

**Functional Servicing and Preliminary
Stormwater Management Report**

95 Cook Street and 103-107 Napier Street

City of Barrie

WMI File # 21-694

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1.0 Background

1.1 General

WMI & Associates Limited has been retained by Solid General Contractors to prepare a Functional Servicing and Preliminary Stormwater Management Report in support of a proposed Townhome development located at 95 Cook Street and 103-107 Napier Street, in the City of Barrie.

This report presents an investigation of existing services and drainage patterns, conceptual designs for proposed watermain, sanitary sewers, and stormwater management controls in support of planning applications. The level of detail presented is sufficient to support planning level approvals and shall serve as the basis for detailed design.

Fundamental servicing and drainage objectives, as detailed in this report, are based on drainage and servicing constraints, pre-consultation information from the City of Barrie, Lake Simcoe Regional Conservation Authority (LSRCA) design guidelines, and best management practices as set out by the Ministry of the Environment, Conservation and Parks (MECP). Plan and profile drawings of the surrounding municipal roads were also referenced to determine the extent of existing utilities and municipal infrastructure.

This report is based on a Conceptual Site Plan prepared by Innovative Planning Solutions June 7, 2023. The conceptual Site Plan, and a Site Location Plan are contained in **Appendix A** for reference. Also, refer to the Conceptual Site Servicing and Grading Plans contained in **Appendix A** for pertinent conceptual design details which are discussed throughout this report.

1.2 Site Description

The subject site comprises 1.03ha and consists of 95 Cook Street and portions of 103 and 107 Napier Street. The site is located on institutional and residential lands in a primarily residential area. It is bound to the north, south, east and west by existing low density residential properties. The property is legally referred to as Part of Lot 5, South Side of Napier Street, Part of Lot 6 South Side of Napier Street, Part of Lot 6 North Side of Codrington Street, Registered Plan 6, and Lot 1 and Lot 2 of Registered Plan 1029, in the City of Barrie, County of Simcoe.

The site currently contains an institutional building (St. Giles Church), a large paved parking lot that is accessed from Cook Street, and grassed areas along with some trees around the perimeter of the site. The portion of the site fronting Napier Street consists of two residential dwellings, paved driveways, grassed lawns and a few trees and outbuildings.

The proposed development includes six (6) residential townhouse blocks ranging from 4-9 units for a total of 34 units, an internal road system connecting to Cook Street, and individual driveway access for each unit onto the internal road. It also consists of 4 single detached lots with driveways and frontages directly onto Cook Street. The site will also comprise visitor parking, and a landscaped amenity area. The residential properties on Napier Street will be unchanged from the existing condition except that their rear yards will be reduced in size to accommodate the townhome development. The existing church building and outbuildings in the rear yards of 103 and 107 Napier Street will be removed as part of this development.

2.0 Site Grading

The proposed grading for the residential development intends meet the requirements of the site layout and stormwater management strategy. The following highlights the proposed features:

- Internal road grades will include a saw-tooth pattern to facilitate adequate drainage to catchbasins and surface ponding while also maintaining an overland flow route to Cook Street. Driveway slopes for the individual units will be in the order of 4.0% to 7.0%. Grading has been designed to ensure pedestrian crossings are not impacted by surface ponding for access purposes.
- Earth fill will be required to facilitate overland drainage towards Cook Street. Some retaining walls with heights in the order of 0.50 to 2.5m will be required to facilitate the matching of existing grades at external property boundaries
- Most of the townhome blocks will require a split drainage design, however the south-western most blocks would be best suited as rear walk-outs, to facilitate the required grade drop down to existing property line grades while also minimizing the use of retaining walls.
- Perimeter grades within landscaped areas and around the proposed buildings will generally be between 2.0% to 7.0%, with some areas containing 3:1 slopes as required to match property line grades.
- Rear yard swale grades will be in the order of 0.5% - 4.0% slope to support LID measures and to also avoid existing external grades from being altered.
- The 4 single detached lots will have split drainage design with the front yards draining to Cook Street with grades in the range of 4.0% to 7.0%.

Refer to **Figure 5** for the Grading Concept Plan, contained in **Appendix A**.

3.0 Sanitary Servicing

The site currently contains three (3) sanitary service connections, one to the existing church site that is serviced from the existing 250mm dia. Cook Street sanitary sewer, and two from the existing 250mm dia. Napier Street sewer that currently services the residential dwellings at 103 and 107 Napier Street.

The services to 103 and 107 Napier Street are to remain unaltered. The proposed townhome units are to be serviced by a new 200mm dia. sanitary sewer, extended eastward from Cook Street sanitary sewer, via a new dog-house manhole connection. Each townhome unit will be serviced by individual sanitary service connections that will tie into this sewer. It is proposed to decommission the existing church sanitary service at the Cook Street sanitary sewer main. Each of the 4 single detached lots will be supplied with individual sanitary service connections to the Cook Street sanitary sewer.

In order to confirm if the existing sanitary sewer system on Cook Street is able to accommodate sewage flows from the proposed development, an external servicing analysis has been undertaken. The analysis utilized plan and profile drawings, online mapping, as well as sanitary sewer routing and pipe data from the City's Open Portal online data centre.

From this information, sanitary drainage areas and flows were approximated and existing and proposed condition sanitary design sheets were prepared to analyze existing sewers to the point where they outlet to the nearest trunk sewer (at Codrington / Puget Street). The analysis reveals that the existing sewers are adequate to convey both existing flows and proposed condition flows, considering the added increase from the 34 townhome units and 4 single detached lots.

Since the proposed development has a negligible impact on the existing sewers they are draining into in terms of added flows and existing sewer system capacity, the development can be accommodated by the existing municipal sewage system.

Refer to the existing and proposed condition external sanitary sewer design sheets, and the drainage plans obtained from the City of Barrie, contained in **Appendix B**. Also refer to **Appendix C** for supporting internal sanitary sewage flow calculations.

4.0 Water Servicing

There are existing 150mm and 200mm diameter municipal watermain located on Cook Street and Napier Street, respectively, from which there are water service connections to the church and the 2 residences on Napier Street. Both Cook Street and Napier Street also contain a network of fire hydrants that currently provide fire protection to the local area.

Service to the townhomes is to be accomplished by extending a new 200mm dia. watermain from Cook Street, and providing individual service connections to each unit.

The single detached lots are to have water service connections directly to the existing 150mm diameter Cook Street watermain. It is proposed to maintain the existing water service that was used for the church to service Lot 3, and provide the remaining 3 lots with new water services.

4.1 Fire Protection

Fire protection to the Townhome site will be provided via new internal fire hydrants that will be fed from the proposed 200mm dia. watermain. The spacing of fire hydrants will be such that there is sufficient distance to the front of each townhouse unit and single detached lot, in accordance with minimum OBC and municipal criteria. It is noted that there are currently no fire hydrants in close proximity to the church (nearest is approximately 110m away) so the addition of new watermain and associated fire hydrants will inherently resolve this fire protection deficiency.

The City standard requirement for fire water supply is that the minimum supply of water shall be provided in accordance with the City of Barrie's land use designation (for Townhome developments), or that supply be in accordance with the site-specific fire water demand as determined by a Fire Underwriter's Survey (FUS) demand calculation, whichever is greater. For this development, the land-use fire water demand of 155L/s is the governing requirement.

A hydrant flow test was completed on March 17, 2022 utilizing the fire hydrants located at Cook Street and Napier Street (residual hydrant) and at Cook Street and Strabane Avenue (Flow hydrant). The results from this test indicates that the local municipal water system is generally capable of supplying the City-standard 155L/s fire flow (for Townhomes) at 20 PSI.

A headloss calculation that considers the fire flow + maximum day demand, relative to the anticipated static watermain pressure available from the Cook Street watermain, further confirms that the proposed internal water system is sufficient to supply the proposed development in the event of a fire.

Refer to **Figure 6** in **Appendix A** for the Conceptual Water Servicing Plan and **Appendix C** for supporting water service calculations.

5.0 Utilities

Existing hydro, gas and telecom infrastructure is present along Cook and Napier Streets, and is currently servicing the existing residences.

The local utilities have been contacted to confirm their ability to service this infill development. Specific utility servicing requirements will be confirmed at the detailed design stage.

6.0 Stormwater Management

6.1 Existing Topography and Pre-Development Drainage

Existing grades within the site are generally sloped in the range of 1-5%; however, the grades along the south and east property lines are steeper in the order of 5-15%. The site is predominantly drained via overland sheet flow, with the majority of the site draining to the south-east onto private residential properties fronting Codrington Street and Weldon Street. This drainage outlets through landscaped side yard areas prior to discharging to the Codrington Street storm sewers. A small portion of the site also drains west onto Cook Street and is captured by the Cook Street storm drainage system. It is also noted that rear yards from external residential properties located to the north and west of the site (from 109-113 Cook Street and 95-101 Napier Street) drain onto the subject site via sheet flow.

The pre-development drainage areas consists of 2 internal drainage areas and an external drainage area. Catchment PRE-1 comprises 0.22ha and is the area which drains to Cook Street. PRE-2 comprises 0.88ha and is the area which drains to Codrington Street. Catchment EXT is an external drainage area which comprises 0.24ha.

Refer to the Pre-development Drainage Plan, **Figure 2**, contained in **Appendix A**.

6.2 Subsurface Conditions

Based on data from the Soils Map of Simcoe County, published by the Canada Department of Agriculture (1959), the predominant soil deposit in the area is identified as Vasey Sandy Loam and Tioga Loamy Sand. These soils are considered to have good drainage characteristics, and are classified within Hydrologic Soils Group 'AB'.

A Preliminary Geotechnical Investigation Report has been undertaken on the subject site, by Cambium Inc., dated February 4, 2022. This investigation consisted of 4 boreholes, drilled to depths of 6.2m to 6.6m below the ground surface. Three (3) of the boreholes were outfitted with monitoring wells.

Below the surficial topsoil and parking lot asphalt, the soils generally consist of native and infill sand and silty sand soils. A seam of clayey silt was discovered at approximately 2m depth within one of the boreholes. No groundwater was encountered at the time of borehole drilling, however measurement readings obtained at a later date indicated that groundwater was observed at approximately 5m depth within 2 of the 3 monitoring wells.

A Preliminary Hydrogeological Assessment Report and Water Balance Analysis was also undertaken for the subject site, by Cambium Inc., dated November 23, 2022. This Report reveals that the shallow soils exhibit a percolation rate of approximately 40min/cm (15mm/hr) – 10min/cm (60mm/hr). The results of a water monitoring program indicates that the seasonal high groundwater table remains at a depth of approximately 5.0m within 2 of the 3 boreholes. The Water Balance Assessment contained within this report further reveals that 24% of building rooftop downspouts should be disconnected and runoff be infiltrated, in order to restore water balance to pre-development levels.

Cambium's review of Source Protection and Risk Management reveals the subject site is within a Wellhead Protection Area Q1 and Q2 zone, and that adherence to the Q1 and Q2 policies will be achieved by providing infiltration in accordance with their water balance recommendations.

The Preliminary Geotechnical Investigation Report and Hydrogeological Assessment Report are contained in **Appendix E** for reference.

6.3 Design Criteria Guidelines

The stormwater management design principles for the proposed development are to incorporate the policies and criteria of The Ministry of the Environment, Conservation, and Parks (MECP), the Lake Simcoe Region Conservation Authority (LSRCA), and the City of Barrie, and are to incorporate low impact development (LID) features as a part of the stormwater management system. From this, the stormwater management design criteria for the subject site are summarized below:

- The City of Barrie rainfall intensity-duration-frequency (IDF) curves will be used to determine the peak design flows and runoff volumes for each of the design storm events analyzed.
- Quantity controls are to be provided to attenuate peak flows to pre-development and/or allowable levels for all storm events.
- Quality control will be provided at an 'enhanced' level as defined by The Ministry of the Environment's (MOE) Stormwater Management Planning and Design Manual (March 2003).

- Phosphorus reduction, water balance controls, and runoff volume control will be achieved to the greatest extent possible via on-site LID features as per LSRCA guidelines.
- Erosion and sediment control measures will be implemented prior to and during the construction of the development and maintained until the site is stabilized.

6.4 Post-Development Drainage

Post-development drainage conditions should generally strive to match pre-development conditions as closely as possible. However, for this proposed development the topographical constraints and proposed built form are indicators that altering existing drainage patterns is a preferred solution. The proposed drainage patterns will improve drainage flow characteristics in terms of impact on adjacent properties by directing more post-development flow internally and ultimately to the Cook Street right-of-way. In order to support this proposed solution an external drainage analysis has been completed to determine if the Cook Street storm sewer system can accommodate the revised drainage area.

6.4.1 External Drainage Analysis

Various plan and profile drawings, drainage plans, and data obtained from the City of Barrie's Open Data portal were utilized to identify the routing of storm drainage from Cook Street, towards the ultimate outlet at Kempenfelt Bay / Lake Simcoe.

From this information, an existing condition storm sewer design sheet was prepared to evaluate the capacity of the storm sewer system under the existing/ baseline condition (which only considers catchment PRE1 draining to the Cook Street sewers). This analysis reveals that the existing storm sewers are adequate to convey the 5-year storm event to the outlet.

It is noted that catchment PRE2 is a part of a different drainage system (the Napier Street drainage system), however the desire is to re-direct the majority of site drainage towards the Cook Street drainage system. To evaluate the impacts of added drainage onto Cook Street from the subject site, the existing sewer system was assessed to determine the drainage area that could be applied without requiring significant upgrades to municipal sewers. From this, it was determined that an area of 0.50ha from the subject site can be applied at a runoff coefficient (C) of 0.40. This drainage scenario is herein referred to as the allowable drainage to the Cook Street storm sewers.

This scenario reveals that one section of existing storm sewer is undersized at 112% of full-flow capacity. In order to facilitate sufficient sewer capacity for the development, it is proposed to remove this 10.5m section of 450mm diameter storm sewer located at the intersection of Cook and Codrington Streets and replace with a larger pipe.

Refer to the existing and proposed condition external storm sewer design sheets, and the drainage plans obtained from the City of Barrie, contained within **Appendix B**.

6.4.2 Internal Drainage

The proposed internal drainage patterns will be such that the entire internal roadway, auxiliary parking areas, the front yards of the Townhomes, front yards of the single detached lots and portion of the rear yards will drain towards Cook Street. Due to topographical constraints the rear yards and landscape areas around the perimeter of the site are not able to drain to Cook Street. The impacts of this drainage are proposed to be minimized, however, as the drainage area will be small and the proposed LIDs will retain stormwater for infiltration into the native soils, thereby further mitigating nuisance flows onto adjacent low-lying lands from frequent storm events.

The internal site area that is to drain to Cook Street via a storm sewer connection comprises 0.52ha and is herein identified as catchment A1A. The front yards of the 4 single detached lots, which comprises 0.05ha, also drains directly to Cook Street; is identified as catchment A1B.

The perimeter landscape area which cannot drain to Cook Street is herein identified as catchment A2. It comprises 0.53ha and is to be drained primarily via a rear yard swale, and is to outlet via sheet flow towards the south via longitudinal overflow weir built into an infiltration trench. Additional infiltration trenches are provided within the swale to promote infiltration along this drainage route.

Catchment EXT which drains into the subject site will be unchanged in the post development condition, and will be accommodated by the aforementioned swale that services catchment A2.

Table 1 below summarizes the uncontrolled pre- and post-development peak flows for various return period design storms.

Table 1: Pre- and Post-Development Uncontrolled Peak Flows

Catchment	A	T _c	C	Q ₂	Q ₅	Q ₁₀	Q ₂₅	Q ₅₀	Q ₁₀₀
I.D.	(ha)	(min.)		(m ³ /s)	(m ³ /s)	(m ³ /s)	(m ³ /s)	(m ³ /s)	(m ³ /s)
EXT	0.24	10.0	0.40	0.022	0.029	0.034	0.043	0.053	0.060
PRE1	0.22	10.0	0.40	0.020	0.027	0.031	0.040	0.048	0.055
PRE2	0.88	10.0	0.35	0.071	0.093	0.108	0.140	0.169	0.193
PRE Total	1.10	10.0	0.36	0.091	0.120	0.139	0.179	0.217	0.248
A1A	0.52	10.0	0.74	0.089	0.117	0.135	0.174	0.211	0.241
A1B	0.05	10.0	0.61	0.007	0.009	0.011	0.014	0.017	0.019
A2	0.53	10.0	0.37	0.045	0.059	0.069	0.089	0.107	0.123
POST Total (Uncontrolled)	1.10	10.0	0.56	0.141	0.185	0.215	0.277	0.334	0.383

Since catchment A2 flows are less than the PRE2 flows, quantity controls are not required for this catchment. However, since the total POST flow exceeds the total PRE flows, quantity controls are required to attenuate post-development peak flows.

Table 2 below illustrates the allowable flows to Cook Street based on the external drainage analysis, along with the A1A + A1B uncontrolled peak flows for comparison purposes.

Table 2: Allowable and Post-Development Uncontrolled Flows to Cook Street

Catchment	A	T _c	C	Q ₂	Q ₅	Q ₁₀	Q ₂₅	Q ₅₀	Q ₁₀₀
I.D.	(ha)	(min.)		(m ³ /s)	(m ³ /s)	(m ³ /s)	(m ³ /s)	(m ³ /s)	(m ³ /s)
To Cook Street (Allowable)	0.50	10.0	0.40	0.046	0.061	0.070	0.091	0.109	0.125
A1A + A1B	0.57	10.0	0.73	0.096	0.126	0.146	0.188	0.227	0.260

Since A1A + A1B flows exceed the allowable flows to Cook Street (area = 0.50ha @ C = 0.40), quantity controls are also required to not exceed the capacity of the external storm sewers.

Refer to **Figure 3** for the Post-Development Drainage Plan, contained in **Appendix A**.

6.5 Quantity Control

It is noted that catchment A1B cannot be captured internally, therefore over-controlling catchment A1A flows is required.

Attenuation of catchment A1A peak flows will be achieved by storage within the internal storm sewer and underground chamber system, and via surface ponding within the internal roads. This system is proposed to consist of perforated sub drainage pipes with clear stone bedding, as well as storm pipes, manholes, and catchbasins, and an orifice control within the control manhole (volumes within clearstone are omitted for quantity control calculation purposes). The internal road will be graded with a saw-tooth grading pattern, and the storm sewers / inlet catchbasins placed at the center of the roads, so to accommodate the ponding in such a manner that will optimize storage volumes while minimizing ponding depths to no greater than 0.25m.

Table 3 below provides a summary of the post-development controlled peak flows and maximum storage volumes required to achieve the targeted release rates.

Table 3: Post-Development Controlled Peak Flows and Max Storage Volumes

Catchment I.D.	A (ha)	Q ₂ (m ³ /s)	Q ₅ (m ³ /s)	Q ₁₀ (m ³ /s)	Q ₂₅ (m ³ /s)	Q ₅₀ (m ³ /s)	Q ₁₀₀ (m ³ /s)	Max Storage (m ³)
A1A (Controlled)	0.52	0.039	0.051	0.059	0.077	0.093	0.106	102.6
A1B (Uncontrolled)	0.05	0.007	0.009	0.011	0.014	0.017	0.019	-
A1A + A1B	0.57	0.046	0.061	0.070	0.091	0.109	0.125	
A2 (Uncontrolled)	0.53	0.045	0.059	0.069	0.089	0.107	0.123	-
POST (Controlled)	1.67	0.091	0.120	0.139	0.179	0.217	0.248	-

In comparing pre-development peak and allowable flows from Tables 1 and 2, and the controlled flows from Table 3, it can be seen that the post-development release rates for all storm events can be achieved to allowable levels for catchments A1A and A1B. Also, the total controlled flows from the site in the post-development condition do not exceed the total pre-development peak flows during any of the storm events.

Specifically, peak flow attenuation from Area A1A will be achieved by underground and roadway surface storage to a maximum volume of 102.6m³ during the 100 year storm event.

Refer to **Appendix D** for supporting conceptual storm drainage and stormwater management calculations.

6.6 Quality Control

To provide runoff quality control at an enhanced level (80% Total Suspended Solids removal), a treatment train approach is to be employed for catchment A1A. This catchment contains the proposed internal road and driveways for the proposed rental units, which is the primary source of contaminated runoff. The treatment train will consist of infiltration and filtering of stormwater through the underground perforated pipe system and through treatment by an oil/grit separator (OGS) with Enhanced Verification Treatment (ETV) capabilities.

The runoff from catchment A1B drains directly to the Cook Street right-of-way, and as such does not permit any quality controls to be implemented; however, considering this small area primarily consists of front yards it is expected that the runoff would be primarily uncontaminated.

Runoff from catchment A2 is not proposed to be quality controlled since this area largely comprises rooftop and landscaped areas which produces uncontaminated runoff. However, this area is to drain by grass swales and infiltration trenches which will act to filter and retain stormwater and associated sediment, thereby promoting the treatment train approach for stormwater management.

Detailed quality control calculations will be provided at the detailed design stage.

6.7 Water Balance Controls

Water Balance Controls are proposed in accordance with LSRCA design guidelines, and are based on the findings of the Water Balance Assessment conducted by Cambium Inc. The Water Balance Analysis identifies that there is a net deficit of 604 m³ of infiltration annually but this can be mitigated through the diversion of 24% of the total rooftop water for infiltration. Drainage from approximately one-half of the rooftop area is to be directed to infiltration trenches which will provide the requisite water balance to pre-development conditions. It is noted that the soils present in the area are generally characterized as having moderate permeability (an estimated infiltration rate of 4-38mm/hr), and the seasonal high ground water table is identified as being approximately 5.0m below the existing ground surface. It is therefore expected that infiltration based water balance measures can be implemented.

The conceptual design proposes a number of Low Impact Development (LID) measures to promote infiltration, predominantly through infiltration trenches around the perimeter rear-yard swale, as well as within the clear stone base of the underground storm pipes and stormwater detention chambers.

The volumetric capacity of the infiltration trenches and clear stone storm sewer bedding are intended to be maximized to provide the greatest peak flow attenuation benefits, while also adhering to the typical maximum physical dimensions (as guided by the MOE Stormwater Management Planning and Design Manual). This is to ensure that effective quality and water balance controls will also be achieved, and to ensure sufficient long term performance.

It is also noted that evapotranspiration will occur through the proposed grass swales and through the perimeter landscape areas, which further promotes water balance and supports the integrated treatment train approach for stormwater management.

Refer to preliminary runoff retention calculations for the proposed infiltration trenches and underground storm pipes/chambers contained in **Appendix D**.

6.8 Phosphorous Controls

In accordance with LSRCA policy for new development sites within the Lake Simcoe watershed, Stormwater Management Best Management Practices (BMPs) are to be implemented to achieve measurable reductions in phosphorous loading from post-development runoff.

Based on the proposed built form and soil conditions, the preferred mechanism for providing phosphorus control of stormwater runoff is by way of infiltration into the native soils. To achieve a high-level of infiltration, infiltration trenches, perforated storm pipes with clear stone bedding and within the stone base of the stormwater detention

chambers are proposed. Additional phosphorus removal benefits are provided with an Oil-Grit Separator (OGS) with ETV treatment capabilities.

To quantify the effectiveness of the proposed BMPs, a pre- and post-development phosphorous loading analysis was undertaken using the Lake Simcoe Phosphorous Loading Development Tool (TP Tool), prepared for the Ontario Ministry of the Environment.

The Phosphorous removal efficiency of a perforated pipe infiltration/exfiltration system is 87% and infiltration trenches are 60%, as determined through studies referenced in support of the development of the TP Tool. As per the LSRCA's Technical Guideline for Stormwater Management Submissions, OGS with ETV treatment capabilities are credited with 20% Phosphorus removal efficiency. From these efficiencies and from the drainage characteristics of the subject site, the TP Tool indicates that the total post-development phosphorous export from the site is **0.40kg/yr** with the perforated pipe BMP, infiltration trenches, and OGS whereas the phosphorous export from the site without the BMP is **1.45kg/yr**. This represents a **72%** TP load reduction with the implementation of the proposed BMPs.

For supporting calculations, refer to the Lake Simcoe Phosphorous Loading Development Tool Project Development Summary sheet located in **Appendix D**.

6.9 Runoff Volume Controls

Runoff volume controls are also proposed to be provided in accordance with the LSRCA Guidelines.

The objective of runoff volume control is to provide runoff volume reduction through stormwater retention (via practices such as infiltration, evapotranspiration), runoff filtration, and through the application rate control BMPs, in this order of priority. The primary method of providing runoff volume control for this project is by retention and infiltration through the proposed infiltration trenches, the exfiltration/ perforated pipe system as well as within the base stone of the underground storm detention chambers.

Due to the restricted space that is available for implementing LIDs due to the close proximity of buildings to property lines and the congestion of other services and utilities proposed within the internal road, it is not reasonably possible to retain the full 25mm rainfall depth over all impervious areas. Therefore, providing LIDs that are capable of retaining 12.5mm rainfall depth are proposed.

The total impervious areas within the site is equal to 5900m². A rainfall depth of 12.5mm over this area equates to a total volume of 73.75m³ that is required to be retained onsite to meet the target. The storage provided within the infiltration trenches (estimated 42.5m³), exfiltration system (estimated 15.5m³) and the stone base of the Stormtech chambers (estimated 15.75m³) will meet the required runoff volume

requirements. The storage volumes within these systems will be confirmed at the detailed design stage.

Supporting infiltration/ exfiltration trench calculations are contained in **Appendix D** for reference.

6.10 Other Contaminants

It is noted that other contaminants such as heavy metals, oil, grease, pesticides, bacteria and other nutrients could be present in stormwater runoff. These contaminants are not expected in significant concentrations due to the proposed land use (residential development), therefore will not be a concern that requires any additional/ specific form of quality controls that the proposed LID's within the treatment train will already provide.

The application of winter salt is expected to occur onsite to address safety concerns, however the need for significant application is inherently minimized due to the mild slopes/ grades within the proposed internal roadway. Directing the majority of rooftop drainage to rear yards will also inherently reduce the need for heavy salt application on sidewalks.

The temperature of stormwater is not expected to be a concern also due to the site's outlet being a fair distance away from the receiving watercourse as noted above, and any associated fish habitat that may otherwise be impacted.

7.0 Sediment and Erosion Controls

Effective erosion and sediment control must be established prior to construction commencement and maintained until the site has been stabilized. Pro-active measures will be required to limit the amount of sediment travelling downstream. Where site grading is required, exposure of the soil during construction should be minimized to avoid erosion and sedimentation.

Silt Fence: Silt fence will be placed on the down slope of all excavated material to prevent sediment transport onto adjacent properties and the municipal roadways. Periodic inspections and repairs to the silt fence should be performed regularly, as well as after every rainfall event.

Storm Sewer Inlets: Filter cloth complete with clear stone cover at storm sewer inlet structures (i.e. catchbasins), will ensure sediment laden overland runoff during construction is cleansed before entering the municipal storm sewer system.

Mud Mat: Mud tracking from construction traffic must be controlled through the use of a mud-mat consisting of large diameter rip-rap located at the construction site entrance/exit.

Vegetated Buffers: Existing treed and lawn areas along the development limits are to be maintained wherever possible. These areas will provide a natural barrier to filter potentially sediment-laden overland flow before it is released from the site.

Monitoring and Inspection: Erosion monitoring and sediment removal should be undertaken every week, and after every rainfall event. All damaged or clogged control devices or fencing must be repaired immediately.

8.0 Summary

This Functional Servicing and Preliminary Stormwater Management Report demonstrates how the proposed 95 Cook Street & 103-107 Napier Street townhome development can be serviced by existing municipal services, and how storm runoff can be controlled so to not impose any adverse effects on the surrounding environment.

Specifically:

- Storm drainage will be accomplished by an internal drainage system consisting of storm sewers and drainage swales, such that drainage to Cook Street will be maximized.
- An external drainage analysis confirms that the Cook Street drainage system can accommodate a minor increase in peak flows from the proposed development.
- Peak flow attenuation will be provided by underground storage detention chambers/ pipes as well as by surface storage within the internal road. Controls are such that post-development flows meet pre-development levels and such that one section of municipal storm sewer is required to be upsized.
- An enhanced level of quality control (80% TSS removal) will be provided by infiltration-based LIDs and an oil/grit separator.
- Water balance and Phosphorous controls will be provided by infiltration based LIDs consisting of infiltration trenches and perforated drainage pipes, and an ETV verified oil/grit separator.
- Fire and potable water servicing will be provided by a new watermain extended from the existing municipal watermain on Cook Street and establishing individual service connections to each unit.
- Sanitary sewer servicing will be provided by extending a new sanitary sewer into the site from the existing Cook Street sewer and establishing individual service connections to each unit.

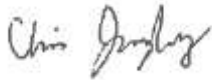
- The use of silt fence, clear stone and filter cloth inlet protection, a construction mud mat, and vegetated buffers will provide adequate sediment and erosion controls during construction.

Based on the above we recommend that this report be accepted in support of planning level approvals.

Should you have any questions, or require additional information, please contact the undersigned.

Prepared by:

WMI & Associates Limited



Chris Jungkunz, P.Eng.

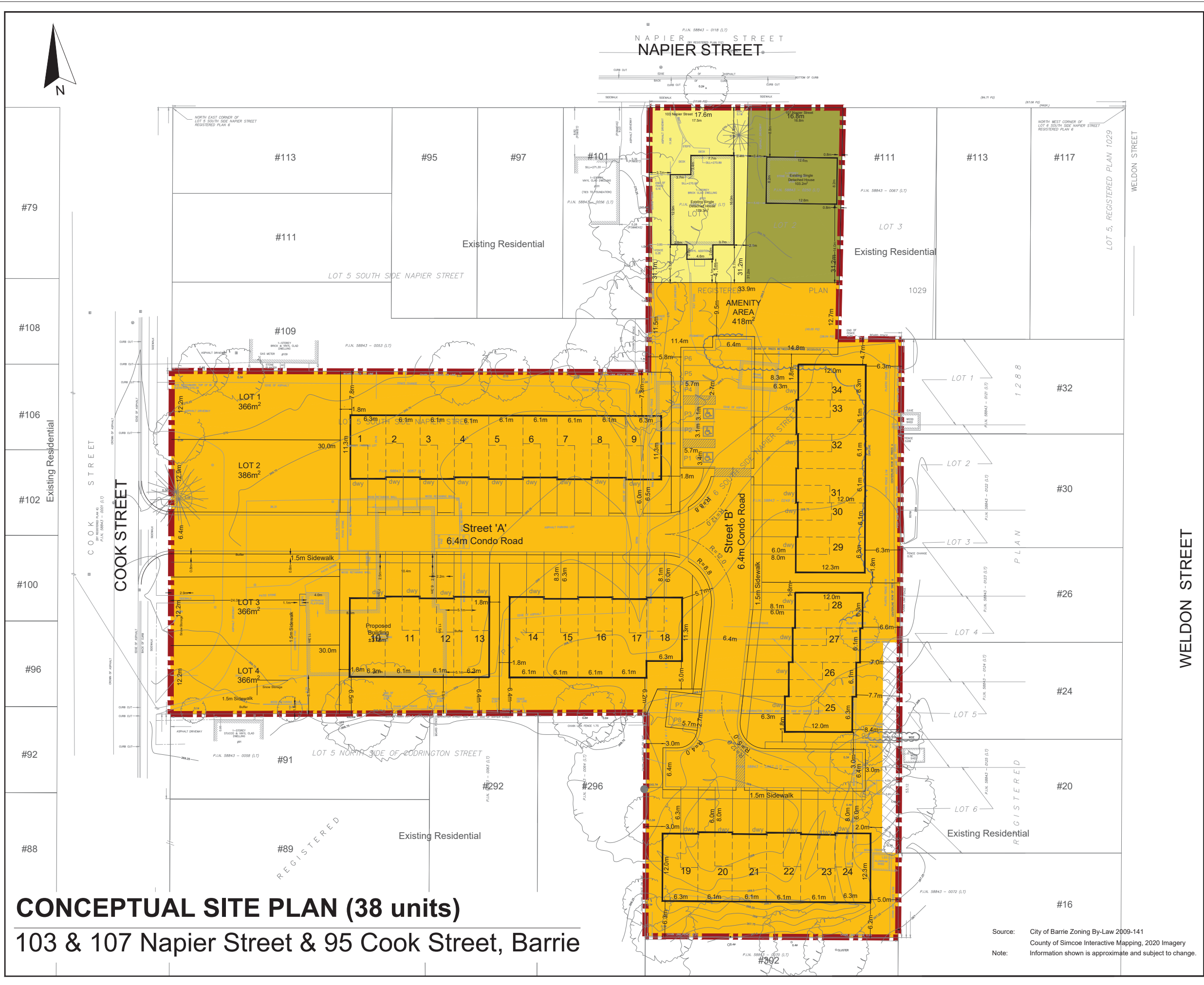


Jonathan P. Reimer, P.Eng.

\\wminas\Public\Data\Projects\2021\21-694\Design\Reports\FSR_No2\Assembly\240807_FSR_SWM.docx

APPENDIX A

FIGURES/DRAWINGS



KEY MAP

CONCEPTUAL SITE PLAN

103 & 107 Napier Street & 95 Cook Street, Barrie

Scale 1:300

LEGEND

- SUBJECT LANDS (11,338m²)
- 103 NAPIER STREET (542m²)
- 107 NAPIER STREET (522m²)
- CONDOMINIUM TOWNHOUSES (10,161m²)
- AREA BEING USED BY #20 & 24 WELDON ST. (113m²)

34 6.1m / 20' TOWNHOUSES
4 12.2m / 40' SINGLE DETACHED LOTS

FOR DISCUSSION PURPOSES ONLY

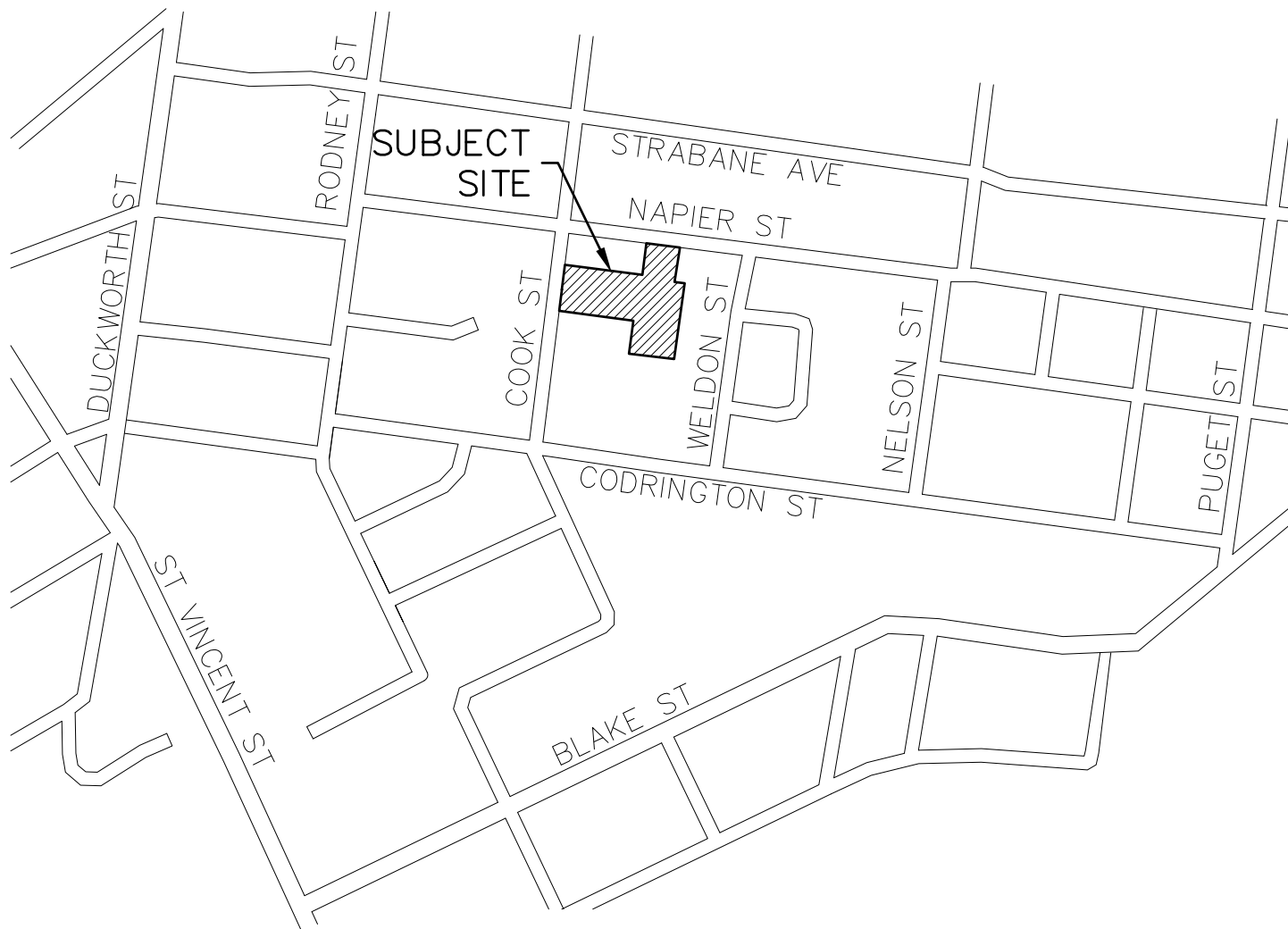
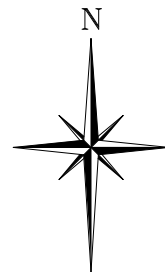
JUNE 7, 2023

IPS INNOVATIVE PLANNING SOLUTIONS
PLANNERS • PROJECT MANAGERS • LAND DEVELOPERS
647 WELHAM ROAD, UNIT 9A, BARRIE, ONTARIO, L4N 0B7
tel: 705 • 812 • 3281 fax: 705 • 812 • 3438 e: info@ipsconsultinginc.com www.ipsconsultinginc.com

Date:	June 7, 2022	Drawn By:	B.H.
File:	20-1006	Checked:	C.S.

Source: City of Barrie Zoning By-Law 2009-141
County of Simcoe Interactive Mapping, 2020 Imagery

Note: Information shown is approximate and subject to change.



Drawing Title

SITE LOCATION PLAN

Project Title

95 COOK STREET +
103-107 NAPIER STREET



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119 Collier Street
Barrie, Ontario
L4M 1H5
705-797-2027
www.wmiengineering.ca

Drawn By
CJ

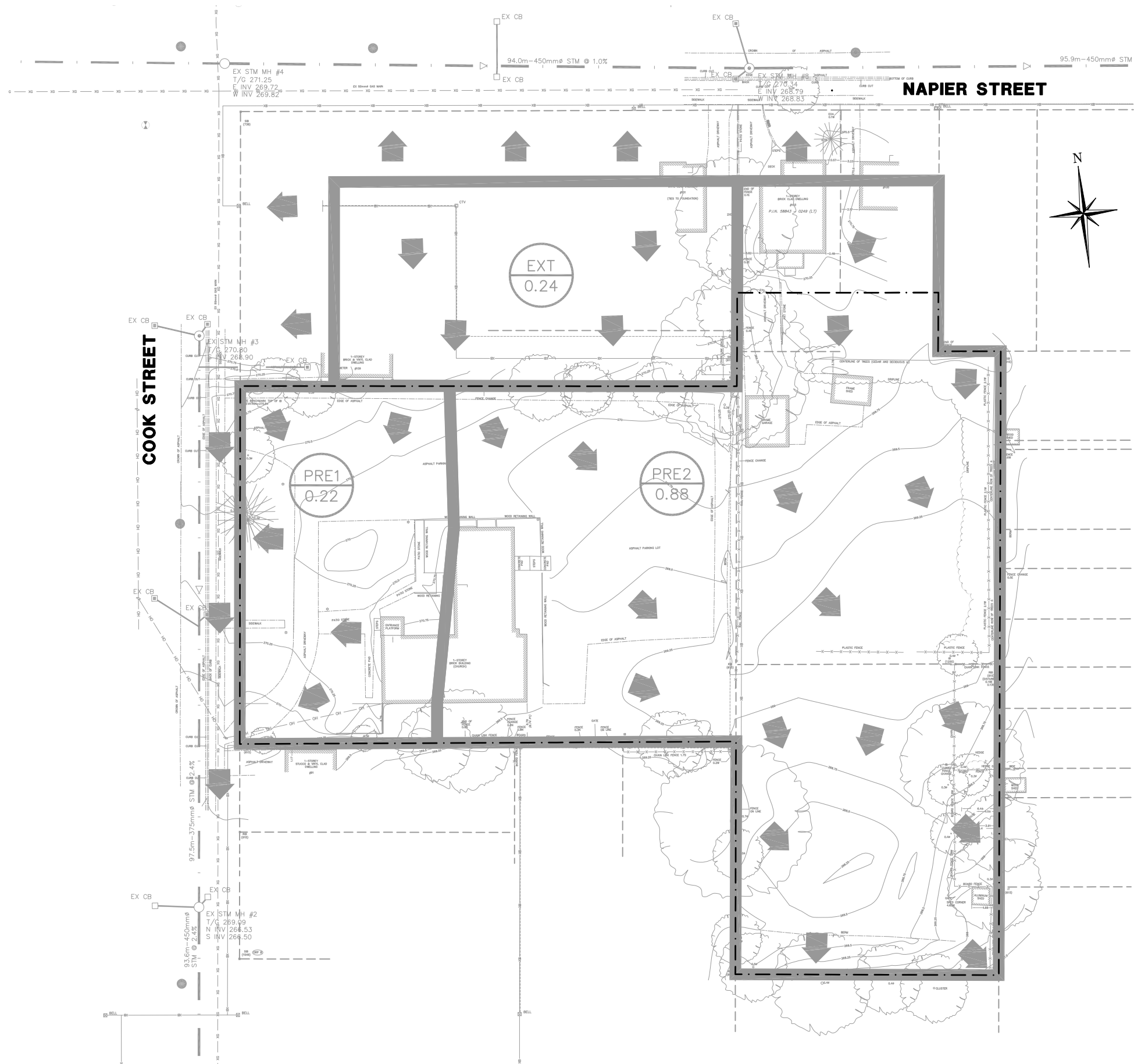
Scale
N.T.S.

Checked By
DAI

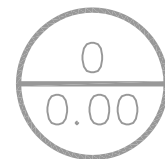
Project No.
21-694

Figure No.

FIG1



Legend:



CATCHMENT IDENTIFICATION

CATCHMENT AREA (HA)



LIMITS OF CATCHMENT AREA



OVERLAND FLOW DIRECTION

NOTE:

LOCATION OF EXISTING MUNICIPAL
INFRASTRUCTURE IS APPROXIMATE.

Drawing Title

PRE-DEVELOPMENT
DRAINAGE PLAN

Project Title

95 COOK STREET +
103-107 NAPIER STREET



WMI & Associates Limited
119 Collier Street
Barrie, Ontario
L4M 1H5
705-797-2027
www.wmiengineering.ca

Drawn By
CJ

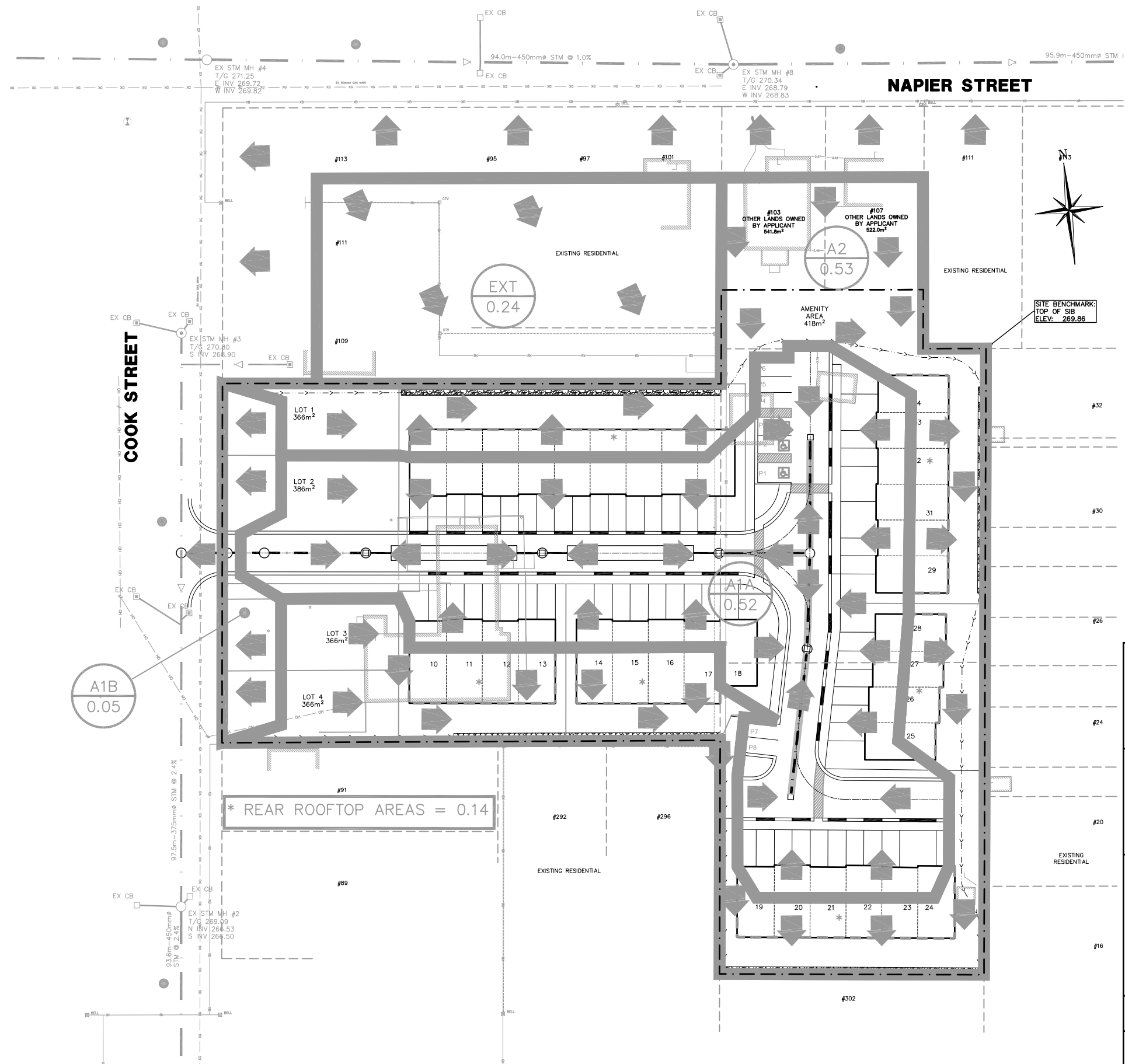
Checked By
JR

Figure No.

Scale
1: 750

Project No.
21-694

FIG 2



Legend:

0

0.00

CATCHMENT IDENTIFICATION

CATCHMENT AREA (HA)

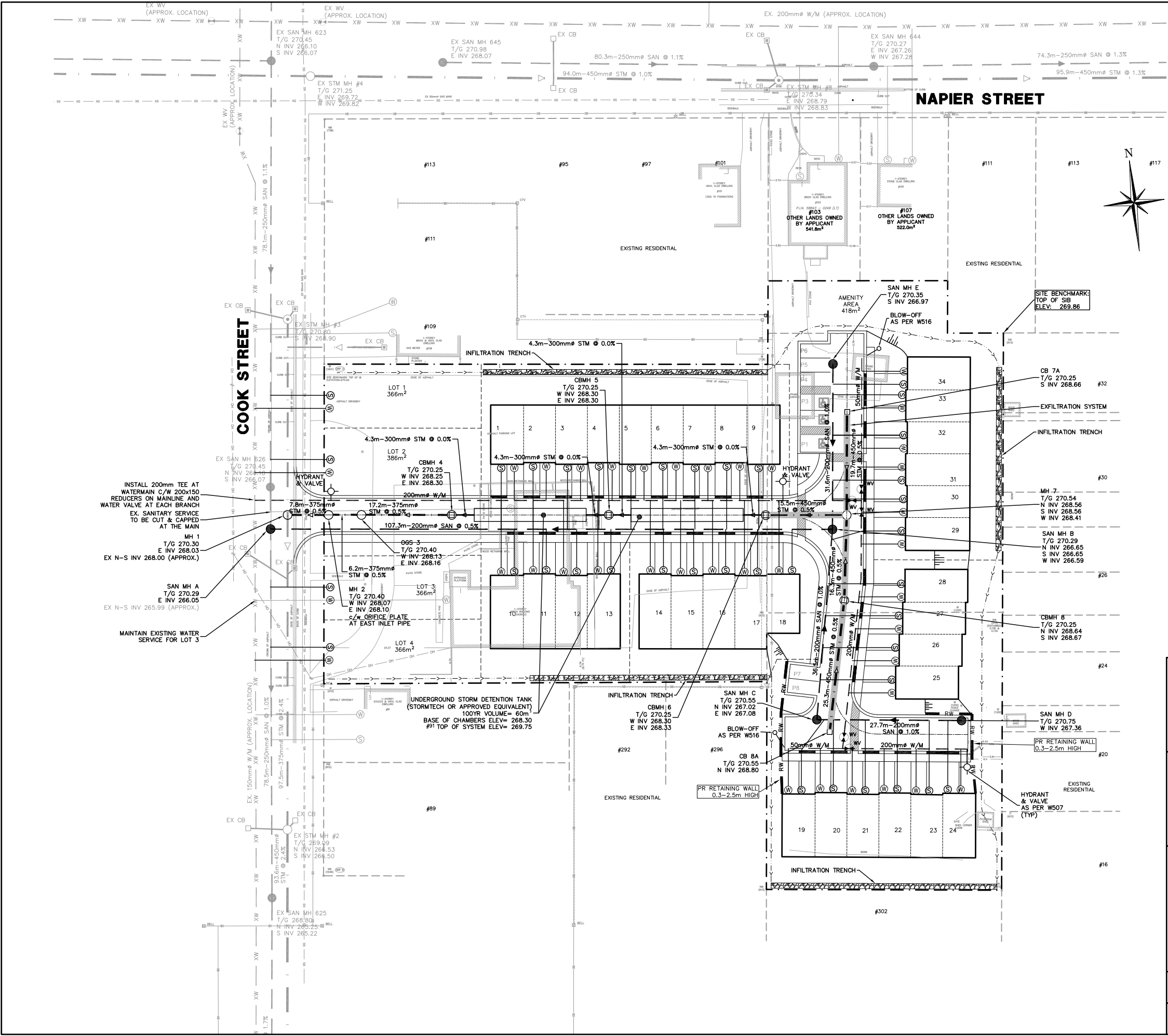
LIMITS OF CATCHMENT AREA

LIMITS OF SUB-CATCHMENT AREA

OVERLAND FLOW DIRECTION

NOTE:
LOCATION OF EXISTING MUNICIPAL
INFRASTRUCTURE IS APPROXIMATE.

Drawing Title		
POST-DEVELOPMENT DRAINAGE PLAN		
Project Title		
95 COOK STREET + 103-107 NAPIER STREET		
 WMI & Associates Limited 119 Collier Street Barrie, Ontario L4M 1H5 705-797-2027 www.wmiengineering.ca		
Drawn By	Checked By	Figure No.
CJ	JR	
Scale	Project No.	FIG 3
1: 750	21-694	



- Legend:**
- EXISTING FEATURES (EX)**
- EX SIB EX STD IRON BAR EX WS EX WATER SERVICE
 - EX IB EX IRON BAR EX HYD EX FIRE HYD.
 - EX UP EX UTILITY POLE NS EX ST NAME SIGN
 - EX CB PED EX BELL PED SS EX STOP SIGN
 - EX HYDRO TRANSFORMER EX ELEVATION
 - EX FENCE
 - EX U/G GASMAIN
 - EX U/G BELL
 - EX U/G HYDRO
 - EX WV EX WATERMAIN & VALVE
 - EX SAN EX SAN SEWER & MH
 - EX STM EX STM SEWER & MH

- PROPOSED FEATURES (PR)**
- PR WATER SERVICE
 - PR SANITARY SERVICE
 - PR STORM SERVICE
 - PR WATERMAIN
 - PR FIRE HYDRANT
 - PR WATER VALVE
 - PR SANITARY SEWER
 - PR SANITARY MANHOLE
 - PR STORM SEWER
 - PR EXFILTRATION SYSTEM
 - PR CATCHBASIN MANHOLE
 - PR MANHOLE
 - PR CATCHBASIN
 - PR SWALE
 - PR INFILTRATION TRENCH
 - PR RETAINING WALL
 - PR ELEVATION
 - PR MATCH EXISTING ELEVATION
 - PR 3:1 SLOPE

NOTE:
LOCATION OF EXISTING MUNICIPAL INFRASTRUCTURE IS APPROXIMATE.

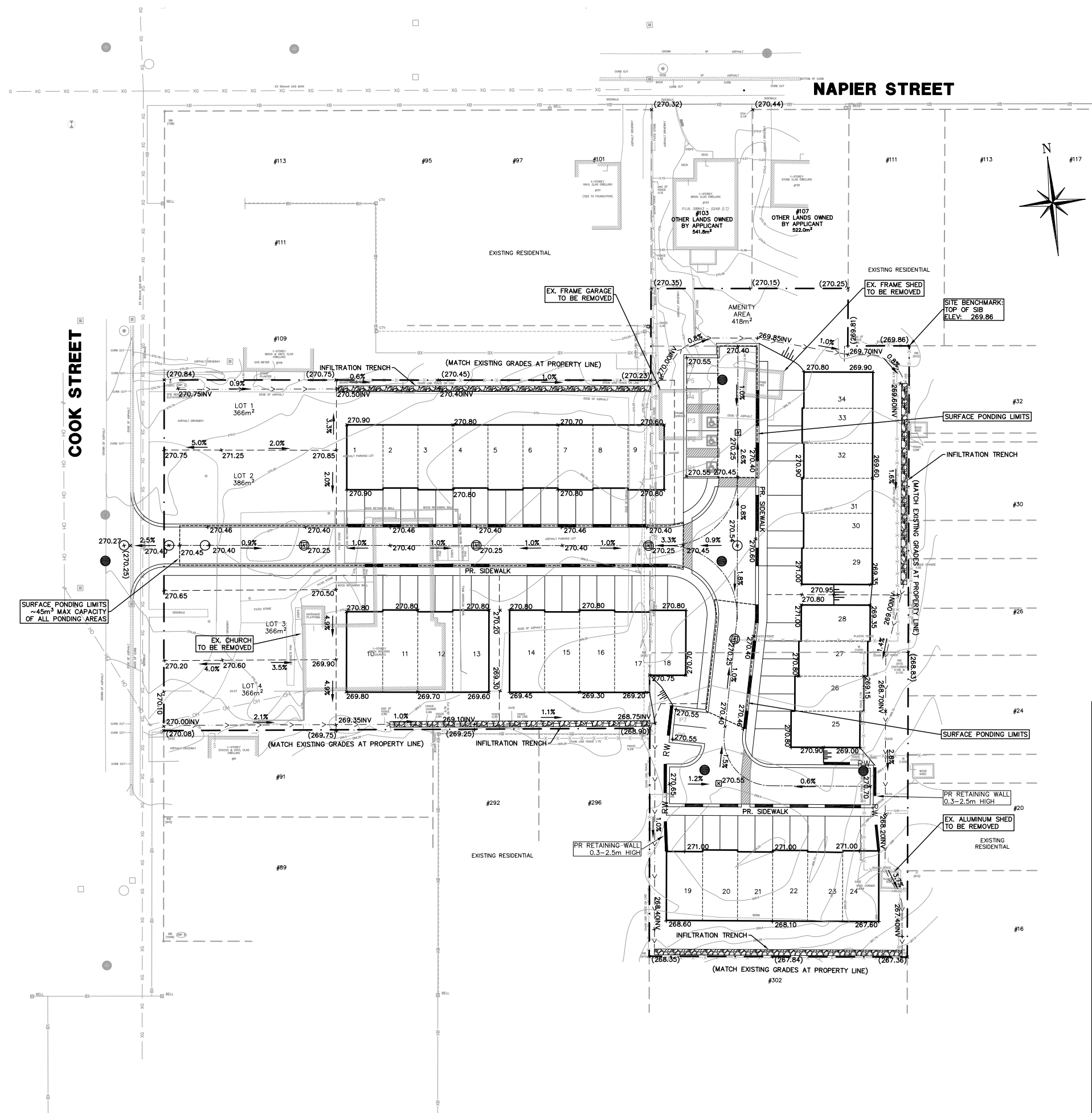
Drawing Title
**CONCEPTUAL SITE
SERVICING PLAN**

Project Title
**95 COOK STREET +
103-107 NAPIER STREET**



WMI & Associates Limited
119 Collier Street
Barrie, Ontario
L4M 1H5
705-797-2027
www.wmiengineering.ca

Drawn By CJ	Checked By JR	Figure No. FIG 4
Scale 1: 750	Project No. 21-694	



- Legend:**
- EXISTING FEATURES (EX)**
- EX SIB EX STD IRON BAR EX WS EX WATER SERVICE
 - EX IB EX IRON BAR EX HYD EX FIRE HYD.
 - EX UP EX UTILITY POLE NS EX ST NAME SIGN
 - EX BELL PED SS EX STOP SIGN
 - EX HYDRO TRANSFORMER EX ELEVATION
 - EX FENCE
 - EX U/G GASMAIN
 - EX U/G BELL
 - EX U/G HYDRO
 - EX WV EX WATERMAIN & VALVE
 - EX SAN @ 0.0% EX SAN SEWER & MH
 - EX STM @ 0.0% EX STM SEWER & MH

- PROPOSED FEATURES (PR)**
- PR WATER SERVICE
 - PR SANITARY SERVICE
 - PR STORM SERVICE
 - PR WATERMAIN
 - PR FIRE HYDRANT
 - PR WATER VALVE
 - PR SANITARY SEWER
 - PR SANITARY MANHOLE
 - PR STORM SEWER
 - PR EXFILTRATION SYSTEM
 - PR CATCHBASIN MANHOLE
 - PR MANHOLE
 - PR CATCHBASIN
 - PR SWALE
 - PR INFILTRATION TRENCH
 - PR RETAINING WALL
 - PR ELEVATION
 - PR MATCH EXISTING ELEVATION
 - PR 3:1 SLOPE

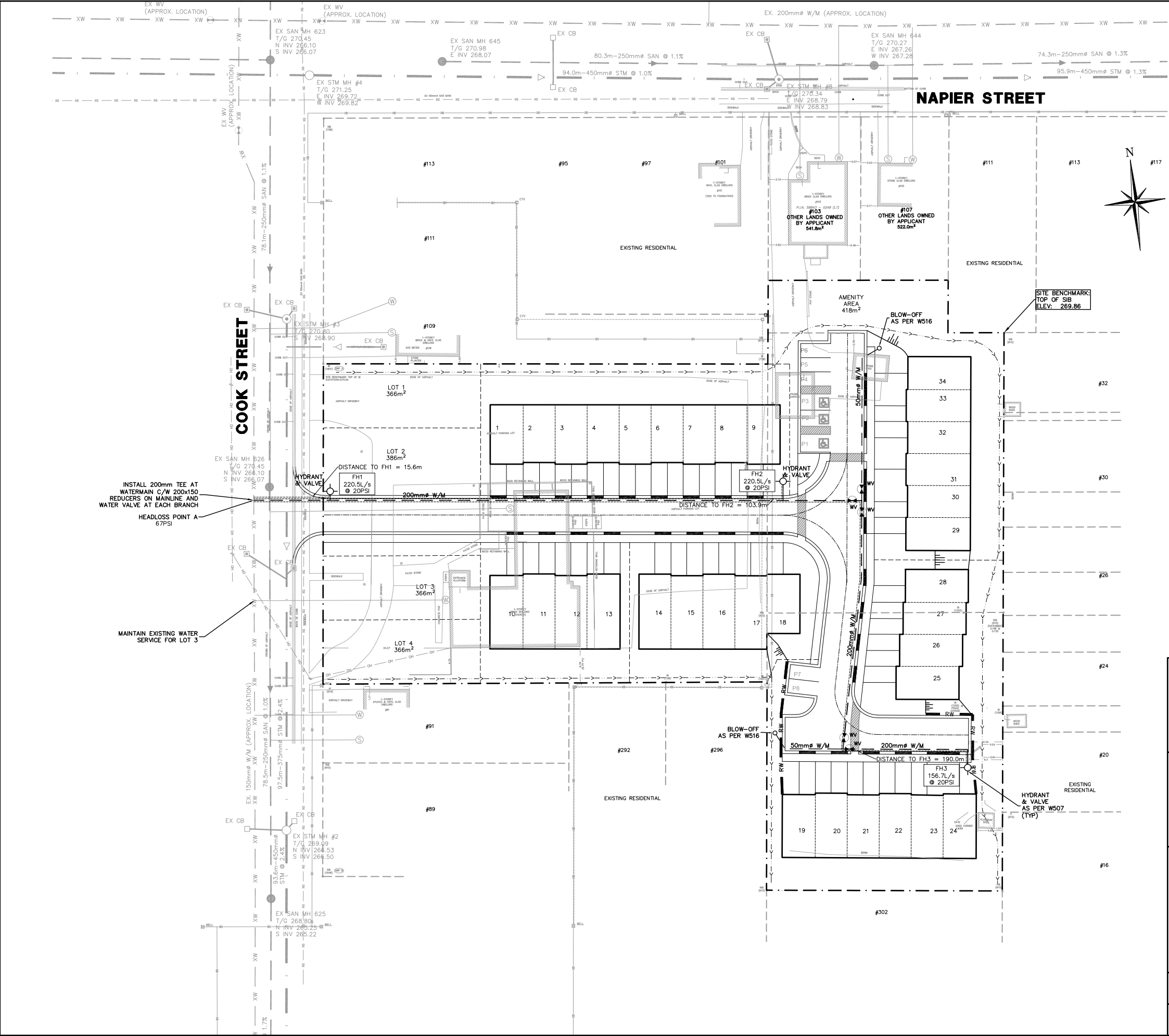
NOTE:
LOCATION OF EXISTING MUNICIPAL INFRASTRUCTURE IS APPROXIMATE.

Drawing Title
CONCEPTUAL GRADING PLAN

Project Title
95 COOK STREET +
103-107 NAPIER STREET

wmi
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Barrie, Ontario
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705-797-2027
www.wmiengineering.ca

Drawn By CJ	Checked By JR	Figure No. FIG 5
Scale 1: 750	Project No. 21-694	



Legend:

EXISTING FEATURES (EX)

- EX SIB EX STD IRON BAR EX WS EX WATER SERVICE
- EX IB EX IRON BAR EX HYD EX FIRE HYD.
- EX UP EX UTILITY POLE NS EX ST NAME SIGN
- EX CB EX BELL PED SS EX STOP SIGN
- EX HYDRO TRANSFORMER EX ELEVATION
- EX FENCE
- EX U/G GASMAIN
- EX U/G BELL
- EX U/G HYDRO
- EX WV EX WATERMAIN & VALVE
- EX SAN EX SAN SEWER & MH
- EX STM EX STM SEWER & MH

PROPOSED FEATURES (PR)

- PR WATER SERVICE
- PR SANITARY SERVICE
- PR STORM SERVICE
- PR WATERMAIN
- PR FIRE HYDRANT
- PR WATER VALVE
- PR SANITARY SEWER
- PR SANITARY MANHOLE
- PR STORM SEWER
- PR EXFILTRATION SYSTEM
- PR CATCHBASIN MANHOLE
- PR MANHOLE
- PR CATCHBASIN
- PR SWALE
- PR INFILTRATION TRENCH
- PR RETAINING WALL
- PR ELEVATION
- PR MATCH EXISTING ELEVATION
- PR 3:1 SLOPE
- DISTANCE TO FIRE HYDRANT
- FIRE HYDRANT AVAILABLE FLOW MINIMUM PRESSURE

NOTE:
LOCATION OF EXISTING MUNICIPAL INFRASTRUCTURE IS APPROXIMATE.

Drawing Title
CONCEPTUAL WATER SERVICING PLAN

Project Title
95 COOK STREET + 103-107 NAPIER STREET



WMI & Associates Limited
119 Collier Street
Barrie, Ontario
L4M 1H5
705-797-2027
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Drawn By CJ	Checked By JR	Figure No. FIG 6
Scale 1: 750	Project No. 21-694	

APPENDIX B

EXTERNAL DRAINAGE CALCULATIONS AND REFERENCES



External Storm Sewer Design Sheet

95 Cook Street + 103-107 Napier Street - Existing Condition

<<< Elements Requiring Input Information

Rational Method Calculation:

$$Q = 2.78 \cdot (C_F \cdot C \cdot I \cdot A)$$

where,

Q = peak flow rate (L/s)

C_F = runoff coefficient factor for storms > **10-yr** (C_F = 1.0 for the 2, 5 & 10-yr storm events and

C_F = 1.1, 1.2 & 1.25 for the 25, 50 & 100-yr storm events respectively)

C = runoff coefficient

I = rainfall intensity (mm/hr)

A = area (ha)

Manning's Formula Calculation:

$$V = (k \cdot R^{2/3} \cdot S^{1/2}) / n$$

$$Q = V \cdot A$$

MOE Velocity Requirements: 0.8m/s - 6.0m/s

where,

V = mean velocity (m/s)

k = 1.0 for SI units

R = hydraulic radius (m)

S = friction slope (m/m)

n = Mannings Coefficient

0.013

Rainfall Intensity Calculation:

$$I = \frac{A}{(T + B)^C}$$

Rainfall IDF Data:

Barrie WPCC 1979-2003 adjusted for climate change

5-year **100-year**

A = **843.019** **1383.628**

B = **4.582** **4.905**

C = **0.763** **0.754**

where,

I = Rainfall Intensity (mm/hr)

T = Time of Concentration (min.)

A = Rainfall IDF Coefficient

Runoff Coeff. Factors, C_F = 1.00 1.25

B = Rainfall IDF Coefficient

C = Rainfall IDF Coefficient

Date: **06-Aug-24**

Project No: **21-694**

Prepared by: **CJ**

Location			Runoff Calculation Data									Sewer Calculation Data							Sewer Profile Data						
Street	*Upstream MH	Downstream MH	Drainage Areas (ha)				Individual 2.78CA	Accumulated 2.78CA	Time of Concentration	Storm Event	Rainfall Intensity	Peak Runoff Flow	Diameter	Slope	Length	Capacity	Velocity	Pipe Flow Time	Pipe Storage Volume	Fall in Sewer	Drop in MH (m)	Top of Grate Elevation (m)		Invert Elevation (m)	
			C =	C =	C =	C =															DS	US	DS	US	
			0.20	0.40	0.50	0.75																			
Cook St	100103918	100103913		0.25			0.28	0.28	10.00	5-year	109.11	30.33	375	2.40	97.50	283.36	2.49	0.65	11.1	2.34					
**Cook St	100103913	100103911		1.58			1.76	2.03	10.65	5-year	105.51	214.72	450	2.40	93.60	460.78	2.81	0.56	15.4	2.25					
Codrington St		100103593		2.15			2.39	2.39	10.00	5-year	109.11	260.85													
Cook St	100103911	100103593		0.60			0.67	2.70	11.21	5-year	102.67	277.43	450	0.90	10.50	282.17	1.72	0.10	1.7	0.09					
Cook St	100103593	120067907		0.71			0.79	5.88	11.31	5-year	102.17	600.99	525	2.80	69.25	750.75	3.36	0.34	15.5	1.94					
A1 - Rodney Street	EX MH1	MH2		0.49			0.54	0.54	10.00	5-year	109.11	59.45	300	3.50	73.66	188.73	2.59	0.47	5.4	2.58					
A2 - Mountbatten Rd.	MH3	MH4		1.10			1.22	1.22	10.00	5-year	109.11	133.46	375	1.00	97.00	182.91	1.60	1.01	11.1	0.97					
A3 - Mountbatten Rd.	MH4	MH2		0.90			1.00	2.22	11.01	5-year	103.68	230.59	450	1.76	81.02	394.59	2.40	0.56	13.3	1.43					
A4 - Mountbatten Cres.	MH5	EX MH6		1.28			1.42	1.42	10.00	5-year	109.11	155.30	675	0.75	65.00	759.45	2.06	0.53	24.0	0.49					
A5 - Mountbatten Cres.	EX MH6	MH2		0.23			0.26	1.68	10.53	5-year	106.19	178.31	675	0.78	65.12	774.49	2.10	0.52	24.1	0.51					
A6 - Rodney Street	MH2	MH7		0.22			0.24	4.69	11.57	5-year	100.92	473.57	675	2.71	58.00	1443.61	3.91	0.25	21.4	1.57					
Codrington St		MH8		1.80			2.00	2.00	10.00	5-year	109.11	218.38													
A7 - Rodney Street	MH7	MH8		0.20			0.22	4.92	11.82	5-year	99.76	490.30	675	3.10	54.50	1544.00	4.18	0.22	20.1	1.69					
A8 - Rodney Street	MH8	MH9		0.09			0.10	7.02	12.03	5-year	98.76	692.96	750	3.86	56.43	2281.81	5.00	0.19	25.7	2.18					
A9 - Rodney Street	MH9	MH10		0.29			0.32	7.34	12.22	5-year	97.91	718.61	750	1.35	56.28	1349.44	2.96	0.32	25.7	0.76					
A10 - Lakeview Cres.	MH11	MH10		0.62			0.69	0.69	10.00	5-year	109.11	75.22	375	1.58	43.55	229.92	2.02	0.36	5.0	0.69					
A11 - Rodney Street	MH10	120067867		2.00			2.22	10.25	12.54	5-year	96.53	989.66	750	2.85	81.79	1960.69	4.30	0.32	37.3	2.33					
A12 - Highland Ave.	120067907	DDRN00142		0.70			0.78	6.66	11.65	5-year	100.51	669.50	600	1.72	75.50	840.09	2.88	0.44	22.0	1.30					
A13 - Highland Ave.	DDRN00142	DDRN00139		0.24			0.27	6.93	12.09	5-year	98.50	682.36	600	3.23	52.00	1151.23	3.94	0.22	15.2	1.68					
A14 - Highland Ave.	DDRN00139	120067867		0.16			0.18	7.11	12.31	5-year	97.52	692.92	600	1.54	52.60	794.91	2.72	0.32	15.4	0.81					
A15 - Rodney Street	120067867	120067954		0.23			0.26	17.61	12.86	5-year	95.19	1676.61	750	3.16	48.33	2064.57	4.53	0.18	22.0	1.53					
Rodney St	120067954	120027195		0.08			0.09	17.70	13.03	5-year	94.45	1672.08	750	8.40	25.56	3366.09	7.38	0.06	11.7	2.15					
White Pine Pl (total)		120027195		1.57			1.75	1.75	10.00	5-year	109.11	190.48													
Rodney St	120027195	120027194		0.06			0.07	19.52	13.09	5-year	94.22	1838.85	750	8.40	20.34	3366.09	7.38	0.05	9.3	1.71					
Rodney St	120027194	120027193		0.04			0.04	19.56	13.14	5-year	94.03	1839.19	750	4.70	12.56	2517.88	5.52	0.04	5.7	0.59					
Rodney St	120027193	120027191		0.04			0.04	19.60	13.18	5-year	93.88	1840.26	750	4.60	12.88	2490.95	5.46	0.04	5.9	0.59					
Rodney St	120027191	100103613		0.02			0.02	19.63	13.21	5-year	93.72	1839.39	750	20.10	7.06	5206.96	11.42	0.01	3.2	1.42					
Collingwood St (Total)		100103613		2.86			3.18	3.18	10.00	5-year	109.11	346.99													
Rodney St	100103613	100103614		0.10			0.11	22.92	13.23	5-year	93.68	2146.91	675	6.90	44.89	2303.51	6.24	0.12	16.6	3.10					
Rodney St	100103614	100103608		0.26			0.29	23.21	13.35	5-year	93.20	2162.89	675	7.06	55.34	2330.07	6.31	0.15	20.4	3.91					
Rodney St	100103608	100103607		0.05			0.06	23.26	13.49	5-year	92.62	2154.67	675	7.09	28.07	2335.01	6.32	0.07	10.4	1.99					
Blake St		100103607		1.40			1.56	1.56	10.00	5-year	109.11	169.85													
Blake St		120084869		0.10			0.11	0.11	10.00	5-year	109.11	12.13													
***Rodney St	100103607	120084869		0.05			0.06	24.88	13.57	5-year	92.33	2296.84	825	3.00	12.65	2593.75	4.70	0.04	7.0	0.38					
***Rodney St	120084869	120084870		0.27			0.30	25.29	13.61	5-year	92.16	2330.44	825	3.00	55.85	2593.75	4.70	0.20	30.8	1.68					

Sum of Drainage Areas (ha): 0.00 22.74 0.00 0.00

Total Drainage Area (ha): 22.74

NOTES: - Storm data taken from: City of Barrie Engineering Department Drawings- Storm Drainage Plan STM1 2015-001-002, 2015-001-013, 2015-001-014; and, opendata.barrie.ca/datasets/storm-linear.

* - Where no upstream manholes are identified, only the total drainage area contributing to the downstream manhole was considered. as applicable to the subject site.

** - 0.22ha (Catchment PRE1) is included in this total drainage area.

*** - Pipe slopes are estimated (no data available).



External Storm Sewer Design Sheet
95 Cook Street + 103-107 Napier Street - Proposed Condition

Elements Requiring Input Information

Rational Method Calculation:

$Q = 2.78 \cdot (C_F \cdot C \cdot I \cdot A)$

where,

Q = peak flow rate (L/s)

C_F = runoff coefficient factor for storms **≥ 10-yr** (C_F = 1.0 for the 2, 5 & 10-yr storm events and C_F = 1.1, 1.2 & 1.25 for the 25, 50 & 100-yr storm events respectively)

C = runoff coefficient

I = rainfall intensity (mm/hr)

A = area (ha)

Manning's Formula Calculation:

$V = (k \cdot R^{2/3} \cdot S^{1/2}) / n$

$Q = V \cdot A$

MOE Velocity Requirements: 0.8m/s - 6.0m/s

where,

V = mean velocity (m/s)

k = 1.0 for SI units

R = hydraulic radius (m)

S = friction slope (m/m)

n = Mannings Coefficient

0.013

Rainfall Intensity Calculation:

$I = \frac{A}{(T + B)^C}$

Rainfall IDF Data:

Barrie WPCC 1979-2003 adjusted for climate change

where,

A =

5-year

100-year

843.019

1383.628

I = Rainfall Intensity (mm/hr)

B =

4.582

4.905

T = Time of Concentration (min.)

C =

0.763

0.754

A = Rainfall IDF Coefficient

Runoff Coeff. Factors, C_F =

1.00

1.25

B = Rainfall IDF Coefficient

C = Rainfall IDF Coefficient

Date: 06-Aug-24

Project No: 21-694

Prepared by: CJ

Location			Runoff Calculation Data										Sewer Calculation Data							Sewer Profile Data						
Street	*Upstream MH	Downstream MH	Drainage Areas (ha)				Individual 2.78CA	Accumulated 2.78CA	Time of Concentration	Storm Event	Rainfall Intensity	Peak Runoff Flow	Diameter	Slope	Length	Capacity	Velocity	Pipe Flow Time	Pipe Storage Volume	Fall in Sewer	Drop in MH (m)	Top of Grate Elevation (m)		Invert Elevation (m)		
			C =	C =	C =	C =															DS	US	DS	US	DS	DS
			0.20	0.40	0.75	0.86																				
Cook St	100103918	100103913		0.25			0.28	0.28	10.00	5-year	109.11	30.33	375	2.40	37.60	283.36	2.49	0.25	4.3	0.90						
**Cook St	100103913	100103911		1.86			2.07	2.35	10.25	5-year	107.69	252.67	450	2.40	93.60	460.78	2.81	0.56	15.4	2.25						
Codrington St		100103593		2.15			2.39	2.39	10.00	5-year	109.11	260.85														
Cook St	100103911	100103593		0.60			0.67	3.01	10.81	5-year	104.71	315.54	450	0.90	10.50	282.17	1.72	0.10	1.7	0.09						
Cook St	100103593	120067907		0.71			0.79	6.19	10.91	5-year	104.18	645.28	525	2.80	69.25	750.75	3.36	0.34	15.5	1.94						
A1 - Rodney Street	EX MH1	MH2		0.49			0.54	0.54	10.00	5-year	109.11	59.45	300	3.50	73.66	188.73	2.59	0.47	5.4	2.58						
A2 - Mountbatten Rd.	MH3	MH4		1.10			1.22	1.22	10.00	5-year	109.11	133.46	375	1.00	97.00	182.91	1.60	1.01	11.1	0.97						
A3 - Mountbatten Rd.	MH4	MH2		0.90			1.00	2.22	11.01	5-year	103.68	230.59	450	1.76	81.02	394.59	2.40	0.56	13.3	1.43						
A4 - Mountbatten Cres.	MH5	EX MH6		1.28			1.42	1.42	10.00	5-year	109.11	155.30	675	0.75	65.00	759.45	2.06	0.53	24.0	0.49						
A5 - Mountbatten Cres.	EX MH6	MH2		0.23			0.26	1.68	10.53	5-year	106.19	178.31	675	0.78	65.12	774.49	2.10	0.52	24.1	0.51						
A6 - Rodney Street	MH2	MH7		0.22			0.24	4.69	11.57	5-year	100.92	473.57	675	2.71	58.00	1443.61	3.91	0.25	21.4	1.57						
Codrington St		MH8		1.80			2.00	2.00	10.00	5-year	109.11	218.38														
A7 - Rodney Street	MH7	MH8		0.20			0.22	4.92	11.82	5-year	99.76	490.30	675	3.10	54.50	1544.00	4.18	0.22	20.1	1.69						
A8 - Rodney Street	MH8	MH9		0.09			0.10	7.02	12.03	5-year	98.76	692.96	750	3.86	56.43	2281.81	5.00	0.19	25.7	2.18						
A9 - Rodney Street	MH9	MH10		0.29			0.32	7.34	12.22	5-year	97.91	718.61	750	1.35	56.28	1349.44	2.96	0.32	25.7	0.76						
A10 - Lakeview Cres.	MH11	MH10		0.62			0.69	0.69	10.00	5-year	109.11	75.22	375	1.58	43.55	229.92	2.02	0.36	5.0	0.69						
A11 - Rodney Street	MH10	120067867		2.00			2.22	10.25	12.54	5-year	96.53	989.66	750	2.85	81.79	1960.69	4.30	0.32	37.3	2.33						
A12 - Highland Ave.	120067907	DDRN00142		0.70			0.78	6.97	11.25	5-year	102.45	714.32	600	1.72	75.50	840.09	2.88	0.44	22.0	1.30						
A13 - Highland Ave.	DDRN00142	DDRN00139		0.24			0.27	7.24	11.69	5-year	100.35	726.41	600	3.23	52.00	1151.23	3.94	0.22	15.2	1.68						
A14 - Highland Ave.	DDRN00139	120067867		0.16			0.18	7.42	11.91	5-year	99.32	736.69	600	1.54	52.60	794.91	2.72	0.32	15.4	0.81						
A15 - Rodney Street	120067867	120067954		0.23			0.26	17.93	12.86	5-year	95.19	1706.25	750	3.16	48.33	2064.57	4.53	0.18	22.0	1.53						
Rodney St	120067954	120027195		0.08			0.09	18.01	13.03	5-year	94.45	1701.48	750	8.40	25.56	3366.09	7.38	0.06	11.7	2.15						
White Pine PI (total)		120027195		1.57			1.75	1.75	10.00	5-year	109.11	190.48														
Rodney St	120027195	120027194		0.06			0.07	19.83	13.09	5-year	94.22	1868.18	750	8.40	20.34	3366.09	7.38	0.05	9.3	1.71						
Rodney St	120027194	120027193		0.04			0.04	19.87	13.14	5-year	94.03	1868.46	750	4.70	12.56	2517.88	5.52	0.04	5.7	0.59						
Rodney St	120027193	120027191		0.04			0.04	19.91	13.18	5-year	93.88	1869.49	750	4.60	12.88	2490.95	5.46	0.04	5.9	0.59						
Rodney St	120027191	100103613		0.02			0.02	19.94	13.21	5-year	93.72	1868.57	750	20.10	7.06	5206.96	11.42	0.01	3.2	1.42						
Collingwood St (Total)		100103613		2.86			3.18	3.18	10.00	5-year	109.11	346.99														
Rodney St	100103613	100103614		0.10			0.11	23.23	13.23	5-year	93.68	2176.08	675	6.90	44.89	2303.51	6.24	0.12	16.6	3.10						
Rodney St	100103614	100103608		0.26			0.29	23.52	13.35	5-year	93.20	2191.91	675	7.06	55.34	2330.07	6.31	0.15	20.4	3.91						
Rodney St	100103608	100103607		0.05			0.06	23.57	13.49	5-year	92.62	2183.51	675	7.09	28.07	2335.01	6.32	0.07	10.4	1.99						
Blake St		100103607		1.40			1.56	1.56	10.00	5-year	109.11	169.85														
Blake St		120084869		0.10			0.11	0.11	12.00	5-year	98.91	11.00														
***Rodney St	100103607	120084869		0.05			0.06	25.19	13.57	5-year	92.33	2325.59	825	3.00	12.65	2593.75	4.70	0.04	7.0	0.38						
***Rodney St	120084869	120084870		0.27			0.30	25.60	13.61	5-year	92.16	2359.14	825	3.00	55.85	2593.75	4.70	0.20	30.8	1.68						

Sum of Drainage Areas (ha): 0.00 23.02 0.00 0.00

Total Drainage Area (ha): 23.02

NOTES: - Storm data taken from: City of Barrie Engineering Department Drawings- Storm Drainage Plan STM1 2015-001-002, 2015-001-013, 2015-001-014; and, opendata.barrie.ca/datasets/storm-linear.

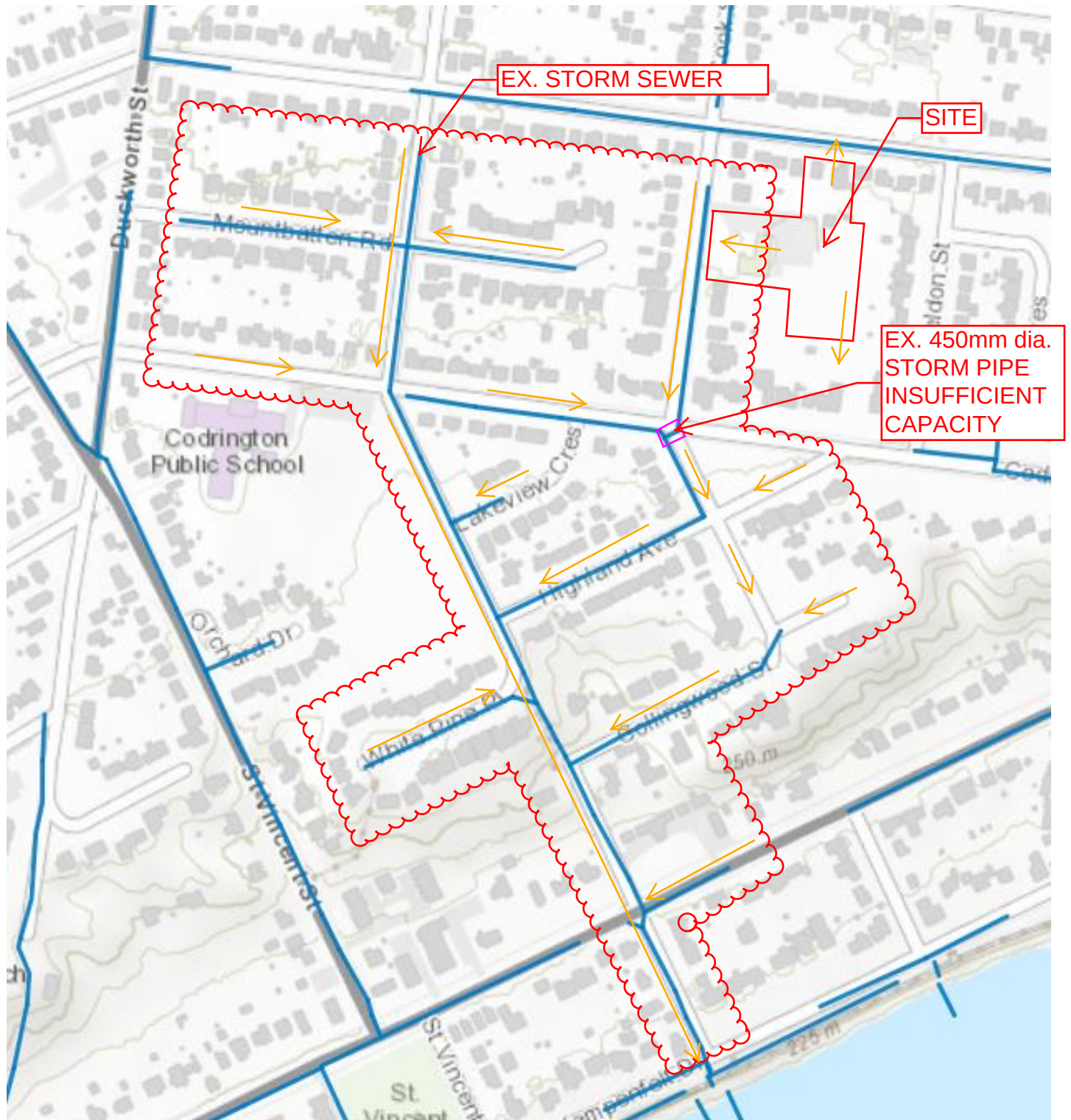
* - Where no upstream manholes are identified, the total drainage area contributing to the downstream manhole was considered, as applicable to the subject site.

** - A total of 0.50ha from the subject site contributes to Cook Street and is included In this overall drainage area. This is an increase of 0.28ha over the existing condition (0.50ha-0.22ha).

*** - Pipe slopes are estimated (no data available).

Storm sewers identified as undercapacity.

External Storm Drainage Plan



Storm Drainage Flow Direction →

Storm Drainage Area (Approx.) ☁

Over-capacity Storm Pipe □

Existing Storm Sewer Pipe —



External Sanitary Sewer Design Sheet
95 Cook Street + 103-107 Napier Street (Proposed)

Elements Requiring Input Information

Peak Flow Formulae: $Q_{pop} = (P \cdot q \cdot M) / 86.4$ (L/s) $Q_{Comm/Inst} = \text{Design Flow} \times \text{Peaking Factor}$ (L/s) $Q_{ind} = \text{Design Flow} \times \text{Peaking Factor}$ (L/s) $Q_{infil} = i \cdot A$ (L/s), where A = Area (ha) $Q_t = Q_{pop} + Q_{Comm/Inst} + Q_{ind} + Q_{infil}$ (L/s) MOE Velocity Requirements: 0.6m/s - 3.0m/s	where, P = population in 1000's q = residential sewage unit flow rate M = Ultimate Flow Factor (residential peaking factor) (Harmon) $M = 1 + (14 / (4 + P^{0.5}))$ Q_{pop} = peak population flow (L/s) $Q_{Comm/Inst}$ = peak commercial/institutional flow (L/s) Q_{ind} = peak industrial flow (L/s) Q_{infil} = peak extraneous (i.e. infiltration) flow (L/s) i = peak extraneous (i.e. infiltration) unit flow rate Q_t = total peak design flow (L/s)	Comm/Inst Industrial Res - SFD *Single Family Dwellings: q: 225 L/cap./day Res - MFD **Multi-Family Dwellings: q: 225 L/cap./day Infiltration (City of Barrie Sanitary Infrastructure Design Standard 2023) Mannings Coefficient Peaking Factor: 1.5 Peaking Factor: 2 ppd = 3.13 ppu = 2.34 i: 0.1 L/s/ha n: 0.013
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Date: 06-Aug-24
Project No: 21-694
Prepared by: CJ

Location			Sewage Flow Calculation Data														Sewer Calculation Data					Sewer Profile Data								
Street	Upstream MH	Downstream MH	Res - SFD # of Units	Res - SFD # of People	Res - MFD # of Units	Res - MFD # of People	***Comm/Inst Total Daily Flow (L/day)	Industrial Total Daily Flow (L/day)	Cum. Res - SFD # of People	Cum. Res - MFD # of People	Cum. Comm/Inst Total Daily Flow (L/day)	Cum. Industrial Total Daily Flow (L/day)	Residential Peaking Factor	Sewage Flow (L/s)	Infiltration			Total Flow (L/s)	Dia. (mm)	Slope (%)	Length (m)	Capacity (L/s)	Velocity (m/s)	Fall in Sewer (m)	Drop in MH (m) DS	Top of Grate Elevation (m) US		Invert Elevation (m) US		DS
Rodney	100301677	100301703	8	25		0			25	0	0	0	4.37	0.28	0.63	0.63	0.06	0.35	200	1.10	96.4	35.89	1.11	1.06						
Strabane	100301703	100301702	3	9		0			34	0	0	0	4.34	0.39	0.48	1.11	0.11	0.50	250	1.40	73.5	73.41	1.45	1.03						
Strabane	100301702	100301701	9	28		0			63	0	0	0	4.29	0.70	1.08	2.19	0.22	0.92	250	1.26	75.3	69.64	1.37	0.95						
Strabane	100301701	100301621	2	6		0			69	0	0	0	4.28	0.77	0.31	2.50	0.25	1.02	250	0.85	74.2	57.20	1.13	0.63						
Cook	100301621	100301622	7	22		0			91	0	0	0	4.25	1.00	0.62	3.12	0.31	1.32	250	0.86	61.8	57.53	1.14	0.53						
Cook	100301622	100301623	2	6		0			97	0	0	0	4.25	1.07	0.36	3.48	0.35	1.42	250	1.07	62.6	64.17	1.27	0.67						
Napier	100301647	100301646	13	41		0			41	0	0	0	4.33	0.46	1.19	1.19	0.12	0.58	250	1.11	78.1	65.36	1.29	0.87						
Napier	100301646	100301623	10	31		0			72	0	0	0	4.28	0.80	0.88	2.07	0.21	1.01	250	2.06	107.7	89.04	1.76	2.22						
Cook	100301623	100301626	8	25		0			194	0	0	0	4.15	2.10	0.52	6.07	0.61	2.70	250	1.88	101.9	85.06	1.68	1.92						
***Cook	100301626	100301625	12	38	34	79.56			232	80	0	0	4.07	3.30	1.88	7.95	0.80	4.09	250	1.11	8.0	65.36	1.29	0.09						
Cook	100301625	100301624	2	6		0			238	80	0	0	4.07	3.36	0.32	8.27	0.83	4.19	250	1.04	78.5	63.27	1.25	0.82						
Codrington	100301689	100301690	5	16		0			16	0	0	0	4.39	0.18	0.61	0.61	0.06	0.24	200	1.00	89.2	34.22	1.06	0.89						
Codrington	100301690	120079766	4	13		0			28	0	0	0	4.36	0.32	0.46	1.07	0.11	0.43	200	1.00	72.8	34.22	1.06	0.73						
Rodney	120079822	120079821	8	25		0			25	0	0	0	4.37	0.28	0.69	0.69	0.07	0.35	250	3.50	80.1	116.06	2.29	2.80						
Mountbatten Road	120200197	120079846	8	25		0			25	0	0	0	4.37	0.28	0.88	0.88	0.09	0.37	250	1.00	85.5	62.04	1.22	0.86						
Mountbatten Road	120079846	120079821	8	25		0			50	0	0	0	4.31	0.56	0.60	1.48	0.15	0.71	250	2.40	86.0	96.11	1.90	2.06						
Mountbatten Cres	120079858	120079857	6	19		0			19	0	0	0	4.38	0.21	0.22	0.22	0.02	0.24	250	1.00	27.1	62.04	1.22	0.27						
Mountbatten Cres	120079857	120079856	4	13		0			31	0	0	0	4.35	0.35	0.89	1.11	0.11	0.47	250	0.40	55.1	39.24	0.77	0.22						
Mountbatten Cres	120079856	120079821	2	6		0			38	0	0	0	4.34	0.42	0.42	1.53	0.15	0.58	250	0.41	61.5	39.72	0.78	0.25						
Rodney	120079821	120079767	3	9		0			122	0	0	0	4.22	1.34	0.50	4.20	0.42	1.76	250	0.50	55.8	43.87	0.87	0.28						
Rodney	120079767	120079766	0	0		0			122	0	0	0	4.22	1.34	0.11	4.31	0.43	1.77	250	0.50	56.1	43.87	0.87	0.28						
Codrington	120079766	100301692	7	22		0			172	0	0	0	4.17	1.87	0.54	5.92	0.59	2.46	200	1.00	72.9	34.22	1.06	0.73						
Codrington	100301692	100301674	5	16		0			188	0	0	0	4.16	2.03	0.53	6.45	0.65	2.68	200	0.80	62.1	30.60	0.94	0.50						
Easement	120200202	100301694	2	6		0			6	0	0	0	4.43	0.07	0.02	0.02	0.00	0.07	200	0.40	22.5	21.64	0.67	0.09						
Easement	100301694	100301674	0	0		0			6	0	0	0	4.43	0.07	0.02	0.04	0.00	0.08	200	0.40	58.5	21.64	0.67	0.23						
Codrington	100301674	100301673	1	3		0			197	0	0	0	4.15	2.13	0.20	6.69	0.67	2.80	200	0.80	15.9	30.60	0.94	0.13						
Codrington	100301673	100301624	3	9		0			207	0	0	0	4.14	2.23	0.38	7.07	0.71	2.93	200	1.00	75.0	34.22	1.06	0.75						
Codrington	100301624	100301675	3	9		0			454	80	0	0	3.96	5.50	1.04	16.38	1.64	7.14	200	2.00	94.7	48.39	1.49	1.89						
Codrington	100301675	100301880	3	9.39		0			463	80	0	0	3.96	5.60	1.01	17.39	1.74	7.34	200	2.00	95.4	48.39	1.49	1.91						
Weldon Cres	100301876	100301877	11	34		0			34	0	0	0	4.34	0.39	1.47	1.47	0.15	0.54	200	0.40	76.3	21.64	0.67	0.31						
Weldon Cres	100301877	100301878	2	6		0			41	0	0	0	4.33	0.46	0.26	1.73	0.17	0.63	200	0.40	65.2	21.64	0.67	0.26						
Weldon Cres	100301878	100301879	0	0		0			41	0	0	0	4.33	0.46	0.14	1.87	0.19	0.65	200	0.40	2.0	21.64	0.67	0.01						
Weldon St	100301875	100301879	11	34		0			34	0	0	0	4.34	0.39	0.92	0.92	0.09	0.48	250	3.20	105.6	110.98	2.19	3.38						
Weldon St	100301879	100301880	1	3		0			78	0	0	0	4.27	0.87	0.36	3.15	0.32	1.19	250	0.52	70.9	44.74	0.88	0.37						
Codrington	100301880	100301881	5	16		0			557	80	0	0	3.92	6.50	1.36	21.90	2.19	8.69	200	0.53	67.9	24.91	0.77	0.36						
Codrington	100301881	100307540	3	9		0			567	80	0	0	3.91	6.58	0.81	22.71	2.27	8.85	200	0.40	64.5	21.64	0.67	0.26						
Codrington	100307540	100301630	6	19		0			585	80	0	0	3.91	6.77	0.85	23.56	2.36	9.13	250	0.40	64.8	39.24	0.77	0.26						
Codrington	100301630	100301628	0	0		0			585	80	0	0	3.91	6.77	0.02	23.58	2.36	9.13	250	2.00	13.9	87.74	1.73	0.28						
Napier	100301645	100301644	10	31		0			31	0	0	0	4.35	0.35	0.94	0.94	0.09	0.45	250	1.05	80.6	63.57	1.25	0.85						
Napier	100301644	100301643	6	19		0			50	0	0	0	4.31	0.56	0.80	1.74	0.17	0.74	250	1.32	73.5	71.28	1.41	0.97						
Napier	100301643	100301642	12	38		0			88	0	0	0	4.26	0.97	1.20	2.94	0.29	1.27	250	3.00	105.6	107.45	2.12	3.17						
Napier	100301642	100301641	10	31		0			119	0	0	0	4.22	1.31	0.70	3.64	0.36	1.67	250	2.00	107.4	87.74	1.73	2.15						
Nelson	100301641	100301873	7	22		0			141	0	0	0	4.20	1.54	0.55	4.19	0.42	1.96	200	1.50	65.2	41.91	1.29	0.98						
Nelson	100301873	100301869	6	19		0			160																					



External Sanitary Sewer Design Sheet
95 Cook Street + 103-107 Napier Street (Existing)

<<< Elements Requiring Input Information

Peak Flow Formulae:

$Q_{pop} = (P \times q \times M) / 86.4$ (L/s)
 $Q_{Comm/Inst} = \text{Design Flow} \times \text{Peaking Factor}$ (L/s)
 $Q_{Ind} = \text{Design Flow} \times \text{Peaking Factor}$ (L/s)
 $Q_{Infil} = P \times A$ (L/s), where A = Area (ha)
 $Q_0 = Q_{pop} + Q_{Comm/Inst} + Q_{Ind} + Q_{Infil}$ (L/s)

MOE Velocity Requirements: 0.6m/s - 3.0m/s

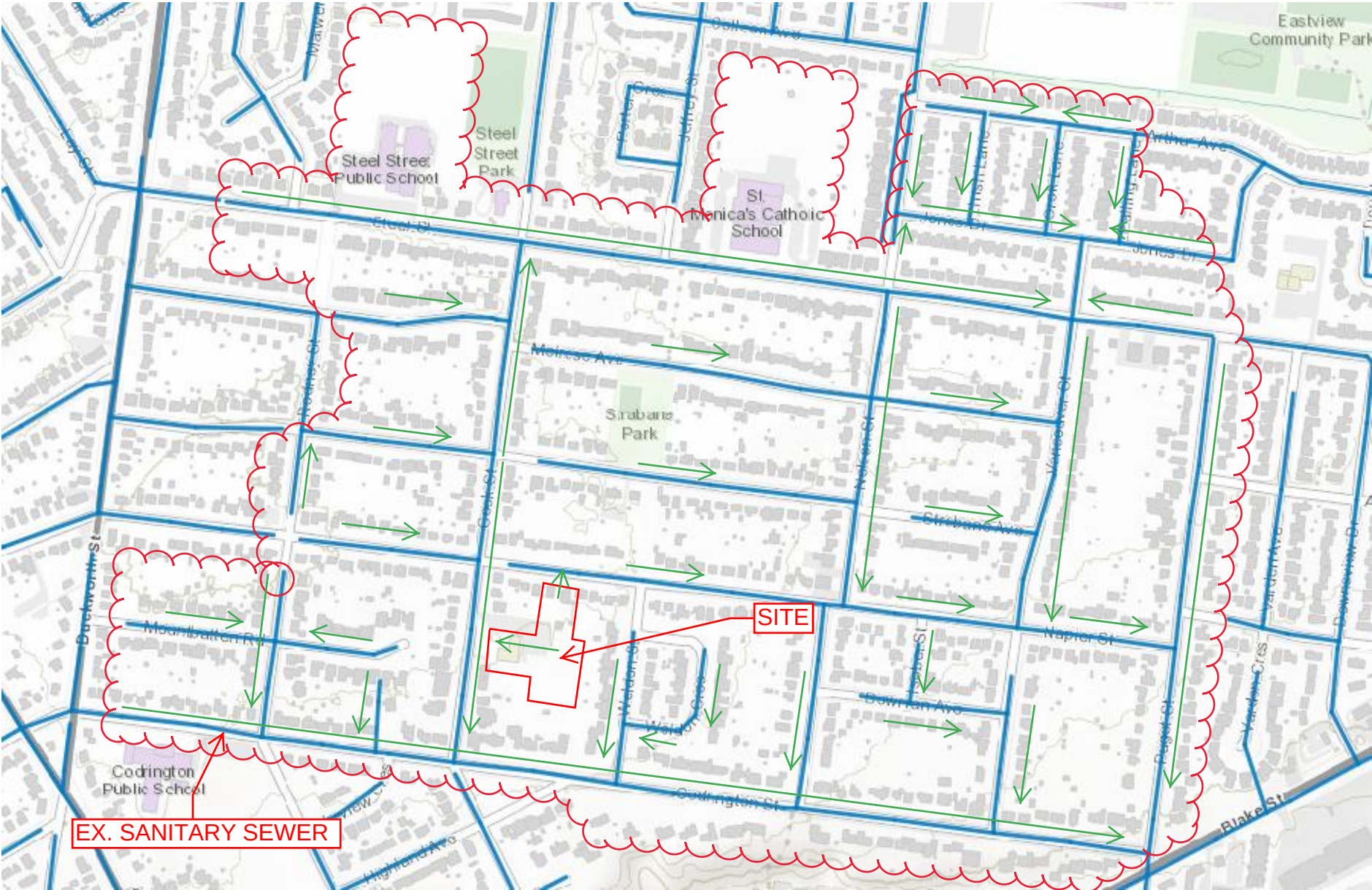
where, P = population in 1000's
 q = residential sewage unit flow rate
M = Ultimate Flow Factor (residential peaking factor)
(Harmon) $M = 1 + (14 / (4 + P^{0.5}))$
 Q_{pop} = peak population flow (L/s)
 $Q_{Comm/Inst}$ = peak commercial/institutional flow (L/s)
 Q_{Ind} = peak industrial flow (L/s)
 Q_{Infil} = peak extraneous (i.e. infiltration) flow (L/s)
 i = peak extraneous (i.e. infiltration) unit flow rate
 Q_0 = total peak design flow (L/s)

Comm/Inst Peaking Factor: 1.5
Industrial Peaking Factor: 2
Res - SFD *Single Family Dwellings: q: 225 L/cap./day ppd = 3.13
Res - MFD **Multi-Family Dwellings: q: 225 L/cap./day ppu = 2.34
Infiltration i: 0.1 L/s/ha
(City of Barrie Sanitary Infrastructure Design Standard 2023)
Mannings Coefficient n: 0.013

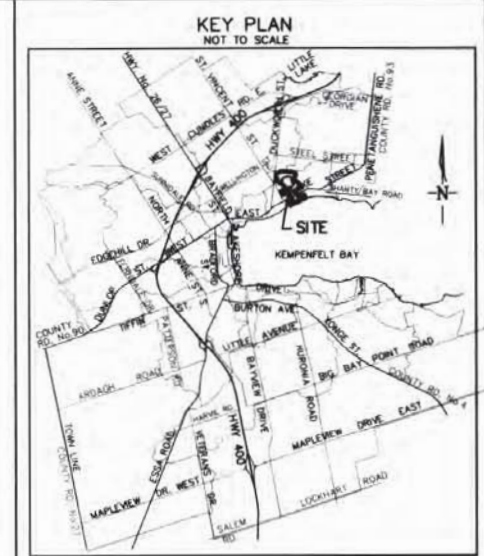
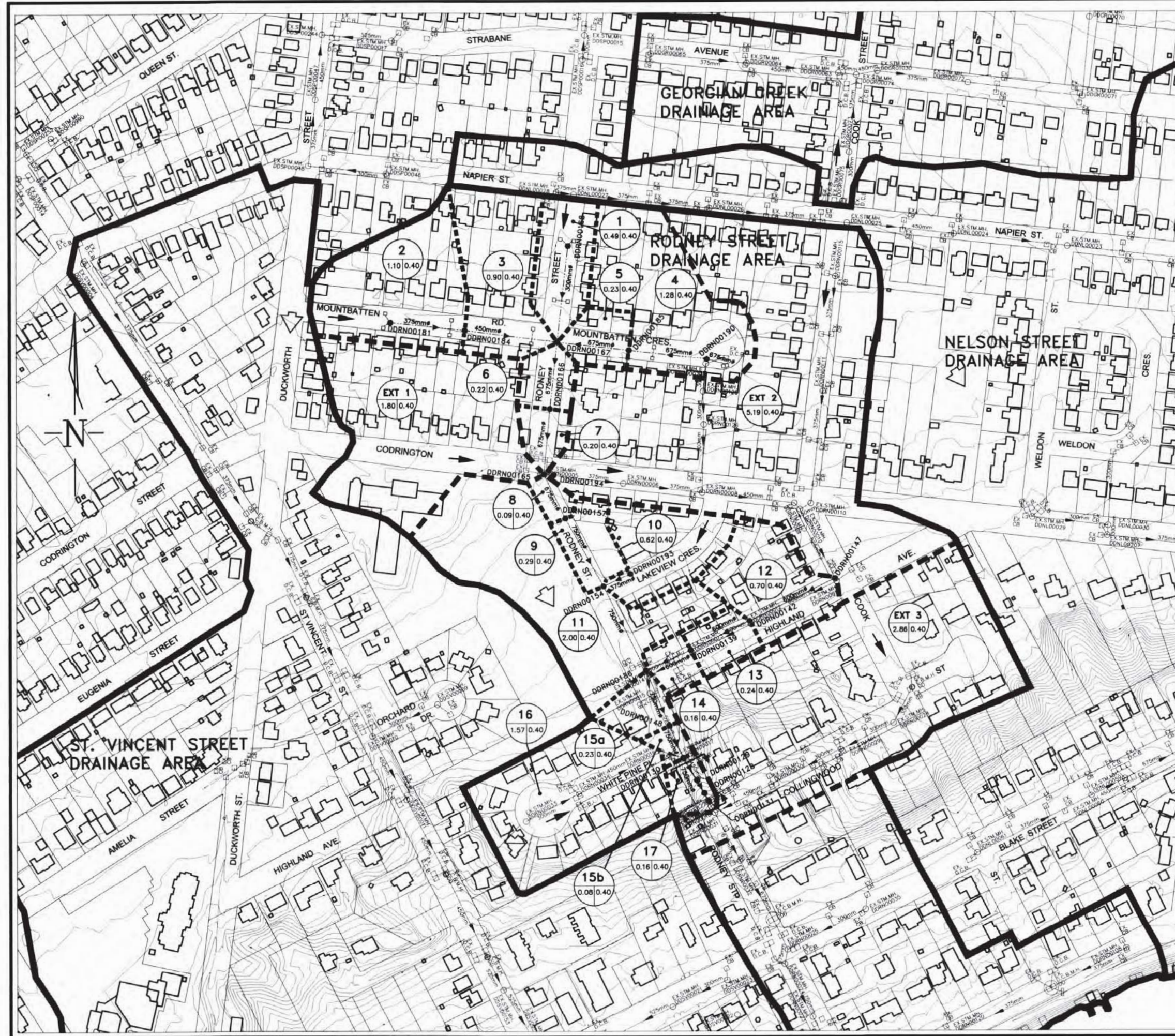
Date: 06-Aug-24
Project No: 21-694
Prepared by: CJ

Location			Sewage Flow Calculation Data													Sewer Calculation Data					Sewer Profile Data								
Street	Upstream MH	Downstream MH	Res - SFD # of Units	Res - SFD # of People	Res - MFD # of Units	Res - MFD # of People	Comm/Inst Total Daily Flow (L/day)	Industrial Total Daily Flow (L/day)	Cum. Res - SFD # of People	Cum. Res - MFD # of People	Cum. Comm/Inst Total Daily Flow (L/day)	Cum. Industrial Total Daily Flow (L/day)	Residential Peaking Factor	Sewage Flow (L/s)	Infiltration			Total Flow (L/s)	Dia. (mm)	Slope (%)	Length (m)	Capacity (L/s)	Velocity (m/s)	Fall in Sewer (m)	Drop in MH (m)	Top of Grate Elevation (m)		Invert Elevation (m)	
			Units	People	Units	People			People	People	L/day	L/day		L/s	Individual Area (ha)	Cumulative Area (ha)	Flow (L/s)	L/s				(L/s)	(m/s)		DS	US	DS	US	DS
Rodney	100301677	100301703	8	25		0			25	0	0	0	4.37	0.28	0.63	0.63	0.06	0.35	200	1.10	96.4	35.89	1.11	1.06					
Strabane	100301703	100301702	3	9		0			34	0	0	0	4.34	0.39	0.48	1.11	0.11	0.50	250	1.40	73.5	73.41	1.45	1.03					
Strabane	100301702	100301701	9	28		0			63	0	0	0	4.29	0.70	1.08	2.19	0.22	0.92	250	1.26	75.3	69.64	1.37	0.95					
Strabane	100301701	100301621	2	6		0			69	0	0	0	4.28	0.77	0.31	2.50	0.25	1.02	250	0.85	74.2	57.20	1.13	0.63					
Cook	100301621	100301622	7	22		0			91	0	0	0	4.25	1.00	0.62	3.12	0.31	1.32	250	0.86	61.8	57.53	1.14	0.53					
Cook	100301622	100301623	2	6		0			97	0	0	0	4.25	1.07	0.36	3.48	0.35	1.42	250	1.07	62.6	64.17	1.27	0.67					
Napier	100301647	100301646	13	41		0			41	0	0	0	4.33	0.46	1.19	1.19	0.12	0.58	250	1.11	78.1	65.36	1.29	0.87					
Napier	100301646	100301623	10	31		0			72	0	0	0	4.28	0.80	0.88	2.07	0.21	1.01	250	2.06	107.7	89.04	1.76	2.22					
Cook	100301623	100301626	8	25		0			194	0	0	0	4.15	2.10	0.52	6.07	0.61	2.70	250	1.88	101.9	85.06	1.68	1.92					
***Cook	100301626	100301625	8	25		0	3600		219	0	3600	0	4.13	2.42	1.88	7.95	0.80	3.21	250	1.11	78.1	65.36	1.29	0.87					
Cook	100301625	100301624	2	6		0			225	0	3600	0	4.13	2.49	0.32	8.27	0.83	3.31	250	1.04	78.5	63.27	1.25	0.82					
Codrington	100301689	100301690	5	16		0			16	0	0	0	4.39	0.18	0.61	0.61	0.06	0.24	200	1.00	89.2	34.22	1.06	0.89					
Codrington	100301690	120079766	4	13		0			28	0	0	0	4.36	0.32	0.46	1.07	0.11	0.43	200	1.00	72.8	34.22	1.06	0.73					
Rodney	120079822	120079821	8	25		0			25	0	0	0	4.37	0.28	0.69	0.69	0.07	0.35	250	3.50	80.1	116.06	2.29	2.80					
Mountbatten Road	120200197	120079846	8	25		0			25	0	0	0	4.37	0.28	0.88	0.88	0.09	0.37	250	1.00	85.5	62.04	1.22	0.86					
Mountbatten Road	120079846	120079821	8	25		0			50	0	0	0	4.31	0.56	0.60	1.48	0.15	0.71	250	2.40	86.0	96.11	1.90	2.06					
Mountbatten Cres	120079858	120079857	6	19		0			19	0	0	0	4.38	0.21	0.22	0.22	0.02	0.24	250	1.00	27.1	62.04	1.22	0.27					
Mountbatten Cres	120079857	120079856	4	13		0			31	0	0	0	4.35	0.35	0.89	1.11	0.11	0.47	250	0.40	55.1	39.24	0.77	0.22					
Mountbatten Cres	120079856	120079821	2	6		0			38	0	0	0	4.34	0.42	0.42	1.53	0.15	0.58	250	0.41	61.5	39.72	0.78	0.25					
Rodney	120079821	120079767	3	9		0			122	0	0	0	4.22	1.34	0.50	4.20	0.42	1.76	250	0.50	55.8	43.87	0.87	0.28					
Rodney	120079767	120079766	0	0		0			122	0	0	0	4.22	1.34	0.11	4.31	0.43	1.77	250	0.50	56.1	43.87	0.87	0.28					
Codrington	120079766	100301692	7	22		0			172	0	0	0	4.17	1.87	0.54	5.92	0.59	2.46	200	1.00	72.9	34.22	1.06	0.73					
Codrington	100301692	100301674	5	16		0			188	0	0	0	4.16	2.03	0.53	6.45	0.65	2.68	200	0.80	62.1	30.60	0.94	0.50					
Easement	120200202	100301694	2	6		0			6	0	0	0	4.43	0.07	0.02	0.02	0.00	0.07	200	0.40	22.5	21.64	0.67	0.09					
Easement	100301694	100301674	0	0		0			6	0	0	0	4.43	0.07	0.02	0.04	0.00	0.08	200	0.40	58.5	21.64	0.67	0.23					
Codrington	100301674	100301673	1	3		0			197	0	0	0	4.15	2.13	0.20	6.69	0.67	2.80	200	0.80	15.9	30.60	0.94	0.13					
Codrington	100301673	100301624	3	9		0			207	0	0	0	4.14	2.23	0.38	7.07	0.71	2.93	200	1.00	75.0	34.22	1.06	0.75					
Codrington	100301624	100301675	3	9		0			441	0	3600	0	4.00	4.66	1.04	16.38	1.64	6.30	200	2.00	94.7	48.39	1.49	1.89					
Codrington	100301675	100301880	3	9		0			451	0	3600	0	4.00	4.76	1.01	17.39	1.74	6.50	200	2.00	95.4	48.39	1.49	1.91					
Weldon Cres	100301876	100301877	11	34		0			34	0	0	0	4.34	0.39	1.47	1.47	0.15	0.54	200	0.40	76.3	21.64	0.67	0.31					
Weldon Cres	100301877	100301878	2	6		0			41	0	0	0	4.33	0.46	0.26	1.73	0.17	0.63	200	0.40	65.2	21.64	0.67	0.26					
Weldon Cres	100301878	100301879	0	0		0			41	0	0	0	4.33	0.46	0.14	1.87	0.19	0.65	200	0.40	2.0	21.64	0.67	0.01					
Weldon St	100301875	100301879	11	34		0			34	0	0	0	4.34	0.39	0.92	0.92	0.09	0.48	250	3.20	105.6	110.98	2.19	3.38					
Weldon St	100301879	100301880	1	3		0			78	0	0	0	4.27	0.87	0.36	3.15	0.32	1.19	250	0.52	70.9	44.74	0.88	0.37					
Codrington	100301880	100301881	5	16		0			545	0	3600	0	3.95	5.66	1.36	21.90	2.19	7.85	200	0.53	67.9	24.91	0.77	0.36					
Codrington	100301881	100307540	3	9		0			554	0	3600	0	3.95	5.76	0.81	22.71	2.27	8.03	200	0.40	64.5	21.64	0.67	0.26					
Codrington	100307540	100301630	6	19		0			573	0	3600	0	3.94	5.94	0.85	23.56	2.36	8.30	250	0.40	64.8	39.24	0.77	0.26					
Codrington	100301630	100301628	0	0		0			573	0	3600	0	3.94	5.94	0.02	23.58	2.36	8.30	250	2.00	13.9	87.74	1.73	0.28					
Napier	100301645	100301644	10	31		0			31	0	0	0	4.35	0.35	0.94	0.94	0.09	0.45	250	1.05	80.6	63.57	1.25	0.85					
Napier	100301644	100301643	6	19		0			50	0	0	0	4.31	0.56	0.80	1.74	0.17	0.74	250	1.32	73.5	71.28	1.41	0.97					
Napier	100301643	100301642	12	38		0			88	0	0	0	4.26	0.97	1.20	2.94	0.29	1.27	250	3.00	105.6	107.45	2.12	3.17					
Napier	100301642	100301641	10	31		0			119	0	0	0	4.22	1.31	0.70	3.64	0.36	1.67	250	2.00	107.4	87.74	1.73	2.15					
Nelson	100301641	100301873	7	22		0			141	0	0	0	4.20	1.54	0.55	4.19	0.42	1.96	200	1.50	65.2	41.91	1.29	0.98					
Nelson	100301873	100301869	6	19		0			160	0	0	0	4.18	1.74	0.74	4.93	0.49	2.23	200	1.50	91.1	41.91	1.29	1.37					
Nelson	100301869	100301629	2	6		0			166	0	0	0	4.18	1.81	0														

External Sanitary Drainage Plan



- Sanitary Flow Direction →
- Sanitary Drainage Area (Approx.)
- Existing Sanitary Sewer Pipe



STORM LEGEND

- DRAINAGE BOUNDARY
- CATCHMENT BOUNDARY
- SUB-CATCHMENT BOUNDARY
- MAJOR SYSTEM FLOW
- MINOR SYSTEM FLOW
- SUBCATCHMENT
- AREA (ha) RUNOFF COEFFICIENT
- EXISTING STORM SEWER
- PROPOSED STORM SEWER
- EXISTING CATCH BASIN
- PROPOSED CATCH BASIN
- EXISTING STORM MANHOLE
- PROPOSED STORM MANHOLE
- PROPOSED CATCH BASIN

THE INFORMATION PRESENTED HAS BEEN PREPARED FOR DEPARTMENT USE ONLY. THE CITY OF BARRIE, ITS EMPLOYEES OR AGENTS, DO NOT UNDERTAKE TO GUARANTEE THE VALIDITY OF THE CONTENTS AND WILL NOT BE LIABLE FOR ANY CLAIMS FOR DAMAGES OR LOSS OF USE ARISING FROM THEIR APPLICATION OR INTERPRETATION, BY ANY PARTY.

NO.	REVISIONS	DATE	APPROVED

CITY OF BARRIE
APPROVED
 DATE: Jan 9, 2015
 [Signature]
 DIRECTOR OF ENGINEERING

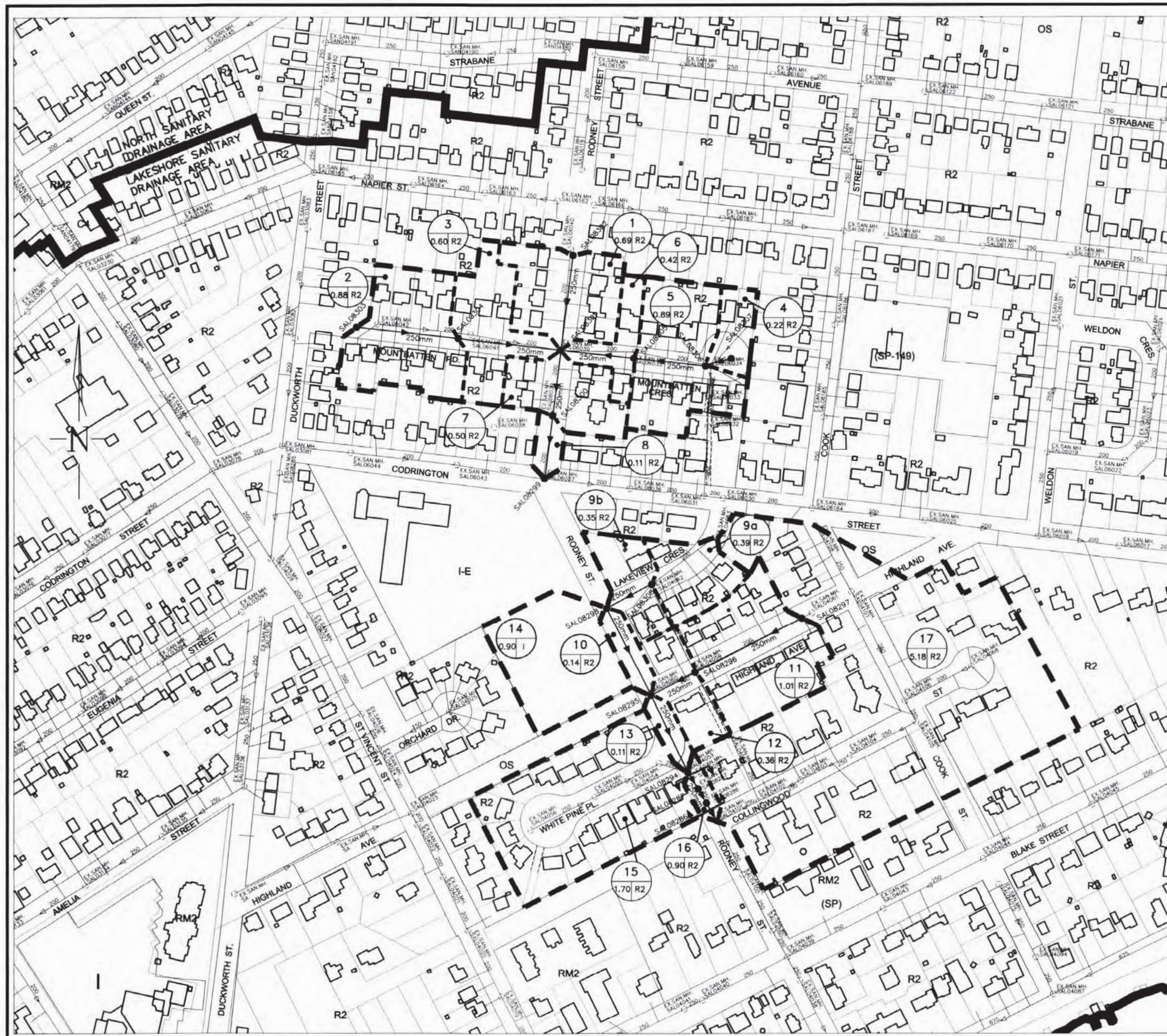
HIGHLAND AVE., MOUNTBATTEN RD., & RODNEY ST., RECONSTRUCTION
RODNEY ST. UNOPENED ROAD ALLOWANCE INFRASTRUCTURE IMPROVEMENTS

STORM DRAINAGE PLAN

The City of
BARRIE
 ENGINEERING DEPARTMENT

SCALE: HOR. 1:1500	VERT. N/A	DRAWING NO. 2015-001T
DESIGN C.L.M.	DRAWN C.L.M.	SHEET NO. STM1
REVIEWED L.H.B.	DATE 2015.01.03	

2015-001-001



LEGEND

- SANITARY DRAINAGE DIVIDE
- CATCHMENT BOUNDARY
- LOCAL BOUNDARY
- EXISTING SANITARY SEWER AND MAINTENANCE HOLE
- PROPOSED SANITARY SEWER AND MAINTENANCE HOLE
- AREA NUMBER
- ZONING
- AREA (ha)

THE INFORMATION PRESENTED HAS BEEN PREPARED FOR DEPARTMENT USE ONLY. THE CITY OF BARRIE, ITS EMPLOYEES OR AGENTS, DO NOT UNDERTAKE TO GUARANTEE THE VALIDITY OF THE CONTENTS AND WILL NOT BE LIABLE FOR ANY CLAIMS FOR DAMAGES OR LOSS OF USE ARISING FROM THEIR APPLICATION OR INTERPRETATION, BY ANY PARTY.

NO.	REVISIONS	DATE	APPROVED

CITY OF BARRIE
APPROVED
DATE: Jan 9, 2015
[Signature]



HIGHLAND AVE., MOUNTBATTEN RD., & RODNEY ST., RECONSTRUCTION
RODNEY ST. UNOPENED ROAD
ALLOWANCE INFRASTRUCTURE IMPROVEMENTS

SANITARY DRAINAGE PLAN

The City of
BARRIE
ENGINEERING DEPARTMENT

SCALE HOR. 1:1500	VERT. N/A	DRAWING NO. 2015-001T
DESIGN C.L.M.	DRAWN C.L.M.	SHEET NO. SAN1
REVIEWED L.H.B.	DATE 2015.01.03	

2015-001-002



SANITARY SEWER DESIGN

Land Use or Zoning Designation Basis (Residential)

DESIGN SHEET

FILE NO

SAN-1

T04-HIG

CONTRACT / PROJECT

Highland Ave., Mountbatten Cres.,
Mountbatten Rd., Rodney St.
Reconstruction

$$n \geq 0.013$$

$$M = 1 + [14 / (4 + P^{0.5})]$$

$$Q_p = P \cdot q \cdot M / 86.4$$

$$Q_i = I \cdot A$$

$$Q_{tot} = Q_p + Q_i$$

(Harmon peaking factor where; $2 \leq M \leq 4$)

(Peak population flow where; $q = 225$ L/day/person; P = population in thousands)

(Peak extraneous flow: $I = 0.1$ L/s/ha over development area)

(Total peak flow as the sum of peak population flow and peak extraneous flow)

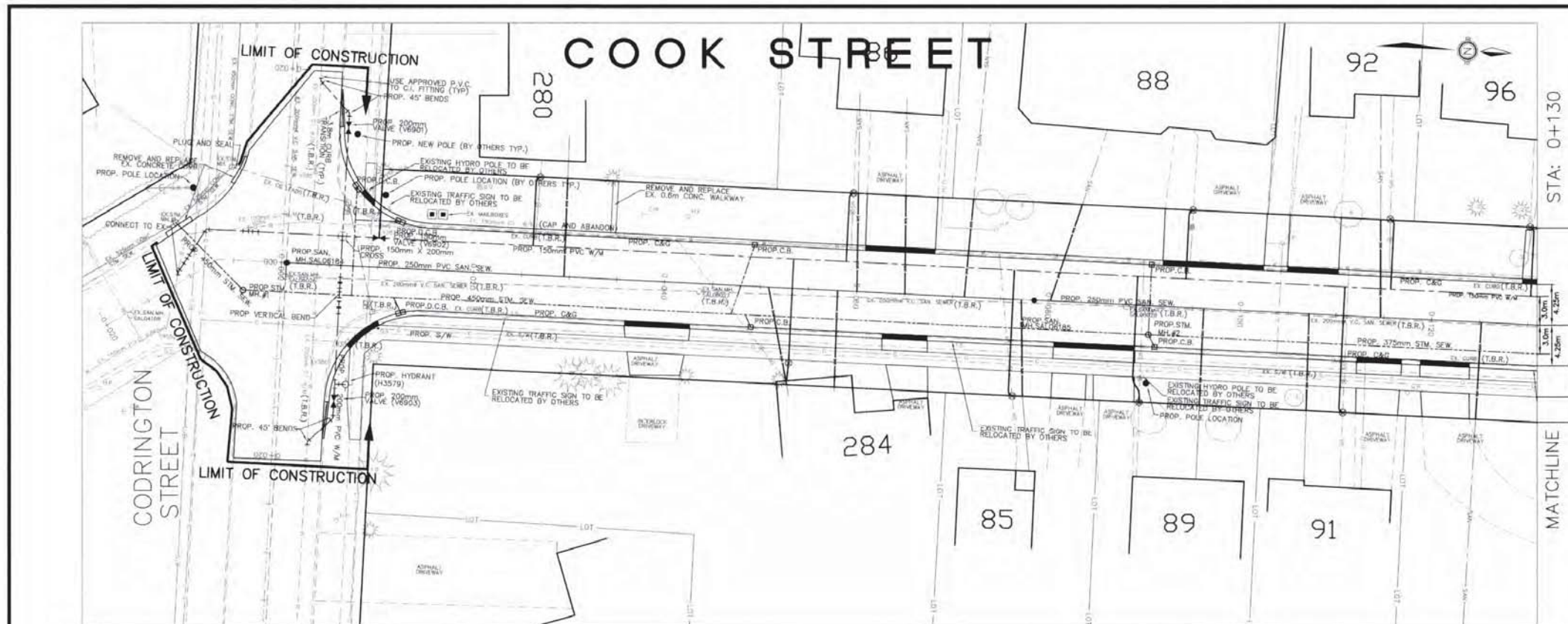
STREET \ AREA	MAINTENANCE HOLE		LAND USE	DEV. DENSITY (units/ha)	POP. DENSITY (ppu)	AREA (ha)	POP.	POP. (ACC)	M PEAKING FACTOR	Q _p (L/S)	AREA (ACC) (ha)	Q _i (L/S)	Q _{tot} (L/S)	L (m)	D (mm)	S (%)	Q FULL (L/S)	V FULL (m/s)
	FROM	TO																
A1 - Rodney Street	SAL08302	SAL08301	R2	25	3.13	0.69	54	54	4.00	0.56	0.69	0.07	0.63	80.09	250	3.50	111.25	2.27
A2 - Mountbatten Road	SAL08303	SAL08304	R2	25	3.13	0.88	69	69	4.00	0.72	0.88	0.09	0.81	85.51	250	1.00	59.47	1.21
A3 - Mountbatten Road	SAL08304	SAL08301	R2	25	3.13	0.60	47	116	4.00	1.21	1.48	0.15	1.36	85.98	250	0.50	42.05	0.86
A3 - Mountbatten Crescent	SAL08307	SAL08306	R2	25	3.13	0.22	18	18	4.00	0.19	0.22	0.02	0.21	27.05	250	1.00	59.47	1.21
A4 - Mountbatten Crescent	SAL08306	SAL08305	R2	25	3.13	0.89	70	88	4.00	0.92	1.11	0.11	1.03	68.11	250	0.40	37.61	0.77
A3 - Mountbatten Crescent	SAL08305	SAL08301	R2	25	3.13	0.42	33	121	4.00	1.26	1.53	0.15	1.41	61.50	250	0.40	37.61	0.77
A7 - Rodney Street	SAL08301	SAL08300	R2	25	3.13	0.50	40	331	4.00	3.45	7.15	0.71	4.16	55.80	250	1.08	61.80	1.26
A8 - Rodney Street	SAL08300	SAL08299	R2	25	3.13	0.11	9	340	4.00	3.54	7.26	0.73	4.27	55.80	250	0.40	37.61	0.77
A9a - Lakeview Crescent	Ex. SAL04063	SAL08308	R2	25	3.13	0.39	31	31	4.00	0.32	0.39	0.04	0.36	62.93	250	2.87	100.74	2.05
A9b - Lakeview Crescent	SAL08308	SAL08298	R2	25	3.13	0.35	28	59	4.00	0.61	0.74	0.07	0.69	42.67	250	4.00	118.94	2.42
A14 - Codrington Public School		SAL08298	I	28	m ³ /day/ha	0.90				0.29	0.90	0.09	0.38					
A10 - Rodney Street	SAL08298	SAL08295	R2	25	3.13	0.14	11	410	4.00	4.56	9.04	0.90	5.47	81.04	250	4.85	130.96	2.67
A11 - Highland Avenue	SAL08297	SAL08296	R2	25	3.13	1.01	80	80	4.00	0.83	1.01	0.10	0.93	101.16	250	4.12	120.71	2.46
A12 - Highland Avenue	SAL08296	SAL08295	R2	25	3.13	0.36	29	109	4.00	1.14	1.37	0.14	1.27	39.97	250	1.50	72.83	1.48
A13 - Rodney Street	SAL08295	SAL08294	R2	25	3.13	0.11	9	528	3.96	5.45	10.52	1.05	6.50	73.82	250	0.88	55.79	1.14
A15 - White Pine Place	SAL04054	SAL08294	R2	25	3.13	1.70	134	134	4.00	1.40	1.70	0.17	1.57	15.70	250	6.10	146.87	2.99
A16 - Rodney Street	SAL08294	SAL08287	R2	25	3.13	0.90	71	733	3.88	7.41	13.12	1.31	8.72	15.70	250	6.10	146.87	2.99
A16 - Rodney Street	SAL08297	SAL08286	R2	25	3.13		0	733	3.88	7.41	13.12	1.31	8.72	17.80	250	6.10	146.87	2.99
A16 - Rodney Street	SAL08296	SAL04101	R2	25	3.13		0	733	3.88	7.41	13.12	1.31	8.72	15.30	250	6.10	146.87	2.99
A17 - Collingwood Street	SAL04102	SAL04101	R2	25	3.13	5.18	406	406	4.00	4.23	5.18	0.52	4.75	38.30	250	4.00	118.94	2.42

DATE: Rev 2014/11/10

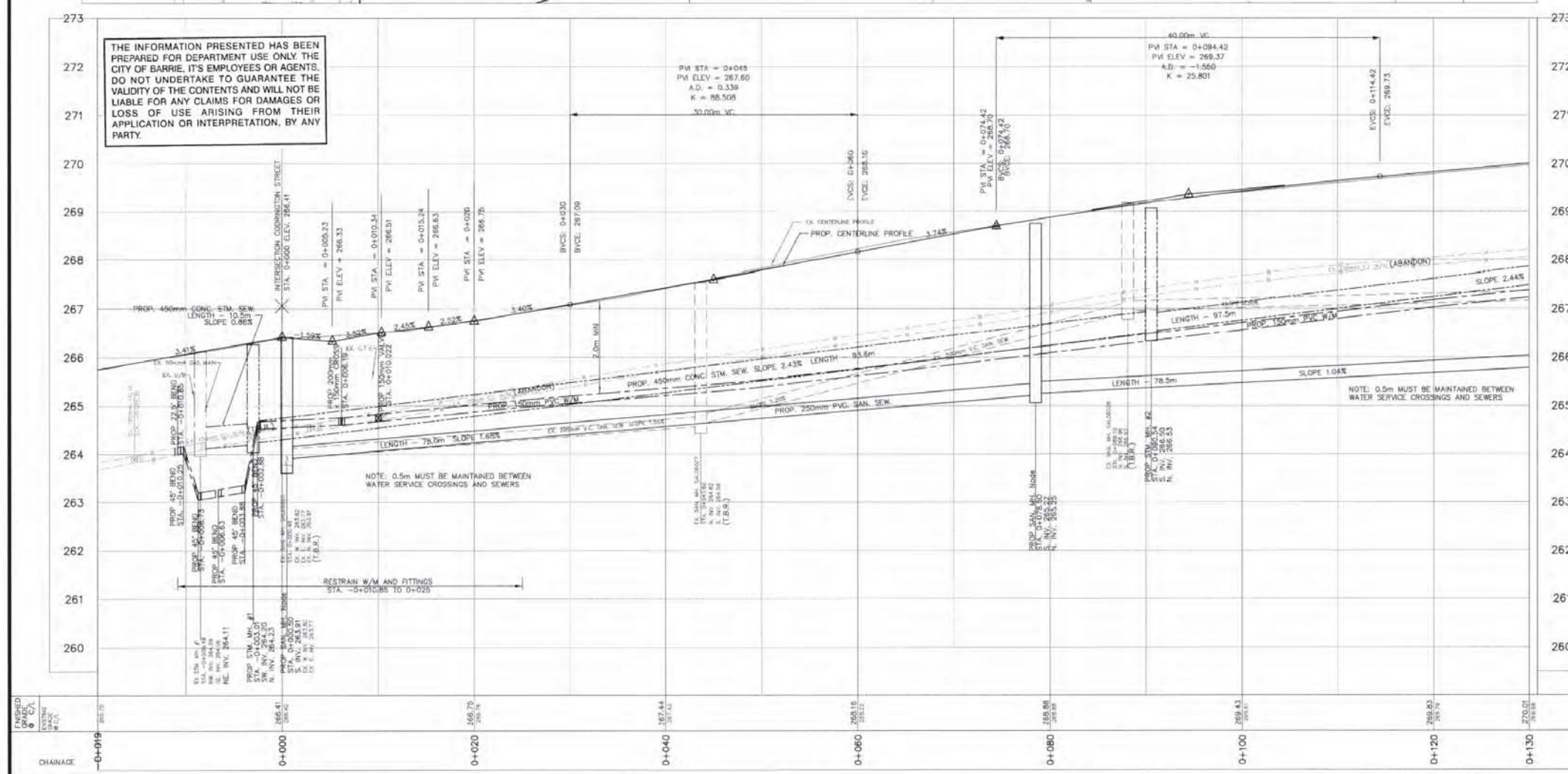
CALCULATED BY: C. McCulligh

CHECKED BY:

L.H. Borgdorff



- GENERAL NOTES**
- EXISTING SANITARY SERVICE TO BE MAINTAINED AT ALL TIMES.
 - EXISTING SANITARY LATERAL TO BE REPLACED FROM SEWER MAIN TO PROPERTY LINE UNLESS SHOWN OTHERWISE.
 - PROPOSED SANITARY LATERALS TO BE A MINIMUM 100mm DIA., DR-28 UNLESS NOTED OTHERWISE OR EXISTING SERVICE FOUND IN THE FIELD TO BE LARGER, INSTALLED FROM NEW MAIN WITH APPROVED MANUFACTURED TEES AND CONNECTED TO EXISTING SANITARY LATERALS AT PROPERTY LINE UNLESS SHOWN OTHERWISE.
 - NOT ALL SANITARY SERVICES ARE SHOWN ON DRAWINGS. CONTRACTOR TO VERIFY SANITARY SERVICE LOCATIONS IN FIELD.
 - ALL SINGLE CATCH BASIN LEADS TO BE 250mm AND DOUBLE CATCH BASIN LEADS TO BE 300mm (SEE GENERAL NOTES, SHEET DET1).
 - LOCATION OF GAS MAIN PER EXHIBIT CONSUMERS GAS MARKED DRAWINGS. ALL EXISTING MAINS AND SERVICES TO BE FIELD LOCATED.
 - EXISTING HYDRO, BELL AND CABLE SERVICES MARKED ON DRAWINGS. ARE AS PER UTILITY COMPANY DRAWINGS. ALL SERVICES TO BE FIELD LOCATED.
 - ALL DRIVEWAYS TO BE REMOVED AND RECONSTRUCTED FROM CURB TO LIMITS SHOWN ON DRAWINGS.
 - CONC. PAVEMENT DRIVEWAYS TO BE REINFORCED WITH 200mm GRANULAR 'A' AND IN ACCORDANCE WITH OPSD 561.010.
 - FOR GENERAL NOTES & LEGEND SEE DETAIL SHEET DET1.
 - ALL MAINTENANCE HOLES TO BE 1200mm UNLESS SHOWN OTHERWISE.
 - CONCRETE CURB AND GUTTER PER OPSD 600.040.
 - CONCRETE CURB PER OPSD 600.110.
 - ALL CONCRETE STORM SEWER TO BE CL 65-D.
 - ALL SANITARY SEWER TO BE PVC DR-35.
 - EXISTING ASPHALT WITHIN LIMITS OF CONSTRUCTION TO BE REMOVED.
 - MAINTAIN STORM DRAINAGE SYSTEM DURING CONSTRUCTION AND AVOID SILTATION AND EROSION.
 - EXISTING TREES TO BE PROTECTED DURING CONSTRUCTION.
 - PROPOSED FLEXIBLE STORM LEADS TO BE INSTALLED AT CONCRETE STORM MAIN WITH APPROVED MORTAR IN ADAPTOR-SANDED.
 - PROP. STORM SEWER CONNECTIONS TO EX. MANHOLES TO BE CURED.
 - FOR TYPICAL SECTIONS SEE PPS.
 - UTILITY CROSSINGS TO BE SUPPORTED AS REQUIRED.
 - (T.B.R.) - (TO BE REMOVED)
 - (TYP.) - (TYPICAL)
- WATERMAIN NOTES**
- ALL WATERMAIN TO BE PVC DR18 CL150.
 - INSTALL 18mm COPPER WATER SERVICES FROM NEW PVC WATERMAIN TO NEW CURB STOP ON P/L INCLUDING CONNECTION TO THE EXISTING SERVICE.
 - TRANSFER WATER SERVICES AFTER ALL TESTING AND CHLORINATING HAS BEEN COMPLETED.
 - WATER SERVICE TO BE MAINTAINED AT ALL TIMES DURING CONSTRUCTION.
 - FOR GENERAL WATERMAIN NOTES SEE DETAIL SHEET DET1.



BENCH MARKS

DISTANCE NOTE
DISTANCES SHOWN HEREON ARE GROUND DISTANCES AND CAN BE CONVERTED TO GRID DISTANCES BY MULTIPLYING BY THE COMBINED SCALE FACTOR OF 0.9997002.

BEARING NOTE
BEARINGS HEREIN ARE GRID BEARINGS AND ARE DERIVED FROM CONTROL MONUMENTS (D1086049) (N=4317080.409, E=807007.777) AND (D10860467) (N=4317244.234, E=800499.094), AND ARE REFERRED TO THE CENTRAL MERIDIAN (81 DEGREES OF LONGITUDE) IN ZONE 17 AND ARE BASED ON NAD83.

BENCH MARK V010865460
269.955 - BROWN BRICK SCHOOL (STEEL STREET PUBLIC SCHOOL) ON NORTH SIDE OF STEEL STREET 0.3km EAST OF DUCKWORTH STREET IN THE CITY OF BARRIE. TABLET IS SET HORIZONTALLY IN SOUTHERLY FACE OF CONCRETE FOUNDATION, 37.3m NORTH OF CENTERLINE OF STEEL STREET AND 5.15m EAST OF SOUTHWEST BUILDING CORNER.

BENCH MARKS WILL BE FROM CITY OF BARRIE VERTICAL CONTROL NETWORK. INITIAL BENCH MARK TO BE OF 2nd ORDER ACCURACY.

NO.	REVISIONS	DATE	APPROVED

CITY OF BARRIE
APPROVED
DATE: July 21, 06
R. W. McArthur, P. Eng.
DIRECTOR OF ENGINEERING

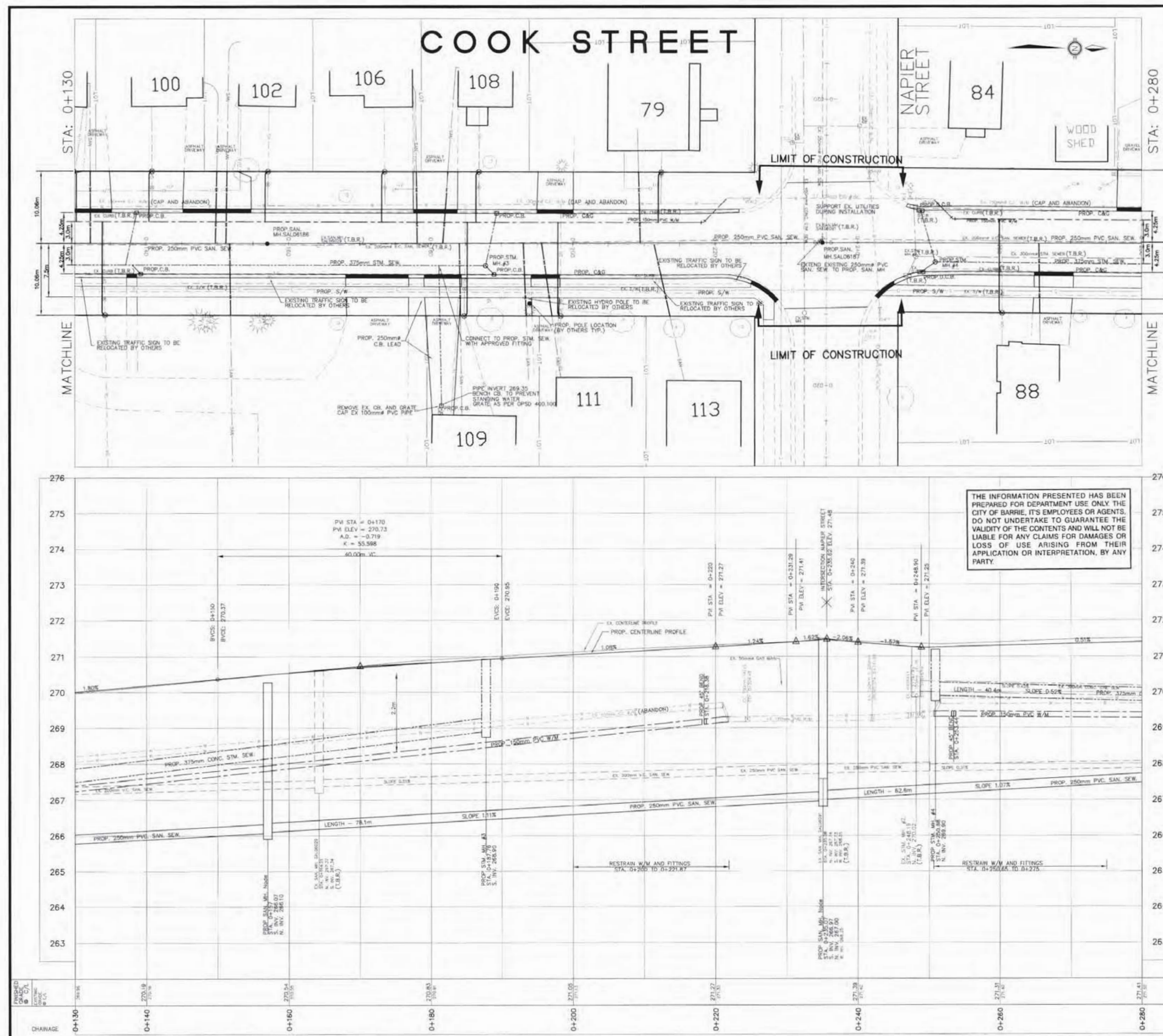
COOK STREET RECONSTRUCTION
CODRINGTON STREET TO STEEL STREET
STA. -0+020 TO 0+130

CITY OF BARRIE
ENGINEERING DEPARTMENT

SCALE HOR. 1"=250' VERT. 1"=50'
DESIGN J.A.H. DRAWN J.A.H.
REVIEWED L.H.B. DATE 2006.07.04

DRAWING NO. 2006-18
SHEET NO. PP1

2006-018-004



KEY PLAN

GENERAL NOTES

- EXISTING SANITARY SERVICE TO BE MAINTAINED AT ALL TIMES.
- EXISTING SANITARY LATERAL TO BE REPLACED FROM SEWER MAIN TO PROPERTY LINE UNLESS SHOWN OTHERWISE.
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- PROPOSED FLEXIBLE STORM LEADS TO BE INSTALLED AT CONCRETE STORM MARK WITH APPROVED MORTAR ON ADAPTOR-SANDED.
- PROP. STORM SEWER CONNECTIONS TO EX. MANHOLES TO BE CORRED.
- FOR TYPICAL SECTIONS SEE PPS.
- UTILITY CROSSINGS TO BE SUPPORTED AS REQUIRED.
- (1.5M) - (1.5M) BE REMOVED
- (TYP.) - (TYPICAL)

WATERMAIN NOTES

- ALL WATERMAIN TO BE PVC DR18 CL150.
- INSTALL 19mm COPPER WATER SERVICES FROM NEW PVC WATERMAIN TO NEW CURB STOP ON P.A. INCLUDING CONNECTION TO THE EXISTING SERVICE.
- TRANSFER WATER SERVICES AFTER ALL TESTING AND CHLORINATING HAS BEEN COMPLETED.
- WATER SERVICE TO BE MAINTAINED AT ALL TIMES DURING CONSTRUCTION.
- FOR GENERAL WATERMAIN NOTES SEE DETAIL SHEET DET.

BENCH MARKS

DISTANCE NOTE
DISTANCES SHOWN HEREON ARE GROUND DISTANCES AND CAN BE CONVERTED TO GRID DISTANCES BY MULTIPLYING BY THE COMBINED SCALE FACTOR OF 0.9997002.

BEARING NOTE
BEARINGS HEREON ARE GRID BEARINGS AND ARE DERIVED FROM CONTROL MONUMENTS 010560481 (N=4917080.40M, E=667007.77M) AND 010660487 (N=4917244.23M, E=665499.08M) AND ARE REFERRED TO THE CENTRAL MERIDIAN (181 DEGREES OF LONGITUDE) IN ZONE 17 AND ARE BASED ON NAD83.

BENCH MARK V010665470
269.935 - BROWN BRICK SCHOOL (STEEL STREET PUBLIC SCHOOL) ON NORTH SIDE OF STEEL STREET 0.5m EAST OF QUAKWORTH STREET IN THE CITY OF BARRIE. TABLET IS SET HORIZONTALLY IN SOUTHERLY FACE OF CONCRETE FOUNDATION, 37.2m NORTH OF CENTERLINE OF STEEL STREET AND 5.15m EAST OF SOUTHWEST BUILDING CORNER.

BENCH MARKS WILL BE FROM CITY OF BARRIE VERTICAL CONTROL NETWORK. INITIAL BENCH MARK TO BE OF 2nd ORDER ACCURACY.

NO.	REVISIONS	DATE	APPROVED

CITY OF BARRIE
APPROVED
DATE: JUN 21/06
A. V. W. A. H. P. E.
IN CHARGE OF ENGINEERING

COOK STREET RECONSTRUCTION

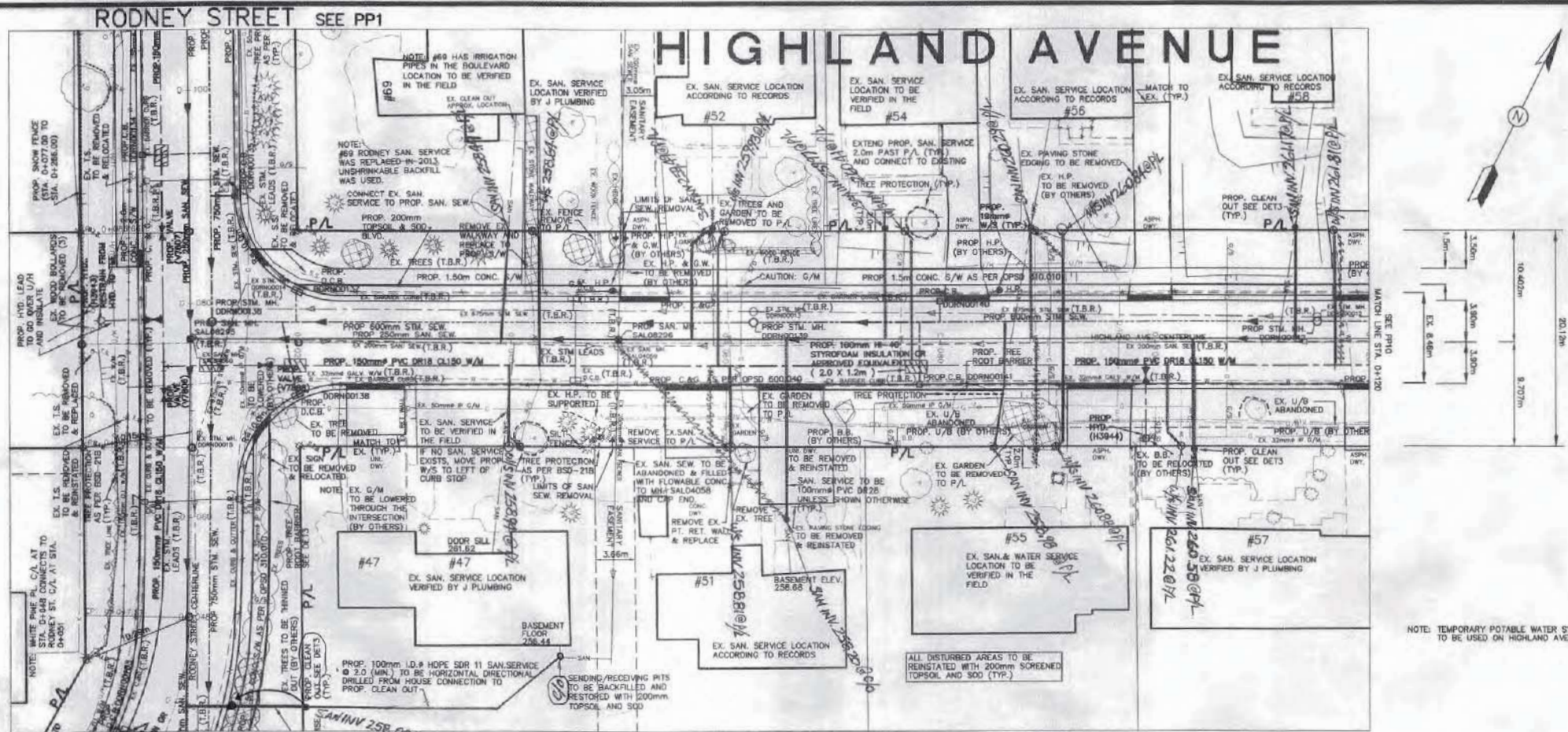
CODRINGTON STREET TO STEEL STREET
STA. 0+130 TO 0+280

CITY of BARRIE

ENGINEERING DEPARTMENT

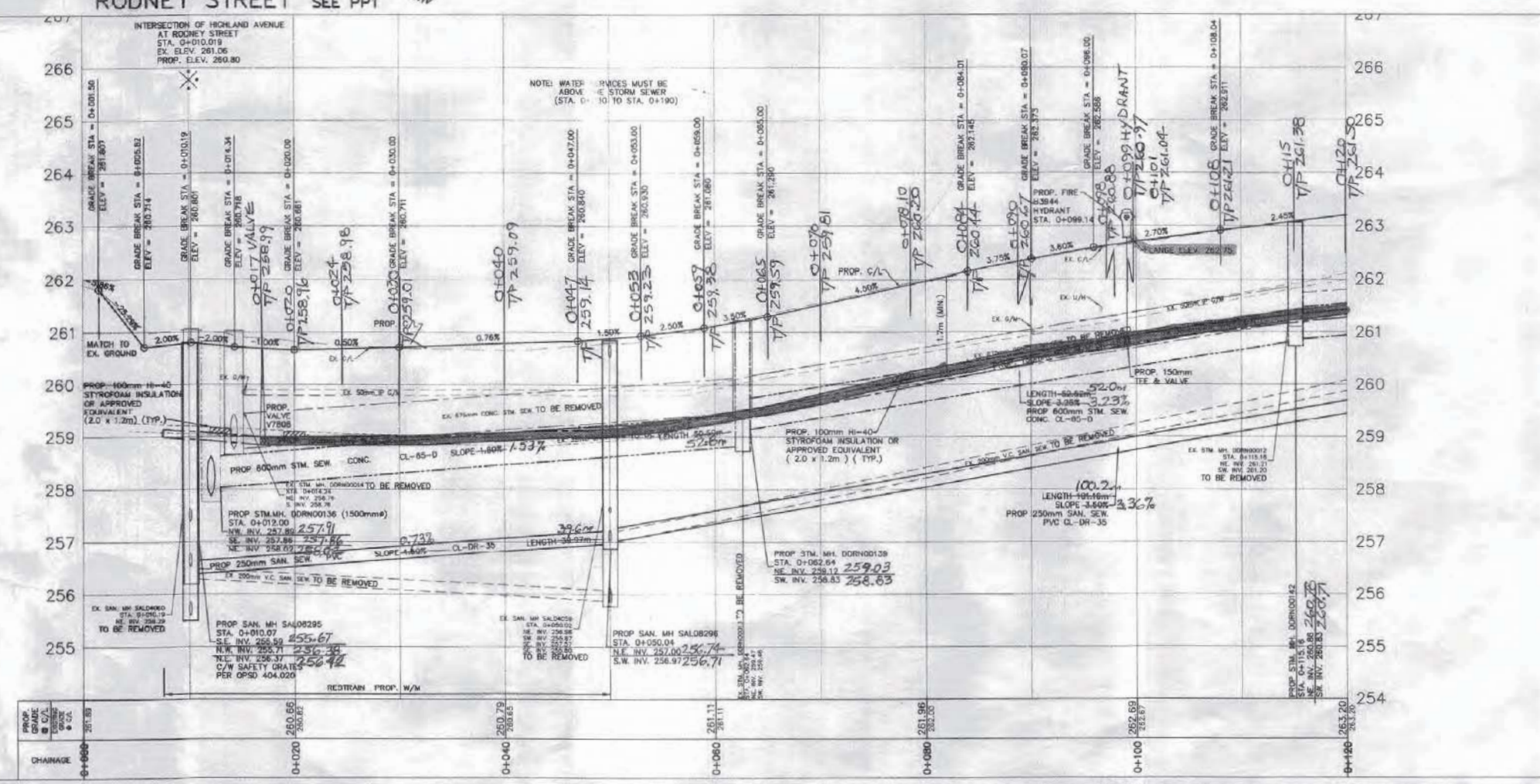
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DESIGN J.H.H.	DRAWN J.H.H.	SHEET NO. PP2
REVIEWED L.H.B.	DATE 2006.07.04	

2006-018-005



- GENERAL NOTES**
1. REFER TO CURRENT CITY OF BARRIE STANDARDS FOR APPLICABLE GENERAL NOTES.
 2. FOR TYPICAL SECTIONS SEE DET1 & DET2 DWGS.
 3. FOR STREETLIGHTING SEE DRAWINGS E01, E02, E03, E04, E05, E06, E07, E08.
 4. WATER SERVICES ARE TO BE INSTALLED TO ENSURE THEY WON'T FREEZE. MAINTAIN SEPARATION FROM THE STORM SEWER AND/OR INSULATE.
 5. SANITARY SERVICE LATERALS TO EXTEND 2.0m PAST PROPERTY LINE AND CONNECT TO EXISTING.
 6. SANITARY SERVICE LATERALS MINIMUM PIPE SLOPE TO BE 2.0% MAX. 8.0%.
 7. FOR PAYMENT MARKINGS SEE GRADING PLANS.
 8. EXISTING SANITARY SERVICE LOCATIONS SHOWN ACCORDING TO RECORDS, UNLESS OTHERWISE NOTED.

THE INFORMATION PRESENTED HAS BEEN PREPARED FOR DEPARTMENT USE ONLY THE CITY OF BARRIE, ITS EMPLOYEES OR AGENTS. DO NOT UNDERTAKE TO GUARANTEE THE VALIDITY OF THE CONTENTS AND WILL NOT BE LIABLE FOR ANY CLAIMS FOR DAMAGES OR LOSS OF USE ARISING FROM THEIR APPLICATION OR INTERPRETATION, BY ANY PARTY.



BENCH MARKS

DISTANCE NOTE
DISTANCES SHOWN HEREON ARE GRID DISTANCES AND CAN BE CONVERTED TO GROUND DISTANCES BY MULTIPLYING BY THE COMBINED SCALE FACTOR OF 1.0003.

BEARING NOTE
BEARINGS HEREON ARE GRID BEARINGS AND ARE DERIVED FROM CONTROL MONUMENTS D019605481 (N=491633, E=605557) AND D0120000225 (N=4917070.929, E=606095.104) AND ARE REFERRED TO THE CENTRAL MERIDIAN (81 DEGREES OF LONGITUDE) IN ZONE 17 AND ARE BASED ON NAD83 (ORIGINAL) UTM COORDINATES.

BENCH MARK V010865481
271.586 - BEIGE BRICK SCHOOL (COWORTH PUBLIC SCHOOL) ON THE SOUTH SIDE OF COWORTH STREET 0.12m EAST OF DUCKWORTH STREET IN CITY OF BARRIE. TABLET IS SET HORIZONTALLY IN NORTH FACE OF CONCRETE FOUNDATION, 25.4m SOUTH OF CENTERLINE OF COWORTH STREET & 1.2m WEST OF NORTH-EAST BUILDING CORNER.

BENCH MARKS WILL BE FROM CITY OF BARRIE VERTICAL CONTROL NETWORK. INITIAL BENCH MARK TO BE OF 2nd ORDER ACCURACY.

NO.	REVISIONS	DATE	APPROVED
1	THIS DRAWING HAS BEEN REVISIONED. IN PART, BASED UPON INFORMATION PROVIDED BY THE CITY OF BARRIE. THE CITY OF BARRIE IS NOT RESPONSIBLE FOR THE ACCURACY OF THE INFORMATION PROVIDED BY THE CITY OF BARRIE. THE CITY OF BARRIE IS NOT RESPONSIBLE FOR THE ACCURACY OF THE INFORMATION PROVIDED BY THE CITY OF BARRIE.		

CITY OF BARRIE APPROVED

DATE: Jan 9, 2015

Ant. Kozak
DIRECTOR OF ENGINEERING

L.H. BORDORFF
REGISTERED PROFESSIONAL ENGINEER
2015-01-01

HIGHLAND AVE., MOUNTBATTEN RD., & RODNEY ST., RECONSTRUCTION

RODNEY STREET TO COOK STREET

HIGHLAND AVENUE
STA. 0+000 TO STA. 0+120

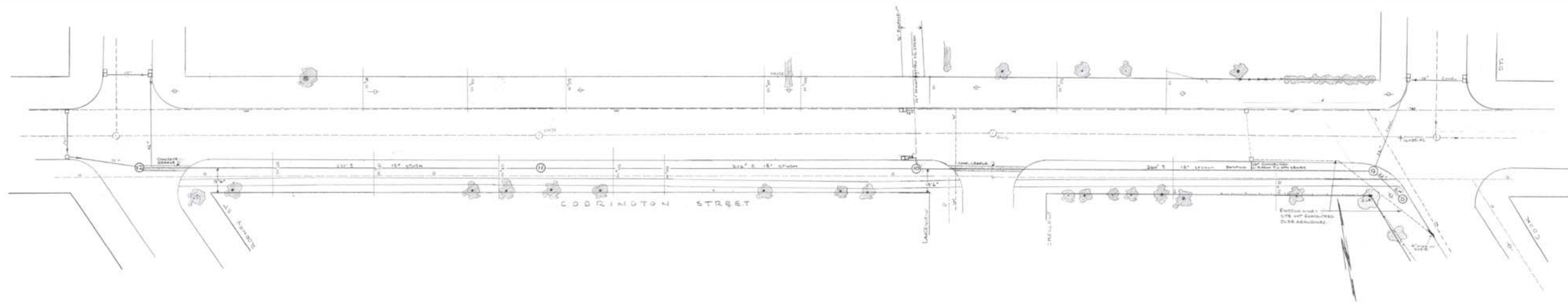
The City of BARRIE ENGINEERING DEPARTMENT

SCALE: HOR. 1:250 VERT. 1:50 CONTRACT NO. 2015-001T

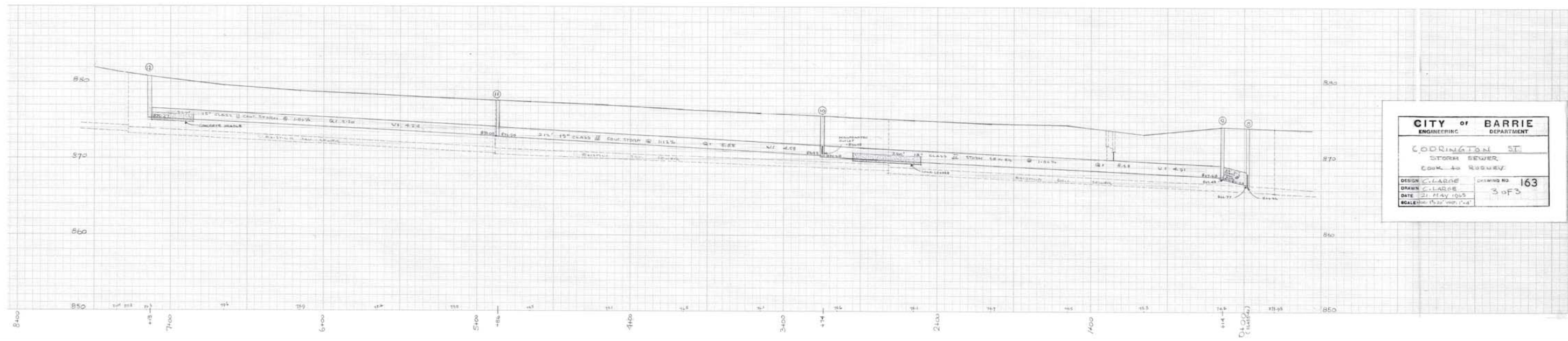
DESIGN C.L.M. DRAWN C.L.M. SHEET NO. PP9

REVIEWED L.H.B. DATE 2015.01.03

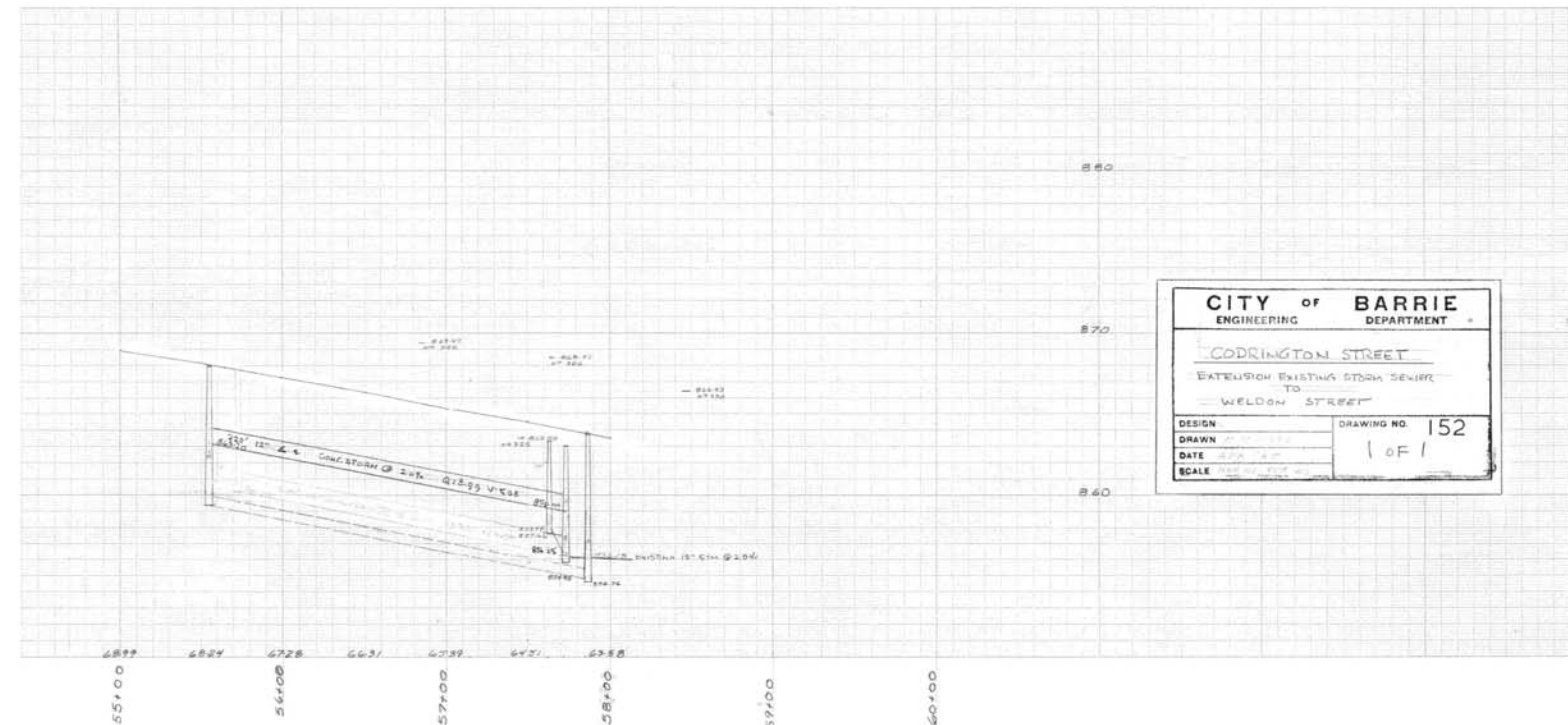
2015-001-013



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CITY OF BARRIE	
ENGINEERING	DEPARTMENT
CODRINGTON ST	
STORM SEWER	
CONK. TO RISEWAY	
DESIGN C. LARSEN	DRAWING NO. 163
DRAWN C. LARSEN	3 OF 3
DATE 21 MAY 1965	
SCALE 1" = 40' HORIZ. 1" = 4' VERT.	

[illegible]

APPENDIX C

SANITARY AND WATER SERVICING CALCULATIONS



**TOTAL DAILY SANITARY DESIGN FLOW CALCULATIONS
INTERNAL**

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street + 103-107 Napier Street

Prepared By: CJ

<<< Elements Requiring Input Information

Total Daily Design Flow Calculations

References: - City of Barrie Sanitary Infrastructure Design Standard 2023
- Ontario Building Code (OBC), 2012, Division B, Part 8, Table 8.2.1.3.A. Residential Occupancy & Table 8.2.1.3.B. Other Occupancies

Proposed Condition:

Establishment:	# of people	# of water closets	# of fuel outlets	# of seats	Gross Floor Area (m ²)	Land Area (ha)	Total Daily Design Sanitary Sewage Volume	Total Daily Design Sanitary Sewage Flow (L/day)
Residential Uses:								
Townhouses (34 units @ 2.34 ppu (medium density))	80						225 L/person L/person	17,901 0 0
Subtotal =	80							17,901

Harmon Formula, $M = 1 + \frac{14}{(4 + P^{0.5})}$
where, P = Design population in 1000s

Peaking Factor, M = 4.27
Peak Total Daily Design Sanitary Sewage Flow (L/day) = 76,437
Peak Extraneous Unit Flow (L/s/ha) = 0.10
*Land Area (ha) = 0.98
Peak Extraneous Flow (L/day) = 8467
Peak Total Daily Design Flow (L/day) = 84,904

Total Average Daily Design Flow (L/day) = 17,901
Peak Total Daily Design Flow (L/sec) = 0.983

Note: * Land area is total site area (1.03ha) - Portion of Single Detached Lots Drain directly to Cook Street (0.05ha) for internal site area of 0.98ha.
The 4 single detached lots sanitary services drain directly to sanitary sewer on Cook Street.

\\wminas\Public\Data\Projects\2021\21-694\Design\Sanitary\FSR_No2\240806_Total_Daily_Sanitary_Design_Flow_Calcs.xlsx\Sani_Design_Flows (Total Site)



**TOTAL DAILY SANITARY DESIGN FLOW CALCULATIONS
TOTAL SITE**

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street + 103-107 Napier Street

Prepared By: CJ

<<< Elements Requiring Input Information

Total Daily Design Flow Calculations

References: - City of Barrie Sanitary Infrastructure Design Standard 2023
- Ontario Building Code (OBC), 2012, Division B, Part 8, Table 8.2.1.3.A. Residential Occupancy & Table 8.2.1.3.B. Other Occupancies

Proposed Condition:

Establishment:	# of people	# of water closets	# of fuel outlets	# of seats	Gross Floor Area (m ²)	Land Area (ha)	Total Daily Design Sanitary Sewage Volume	Total Daily Design Sanitary Sewage Flow (L/day)
Residential Uses:								
Townhouses (34 units @ 2.34 ppu (medium density))	80						225 L/person	17,901
Single Detached Lots (4 lots @ 3.13 ppu (low density))	13						225 L/person	2,817
								0
Subtotal =	92							20,718

Harmon Formula, $M = 1 + \frac{14}{(4 + P^{0.5})}$
where, P = Design population in 1000s

Peaking Factor, M = 4.25
Peak Total Daily Design Sanitary Sewage Flow (L/day) = 88,052
Peak Extraneous Unit Flow (L/s/ha) = 0.10
*Land Area (ha) = 1.03
Peak Extraneous Flow (L/day) = 8899
Peak Total Daily Design Flow (L/day) = 96,951

Total Average Daily Design Flow (L/day) = 20,718
Peak Total Daily Design Flow (L/sec) = 1.122

Note: * Land area is total site area (1.03ha).



Internal Sanitary Sewer Design Sheet
95 Cook Street + 103-107 Napier Street

<<< Elements Requiring Input Information

Peak Flow Formulae:
 $Q_{pop} = (P \cdot q \cdot M) / 86.4$ (L/s)
 $Q_{Comm/Inst} = \text{Design Flow} \times \text{Peaking Factor}$ (L/s)
 $Q_{ind} = \text{Design Flow} \times \text{Peaking Factor}$ (L/s)
 $Q_{infil} = i \cdot A$ (L/s), where A = Area (ha)
 $Q_d = Q_{pop} + Q_{Comm/Inst} + Q_{ind} + Q_{infil}$ (L/s)

MOE Velocity Requirements: 0.6m/s - 3.0m/s

where, P = population in 1000's
q = residential sewage unit flow rate
M = Ultimate Flow Factor (residential peaking factor)
(Harmon) $M = 1 + (14 / (4 + P^{0.5}))$
 Q_{pop} = peak population flow (L/s)
 $Q_{Comm/Inst}$ = peak commercial/institutional flow (L/s)
 Q_{ind} = peak industrial flow (L/s)

 Q_{infil} = peak extraneous (i.e. infiltration) flow (L/s)
i = **peak** extraneous (i.e. infiltration) unit flow rate

 Q_d = total peak design flow (L/s)

Comm/Inst Peaking Factor: **2**
Industrial Peaking Factor: **3**
Res - SFD Single Family Dwellings: q: **225** L/cap./day ppd = **3.13**
Res - MFD Multi-Family Dwellings: q: **225** L/cap./day ppu = **2.34**

Infiltration
i: **0.1** L/s/ha
(as per City of Barrie Sanitary Sewage Collection System Policies and Design Guidelines (SSCSPDG) 2017)
Mannings Coefficient
n: **0.013**

Date: 06-Aug-24
Project No: 21-694
Prepared by: CJ

Location			Sewage Flow Calculation Data															Sewer Calculation Data					Sewer Profile Data								
Street	Upstream MH	Downstream MH	Res - SFD # of Units	Res - SFD # of People	Res - MFD # of Units	*Res - MFD # of People	Comm/Inst Total Daily Flow (L/day)	Industrial Total Daily Flow (L/day)	Cum. Res - SFD # of People	Cum. Res - MFD # of People	Cum. Comm/Inst Total Daily Flow (L/day)	Cum. Industrial Total Daily Flow (L/day)	Residential Peaking Factor	Sewage Flow (L/s)	Infiltration			Total Flow (L/s)	Dia. (mm)	Slope (%)	Length (m)	Capacity (L/s)	Velocity (m/s)	Fall in Sewer (m)	Drop in MH (m) DS	Top of Grate Elevation (m) US		Invert Elevation (m) US		DS	
															Individual Area (ha)	Cumulative Area (ha)	Flow (L/s)									DS	US	DS	US		
B	D	C		0	6	14.04			0	14.04	0	0	4.40	0.16	0.17	0.17	0.02	0.18	200	1.00	27.7	34.22	1.06	0.28							
B	C	B		0	5	11.7			0	25.74	0	0	4.37	0.29	0.12	0.29	0.03	0.32	200	1.00	36.5	34.22	1.06	0.37							
B	E	B		0	5	11.7			0	11.7	0	0	4.41	0.13	0.19	0.19	0.02	0.15	200	1.00	31.6	34.22	1.06	0.32							
A	B	A		0	18	42.12			0	79.56	0	0	4.27	0.88	0.55	1.03	0.10	0.99	200	0.50	107.3	24.19	0.75	0.54			INPUT VALUE				INPUT VALUE

Individual Totals: 0 79.56 0 0 1.03
Cumulative # of People (SFD + MFD): 79.56

NOTES: * # of people for the Multi-Family Residential Dwellings (Townhouses, apartments, etc.) is calculated based on # of units x population density (2.34 for medium density as per SSCSPDG).



TOTAL DAILY DOMESTIC WATER SUPPLY FLOW CALCULATIONS
95 Cook Street + 103-107 Napier Street

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street + 103-107 Napier Street

Prepared By: CJ



<<< Elements Requiring Input Information

Total Daily Design Flow Calculations

References:

- Ontario Building Code (OBC), 2012, Division B, Part 8, Table 8.2.1.3.A. Residential Occupancy & Table 8.2.1.3.B. Other Occupancies
- Ministry of the Environment (MOE), Design Guidelines for Drinking-Water Systems (2008), Chapter 3
- City of Barrie Drinking Water Infrastructure Design Standard (2024)

Proposed Condition:

Establishment:	# of people	# of water closets	# of fuel outlets	# of seats	Gross Floor Area (m ²)	Land Area (ha)	Total Daily Design Volume		Avg Day Demand ADD (L/s)	Max Day Demand MDD (L/s)	Peak Hourly Demand PHD (L/s)
Residential Uses:											
Townhouses (34 units @ 2.57 ppu (medium density))	87.0						225	L/person	0.23	1.55	2.33
Single Detached (4 @ 3.25 ppu (low density))	13.0						225	L/person	0.03	0.23	0.35
Subtotal =	100.0								0.26	1.78	2.68
									Peaking Factor =	6.82	10.28

Notes:

\\wminas\Public\Data\Projects\2021\21-694\Design\Water\FSR_No2\240806_Total_Daily_Domestic_Water_Supply_Flow_Calcs.xlsx\Water_Supply_Flows



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**FIRE PROTECTION WATER SUPPLY
DESIGN CALCULATIONS - Townhome Development**

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street & 103-107 Napier

Prepared By: CJ

Fire Protection Water Supply

<<< Elements Requiring Input Information

Ref: Water Supply for Public Fire Protection, Fire Underwriters Survey, 2020, Part 2

"Z:\Technical\Fire_Protection\FUS_2020.pdf"

RFF = $220 \times C \times \sqrt{A}$ where, RFF = the Required Fire Flow (L/min)

C = Construction Coefficient related to type of construction

- C = 1.5 for **Type V** Wood Frame Construction
0.8 for **Type IV - A** Mass Timber Construction
0.9 for **Type IV - B** Mass Timber Construction
1.0 for **Type IV - C** Mass Timber Construction
1.5 for **Type IV - D** Mass Timber Construction
1.0 for **Type III** Ordinary Construction
0.8 for **Type II** Noncombustible Construction
0.6 for **Type I** Fire Resistive Construction

A = Total Effective Area (m^2) is the largest Floor Area plus the following percentages of the total area of the other floors:

- 1) For a building classified with a Construction Coefficient from 1.0 to 1.5:
 - a) 100% of all Floor Areas are considered in determining the Total Effective Area to be used in the formula.
- 2) For a building classified with a Construction Coefficient below 1.0:
 - a) if any vertical openings in the building (ex. Interconnected floor spaces, atria, elevators, escalators, etc.) are unprotected, consider the two largest adjoining floor areas plus 50% of all floors immediately above them up to a maximum of eight; or
 - b) if all vertical openings and exterior vertical communications are properly protected in accordance with the National Building Code, consider only the single largest Floor Area plus 25% of each of the two immediately adjoining floors.

Refer to the FUS for the assistance in determining the total effective area for:

- High One Storey Buildings
- Subdividing Buildings (Vertical Firewalls)
- Basements
- Open Parking Garages

Procedural steps to determine the Required Fire Flow (RFF):

A.	C =	1.5		
B.	A =	180	m^2	
C.	RFF ₁ =	4000	L/min	< Nearest 1000 L/min
	Occupancy and Contents Adjustment Factor	-15.0%		< Refer to Table 3 Recommended Occupancy/Contents Charges by Major Occupancy Examples
D.	RFF ₂ =	3400		< Refer to Table 4 Sprinkler Credits
	Automatic Sprinkler Protection	0.0%		
E.	Sprinkler Reduction =	0	L/min	
	Exposure Adjustment Charge	26.0%		< Refer to Table 6 Exposure Charges (75% max.)
F.	Exposure Increase =	884	L/min	Vertical Fire Walls can result in no exposure charge
G.	RFF _{FINAL} =	4000	L/min	< Nearest 1000 L/min
		67	L/s	

From Table 1:

Required Duration of Fire Flow = 1.5 hrs

Notes: - A = Largest Townhouse Unit (Unit 13 = 14.3m x 6.3m = 90m²) with 2 aboveground floors
- Residential, Limited Combustible Contents, -15% Occupancy/Contents Charge
- Vertical firewalls to be installed between units
- Exposure distance to Unit 14 is 3.6m, Exposed Bldg's Length-Height Factor is 28.6 (14.3m long x 2-storey) and is Type V construction without unprotected openings = 16% Charge
- Exposure distance to Units 1-9 is 21m, Exposed Bldg's Length-Height Factor is 110.6 (55.3m long x 2-storey) and is Type V construction without unprotected openings = 10% Charge



Watermain Headloss Calculations - MDD + FF
95 Cook Street + 103-107 Napier Street

<<< Elements Requiring Input Information

$$\text{Velocity, } V = \frac{Q}{A} \quad (\text{m/s})$$

where, Q = Flow (m^3/s)
 A = Cross-Sectional Area (m^2)

$$\text{Minor Head Loss, } H_L = (K_1 + K_2 + K_3 \dots) \times V^2 / 2g$$

where, $\Sigma K = (K_1 + K_2 + K_3 \dots)$
 V = mean velocity (m/s)
 g = 9.81 (acceleration due to gravity, m/s^2)

Hazen-Williams Equation (re-arranged for Friction Slope)

$$\text{Friction Slope, } S = \frac{(V)^{1.054}}{(0.85CR^{0.63})^{1.054}} \times 100 \quad (\text{m}/100\text{m})$$

where, V = mean velocity (m/s)
 k = 0.85 for SI units
 C = Roughness Coefficient
 R = hydraulic radius (m)

$$\text{Total Head Loss} = \text{Friction Head Loss} + \text{Minor Head Loss}$$

$$\text{Pressure (psi)} = \text{Pressure Head (m)} \times 1.422$$

$$\text{Total HGL} = \text{Ground Elev.} + \text{Pressure Head}$$

Date: 06-Aug-24
Project No: 21-694
Prepared by: CJ

Description	Pipe Design Coefficient C	Forcemain						Sum of Minor Loss Coeff. ΣK =	Minor Head Loss (m)	Total Head Loss (m)	Total Pressure Loss (psi)	Pressure @ Pt. A (psi)	Pressure Head @ Pt. A (m)	Ground Elev. @ Pt. A (m)	Total HGL @ Pt. A (m)	Ground Elev. @ Pt. B (m)	Total HGL @ Pt. B (m)	Pressure Head @ Pt. B (m)	Pressure @ Pt. B (psi)
		Flow (L/s)	Diameter (mm)	Velocity (m/s)	Unit Friction Head Loss (m/100m)	Distance (m)	Friction Head Loss (m)												
FH3	110	156.55	200	4.98	14.45	190.00	27.46	3.92	4.96	32.42	46.10	67	47.12	270.35	317.47	270.90	285.05	14.15	20.12
FH2	110	156.55	200	4.98	14.45	103.90	15.01	1.44	1.82	16.84	23.94	67	47.12	270.35	317.47	270.60	300.63	30.03	42.70
FH1	110	156.55	200	4.98	14.45	15.60	2.25	1.44	1.82	4.08	5.80	67	47.12	270.35	317.47	270.65	313.39	42.74	60.78

Loss Coefficient:

NOTES:	FH3-	1 - 3 90° Bends @ K=1 2 - 6 Valves @ K=0.12 3 - Sudden Enlargement (3:4) @ K=0.2	FH2-	1 - 1 90° Bends @ K=1 2 - 2 Valves @ K=0.12 3 - Sudden Enlargement (3:4) @ K=0.2	FH1-	1 - 1 90° Bends @ K=1 2 - 2 Valves @ K=0.12 3 - Sudden Enlargement (3:4) @ K=0.2
--------	------	--	------	--	------	--

- Maximum Daily Demand (1.55L/s) + Townhouse fire flow (155L/s - as per City of Barrie) governs watermain size requirements (156.55L/s). The 4 Single Detached Lots are not supplied from the internal watermain.
- Pressure @ Point A = Residual pressure under dual port flow from the Vipond Inc. fire flow test results dated March 17, 2022. Point A is located at the proposed internal watermain connection to the existing Cook Street watermain.
- The Pressure @ Point B (applicable fire hydrant) is required to be greater than 20PSI under the fire flow + MDD scenario
- Refer to Figure 6 for an illustration of hydrant locations and various attributes in support of these calculations.



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Watermain Headloss Calculations - FF @ 20PSI 95 Cook Street + 103-107 Napier Street

<<< Elements Requiring Input Information

$$\text{Velocity, } V = \frac{Q}{A} \quad (\text{m/s})$$

where, Q = Flow (m^3/s)
 A = Cross-Sectional Area (m^2)

$$\text{Minor Head Loss, } H_L = (K_1 + K_2 + K_3 \dots) \times V^2 / 2g$$

where, $\sum K = (K_1 + K_2 + K_3 \dots)$
 V = mean velocity (m/s)
 g = 9.81 (acceleration due to gravity, m/s^2)

Hazen-Williams Equation (re-arranged for Friction Slope)
(Friction Head Loss Calculation)

$$\text{Friction Slope, } S = \frac{(V)^{1/0.54}}{(0.85CR^{0.63})^{1/0.54}} \times 100 \quad (\text{m}/100\text{m})$$

where, V = mean velocity (m/s)
 k = 0.85 for SI units
 C = Roughness Coefficient
 R = hydraulic radius (m)

Total Head Loss = Friction Head Loss + Minor Head Loss

$$\text{Pressure (psi)} = \text{Pressure Head (m)} \times 1.422$$

$$\text{Total HGL} = \text{Ground Elev.} + \text{Pressure Head}$$

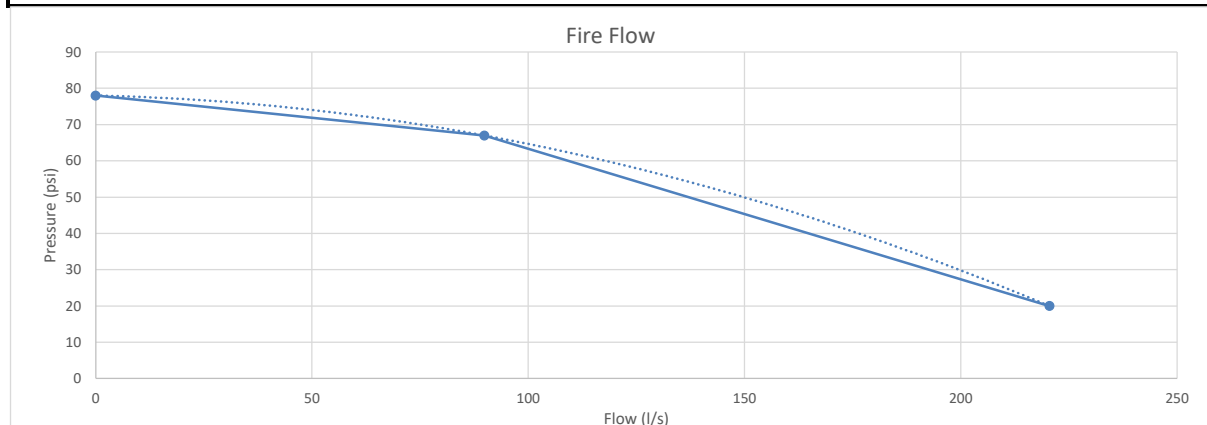
Date: 06-Aug-24
Project No: 21-694
Prepared by: CJ

Description	Pipe Design Coefficient C	Forcemain						Sum of Minor Loss Coeff. $\sum K$	Minor Head Loss (m)	Total Head Loss (m)	Total Pressure Loss (psi)	Pressure @ Pt. A (psi)	Pressure Head @ Pt. A (m)	Ground Elev @ Pt. A (m)	Total HGL @ Pt. A (m)	Ground Elev @ Pt. B (m)	Total HGL @ Pt. B (m)	Pressure Head @ Pt. B (m)	Pressure @ Pt. B (psi)
		Flow (L/s)	Diameter (mm)	Velocity (m/s)	Unit Friction Head Loss (m/100m)	Distance (m)	Friction Head Loss (m)												
FH3	110	156.7	200	4.99	14.48	190.00	27.51	3.92	4.97	32.48	46.18	67	47.12	270.35	317.47	270.90	284.99	14.09	20.04
*FH2	110	223.7	200	7.12	27.99	103.90	29.08	1.44	3.72	32.80	46.64	67	47.12	270.35	317.47	270.60	284.67	14.07	20.00
*FH1	110	463.1	200	14.74	107.68	15.60	16.80	1.44	15.95	32.75	46.57	67	47.12	270.35	317.47	270.65	284.72	14.07	20.01

NOTES: Loss Coefficient:
FH3- 1 - 3 90° Bends @ K=1
2 - 6 Valves @ K=0.12
3 - Sudden Enlargement (3:4) @ K=0.2
FH2- 1 - 1 90° Bends @ K=1
2 - 2 Valves @ K=0.12
3 - Sudden Enlargement (3:4) @ K=0.2
FH1- 1 - 1 90° Bends @ K=1
2 - 2 Valves @ K=0.12
3 - Sudden Enlargement (3:4) @ K=0.2

- Fire flows were adjusted to achieve minimum pressure of 20psi at each hydrant.
- Maximum Daily Demand (1.55L/s) + Townhouse fire flow (155L/s - as per City of Barrie) governs watermain size requirements (156.55L/s). The 4 Single Detached Lots are not supplied from the internal watermain.
- Pressure @ Point A = Residual pressure under dual port flow from the Vipond Inc. fire flow test results dated March 17, 2022. Point A is located at the proposed internal watermain connection to the existing Cook Street watermain.
- The Pressure @ Point B (applicable fire hydrant) is minimum 20PSI, for maximum theoretical fire flow.
- * - The flows for FH1 and FH2 at 20PSI exceed the available fire flow based on the results of the hydrant flow test; therefore, the available fire flow of 220.5L/s governs for these hydrants. Refer to Fire Flow Test (W501) calculations.
- Refer to Figure 6 for an illustration of hydrant locations and various attributes in support of these calculations.

Fire Flow Test (W501 v1.1)		
City of Barrie		
6-Aug-2024		
Hydrant Number (Residual and Static Pressure)	2813	
Hydrant Number(s) (Flow)	3580	
Hydrant Street / Address (Residual and Static Pressure)	Napier @ Cook	
Hydrant Street / Address (Flow)	Strabane @ Cook	
Hydrant Locations Figure (Residual/Static and Flow)	See figure in Flow test results prepared by Vipond (included).	
Date of Test (DD/MM/YYYY)	17-03-2022	
Time (HH:MM AM or PM)	02:30:00 PM	
Time (HH:MM AM or PM)	02:45:00 PM	
Company Name	Vipond	
Employee Name(s)	Len K. Ethan B.	
City of Barrie Employee Name(s)	Rebecca Lynn	
Static Pressure	78	psi
Residual Pressure	67	psi
Hydrant Elevation (Residual and Static Pressure)		m
Hydrant Elevation (Flow)		m
Elevation Difference (m)	0	m
Pitot Pressure - Outlet 1	18	psi
Pitot Pressure - Outlet 2	18	psi
Outlet Size	2.5	inch
Outlet Coefficient	0.9	
Pressure Drop Check (NFPA 291)	14.10	% Minimum pressure drop of 25% is recommended, please consider opening other outlets or flowing additional hydrants
Pressure Drop Check (AWWA M17)	11.00	psi Meets minimum pressure drop recommendation of 10 psi
Q Hydrant Flow - Outlet 1	712.13	US gpm
Q Hydrant Flow - Outlet 2	712.13	US gpm
Q Total Flow	89.86	l/s
Pressure at Desired Fire Flow	20.00	psi
Q Outlet 1 _R	1747.66	US gpm
Q Outlet 2 _R	1747.66	US gpm
Q Total _R	3495.32	US gpm
Q Total _R	220.52	l/s
Have any Cell formulas been changed? (Yes/No)	No	If Yes please indicate which ones and why
Hydrant Colour:	Blue	
Boundary Conditions (ET, Reservoir, BPS, PRV, Wells etc): N/A		
Other Considerations (flushing, fire, operational issues, outlet coefficient etc): N/A		



FLOW TEST RESULTS

DATE : MARCH 17, 2022 TIME VALVE OPENED : 2:30 PM

TIME LAST VALVE CLOSED : 2:45 PM

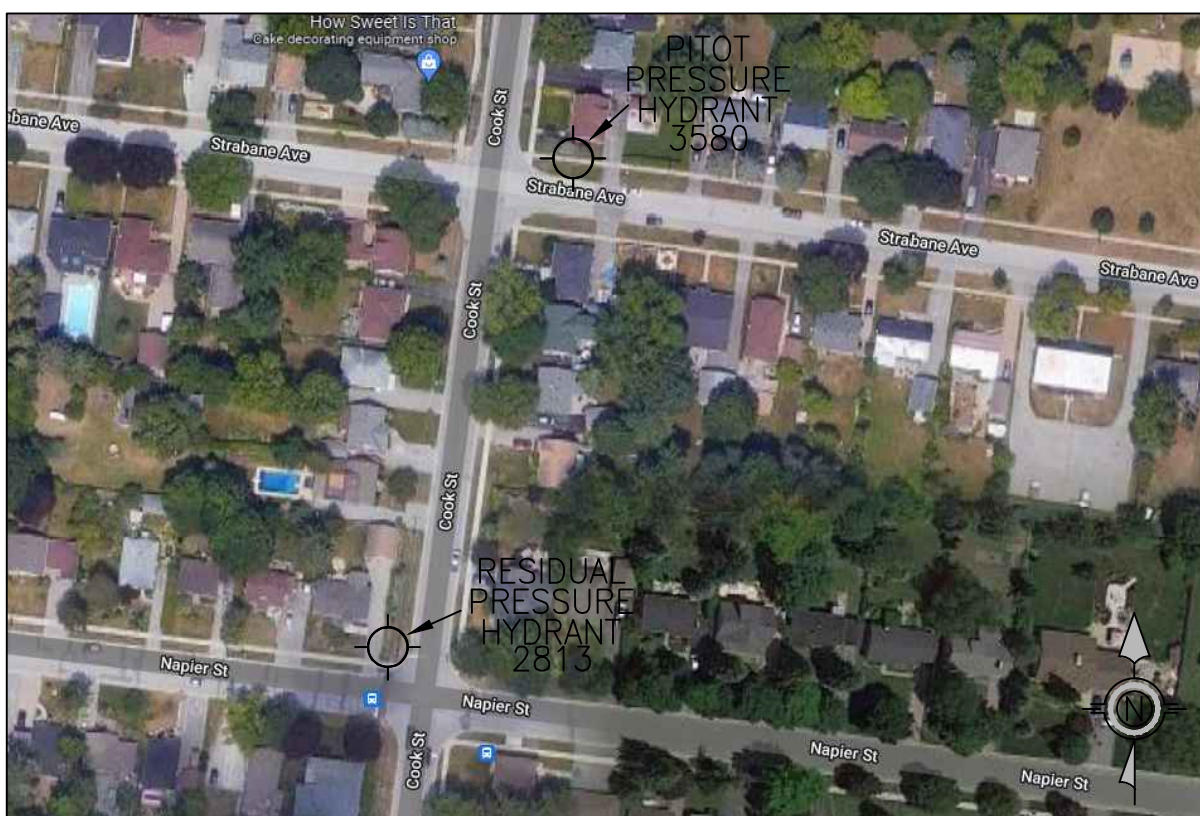
LOCATION : COOK ST & STRABANE

BARRIE

ONTARIO

TEST BY : LEN.K-ETHAN.B

NAME OF CITY OPERATOR : REBECCA LYNN



STATIC PRESSURE : 78 PSI

SIZE OF UNDERGROUND MAIN : 150MM

TEST NO.	NO. OF NOZZLES	NOZZLE DIAMETER (INCHES)	DISCHARGE CO-EFFICIENT	RESIDUAL PRESSURE (PSI)	PITOT PRESSURE (PSI)	DISCHARGE (U.S.GPM)
1	1	1-3/4	0.995	73	44	591
2	1	2-1/2	0.90	70	20	754
3	2	2-1/2	0.90	67	18	1432



COOK ST & STRABANE

BARRIE

ONTARIO

BY : LEN.K/ETHAN.B

OFFICE : BARRIE

TEST BY : VIPOND & PUC

DATE : MARCH 17, 2022

STATIC:

78 PSI

RESIDUAL:

73 PSI

FLOW:

@ 591 GPM

TEST#1

@

754 GPM

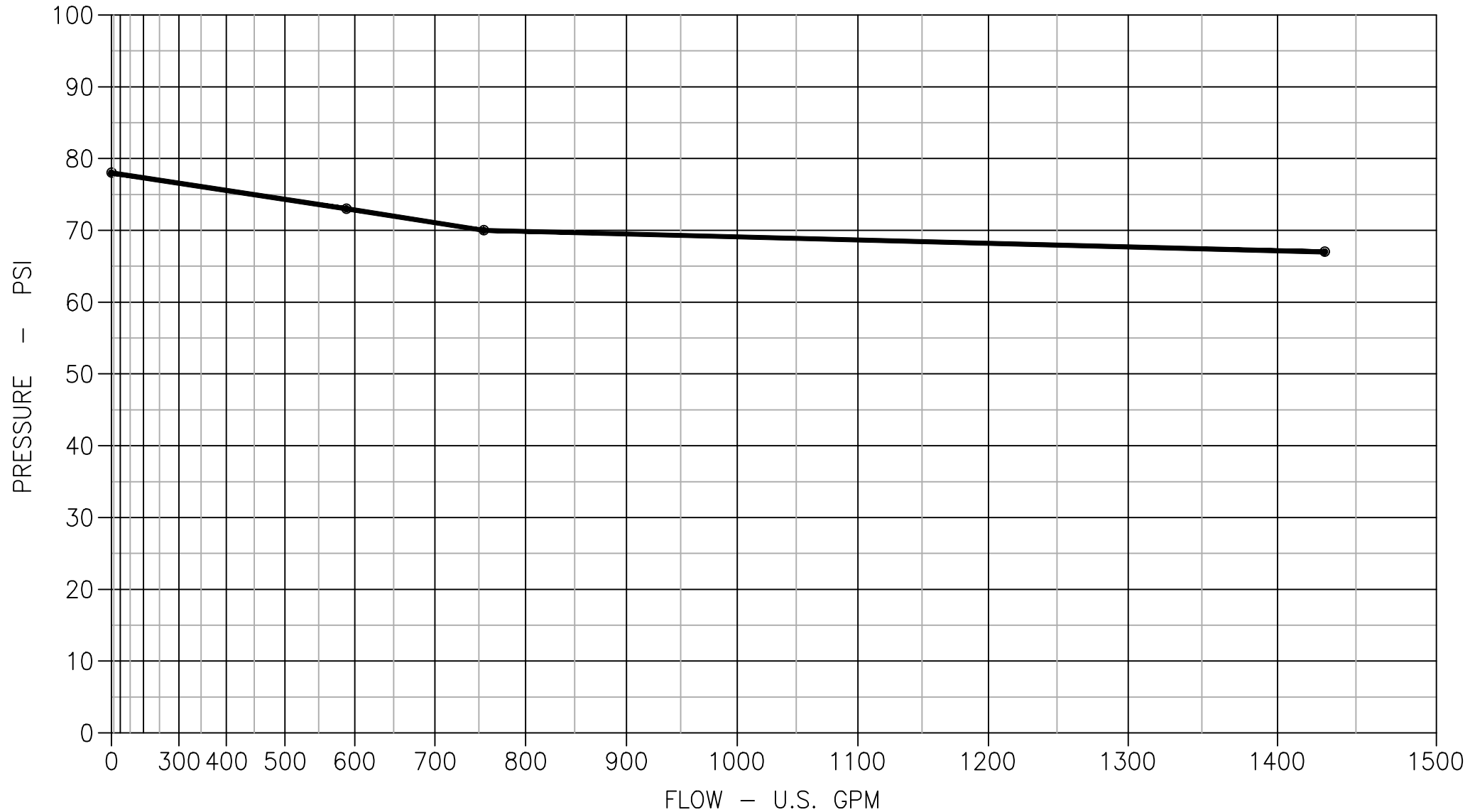
TEST#2

@

1432 GPM

TEST#3

67 PSI



APPENDIX D

STORMWATER MANAGEMENT CALCULATIONS



WMI & Associates Limited
119 Collier Street, Barrie, Ontario L4M 1H5
p (705) 797-2027 f (705) 797-2028

RUNOFF COEFFICIENT CALCULATIONS "C" SPREADSHEET

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street + 103-107 Napier Street

Prepared By: CJ

RUNOFF COEFFICIENT NUMBERS

Land Cover		Hydrologic Soil Groups		
		A-AB	B-BC	C-D
Cultivated Land	0 - 5% grade	0.22	0.35	0.55
	5 - 10% grade	0.3	0.45	0.6
	10 - 30% grade	0.4	0.65	0.7
Pasture Land	0 - 5% grade	0.1	0.28	0.4
	5 - 10% grade	0.15	0.35	0.45
	10 - 30% grade	0.22	0.4	0.55
Woodlot or Cutover	0 - 5% grade	0.08	0.25	0.35
	5 - 10% grade	0.12	0.3	0.42
	10 - 30% grade	0.18	0.35	0.52
Lakes and Wetlands		0.05	0.05	0.05
Impervious Area	(i.e. buildings, roads, parking lot, etc.)	0.95	0.95	0.95
Gravel	(not used for proposed parking or storage areas)	0.4	0.5	0.6
Residential	Single Family	0.3	0.4	0.5
	Multiple (i.e. semi, townhouse, apartment, etc.)	0.5	0.6	0.7
Industrial	Light	0.55	0.65	0.75
	Heavy	0.65	0.75	0.85
Commercial		0.6	0.7	0.8
Unimproved Areas		0.1	0.2	0.3
Lawn	< 2% grade	0.05	0.11	0.17
	2 - 7% grade	0.1	0.16	0.22
	> 7% grade	0.15	0.25	0.35

Ref: Runoff Coefficient Numbers - Adapted from Design Chart 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual", MTO. (1997)



<<< Elements Requiring Input Information

PRE-DEVELOPMENT CONDITION

PRE2

Land Cover		Hydrologic Soil Groups		
		A-AB	B-BC	C-D
Cultivated Land	0 - 5% grade			
	5 - 10% grade			
	10 - 30% grade			
Pasture Land	0 - 5% grade			
	5 - 10% grade			
	10 - 30% grade			
Woodlot or Cutover	0 - 5% grade	0.16		
	5 - 10% grade			
	10 - 30% grade			
Lakes and Wetlands				
Impervious Area	(i.e. buildings, roads, parking lot, etc.)	0.26		
Gravel	(not used for proposed parking or storage areas)			
Residential	Single Family			
	Multiple (i.e. semi, townhouse, apartment, etc.)			
Industrial	Light			
	Heavy			
Commercial				
Unimproved Areas				
Lawn	< 2% grade			
	2 - 7% grade	0.46		
	> 7% grade			

Total Area (ha) = 0.88

Runoff Coefficient, C = 0.35

POST-DEVELOPMENT CONDITION

A1A

Land Cover		Hydrologic Soil Groups		
		A-AB	B-BC	C-D
Cultivated Land	0 - 5% grade			
	5 - 10% grade			
	10 - 30% grade			
Pasture Land	0 - 5% grade			
	5 - 10% grade			
	10 - 30% grade			
Woodlot or Cutover	0 - 5% grade			
	5 - 10% grade			
	10 - 30% grade			
Lakes and Wetlands				
Impervious Area	(i.e. buildings, roads, parking lot, etc.)	0.39		
Gravel	(not used for proposed parking or storage areas)			
Residential	Single Family			
	Multiple (i.e. semi, townhouse, apartment, etc.)			
Industrial	Light			
	Heavy			
Commercial				
Unimproved Areas				
Lawn	< 2% grade			
	2 - 7% grade	0.13		
	> 7% grade			

Total Area (ha) = 0.52

Runoff Coefficient, C = 0.74

POST-DEVELOPMENT CONDITION

A1B

Land Cover		Hydrologic Soil Groups		
		A-AB	B-BC	C-D
Cultivated Land	0 - 5% grade			
	5 - 10% grade			
	10 - 30% grade			
Pasture Land	0 - 5% grade			
	5 - 10% grade			
	10 - 30% grade			
Woodlot or Cutover	0 - 5% grade			
	5 - 10% grade			
	10 - 30% grade			
Lakes and Wetlands				
Impervious Area	(i.e. buildings, roads, parking lot, etc.)	0.03		
Gravel	(not used for proposed parking or storage areas)			
Residential	Single Family			
	Multiple (i.e. semi, townhouse, apartment, etc.)			
Industrial	Light			
	Heavy			
Commercial				
Unimproved Areas				
Lawn	< 2% grade			
	2 - 7% grade	0.02		
	> 7% grade			

Total Area (ha) = 0.05

Runoff Coefficient, C = 0.61

POST-DEVELOPMENT CONDITION

A2

Land Cover		Hydrologic Soil Groups		
		A-AB	B-BC	C-D
Cultivated Land	0 - 5% grade			
	5 - 10% grade			
	10 - 30% grade			
Pasture Land	0 - 5% grade			
	5 - 10% grade			
	10 - 30% grade			
Woodlot or Cutover	0 - 5% grade			
	5 - 10% grade			
	10 - 30% grade			
Lakes and Wetlands				
Impervious Area	(i.e. buildings, roads, parking lot, etc.)	0.17		
Gravel	(not used for proposed parking or storage areas)			
Residential	Single Family			
	Multiple (i.e. semi, townhouse, apartment, etc.)			
Industrial	Light			
	Heavy			
Commercial				
Unimproved Areas				
Lawn	< 2% grade			
	2 - 7% grade	0.36		
	> 7% grade			

Total Area (ha) = 0.53

Runoff Coefficient, C = 0.37



RATIONAL METHOD CALCULATIONS

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street + 103-107 Napier Street

Prepared By: CJ

Elements Requiring Input Information

Rainfall Intensity-Duration-Frequency Coefficients from: Barrie WPCC Station + 15% to account for climate change

2-year	5-year	10-year	25-year	50-year	100-year
A = 675.586	A = 843.019	A = 976.898	A = 1133.123	A = 1251.473	A = 1383.628
B = 4.681	B = 4.582	B = 4.745	B = 4.734	B = 4.847	B = 4.905
C = 0.780	C = 0.763	C = 0.760	C = 0.756	C = 0.753	C = 0.754

Rational Method Formula

$$Q = \frac{C \times I \times A}{360} \quad (\text{m}^3/\text{s})$$

where, C = Runoff Coefficient
I = Rainfall Intensity, (mm/hr)
A = Drainage Area, (ha)

Rainfall Intensity Equation (2-100 year storm events)

$$I_{2-100} = \frac{A}{(B + T_c)^C} \quad (\text{mm/hr})$$

where, A = Rainfall IDF Coefficient
B = Rainfall IDF Coefficient
C = Rainfall IDF Coefficient
T_c = Time of Concentration, (min)

Runoff Coefficient Equations
Based on MTO Drainage Manual (1984), page BD-4

2-year C₂ = C
5-year C₅ = C
10-year C₁₀ = C
25-year C₂₅ = 1.10 x C
50-year C₅₀ = 1.20 x C
100-year C₁₀₀ = 1.25 x C

For storms having a return period of more than 10 years, the Runoff Coefficient, C, will be increased as indicated above, up to a maximum value of 1.

Rainfall Intensity Equation (25mm storm event)
Based on the MOE SWMP Manual (2003), Eq'n 4.9

$$I_{25\text{mm}} = (43 \times C) + 5.9 \quad (\text{mm/hr})$$

where, C = Runoff Coefficient

Catchment I.D.	A (ha)	T _c (min.)	C	Q _{25mm} (m ³ /s)	Q ₂ (m ³ /s)	Q ₅ (m ³ /s)	Q ₁₀ (m ³ /s)	Q ₂₅ (m ³ /s)	Q ₅₀ (m ³ /s)	Q ₁₀₀ (m ³ /s)
*EXT	0.24	10.0	0.40	0.006	0.022	0.029	0.034	0.043	0.053	0.060
*PRE1	0.22	10.0	0.40	0.006	0.020	0.027	0.031	0.040	0.048	0.055
PRE2	0.88	10.0	0.35	0.018	0.071	0.093	0.108	0.140	0.169	0.193
PRE Total	1.10	10.0	0.36	0.024	0.091	0.120	0.139	0.179	0.217	0.248
A1A	0.52	10.0	0.74	0.040	0.089	0.117	0.135	0.174	0.211	0.241
A1B	0.05	10.0	0.61	0.003	0.007	0.009	0.011	0.014	0.017	0.019
A2	0.53	10.0	0.37	0.012	0.045	0.059	0.069	0.089	0.107	0.123
POST Total (Uncontrolled)	1.10	10.0	0.56	0.051	0.141	0.185	0.215	0.277	0.334	0.383
**To Cook Street (Allowable)	0.50	10.0	0.40	0.013	0.046	0.061	0.070	0.091	0.109	0.125
A1A + A1B	0.57	10.0	0.73	0.043	0.096	0.126	0.146	0.188	0.227	0.260
A1A (controlled) = To Cook - A1B				0.010	0.039	0.051	0.060	0.077	0.093	0.106

Note: *C=0.40 is based on drainage plans obtained from the City of Barrie.

**Area is based on 45% of the total drainage area of 1.10ha.



MODIFIED RATIONAL METHOD CALCULATIONS
2-year Design Storm Event

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street + 103-107 Napier Street

Prepared By: CJ

<<< Elements Requiring Input Information

Rainfall Intensity-Duration-Frequency Coefficients from: Barrie WPCC Station + 15% to account for climate change

2-year		5-year		10-year		25-year		50-year		100-year	
A =	675.586	A =	843.019	A =	976.898	A =	1133.123	A =	1251.473	A =	1383.628
B =	4.681	B =	4.582	B =	4.745	B =	4.734	B =	4.847	B =	4.905
C =	0.780	C =	0.763	C =	0.760	C =	0.756	C =	0.753	C =	0.754

Rational Method Formula

$$Q = \frac{C \times I \times A}{360} \quad (\text{m}^3/\text{s})$$

where, C = Runoff Coefficient
I = Rainfall Intensity, (mm/hr)
A = Drainage Area, (ha)

Rainfall Intensity Equation (2-100 year storm events)

$$I_{2-100} = \frac{A}{(B + t_d)^C} \quad (\text{mm/hr})$$

where, A = Rainfall IDF Coefficient
B = Rainfall IDF Coefficient
C = Rainfall IDF Coefficient
 t_d = Storm Duration, (min)

Runoff Coefficient Equations
Based on MTO Drainage Manual (1984), page BD-4

2-year $C_2 = C$
5-year $C_5 = C$
10-year $C_{10} = C$
25-year $C_{25} = 1.10 \times C$
50-year $C_{50} = 1.20 \times C$
100-year $C_{100} = 1.25 \times C$

For storms having a return period of more than 10 years, the Runoff Coefficient, C, will be increased as indicated above, up to a maximum value of 1.

Runoff Volume

$$V_{\text{Runoff}} = Q_{\text{Runoff}} \times t_d \quad (\text{m}^3)$$

where, Q_{Runoff} = Runoff Peak Flow Rate, (m³/sec)
 t_d = Storm Duration, (sec)

Released Volume

$$V_{\text{Released}} = Q_{\text{Released}} \times (t_d + T_c)/2 \quad (\text{m}^3)$$

where, Q_{Released} = Max. Release Rate, (m³/sec)
 t_d = Storm Duration, (sec)
 T_c = Time of Concentration, (sec)

Max. Storage Required

$$V_{\text{Storage}} = V_{\text{Runoff}} - V_{\text{Released}} \quad (\text{m}^3)$$

V_{Runoff} = Runoff Volume, (m³)
 V_{Released} = Released Volume, (m³)

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Catchment I.D.	Storm Event	Area A (ha)	Runoff Coeff. C	Runoff Coeff. C _{MOD}	Time of Conc. T _c (min.)	Storm Time Step (min.)	Release Rate (m ³ /s)
A1A	2-year	0.52	0.74	0.74	10	5	0.039

Storm Duration t_d (min.)	Rainfall Intensity (mm/hr)	Runoff Peak Flow Rate (m ³ /s)	Runoff Volume (m ³)	Released Volume (m ³)	Storage Volume (m ³)	Max. Storage Required (m ³)
10	83.1	0.0888	53.30	23.40	29.90	
15	66.1	0.0707	63.61	29.25	34.36	
20	55.4	0.0592	71.08	35.10	35.98	
25	48.0	0.0513	76.94	40.95	35.99	36.0
30	42.5	0.0454	81.77	46.80	34.97	
35	38.3	0.0409	85.89	52.65	33.24	
40	34.9	0.0373	89.48	58.50	30.98	
45	32.1	0.0343	92.67	64.35	28.32	
50	29.8	0.0318	95.55	70.20	25.35	
55	27.8	0.0297	98.17	76.05	22.12	
60	26.1	0.0279	100.58	81.90	18.68	
65	24.7	0.0264	102.81	87.75	15.06	
70	23.4	0.0250	104.90	93.60	11.30	
75	22.2	0.0237	106.85	99.45	7.40	
80	21.2	0.0226	108.69	105.30	3.39	
85	20.3	0.0217	110.43	111.15	0.00	
90	19.4	0.0208	112.08	117.00	0.00	
95	18.7	0.0199	113.65	122.85	0.00	
100	18.0	0.0192	115.15	128.70	0.00	
105	17.3	0.0185	116.59	134.55	0.00	
110	16.7	0.0179	117.97	140.40	0.00	
115	16.2	0.0173	119.29	146.25	0.00	
120	15.7	0.0167	120.57	152.10	0.00	
125	15.2	0.0162	121.80	157.95	0.00	
130	14.8	0.0158	122.98	163.80	0.00	
135	14.3	0.0153	124.13	169.65	0.00	
140	13.9	0.0149	125.25	175.50	0.00	
145	13.6	0.0145	126.33	181.35	0.00	
150	13.2	0.0142	127.38	187.20	0.00	
155	12.9	0.0138	128.40	193.05	0.00	
160	12.6	0.0135	129.39	198.90	0.00	



MODIFIED RATIONAL METHOD CALCULATIONS
5-year Design Storm Event

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street + 103-107 Napier Street

Prepared By: CJ

<<< Elements Requiring Input Information

Rainfall Intensity-Duration-Frequency Coefficients from: Barrie WPCC Station + 15% to account for climate change

2-year		5-year		10-year		25-year		50-year		100-year	
A =	675.586	A =	843.019	A =	976.898	A =	1133.123	A =	1251.473	A =	1383.628
B =	4.681	B =	4.582	B =	4.745	B =	4.734	B =	4.847	B =	4.905
C =	0.780	C =	0.763	C =	0.760	C =	0.756	C =	0.753	C =	0.754

Rational Method Formula

$$Q = \frac{C \times I \times A}{360} \quad (\text{m}^3/\text{s})$$

where, C = Runoff Coefficient
I = Rainfall Intensity, (mm/hr)
A = Drainage Area, (ha)

Rainfall Intensity Equation (2-100 year storm events)

$$I_{2-100} = \frac{A}{(B + t_d)^C} \quad (\text{mm/hr})$$

where, A = Rainfall IDF Coefficient
B = Rainfall IDF Coefficient
C = Rainfall IDF Coefficient
t_d = Storm Duration, (min)

Runoff Coefficient Equations
Based on MTO Drainage Manual (1984), page BD-4

2-year C₂ = C
5-year C₅ = C
10-year C₁₀ = C
25-year C₂₅ = 1.10 x C
50-year C₅₀ = 1.20 x C
100-year C₁₀₀ = 1.25 x C

For storms having a return period of more than 10 years, the Runoff Coefficient, C, will be increased as indicated above, up to a maximum value of 1.

Runoff Volume

$$V_{\text{Runoff}} = Q_{\text{Runoff}} \times t_d \quad (\text{m}^3)$$

where, Q_{Runoff} = Runoff Peak Flow Rate, (m³/sec)
t_d = Storm Duration, (sec)

Released Volume

$$V_{\text{Released}} = Q_{\text{Released}} \times (t_d + T_c)/2 \quad (\text{m}^3)$$

where, Q_{Released} = Max. Release Rate, (m³/sec)
t_d = Storm Duration, (sec)
T_c = Time of Concentration, (sec)

Max. Storage Required

$$V_{\text{Storage}} = V_{\text{Runoff}} - V_{\text{Released}} \quad (\text{m}^3)$$

V_{Runoff} = Runoff Volume, (m³)
V_{Released} = Released Volume, (m³)

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Catchment I.D.	Storm Event	Area A (ha)	Runoff Coeff. C	Runoff Coeff. C _{MOD}	Time of Conc. T _c (min.)	Storm Time Step (min.)	Release Rate (m ³ /s)
A1A	5-year	0.52	0.74	0.74	10	5	0.051

Storm Duration t _d (min.)	Rainfall Intensity (mm/hr)	Runoff Peak Flow Rate (m ³ /s)	Runoff Volume (m ³)	Released Volume (m ³)	Storage Volume (m ³)	Max. Storage Required (m ³)
10	109.1	0.1166	69.97	30.60	39.37	
15	87.1	0.0931	83.82	38.25	45.57	
20	73.2	0.0783	93.95	45.90	48.05	
25	63.6	0.0680	101.97	53.55	48.42	48.4
30	56.5	0.0603	108.62	61.20	47.42	
35	50.9	0.0544	114.31	68.85	45.46	
40	46.5	0.0497	119.31	76.50	42.81	
45	42.9	0.0458	123.77	84.15	39.62	
50	39.9	0.0426	127.80	91.80	36.00	
55	37.3	0.0398	131.48	99.45	32.03	
60	35.1	0.0375	134.88	107.10	27.78	
65	33.1	0.0354	138.04	114.75	23.29	
70	31.4	0.0336	140.99	122.40	18.59	
75	29.9	0.0319	143.77	130.05	13.72	
80	28.5	0.0305	146.39	137.70	8.69	
85	27.3	0.0292	148.87	145.35	3.52	
90	26.2	0.0280	151.22	153.00	0.00	
95	25.2	0.0269	153.47	160.65	0.00	
100	24.3	0.0259	155.62	168.30	0.00	
105	23.4	0.0250	157.68	175.95	0.00	
110	22.6	0.0242	159.66	183.60	0.00	
115	21.9	0.0234	161.57	191.25	0.00	
120	21.2	0.0227	163.41	198.90	0.00	
125	20.6	0.0220	165.18	206.55	0.00	
130	20.0	0.0214	166.90	214.20	0.00	
135	19.5	0.0208	168.56	221.85	0.00	
140	19.0	0.0203	170.17	229.50	0.00	
145	18.5	0.0197	171.73	237.15	0.00	
150	18.0	0.0193	173.25	244.80	0.00	
155	17.6	0.0188	174.73	252.45	0.00	
160	17.2	0.0184	176.17	260.10	0.00	



MODIFIED RATIONAL METHOD CALCULATIONS
10-year Design Storm Event

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street + 103-107 Napier Street

Prepared By: CJ

<<< Elements Requiring Input Information

Rainfall Intensity-Duration-Frequency Coefficients from: Barrie WPCC Station + 15% to account for climate change

2-year		5-year		10-year		25-year		50-year		100-year	
A =	675.586	A =	843.019	A =	976.898	A =	1133.123	A =	1251.473	A =	1383.628
B =	4.681	B =	4.582	B =	4.745	B =	4.734	B =	4.847	B =	4.905
C =	0.780	C =	0.763	C =	0.760	C =	0.756	C =	0.753	C =	0.754

Rational Method Formula

$$Q = \frac{C \times I \times A}{360} \quad (\text{m}^3/\text{s})$$

where, C = Runoff Coefficient
I = Rainfall Intensity, (mm/hr)
A = Drainage Area, (ha)

Rainfall Intensity Equation (2-100 year storm events)

$$I_{2-100} = \frac{A}{(B + t_d)^C} \quad (\text{mm/hr})$$

where, A = Rainfall IDF Coefficient
B = Rainfall IDF Coefficient
C = Rainfall IDF Coefficient
 t_d = Storm Duration, (min)

Runoff Coefficient Equations
Based on MTO Drainage Manual (1984), page BD-4

2-year $C_2 = C$
5-year $C_5 = C$
10-year $C_{10} = C$
25-year $C_{25} = 1.10 \times C$
50-year $C_{50} = 1.20 \times C$
100-year $C_{100} = 1.25 \times C$

For storms having a return period of more than 10 years, the Runoff Coefficient, C, will be increased as indicated above, up to a maximum value of 1.

Runoff Volume

$$V_{\text{Runoff}} = Q_{\text{Runoff}} \times t_d \quad (\text{m}^3)$$

where, Q_{Runoff} = Runoff Peak Flow Rate, (m³/sec)
 t_d = Storm Duration, (sec)

Released Volume

$$V_{\text{Released}} = Q_{\text{Released}} \times (t_d + T_c)/2 \quad (\text{m}^3)$$

where, Q_{Released} = Max. Release Rate, (m³/sec)
 t_d = Storm Duration, (sec)
 T_c = Time of Concentration, (sec)

Max. Storage Required

$$V_{\text{Storage}} = V_{\text{Runoff}} - V_{\text{Released}} \quad (\text{m}^3)$$

V_{Runoff} = Runoff Volume, (m³)
 V_{Released} = Released Volume, (m³)

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Catchment I.D.	Storm Event	Area A (ha)	Runoff Coeff. C	Runoff Coeff. C _{MOD}	Time of Conc. T _c (min.)	Storm Time Step (min.)	Release Rate (m ³ /s)
A1A	10-year	0.52	0.74	0.74	10	5	0.060

Storm Duration t_d (min.)	Rainfall Intensity (mm/hr)	Runoff Peak Flow Rate (m ³ /s)	Runoff Volume (m ³)	Released Volume (m ³)	Storage Volume (m ³)	Max. Storage Required (m ³)
10	126.4	0.1351	81.05	36.00	45.05	
15	101.2	0.1082	97.38	45.00	52.38	
20	85.3	0.0911	109.37	54.00	55.37	
25	74.1	0.0792	118.87	63.00	55.87	55.9
30	65.9	0.0704	126.76	72.00	54.76	
35	59.5	0.0636	133.52	81.00	52.52	
40	54.4	0.0581	139.45	90.00	49.45	
45	50.2	0.0536	144.75	99.00	45.75	
50	46.6	0.0498	149.54	108.00	41.54	
55	43.6	0.0466	153.92	117.00	36.92	
60	41.1	0.0439	157.97	126.00	31.97	
65	38.8	0.0415	161.72	135.00	26.72	
70	36.8	0.0393	165.24	144.00	21.24	
75	35.0	0.0375	168.54	153.00	15.54	
80	33.5	0.0358	171.65	162.00	9.65	
85	32.0	0.0342	174.61	171.00	3.61	
90	30.7	0.0329	177.42	180.00	0.00	
95	29.6	0.0316	180.09	189.00	0.00	
100	28.5	0.0304	182.66	198.00	0.00	
105	27.5	0.0294	185.11	207.00	0.00	
110	26.6	0.0284	187.47	216.00	0.00	
115	25.7	0.0275	189.74	225.00	0.00	
120	24.9	0.0267	191.93	234.00	0.00	
125	24.2	0.0259	194.04	243.00	0.00	
130	23.5	0.0251	196.09	252.00	0.00	
135	22.9	0.0245	198.07	261.00	0.00	
140	22.3	0.0238	199.99	270.00	0.00	
145	21.7	0.0232	201.85	279.00	0.00	
150	21.2	0.0226	203.66	288.00	0.00	
155	20.7	0.0221	205.43	297.00	0.00	
160	20.2	0.0216	207.15	306.00	0.00	



MODIFIED RATIONAL METHOD CALCULATIONS
25-year Design Storm Event

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street + 103-107 Napier Street

Prepared By: CJ

<<< Elements Requiring Input Information

Rainfall Intensity-Duration-Frequency Coefficients from: Barrie WPCC Station + 15% to account for climate change

2-year		5-year		10-year		25-year		50-year		100-year	
A =	675.586	A =	843.019	A =	976.898	A =	1133.123	A =	1251.473	A =	1383.628
B =	4.681	B =	4.582	B =	4.745	B =	4.734	B =	4.847	B =	4.905
C =	0.780	C =	0.763	C =	0.760	C =	0.756	C =	0.753	C =	0.754

Rational Method Formula

$$Q = \frac{C \times I \times A}{360} \quad (\text{m}^3/\text{s})$$

where, C = Runoff Coefficient
I = Rainfall Intensity, (mm/hr)
A = Drainage Area, (ha)

Rainfall Intensity Equation (2-100 year storm events)

$$I_{2-100} = \frac{A}{(B + t_d)^C} \quad (\text{mm/hr})$$

where, A = Rainfall IDF Coefficient
B = Rainfall IDF Coefficient
C = Rainfall IDF Coefficient
t_d = Storm Duration, (min)

Runoff Coefficient Equations
Based on MTO Drainage Manual (1984), page BD-4

2-year C₂ = C
5-year C₅ = C
10-year C₁₀ = C
25-year C₂₅ = 1.10 x C
50-year C₅₀ = 1.20 x C
100-year C₁₀₀ = 1.25 x C

For storms having a return period of more than 10 years, the Runoff Coefficient, C, will be increased as indicated above, up to a maximum value of 1.

Runoff Volume

$$V_{\text{Runoff}} = Q_{\text{Runoff}} \times t_d \quad (\text{m}^3)$$

where, Q_{Runoff} = Runoff Peak Flow Rate, (m³/sec)
t_d = Storm Duration, (sec)

Released Volume

$$V_{\text{Released}} = Q_{\text{Released}} \times (t_d + T_c)/2 \quad (\text{m}^3)$$

where, Q_{Released} = Max. Release Rate, (m³/sec)
t_d = Storm Duration, (sec)
T_c = Time of Concentration, (sec)

Max. Storage Required

$$V_{\text{Storage}} = V_{\text{Runoff}} - V_{\text{Released}} \quad (\text{m}^3)$$

V_{Runoff} = Runoff Volume, (m³)
V_{Released} = Released Volume, (m³)

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Catchment I.D.	Storm Event	Area A (ha)	Runoff Coeff. C	Runoff Coeff. C _{MOD}	Time of Conc. T _c (min.)	Storm Time Step (min.)	Release Rate (m ³ /s)
A1A	25-year	0.52	0.74	0.81	10	5	0.077

Storm Duration t _d (min.)	Rainfall Intensity (mm/hr)	Runoff Peak Flow Rate (m ³ /s)	Runoff Volume (m ³)	Released Volume (m ³)	Storage Volume (m ³)	Max. Storage Required (m ³)
10	148.3	0.1743	104.59	46.20	58.39	
15	118.9	0.1398	125.79	57.75	68.04	
20	100.2	0.1178	141.40	69.30	72.10	
25	87.2	0.1025	153.79	80.85	72.94	72.9
30	77.5	0.0912	164.08	92.40	71.68	
35	70.0	0.0823	172.92	103.95	68.97	
40	64.0	0.0753	180.69	115.50	65.19	
45	59.1	0.0695	187.63	127.05	60.58	
50	55.0	0.0646	193.91	138.60	55.31	
55	51.5	0.0605	199.66	150.15	49.51	
60	48.4	0.0569	204.97	161.70	43.27	
65	45.8	0.0538	209.91	173.25	36.66	
70	43.4	0.0511	214.52	184.80	29.72	
75	41.4	0.0486	218.86	196.35	22.51	
80	39.5	0.0465	222.96	207.90	15.06	
85	37.8	0.0445	226.85	219.45	7.40	
90	36.3	0.0427	230.55	231.00	0.00	
95	34.9	0.0411	234.07	242.55	0.00	
100	33.7	0.0396	237.45	254.10	0.00	
105	32.5	0.0382	240.68	265.65	0.00	
110	31.4	0.0369	243.79	277.20	0.00	
115	30.4	0.0358	246.79	288.75	0.00	
120	29.5	0.0347	249.67	300.30	0.00	
125	28.6	0.0337	252.46	311.85	0.00	
130	27.8	0.0327	255.16	323.40	0.00	
135	27.1	0.0318	257.77	334.95	0.00	
140	26.4	0.0310	260.31	346.50	0.00	
145	25.7	0.0302	262.77	358.05	0.00	
150	25.1	0.0295	265.17	369.60	0.00	
155	24.5	0.0288	267.50	381.15	0.00	
160	23.9	0.0281	269.76	392.70	0.00	



MODIFIED RATIONAL METHOD CALCULATIONS
50-year Design Storm Event

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street + 103-107 Napier Street

Prepared By: CJ

<<< Elements Requiring Input Information

Rainfall Intensity-Duration-Frequency Coefficients from: Barrie WPCC Station + 15% to account for climate change

2-year		5-year		10-year		25-year		50-year		100-year	
A =	675.586	A =	843.019	A =	976.898	A =	1133.123	A =	1251.473	A =	1383.628
B =	4.681	B =	4.582	B =	4.745	B =	4.734	B =	4.847	B =	4.905
C =	0.780	C =	0.763	C =	0.760	C =	0.756	C =	0.753	C =	0.754

Rational Method Formula

$$Q = \frac{C \times I \times A}{360} \quad (\text{m}^3/\text{s})$$

where, C = Runoff Coefficient
I = Rainfall Intensity, (mm/hr)
A = Drainage Area, (ha)

Rainfall Intensity Equation (2-100 year storm events)

$$I_{2-100} = \frac{A}{(B + t_d)^C} \quad (\text{mm/hr})$$

where, A = Rainfall IDF Coefficient
B = Rainfall IDF Coefficient
C = Rainfall IDF Coefficient
 t_d = Storm Duration, (min)

Runoff Coefficient Equations
Based on MTO Drainage Manual (1984), page BD-4

2-year $C_2 = C$
5-year $C_5 = C$
10-year $C_{10} = C$
25-year $C_{25} = 1.10 \times C$
50-year $C_{50} = 1.20 \times C$
100-year $C_{100} = 1.25 \times C$

For storms having a return period of more than 10 years, the Runoff Coefficient, C, will be increased as indicated above, up to a maximum value of 1.

Runoff Volume

$$V_{\text{Runoff}} = Q_{\text{Runoff}} \times t_d \quad (\text{m}^3)$$

where, Q_{Runoff} = Runoff Peak Flow Rate, (m³/sec)
 t_d = Storm Duration, (sec)

Released Volume

$$V_{\text{Released}} = Q_{\text{Released}} \times (t_d + T_c)/2 \quad (\text{m}^3)$$

where, Q_{Released} = Max. Release Rate, (m³/sec)
 t_d = Storm Duration, (sec)
 T_c = Time of Concentration, (sec)

Max. Storage Required

$$V_{\text{Storage}} = V_{\text{Runoff}} - V_{\text{Released}} \quad (\text{m}^3)$$

V_{Runoff} = Runoff Volume, (m³)
 V_{Released} = Released Volume, (m³)

\\minas\PublicData\Projects\2021\21-694\DesignStorm\FSR_No2\3.0_240806_Modified_Rational_Method_Calcs(A,B,C).xlsx|100-YR

Catchment I.D.	Storm Event	Area A (ha)	Runoff Coeff. C	Runoff Coeff. C _{MOD}	Time of Conc. T _c (min.)	Storm Time Step (min.)	Release Rate (m ³ /s)
A1A	50-year	0.52	0.74	0.89	10	5	0.093

Storm Duration t_d (min.)	Rainfall Intensity (mm/hr)	Runoff Peak Flow Rate (m ³ /s)	Runoff Volume (m ³)	Released Volume (m ³)	Storage Volume (m ³)	Max. Storage Required (m ³)
10	164.1	0.2105	126.31	55.80	70.51	
15	131.9	0.1692	152.27	69.75	82.52	
20	111.4	0.1429	171.43	83.70	87.73	
25	97.0	0.1244	186.65	97.65	89.00	89.0
30	86.3	0.1107	199.32	111.60	87.72	
35	78.0	0.1001	210.21	125.55	84.66	
40	71.4	0.0916	219.78	139.50	80.28	
45	65.9	0.0846	228.34	153.45	74.89	
50	61.4	0.0787	236.09	167.40	68.69	
55	57.5	0.0737	243.18	181.35	61.83	
60	54.1	0.0694	249.74	195.30	54.44	
65	51.1	0.0656	255.83	209.25	46.58	
70	48.5	0.0623	261.54	223.20	38.34	
75	46.2	0.0593	266.90	237.15	29.75	
80	44.2	0.0567	271.97	251.10	20.87	
85	42.3	0.0543	276.77	265.05	11.72	
90	40.6	0.0521	281.34	279.00	2.34	
95	39.1	0.0501	285.70	292.95	0.00	
100	37.7	0.0483	289.87	306.90	0.00	
105	36.4	0.0466	293.87	320.85	0.00	
110	35.2	0.0451	297.72	334.80	0.00	
115	34.1	0.0437	301.42	348.75	0.00	
120	33.0	0.0424	305.00	362.70	0.00	
125	32.1	0.0411	308.45	376.65	0.00	
130	31.2	0.0400	311.79	390.60	0.00	
135	30.3	0.0389	315.02	404.55	0.00	
140	29.5	0.0379	318.16	418.50	0.00	
145	28.8	0.0369	321.21	432.45	0.00	
150	28.1	0.0360	324.18	446.40	0.00	
155	27.4	0.0352	327.06	460.35	0.00	
160	26.8	0.0344	329.87	474.30	0.00	



MODIFIED RATIONAL METHOD CALCULATIONS
100-year Design Storm Event

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street + 103-107 Napier Street

Prepared By: CJ

<<< Elements Requiring Input Information

Rainfall Intensity-Duration-Frequency Coefficients from: Barrie WPCC Station + 15% to account for climate change

2-year		5-year		10-year		25-year		50-year		100-year	
A =	675.586	A =	843.019	A =	976.898	A =	1133.123	A =	1251.473	A =	1383.628
B =	4.681	B =	4.582	B =	4.745	B =	4.734	B =	4.847	B =	4.905
C =	0.780	C =	0.763	C =	0.760	C =	0.756	C =	0.753	C =	0.754

Rational Method Formula

$$Q = \frac{C \times I \times A}{360} \quad (\text{m}^3/\text{s})$$

where, C = Runoff Coefficient
I = Rainfall Intensity, (mm/hr)
A = Drainage Area, (ha)

Rainfall Intensity Equation (2-100 year storm events)

$$I_{2-100} = \frac{A}{(B + t_d)^C} \quad (\text{mm/hr})$$

where, A = Rainfall IDF Coefficient
B = Rainfall IDF Coefficient
C = Rainfall IDF Coefficient
t_d = Storm Duration, (min)

Runoff Coefficient Equations
Based on MTO Drainage Manual (1984), page BD-4

2-year C₂ = C
5-year C₅ = C
10-year C₁₀ = C
25-year C₂₅ = 1.10 x C
50-year C₅₀ = 1.20 x C
100-year C₁₀₀ = 1.25 x C

For storms having a return period of more than 10 years, the Runoff Coefficient, C, will be increased as indicated above, up to a maximum value of 1.

Runoff Volume

$$V_{\text{Runoff}} = Q_{\text{Runoff}} \times t_d \quad (\text{m}^3)$$

where, Q_{Runoff} = Runoff Peak Flow Rate, (m³/sec)
t_d = Storm Duration, (sec)

Released Volume

$$V_{\text{Released}} = Q_{\text{Released}} \times (t_d + T_c)/2 \quad (\text{m}^3)$$

where, Q_{Released} = Max. Release Rate, (m³/sec)
t_d = Storm Duration, (sec)
T_c = Time of Concentration, (sec)

Max. Storage Required

$$V_{\text{Storage}} = V_{\text{Runoff}} - V_{\text{Released}} \quad (\text{m}^3)$$

V_{Runoff} = Runoff Volume, (m³)
V_{Released} = Released Volume, (m³)

\\minas\PublicData\Projects\2021\21-694\DesignStorm\FSR_No2\3.0_240806_Modified_Rational_Method_Calcs(A,B,C).xlsx|100-YR

Catchment I.D.	Storm Event	Area A (ha)	Runoff Coeff. C	Runoff Coeff. C _{MOD}	Time of Conc. T _c (min.)	Storm Time Step (min.)	Release Rate (m ³ /s)
A1A	100-year	0.52	0.74	0.93	10	5	0.106

Storm Duration t _d (min.)	Rainfall Intensity (mm/hr)	Runoff Peak Flow Rate (m ³ /s)	Runoff Volume (m ³)	Released Volume (m ³)	Storage Volume (m ³)	Max. Storage Required (m ³)
10	180.4	0.2411	144.65	63.60	81.05	
15	145.1	0.1938	174.46	79.50	94.96	
20	122.5	0.1637	196.45	95.40	101.05	
25	106.7	0.1426	213.92	111.30	102.62	102.6
30	95.0	0.1269	228.45	127.20	101.25	
35	85.9	0.1147	240.94	143.10	97.84	
40	78.6	0.1050	251.91	159.00	92.91	
45	72.5	0.0969	261.71	174.90	86.81	
50	67.5	0.0902	270.59	190.80	79.79	
55	63.2	0.0845	278.72	206.70	72.02	
60	59.5	0.0795	286.22	222.60	63.62	
65	56.3	0.0752	293.20	238.50	54.70	
70	53.4	0.0714	299.73	254.40	45.33	
75	50.9	0.0680	305.87	270.30	35.57	
80	48.6	0.0649	311.66	286.20	25.46	
85	46.5	0.0622	317.16	302.10	15.06	
90	44.7	0.0597	322.39	318.00	4.39	
95	43.0	0.0574	327.38	333.90	0.00	
100	41.4	0.0554	332.15	349.80	0.00	
105	40.0	0.0534	336.72	365.70	0.00	
110	38.7	0.0517	341.12	381.60	0.00	
115	37.5	0.0501	345.36	397.50	0.00	
120	36.3	0.0485	349.44	413.40	0.00	
125	35.3	0.0471	353.39	429.30	0.00	
130	34.3	0.0458	357.20	445.20	0.00	
135	33.3	0.0446	360.90	461.10	0.00	
140	32.5	0.0434	364.49	477.00	0.00	
145	31.7	0.0423	367.97	492.90	0.00	
150	30.9	0.0413	371.36	508.80	0.00	
155	30.2	0.0403	374.66	524.70	0.00	
160	29.5	0.0394	377.87	540.60	0.00	



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STORMWATER MANAGEMENT CALCULATIONS INFILTRATION TRENCH DESIGN

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street + 103-107 Napier Street

Prepared By: CJ

References: Ministry of the Environment (MOE), Stormwater Management Planning & Design Manual (2003) Section 4.5.6

Infiltration trenches are proposed on-site to provide quality control, water balance, and phosphorus control. The targetted retention volume is 25mm of rainfall from approximately half of the total building rooftop area.

Water Storage Volume:

$$\begin{array}{lcl} \text{Rooftop Area} & & 1400 \text{ m}^2 \\ \text{Rainfall Depth (RV)} & = & 25 \text{ mm} \end{array}$$

$$\begin{array}{lcl} \text{Required Water Storage Volume} & = & \frac{A \text{ (m}^2\text{)} \times \text{RV (mm)}}{1000} \text{ (m}^3\text{)} \\ & = & \frac{1400 \times 25}{1000} = 35.0 \text{ m}^3 \end{array}$$

$$\begin{array}{lcl} \text{Required Gross Infiltration Facility Volume} & = & \text{Required Storage/Voids Ratio of clear stone} \\ & = & \frac{35.0 \text{ m}^3}{0.4} \\ & = & 87.5 \text{ m}^3 \end{array}$$

From the Ministry of the Environment's (MOE) Stormwater Management Design Manual dated March 2003, Page 4-20, Equation 4.2 The maximum allowable soak-away pit/ infiltration trench depth is:

$$\begin{array}{lcl} D_{\max} & = & \frac{P \cdot T}{1000} \text{ where, } P = \text{percolation rate of surrounding native soil (mm/hr)} \\ & & t = \text{retention time (hr)} \\ & = & \frac{15 \text{ mm/hr} \times 48 \text{ hr}}{1000} \\ & = & 0.72 \text{ m} \\ \text{Provided Depth} & = & 0.50 \text{ m} \end{array}$$

Min. Bottom Area:

Based on the Ministry of the Environment's (MOE) Stormwater Management Design Manual dated March 2003, Page 4-26, Equation 4.3: Infiltration Bottom Area is:

Min. Required Bottom Area:

$$\begin{array}{lcl} A & = & \frac{1000 \cdot V}{P \cdot n \cdot t} \text{ where, } A = \text{bottom area (m}^2\text{)} \\ & & V = \text{runoff volume to be infiltrated (m}^3\text{)} \\ & & P = \text{percolation rate of surrounding native soil (mm/hr)} \\ & & n = \text{porosity of the storage media (0.4 for clear stone/1.0 for infiltration basins)} \\ & & t = \text{retention time (hr)} \\ & = & \frac{1000 \times 35}{15 \times 0.4 \times 48} = 121.5 \text{ m}^2 \\ \text{Provided Bottom Area} & = & 177.0 \text{ m}^2 \end{array}$$

Infiltration Facility Dimensions:

Total Length 177.0 m

$$\begin{array}{lcl} \text{Provided Volume:} & = & L \times W \times D \text{ m}^3 \times \text{Qty} \\ & = & 177.0 \text{ m} \times 1.00 \text{ m} \times 0.60 \text{ m} \\ & = & 106.20 \text{ m}^3 \end{array}$$

$$\begin{array}{lcl} \text{Provided Storage Volume (Voids):} & = & \text{Vol.} \times 0.4 \text{ (voids)} \\ & = & 42.5 \text{ m}^3 \end{array}$$

$$\text{Total Provided Infiltration Storage Volume:} = 42.5 \text{ m}^3$$

Notes: - Refer to the latest Hydrogeological Assessment Report for the infiltration rate which was estimated to range from 15mm/hr-60mm/hr, so 15mm/hr was used in the analysis.



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STORMWATER MANAGEMENT CALCULATIONS
EXFILTRATION TRENCH FEATURE DESIGN

Date: 06-Aug-24

Project No.: 21-694

Project: 95 Cook Street + 103-107 Napier Street

Prepared By: CJ

Purpose: Exfiltration trenches are proposed on-site to provide quantity control, runoff volume control and phosphorus reduction benefits. The exfiltration trenches are one aspect of the stormwater management controls for the development, with all controls to provide a minimum of 12.5mm of stormwater retention for the impervious areas.

Elements Requiring Input Information

$$\begin{aligned}\text{Provided Excavation Volume} &= L \times W \times D \quad \text{m}^3 \\ &= 73.7 \text{ m} \times 1.5 \text{ m} \times 0.35 \text{ m} \\ &= 38.7 \text{ m}^3 \\ \text{Provided Volume} &= 15.5 \text{ m}^3 \quad 40\% \text{ porosity of clear stone}\end{aligned}$$

Soil Cover:

Based on the Ministry of the Environment's (MOE) Stormwater Management Design Manual dated March 2003, Page 4-21, Figure 4.4: Soil Cover for Trenches (based on frost heave potential).

$$\text{Min. Soil Cover} = 0.5 \text{ m}$$



Project DEVELOPMENT Summary

DEVELOPMENT: 21-694 95 Cook Street + 103-107 Napier Street

Subwatershed: Barrie Creeks

Total Pre-Development Area (ha):	1.1	Total Pre-Development Phosphorus Load (kg/yr):	1.83
----------------------------------	------------	--	-------------

Pre-Development Land Use	Area (ha)	P coeff. (kg/ha)	P Load (kg/yr)
High Intensity - Comm/Industrial	0.76	1.82	1.38
High Intensity - Residential	0.34	1.32	0.45

POST-DEVELOPMENT LOAD

Post-Development Land Use	Area (ha)	P coeff. (kg/ha)	Best Management Practice applied with P Removal Efficiency	P Load (kg/yr)
High Intensity - Residential	0.05	1.32	NONE	0.07

Catchment A1B (0.05ha)

High Intensity - Residential	0.52	1.32	Treatment Train Approach	92%	0.05
------------------------------	------	------	--------------------------	-----	------

*Catchment A1A: Infiltration/Exfiltration system (87%), Underground Storage (25%) and ETV OGS (20%)
Located within internal road*

High Intensity - Residential	0.53	1.32	Soakaways - Infiltration trenches	60%	0.28
------------------------------	------	------	-----------------------------------	-----	------

Catchment A2: Half of rooftop drainage and rear yards directed to infiltration trenches.

Post-Development Area Altered:	1.10		P Load (kg/yr)
Total Pre-Development Area:	1.10		
Unaffected Area:	0		

Pre-Development: **1.83**
 Post-Development: **1.45**
 Change (Pre - Post): **0.38**

21% Net Reduction in Load

Post-Development (with BMPs): **0.40**
 Change (Pre - Post): **1.43**

78% Net Reduction in Load

DEVELOPMENT: 21-694 95 Cook Street + 103-107 Napier Street
Subwatershed: Barrie Creeks

CONSTRUCTION PHASE LOAD

SUMMARY WITH IMPLEMENTATION OF BMPs		P Load (kg/yr)
Pre-Development:		1.83
Construction Phase Amortized Over 8 Years :	to be determined	
Post-Development:		0.40
Post-Development + Amortized Construction:	to be determined	
Pre-Development Load - Post-Development Load:		1.43
Conclusion:	78% Reduction in Load	
Pre-Development Load - (Post-Development + Amortized Construction Load):		to be determined
Conclusion:	to be determined	
Based on a comparison of Pre-Development and Post-Development loads, and in consideration of Construction Phase loads, the Ministry would encourage the Municipality to:		

APPENDIX E

GEOTECHNICAL REPORT AND HYDROGEOLOGICAL ASSESSMENT



Preliminary Geotechnical Investigation Report

**103 & 107 Napier Street
& 95 Cook Street, Barrie,
Ontario**

December 14, 2022

Prepared for:
2556055 Ontario Inc.

Cambium Reference: 14079-001

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Peterborough | Barrie | Oshawa | Kingston



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1.0 Introduction

Cambium Inc. (Cambium) was retained by Innovative Planning Solutions Inc. (IPS) on behalf of 2556055 Ontario Inc. (Client) to complete a preliminary geotechnical investigation in support of a residential development at 103 & 107 Napier Street and 95 Cook Street, Barrie, Ontario (Site). Cambium understands that the proposed development consists of 35 townhouse units organized into six separate blocks with associated driveways, parking areas and utilities.

The purpose of the geotechnical investigation was to obtain information about the subsurface conditions to provide geotechnical design parameters as input into the design and construction of the proposed development. A Site Plan, including borehole locations, is included as Figure 1 of this report.

This report presents the methodology and findings of the geotechnical investigation to determine the subsurface soil and groundwater conditions and provide design recommendations. Based on the results of this investigation, the report provides geotechnical engineering recommendations pertaining to the proposed development including soil bearing capacity and foundation design, seismic site classification, excavation and dewatering, backfill and compaction, frost depth, sub-drainage, and pavement structure.

As part of Cambium's scope of work at the Site, a hydrogeological study report has been provided under a separate cover.



2.0 Site Description

The Site is located at the southeast of the corner of Cook Street and Napier Street in Barrie, Ontario. At the time of the investigation, the site was developed as two separate parcels which consisted of:

- 95 Cook Street: an existing church, with associated parking areas on the west side of the property and a cleared area on the southeast side of the property.
- 103 Napier Street: an existing dwelling with two sheds on the north side of the property and an open grassy area on the south side of the property.

Following completion of the investigation, an additional parcel was added to the development which consisted of:

- 107 Napier Street: an existing dwelling with one shed on the south side of the property.

The ground elevation at the site was relatively flat, and the site is bordered by Cook Street to the west and by residential lots on all other sides. According to a Geological Survey of Ontario's Quaternary Geology the site contains deposits of till, which has a sandy silt to silt matrix, often high in total matrix carbonate content, and commonly rich in clasts.



3.0 Methodology

3.1 Borehole Investigation

A borehole investigation was conducted at the site on December 8, 2021, to assess subsurface conditions. Four boreholes were advanced at the predetermined locations agreed with IPS. Three of the boreholes were outfitted with monitoring wells and are designated as MW101-21, MW102-21, and MW104-21. The fourth borehole was designated as BH103-21. The boreholes were located within or in the immediate vicinity of the footprints of different townhouse blocks and are shown on Figure 1.

All boreholes were terminated at depths ranging from 6.2 to 6.6 meters below ground surface (mbgs) in native soils. The elevation of each borehole was determined relative to a site benchmark, the top of the northeast corner of the wooden retaining wall on the north side of the existing church, which was surveyed by Rudy Mak Surveying LTD. and was found to have an elevation of 270.13 metres above sea level (masl).

Drilling and sampling was completed using a track-mounted drill rig operating under the supervision of a Cambium geotechnical analyst. The boreholes were advanced to the sampling depths by means of continuous flight solid stem augers with 50 mm O.D. split spoon samplers. Standard Penetration Test (SPT) N values were recorded for the sampled intervals as the number of blows required to drive a split spoon sampler 305 mm into the soil, using a 63.5 kg drop hammer falling 750 mm, as per ASTM D1586 procedures. The SPT N values are used in this report to assess consistency of cohesive soils and relative density of non-cohesive materials. Soil samples were collected at approximately 0.75 m intervals up to a depth of 3.0 mbgs and at 1.5 m intervals thereafter. The encountered soil units were logged in the field using visual and tactile methods, and samples were placed in labelled plastic bags for transport, future reference, possible laboratory testing, and storage. Open boreholes were checked for groundwater and general stability prior to backfilling. The boreholes and monitoring wells were backfilled in accordance with O.Reg. 903, as amended and the Site was restored to pre-investigation conditions.



The prepared borehole logs are provided in Appendix A. Site soil and groundwater conditions and our geotechnical recommendations are presented in the following sections of this report.

3.2 Laboratory Testing

Laboratory soil testing included four Particle Size Distribution Analyses (LS 702) and twenty-nine Natural Moisture Content Analyses (LS 701). Results are presented in Appendix B, summarized on the borehole logs and described in the subsequent sections of this report.



4.0 Subsurface Conditions

The detailed soil profiles encountered in the boreholes are shown on the attached borehole logs in Appendix A. Conditions indicated on the borehole logs are for specific locations only and can vary between and beyond the borehole locations. The soil boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones and should not be interpreted as exact planes of geological change. In addition, the descriptions provided on the borehole logs are inferred from a variety of factors, including visual observations of the soil samples retrieved, laboratory testing, measurements prior to and after drilling, and the drilling process itself (drilling speed, shaking/grinding of the augers, etc.).

Based on the results of the borehole investigation, subsurface conditions at the Site generally consist of topsoil overlying a sand fill and transitioning native sand to silt soils, which extended to the termination depths. Bedrock was not encountered during this geotechnical investigation. Assessments of organic matter content or other topsoil quality tests were beyond the scope of this study.

4.1 Topsoil

Topsoil with some organic content was encountered in three of the boreholes advanced throughout the site (MW101-21, MW102-21, and MW104-21). BH103-21 was advanced through the asphalt parking lot east of the existing church.

The topsoil consisted of a black silt with some sand and organics and was found to be up to 760 mm thick. At the time of the investigation the topsoil was found to be moist with a moisture content ranging from 21.8% to 22.9% based on laboratory analysis.

4.2 Fill Soils

Inferred fill soils were found underlying the topsoil in MW101-21 and beneath the asphalt in BH103-21. No soils identifiable as possible fill material were encountered within MW102-21 or MW104-21, which were advanced in grassy areas to the east and south of the parcel. Based



on a review of historic aerial imagery of the Site, no significant evidence of regrading or other development was found in the vicinity of MW102-21 and MW104-21.

The inferred fill soils consisted of a brown sand with some silt and trace organics in MW101-21 and a brown silt with some sand, and trace gravel in BH103-21. The fill soils ranged in thickness from 760 mm to 850 mm and extended to depths ranging from 0.9 mbgs to 1.5 mbgs. SPT N values for the fill ranged from 5 to 12 indicating a loose to compact relative density. The fill was found to be moist at the time of the investigation, with a natural moisture content ranging from 8.8% to 13.2%.

4.3 Sand to Silty Sand

Native sand to silty sand was encountered in all boreholes beginning at depths ranging from 0.8 mbgs to 1.5 mbgs. The sand to silty sand soils extended to the termination depths of all boreholes except MW102-21 and were found to contain varying amounts of gravel and clay. The sand to silty sand was found based on visual observations during drilling to range in moisture content from dry to wet at the time of the investigation, with a natural moisture content ranging from 1.3% to 14.2%.

SPT N values for the sand to silty sand soils ranged from 12 to 50 blows for 50 mm of penetration indicating a compact to very dense relative density. Below a depth of 1.5 mbgs, the SPT N values within this formation ranged from 33 to 50 blows, indicating a dense to very dense relative density below this depth.

A laboratory particle size distribution analysis was completed on two samples of this soil formation, taken from depths ranging from 1.5 mbgs to 3.5 mbgs in MW101-21 and MW104-21. The analysis results are provided in Appendix B and are summarized in Table 1 below based on the Unified Soil Classification System (USCS).

Table 1 Particle Size Distribution – Sand to Silty Sand

BH	Depth (mbgs)	Description	% Gravel	% Sand	% Silt	% Clay
MW101-21 SS3	1.5 – 2.0	Silty Sand trace Clay	0	70	27	3
MW104-21 SS5	3.0 – 3.5	Sand trace Silt trace Clay	0	88	9	3

4.4 Silt to Sandy Silt

A layer of silt was found underlying the native sand soils in MW102-21 and extended to the termination depth of 6.6 mbgs. The silt was found to contain some clay with traces of sand and gravel. The SPT N value for the silt was 50 indicating a dense relative density. The silt was found to be wet at the time of the investigation, with a natural moisture content of 17% based on laboratory testing.

In BH104-21, a layer of sandy silt with trace amounts of gravel and clay was encountered below the topsoil, between depths of approximately 0.8 mbgs and 1.5 mbgs. An SPT N value of 9 was recorded, which indicates a loose relative density. Based on the laboratory testing, this deposit was found to have a natural moisture content of 12.9%.

A laboratory particle size distribution analysis was completed on one sample of the silt soils taken from a depth of 6.0 mbgs m to 6.6 mbgs in MW102-21. The analysis results are provided in Appendix B and are summarized in Table 2.

Table 2 Particle Size Distribution – Silt to Sandy Silt

BH	Depth (mbgs)	Description	% Gravel	% Sand	% Silt	% Clay
MW102-21 SS7	6.1 – 6.6	Silt some Clay trace Sand trace Gravel	1	4	77	18

4.5 Clayey Silt

A layer of clayey silt was found embedded within the sand soils in BH103-21 at a depth of 2.3 mbgs, extending to approximately 3.0 mbgs. The clayey silt was found to contain some sand and trace gravel components.



The SPT N value for the clayey silt was 30 indicating a very stiff consistency. The clayey silt soil was found to be moist at the time of the investigation, with a natural moisture content of 16.8%.

A laboratory particle size distribution analysis was completed on one sample of the clayey silt soil taken from a depth of 2.3 mbgs to 2.7 mbgs in BH103-21. The analysis results are provided in Appendix B and are summarized in Table 3.

Table 3 Particle Size Distribution – Clayey Silt

BH	Depth (mbgs)	Description	% Gravel	% Sand	% Silt	% Clay
BH103-21 SS4	2.3 – 2.7	Clayey Silt some Sand trace Gravel	1	13	63	23

4.6 Bedrock

Bedrock was not encountered within the investigation depths. The termination depths of the boreholes ranged from 6.2 mbgs to 6.6 mbgs.

4.7 Groundwater

On drilling completion, unstabilized groundwater (free water) was not observed in any of the boreholes. BH103-21 was found to be open (no caving) upon completion. Monitoring wells were outfitted in boreholes MW101-21, MW102-21, and MW104-21 to monitor the static groundwater level and any seepage/upsurge after installation. The groundwater was measured and recorded in each monitoring well on December 20, 2021. The groundwater observations are summarized in Table 4.

The moisture content of the soils generally ranged from 1.3% to 22.9%, however, high moisture content readings in MW101-21, MW102-21, and MW104-21 are likely a result of organic material present in the topsoil layer. It should be noted that soil moisture and groundwater levels at the Site may fluctuate seasonally and in response to climatic events.



Table 4 Groundwater Observations

Well		MW101-21	MW102-21	MW104-21
Top of Pipe Elevation ²		271.34	270.03	269.13
Ground Surface Elevation ²		270.36	269.08	268.17
Stick-up (m)		0.98	0.95	0.96
December 20, 2021	Water Level ¹	Dry	5.40	5.19
	Groundwater Elevation ²	-	263.68	262.98
January 27, 2022	Water Level ¹	Dry	5.75	5.27
	Groundwater Elevation ²	-	263.33	262.93
February 18, 2022	Water Level ¹	Dry	5.93	5.24
	Groundwater Elevation ²	-	263.15	262.93
March 21, 2022	Water Level ¹	Dry	5.77	5.22
	Groundwater Elevation ²	-	263.15	262.95
April 21, 2022	Water Level ¹	Dry	5.58	5.19
	Groundwater Elevation ²	-	263.50	262.98
May 16, 2022	Water Level ¹	Dry	5.63	5.12
	Groundwater Elevation ²	-	263.45	263.05
June 17, 2022	Water Level ¹	Dry	5.85	5.21
	Groundwater Elevation ²	-	263.22	262.96
August 8, 2022	Water Level ¹	Dry	5.95	5.26
	Groundwater Elevation ²	-	263.13	262.91
September 14, 2022	Water Level ¹	Dry	6.04	5.35
	Groundwater Elevation ²	-	263.04	262.82
October 19, 2022	Water Level ¹	Dry	Dry	5.43
	Groundwater Elevation ²	-	-	262.74
Notes ¹ Water Levels recorded in m below ground surface (mbgs) ² Elevations provided in m above sea level (masl)				

4.8 Percolation Time and Hydraulic Conductivity

The particle distribution tests (hydrometer analyses) results were used to identify the percolation time T (min/cm) and hydraulic conductivity k_{fs} (m/sec). To determine the percolation time, the soil was classified according to the USCS, and the T Time was



interpolated based on the USCS gradation charts for the particle size distribution tests as shown in Appendix B. Where applicable, the hydraulic conductivity values were calculated with Puckett's method for fine grained soil and Hazen's formula for granular soil. The estimated percolation time and hydraulic conductivity rates are provided in Table 5.

Table 5 Percolation Times and Hydraulic Conductivity

Borehole/Sample	Sample Depth (mbgs)	Percolation Time (min/cm)	Hydraulic Conductivity (m/s)
MW101-21-SS3	1.5 – 2.0	18	7.8×10^{-4}
MW102-21-SS7	6.1 – 6.6	40	1.2×10^{-6}
BH103-21-SS4	2.3 – 2.7	45	4.6×10^{-7}
MW104-21-SS5	3.0 – 3.5	10	2.0×10^{-3}



5.0 Geotechnical Design Considerations

The following recommendations are based on borehole information and are intended to assist designers. Recommendations should not be construed as providing instructions to contractors, who should form their own opinions about site conditions. It is possible that subsurface conditions beyond the borehole locations may vary from those observed. If significant variations are found before or during construction, Cambium should be contacted so that we can reassess our findings, if necessary.

5.1 Site Preparation

Any topsoil and other disturbed material encountered should be excavated and removed beneath any areas of the Site to be developed; additionally, this material should be excavated and removed to a minimum distance of 3 m around building footprints. Any topsoil and materials with significant quantities of organics and deleterious materials (i.e., construction debris, etc.) are not appropriate for use as fill.

The exposed subgrades should be proof-rolled and inspected by a qualified geotechnical engineer prior to placement of any granular fill. Any loose/soft soils identified at the time of proof-rolling that are unable to uniformly be compacted should be sub-excavated and removed. The excavations created through the removal of these materials should be backfilled with approved engineered fill consistent with the recommendations provided below.

The near surface sand to sandy silt soils can become unstable if they are wet or saturated. Such conditions are common in the spring and late fall. Under these conditions, temporary use of granular fill, and possible reinforcing geotextiles, may be required to prevent severe rutting on construction access routes.

5.2 Frost Penetration

Based on climate data and design charts, the maximum frost penetration depth below the surface at the site is estimated at 1.5 mbgs.



Exterior footings for the proposed structures should be situated at or below this depth for frost penetration or should be appropriately protected.

It is assumed that the pavement structure thickness will be less than 1.5 m, so grading and drainage are important for good pavement performance and life expectancy. Any services should be located below this depth or be appropriately insulated.

5.3 Excavations

The following recommendations for required excavations apply to subgrade elevation depths from 1.5 mbgs (frost penetration depth) to 3.0 mbgs (approximate excavation depth where basements are constructed or for public utility tie ins).

If greater excavation depths are planned, Cambium should be contacted to review and adjust these recommendations, if necessary.

All excavations must be carried out in accordance with the latest edition of the Occupational Health and Safety Act (OHSA). The soils encountered throughout the borehole investigation may generally be classified as Type 3 soils above the groundwater table. Below the groundwater table, the native soils found at site should be classified as Type 4 soils. Type 3 soils may be excavated with side slopes no steeper than 1H:1V, and Type 4 soils may be excavated with side slopes no steeper than 3H:1V.

The groundwater levels measured in the monitoring wells are provided in Table 4. Based on these observations, it is unlikely that free groundwater will be encountered to the excavation depths stated above. Seepage of perched groundwater or any precipitation, run-off or meltwater contained within upper soil layers into the excavation is possible.

Excavation side slopes should be protected from exposure to precipitation and associated ground surface runoff and should be inspected regularly for signs of instability. If localized instability is noted during excavation or if wet conditions are encountered, the side slopes should be flattened as required to maintain safe working conditions.

The planning of excavation works, and related design should consider existing residential developments surrounding the site. In areas bordering neighbouring properties with structures



sensitive to settlement (houses, pools, etc.), for example along the east side of the parcel, the use of vertical shoring methods should be considered (for example, soldier piles and lagging) to reduce settlements. The shoring including any necessary bracing must be designed by a qualified geotechnical engineer.

5.4 Dewatering

Based on the assumed excavation depths described in Section 5.3, the excavations may not encounter groundwater. However, some groundwater seepage may generally be expected due to climatic conditions (precipitation, runoff, etc.).

Groundwater seepage into the excavation, if encountered, should be controllable with filtered sumps and pumps and a Permit to Take Water (PTTW) from the Ministry of the Environment, Conservation and Parks (MECP) will not be required.

It is noted that the elevation of the groundwater table will vary due to seasonal conditions and in response to heavy precipitation events. Consideration should be given to measuring the monitoring wells over the spring months to estimate the seasonal high groundwater elevations.

5.5 Foundation Design

Design and construction recommendations for potential foundation systems are outlined below. It is understood that the site may be regraded, and our foundation recommendations may change depending upon the final grades. Cambium should be contacted to review the final grading plan and provide any necessary changes to our foundation recommendations.

It is noted that the foundation recommendations have been developed based on the proposed design and construction of residential development. If additional structures are to be constructed at the site in different locations, Cambium should be contacted for further foundation recommendations. Two foundation options are recommended for this site, including:

- Shallow foundations on undisturbed native cohesionless soils; or
- Shallow foundations on engineered fill

All footings must be provided with at least 1.5 m of earth cover or equivalent insulation for frost protection. Footings stepped from one level to another must be at a slope not exceeding 10H:7V.

5.5.1 Foundations on Native Soil

The structures may be supported on standard strip and spread footings placed at or below frost depth (1.5 m or below). Foundations constructed on undisturbed native soil may be designed using the allowable bearing capacity at serviceability limit state (SLS) and ultimate limit state (ULS) summarized in Table 6.

Table 6 Bearing Capacities – Shallow Foundations on Native Soils

Borehole	Depth (mbgs)	Elevation (masl)	Maximum Geotechnical Reaction SLS (kPa)	Maximum Geotechnical Reaction ULS (kPa)
BH101-21	Below 1.5	Below 268.8	200	250
BH102-21	Below 0.8	Below 268.2	200	250
BH103-21	0.8 – 1.5	268.4 – 267.6	100	140
	Below 1.5	Below 267.6	200	250
BH104-21	0.8 – 1.5	267.4 – 266.6	100	140
	Below 1.5	Below 266.6	200	250

Note: The bearing capacities given in this Table assume that foundations are embedded to the frost penetration depth in native soils. If the foundation overburden is increased using imported fill, Cambium may be contacted to adjust these bearing capacities according to actual regrading plans.

Settlement potential at the above-noted SLS loadings is less than 25 mm and differential settlement should be less than 10 mm.

The quality of the subgrade should be inspected by Cambium during construction, prior to constructing the footings, to confirm bearing capacity estimates.

The bearing capacities provided in Table 6 are applicable for foundations constructed on undisturbed native soils, which were encountered between 0.8 and 1.5 mbgs. If the grade is raised prior to foundation construction, the foundations must extend to the native soils and be designed per the estimated bearing capacity values provided in Table 6.



Fill was encountered in some boreholes and the depth was found to range between 0.8 to 1.5 mbgs. It is noted that due to the variation in thickness of the earth fill across the site, there may be other areas where the earth fill is deeper than 1.5 mbgs.

5.5.2 Foundations on Engineered Fill

Engineered fill should be placed and constructed as outlined in Section 5.6.1.

Foundations placed on approved engineered fill at a depth at least 1.5 m below final grade, with a minimum fill thickness of 1 m between subgrade/base of foundation and subgrade of imported fill, may be designed using a bearing capacity of 150 kPa at SLS and 200 kPa ULS.

Post-construction settlement will occur following the placement of engineered fill and is estimated to be in the order of 1% of the height of the placed fill. Generally, if granular soil is placed as engineered fill, the settlement will occur within ± 4 weeks. Foundations for structures should not be constructed until post-construction settlement has been completed.

5.6 Backfill and Compaction

Excavated topsoil from the Site is not appropriate for use as fill below grading areas.

Excavated sand soils not containing organics or significant deposits of clay may be appropriate for use as fill below grading areas, provided that the actual or adjusted moisture content at the time of construction is within a range that permits compaction to required densities. Some moisture content adjustments may be required depending upon seasonal conditions.

Foundation wall and any buried utility backfill material should consist of free-draining imported granular material. Typically, backfill should be placed in maximum 300 mm thick lifts and should be compacted to a minimum of 98% of Standard Proctor Maximum Dry Density (SPMDD). Backfill adjacent to the structural elements (i.e., foundation walls) should be compacted to 95% of SPMDD taking care not to damage the adjacent structures. The backfill material in the upper 300 mm below the pavement subgrade elevation should be compacted to 100% of SPMDD in all areas.

All existing vegetation, topsoil, organic and non-organic fills, and any loose soils shall be removed down to a competent base. Backfill areas must be approved by a qualified geotechnical engineer prior to placement of any new fill, to ensure the suitability of subgrade conditions.

5.6.1 Engineered Fill

When the fill is treated as an engineered fill to support structural elements such as foundations and / or floor slabs the following is recommended for the construction of engineered fill:

- I. Remove any and all existing vegetation, surficial topsoil / organics, organic fills or fills and any loose soils to a competent subgrade for a suitable envelope.
- II. The area of the engineered fill should extend horizontally 1 m beyond the outside edge of the foundations then extend downward at a 1H:1V slope to the competent approved native soil.
- III. The subgrade or base of the engineered fill area must be approved by Cambium prior to placement of any new fill, to ensure that suitability of subgrade condition.
- IV. Place approved OPSS 1010.MUNI SSM or Granular 'B' Type I material at a moisture content at or near optimum moisture in suitable maximum 200 mm thick lifts, compacted to 100% of SPMDD. If native soils from the site are not used as engineered fill, imported material for engineered fill should consist of clean, non-organic soils, free of chemical contamination or deleterious material. Any frost penetration into the fill material must be removed prior to placement of subsequent lifts of fill and reviewed by Cambium.
- V. The moisture content of the engineered fill will need to be close enough to optimum at the time of placement to allow for adequate compaction.
- VI. Full time testing and inspection of the engineered fill will be required for it to be used as a founding material, as outlined in Section 4.2.2.2 of the Ontario Building Code.
- VII. To account for varying founding soils, the footings and foundation walls should be suitably reinforced to mitigate potential settlement cracking.

5.7 Subdrains

Provisions should be made for draining the basement wall backfill to prevent buildup of hydrostatic pressures; this could consist of geotextile-wrapped perforated plastic sub-drains covered on all sides by 19 mm crushed clear stone around the perimeter of the foundation appropriately sloped and drained to the stormwater management system or other suitable positive frost-free outlet. It is recommended the basement floor slab is constructed at least 500 mm above the seasonal high groundwater table.

5.8 Seismic Site Classification

The Ontario Building Code (OBC) specifies that the structures should be designed to withstand forces due to earthquakes. For the purpose of earthquake design, geotechnical information shall be used to determine the “Site Class”. The parameters for determination of Site Classification for Seismic Site Response are set out in Table 4.1.8.4A of the OBC (2012). The classification is based on the determination of the average shear wave velocity in the top 30 metres of the site stratigraphy, where shear wave velocity (v_s) measurements have been taken. Alternatively, the classification is estimated on the basis of rational analysis of undrained shear strength (s_u) or penetration resistances (N_{60} values). Based on the explored soil properties and in accordance with Table 4.1.8.4.A, it is recommended that Site Class “D” (stiff soil) be applied for structural design at the Site.

Peak ground acceleration and spectral acceleration (period of 0.2 seconds) for the site are calculated to be 0.063g and 0.108g respectively using the 2015 National Building Code Seismic Hazard Calculation. A detailed report of the calculation and its results can be found in Appendix C.

5.9 Lateral Earth Pressure

Lateral earth pressure coefficients (K) are shown along with soil mechanical parameters that may be used for the geotechnical design of temporary and permanent structures in Table 7. The coefficients provided assume that the surface of the granular backfill is horizontal against any proposed building, and the wall is vertical and smooth. Cambium should be contacted to

provide updated lateral earth pressure coefficients should the assumptions differ to those noted and if the soil is to be sloped at an angle behind the retaining wall.

Table 7 Unfactored Soil Parameters

Soil	Bulk Unit Weight γ [kN/m ³]	Internal Friction Angle Φ' [°]	Cohesion c' [kPa]	Active earth pressure coefficient K_a [-]	Passive earth pressure coefficient K_p [-]	At-rest earth pressure coefficient K_o [-]
Sand to Silty Sand <i>compact to very dense</i>	19.5	32.5	0	0.30	3.32	0.46
Silt, Sandy Silt, Clayey Silt <i>stiff to hard</i>	19	27.5	5	0.37	2.72	0.54
Engineered Fill (i.e. OPSS Granular B)	20	33	0	0.30	3.35	0.46

Walls subject to unbalanced earth pressures must be designed to resist a pressure that can be calculated based on the following equation:

$$P = K[\gamma(h - h_w) + \gamma' h_w + q] + \gamma_w h_w$$

- Where,
- P = the horizontal pressure at depth, h (m)
 - K = the earth pressure coefficient
 - h_w = the depth below the ground water level (m)
 - γ = the bulk unit weight of soil, (kN/m³)
 - γ' = the submerged unit weight of the exterior soil, ($\gamma_{sat} - \gamma_w$, with $\gamma_w = 10$ kN/m³)
 - q = the complete surcharge loading (kPa)

The wall backfill must be drained effectively to eliminate hydrostatic pressures on the wall that would otherwise act in conjunction with the earth pressure. In this case, the above equation is simplified to:

$$P = K[\gamma h + q]$$

The factored geotechnical resistance to sliding of foundation elements is developed by friction between the base of the footing and the soil. This friction (R) depends on the normal load at the soil contact (N) and the frictional resistance of the soil ($\tan \phi$) expressed as $R_f = N \tan \phi$, which is the unfactored resistance. The factored geotechnical resistance at ULS is $R_f = 0.8 N \tan \phi$.

5.10 Slabs-on-grade

Inorganic native soils at the Site are considered competent to support floor slab loads. To create a stable working surface and to distribute loadings, all slabs-on-grade should be constructed on a minimum of 200 mm of OPSS 1010 Granular A compacted to 98% of SPMDD. For basement floor slabs, consideration should be given to using a 200 mm thick layer of 19 mm diameter clear crushed stone connected to perimeter drains below the floor slab to assist with drainage.

5.11 Pavement Design

The performance of the pavement is dependent upon proper subgrade preparation. All topsoil and organic materials should be removed down to native material and backfilled with approved engineered fill or native material, compacted to 95% of SPMDD. The backfill material in the upper 300 mm below the pavement subgrade elevation should be compacted to 100% of SPMDD in all areas. The subgrade should be proof rolled and inspected by a geotechnical engineer. Any areas where rutting or appreciable deflection is noted should be sub-excavated and replaced with suitable fill. The fill should be compacted to at least 100% of SPMDD.

The recommended minimum pavement structure design has been developed for two traffic loading scenarios; light duty and heavy duty. The heavy-duty design is appropriate for areas where heavy traffic is anticipated and meets the City of Barrie's minimum pavement requirements for a residential local road, while the light duty design is appropriate for areas where light traffic is anticipated. The recommended minimum pavement structure is provided in Table 8.



Table 8 Recommended Minimum Pavement Structure

Pavement Layer	Light Duty	Heavy Duty
Surface Course Asphalt	40 mm HL3 or HL4	40 mm HL3 or HL4
Binder Course Asphalt	50 mm HL8	70 mm HL8
Granular Base	150 mm OPSS 1010 Granular A	150 mm OPSS 1010 Granular A
Granular Subbase	300 mm OPSS 1010 Granular B	450 mm OPSS 1010 Granular B

Material and thickness substitutions must be approved by the Design Engineer.

The thickness of the subbase layer could be increased at the discretion of the Engineer, to accommodate site conditions at the time of construction, including soft or weak subgrade soil replacement.

Compaction of the subgrade should be verified by the Engineer prior to placing the granular fill. Granular layers should be placed in 150 mm maximum loose lifts and compacted to at least 100% of SPMDD. The granular materials specified should conform to OPSS standards, as confirmed by appropriate materials testing.

The final asphalt surface should be sloped at a minimum of 2% to shed runoff. Abutting pavements should be sawcut to provide clean vertical joints with new pavement areas.

5.12 Buried Utilities

Trench excavations should generally consider Type 3 soil conditions which can be excavated with unsupported side slopes no steeper than 1H:1V.

Bedding and cover material for any services should consist of OPSS 1010-3 Granular A or B Type II, placed in accordance with pertinent Ontario Provincial Standard Drawings (OPSD 802.010). The bedding and cover material shall be placed in maximum 200 mm thick lifts and should be compacted to at least 95% of SPMDD.

The cover material shall be a minimum of 300 mm over the top of the pipe and compacted to 95% of SPMDD, taking care not to damage the utility pipes during compaction.



5.13 Design Review and Inspections

Testing and inspections should be carried out during construction operations to test concrete and to examine and approve subgrade conditions, placement and compaction of fill materials, granular base courses, and asphaltic concrete.

Cambium should be contacted to review and approve design drawings, prior to tendering or commencing construction, to ensure that all pertinent geotechnical-related factors have been addressed. It is important that onsite geotechnical supervision be provided at this site for excavation and backfill procedures, deleterious soil removal, subgrade inspections and compaction testing.

5.13.1 Inspections and Testing

Testing and inspections should be carried out during construction operations to examine and approve subgrade conditions and placement and compaction of fill materials. Cambium should be contacted to review and approve design drawings prior to commencing construction to ensure that all pertinent geotechnical-related factors have been addressed.



6.0 Closing

Please note that this work program and report are governed by the attached Qualifications and Limitations. If you have questions or comments regarding this document, please do not hesitate to contact the undersigned at (705) 719-0700.

Respectfully submitted,

Cambium Inc.

Josef Schweighofer, B.Sc., M.Sc.
Project Coordinator - Geotechnical

Rob Gethin, P.Eng.
Group Manager – Geotechnical



RG/js/bw



7.0 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.

Facts, conditions, information and circumstances may vary with time and locations and Cambium's work is based on a review of such matters as they existed at the particular time and location indicated in its reports. No assurance is made by Cambium that the facts, conditions, information, circumstances or any underlying assumptions made by Cambium in connection with the work performed will not change after the work is completed and a report is submitted. If any such changes occur or additional information is obtained, Cambium should be advised and requested to consider if the changes or additional information affect its findings or results.

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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.

Only conditions at the site and locations chosen for study by the client are evaluated; no adjacent or other properties are evaluated unless specifically requested by the client. Any physical or other aspects of the site chosen for study by the client, or any other matter not specifically addressed in a report prepared by Cambium, are beyond the scope of the work performed by Cambium and such matters have not been investigated or addressed.

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Limitation of Liability

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Personal Liability

The client expressly agrees that Cambium employees shall have no personal liability to the client with respect to a claim, whether in contract, tort and/or other cause of action in law. Furthermore, the client agrees that it will bring no proceedings nor take any action in any court of law against Cambium employees in their personal capacity.



Appended Figures

**GEOTECHNICAL
INVESTIGATION**
103 Napier Street and 95 Cook Street
Barrie, Ontario

LEGEND

- Borehole
- Monitoring Well

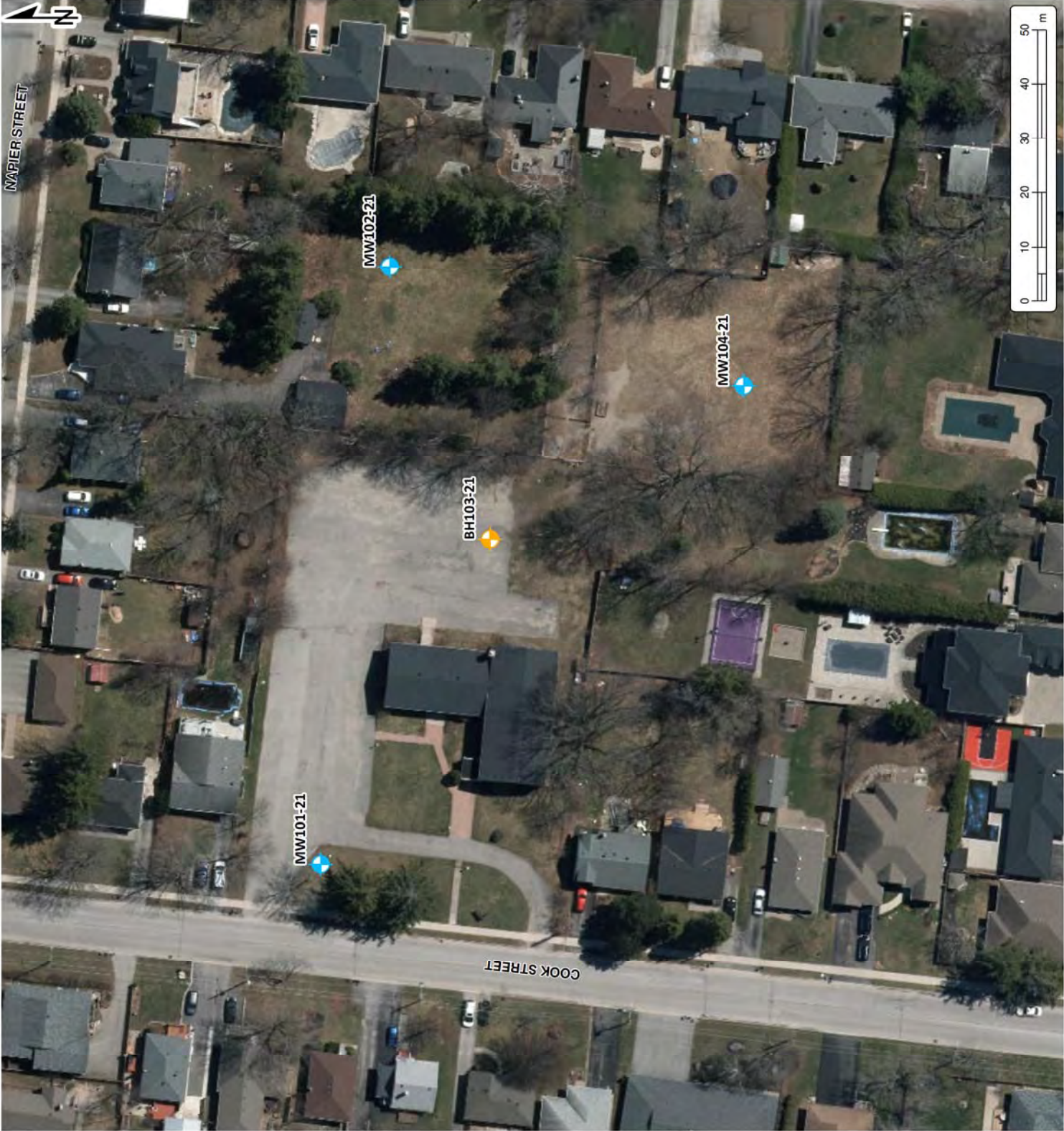
Notes:
Base mapping features are © Queen's Printer of Ontario, 2015 (this does not constitute an endorsement by the Ministry of Natural Resources or the Ontario Government).
Distances on this plan are in metres and can be converted to feet by multiplying by 1.0936.
Cambium Inc. makes every effort to 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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SITE LOCATION MAP

Project No.:	14079-001	Date:	December 2021
Scale:	1:1,000	Projection:	NAD 1983 UTM Zone 17N
Created by:	TLC	Checked by:	RG
Figure:	1		





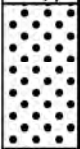
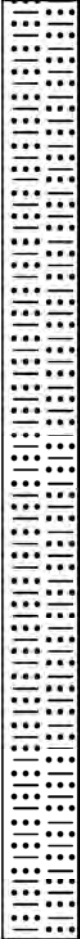
Appendix A

Borehole Logs



Client: Innovative Planning Solutions
Contractor: Landshark Drilling
Location: 95 Cook Street, Barrie, Ontario

Project Name: 103 Napier Street and 95 Cook Street, Barrie, ON
Method: Hollow Stem Auger
UTM: 17T: 4916983 m north, 605915 m east
Project No.: 14079-001
Date Completed: December 8, 2021
Elevation: 270.36 mASL

SUBSURFACE PROFILE				SAMPLE													
Elevation (m)	Depth	Lithology	Description	Number	Type	% Recovery	SPT (N)	% Moisture			SPT (N)		Well Installation	Remarks			
								25	50	75	10	20	30	40			
270	0		Topsoil: Black silt, some sand, some organics, loose, moist [TOPSOIL]	1	SS	40	4								Monument Cap	Top of Pipe (TOP) elevation: 271.34 mASL Well dry when measured on December 20, 2021	
269	1		Sand: Brown sand, some silt, trace organics, loose, moist [FILL]	2	SS	80	7								Bentonite Plug PVC Standpipe	GSA SS3: 0% Gravel 70% Sand 27% Silt 3% Clay	
268	2		Silty Sand: Brown silty sand, trace clay, very dense, dry	3	SS	60	50/280 mm										
267	3			4	SS	60	50/280 mm										
266	4			5	SS	60	50/230 mm										
265	5			6	SS	70	50/280 mm										
264	6		-more silt, moist	7	SS	70	50/205 mm										
263	7		Borehole terminated at 6.5 mbgs in silty sand due to target depth														

Monument
Cap

Bentonite Plug
PVC Standpipe

Sand Pack
PVC Screen

Cap

Top of Pipe (TOP) elevation: 271.34 mASL Well dry when measured on December 20, 2021

GSA SS3:
0% Gravel
70% Sand
27% Silt
3% Clay



MW102-21

Project No.: 14079-001

Date Completed: December 8, 2021

Elevation: 269.08 mASL

Input By: BW



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Log of Borehole:

BH103-21

Page 1 of 1

Client: Innovative Planning Solutions
Contractor: Landshark Drilling
Location: 95 Cook Street, Barrie, Ontario

Project Name: 103 Napier Street and 95 Cook Street, Barrie, ON
Method: Hollow Stem Auger
UTM: 17T: 4916952 m north, 605975 m east
Project No.: 14079-001
Date Completed: December 8, 2021
Elevation: 269.30 mASL

SUBSURFACE PROFILE				SAMPLE												
Elevation (m)	Depth	Lithology	Description	Number	Type	% Recovery	SPT (N)	% Moisture			SPT (N)				Well Installation	Remarks
								25	50	75	10	20	30	40		
0			Asphalt: Asphalt thickness: 50 mm													Borehole open and dry upon completion
269			Silt: Brown silt, some sand, trace gravel, loose, moist [FILL]	1	SS	60	5									
			-compact	2A												
1			Silty Sand: Brown silty sand, trace gravel, compact, moist	2B	SS	80	12									
268			Sand: Brown sand, some gravel, trace silt, dense, dry	3	SS	70	49									
2			Clayey Silt: Brown clayey silt, some sand, trace gravel, very stiff, moist	4	SS	90	30									
267			Sand: Brown sand, trace gravel, trace silt, very dense, dry	5	SS	70	50/205 mm									
266																
4																
265																
5				6	SS	0	50/50 mm									
264																
6																
263			-grey, more gravel	7	SS	20	50/100 mm									broken cobbles in spoon
7			Borehole terminated at 6.2 mbgs in sand due to target depth achieved.													

Borehole open and dry upon completion

GSA SS4:
1% Gravel
13% Sand
63% Silt
23% Clay

broken cobbles in spoon

Logged By: BW

Input By: BW



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Log of Borehole:

MW104-21

Page 1 of 1

Client: Innovative Planning Solutions
Contractor: Landshark Drilling
Location: 95 Cook Street, Barrie, Ontario

Project Name: 103 Napier Street and 95 Cook Street, Barrie, ON
Method: Hollow Stem Auger
UTM: 17T: 4916905 m north, 606003 m east
Project No.: 14079-001
Date Completed: December 8, 2021
Elevation: 268.17 mASL

SUBSURFACE PROFILE				SAMPLE												
Elevation (m)	Depth	Lithology	Description	Number	Type	% Recovery	SPT (N)	% Moisture			SPT (N)				Well Installation	Remarks
								25	50	75	10	20	30	40		
268	0		Topsoil: Black silt, some sand, some organics, loose, moist [TOPSOIL]	1	SS	20	7									Top of Pipe (TOP) elevation: 269.13 mASL Groundwater measured at 5.19 mbgs (262.98 mASL) on December 20, 2021
267	1		Sandy Silt: Brown sandy silt, trace organics, trace gravel, trace clay, loose, wet	2	SS	70	9									
266	2		Sand: Brown sand, trace silt, trace clay, dense, wet	3	SS	50	33									
				4	SS	60	37									
265	3			5	SS	70	50									GSA SS5: 0% Gravel 88% Sand 8% Silt 3% Clay
264	4															
			-very dense	6	SS	60	50/255 mm									
263	5															
262	6		-saturated	7	SS	90	50/180 mm									
	7		Borehole terminated at 6.4 mbgs in sand due to target depth achieved.													

Logged By: BW

Input By: BW



Appendix B

Physical Laboratory Testing Results

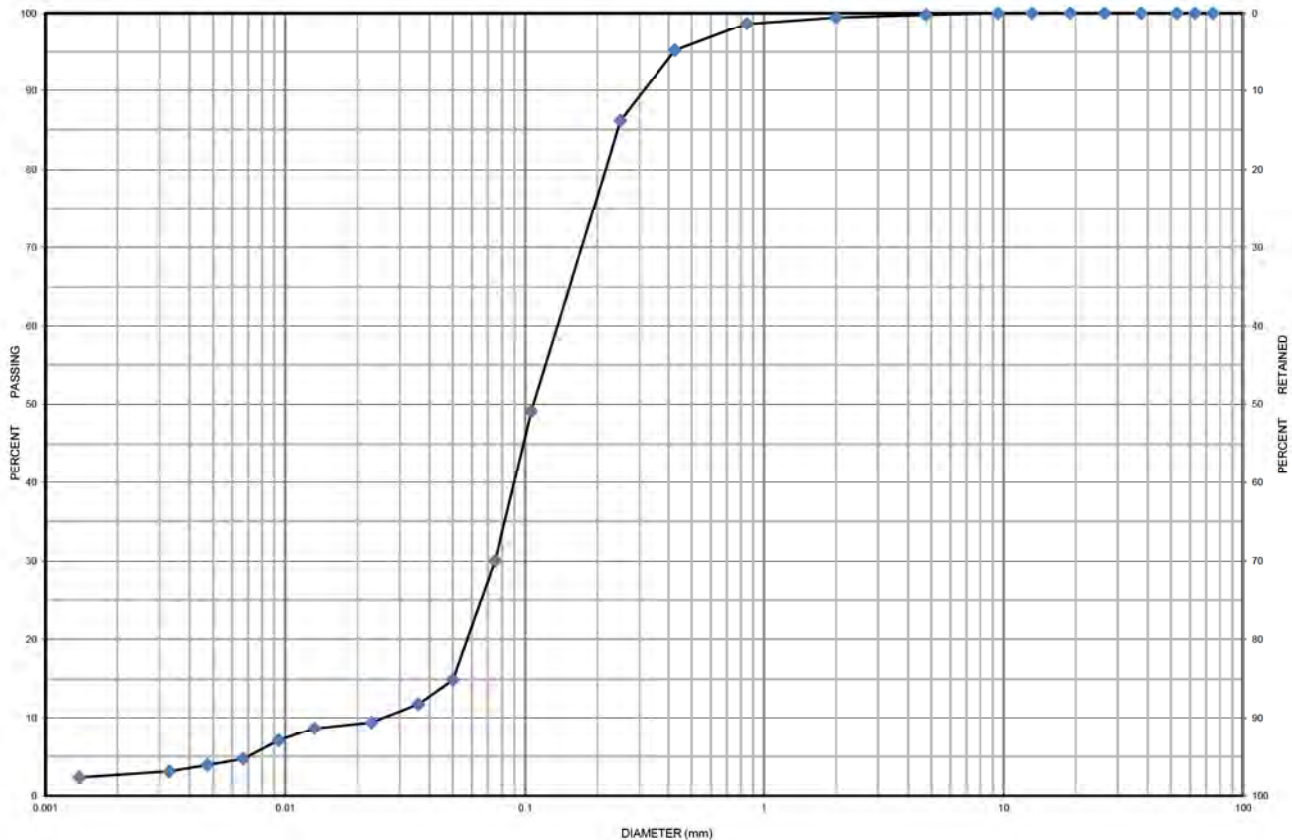


Grain Size Distribution Chart

Project Number: 14079-001 Client: Innovative Planning Solutions
Project Name: 103 Napier St. & 95 Cook St., Barrie
Sample Date: December 8, 2021 Sampled By: Ben White - Cambium Inc.
Location: BH 101-21 SS 3 Depth: 1.5 m to 2 m Lab Sample No: S-21-1686

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM

MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDERS
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 101-21	SS 3	1.5 m to 2 m	0	70	27	3	6.6
Description		Classification	D ₆₀	D ₃₀	D ₁₀	C _u	C _c
Silty Sand trace Clay		SM	0.145	0.075	0.026	5.58	1.49

Additional information available upon request

Issued By: 
(Senior Project Manager)

Date Issued: December 16, 2021

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Form: L6V.2 - Grad.Hydo

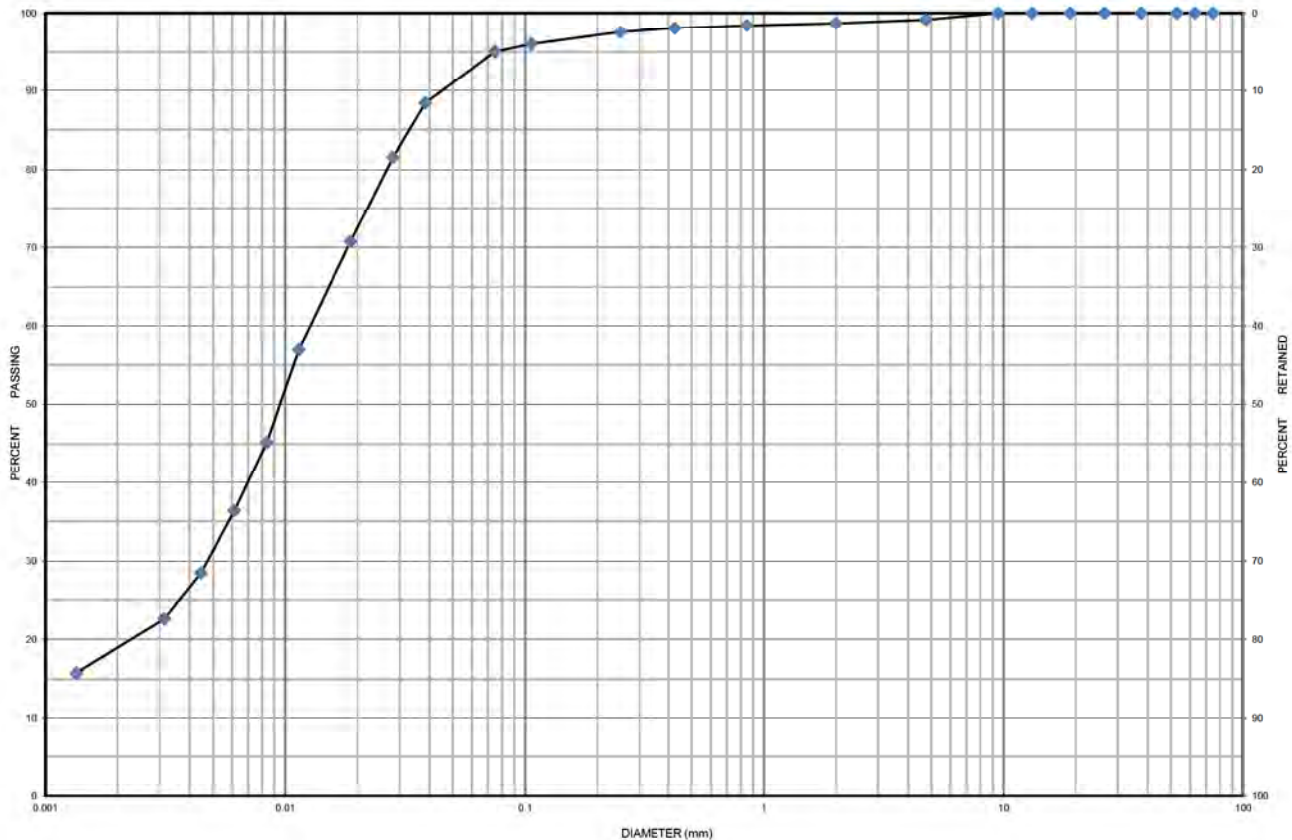


Grain Size Distribution Chart

Project Number: 14079-001 **Client:** Innovative Planning Solutions
Project Name: 103 Napier St. & 95 Cook St., Barrie
Sample Date: December 8, 2021 **Sampled By:** Ben White - Cambium Inc.
Location: BH 102-21 SS 7 **Depth:** 6.1 m to 6.6 m **Lab Sample No:** S-21-1687

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM

MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDERS
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 102-21	SS 7	6.1 m to 6.6 m	1	4	77	18	17.0
Description		Classification	D ₆₀	D ₃₀	D ₁₀	C _u	C _c
Silt some Clay trace Sand trace Gravel		ML	0.0140	0.0047	-	-	-

Additional information available upon request

Issued By: 
(Senior Project Manager)

Date Issued: December 16, 2021

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Form: L6V.2 - Grad.Hydo

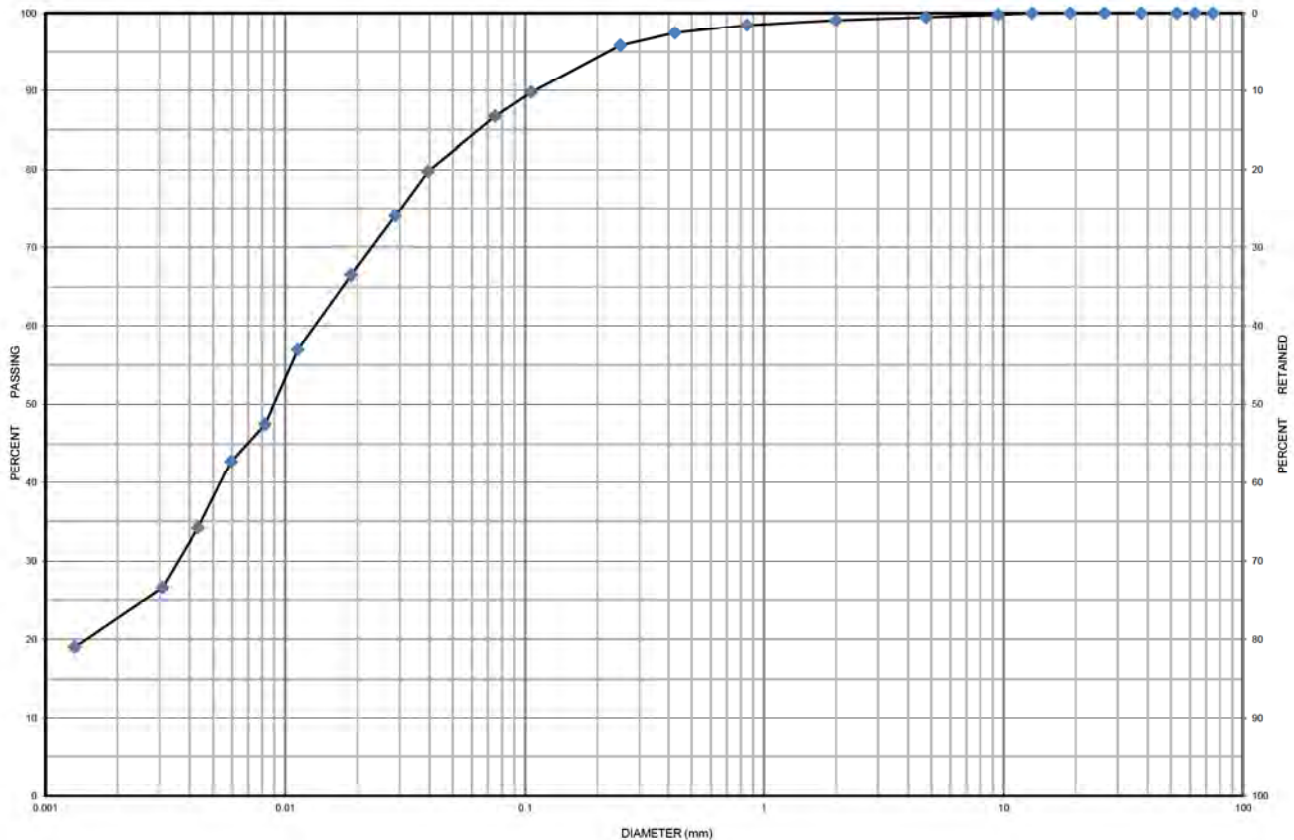


Grain Size Distribution Chart

Project Number: 14079-001 Client: Innovative Planning Solutions
Project Name: 103 Napier St. & 95 Cook St., Barrie
Sample Date: December 8, 2021 Sampled By: Ben White - Cambium Inc.
Location: BH 103-21 SS 4 Depth: 2.3 m to 2.7 m Lab Sample No: S-21-1688

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM

MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDERS
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 103-21	SS 4	2.3 m to 2.7 m	1	13	63	23	16.8
Description		Classification	D ₆₀	D ₃₀	D ₁₀	C _u	C _c
Clayey Silt some Sand trace Gravel		ML	0.0140	0.0036	-	-	-

Additional information available upon request

Issued By: 
(Senior Project Manager)

Date Issued: December 16, 2021

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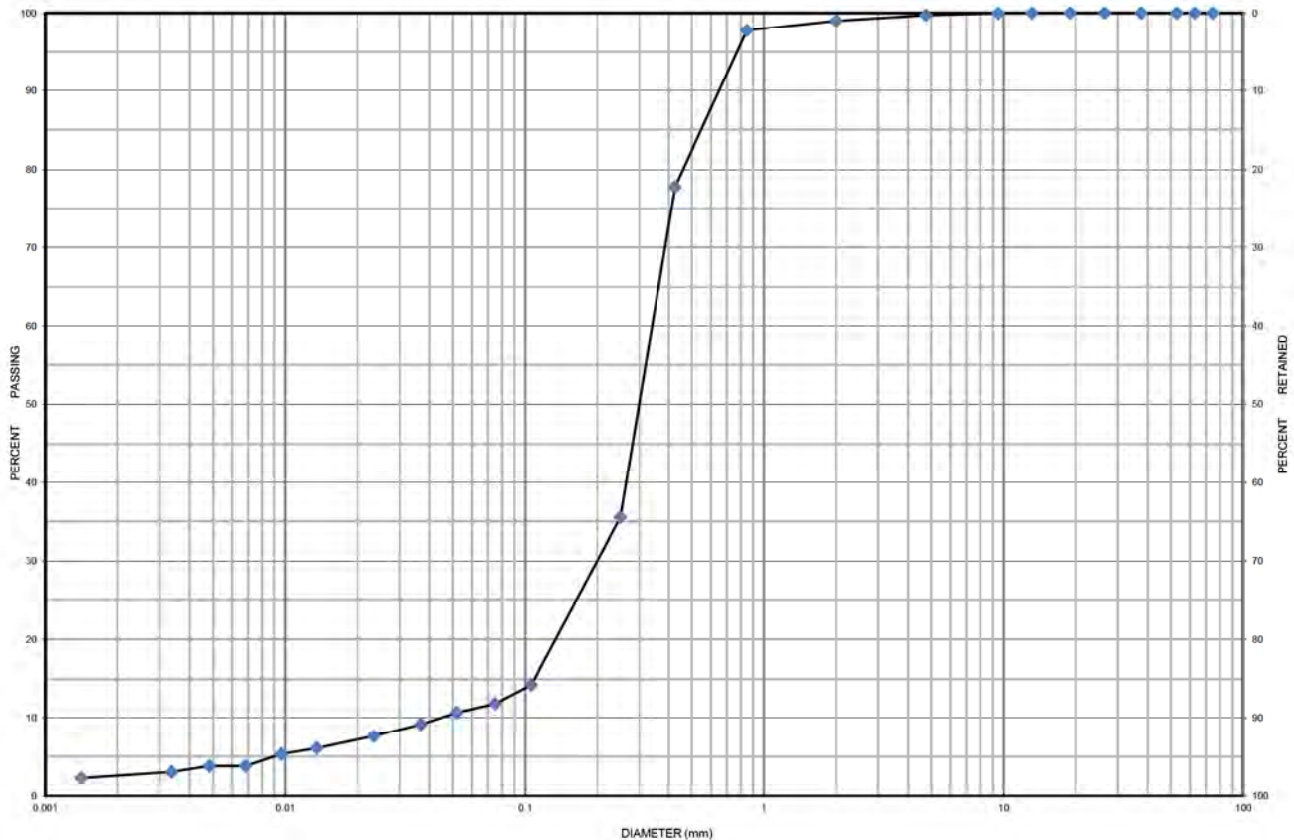
Form: L6V.2 - Grad.Hydo



Grain Size Distribution Chart

Project Number: 14079-001 **Client:** Innovative Planning Solutions
Project Name: 103 Napier St. & 95 Cook St., Barrie
Sample Date: December 8, 2021 **Sampled By:** Ben White - Cambium Inc.
Location: BH 104-21 SS 5 **Depth:** 3 m to 3.5 m **Lab Sample No:** S-21-1689

UNIFIED SOIL CLASSIFICATION SYSTEM					
CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDERS
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 104-21	SS 5	3 m to 3.5 m	0	88	9	3	6.4
Description		Classification	D ₆₀	D ₃₀	D ₁₀	C _u	C _c
Sand trace Silt trace Clay		SW	0.345	0.200	0.045	7.67	2.58

Additional information available upon request

Issued By: *John Baird* **Date Issued:** December 16, 2021
 (Senior Project Manager)



Moisture Content



Project Number: 14079-001

Project Name: 103 Napier St. & 95 Cook St., Barrie

Client: Innovative Planning Solutions

Date Taken: 2021-12-08

Lab Number: S-21-1685

Date Tested: 2021-12-13

Tested By: J. O'Brien

Borehole Number	Sample Number	Sample Depth (m)	Water Weight (g)	Water Content (%)	Additional Observations
101	1	0.00-0.61	33.4	21.8	1
101	2	0.76-1.37	27.6	13.2	1
101	3	1.52-1.98	43.3	6.6	NR
101	4	2.29-2.71	12.1	4.1	
101	5	3.05-3.43	5.5	2.4	
101	6	4.57-5.00	10.1	3.7	
101	7	6.10-6.64	22.0	7.4	
102	1	0.00-0.61	35.4	22.6	1
102	2	0.76-1.22	28.9	8.7	
102	3	1.52-1.98	20.1	7.3	
102	4	2.29-2.71	10.0	3.7	
102	5	3.05-3.51	11.9	4.0	
102	6	4.57-5.03	5.4	2.1	
102	7	6.10-6.55	137.9	17.0	NR
103	1	0.06-0.67	23.2	10.6	
103	2A	0.76-0.91	23.4	10.6	NR,1
103	2B	0.91-1.37	19.7	8.8	
103	3	1.52-1.98	17.1	5.3	
103	4	2.29-2.74	152.4	16.8	NR
103	5	3.05-3.41	16.7	6.1	
103	7	6.10-6.19	3.8	1.3	NR
104	1	0.00-0.61	31.5	22.9	NR,1
104	2	0.76-1.37	37.0	12.9	
104	3	1.52-1.98	12.5	6.2	
104	4	2.29-2.74	17.6	7.6	
104	5	3.05-3.51	42.3	6.4	NR
104	6	4.57-4.97	13.5	5.6	

- 1 – Contains organics

2 – Contains rubble

3 – Hydrocarbon Odour

4 – Unknown Chemical Odour

5 – Saturated – free water visible
- 6 – Very moist – near optimum moisture content

7 – Moist – below optimum moisture

8 – Dry – dry texture – powdery

9 – Very small – caution may not be representative

10 – Hold sample for gradation analysis



Moisture Content



Project Number: 14079-001
Project Name: 103 Napier St. & 95 Cook St., Barrie
Client: Innovative Planning Solutions
Date Taken: 2021-12-08

Lab Number: S-21-1685
Date Tested: 2021-12-13
Tested By: J. O'Brien

Borehole Number	Sample Number	Sample Depth (m)	Water Weight (g)	Water Content (%)	Additional Observations
104	7	6.10-6.55	44.2	14.2	

- 1 – Contains organics
- 2 – Contains rubble
- 3 – Hydrocarbon Odour
- 4 – Unknown Chemical Odour
- 5 – Saturated – free water visible
- 6 – Very moist – near optimum moisture content
- 7 – Moist – below optimum moisture
- 8 – Dry – dry texture – powdery
- 9 – Very small – caution may not be representative
- 10 – Hold sample for gradation analysis



Appendix C

2015 National Building Code Seismic Hazard Values

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 44.398N 79.669W

User File Reference: 103 Napier St., 95 Cook St.

2022-01-24 13:32 UT

Requested by: Cambium Inc.

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.080	0.049	0.032	0.011
Sa (0.1)	0.110	0.071	0.047	0.017
Sa (0.2)	0.108	0.071	0.049	0.019
Sa (0.3)	0.092	0.062	0.043	0.017
Sa (0.5)	0.077	0.052	0.036	0.013
Sa (1.0)	0.047	0.031	0.021	0.006
Sa (2.0)	0.025	0.016	0.010	0.003
Sa (5.0)	0.006	0.004	0.002	0.001
Sa (10.0)	0.003	0.002	0.001	0.000
PGA (g)	0.063	0.041	0.027	0.009
PGV (m/s)	0.064	0.040	0.026	0.008

Notes: Spectral ($S_a(T)$, where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s . Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information



Natural Resources
Canada

Ressources naturelles
Canada

Canada



Hydrogeological Assessment Report, 103 & 107 Napier Street and 95 Cook Street, Barrie, Ontario.

December 14, 2022

Prepared for:
2556055 Ontario Inc

Cambium Reference: 14079-001

CAMBIUM INC.

866.217.7900

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Peterborough | Barrie | Oshawa | Kingston



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1.0 Introduction

Cambium Inc. (Cambium) was retained by 2556055 Ontario Inc (the Client) c/o Innovative Planning Solutions to complete a hydrogeological assessment of the property located at 103 and 107 Napier Street and 95 Cook Street, City of Barrie, Ontario (the Site).

The hydrogeological assessment is required as part of the application process for Official Plan Amendment and Zoning By-law Amendment to permit 35 new townhomes, including 13, 2-storey towns and 22, 3-storey towns. The total area of the property is approximately 0.98 hectares (2.43 acres).

The purpose of the hydrogeological assessment is to assess the subsurface conditions at the Site in terms of soil and groundwater conditions, water levels and elevations to characterize the local groundwater regime for the construction of a townhouse complex and two single-family dwellings, along with associated parking, driveways, and landscaped areas.

1.1 Scope of Work

This hydrogeological assessment was conducted with the following tasks:

- **Review of available background information:** a review of available geological and hydrogeological information for the site and surrounding areas and the previous investigation reports completed for the Site, was conducted to provide background information to allow for characterization of the Site's soil and groundwater conditions.
- **Detailed site inspection:** an inspection of the Site was completed to review existing site conditions including identification of any hydrogeological features such as significant areas of potential groundwater recharge or areas of groundwater discharge.
- **Measurement of groundwater levels:** groundwater levels were measured in the existing monitoring wells to establish and/or confirm the general groundwater flow condition. Long-term, four-season water level monitoring is also being completed.
- **In-Situ Hydraulic Conductivity Tests:** completed in-situ hydraulic conductivity tests or Single well Response Tests (SWRTs) in three monitoring wells to estimate the hydraulic



conductivity of the underlying soils and/or bedrock, which will be used for assessing the potential dewatering requirements.

- **In-Situ Soil Infiltration Tests:** will be completed during spring-summer months using the Guelph Permeameter equipment at selected LID locations to assess the soil percolation and infiltration rates.
- **Water Balance (Preliminary):** a preliminary water balance study was completed for the proposed development using the Thornthwaite-Mather approach and the climatic data obtained from Environment Canada.
- **Source Water Protection:** an assessment of Source Water Protection and Site development will be completed to estimate likely impacts of the development on City's water supply.
- **Report Preparation:** a hydrogeological report was prepared presenting the results, findings, and recommendations of this investigation.

It should be noted that a geotechnical investigation is being completed concurrently at the Site by Cambium. The data or information obtained in the current and former investigations has been incorporated into this hydrogeological assessment report.

1.2 Site Description and Site Development

The total area of the property is approximately 0.98 ha (2.43 acres) in size and is located southeast of the corner of Cook Street and Napier Street. At the time of the study, the Site was developed as two separate parcels which consisted of the following:

- 95 Cook Street: an existing church, with associated parking areas on the west side of the property and a cleared area on the southeast side of the property.
- 103 Napier Street: an existing dwelling with two sheds on the north side of the property and an open grassy area on the south side of the property.

Following completion of the investigation, an additional parcel was added to the development which consisted of:



- 107 Napier Street: an existing dwelling with one shed on the south side of the property.

The ground elevation at the Site was relatively flat, and is bordered by Cook Street to the west, Napier Street to the north and by residential dwellings on the other two sides.

It is proposed that the Site be developed into a residential development consisting of 35 townhouse units organized into six separate blocks with associated driveways, landscape areas and parking areas. Water and wastewater services are being provided by the City of Barrie.

The regional location of the Site is outlined on Figure 1, the property and surrounding areas outlined on Figure 2 and the proposed development plan is included in Appendix A.



2.0 Environmental Features

To assess environmental features, databases maintained by the Ministry of Natural Resources and Forestry (MNRF), the Ministry of Environment, Conservation and Parks (MECP), and the Lake Simcoe Region Conservation Authority (LSRCA) were reviewed.

Based on the data reviewed, the Site is situated within Barrie Creeks Subwatershed, under the authority of the LSRCA Source Protection Area. The local drainage continues south and southeastward discharging into the Lake Simcoe which is situated at about 600 m south of the Site.

No wetlands or woodlands are situated on the Site. The majority of the Site is covered with built up and paved areas. The Site is not situated within the LSRCA regulated areas as per Ont. Reg. 179/06 and therefore, development restrictions do not apply to the proposed development.

As per MNRF Natural Heritage System database the Site does not have any Areas of Environmental Significance or Areas of Natural and Scientific Interest (ANSI).

As shown on the Ministry of Environment, Conservation and Parks (MECP) Source Water Protection Atlas map and Lake Simcoe Source Protection Plan, the Site is not located in groundwater vulnerable areas such as

- Wellhead Protection Area (WHPA-A, B, C and D),
- Highly Vulnerable Area (HVA)
- Issue Contributing Area (ISA), or
- Significant Groundwater Recharge Area (SGRA).

However, the Site is within a WHPA Q1 and Q2, related to groundwater recharge management area surrounding a municipal water supply aquifer (Appendix A).



3.0 Physical Setting

3.1 Topography and Drainage

The Site is located within the Barrie Creeks subwatershed of the Lake Simcoe watershed area. Based on the regional topographic map of the area, the general slope of the terrain is south and southeastwards with an elevation of about 270 meters above sea level (masl) in the north and northwest to about 265 masl in the east and southeast with gradual slope towards Lake Simcoe (Appendix A).

Based on the borehole location survey, the highest elevation of about 270.6 masl was noted in the northwest, with ground sloping southeast to the lowest elevation of about 268.17 masl, indicating generally a flat to gently sloping topography across the Site.

3.2 Physiography

The Site is located in the physiographic region known as Simcoe Uplands in the northern portion of the Barrie Creeks subwatershed and is defined as distinct upland areas of rolling till plains that are broken up by steep-sided, flat-floored valleys. In the Barrie area, these valleys tend to be oriented from east to west. The Simcoe Uplands generally make up the topographic highs, rising up to 100 m above the adjacent Simcoe Lowlands. Simcoe Uplands are characterized by a deposition of a variety of coarse and fine grained sediments (Chapman & Putnam, 1984).

3.3 Overburden Geology

In general, the study area is characterized by glaciolacustrine deposits, interpreted to have been deposited by the Laurentide Ice Sheet during the Wisconsin glaciations. The Paleozoic bedrock topography appears to strongly influence the overlying Quaternary sediment thickness and distribution (OGS, 2019) The overburden is primarily consisting of stone-poor, carbonate-derived silty to sandy till.



3.4 Bedrock Geology

According to Miscellaneous Release – Data 219 from the Ontario Geological Survey (Chapman, L.J. and D.F. Putnam, OGS, 2007), the bedrock in the area of the Site consists of Middle Ordovician rocks from the Simcoe Group. The Simcoe Group consists of four formations that dip gently towards the southwest: Gull River Formation, Bobcaygeon Formation, Verulam Formation and the Lindsay Formation from oldest to youngest. Simcoe Group primarily composed of limestone, dolostone, shale, arkose, and sandstone formations.



4.0 MECP Well Records Assessment

The Ministry of Environment Conservation and Parks (MECP) Water Well Information System (WWIS) was accessed to review water well records in the area of the Site. There were only three well records located within approximately 500 m radius of the Site (Figure 3).

As per the MECP records, the wells were installed between 1977 and 2016 to depth ranging from 6.1 mbgs to 128.3 mbgs. Overburden generally consisted of brown to grey fine to coarse sand and silt with gravel and cobbles, trace clay.

MWCP Well Records #7188109 and #7262481 were installed as monitoring wells, while #5714857 was installed as water supply well, however, the well was dry and was later abandoned. No data was available about the static water levels and/or recommended yield rates.

Well records are presented in Appendix B.



5.0 Borehole Drilling and Monitoring Well Installation

5.1 Borehole Investigation-Geotechnical

Cambium completed a geotechnical investigation at the Site on December 8, 2021. A total of four boreholes, designated as BH101-21 through BH104-21, were advanced to depths ranging from 6.2 m to 6.6 m below ground surface (mbgs). Three of the boreholes were outfitted as monitoring wells and designated as MW101-21, MW102-21, and MW104-21. Borehole locations are depicted on Figure 4 . Borehole logs are included in Appendix C.

Following is the general stratigraphy as encountered at the Site during the investigation.

Topsoil

Topsoil with some organic content was encountered in three of the boreholes advanced throughout the site (MW101-21, MW102-21, and MW104-21). BH103-21 was advanced through the asphalt parking lot east of the existing church.

The topsoil consisted of a black silt with some sand and organics and was found to be up to 760 mm thick.

Fill

Inferred fill soils were found underlying the topsoil in MW101-21 and beneath the asphalt in BH103-21. No fill material was encountered within MW102-21 or MW104-21, which were advanced in grassy areas to the east and south of the parcel.

The inferred fill soils consisted of a brown sand with some silt and trace organics in MW101-21 and a brown silt with some sand, and trace gravel in BH103-21. The fill soils ranged in thickness from 760 mm to 850 mm and extended to depths ranging from 0.9 mbgs to 1.5 mbgs.

Sand to Silty Sand

Native sand to silty sand materials were encountered in all boreholes beginning at depths ranging from 0.8 mbgs to 1.5 mbgs. The sand to silty sand soils extended to the termination



depths of all boreholes except MW102-21 and were found to contain varying amounts of gravel and clay.

Silt to Sandy Silt

A layer of silt was found underlying the native sandy soils in MW102-21 and extended to the termination depth of 6.6 mbgs. The silt was found to contain some clay with traces of sand and gravel. In BH104-21, a layer of sandy silt with trace amounts of gravel and clay was encountered below the topsoil, between depths of approximately 0.8 mbgs and 1.5 mbgs.

Clayey Silt

A layer of clayey silt was found within the sandy soils in BH103-21 at a depth of 2.3 mbgs, extending to approximately 3.0 mbgs. The clayey silt was found to contain some sand and trace gravel.

Bedrock

Bedrock was not encountered during the geotechnical investigation. Drilling was terminated at depths of between 6.2 mbgs and 6.6 mbgs.

Well construction details are presented below in Table 1.

Table 1 Monitoring Well Installation Details

Borehole	Termination Depth (mbgs)	Ground Elevation (masl)	Screen Details	
			Screen Top (masl)	Screen Bottom (masl)
MW101-21	6.5	270.36	267.26	264.26
MW102-21	6.6	269.08	265.98	262.98
MW104-21	6.2	268.17	265.07	262.07

5.2 Groundwater Elevations

As part of hydrogeological assessment, stabilized water level monitoring was completed. Groundwater levels were measured on two occasions during December 20, 2021, and January 27, 2022. The recorded groundwater levels are presented in Table 2 below.



A long-term twelve month water level monitoring is being completed at the Site to characterize the seasonal water table elevations across the Site. A separate letter report will be submitted after the conclusion of the monitoring at the Site.

Table 2 Measured Groundwater Levels

Well		MW101-21	MW102-21	MW104-21
Top of Pipe Elevation (masl)		271.34	270.03	269.13
Ground Surface Elevation (masl)		270.36	269.08	268.17
Stick-up (m)		0.98	0.95	0.96
Dec. 20, 2021	Water Level (mbgs)	Dry	5.40	5.19
	Groundwater Elev.(masl)	-	263.68	262.98
Jan. 27, 2022	Water Level (mbgs)	Dry	5.75	5.27
	Groundwater Elev.(masl)	-	263.33	262.93
Feb. 18, 2022	Water Level (mbgs)	Dry	5.93	5.24
	Groundwater Elev.(masl)	-	263.15	262.93
March 21, 2022	Water Level (mbgs)	Dry	5.77	5.22
	Groundwater Elev.(masl)	-	263.15	262.95
April 21, 2022	Water Level (mbgs)	Dry	5.58	5.19
	Groundwater Elev.(masl)	-	263.50	262.98
May 16, 2022	Water Level (mbgs)	Dry	5.63	5.12
	Groundwater Elev.(masl)	-	263.45	263.05
Jun 17, 2022	Water Level (mbgs)	Dry	5.85	5.21
	Groundwater Elev.(masl)	-	263.22	262.96
Aug. 8, 2022	Water Level (mbgs)	Dry	5.95	5.26
	Groundwater Elev.(masl)	-	263.13	262.91
Sept. 14, 2022	Water Level (mbgs)	Dry	6.04	5.35
	Groundwater Elev.(masl)	-	263.04	262.82
Oct. 19, 2022	Water Level (mbgs)	Dry	Dry	5.43
	Groundwater Elev.(masl)	-	-	262.74

As presented above, monitoring well MW101-21 was dry during all the monitoring events, while groundwater levels in wells MW102-21 and MW104-21 ranged from 5.12 mbgs to 6.04 mbgs, and the elevations ranged from 262.98 masl to 263.68 masl, respectively.

The spring water levels ranged from 5.12 mbgs to 5.58 mbgs, while the elevation was between 262.95 masl and 263.50 masl.

The water level fluctuations (i.e. difference between the highest and the lowest water levels) were minimal with 0.63 m at MW101-21 and 0.23 at MW104-21.

5.3 Direction of Groundwater Flow

Based on the groundwater elevation data obtained from the monitoring events, a site-specific groundwater configuration map could not be constructed as only two monitoring wells had defined water levels. Based on the water table elevations at MW101-21 and MW104-21, a horizontal hydraulic gradient of 0.005 m/m was estimated, with general water table sloping towards southeast.

5.4 Particle Size Distribution

Physical soil laboratory testing was completed on four samples collected during the geotechnical drilling and percolation times (T-Times) were estimated based on the Unified Soil Classification System (USCS). Gradation charts for the particle size distribution tests are provided in Appendix D and are summarized in Table 3 below.

Table 3 Grain Size Analysis Data

BH	Depth (mbgs)	Description	% Gravel	% Sand	% Silt	% Clay	Percolation Rate (min/cm)
MW101-21-SS3	1.5 – 2.0	Silty Sand trace Clay	0	70	27	3	18
MW102-21-SS7	6.1 – 6.6	Clayey Silt, trace sand and gravel	1	4	77	18	40
BH103-21-SS4	2.3 – 2.7	Clayey Silt, some sand and trace gravel	1	13	63	23	45
MW104-21-SS5	3.0 – 3.5	Sand trace Silt trace Clay	0	88	9	3	10

Based on the data above, the percolation times (T-Times) ranged from as low as 45 min/cm to as high as 10 min/cm, with a geometric average of 23.85 min/cm.

Where applicable, the hydraulic conductivity values were calculated with Puckett's method for fine grained soil and Hazen's formula for granular soil. The estimated percolation time and hydraulic conductivity rates are provided in Table 4.



Table 4 Percolation Times and Hydraulic Conductivity

Borehole/Sample	Sample Depth (mbgs)	Percolation Time (min/cm)	Hydraulic Conductivity (m/s)
MW101-21-SS3	1.5 – 2.0	18	7.8×10^{-4}
MW102-21-SS7	6.1 – 6.6	40	1.2×10^{-6}
BH103-21-SS4	2.3 – 2.7	45	4.6×10^{-7}
MW104-21-SS5	3.0 – 3.5	10	2.0×10^{-3}

Based on the above, the geometric mean hydraulic conductivity was calculated at 3.05×10^{-5} m/sec.

Based on the results of the hydraulic conductivity (cm/s), the corresponding infiltration rate (mm/hr) will be estimated using the approximate relationship presented in the *Low Impact Development Stormwater Management Planning and Design Guide* (TRCA and CVCA, 2010, Appendix C). Accordingly, the infiltration rates ranged from as low as 4 mm/hr to as high as 38 mm/hr.

6.0 Construction Dewatering

Construction dewatering is intended to lower the groundwater levels in the excavation area in order to ensure a dry and safe working condition.

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 development, such as the foundation and/or basement elevation, as well as the size of proposed structure.

Proposed Development, Anticipated Excavation and Dewatering

The proposed development will include construction of 35 townhouse units organized into six separate blocks with associated driveways landscape areas and parking areas. The proposed townhouses might include a one level basement (Appendix A). Based on the grade elevations of the existing Church building and residential buildings at the Site, it was assumed that the established grade elevation or finished floor elevation (FFE) would be about 269.75 masl and the depth to the proposed one level basement would be 3.0 m at an elevation of 266.75 masl. Therefore, final excavation elevation would be 266.30 masl including an allowance (0.45 m) for the basement slab and the underneath granular base.

Based on the groundwater monitoring data, the highest measured and recorded spring groundwater elevation would be 263.50 masl, for the monitoring event of April 21, 2022. However, depth to water level and elevation were noted as 5.40 mbgs and 263.68 masl on December 21, 2021 and were considered as a worst-case-scenario.

The following assumptions and assumed parameters were considered in estimating the construction dewatering rate.

- The highest groundwater elevation was assumed at 263.68 masl.
- Established grade or finished floor elevation was assumed at 269.75 masl.
- One level basement excavation elevation was estimated at 266.30 masl.
- The target dewatering elevation (1 m below the basement level) would be 265.30 masl.



- The average hydraulic conductivity at 3.05×10^{-5} m/sec.

Based on the above data, the highest water table elevation of 263.80 masl is situated at about 1.50 m below the deepest excavation elevation of 265.30 masl. The open-cut excavation will cut through the native sand, silty sand and clayey silt sediments but will not be intersecting the groundwater table, as the water table lies well below the bottom excavation elevation.

Therefore, temporary short-term groundwater control (construction dewatering) will not be anticipated during the excavation for the one level basement.

Also, the one level basement slab elevation estimated at 266.30 masl, was well above the water table elevation of 263.80 masl and therefore, long-term permanent sub-drain drainage was not expected at the Site.



7.0 Water Balance Assessment

Based on the Thornthwaite and Mather methodology (1957), the water balance is an accounting of water in the hydrologic cycle. Precipitation (P) falls as rain and snow. It can run off towards lakes and streams (R), infiltrate to the groundwater table (I), or evaporate from ground or evapotranspiration by vegetation (ET). When long-term average values of P, R, I, and ET are used, there is minimal or no net change to groundwater storage (ΔS).

The annual water budget can be expressed as:

$$P = ET + R + I + \Delta S$$

Where:

P = Precipitation (mm/year)

ET = Evapotranspiration (mm/year)

R = Run-off (mm/year)

I = Infiltration (mm/year)

ΔS = Change in groundwater storage (taken as zero) (mm/year)

It is noted that the water balance described herein does not account for catchment areas that extend off-site. The calculations compare the pre- and post-development water balance changes within the Site boundaries.

The pre-development portion of the Site consists of a residential building, two smaller sheds south on Napier Street and a Church building with an entrance from Cook Street, in addition to landscape and paved areas.

It is understood that the Site be developed into a residential development consisting of 35 townhouse units organized into six separate blocks with associated driveways, landscape areas and parking areas. It is also understood that part of the existing Church building will be demolished to make a way for the proposed roadway.

Based on the available design information, the development area at the Site can be generally categorized into three types as paved area, roof area, and landscape areas. The pre- and post-development plans of the proposed development are shown in Figure 5 and Figure 6. respectively. A summary of the surface areas of the development is listed in Table 5.

Table 5 Pre- and Post-Development Site Statistics

Type of Land Coverage	Pre-Development Areas (m ²)	Post Development Areas (m ²)
Paved Area	2,683	2,744
Building Roof Area	603	2,937
Landscape/Vegetated Area	6,538	4,143
Total (m²)	9,824	9,824

Supporting information referenced herein (including detailed water balance calculations) is attached in Appendix E.

7.1 Water Surplus

Water surplus is calculated by determining the difference between precipitation and evapotranspiration (changes in soil water storage was assumed to be negligible over the course of a year). The volume of water surplus is further sub-divided into portions that infiltrate the on-site soils and that are directed off-site as runoff.

The climatic data including monthly average temperature and precipitation were obtained from Environment Canada for the Barrie WPCC weather station (Climate Identifier: 6110557) located about 5 km from the Site. The data were available between the years 1973 to 2006 (i.e. 33 years). Accordingly, the average annual evapotranspiration was estimated to be about 545 mm/annum using the USGS Thornthwaite Monthly Water Balance methodology (Appendix E), and the average annual precipitation was recorded to be 933 mm/annum. Therefore, the available water surplus of the Site was calculated to be 388 mm/yr.



Evapotranspiration does not occur from structures, paved areas, or gravel surfaces. It was assumed that 10% of precipitation falling on these surfaces is lost directly to evaporation. The remaining depth (i.e., 90% of precipitation) was considered surplus and converted to infiltration and/or runoff.

7.2 Infiltration Rates

The volume of surplus water that infiltrates through pervious surfaces on-site was determined by applying an infiltration factor to the surplus depth. The surplus water that does not infiltrate into pervious surfaces will leave the Site as surface water runoff. The infiltration factor varies from 0 to 1 and is estimated based on topography, soils, and vegetation cover as per the *Stormwater Management Planning and Design Manual* (Ministry of the Environment, 2003).

The rate of infiltration at a site is expected to vary, based on a number of factors to be considered in any infiltration model. To partition the available water surpluses into infiltration and surface run-off, the Ministry of Environment, Conservation and Parks (MECP) infiltration factor was used. The MECP Storm Water Management Planning and Design Manual (2003) methodology for calculating total infiltration based on topography, soil type and land cover was used, and a corresponding run-off component was calculated for the soil moisture storage conditions.

The Site is relatively a flat topography, and based on the results of the borehole investigation, the subsurface conditions at the Site consist predominantly of sandy silt to silty sand to a depth of about 6.6 mbgs, with intercalations of clayey silt between 2.3 mbgs and 3.0 mbgs.

The calculation of infiltration and runoff in the stages of pre-development and post-development is provided in Appendix E, and are presented in Table 6 and Table 9, below.

7.3 Pre-Development Water Balance

The water balance for the existing conditions of the Site is summarized in Table 6. The pre-development infiltration rate was calculated to be 1,649 m³/yr and the runoff rate was 3,647 m³/yr.

Table 6 Pre-Development Water Balance

Land Use		Area (m ²)	Precipitation (m ³)	Evapotranspiration (m ³)	Infiltration (m ³)	Run-off (m ³)
Impervious Areas	Paved Area	2,683	2,503	250	-	2,253
	Roof Area	603	562.60	56	-	506
Pervious Areas	Landscape Area	6,538	6,100	3,563	1,649	888
Total			9,824	9,166	1,649	3,647
Assuming no infiltration occurring in paved and roof areas, and 10% of precipitation to be evaporated from paved and roof areas.						

7.4 Post-Development Water Balance

The post-development water balance is summarized in Table 7. The post-development infiltration rate was calculated to be 1,045 m³/yr and the runoff volume was estimated at 5,333 m³/yr.

Table 7 Post-Development Water Balance

Land Use		Area (m ²)	Precipitation (m ³)	Evapotranspiration (m ³)	Infiltration (m ³)	Run-off (m ³)
Impervious Areas	Paved Area	2,744	2,560	256	-	2,304
	Roof Area	2,937	2,740	274	-	2,466
Pervious Areas	Landscape Area	4,143	3,865	2,258	1,045	563
Total		9,824	9,166	2,788	1,045	5,333

7.5 Water Balance Comparison

The water balances of the pre-development and post-development scenarios are summarized below in Table 8.

Table 8 Water Balance Comparison

	Precipitation (m ³)	Evapotranspiration (m ³)	Infiltration (m ³)	Run- off (m ³)
Pre-Development	9,166	3,870	1,649	3,647
Post-Development	9,166	2,788	1,045	5,333
Change in Volume			604	1,686
Change in %			37	46

Based on the above, there is an infiltration deficit of about 604 m³/year compared to the pre-development infiltration. The runoff rate upon development of the Site will increase by 1,686 m³/year.

Table 9 Requirement of Infiltration from Roof Run-off

Volume of Pre-Development Infiltration (m ³ /annum)	1,649
Volume of Post-Development Infiltration (m ³ /annum)	1,045
Deficit from Pre to Post Development Infiltration (m ³ /annum)	604
% of Roof Runoff required to match the pre-development Infiltration	24

Based on the above calculations, a summary of the water balance could be provided as follows:

- 1) There is a net increase in run-off at the Site of about 1,686 m³/annum, from 3,647 m³/annum to 5,333 m³/annum. This increase is a result of the development of the Site with more impervious areas such as roof and paved areas and decrease in pervious landscape areas.
- 2) Post-development landscape area was decreased by about 2,395 m², when compared to the pre-development landscape, resulting in less infiltration across the Site.
- 3) Without implementing any mitigation measures, there is a net deficit of about 604 m³/annum in the post-development infiltration on a yearly basis.
- 4) Based on the estimation, a diversion of about 24% general roof water for infiltration, the proposed development would maintain the pre-development infiltration after the development. Therefore, Cambium would recommend the implementation of any

suitable Low Impact Development (LID) measures at the Site in its present design to account for the infiltration deficit.

7.6 Discussions on LID Measures

It is known that low impact development (LID) practices have received increasing attention as these strategies attempt to capture the runoff and mimic the natural hydrologic cycle.

In general, there are two primary categories of LIDs. The first promotes the infiltration of Stormwater close to the source. These infiltration type LIDs are preferred when hydrogeological and physical conditions are optimal and allow for their emplacement. The proposed development does not include any Stormwater management pond to enhance the lost infiltration due to the Site development with paved and roof areas. Therefore, the second option described below could be considered.

The second option captures and slowly releases the water to the groundwater water system through the process of storage and filtration by infiltration LIDs.

The roof surfaces included in the proposed development will generate approximately 2,466 m³/annum. In order to reduce the infiltration deficit and achieve water balance benefits, the option of roof downspout disconnection should be considered. This involves directing flow from roof downspouts to a pervious area that drains away from the building.

Properly connected downspouts, patio/yard drains and foundation drains will direct clean water to the ground surface, where it will infiltrate. Downspouts should discharge to a gradual sloped pervious area at least about 3 m away from the foundation that conveys runoff away from the building. Considering a conservative runoff reduction rate estimate for roof downspout disconnection at 25%, the general roof water for infiltration would fully compensate the infiltration deficit caused due to the Site development.

As another alternative, given the proposed Site layout, there is enough space available for the implementation of LID measures, either by means of infiltration galleries or infiltration trenches or any other suitable means. If requested, Cambium can complete in-situ soil infiltration tests during the spring/summer months using Guelph Permeameter at the proposed LID locations, if



any, in order to accurately estimate the infiltration rates for the design and implementation of LIDs across the Site.

It should be noted that, Cambium is not providing any design of LID facilities, it would be beneficial to consult with design engineers for the LID design recommendations.



8.0 Source Water Protection and Risk Management

As per the LSRCA Source Protection Plan (SPP), the Subject Site is located in a groundwater vulnerable area such as Wellhead Protection Area Q1/Q2 (WHPA-Q1/Q2) (Appendix A).

8.1 WHPA-Q1/Q2

WHPA Q1- refers to the area where activities that take water without returning it to the same source may be a threat; while WHPA Q2- refers to the area where activities that reduce recharge may be a threat. WHPA-Q1 (area affected by groundwater use) and WHPA-Q2 (area affected by recharge reduction) for the municipal wells in Barrie area were delineated through the application of a numerical groundwater flow model that considered all known high volume groundwater users. In other words, WHPA-Q2 delineates an area where there is potential for threats from reductions in groundwater recharge (i.e. new development).

In the present development scenario, the proposed development is for residential development and therefore, more impervious areas will be generated compared to the pre-development, thereby reducing groundwater recharge to the municipal aquifer.

Due to the fact that there is a net deficit in the infiltration compared to pre-development scenario and therefore, there is a negative impact to the groundwater recharge due to the proposed nature of the development in the study area. The water balance assessment for the proposed development indicated an infiltration deficit of 604 m³/annum.

Therefore, it is required to meet the pre-development water balance by implementing the Low Impact Development measures such as downspout disconnection techniques or any suitable measures where practicable, demonstrating recharge will be maintained across the Site.

Cambium also recommends using the Best Management Practices (BMPs) so as to avoid overland flow of any contaminants to the natural environment, especially to the Lake Simcoe.

The Site will be under municipal sewage service and as such is not expected to cause any groundwater contamination by nitrates.



The major land use practices at the proposed development do not include the storage & handling of large quantities of road salt and snow storage and handling, hence, the development of Salt Management Plans and Snow Storage Plans is not required for the proposed development.



9.0 Assessment of Potential Impacts

Based on the information available, the residential development at the Site is proposed to be developed with townhouse units with possible one level basement. There is no construction dewatering, either short-term or long-term involved at the Site due to deep water table conditions. The potential impacts due to the Site development were assessed as below.

9.1 Natural Features

As discussed, no natural features such as wetlands, woodlands, ponds, and creeks located on the Site, there should be no impacts on the local natural features, due to the Site development. The Site is not situated within the LSRCA regulated areas as per Ont. Reg. 179/06 and therefore, development restrictions do not apply to the proposed development.

9.2 Water Supply Wells near the Site

The proposed development is being developed with one level basement, and that no dewatering will be required for the completion of the proposed development, therefore, impacts on the local water wells (private or public), if any will not be anticipated to be associated with the dewatering activity.

9.3 Considerations on Drinking Water Vulnerability

Based on the MECP Source Protection Information Atlas, the Site is situated within WHPA-Q1/Q2 area related to groundwater recharge management; therefore, it is required to meet the pre-development water balance by implementing the suitable Low Impact Development measures, demonstrating recharge will be maintained across the Site. Section 8 of this report has a detailed discussion on the issue of source water protection and all the land use policies such as following best management practices and utilizing LIDs to compensate infiltration deficit be implemented as recommended.



10.0 Conclusions And Recommendations

Cambium Inc. (Cambium) was retained by 2556055 Ontario Inc (the Client) to complete a hydrogeological assessment of the property located at 103 and 107 Napier Street and 95 Cook Street, City of Barrie, ON (the Site).

The Site has no wetlands or woodlands or any regulated areas that overlap the Site. As such, the proposed development restrictions under Ont. Reg. 179/06 made under the *Conservation Authorities Act, 1990*, do not apply to the proposed development.

The measured spring groundwater levels in the monitoring wells ranged from 5.12 mbgs to 5.58 mbgs, while the elevation was between 262.95 masl and 263.50 masl.

The water level fluctuations (i.e. difference between the highest and the lowest water levels) were minimal with 0.63 m at MW101-21 and 0.23 at MW104-21.

Groundwater flow direction could not be determined as only two monitoring wells had defined water levels and the third monitoring well was consistently dry.

Site development plan proposes the construction of a townhouse complex with a possible one level basement. The proposed development is not anticipated to involve any short-term construction dewatering or a permanent long-term sub-drain dewatering due to deep water table conditions across the Site. The highest water table elevation of 263.80 masl is situated at about 1.50 m below the deepest excavation elevation of 265.30 masl and therefore, no dewatering is expected at the Site.

The conceptual water balance indicates that there will be an infiltration deficit of about 604 m³/annum in the post-development infiltration upon development of the Site, compared to the pre-development. Based on the estimation, a diversion of 24% of general roof water for infiltration, the proposed development would maintain an enhanced infiltration after the development.

Considering a conservative runoff reduction rate estimate for roof downspout disconnection at 25%, the roof water for infiltration would fully compensate the infiltration deficit caused due to



the Site development. Therefore, Cambium would recommend the implementation of any Low Impact Development (LID) measures at the Site in its present design.

Since the Site is situated within a WHPA Q1/Q2, it is required to meet the pre-development water balance by implementing the Low Impact Development measures such as downspout disconnection techniques or any suitable measures where practicable, demonstrating pre-development recharge will be maintained across the Site.

Based on the hydrogeological investigation, no environmental impacts were anticipated due to the proposed Site development.



11.0 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.

Respectfully submitted,

Cambium Inc.

Sudhakar Kurli, M.Sc. P.Geo.
Project Manager

Kevin Warner, M.Sc., P.Geo (Ltd). BCIN
Manager-Water & Wastewater

12.0 References

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13.0 Standard Limitations

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Appended Figures

2556055 ONTARIO INC.
107 Napier Street and 95 Cook Street,
Barrie, Ontario

Highway
 Major Road
 Minor Road
 Watercourse
 Water Area
 Provincial Park
 Wooded Area
 Built Up Area

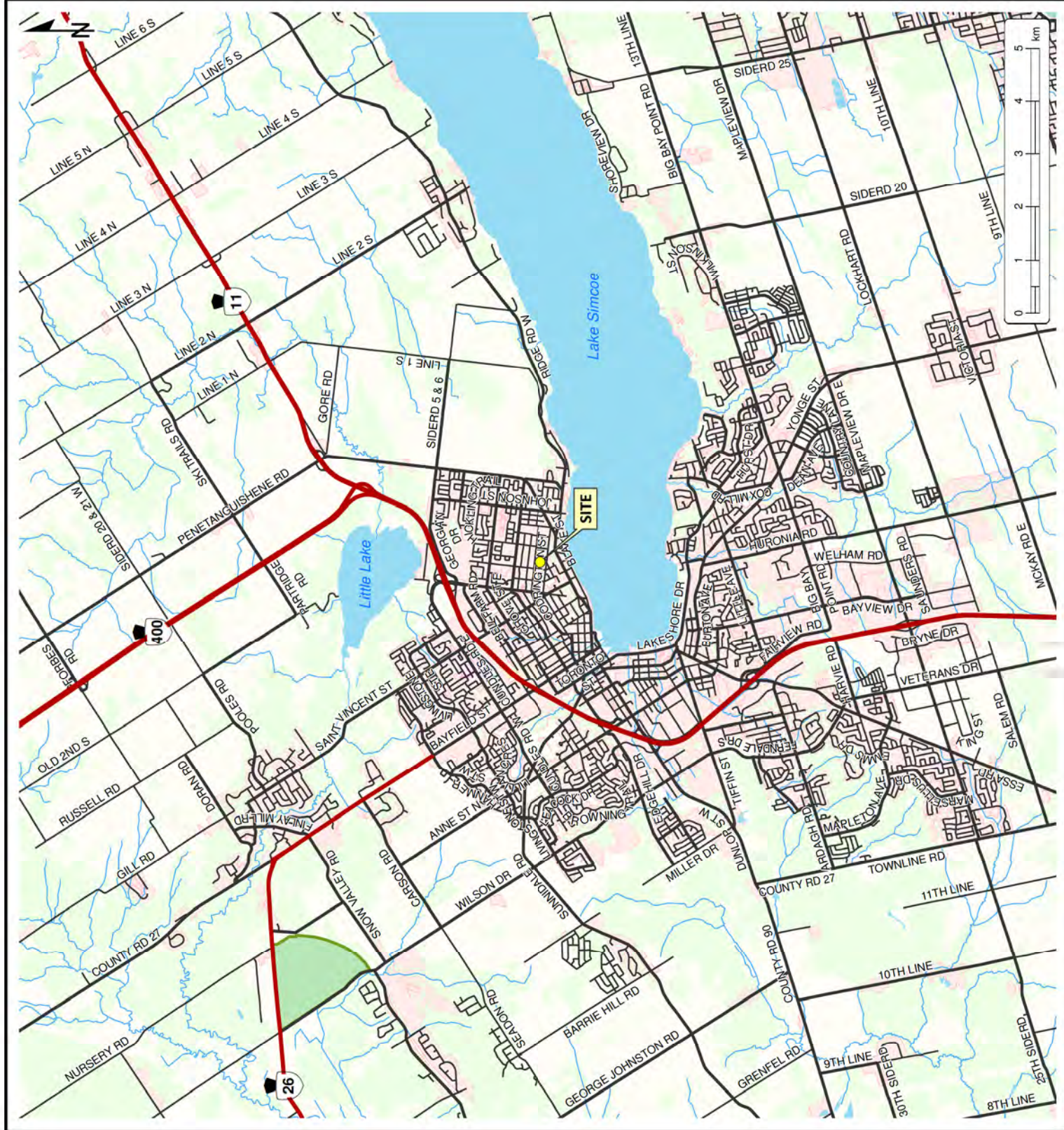
Notes:
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REGIONAL LOCATION PLAN

Project No.:	14079-001	Date:	February 2022
Scale:	1:100,000	Rev.:	
		Projection:	NAD 1983 UTM Zone 17N
Created by:	MAT	Checked by:	SK
		Figure:	1



**HYDROGEOLOGICAL
ASSESSMENT**
2556055 ONTARIO INC.
107 Napier Street and 95 Cook Street,
Barrie, Ontario

LEGEND

 Site (approximate)

Notes:
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SITE PLAN

Project No.:	14079-001	Date:	February 2022
Scale:	1:1,000	Projection:	NAD 1983 UTM Zone 17N
Created by:	MAT	Checked by:	SK
		Figure:	2



HYDROGEOLOGICAL ASSESSMENT

2556055 ONTARIO INC.
107 Napier Street and 95 Cook Street,
Barrie, Ontario

LEGEND

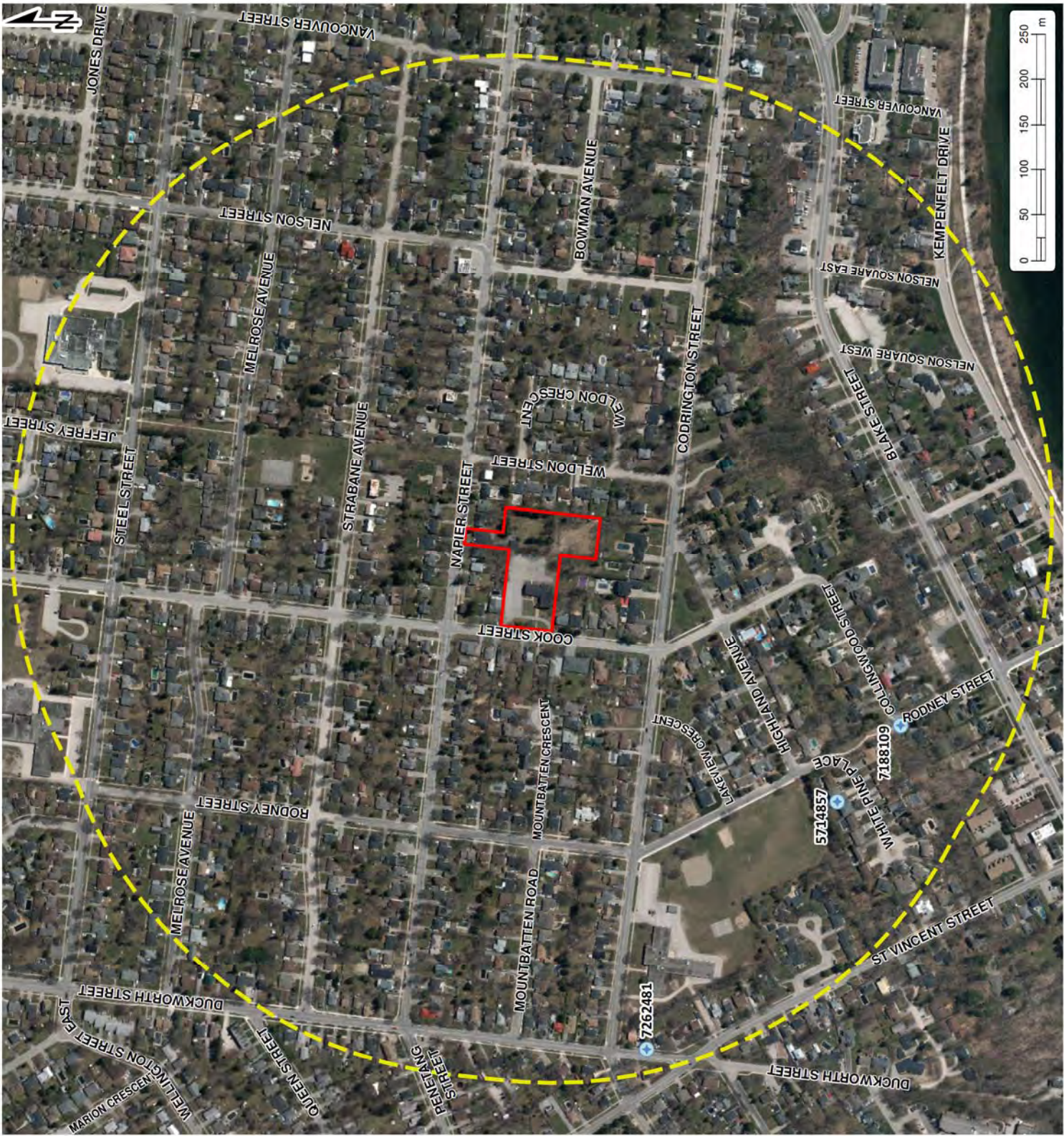
- Water Well Record
- 500m Study Area
- Site (approximate)

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MECP WELL RECORDS WITHIN 500m OF SITE

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Scale:	1:5,000	Projection:	NAD 1983 UTM Zone 17N
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		Figure:	3



**HYDROGEOLOGICAL
ASSESSMENT**
2556055 ONTARIO INC.
107 Napier Street and 95 Cook Street,
Barrie, Ontario

LEGEND

- Borehole
- Monitoring Well
- Site (approximate)

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BOREHOLE LOCATION PLAN

Project No.:	14079-001	Date:	February 2022
Scale:	1:1,000	Projection:	NAD 1983 UTM Zone 17N
Created by:	MAT	Checked by:	SK
		Figure:	4



**HYDROGEOLOGICAL
ASSESSMENT**
2556055 ONTARIO INC.
107 Napier Street and 95 Cook Street,
Barrie, Ontario

LEGEND

- Roof
- Paved
- Landscaped
- Site (approximate)

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PRE-DEVELOPMENT PLAN

Project No.:	14079-001	Date:	November 2022
Scale:	1:1,000	Projection:	NAD 1983 UTM Zone 17N
Created by:	MAT	Checked by:	SK
			Figure: 5



	Area (m ²)
Roof Area	602.8
Paved Area	2,683.1
Landscaped Area	6,537.7

HYDROGEOLOGICAL ASSESSMENT

2556055 ONTARIO INC.
107 Napier Street and 95 Cook Street,
Barrie, Ontario

LEGEND

- Roof
- Paved
- Landscaped
- Site (approximate)

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POST-DEVELOPMENT PLAN

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Scale:	1:1,000	Rev.:	
Projection:	NAD 1983 UTM Zone 17N	Created by:	MAT
Checked by:	SK	Figure:	6

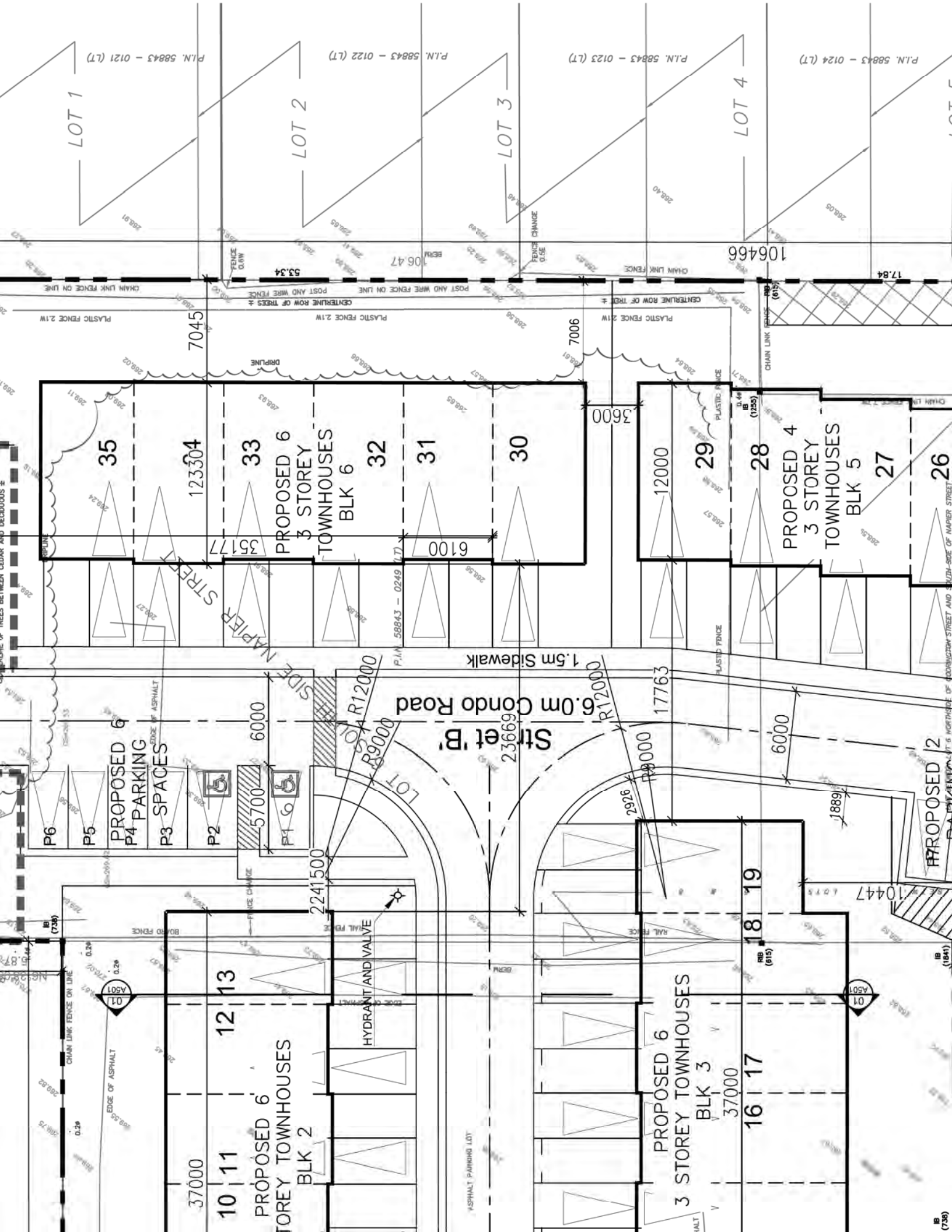


	Area (m ²)
Roof Area	2,937.2
Paved Area	2,743.9
Landscaped Area	4,142.5



Appendix A

Site Development Plans



Map created: 2/7/2022

ANSI

- Provincial Park



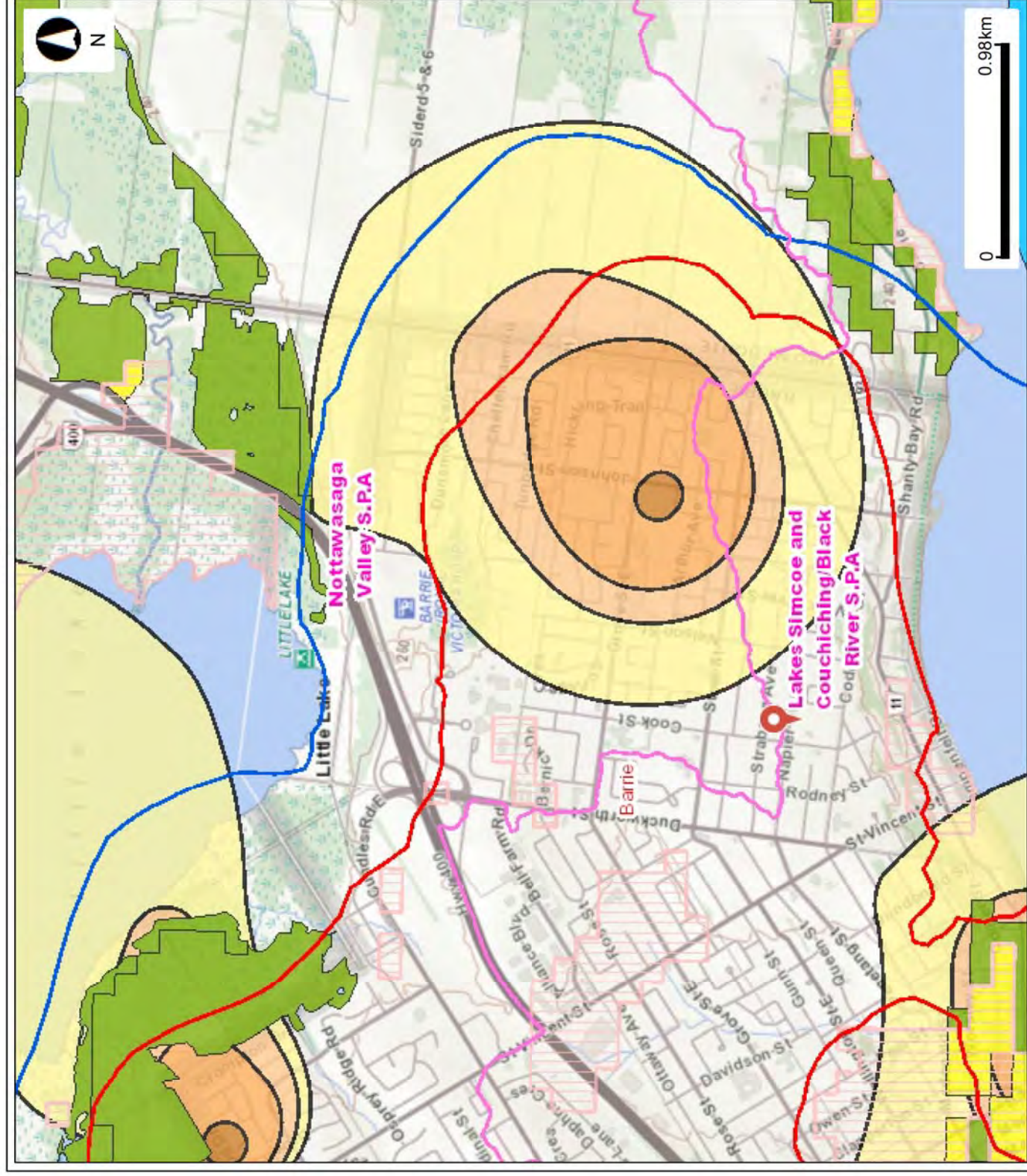
Kilometres Absence of a feature in the map does not mean they do not exist in this area.

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WHPA Q1/Q2 Areas



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Appendix B

MECP Well Records

OWNER (SURNAME FIRST) BARRIE PUC	28-47 605700	ADDRESS Bayfield St Dorrie	DATE COMPLETED DAY 28 NO 11 YR 72
1-2-07	4916400	5	0850

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET	
				FROM	TO
Brown	clay	gravel + boulders	stiff	0	19
Brown	clay	gravel	stiff	19	27
Grey	clay		hard	27	43
Grey	clay	gravel	stiff	43	49
Grey	clay	sand	layers	49	73
Blue	clay		hard	73	186
Grey	clay	sand	layers	186	245
Grey	clay		stiff	245	253
Grey	clay		hard	253	277
Grey	sand	(silty)	packed	277	324
Grey	clay		hard	324	333
Grey	clay	sand	layers	333	345

31	00196051113	002760511173	004340573	004920511173	00732052874	018630573	1
32	02482052874	027720573	03242288479	033320573	03452052874	03852280679	1

41	WATER RECORD
WATER FOUND AT - FEET	KIND OF WATER
10-13	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
15-18	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
20-23	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
25-28	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
30-33	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51	CASING & OPEN HOLE RECORD		
INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET
10-11	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE		13-16
17-18	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE		20-23
24-25	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE		27-30

SCREEN	SIZE(S) OF OPENING (SLOT NO.)	DIAMETER	LENGTH
		INCHES	FEET
	MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN	

61	PLUGGING & SEALING RECORD	
DEPTH SET AT - FEET	MATERIAL AND TYPE	(CEMENT GROUT, LEAD PACKER, ETC.)
FROM TO		
10-13	14-17	
18-21	22-25	
26-29	30-33	

71	PUMPING TEST METHOD	10	PUMPING RATE	15-16	DURATION OF PUMPING	17-18
1 ☐ PUMP 2 ☐ BAILER			GPM	HOURS	MINS	
STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING	1 ☐ PUMPING 2 ☐ RECOVERY			
19-21	22-24	15 MINUTES 26-28 30 MINUTES 29-31 45 MINUTES 32-34 60 MINUTES 35-37				
IF FLOWING, GIVE RATE	PUMP IN TAKE SET AT	WATER AT END OF TEST	1 ☐ CLEAR 2 ☐ CLOUDY			
RECOMMENDED PUMP TYPE	RECOMMENDED PUMP SETTING	RECOMMENDED PUMPING RATE				
☐ SHALLOW ☐ DEEP						

LOCATION OF WELL
IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.
DRILLERS REMARKS:

FINAL STATUS OF WELL	1 ☐ WATER SUPPLY 2 ☒ OBSERVATION WELL 3 ☐ TEST HOLE 4 ☐ RECHARGE WELL	5 ☐ ABANDONED, INSUFFICIENT SUPPLY 6 ☐ ABANDONED, POOR QUALITY 7 ☐ UNFINISHED
WATER USE	1 ☐ DOMESTIC 2 ☐ STOCK 3 ☐ IRRIGATION 4 ☐ INDUSTRIAL 5 ☐ OTHER	5 ☐ COMMERCIAL 6 ☐ MUNICIPAL 7 ☐ PUBLIC SUPPLY 8 ☐ COOLING OR AIR CONDITIONING 9 ☐ NOT USED
METHOD OF DRILLING	1 ☐ CABLE TOOL 2 ☐ ROTARY (CONVENTIONAL) 3 ☐ ROTARY (REVERSE) 4 ☐ ROTARY (AIR) 5 ☐ AIR PERCUSSION	6 ☐ BORING 7 ☐ DIAMOND 8 ☐ JETTING 9 ☐ DRIVING

NAME OF WELL CONTRACTOR	LICENCE NUMBER	DATE RECEIVED	INSPECTOR
Inter. Water Supply Co.	2801	040178	
ADDRESS			

: ONLY	DATA SOURCE	58	CONTRACTOR	59-62	DATE RECEIVED	63-68	80
	DATE OF INSPECTION		INSPECTOR				

Overburden and Bedrock Materials/Abandonment Sealing Record (see instructions on the back of this form)

Annular Space	Results of Well Yield Testing
---------------	-------------------------------

Method of Construction		Well Use		Pumping rate (l/min / GPM)	
☐ Cable Tool	☐ Diamond	☐ Public	☐ Commercial	☐ Not used	3
☒ Rotary (Conventional)	☐ Jetting	☐ Domestic	☐ Municipal	☐ Dewatering	4
☐ Rotary (Reverse)	☐ Driving	☐ Livestock	☐ Test Hole	☒ Monitoring	5
☐ Boring	☐ Digging	☐ Irrigation	☐ Cooling & Air Conditioning		10
☐ Air percussion		☐ Industrial			15
☐ Other, specify _____		☐ Other, specify _____			

Construction Record - Screen				
Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft)	
			From	To
2"	plastic	010	10'	20'

Insufficient Supply

☐ Abandoned, Poor Water Quality

☐ Abandoned, other, specify _____

☐ Other, specify _____

Map of Well Location

Please provide a map below following instructions on the back.

Well Contractor and Well Technician Information			
---	--	--	--

Mailing Address: 7900 REELE STREET SUITE 200 CONCORD ON L4K 2A3

Well Location				
Address of Well Location (Street Number/Name) DULK WORTH STREET		Township	Lot	Concession
County/District/Municipality SIMCOE COUNTY		City/Town/Village BARRIE	Province Ontario	Postal Code
UTM Coordinates Zone Easting Northing NAD 83 17 605441 4916835		Municipal Plan and Sublot Number		Other

Overburden and Bedrock Materials/Abandonment Sealing Record (see instructions on the back of this form)					
General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft)	
	SAND		Sand / Cobble	From	To

Annular Space			
Depth Set at (m/ft)	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)	
From To			
30 25	SAND, SILICA	0.025	
25 6"	BENTONITE	0.015	
6" 0"	ASPHALT	0.015	

Method of Construction	Well Use
☐ Cable Tool ☐ Rotary (Conventional) ☐ Rotary (Reverse) ☒ Boring ☐ Air percussion ☐ Other, specify	☐ Diamond ☐ Jetting ☐ Driving ☐ Digging ☐ Public ☐ Domestic ☐ Livestock ☐ Irrigation ☐ Industrial ☐ Other, specify ☐ Commercial ☐ Municipal ☒ Test Hole ☐ Cooling & Air Conditioning ☐ Not used ☐ Dewatering ☒ Monitoring

Construction Record - Casing				Status of Well	
Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft)		
			From To		
2"	PVC		0 25'		

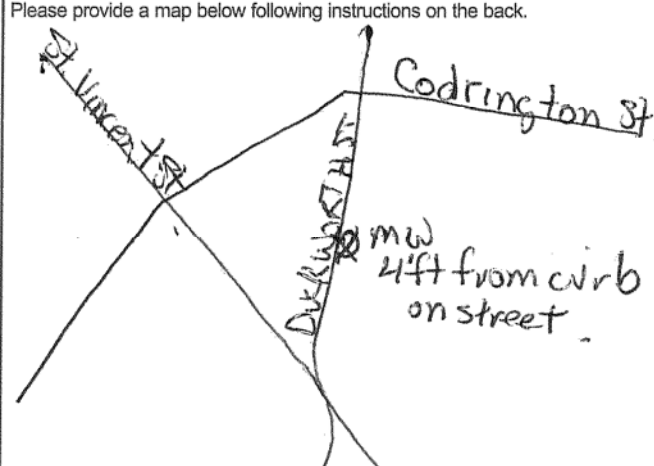
☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, specify
☐ Other, specify

Construction Record - Screen					
Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft)		
			From To		
2"	PLASTIC	10	25' 30'		

Water Details		Hole Diameter	
Water found at Depth (m/ft) ☐ Gas ☐ Other, specify	Kind of Water: ☐ Fresh ☐ Untested	Depth (m/ft) From To	Diameter (cm/in)
Water found at Depth (m/ft) ☐ Gas ☐ Other, specify	Kind of Water: ☐ Fresh ☐ Untested		
Water found at Depth (m/ft) ☐ Gas ☐ Other, specify	Kind of Water: ☐ Fresh ☐ Untested		

Well Contractor and Well Technician Information	
Business Name of Well Contractor Fisher Environmental Ltd.	Well Contractor's Licence No. 6946
Business Address (Street Number/Name) 15-400 GUNA PARK DR	Municipality MARKHAM

Results of Well Yield Testing			
After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify		Draw Down	
		Time (min)	Water Level (m/ft)
If pumping discontinued, give reason:		Static Level	
Pump intake set at (m/ft)		1	1
Pumping rate (l/min / GPM)		2	2
Duration of pumping hrs + min		3	3
Final water level end of pumping (m/ft)		4	4
If flowing give rate (l/min / GPM)		5	5
Recommended pump depth (m/ft)		10	10
Recommended pump rate (l/min / GPM)		15	15
Well production (l/min / GPM)		20	20
Disinfected? ☐ Yes ☐ No		25	25
		30	30
		40	40
		50	50
		60	60

Map of Well Location
Please provide a map below following instructions on the back.

Comments:



Appendix C

Borehole Logs



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Oshawa
Kingston
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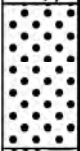
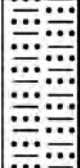
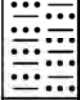
Log of Borehole:

MW101-21

Page 1 of 1

Client: Innovative Planning Solutions
Contractor: Landshark Drilling
Location: 95 Cook Street, Barrie, Ontario

Project Name: 103 Napier Street and 95 Cook Street, Barrie, ON
Method: Hollow Stem Auger
UTM: 17T: 4916983 m north, 605915 m east
Project No.: 14079-001
Date Completed: December 8, 2021
Elevation: 270.36 mASL

SUBSURFACE PROFILE				SAMPLE														
Elevation (m)	Depth	Lithology	Description	Number	Type	% Recovery	SPT (N)	% Moisture			SPT (N)			Well Installation	Remarks			
								25	50	75	10	20	30	40				
270	0		Topsoil: Black silt, some sand, some organics, loose, moist [TOPSOIL]	1	SS	40	4								Monument Cap	Top of Pipe (TOP) elevation: 271.34 mASL Well dry when measured on December 20, 2021		
269	1		Sand: Brown sand, some silt, trace organics, loose, moist [FILL]	2	SS	80	7								Bentonite Plug PVC Standpipe		GSA SS3: 0% Gravel 70% Sand 27% Silt 3% Clay	
268	2		Silty Sand: Brown silty sand, trace clay, very dense, dry	3	SS	60	50/280 mm											
267	3			4	SS	60	50/280 mm											
266	4			5	SS	60	50/230 mm											
265	5			6	SS	70	50/280 mm								Sand Pack PVC Screen			
264	6		-more silt, moist	7	SS	70	50/205 mm								Cap			
263	7		Borehole terminated at 6.5 mbgs in silty sand due to target depth															

Logged By: BW

Input By: BW



Client: Innovative Planning Solutions

Project Name: 103 Napier Street and 95 Cook Street, Barrie, ON Project No.: 14079-001

Contractor: Landshark Drilling

Method: Hollow Stem Auger

Date Completed: December 8, 2021

Location: 103 Napier Street, Barrie, Ontario

UTM: 17T: 4916970 m north, 606025 m east

Elevation: 269.08 mASL

SUBSURFACE PROFILE				SAMPLE												
Elevation (m)	Depth	Lithology	Description	Number	Type	% Recovery	SPT (N)	% Moisture			SPT (N)			Well Installation	Remarks	
								25	50	75	10	20	30	40		
269	0		Topsoil: Black silt, some sand, some organics, trace gravel, loose, moist [TOPSOIL]	1	SS	20	6								Monument Cap Bentonite Plug PVC Standpipe Sand Pack PVC Screen Cap	Top of Pipe (TOP) elevation: 270.03 mASL Groundwater measured at 5.4 mbgs (263.68 mASL) on December 20, 2021
268	1		Silty Sand: Brown silty sand, some gravel, compact, moist	2	SS	60	27									
			Sand: Brown sand, some gravel, trace silt, very dense, saturated	3	SS	50	50									
267	2		-less gravel, wet	4	SS	50	50/280 mm									
			-dense	5	SS	60	45									
266	3															
265	4		-moist	6	SS	50	50									
264	5															
			Silt: Brown, silt, some clay, trace sand, trace gravel, dense, wet	7	SS	80	50									
263	6															
			Borehole terminated at 6.6 mbgs in silt due to target depth achieved.													
	7															



Client: Innovative Planning Solutions
Contractor: Landshark Drilling
Location: 95 Cook Street, Barrie, Ontario

Project Name: 103 Napier Street and 95 Cook Street, Barrie, ON
Method: Hollow Stem Auger
UTM: 17T: 4916952 m north, 605975 m east
Project No.: 14079-001
Date Completed: December 8, 2021
Elevation: 269.30 mASL

SUBSURFACE PROFILE				SAMPLE												
Elevation (m)	Depth	Lithology	Description	Number	Type	% Recovery	SPT (N)	% Moisture			SPT (N)				Well Installation	Remarks
								25	50	75	10	20	30	40		
0			Asphalt: Asphalt thickness: 50 mm													Borehole open and dry upon completion
269			Silt: Brown silt, some sand, trace gravel, loose, moist [FILL]	1	SS	60	5									
			-compact	2A												
1			Silty Sand: Brown silty sand, trace gravel, compact, moist	2B	SS	80	12									GSA SS4: 1% Gravel 13% Sand 63% Silt 23% Clay
268			Sand: Brown sand, some gravel, trace silt, dense, dry	3	SS	70	49									
2			Clayey Silt: Brown clayey silt, some sand, trace gravel, very stiff, moist	4	SS	90	30									
267			Sand: Brown sand, trace gravel, trace silt, very dense, dry	5	SS	70	50/205 mm									
266																
4																
265				6	SS	0	50/50 mm									
5																
264																
6																
263			-grey, more gravel	7	SS	20	50/100 mm									broken cobbles in spoon
			Borehole terminated at 6.2 mbgs in sand due to target depth achieved.													
7																

Borehole open and dry upon completion

GSA SS4:
1% Gravel
13% Sand
63% Silt
23% Clay

broken cobbles in spoon



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Log of Borehole:

MW104-21

Page 1 of 1

Client: Innovative Planning Solutions
Contractor: Landshark Drilling
Location: 95 Cook Street, Barrie, Ontario

Project Name: 103 Napier Street and 95 Cook Street, Barrie, ON
Method: Hollow Stem Auger
UTM: 17T: 4916905 m north, 606003 m east
Project No.: 14079-001
Date Completed: December 8, 2021
Elevation: 268.17 mASL

SUBSURFACE PROFILE				SAMPLE												
Elevation (m)	Depth	Lithology	Description	Number	Type	% Recovery	SPT (N)	% Moisture			SPT (N)				Well Installation	Remarks
								25	50	75	10	20	30	40		
268	0		Topsoil: Black silt, some sand, some organics, loose, moist [TOPSOIL]	1	SS	20	7									Top of Pipe (TOP) elevation: 269.13 mASL Groundwater measured at 5.19 mbgs (262.98 mASL) on December 20, 2021
267	1		Sandy Silt: Brown sandy silt, trace organics, trace gravel, trace clay, loose, wet	2	SS	70	9									
266	2		Sand: Brown sand, trace silt, trace clay, dense, wet	3	SS	50	33									
				4	SS	60	37									
265	3			5	SS	70	50									GSA SS5: 0% Gravel 88% Sand 8% Silt 3% Clay
264	4															
			-very dense	6	SS	60	50/255 mm									
263	5															
262	6		-saturated	7	SS	90	50/180 mm									
	7		Borehole terminated at 6.4 mbgs in sand due to target depth achieved.													

Logged By: BW

Input By: BW



Appendix D

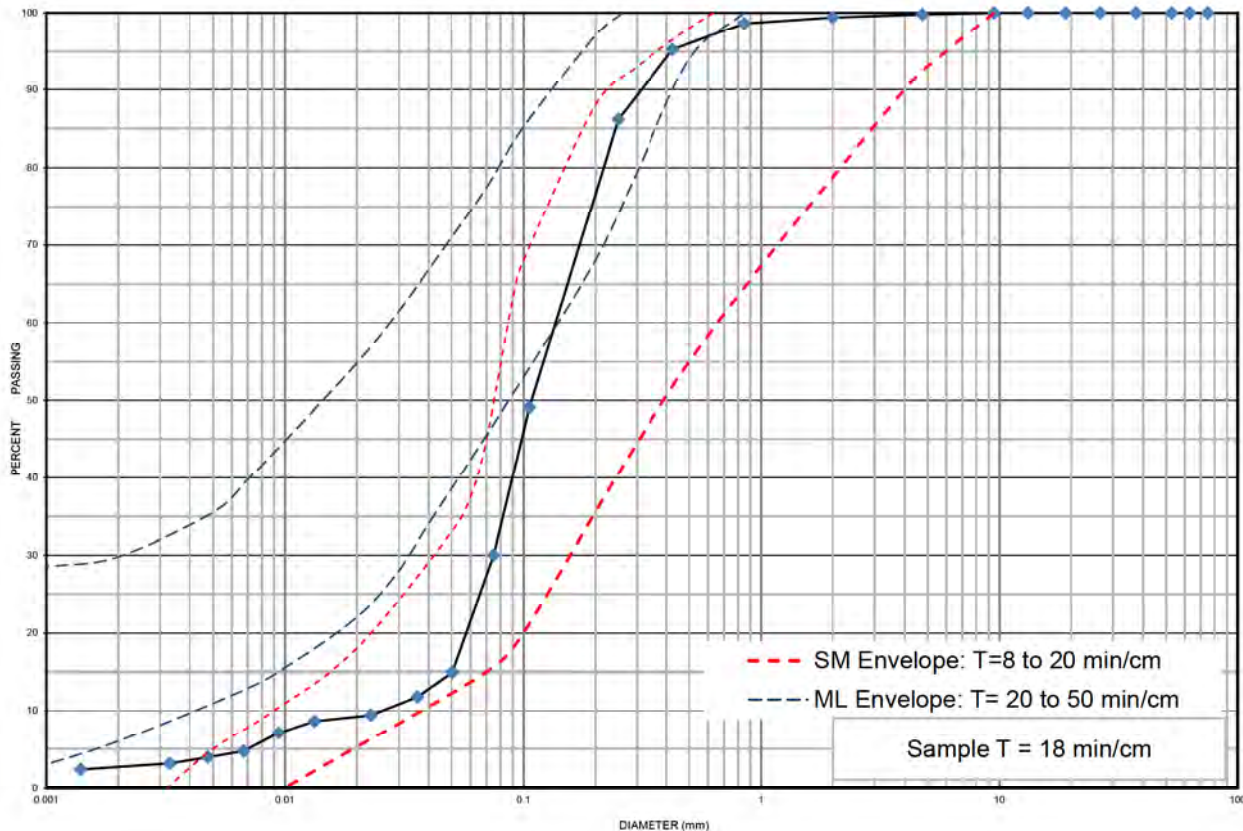
Grain Size Analysis Data



Grain Size Distribution Chart

Project Number: 14079-001 **Client:** Innovative Planning Solutions
Project Name: 103 Napier St. & 95 Cook St., Barrie
Sample Date: December 8, 2021 **Sampled By:** Ben White - Cambium Inc.
Location: BH 101-21 SS 3 **Depth:** 1.5 m to 2 m **Lab Sample No:** S-21-1686

UNIFIED SOIL CLASSIFICATION SYSTEM					
CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDER
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 101-21	SS 3	1.5 m to 2 m	0	70	27	3	6.6
Description		Classification	D ₆₀	D ₃₀	D ₁₀	C _u	C _c
Silty Sand trace Clay		SM	0.145	0.0750	0.0	5.58	1.49

Additional information available upon request

Issued By: 
 (Senior Project Manager)

Date Issued: January 24, 2022

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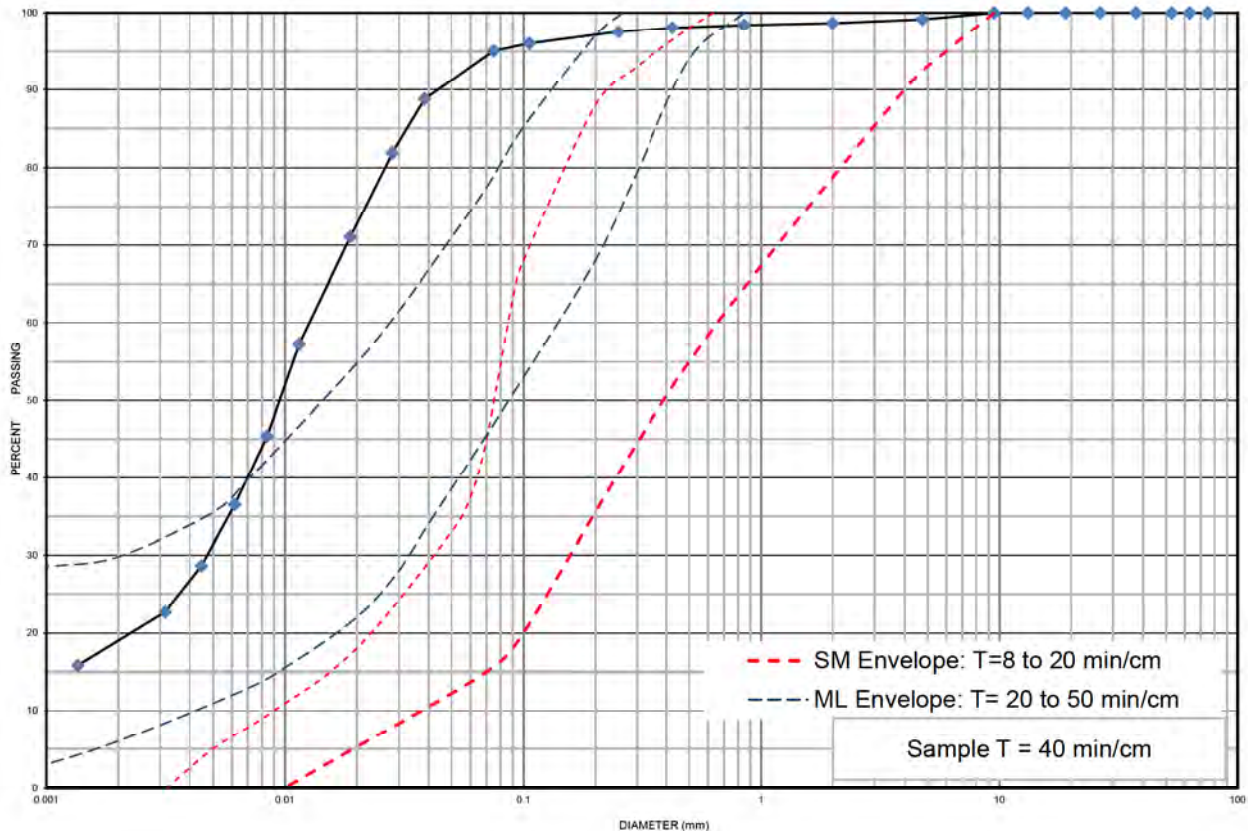
Form: L6V.2 - Grad.Hydo



Grain Size Distribution Chart

Project Number: 14079-001 **Client:** Innovative Planning Solutions
Project Name: 103 Napier St. & 95 Cook St., Barrie
Sample Date: December 8, 2021 **Sampled By:** Ben White - Cambium Inc.
Location: BH 102-21 SS 7 **Depth:** 6.1 m to 6.6 m **Lab Sample No:** S-21-1687

UNIFIED SOIL CLASSIFICATION SYSTEM					
CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDER
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 102-21	SS 7	6.1 m to 6.6 m	1	4	77	18	17.0
Description		Classification	D ₆₀	D ₃₀	D ₁₀	C _u	C _c
Silt some Clay trace Sand trace Gravel		ML	0.014	0.0047	-	-	-

Additional information available upon request

Issued By:
(Senior Project Manager)

Date Issued: January 24, 2022

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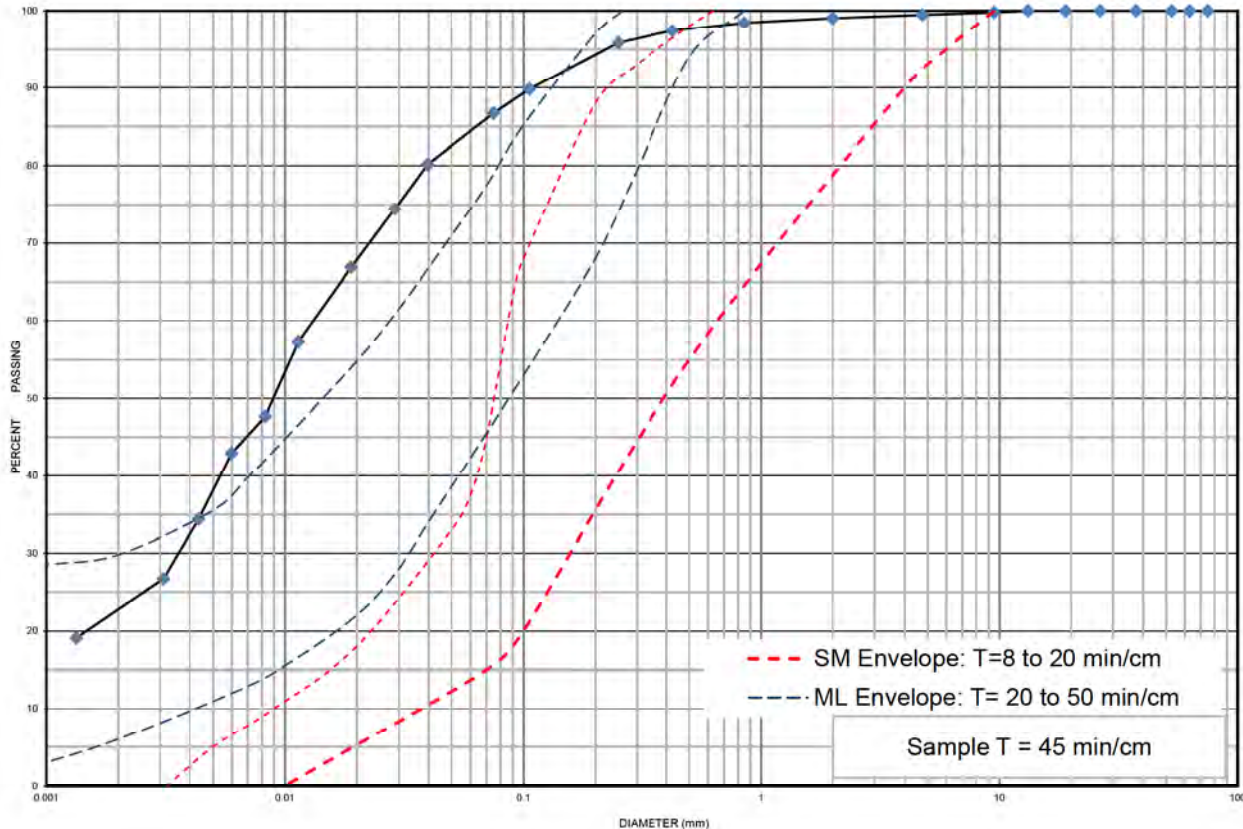
Form: L6V.2 - Grad.Hydo



Grain Size Distribution Chart

Project Number: 14079-001 **Client:** Innovative Planning Solutions
Project Name: 103 Napier St. & 95 Cook St., Barrie
Sample Date: December 8, 2021 **Sampled By:** Ben White - Cambium Inc.
Location: BH 103-21 SS 4 **Depth:** 2.3 m to 2.7 m **Lab Sample No:** S-21-1688

UNIFIED SOIL CLASSIFICATION SYSTEM					
CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDER
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 103-21	SS 4	2.3 m to 2.7 m	1	13	63	23	16.8
Description		Classification	D ₆₀	D ₃₀	D ₁₀	C _u	C _c
Clayey Silt some Sand trace Gravel		ML	0.014	0.0036	-	-	-

Additional information available upon request

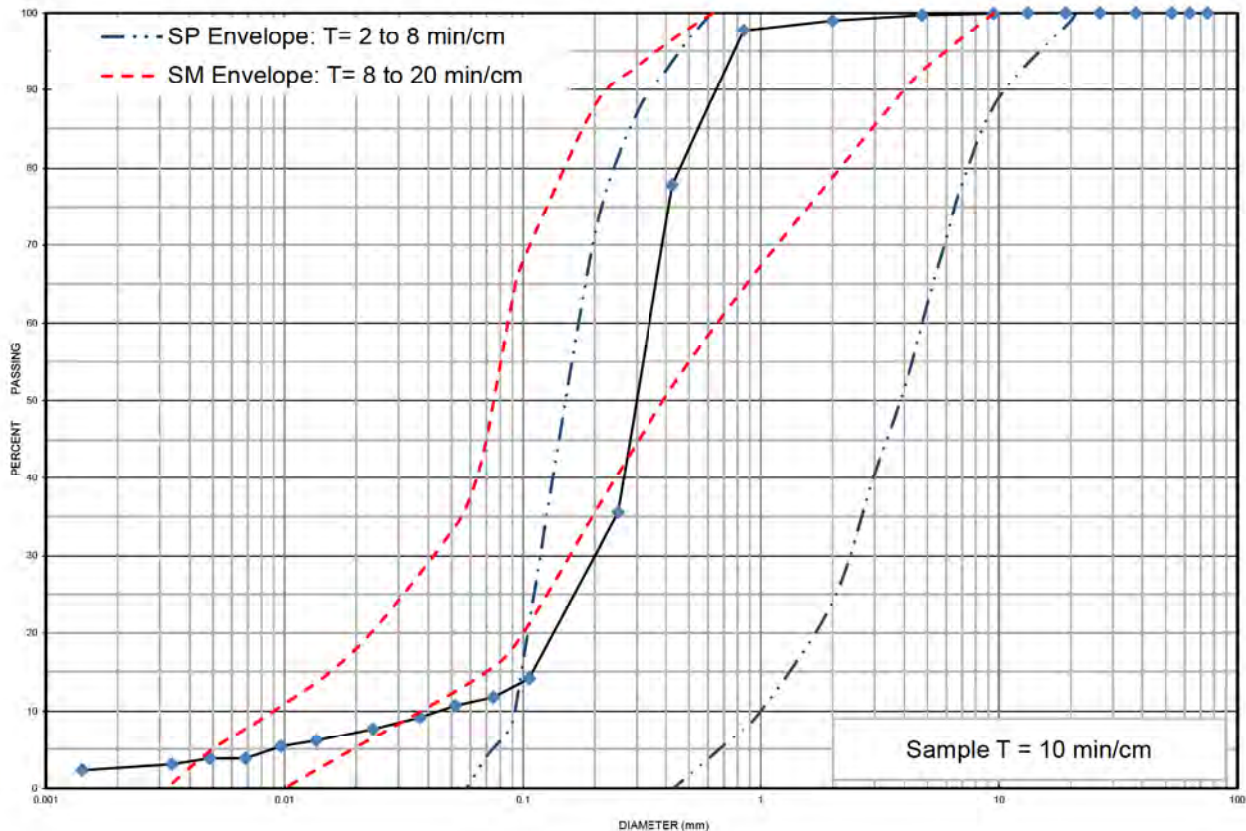
Issued By:  (Senior Project Manager) **Date Issued:** January 24, 2022



Grain Size Distribution Chart

Project Number: 14079-001 **Client:** Innovative Planning Solutions
Project Name: 103 Napier St. & 95 Cook St., Barrie
Sample Date: December 8, 2021 **Sampled By:** Ben White - Cambium Inc.
Location: BH 104-21 SS 5 **Depth:** 3 m to 3.5 m **Lab Sample No:** S-21-1689

UNIFIED SOIL CLASSIFICATION SYSTEM					
CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDER
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 104-21	SS 5	3 m to 3.5 m	0	88	9	3	6.4
Description		Classification	D ₆₀	D ₃₀	D ₁₀	C _u	C _c
Sand trace Silt trace Clay		SW	0.345	0.2000	0.0	7.67	2.58

Additional information available upon request

Issued By: 
 (Senior Project Manager)

Date Issued: January 24, 2022

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Form: L6V.2 - Grad.Hydo



Appendix E

Thornthwaite Water Balance

Barrie

	THORNTHWAITE-TYPE MONTHLY WATER-BALANCE MODEL														
	modified from Dingman 2001: ex. 7-13, Box 7-3 using ET model of Hamon (1963)														
	Input Data				Computed Values					Surplus	388	mm/yr			
	Location: Barrie			Lat. =		44.2 degree		SOILmax =		150 mm					
						0.77 rad									
Declination (deg)	-21.3	-13.3	-2.0	9.8	18.9	23.3	21.3	13.7	3.0	-9.0	-18.6	-23.3			
Declination (rad)	-0.37	-0.23	-0.03	0.17	0.33	0.41	0.37	0.24	0.05	-0.16	-0.32	-0.41			
DayLength (hr)*	9.0	10.2	11.7	13.3	14.6	15.3	15.0	13.8	12.4	10.8	9.5	8.7			
*For lat. > 66.5, replace #NUM! with 24 in summer; 0 in winter.															
			MONTHLY WATER BALANCE DATA												
			Temperatures in C, water-balance terms in mm.												
Month:	J	F	M	A	M	J	J	A	S	O	N	D	Year		
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====		
P	83	62	58	62	82	85	77	90	94	78	89	74	933		
T	-7.7	-6.6	-2.1	5.6	12.3	17.9	20.8	19.7	15.3	8.7	2.7	-3.5			
F	0.00	0.00	0.00	0.93	1.00	1.00	1.00	1.00	1.00	1.00	0.45	0.00			
RAIN	0	0	0	58	82	85	77	90	94	78	40	0	604		
SNOW	83	62	58	4	0	0	0	0	0	0	49	74	329		
PACK	183	244	302	20	0	0	0	0	0	0	27	100			
MELT	0	0	0	286	20	0	0	0	0	0	22	0	329		
INPUT (W _m)	0	0	0	344	103	85	77	90	94	78	62	0	932		
PET	0	0	0	40	68	100	116	100	69	40	23	0	557		
W _m - PET	0	0	0	304	35	-15	-39	-10	25	38	39	0			
SOIL	150	150	150	150	150	136	105	98	123	150	150	150			
Δ SOIL	0	0	0	0	0	-14	-31	-7	25	27	0	0			
ET	0	0	0	40	68	99	108	97	69	40	23	0	545		
SURP=W-ET-Δ SOIL	0	0	0	304	35	0	0	0	0	10	39	0	388		
DEFIC=PET-ET	0	0	0	0	0	1	8	3	0	0	0	0	12		

DETAILED WATER BALANCE CALCULATIONS
103 Napier Street and 95 Cook Street, City of Barrie, ON

1 Climate Information

Precipitation	933 mm/a
Actual Evapotranspiration	545 mm/a
Water Surplus	388 mm/a

2 Infiltration Rates

Table 2 Approach - Infiltration factors

Topography: Flat to Gently Sloping Land	0.3
Soil Type: predominantly open silty sand to sandy silt	0.25
Cover: Open Land	0.1
Total	0.65

Infiltration (0.65 x 388)	252 mm/a
Run-off (388-252)	136 mm/a

Table 3 Approach - Typical Recharge Rates

Coarse Sand and Gravel	>250	mm/a
Fine to medium sand	200-250	mm/a
Silty sand to sandy silt	150-200	mm/a
Silt	125-150	mm/a
Clayey Silt	100- 125	mm/a
Clay	<100	mm/a

Site development area is underlain predominantly by sandy silt to silty sand.

Based on the above, the recharge rate is typically	150-200	mm/a
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3 Pre-Development Property Statistics

	ha	m2
Paved Area	0.27	2,683
Roof Area	0.06	603
Landscape Area	0.65	6,538
Total	0.98	9824

4 Post-Development Property Statistics

	ha	m2
Paved Area	0.27	2,744
Total Building Roof Area	0.29	2,937
Landscape Area	0.41	4,143
Total Land Area	0.98	9824

5 Pre-Development Water Balance

Land Use		Area (m ²)	Precipitation (m ³)	Evapotranspiration (m ³)	Infiltration (m ³)	Run-off (m ³)
Impervious Areas	Paved Area	2,683	2,503	250	-	2,253
	Roof Area	603	563	56	-	506
Pervious Areas	Landscape Area	6,538	6,100	3,563	1,649	888
		9,824	9,166	3,870	1,649	3,647

Assuming no infiltration occurring in paved and roof areas, and 10% of precipitation to be evaporated from paved and roof areas.

6 Post-Development Water Balance

Land Use		Area (m ²)	Precipitation (m ³)	Evapotranspiration (m ³)	Infiltration (m ³)	Run-off (m ³)
Impervious Areas	Paved Area	2,744	2,560	256	-	2,304
	Roof Area	2,937	2,740	274	-	2,466
Pervious Areas	Landscape Area	4,143	3,865	2,258	1,045	563
		9,824	9,166	2,788	1,045	5,333

7 Comparison of Pre- and Post -Development

	Precipitation (m ³)	Evapotranspiration (m ³)	Infiltration (m ³)	Run-off (m ³)
Pre-Development	9,166	3,870	1,649	3,647
Post-Development	9,166	2,788	1,045	5,333
Change in Volume			604	1,686
Change in %			37	46

8 Requirement for Infiltration of Roof Run-off

Volume of Pre-Development Infiltration (m ³ /annum)	1,649
Volume of Post-Development Infiltration (m ³ /annum)	1,045
Deficit from Pre to Post Development Infiltration (m ³ /annum)	604
Percentage of Roof Runoff required to match the pre-development infiltration (%)	24