodated.
Efficient Utilization of Future Development Land	High/ Medium / Low	✓	Measures the efficiency for development.
Crossing of the Hydro Corridor	No. of Crossings	✓	
Property Required	ha	✓	
Cost			
Capital Cost	$	✓	
Operating Costs	$	✗	
Life Cycle Cost	$	✗	

Factors and Sub-Factors	Unit of Measure	Carried Forward ?	Remarks
Engineering			
Stormwater Runoff	High / Medium / Low	X	
Accessibility for maintenance of sanitary sewer	High/low	X	
Biehn Drive Stormwater Enhancement	High/High-Medium /Low	X	
Sanitary Sewer Alignment	Yes/No	X	
Overland Stormwater Management Route	Order of Magnitude	X	

Appendix D

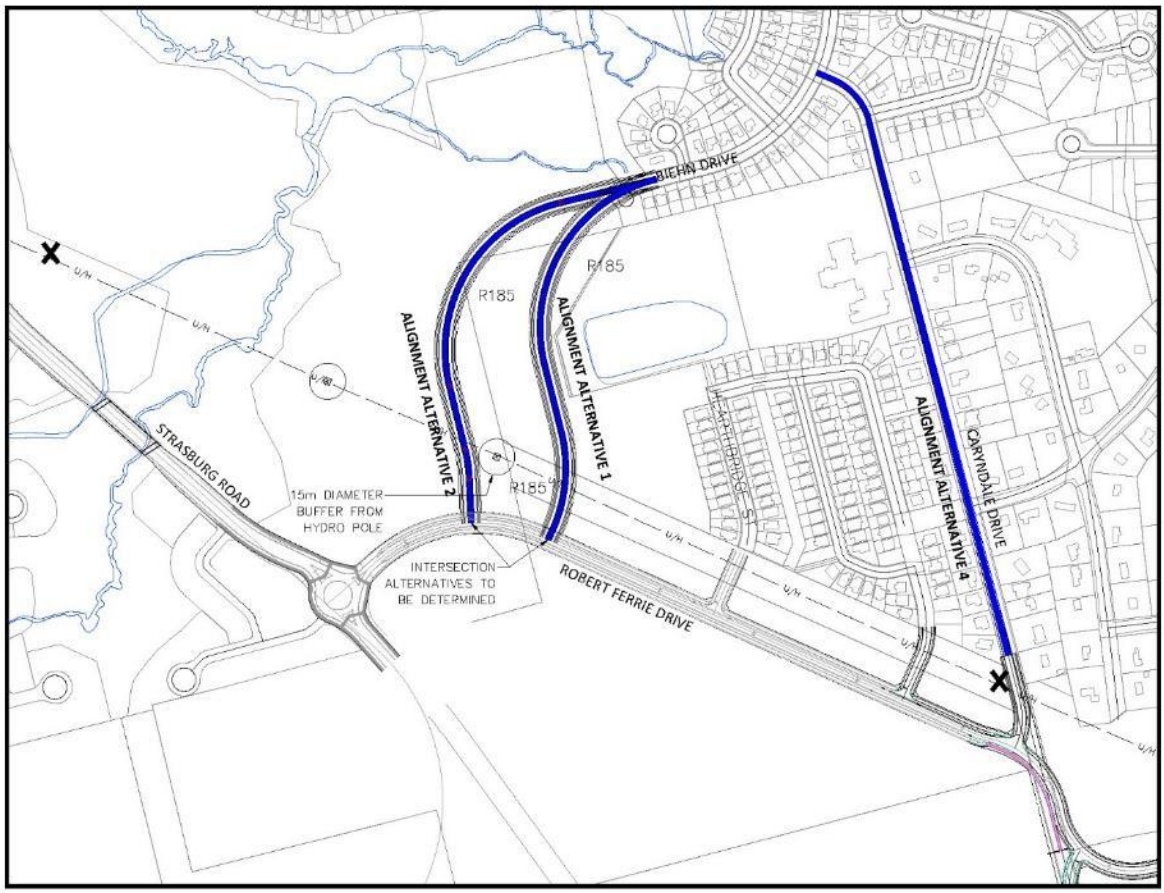
Sub-Factor Definitions

BT ENGINEERING
BTE

Biehn Drive Alignment Alternatives

Alternative	Description
Do Nothing	Existing - Caryndale Drive
Alternative 1	Connect Biehn Drive to Robert Ferrie Drive – East Alignment
Alternative 2	Connect Biehn Drive to Robert Ferrie Drive – Central Alignment
Alternative 4	Existing - Caryndale Drive Provide an Active Transportation Link Municipal Trunk Sewer to follow Alternative 1

Biehn Drive Alignment Alternatives



Scoring Legend based on the Likert system:

	Score
Extreme Negative impact / Highly Unsatisfactory	0.00
Negative impact (Intermediate)	0.25
Neutral / No change / No impact	0.50
Positive Impact (Intermediate)	0.75
Extreme Positive Impact / Highly Satisfactory	1.00

Transportation

Supports Urban Transit Service

Definition: This sub-factor measures the ability to accommodate future transit service, supporting City and Regional Transportation Master Plan objectives to promote alternative travel modes and to support planned area development.

Mitigation: None.

Alternatives:

Alternative	Score
Do Nothing	0
Alternative 1	1
Alternative 2	0.75
Alternative 4	0.25

Transportation

Improved Emergency Response

Definition: This sub-factor considers the benefit to emergency response. To improve the emergency response to the neighbourhood, the provision of alternative routes with an additional access to the community is preferred.

Mitigation: None.

Alternatives:

Alternative	Score
Do Nothing	0
Alternative 1	1
Alternative 2	1
Alternative 4	0

Transportation

Roadway Safety

Definition: This sub-factor measures the length of area collector roads where traffic volumes would be reduced, supporting existing and planned neighbourhood traffic calming measures to improve traffic safety. Alternatives which benefit the greatest length of existing collector roads are preferred.

Mitigation: Implementation of additional traffic calming measures including the potential use of roundabout control can be considered where traffic volumes would not be reduced.

Alternatives:

Alternative	Score
Do Nothing	0
Alternative 1	1
Alternative 2	1
Alternative 4	0.25

Transportation

Compatibility with Integrated Transportation Master Plan

Definition: This sub-factor measures the compatibility with the Integrated Transportation Master Plan which was the basis for the approval of all existing area development. Those alternatives which will result in a more even distribution of traffic consistent with the current roadway classifications are preferred.

This sub-factor considers the existing roadway classifications and the potential requirement to reclassify Caryndale Drive from a minor collector to a major collector. Those alternatives which would allow the existing classifications to be maintained and would not require Caryndale Drive to be reclassified to a major collector are preferred.

Mitigation: None.

Alternatives:

Alternative	Score
Do Nothing	0
Alternative 1	1
Alternative 2	1
Alternative 4	0

Transportation

Safety of School Zone

Definition: This sub-factor considers traffic safety within area School Safety zones. Those alternatives which avoid passing the Brigadoon Public School located on Caryndale Drive are preferred.

Mitigation: Additional traffic calming to further control traffic speeds and increased enforcement.

Use of school crossing guards.

Alternatives:

Alternative	Score
Do Nothing	0
Alternative 1	1
Alternative 2	1
Alternative 4	0.25

Transportation

Personal Security of Pedestrians and Cyclists

Definition: This sub-factor considers the personal security of pedestrians and cyclist where there is a multi-use path adjacent to a roadway. Those alternatives with a multi-use path adjacent to the roadway are preferred.

Mitigation: None.

Alternatives:

Alternative	Score
Do Nothing	0
Alternative 1	0.75
Alternative 2	0.75
Alternative 4	0.25

Transportation

Intersection Spacing/Safety

Definition: This subfactor considers the standard spacing of intersections (250 m) along Robert Ferrie Drive and the effects that closely spaced intersections can have upon traffic operations and vehicle conflicts due to traffic queuing on future development north of Robert Ferrie Drive. The measurement for this sub-factor is in metres. Alternatives that satisfy intersection spacing standards and avoid directing traffic through closely spaced intersections are preferred.

Minimum TAC intersection spacing 250 m.

Mitigation: None.

Alternatives:

Alternative	Score
Do Nothing	0.25
Alternative 1	0.75
Alternative 2	0
Alternative 4	0.25

Natural Environment

Wildlife Habitat

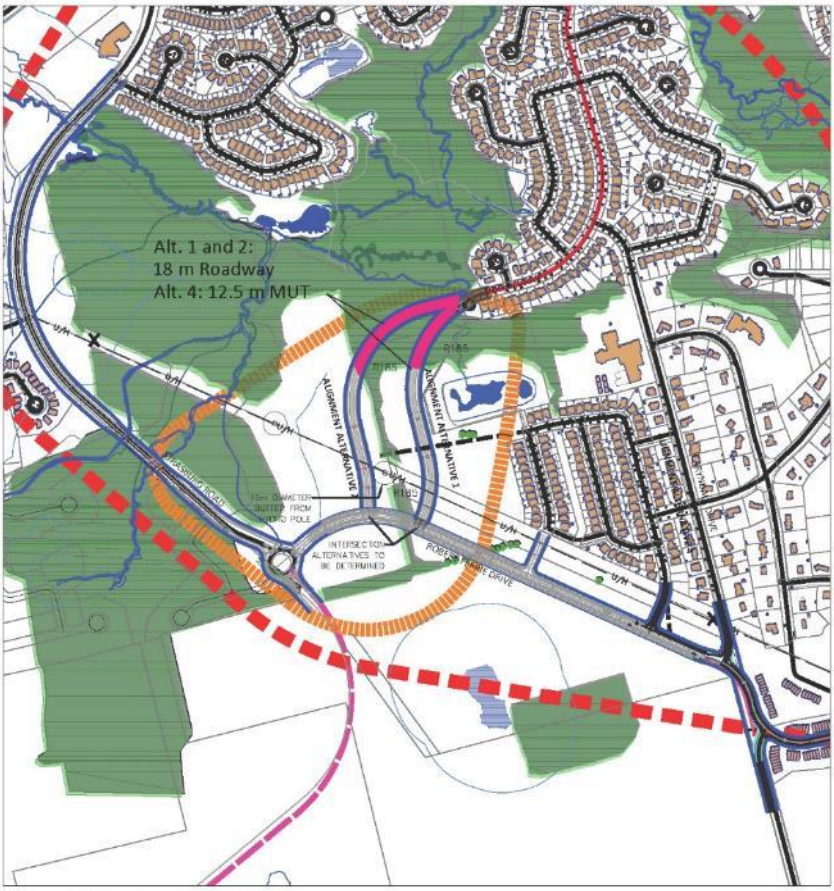
Definition: This sub-factor measures the removal of Wildlife Habitat within the right-of-way, along any of the proposed alternative Alignments.

Those alternatives that remove the least amount of wildlife habitat are preferred.

Mitigation: To be considered for the Technically Preferred Alternative using Best Management Practises and identify enhancement opportunities.

Alternatives:

Alternative	Score
Do Nothing	1
Alternative 1	0
Alternative 2	0
Alternative 4	0.5



Legend

Tree Canopy

Wildlife Habitat Removed

Local Study Area

Broader Study Area

Natural Environment
Source: MTE Survey Aug. 9 2021

City of Kitchener
Biehn Drive Extension Environmental Assessment Study
Municipal Class Environmental Assessment
NTS

Natural Environment

Accommodating Wildlife Movement

Definition: This sub-factor measures the impact on wildlife habitats crossings. The measurement for this sub-factor is the width of the right-of-way and level of traffic for each alternative. The alternative with a narrow right-of-way width and least amount of traffic is preferred.

Do Nothing: No traffic

Alternative 1: Traffic and 26 m ROW 6.6 m paved street and provides a wildlife culvert.

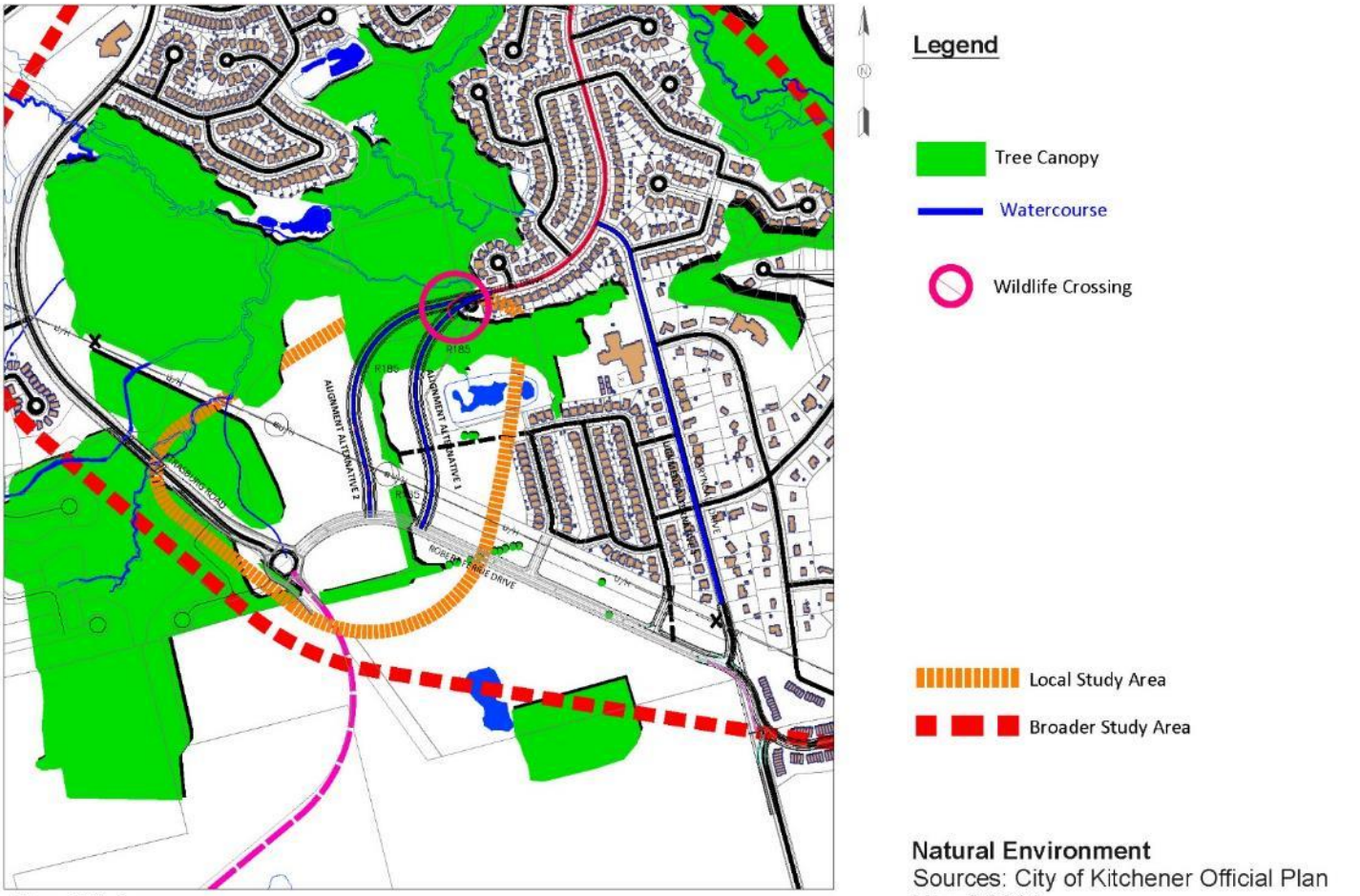
Alternative 2: Traffic and 26 m ROW 6.6 m paved street.

Alternative 4: No traffic.

Mitigation: Provide or enhance alternative wildlife crossings along the alignment.

Alternatives:

Alternative	Score
Do Nothing	1
Alternative 1	0.25
Alternative 2	0
Alternative 4	0.5



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NTS

Natural Environment
Sources: City of Kitchener Official Plan Map 6 2014.
GRCA Open Data License V2 Regulatory Floodplain

Natural Environment

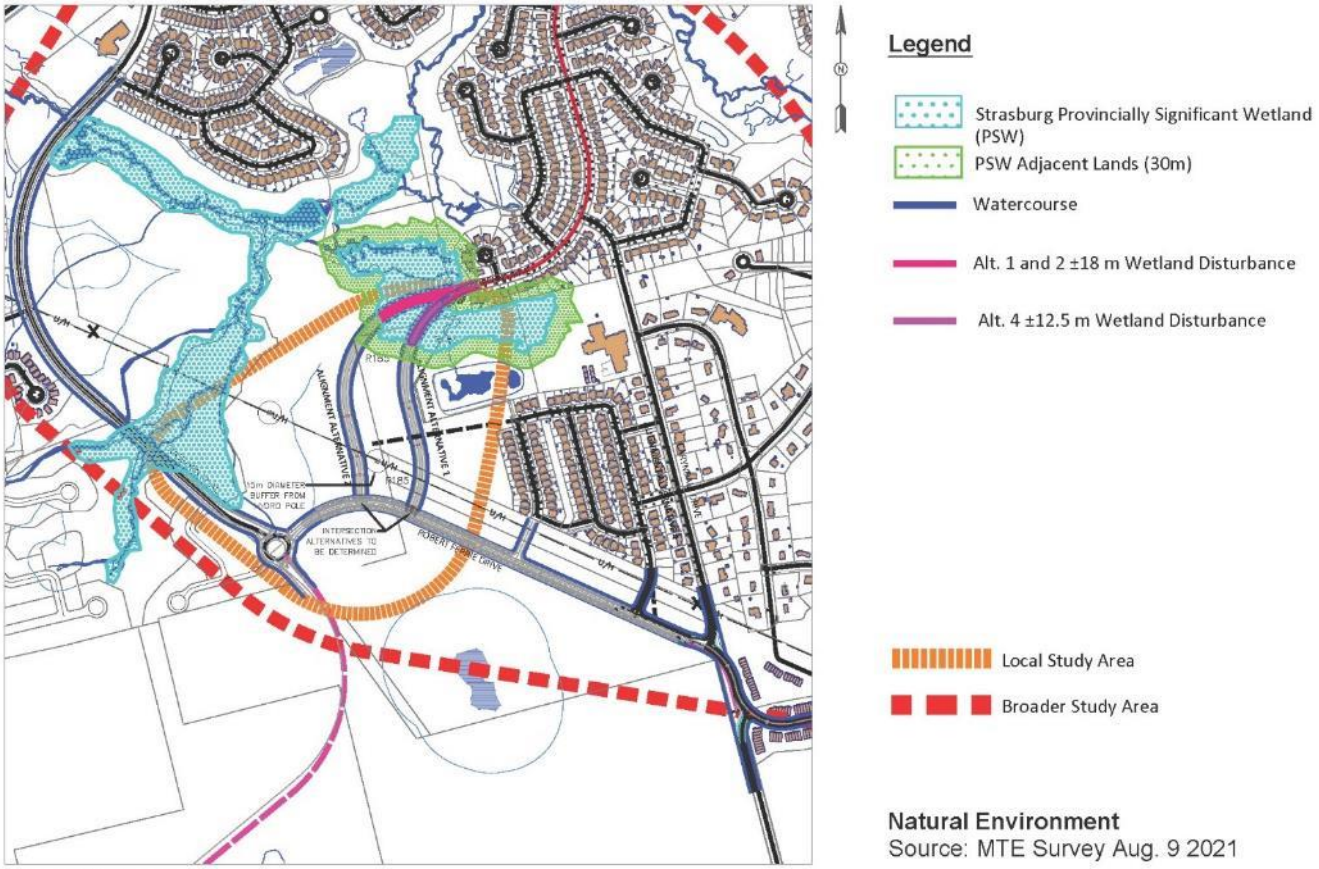
Provincially Significant Wetlands Removed

Definition: This sub-factor measures the removal of Provincially Significant wetlands, including the removal of the tree canopy. The removal of wetland and tree canopy can result in direct habitat loss, may contaminate adjacent habitat, and may also alter existing stream flow and hydrologic patterns. The measurement for this sub-factor is in hectares. Those alternatives that affect the least area of wetlands and tree canopy are preferred.

Mitigation: Develop a wetland mitigation plan prior to construction. The plan will detail pre- and post-construction methodology and practices to prevent contamination or alteration to existing wetland conditions and enhancements or creation opportunities.

Alternatives:

Alternative	Score
Do Nothing	1
Alternative 1	0
Alternative 2	0
Alternative 4	0.5



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Natural Environment

Potential Black Ash Impacted

Definition: This sub-factor measures the potential impact to Black Ash, recently added to the Species at Risk. The City has committed to provide compensation for any loss of Black Ash trees. Those alternatives that affect the least area of Black Ash are preferred.

Mitigation: Compensation.

Alternatives:

Alternative	Score
Do Nothing	1
Alternative 1	0
Alternative 2	0
Alternative 4	0.5

Natural Environment

Groundwater Infiltration of Rainfall

Definition: This sub-factor measures the loss of water permeable area within the Provincially Significant wetlands. The removal of permeable wetland area can result in direct reduction in groundwater and may also alter existing stream flow and hydrologic patterns. The measurement for this sub-factor is in hectares. Those alternatives that affect the least area are preferred.

Mitigation: Introduce LID treatment to allow water infiltration.

Alternatives:

Alternative	Score
Do Nothing	1
Alternative 1	0.25
Alternative 2	0.25
Alternative 4	0.5

Socio-Economic Environment

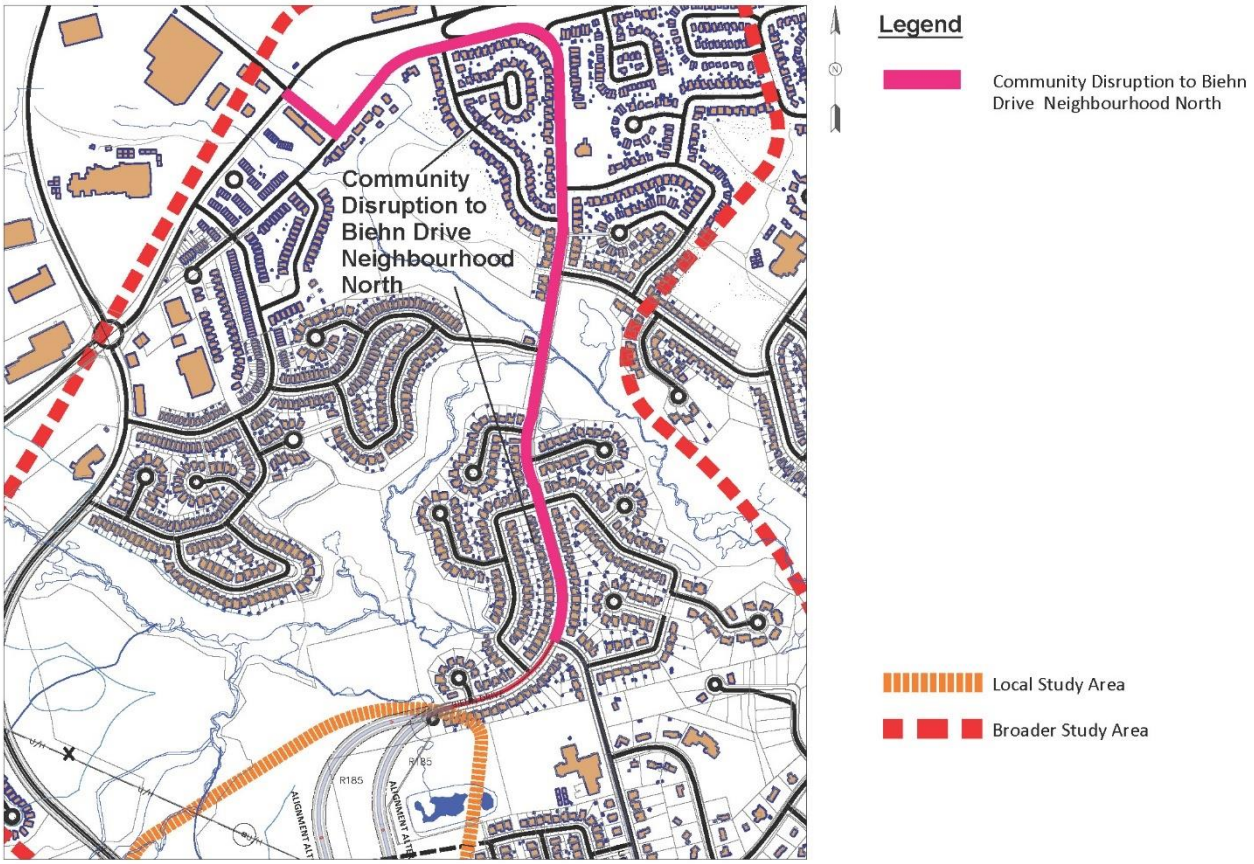
Community Disruption to Biehn Drive North

Definition: This sub-factor measures the impact to neighbourhoods. The measurement for this sub-factor is the length of corridor within the Biehn Drive north neighbourhood. Those alternatives that impact the least number of kilometres within the Biehn Drive north neighbourhood are preferred.

Mitigation: None. (Traffic calming measures are already being developed for implementation.)

Alternatives:

Alternative	Score
Do Nothing	0.5
Alternative 1	1
Alternative 2	1
Alternative 4	0.5



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Municipal Class Environmental Assessment
NTS

Socio-Economic Environment

Socio-Economic Environment

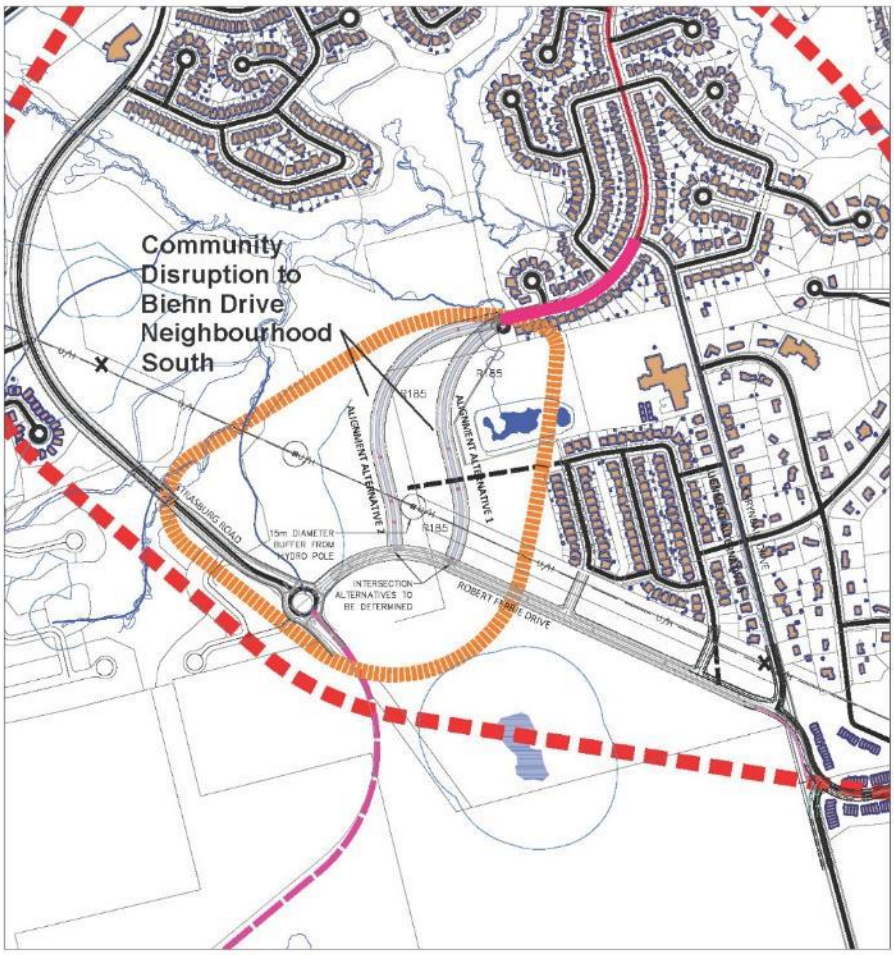
Community Disruption to Biehn Drive South

Definition: This sub-factor measures the impact to neighbourhoods. The measurement for this sub-factor is the length of corridor within the Biehn Drive south neighbourhood. Those alternatives that impact the shortest section within the Biehn Drive south neighbourhood are preferred.

Mitigation: Traffic calming measures.

Alternatives:

Alternative	Score
Do Nothing	0.5
Alternative 1	0.25
Alternative 2	0.25
Alternative 4	0.5



Legend

Community Disruption to Biehn Drive Neighbourhood South

Local Study Area

Broader Study Area

City of Kitchener
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Municipal Class Environmental Assessment
NTS

Socio-Economic Environment

Socio-Economic Environment

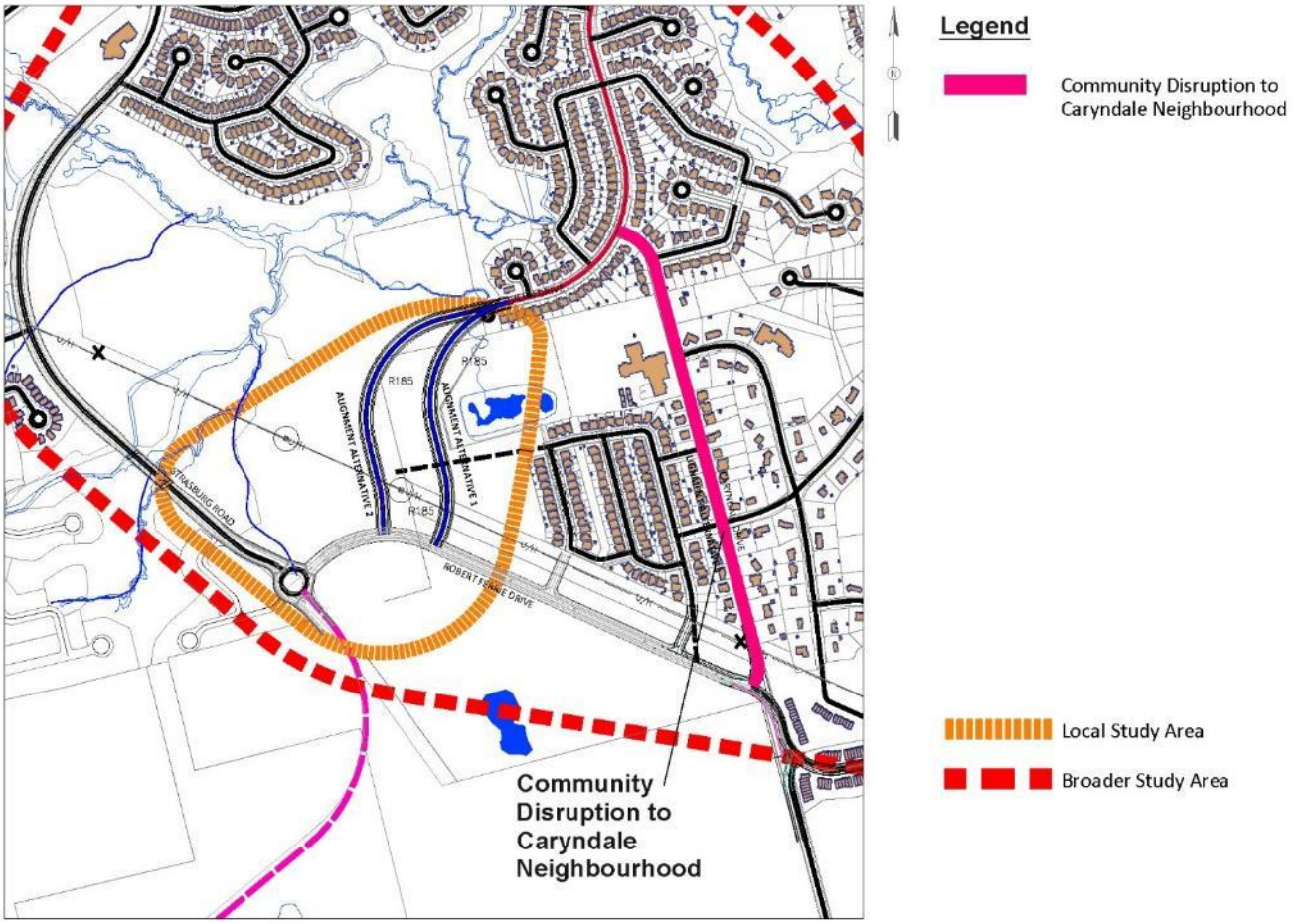
Community Disruption to Caryndale

Definition: This sub-factor measures the impact to neighbourhoods. The measurement for this sub-factor is the length of corridor within the Caryndale neighbourhood. Those alternatives that impact the least number of kilometres within the Caryndale neighbourhood are preferred.

Mitigation: None. (Traffic calming measures have already been implemented.)

Alternatives:

Alternative	Score
Do Nothing	0.25
Alternative 1	0.75
Alternative 2	0.75
Alternative 4	0.5



City of Kitchener
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Municipal Class Environmental Assessment
NTS

Socio-Economic Environment

Land Use and Property

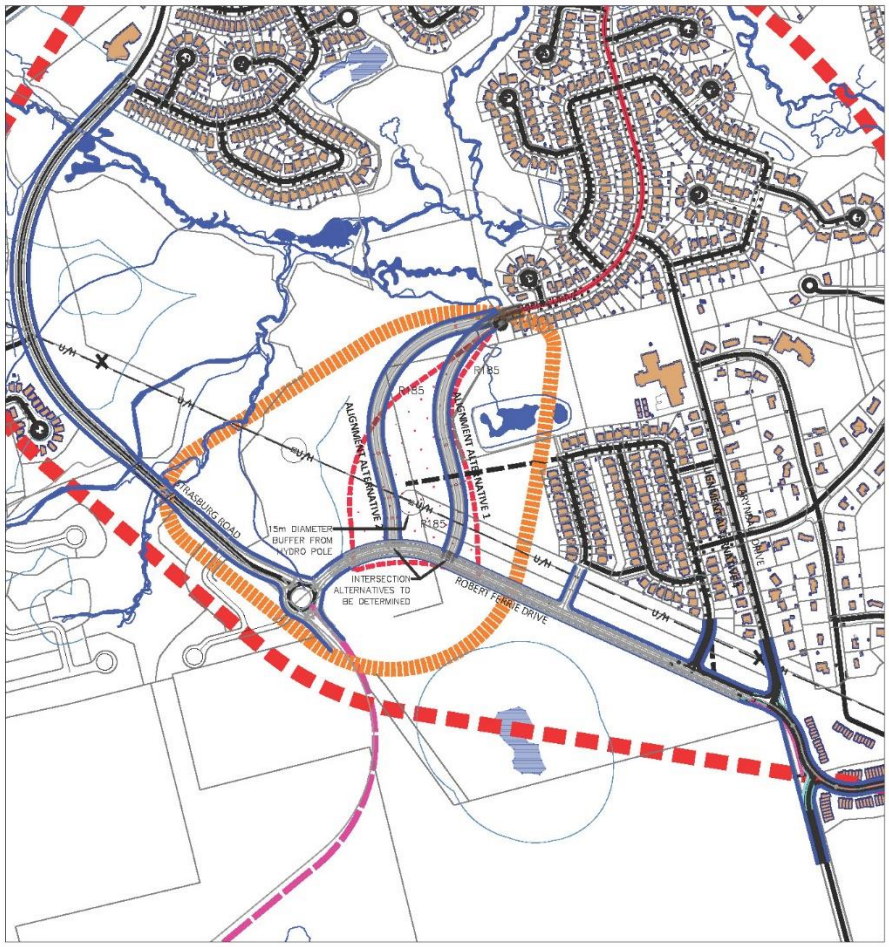
Supports the City of Kitchener's Official Plan

Definition: This sub-factor measures whether the alignment alternative supports the City of Kitchener Official Plan. The measurement for this sub-factor is Yes/ No. Those alternatives that support the Official Plan, which was the basis for all existing development, are preferred.

Mitigation: None.

Alternatives:

Alternative	Score
Do Nothing	0
Alternative 1	1
Alternative 2	1
Alternative 4	0.25



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NTS

Land Use

Land Use and Property

Efficient Utilization of Land

Definition: This sub-factor measures whether the alignment alternative supports the efficient use of lands. Those alternatives that best support access and maximize the land available for development are preferred.

Mitigation: None.

Alternatives:

Alternative	Score
Do Nothing	0
Alternative 1	1
Alternative 2	0.5
Alternative 4	0.25

Land Use and Property

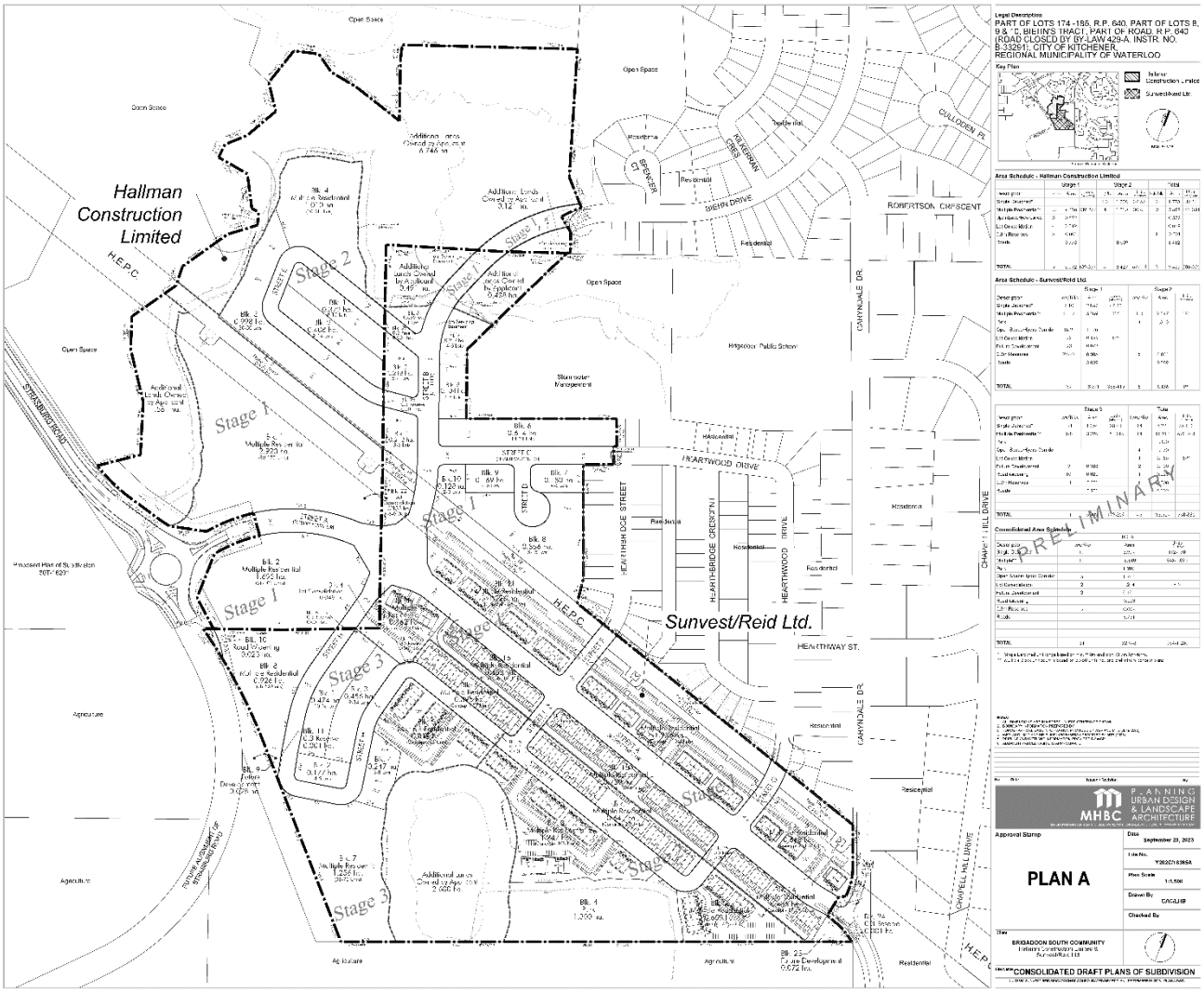
Crossing of the Hydro Corridor

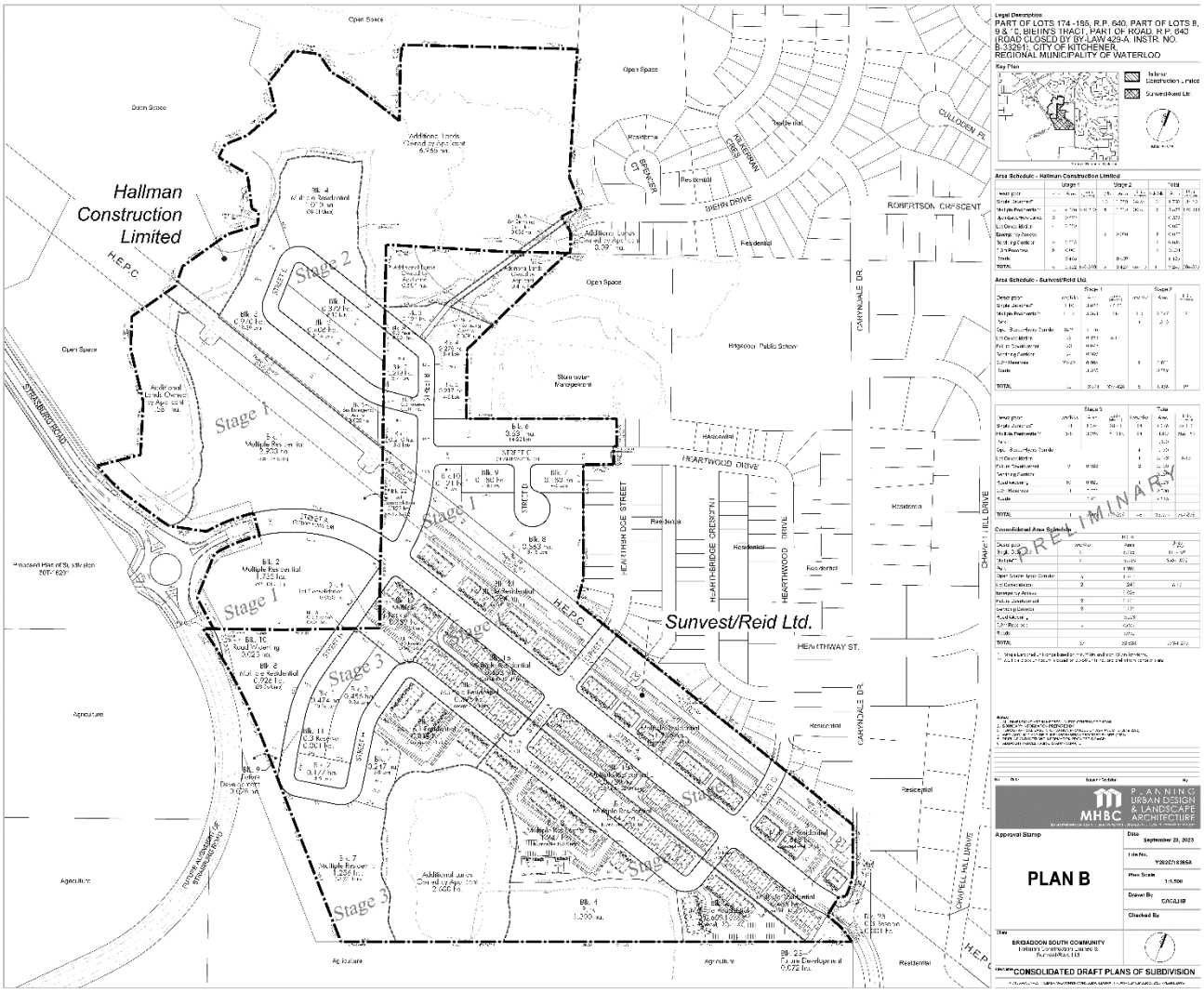
Definition: This sub-factor measures the number of crossings of the hydro corridor. The hydro corridor is a high voltage transmission line. Each crossing/conflict with the hydro corridor will require additional approval from Hydro One. The proposed extension of Biehn Drive would result in one crossing of the hydro corridor. Alternatives with the least number of hydro corridor crossings are preferred. A revised subdivision plan has only one crossing resulting in all the alternatives are equal.

Mitigation: Limit parking under the transmission lines.

Alternatives:

Alternative	Score
Do Nothing	0.5
Alternative 1	0.5
Alternative 2	0.5
Alternative 4	0.5


Hallman Construction Limited
Sunvest/Reid Ltd.
HEARTWOOD DRIVE
HEATHERWOOD DRIVE
HEATHERIDGE CRESCENT
HEATHMEADOW STREET
HEATHERWAY ST.
CAMPBELL HILL DRIVE
CAMPDALE DR.
ROBERTSON CRESCENT
BIEHN DRIVE
CALLODEN PL.
BROWER CT.
ALDERMAN CRES.
STRASBURG ROAD
H.E.P.C.
Open Space
Residential
Agriculture
Stage 1
Stage 2
Stage 3
PRELIMINARY
PLAN A
CONSOLIDATED DRAFT PLANS OF SUBDIVISION
PLANNING URBAN DESIGN & LANDSCAPE ARCHITECTURE
MHBC


Hallman Construction Limited
Sunvest/Reid Ltd.
Stage 1
Stage 2
Stage 3
HEARTWOOD DRIVE
HEATHERWOOD DRIVE
HEATHERBRIDGE CRESCENT
HEATHERWOOD STREET
HEATHWAY ST.
BIEHN DRIVE
ROBERTSON CRESCENT
CAMPDALE DR.
CAMPBELL HILL DRIVE
CALLODEN PL.
BROWER CT.
ALDERMAN CRES.
STRASBURG ROAD
H.E.P.C.
Open Space
Residential
Agriculture
Brigadoon Public School
Stormwater Management
PLAN B
CONSOLIDATED DRAFT PLANS OF SUBDIVISION
PRELIMINARY

Cost

Capital Cost

Definition: This sub-factor measures the total capital cost of the alternative (including land purchasing, permitting, etc.). Cost estimates are for the alternative alignments in 2023. Those alternatives with the lowest capital cost are preferred.

Mitigation: Not applicable.

Alternatives:

Alternative	Score
Do Nothing	1
Alternative 1	0
Alternative 2	0
Alternative 4	0.25

Appendix M

Council Resolution

BT ENGINEERING

City of Kitchener
Resolution Page
Council Meeting

Title: Biehn Drive and Sanitary Trunk Sewer Environmental Assessment, DSD-2024-374, listed as item 7.1.c (Cont'd)

Date: Monday, December 16, 2024

Moved by Councillor M. Johnston

Seconded by Councillor D. Schnider

"That the Biehn Drive and Trunk Sanitary Sewer Extension Class Environmental Assessment (EA) - Environmental Study Report (ESR), prepared by BT Engineering, dated November 2024, attached to Development Services Department report DSD-2024-374, be received; and further,

That the Biehn Drive and Trunk Sanitary Sewer Extension Environmental Study Report (ESR), be filed with the Ministry of the Environment Conservation and Parks (MECP) for the mandatory thirty (30) day review period as required by the Environmental Assessment (EA) Act."

Carried, on a recorded vote

Internal memo

Corporate Services Department

www.kitchener.ca

Date: March 9, 2023

To: E. Riek, Project Manager

From: M. Mills, Committee Administrator

cc: C. Reyes

Subject: Biehn Drive and Sanitary Trunk Sewer Extension Class Environmental Assessment (EA) - Environmental Study Report

This is to advise that City Council at its regular meeting held on Monday, February 27, 2023 passed the following resolution:

> “That the following motion be **deferred to the March 20, 2023 Council Meeting** to allow an opportunity to further review the scoring for alternative 4 outlined in the Environmental Assessment; the traffic demand needs for the community; alternative servicing and construction options; additional environmental impacts such as flooding and salt contamination; impacts on future development and housing supply; and, future construction of Robert Ferrie Drive:
>
> > "That the Biehn Drive and Trunk Sanitary Sewer Extension Class Environmental Assessment (EA) - Environmental Study Report (ESR), prepared by BT Engineering, dated January 18, 2023, be received; and, That the Biehn Drive and Trunk Sanitary Sewer Extension Environmental Study Report (ESR), be filed with the Ministry of the Environment Conservation and Parks (MECP) for the mandatory thirty (30) day review period as required by the Environmental Assessment (EA) Act, as outlined in Development Services Department report DSD-2022-188."

M. Mills

Summary/Conclusion of New Information Presented for March 20, 2023

by Bonnie Bender-Vargas

Re: Biehn Dr. Extension

Good Evening Mayor and Council Members.

Before I begin our conclusion, I would like to thank Councillors Chapman, Deneault, and Owodunni for joining us on the walking tour of our wetland and trails around the end of Biehn Dr., as well as Regional Councillor James and David Weber from the Green Party.

In summary, there is a solution that enables us to satisfy the needs of development with those of the environment and preserving our green space. The answer is simple: a combination of Alternatives 1 and 4 from the Environmental Study Report, where traffic is routed along Caryndale Drive and municipal services are installed using directional drilling – without the need for extending Biehn Drive through PSW-30.

This solution would:

- Safeguard the wetland, including its vegetation, streams and pond
- Protect wildlife such as the brook trout and other species, endangered or otherwise
- Prevent groundwater and drinking water contamination caused by salt runoff
- Maintain critical flood-prevention infrastructure and minimize insurance costs
- Respect the warnings and forecasts from the environmental experts … yes, we have a climate emergency. A lot has happened since the 30 years that this has been "on the books," and I would hope that elected officials execute plans based on the best, current data

The results of the "risk" solution, by extending Biehn Dr, seem to "split hairs" in that we really don't know what will happen to the wetland until it happens … then it's too late. But we do know for sure that:

- The wetland would absolutely and unavoidably, suffer damage from the construction of a trenched sewer and road extension
- Construction would be disruptive to wildlife during the process, and despite the proposed culvert, would almost certainly result in injuries and roadkill once traffic begins to flow.
- The brook trout would be affected, due to their well-known and data-backed sensitivity to salt runoff
- There is a huge concern of the impact of salt runoff on groundwater, which is a stated concern of the Region of Waterloo
- There is a real possibility of impact on the availability and cost of flood insurance in an already flood-prone area, should construction impact the wetland's ability to absorb storm water

Bulldoze and build, bulldoze and build. This is what some call progress.

I would define progress as working together with the City, its development interests, and local residents, to protect wetlands, in order to achieve the common goal: smart, and still profitable, development that maximizes preservation of green space for the benefit of all.

Trees filter air pollution and purify water. The more trees we remove, and wetlands we damage, the less filter we have. A CTV article from February 17, 2023, which was cross-posted to the front page of the Waterloo Region Record on February 27th, noted that Kitchener was ranked fourth out of the most polluted 16 Canadian cities, based on measurements of airborne fine particulate matter. This equates to each Kitchener resident inhaling 115 cigarettes per year, whether they want to or not. Paving wetlands results in irreversible damage for innumerable species of trees and wildlife, and, yes, including our own species.

Our presenters provided you with research from renowned experts to save the Wetland, including:

Dr. Nandita Basu, Professor Gail Krantzberg, and from the Government of Canada's heavily promoted video we watched earlier this evening. The Government's core thesis is that wetlands are a major line of defence in nature-based climate change solutions.

The City of Kitchener has been a leader and put itself on the map in so many ways, including the work with directional drilling on Dodge Drive. Let's continue that progress and not follow in the footsteps of Oakville, which is facing a class-action lawsuit from residents over water damage due to overzealous development. We can respect and be stewards of the Wetland, and yet continue to satisfy those who build and develop the infrastructure, roads, and buildings we need… just by looking at alternatives. There are always alternatives if we just work together and keep an open mind. Let's look at the using Caryndale Dr. as the traffic route to Robert Ferrie. Let's look at Directional Drilling.

As our mayor has stated in the past: "Build a better Kitchener together", "Work together with our citizens." With the many attendees joining us this evening, both in person and virtually, we, citizens of this City, ask that you be a leader when voting on this matter.

Thank You.

Thank you Mayor and council.

I am here to address the Biehn Dr. Extension project and speak to what us residents encounter having our houses in this wetland. It is my hope that with this information, you can make an informed decision that will not negatively impact the houses in the area.
We have lived in our house for 6 years and we learned quickly that our house and many others had water and flooding issues that dated back to the building of these houses. The first spring we were in the house, the basement flooded. We demo'ed the basement and left it for 2 years. In that time we had 3 additional floods. The constant presence of the water table against the concrete foundations causes regular cracks. Some homeowners have not been able to get insurance or have such high deductibles that it renders the insurance useless to protect them, such is my neighbours situation in which their deductible soared to $5000.
Every house in this area has sump pumps, usually 2 as back ups are needed. They regularly run even in the winter.

So what does this mean to you? And how can we as a city address these concerns?

Recently, a study from the University of Waterloo was published regarding the effects of climate change on the Canadian housing market. Its purpose was to inform home owners, mortgage lenders and municipalities. It examined whether catastrophic flooding affects house sold prices, days on market and number of listings. The 2 primary factors of climate change they noted was increased overall precipitation and loss of natural infrastructure (eg forests, grasslands and wetlands) which act as sponges. Among other detrimental effects to the market, the biggest and most notable finding was a 44.3% reduction in listings. As low level of listings is a significant factor in housing affordability, we should be mindful of that.

It gave 6 recommendations, one of which was directed specifically to governments. It was recommended to enforce guidelines and standards to retain and restore natural infrastructure to limit current and future flood risk. Many delegations have spoken on the harm that road construction will do to this area and was admitted by the consultants that this construction would likely raise the water table in the area. That's a concern not only for current residents but for the potential new ones. We don't want the city council to continue with the project after these many warnings from biologists, engineers, and residents alike. The implications of continuing this project in the suggested form with the full knowledge of how we and future homeowners will be negatively affected is arguably a big liability for council. There is currently a $1B class action suit by Oakville residents against the city and province claiming certain development made some homes into a flood plain that were previously not in one.
Should the water table rise and flood our homes are we prepared for the possibility of a class action law suit?
I urge you to consider the detrimental effects this project will have on us. There are many experts that agree with protecting wetlands: let's listen to them.

Biehn Drive Extension Presentation – Council Meeting March 20, 2023

Mayor and Council Members

My name is Kelli Kuzyk and I am a long-time resident of Brigadoon living on Caryndale Drive very close to Brigadoon School. A few weeks ago, I presented information regarding the changes and improvements I have personally seen in the local traffic flow in the Biehn and Caryndale Drive area.

Further to our presentations, concerns were raised by City Staff regarding better public transit and accessibility to the neighbourhood by emergency services — it is these two issues I will address tonight.

Brigadoon is a fully developed subdivision yet has always lacked good transit options since it was completed in 1989. Today, the closest bus stop for Brigadoon residents is on the corner of Biehn and Black Walnut Drives, about a 12 minute walk for many people in this area. We are aligned with the City that transit access should be expanded. Opportunities already exist to incorporate bus stops within Hearthwood Hills, a subdivision off of Caryndale Drive and to return the bus stop back onto Biehn Drive that was close to the intersection of Caryndale. Future opportunities also exist to put in new transit stops within the new development that is being planned with the goal of aligning all routes in the area, including those already present in the Doon South Community. We do believe with these improvements, we can link the various communities together and create a far better transit solution going forward.

(1st slide)

We also heard at the last Committee meeting concerns raised by the City about the inability of emergency services to fully access Biehn Drive south of Marl Meadow in the event of a road closure. I would like to refer you to the map on your screen with the streets outlined in pink. You will note that both Kilkerran and Robertson Crescents allow for ample access to Biehn Drive. Kilkerran connects with Biehn at two points, while Robertson Crescent enables a bypass of part of Biehn Drive using Caryndale. We believe that both these routes adequately meet the needs of emergency services to fully access Biehn Drive

appropriately without the need for the extension going through a wetland. Further, in the 35 years residents have lived in this area on Biehn Drive, we are not aware of any issue being reported where access was ever impeded.

(2nd slide)

In light of my remarks, we respectfully urge you to fully consider this new information presented tonight. Alternative 4 as shown on the map in purple will work well for the current and anticipated traffic flow connecting the various communities; the Alternative 1 route in yellow will address the need to put in the municipal services in conjunction with directional drilling but with no planned extension of Biehn Drive. We also shouldn't lose sight of the potential of enhancing the trail system in the new development to link to Brigadoon Woods without invasive measures. We know that the existence of lots of green space and trails is very attractive for potential homeowners.

Truly, this is a win-win solution for all parties, including the Developers and the wildlife in PSW-30, as well as Ward's Pond. It is the best solution for preserving our wetland and its habitat which is so precious to this area. It eliminates a great deal of liability and risk to the City should groundwater become contaminated, and should flooding and property damage ensue — damage that would no doubt result in lawsuits —AND it still allows for good traffic flow, new transit options, and adequate emergency services access.

Thank you for allowing our presence and voices to be seen and heard again. Thank you for keeping our environment at the forefront as you discuss and vote on this. Together we can implement a solution that is responsible, viable, but most importantly protects the wetlands that need protecting.

Tributaries and Confluences in the **Provincially Significant Wetlands** (PSW-30)

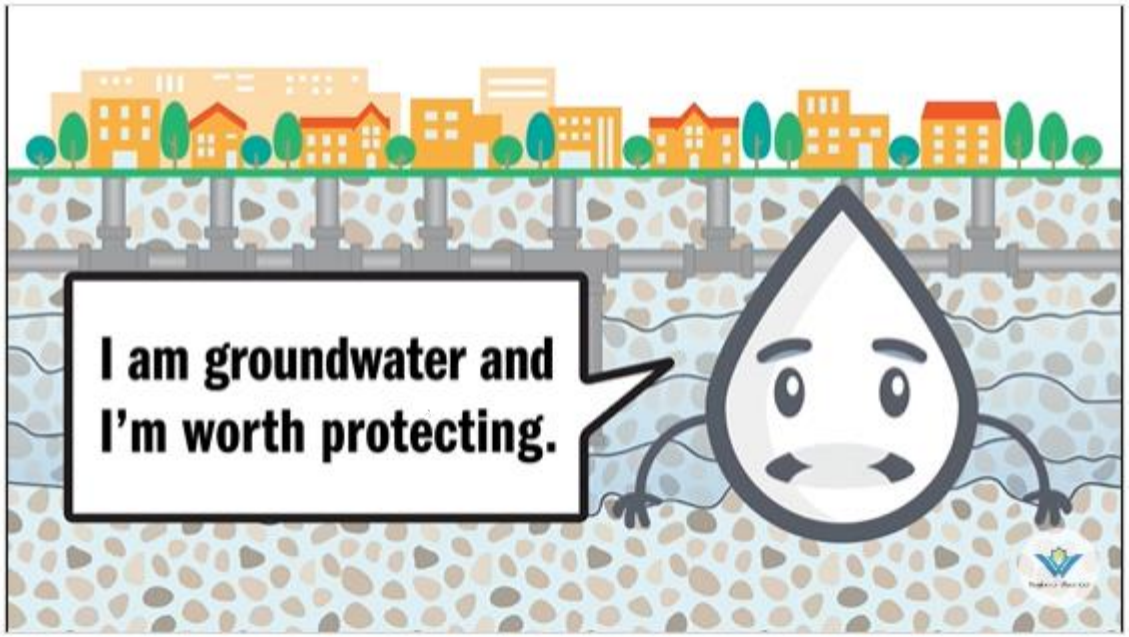
Protecting Natural Biodiversity in the PSW-30

In 2010, the City of Kitchener invested $2 million in the rehabilitation of Strasburg Creek and Wards Pond.

Project Success

Since its rehabilitation in the summer of 2010, Strasburg Creek has demonstrated significant improvements in aquatic environments within Strasburg Creek and Wards Pond.

Region of Waterloo Committed to Protecting Groundwater



Region of Waterloo website design

Region of Waterloo poster design

Wetland Discharge, Confluence, Tributary

Wetlands discharge water to the watershed.

Confluence: where two or more bodies of water meet, usually refers to the joining of tributaries.

Tributary: stream flowing into a larger river, pond, or lake

Dr. Nandita Basu, University of Waterloo
Professor & Canada Research Chair in Global Water Sustainability and Ecohydrology
Director, Collaborative Water Program
Civil and Environmental Engineering

Feb 6 2023, Podcast CBC Morning Edition KW

Small and Isolated Wetlands should be protected rather than paved over

> "They are so important because they catch the pollutant run-off from our farm fields, from our paved roads, and retain them, they hold onto them and that pollutant doesn't show up in our lakes, our rivers, our downstream water bodies. They are a big filter."

> "We found that if you have a small wetland that is in your neighbourhood or in your backyard, that actually can be twice as effective at retaining pollutants than the wetlands you can see near the lake."

> Once a wetland is gone, can it ever be brought back? ... "it takes hundreds of years"

> "Wetlands store carbon, and these functions take hundreds of years to develop."

> "When you see population increase, pollution increases. If you take away one in my neighbourhood and take away one your neighbourhood, over time the filtering ability of the landscape goes away so you get more pollutants in our beaches, in our lakes,... there's toxins in our drinking water from harmful algal blooms, and problem keeps increasing with the changing climate."

Dr. Nandita Basu, University of Waterloo
Professor & Canada Research Chair in Global Water Sustainability and Ecohydrology
Director, Collaborative Water Program
Civil and Environmental Engineering

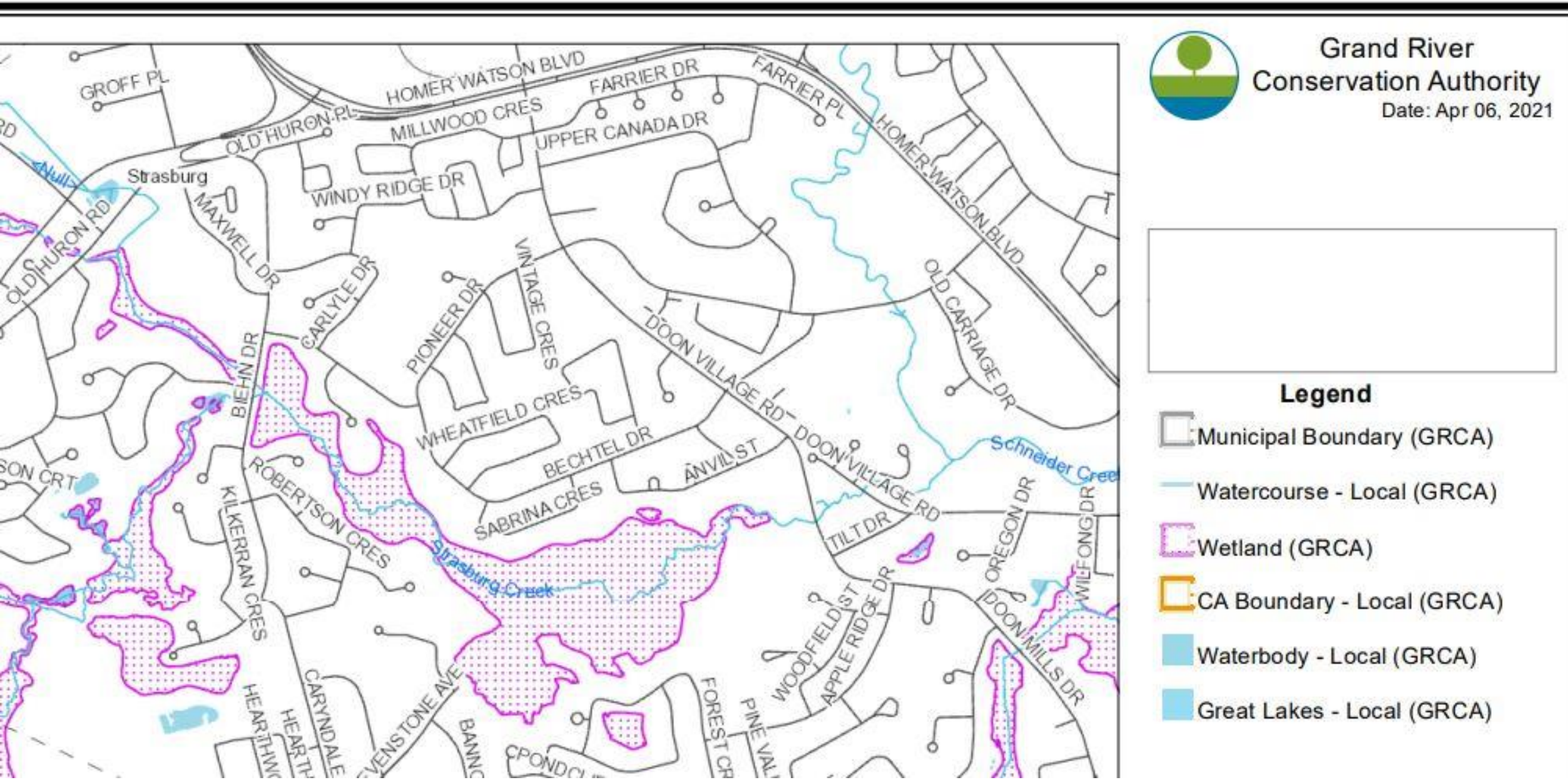
Feb 6 2023, Podcast CBC Morning Edition KW

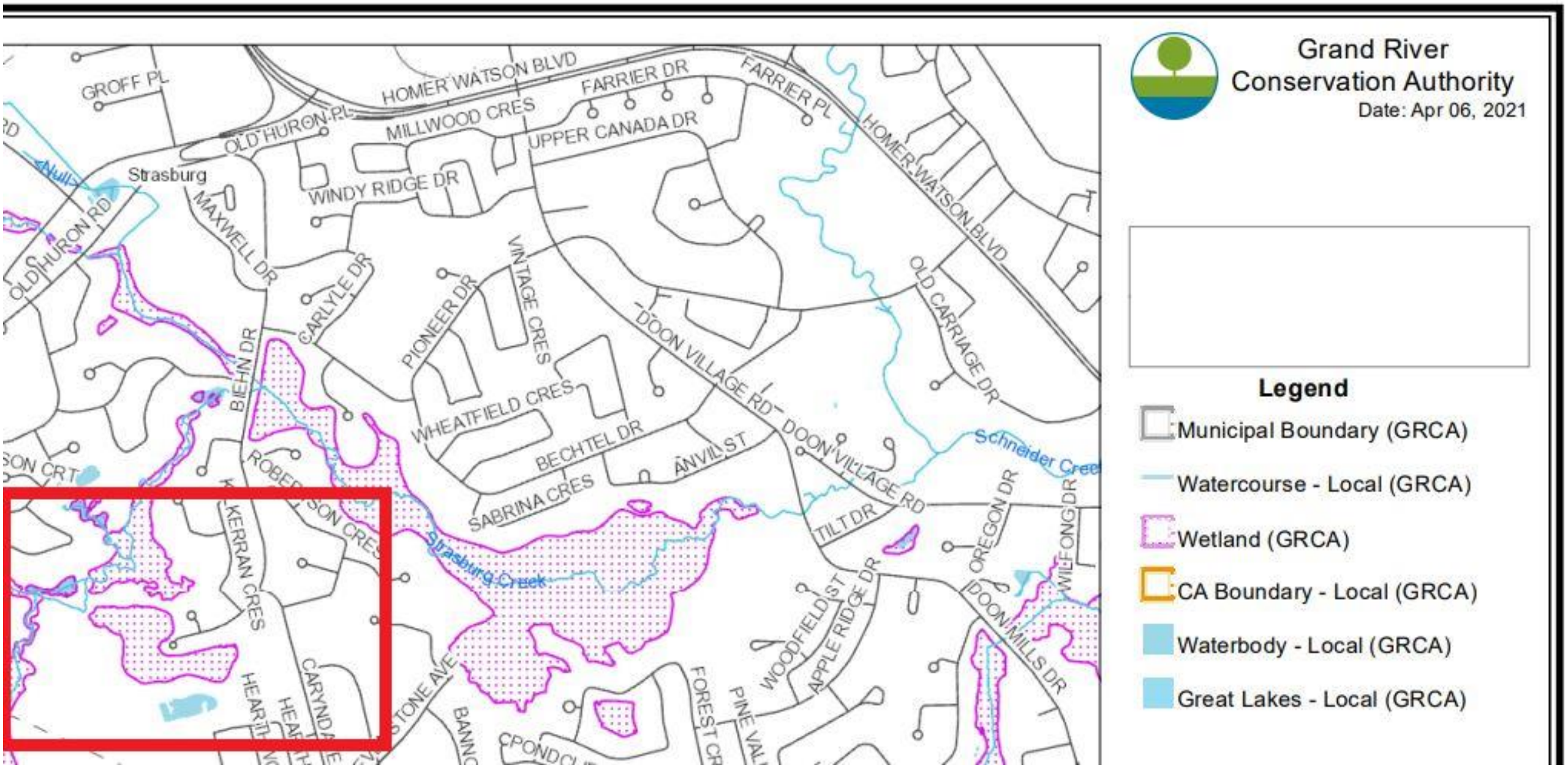
> “Sometimes they don't look the prettiest because they are cleaning your pollutants.”

Eric Hodgins, Manager Hydrogeology and Water Programs
Region of Waterloo

- "Our experience and observations is limited to the impacts to the Region's drinking water supply wells. With that being said, the additional road would require winter maintenance, and the application of salt both flows overland into stormwater basins and related wetlands as well as infiltrates into the groundwater. The degree to which it infiltrates or runs off at any location would be determined by the type of soils, grading, and construction profile of the road and could vary at different locations along a road length. The Region is not aware of these details for this road in part because there was no assessment of impact to source water conducted as part of the Environmental Assessment by the city."

Green=storm, blue=water


Grand River
Conservation Authority
Date: Apr 06, 2021
Legend
Municipal Boundary (GRCA)
Watercourse - Local (GRCA)
Wetland (GRCA)
CA Boundary - Local (GRCA)
Waterbody - Local (GRCA)
Great Lakes - Local (GRCA)
Strasburg
GROFF PL
HOMER WATSON BLVD
OLD HURON PL
MILLWOOD CRES
FARRIER DR
FARRIER PL
UPPER CANADA DR
HOMER WATSON BLVD
WINDY RIDGE DR
OLD HURON RD
MAXWELL DR
CARLYLE DR
PIONEER DR
VINTAGE CRES
DOON VILLAGE RD
OLD CARRIAGE DR
WHEATFIELD CRES
BECHTEL DR
ANVIL ST
SABRINA CRES
ROBERTSON CRES
KILKERRAN CRES
Strasburg Creek
Schneider Creek
TILT DR
OREGON DR
WILFONG DR
DOON MILLS DR
WOODFIELD ST
APPLE RIDGE DR
FOREST CR
PINE VAL
CARYNDALE
HEARTHW
BANN
POND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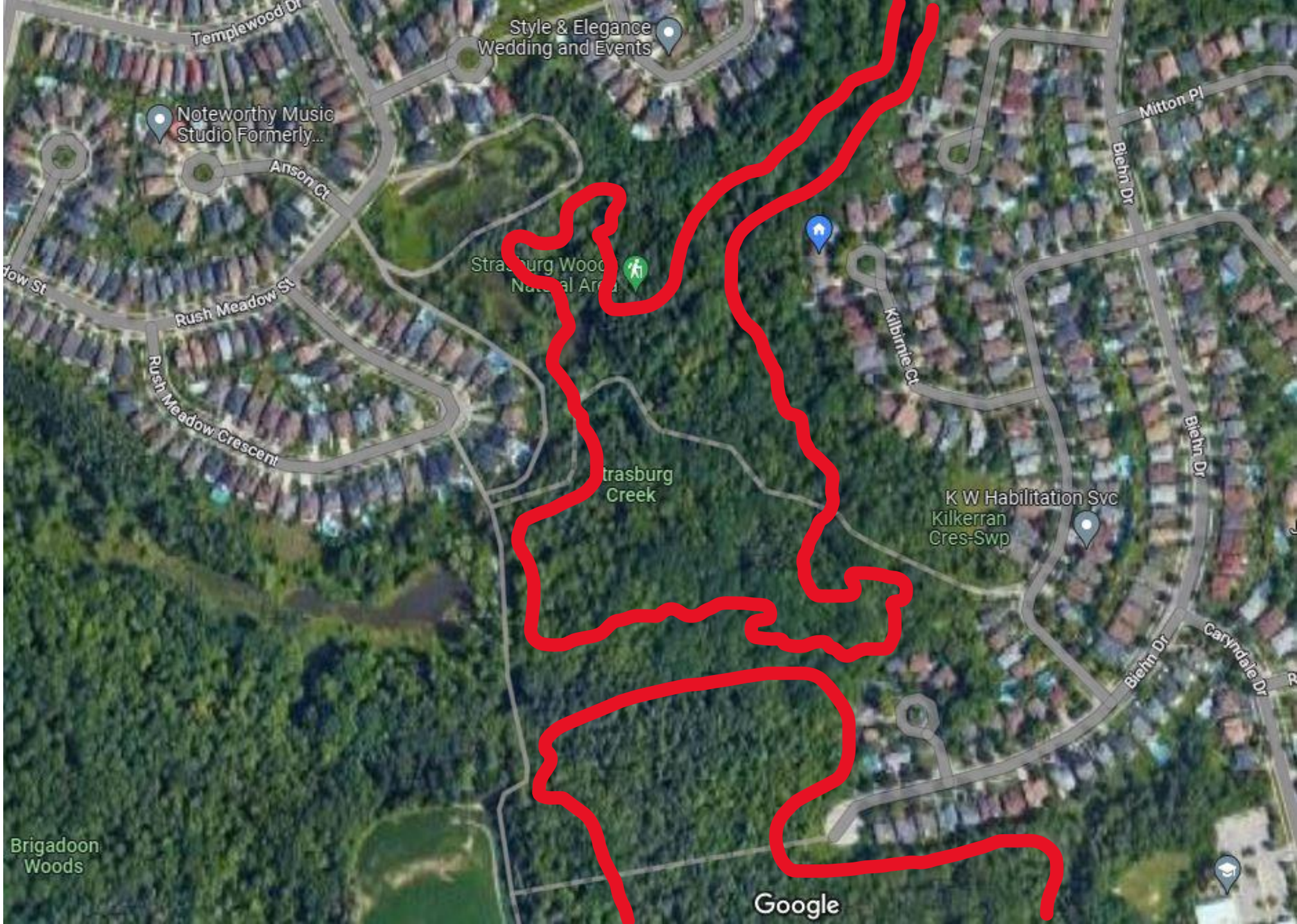
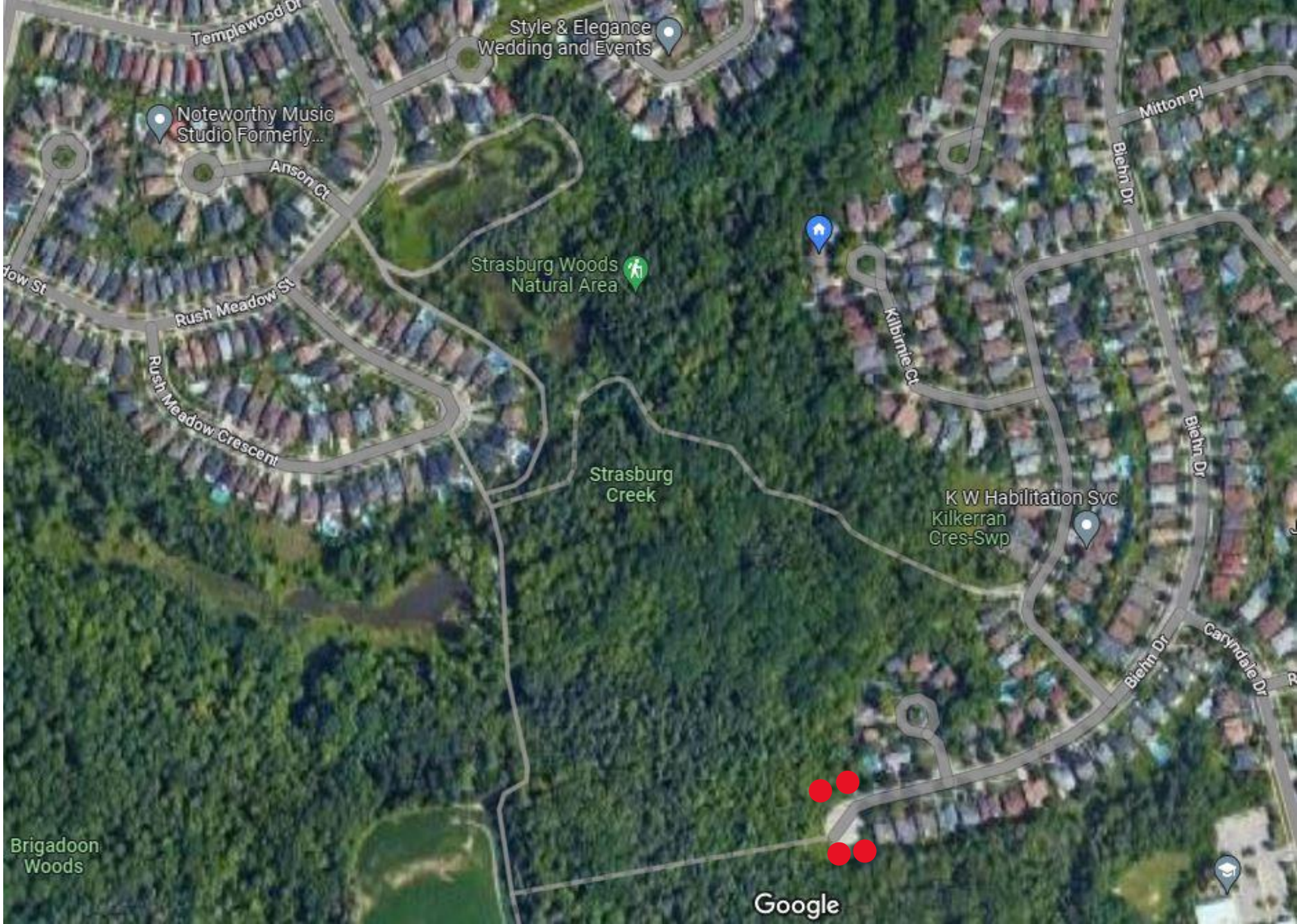
OREGON DR
WILFONG DR
Strasburg Creek
KERRAN CRES
WOODFIELD ST
APPLE RIDGE DR
DOON MILLS DR
STONE AVE
FOREST CR
PINE VAL

Aerial view of PSW-30 surrounding the end of Biehn Drive discharges into Strasburg Creek

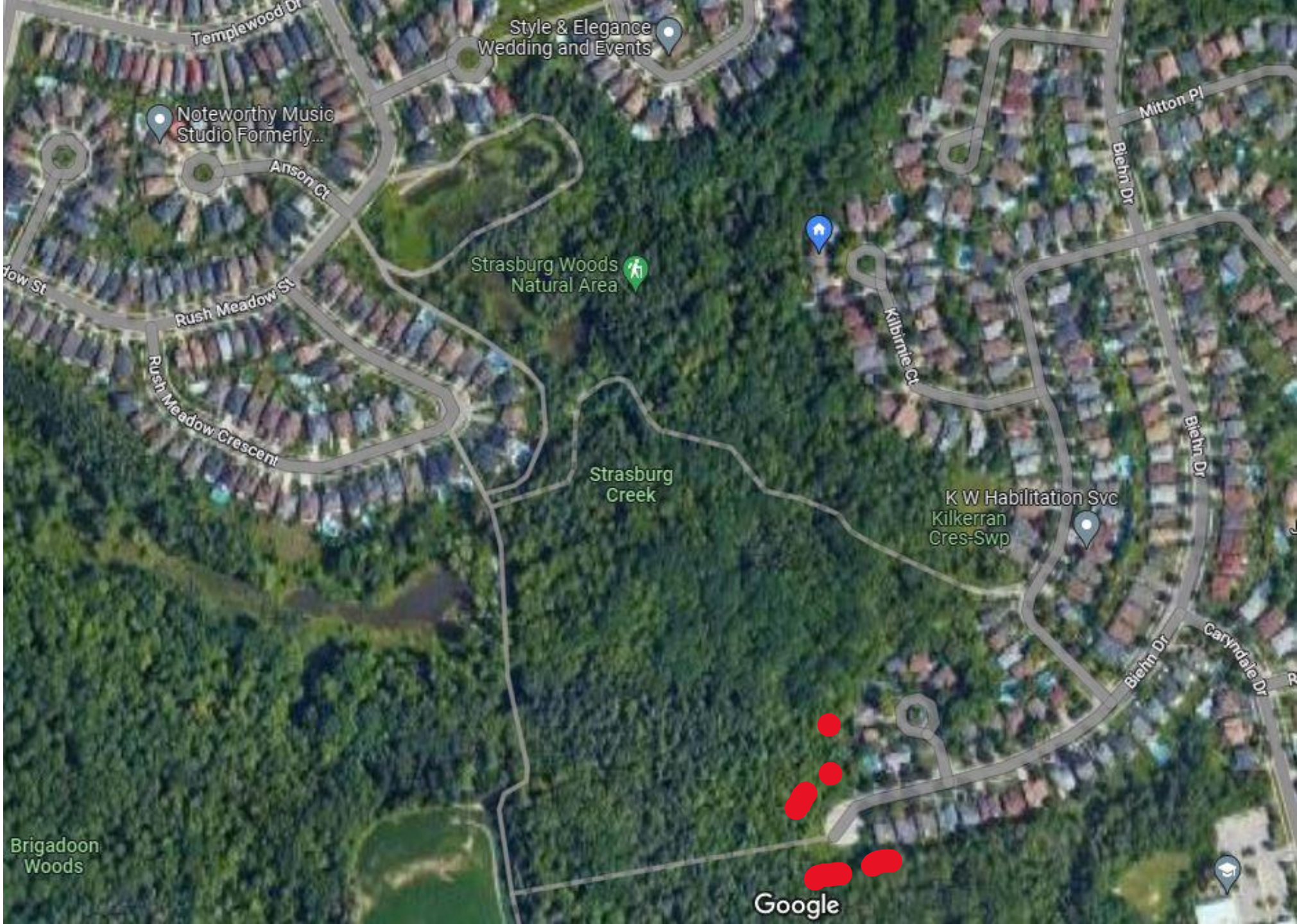


Stormwater enters the Strasburg Creek

- Salt contamination
- 6PPD-quinone (tires)
- Increased road temperatures

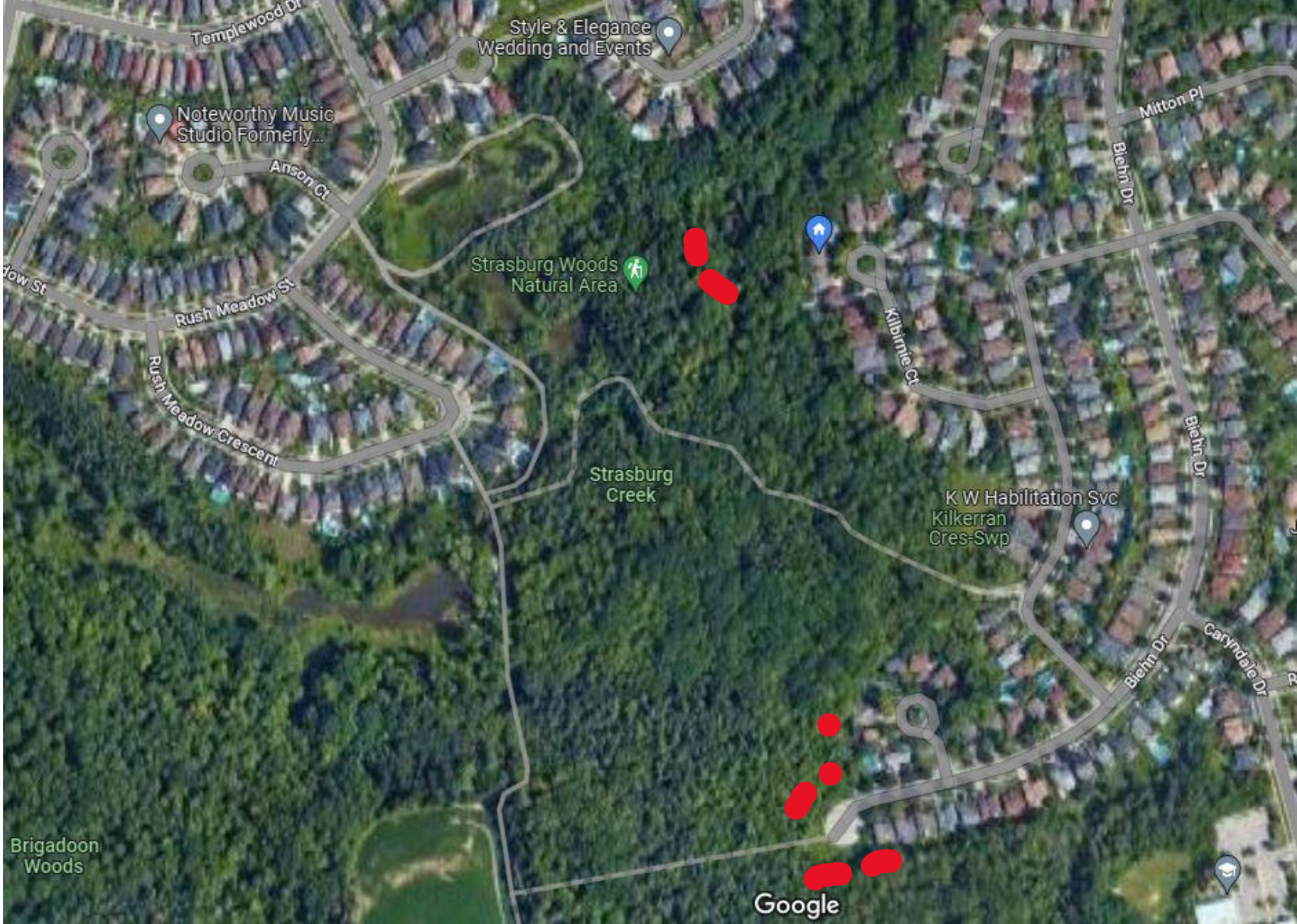


Multiple wetland discharge points enter the stream.



Discharge points add to stormwater run-off.

Multiple confluence points connecting together to feed into Strasburg creek.



Templewood Dr
Style & Elegance
Wedding and Events
Noteworthy Music
Studio Formerly...
Mitton Pl
Biehn Dr
Kilbirnie Ct
Biehn Dr
K W Habilitation Svc
Kilkerran
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Kilkerran Cres-Swp
Biehn Dr
Caryndale Dr
Brigadoon Woods
Google

Well at Kilkerren and Box Culvert Confluence

Strasburg Creek- Impacts of Development

Impact through:

- Salt run-off
- 6PPD-quinone (tires)
- Elevated street temperatures effect water temperature entering the stream confluence

Under scouring of tree roots results in loss of tree canopy and shade to maintain stream temperatures.

This community needs the Kitchener City Council to reconsider not disrupting the Provincial Significant Wetland 30 to protect the city's drinking water and the surrounding ecological habitats.

References

- Nandita Basu, PhD. : Podcast: *Small and Isolated Wetlands should be protected rather than paved over*
  > Professor & Canada Research Chair in Global Water Sustainability and Ecohydrology
  > Director, Collaborative Water Program
  > Civil and Environmental Engineering, University of Waterloo
  > Earth and Environmental Sciences, University of Waterloo
  > Canada Research Chair
- Eric Hodgins

  >Manager for Hydrogeology and Source Water at Region of Waterloo