C.C. Tatham & Associates Ltd.
Consulting Engineers

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Town of Innisfil

Municipal Class Environmental Assessment

Final Report

prepared by:

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prepared for:

Town of Innisfil

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Abstract

This Comprehensive Stormwater Management Master Plan report has been completed by the Town of Innisfil (Town) to comply with the Lake Simcoe Protection Plan. This report has assessed the Town's settlement areas with respect to stormwater management. The areas included within this report are: Innisfil Heights, Stroud, Gilford, Big Bay Point, Lefroy, Alcona, Fennell's Corners, Sandy Cove, Churchill, Cookstown and the Highway 89/Highway 400 development area. This report discusses the existing conditions of the settlement areas, as well as the impacts that future development will have on stormwater management infrastructure. A detailed inventory of all existing stormwater management ponds is provided, along with suggested retrofit opportunities to increase the function of each facility. The goal of this report is to provide solutions to improve water quality and reduce phosphorous loading to Lake Simcoe. A number of alternatives are presented and assessed to enhance stormwater quality within the Town.

Executive Summary

C.C. Tatham & Associates Ltd. has been retained by the Town of Innisfil (Town) to prepare a Comprehensive Stormwater Management Master Plan (CSWM-MP) for all settlement areas within the Town in accordance with the Lake Simcoe Protection Act, 2008. The Town is located along the southwest shoreline of Lake Simcoe and is bounded by Lake Simcoe to the east, the City of Barrie to the north, The Township of Essa to the west and Bradford West Gwillimbury to the south. There are a number of existing stormwater management (SWM) facilities within the Town, consisting of wet ponds, dry ponds and wetlands.

This CSWM-MP will establish opportunities and constraints as they relate to stormwater quality and quantity and serve to establish a comprehensive master drainage and SWM framework to identify existing SWM improvement opportunities and to guide all future development in each settlement area. The implementation of drainage improvements will result in opportunities to minimize erosion, phosphorus loadings, and changes in water balance throughout the Lake Simcoe watershed which are in alignment with the requirements and objectives of the Lake Simcoe Protection Plan.

An assessment of stormwater peak flows for existing and future land use conditions was evaluated to determine the impact of future development within the Town. Subcatchments within the Town were modelled for the 2-year to 100-year and Regional storm events. Results indicate that peak flows will increase due to future development; however, these flows can be controlled to existing conditions using SWM quantity controls.

A phosphorous budget analysis has been completed for all study areas for the existing and future land use conditions. These calculations applied phosphorus removal rates based on existing and future SWM controls. Low Impact Development (LID) SWM controls are recommended for future developments in order to minimize phosphorous loading to Lake Simcoe.

A water balance assessment was completed for the existing and future land use conditions to establish the deficit in infiltration due to increased development in the Town. As was expected, the results show that infiltration will decrease due to future development. In accordance with the LSPP and the Lake Simcoe Region Conservation Authority, all new major developments must show that best efforts have been made to match pre development infiltration rates. It is recommended that the following SWM practices be implemented into new developments in order to achieve site water balance; soakaway pits, bioretention cells, rainwater gardens, infiltration trenches, and disconnected roof leaders.

A detailed list of all existing SWM facilities was compiled and assessed with respect to existing performance. Each facility was rated based on the relative benefit that the facility would have if it were retrofit to provide increased SWM quality control. A total of four (4) SWM facilities were identified as highest priority for retrofits. These facilities are:

- Pond #10-2 Village North Dempster (Stroud);
- Pond #10-1 Brandy Lane (Stroud);
- Pond #9-2 Southview (Stroud); and
- Pond #8-1 Trillium Industrial (Innisfil Heights).

A preferred overall alternative has been determined for the Town as a whole for existing and future developments. For existing developments, implementing a SWM retrofit program is recommended, as well as providing improvements to existing stormwater runoff be implemented by installing SWM LID measures, where appropriate. Retrofit opportunities should be considered whenever reconstruction/improvement works are proposed to any existing development (road re-surfacing, underground servicing work, etc.).

With regard to future developments within the Town, a number of general recommendations are outlined below.

- In areas where soil/groundwater conditions permit, implementation of SWM LID source controls (soakaways, rainwater gardens, infiltration trenches, bioretention, green roofs, rainwater harvesting) and conveyance LIDs (enhanced grass swales, perforated pipe systems, vegetated filter strips) should be provided to improve water quality and promote infiltration.
- A treatment train or multi-layer approach to stormwater management should be utilized. For example, where at-source and conveyance LIDs are utilized for quality control and infiltration, a dry pond can be used to provide the required post-to-pre quantity controls.
- Where required, over control of peak flows should be provided in on-site SWM facilities to reduce downstream peak flows and reduce flooding.
- As-built surveys are required as part of all newly constructed SWM facilities for the purpose of confirming the design storage volumes exist and for determining sediment accumulation throughout the lifespan of the facility.

A detailed list of recommendations for each study area is provided in Section 10 of this report.

1 Introduction

C.C. Tatham & Associates Ltd. (CCTA) has been retained by the Town of Innisfil (Town) to prepare a Comprehensive Stormwater Management Master Plan (CSWM-MP) for all settlement areas within the Town in accordance with the Lake Simcoe Protection Act, 2008. The Town is located along the southwest shoreline of Lake Simcoe and is bounded by Lake Simcoe to the east, the City of Barrie to the north, The Township of Essa to the west and Bradford West Gwillimbury to the south. The locations of the settlement areas within the Town are shown on Figure 1.

The Town elected to divide the CSWM-MP study work into two components. Part 1 was completed by Hatch Mott MacDonald in 2012, and focused on assessing the existing stormwater management (SWM) facilities, and identifying retrofit opportunities. The following report builds upon the data compiled in the Part 1 report in order to provide a complete CSWM-MP as per the “Comprehensive Stormwater Management Master Plan Guidelines” document developed by the Lake Simcoe Region Conservation Authority (LSRCA) and published in April 2011.

1.1 General Background

In December 2008, the Lake Simcoe Protection Act was passed by the Ontario Legislature and the Lake Simcoe Protection Plan (LSPP) followed in July 2009. The intent of the LSPP is to protect and restore the ecological health of Lake Simcoe and its watershed and it includes SWM policies to improve the management of stormwater runoff from both existing and future development. LSPP Policy 4.5 SA states that within five years of the date the plan came into effect, municipalities, in collaboration with LSRCA, must prepare and implement CSWM-MPs for their settlement areas located in the Lake Simcoe watershed. The CSWM-MPs will serve as a tool for municipalities to improve existing drainage infrastructure (including SWM facilities). It will define a strategy to establish guidelines to manage stormwater quality and quantity, and reduce phosphorus loadings prior to and following development. An evaluation of stormwater retrofit opportunities will also be established.

1.2 Background Reports & Data Gap Analysis

1.2.1 Background Reports

This report was prepared using a number of past reports and provincial guidelines on water resources and the environment, including the following publications:

- <u>Conservation Authority Guidelines for Hydrogeological Assessments</u>, Various Conservation Authority Hydrogeologists, June 2013;
- <u>Technical Guidelines for Stormwater Management Submissions</u>, LSRCA, April 26, 2013;

- Lake Simcoe Region Conservation Authority Watershed Development Policies, LSRCA, March 2012;

- Approved Lake Simcoe and Couchiching - Black River Source Protection Area, Part 1: Lake Simcoe Watershed Assessment Report, LSRCA, Nottawasaga Valley Conservation Authority and Severn Sound Environmental Association, November 2011;

- Comprehensive Stormwater Management Master Plan Guidelines, LSRCA, April 2011;

- Estimation of the Phosphorus Loadings to Lake Simcoe, The Louis Berger Group Inc., September 2010;

- Lake Simcoe Phosphorus Reduction Strategy, Ministry of the Environment (MOE), now known as Ministry of Environment and Climate Change (MOECC) , June 2010;

- Lake Simcoe Protection Plan, MOECC, July 2009;

- Lake Simcoe Region Conservation Authority Integrated Watershed Management Plan, LSRCA, June 2008;

- Low Impact Development Stormwater Management Planning and Design Guide, Credit Valley Conservation (CVC) & Toronto and Region Conservation (TRCA), 2010

- County of Simcoe Official Plan, County of Simcoe, August 2007;

- Natural Heritage System for the Lake Simcoe Watershed Phase 1: Components and Policy Templates, LSRCA, July 2007;

- Provincial Policy Statement, Ministry of Municipal Affairs and Housing, April 2014;

- Town of Innisfil Official Plan, Town of Innisfil, July 2006;

- Stormwater Management Practices Planning and Design Manual, MOECC, 2003; and

- Hydrologic Modelling Hewitt's, Sandy Cove, Mooselanka, Gilford, Lovers Creeks and the City of Barrie Annexation Area, URS, July 2011

- Innisfil Creeks Subwatershed Plan, LSRCA, 2012

- Barrie Creeks, Lovers Creek, and Hewitt's Creek Subwatershed Plan, LSRCA, 2012

- Stormwater Management Master Plan - Part 1, Hatch Mott MacDonald for Town of Innisfil, February 2012

- Phosphorous Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed, Hutchinson Environmental Sciences Ltd. for MOECC, March 30, 2012.

1.2.2 Data Gap Analysis

CCTA has reviewed the background reports and has utilized the available information from the LSRCA, County of Simcoe (County) and the Town of Innisfil (Town) to identify data gaps that must be addressed in order to fulfil the completion of a Master Plan.

Specifically, an existing and proposed condition hydrologic analysis of the study area is required. Phosphorous loading and water balance calculations are also required. Other data gaps with respect to erosion analyses along the receiving watercourses downstream of the areas proposed for development were identified by LSRCA for inclusion as part of the Master Plan and are required to meet the policies of the LSPP.

As described below, there were several available sources of land use data that were used to establish the background data and mapping. Differences were noticed between the sources that could lead to discrepancies in our modelling due to the varying land use designations used by different data sources. For example, the land use categories in the Existing Land Category (ELC) GIS file provided by LSRCA differ from the land use categories in the Official Plan (OP) GIS file used by the Town. This presented challenges when trying to accurately represent the land types as curve numbers (CN), runoff coefficients (RC), impervious percentages, and phosphorus loading categories.

The most frequent challenge was encountered when an existing developed area (ELC) has a different zoning category for future development in the OP land use (i.e. existing development that is categorized as urban by ELC is classified as medium density residential in the OP thus having slightly different corresponding design parameters). As an example, the Fennell's Corners study area is shown to be 99.8% developed in the ELC mapping, however the OP mapping shows it to be only 98.7% developed. We reviewed this issue in detail and to ensure the model parameters used are consistent given the different data sources, we have created 'Land Use Conversion Tables' to most accurately equate and adjust the land uses.

1.3 Master Planning Class Environmental Assessment Process

This CSWM-MP was developed following the Municipal Class Environmental Assessment (EA) process for Master Plans to meet the requirements of the Ontario Environmental Assessment Act for municipal infrastructure without having to undertake individual EAs or requesting a specific exemption from the project. The Municipal Class EA process is a planning and design framework to identify, compare and evaluate alternative solutions to a problem. It considers all aspects of the environment: natural, social, cultural and economic, and involves consultation with the public, affected parties and review agencies throughout the process.

Master Plans are long-range plans that integrate infrastructure improvements for existing and future land uses with environmental assessment planning principles.

This CSWM-MP is proceeding through the first two phases of the Class EA process:

Phase 1: Identify the problem

Phase 2: Identify and assess, at a strategic level, alternative solutions, then recommend the preferred Master Plan that can be implemented as separate subsequent projects.

A Public Information Centre (PIC) was held on May 29, 2014 at the Town of Innisfil Town Hall.

This CSWM-MP report has been prepared upon the conclusion of Phases 1 and 2 of the Class EA process and made available for public comment prior to being approved and adopted by the Town.

Projects undertaken to implement specific recommendations made in this CSWM-MP will be the subject of more detailed investigations to fulfil the documentation requirements of the Class EA process. The required Class EA documentation (public notices, letters and PIC documentation) are provided in Appendix H.

2 Problem & Opportunity Statement

Over the past several decades, the Lake Simcoe watershed has experienced pressures from human activities including urban and rural uses, which have impaired the heath of Lake Simcoe and its watershed. Excessive phosphorus loading has been identified as a key cause of the water quality degradation in the lake. An estimated one-third of the phosphorus loadings to Lake Simcoe are caused by stormwater runoff.

The SWM policies of the LSPP require municipalities to prepare a CSWM-MP for all settlement areas that are located in the Lake Simcoe watershed for the purpose of improving the management of stormwater from existing and future development.

2.1 Study Goals, Objectives and Scope of Work

This CSWM-MP will establish opportunities and constraints as they relate to stormwater quality and quantity and serve to establish a comprehensive master drainage and SWM framework to identify existing SWM improvement opportunities and to guide all future development in each settlement area. The implementation of drainage improvements will result in opportunities to minimize erosion, phosphorus loadings, and changes in water balance throughout the Lake Simcoe watershed which are in alignment with the requirements and objectives of the LSPP.

This CSWM-MP has been developed according to LSRCA's Comprehensive Stormwater Management Master Plan Guidelines (CSWM-MP Guidelines), dated April 26, 2011 to meet the intent of the LSPP.

CCTA met with LSRCA staff in January 2013 and confirmed the project terms of reference.

This CSWM-MP has been organized according to the ten steps of the CSWM-MP Guidelines as follows:

Step 1: Scoping;

Step 2: Determine the Study Area for the Settlement Area;

Step 3: Develop a Characterization of the Study Area;

Step 4: Divide the Area into Management Units Where Appropriate;

Step 5: Evaluate the Cumulative Environmental Impact of Stormwater from Existing and Planned Development;

Step 6: Determine the Effectiveness of Existing Stormwater Management Systems;

Step 7: Identify and Evaluate Stormwater Improvement and Retrofit Opportunities;

Step 8: Establish a Recommended Approach for Stormwater Management for the Study Area;

Step 9: Develop an Implementation Plan for the Recommended Approaches; and

Step 10: Develop Programs for Inspection and Maintenance of Stormwater Management Facilities.

3 Scoping (Step One)

The settlement areas to be considered in the CSWM-MP were identified based on the Town's OP. All areas identified as Urban or Village Settlement that were located within the Lake Simcoe watershed, along with the Big Bay Point Resort area were included. The selection of these areas is consistent with the requirements of Policy 4.5 of the LSPP, which defines settlement areas as "urban areas and rural settlement areas (e.g. cities, towns, villages and hamlets) where development is concentrated and lands are designated in municipal official plans for development over the long term". The following is the list of settlement areas considered:

- Alcona;
- Big Bay Point;
- Fennell's Corners;
- Gilford;
- Innisfil Heights;
- Lefroy;
- Sandy Cove; and
- Stroud.

The majority of the land within the Town of Innisfil which is not included within the boundary of these settlement areas is agricultural/rural, with a limited future development opportunity. As such, these areas are not discussed in detail as there are fewer opportunities for SWM improvements to be made.

The Town also requested that three additional settlement areas, which are identified in the Town's OP but outside the LSRCA watershed boundary, be included in the plan for completeness. These areas are Churchill, Cookstown and the Highway 89/Highway 400 commercial lands, all of which are located in the Nottawasaga Valley Conservation Authority watershed (refer to Figure 1). As these areas are not within the LSRCA watershed, they have been included in the mapping for completeness but were not modeled with respect to water balance, phosphorus loading, or hydrology. The general characteristics of these areas are described in Section 5.

4 Determine the Study Area (Step Two)

In determining the study area limits to be assessed in this CSWM-MP, the Town's settlement areas (as listed in the previous section) were used as a starting point. For the areas of Lefroy, Innisfil Heights, Big Bay Point, Stroud and Fennell's Corners it was determined that the settlement area boundary delineated in the Town's OP encompassed a sufficient amount of stormwater related features and future development land to serve as the study areas for the purpose of this study.

The study areas for Gilford, Sandy Cove and Alcona have been adjusted to account for future development which may occur outside of the Town's current settlement area boundary. The Gilford settlement area has a proposed future residential development to the northwest of the defined settlement area. This area drains to a tributary of White Birch Creek, which drains through the Gilford settlement area before discharging into Lake Simcoe. At the request of Town staff, the Sandy Cove settlement area has been adjusted to include the Appeal 55 area, which is located northwest of the intersection of Lockhart Road and 25th Sideroad. The Alcona study area was expanded beyond the current settlement limit to include the Alcona North and South Secondary Plan areas. It is important to note that the inclusion of these areas in this study does not imply the Town's support for or approval of any proposed development. These additional areas were simply added to the study to ensure completeness.

For the purpose of hydrologic modeling, any upstream areas external to the study area which drain through the study area have been modeled in order to predict peak flows; however the upstream external drainage areas are not considered part of the study area for the purpose of the detailed water balance and phosphorous budget calculations.

5 Develop a Characterization of the Study Areas (Step Three)

The study areas have been characterized according to applicable policies and regulations as well as physical watershed characteristics.

5.1 Relevant Information or Direction in Policy Documents

5.1.1 Growth Plan (2006, Office Consolidation June 2013)

The study area is located within the Greater Golden Horseshoe as defined in the Growth Plan. The Growth Plan for the Greater Golden Horseshoe was prepared under the Places to Grow Act (2005) and provides the principles for guiding decisions on how land is to be developed and how resources are to be managed within the subject lands. The Growth Plan provides population and employment forecasts and policies for municipalities to plan for forecasted growth.

5.1.2 Lake Simcoe Protection Plan (July 2009)

The LSPP was developed following passage of the Lake Simcoe Protection Act, in December 2008. Chapter 4 of the LSPP describes the policies related to stormwater management for both existing and planned development. The specific policies from the LSPP related to SWM are summarized as follows:

4.5-SA Within five years, municipalities will prepare and implement comprehensive SWM master plans in accordance with the Municipal Class Environmental Assessment.

4.6 - SA Municipalities are encouraged to implement stormwater retrofits prior to completing a SWM Master Plan if a stormwater retrofit opportunity has been identified as a priority for a settlement area and is economically feasible.

4.7 - DP Municipalities incorporate into their official plans policies related to reducing stormwater runoff volume and pollutant loadings from major and existing development.

4.8 -DP An application for major development shall be accompanied by a SWM plan that demonstrates:

a. Consistency with SWM Master Plans prepared under Policy 4.5, when completed.

b. Consistency with subwatershed evaluations prepared under Policy 8.3 and water budgets prepared under Policy 5.2 of the LSPP, when completed.

c. An integrated treatment train approach to minimize SWM flows and reliance on end-of-pipe controls through measures including source controls, lot-level controls and conveyance techniques.

d. Through an evaluation of anticipated changes in the water balance between pre-development and post-development, how such changes shall be minimized; and

e. Through an evaluation of anticipated changes in phosphorous loading between pre-development and post-development, how the loadings shall be minimized.

4.9-DP SWM works that are established to serve new major development must be designed to satisfy the Enhanced Protection level specified in Chapter 3 of the MOE's Stormwater Management Planning and Design Manual 2003.

4.10-DP Every owner and operator of a new SWM system shall be required to inspect and maintain the works on a periodic basis.

4.11-DP Every owner and operator of a new priority SWM system shall be required to monitor the operation of works, including monitoring the quality of the effluent from the work, on a periodic basis.

4.12-SA The MOE will review the approvals issued under Section 53 of the Ontario Water Resources Act in respect of existing priority SWM works. If a review of an approval for an existing priority SWM system determines that the conditions in the approval are inadequate, having regard to the objectives of the Plan, including the conditions related to inspection, maintenance and monitoring, the approval will be referred to the Director for the purposes of determining whether an amendment to the approval is necessary to assist in meeting the objectives of the plan.

5.1.3 Provincial Policy Statement (April 2014)

The Provincial Policy Statement is issued under Section 3 of the Planning Act and is used by municipalities to develop their official plans and to make decisions on planning matters. All planning matters within the study area must be consistent with the Provincial Policy Statement.

5.1.4 LSRCA Technical Guidelines for SWM Submissions (April 2013)

The LSRCA Technical Guidelines for SWM Submissions applies to all future development located in an area regulated by LSRCA. This document provides detailed guidance regarding SWM requirements to satisfy the LSRCA Watershed Development Policies and LSPP. A number of key policies from this document are summarized below. It should be noted that at present, the Technical Guidelines for SWM Submissions are being revised, with an updated version expected to be released in September, 2016.

- A 'treatment train' approach to SWM is encouraged, using lot level (including rooftop storage, rear yard storage, disconnected roof leaders), conveyance controls (including grassed swales pervious pipe systems) and end-of-pipe controls (including infiltration basins/trenches, oil grit separators, sand filters, dry ponds, wet ponds, hybrid ponds etc.).

- Quantity control is not required if the site is directly adjacent to Lake Simcoe with a safe outlet or connected to a municipal system that is designed to discharge uncontrolled flows from the site to the lake.

- Unless specified otherwise by a subwatershed study, or fluvial geomorphic analysis, the post-development peak flow rates must not exceed pre-development peak flow rates for the 2-year, 5-year, 10-year, 25-year, 50-year and 100-year design storm events.

- It is the developer's responsibility to demonstrate safe conveyance of the Regulatory Storm (the greater of the 100-year design storm or Hurricane Hazel) through the development to a sufficient outlet, such that no adverse impacts to downstream landowners will result.

- The minimum level of water quality treatment required for any development within the LSRCA watershed is the Enhanced Protection Level as per MOECC's SWM Planning and Design Manual (March 2003). This corresponds to the long-term removal of 80% of suspended solids.

- For all new major developments within the LSRCA, a Phosphorous Loading Study is to be completed. Best efforts shall be employed to minimize any increase in loading.

- For all new major developments within the LSRCA, an evaluation of the site water balance must be completed.

- An erosion and sediment control plan must be provided for all development works.

- The following design storms are to be used for modelling sites with drainage areas greater than 5 ha: Regional Storm event, 4-hour Chicago Distribution, 12-hour SCS Type II distributions, and any subwatershed, watershed or master drainage plan storm distributions.

5.1.5 LSRCA Watershed Development Policy (March 2012)

Section 6 of the LSRCA Watershed Development Policy identifies SWM criteria for development located within the Lake Simcoe Basin. The SWM criteria are defined in greater detail in the LSRCA Technical Guidelines for SWM Submissions described above.

5.1.6 LSRCA Integrated Watershed Management Plan (June 2008)

The LSRCA Integrated Watershed Management Plan was prepared under Section 21 of the Conservation Authorities Act and provides expanded and updated information on the Lake Simcoe Environmental Management Strategy Document, State of the Lake Simcoe Watershed (2003). The Plan is intended to be a holistic road-map to provide future direction for the protection and rehabilitation of the Lake Simcoe watershed ecosystem.

5.1.7 Ministry of the Environment and Climate Change SWM Planning & Design Manual (March 2003)

The MOECC SWM Planning and Design Manual provides technical and procedural guidance for the planning, design, and review of SWM practices across Ontario. It is considered the baseline reference document for design and review of SWM applications for approval under section 53 of the Ontario Water Resources Act as administered by the MOECC. The following provides a summary of where to find key aspects in the document regarding SWM quality controls:

- Section 3.3.1.1 outlines the three water quality protection levels: Enhanced, Normal, and Basic; and
- Section 3.3.2 (Table 3.2) outlines SWM facility volumetric sizing requirements based on the water quality protection level, and the level of imperviousness of the contributing drainage area. The Enhanced Level is applicable to all developments within the LSRCA boundary.

5.1.8 Town of Innisfil Official Plan (July 2006)

The Town of Innisfil OP was adopted in 2006, with OMB approvals in 2009, 2010 and 2011. The plan divides the land uses into designations including: Agriculture, Business Park, Commercial, Industrial, Landfill, Institutional, Natural Environment Area, Parks and Open Space, Residential and Stormwater Management. For a detailed list, please refer to Appendix A.

Schedules B1 through B14 of the OP provide specific land use designations in each of the settlement areas.

The following summarize a number of the stormwater management requirements as outlined in Section 7.2 of the OP.

7.2.1: The flood standard shall generally be the Regional design storm. The Town shall control stormwater runoff from new development sites in order to attenuate the 2-year through 100-year storm events, and shall regulate land uses within the limit of the Regional storm.

7.2.2: Runoff quality and quantity shall be addressed for all storm events.

7.2.3: Due to historic developments in the floodplain, releasing water from upstream SWM ponds can lead to further flooding downstream. In such areas, the municipality will explore means of addressing this matter through such efforts as increased stormwater detention, diversion of stormwaters or establishment of municipal drainage easements. Master drainage plans for new growth areas shall also address this matter and identify means to mitigate flooding caused by stormwater management pond release.

7.2.4: All new developments shall incorporate generally accepted Best Management Practices, which shall be the highest level determined to be technically and economically feasible.

7.2.5: In new or expanded settlement areas, a master drainage plan shall be undertaken as a part of the Secondary Plan preparation.

7.2.6: In areas with a master drainage plan, proponents of developments must show how the development is consistent with the master drainage plan. Functional servicing studies shall demonstrate the consistency and provide detail on stormwater management pond sizes and design.

7.2.7: In areas where there is no master drainage plan, an application for more than five new lots or for industrial, commercial and institutional development where impervious areas of over 1,000 square metres and or chemical storage are proposed, shall be required to submit a SWM plan.

7.2.8: SWM ponds shall be naturalized with the opportunity for public pedestrian pathways located around the ponds while ensuring public safety.

We note that the Town has currently initiated their 5-year review of the existing approved OP.

5.1.9 County of Simcoe Official Plan (August 2007)

Section 3.3.16 of the County's OP requires a SWM report to accompany all plans of subdivision and condominium, the creation of more than five (5) lots or units and all industrial, commercial and institutional development where impervious areas of over 1,000 square metres and/or chemical storage and use is proposed. The SWM report is to be prepared according to municipal, provincial and conservation authority requirements.

5.1.10 County of Simcoe Transportation Master Plan (July 2008)

There are no major transportation improvements proposed in the County of Simcoe Transportation Master Plan applicable to the study area. There are, however, a few areas of proposed road widening.

5.1.11 LSPP Phosphorus Reduction Strategy (June 2010)

The Phosphorus Reduction Strategy is intended to serve as a long term framework to reduce annual phosphorus loading into Lake Simcoe to approximately 44 T/year from 72 T/year, which was the average loading between 2002 and 2007. Urban runoff and stormwater account for an estimated 31% of total phosphorus loads to Lake Simcoe. Specifically related to stormwater management, SWM retrofit opportunities have been identified in the Lake Simcoe watershed to reduce phosphorus loadings by approximately 4.2 T/year through the retrofit of quantity facilities (i.e. dry ponds) into water quantity and quality facilities (i.e. wet ponds, wet/dry ponds, and wetlands). LID practices are encouraged for all new development to promote water retention onsite and to enhance the percolation of water through the soil. The goal of Phosphorus Reduction Strategy Direction #3 is no net increase in phosphorus loading from new development. Phosphorus reduction tools identified in the phosphorus reduction strategy document include:

1. Enhanced Level protection for all new SWM systems;

2. retrofit existing SWM facilities;
3. municipal options, e.g. cash-in-lieu offsetting program;
4. explore potential for treating stormwater before it is released into the watershed from new and existing developments;
5. improved clean-out frequency and maintenance of SWM systems;
6. implement innovative technologies and approaches (i.e. LID, water re-use);
7. OGS units in SWM systems;
8. public education and outreach programs;
9. reduce or eliminate phosphorus rich lawn fertilizers;
10. promote natural meadow field lawns that require little or no fertilizer and reduced lawn cutting; and
11. use of rain barrels to harvest rainwater for watering lawns.

5.1.12 Innisfil Creeks Subwatershed Plan (2012)

The following are a number of relevant recommendations and conclusions from the Subwatershed Plan. Please refer to the Subwatershed Plan for a complete list of recommendations.

Recommendation 8-2 (3-21): That the LSRCA, MNR (Ministry of Natural Resources, now Ministry of Natural Resources and Forestry) and MOE analyse and report the results of the existing and proposed water quality, water quantity, and aquatic and terrestrial natural heritage monitoring programs annually, and that the information be used to update the LSRCA Watershed Report Card. Further, stakeholders should be made aware when updates are available, and be provided access to the monitoring data collected via a web portal, to increase distribution and communication of this data.

Recommendation 6-3: That the MNR, MOE, and LSRCA review the terrestrial natural heritage data provided by the comprehensive monitoring program, when it becomes available, to define site level characteristics or indicators of “high quality” natural heritage features, and provide policy recommendations to subwatershed municipalities (as necessary) to ensure high quality natural heritage features are adequately protected from development and site alteration.

Recommendation 4-8: That municipalities incorporate the requirement for the re-use or diversion of roof top runoff (clean water diversion) from all new development in significant recharge areas away from storm sewers and infiltrated to maintain the predevelopment water balance (except in locations where a hydrogeological assessment indicates that local water table is too high to support such infiltration) in their municipal engineering standards.

Recommendation 4-9: The MOE should only issue Environmental Compliance Approvals (ECA) for new storm water management facilities within significant recharge areas that maintain the pre-development groundwater recharge rates and meet the enhanced water quality criteria outlined in the MOECC Stormwater Management Guidance Document, 2003, as amended from time to time.

Recommendation 4-10: The MOE shall only issue an ECA for SWM facility retrofits within significant recharge areas that attempt to improve, maintain or restore the pre-development water balance, and meet the enhanced water quality criteria outlined in the MOE SWM Guidance Document, 2003, as amended from time to time.

Recommendation 3-1: That the LSRCA, with the support of the MOE, provide a white paper to subwatershed municipalities describing the range of LID technologies that could potentially be used to mitigate the impacts of development on surface and groundwater quality and quantity. Further, that the LSRCA and subwatershed municipalities identify the barriers associated with the uptake of LID technology and, with the support of MOE, develop recommendations for overcoming these barriers.

Recommendation 3-3: That the subwatershed municipalities, with the assistance of the LSRCA, promote the increased use of innovative solutions to address Stormwater management and retrofits such as:

- enhanced street sweeping and catch basin maintenance, particularly in those areas currently lacking stormwater controls;
- improving or restoring vegetation in riparian areas;
- Installation of rainwater harvesting; construction of rooftop storage and/or green roofs; the use of bioretention areas and vegetated ditches along roadways;
- use of soakaway pits, infiltration galleries, permeable pavement and other LID solutions, where conditions permit; and
- on-going inventory, installation, and proper maintenance of oil and grit/hydrodynamic separators combined.

5.1.13 Barrie Creeks, Lovers Creek, and Hewitt's Creek Subwatershed Plan (2012)

Many of the recommendations and conclusions from the Innisfil Creeks Subwatershed Plan are also included in the Barrie Creeks, Lovers Creek, and Hewitt's Creek Subwatershed Plan. A number of additional relevant recommendations are listed below. Please refer to the Subwatershed Plan for a complete list of recommendations.

Recommendation 6-6: That the City of Barrie and Town of Innisfil, with the assistance of the MNR and LSRCA, give consideration to including policies in their respective Official Plans to contribute to the protection of grassland habitats, as necessary, based on the results of Recommendation #6-6, and recognize the need for balance in the approach to development in urban areas.

Recommendation 4-7: Municipalities should amend their planning documents to require that runoff in significant recharge areas meet the enhanced water quality criteria outlined in the MOE SWM Guidance Document, 2003, as amended from time to time, prior to it being infiltrated.

Recommendation 4-13: Municipalities shall collaborate with the LSRCA to promote infiltration of clean water in significant recharge areas, and prioritize stormwater retrofits utilizing water quality controls, and ultimately infiltration devices for treated stormwater runoff.

Recommendation 4-14: The MOE should consider providing financial assistance to implement stormwater management facility retrofits and infiltration projects within significant recharge areas.

Recommendation 3-8: That Official Plans be amended to contain policies that would help minimize impervious surface cover in Barrie, Lovers and Hewitt's Creeks subwatersheds through requirements such as using low impact development solutions, limiting impervious surface areas on new development, and/or providing stormwater rates rebates and incentives to residential and non-residential property owners demonstrating best practices for managing stormwater.

5.2 Watershed Context

The Town is divided by the drainage boundary between LSRCA and NVCA (refer to Figure 1), with a majority of settlement areas located within the LSRCA watershed. The settlement areas of Cookstown, Churchill and the Highway 89/400 Commercial area are located entirely within the NVCA boundary, while Innisfil Heights and Fennell's Corners are located in both the NVCA and LSRCA watershed. Within the LSRCA boundary, the Town is divided into three (3) subwatersheds: Hewitt's Creek, Lovers Creek, and the Innisfil Creeks.

The Innisfil Creeks watershed is 107.2 km^2 in size and is comprised of 17 named streams, all of which flow from west to east into Lake Simcoe with the exception of Strathallan Creek which flows north into Kempenfelt Bay. The Innisfil Creeks subwatershed is located mainly within the Town of Innisfil (96%), with small portions falling with the City of Barrie limits (3.3%) and the Town of Bradford West Gwillimbury (0.7%).

5.2.1 Hewitt's Creek Subwatershed

The Hewitt's Creek subwatershed is the smallest watershed contributing to Lake Simcoe with a total drainage area of 17.5 km^2. The Hewitt's Creek subwatershed is located mainly in the Town of Innisfil (60%), while the remaining 40% is located in the City of Barrie. The Stroud settlement area is located partly in the Hewitt's Creek subwatershed.

5.2.2 Lovers Creek Subwatershed

The Lovers Creek subwatershed has a total drainage area of 59.9 km² and comprises 2.3% of the total drainage area to Lake Simcoe. The Lovers Creek subwatershed is located mainly in the Town of Innisfil (58%), while the remaining 42% is within the City of Barrie. The Stroud and Innisfil Heights settlement areas are located in part in the Lovers Creek subwatershed.

5.2.3 Innisfil Creeks Subwatershed

As the majority of the development within the Town is located near the shoreline of Lake Simcoe, the majority of the study areas are at the downstream end of one or more of the Innisfil Creeks.

The Alcona study area consists of a total of 1,569.1 ha of land and is located along the shores of Lake Simcoe in the central quadrant of the Town. The study area is at the downstream end of Leonard's, Bon Secours, Banks, and Moyer Creeks subwatershed, as well as Burt's Drain and has a total of 21 existing SWM facilities.

The Big Bay Point study area consists of a total of 239.1 ha of land and is the most northern settlement area in the Town. There is no defined creek or stream in the study area; therefore the stormwater runoff drains directly into Lake Simcoe. There are currently no SWM facilities in the study area.

The Fennell's Corners study area consists of a total of 24.2 ha of land. A total of 18.5 ha of this area drain to Lake Simcoe, while the remaining area drains to the NVCA watershed. The study area is approximately 4 km west of Gilford, and is in the headwaters of White Birch Creek. This study area has one existing SWM facility (Pond #15-1).

The Gilford study area is located on the shores of Lake Simcoe, and is the most southerly settlement area. The study area consists of a total of 186.9 ha of land and is located at the downstream end of the White Birch and Gilford Creeks subwatersheds. There are no existing SWM facilities in Gilford.

The Innisfil Heights study area consists of a total of 400.6 ha of land, however 133.4 ha are within the NVCA drainage boundary. The remaining 267.2 ha are located within the headwaters of the Lovers Creek watershed. There are a total of four (4) existing SWM facilities in the study area.

The Lefroy study area consists of a total of 483.8 ha of land and is located on the shores of Lake Simcoe in the southeast quadrant of the Town of Innisfil. The study area is at the downstream end of both the Belle Aire and Carson Creeks subwatersheds. There are no existing Town assumed SWM facilities in Lefroy, however there are three approved facilities which are currently under construction as part of the LSAMI developments. These SWM facilities will not be assumed by the Town until all construction activities in relation to the LSAMI developments has been completed.

The Sandy Cove study area is 501.5 ha of land in size and is located on the shores of Lake Simcoe in the northeast quadrant of the Town. This study area is at the downstream end of both the Sandy Cove Creek and Mooselanka Creeks. Sandy Cove currently has two (2) existing SWM facilities.

The Stroud study area consists of a total of 233.2 ha, and is located within the headwaters of both the Hewitt's and Lovers Creeks watersheds. Approximately 109.3 ha drains to Hewitt's Creek, while the remaining 123.9 ha drains to Lovers Creek. There are a total of four (4) existing SWM facilities in the study area, with an additional approved facility (Pond #10-4) currently under construction for the Innisfil Executive Estates development.

5.3 Natural Heritage System Information

The LSRCA Natural Heritage System for the Lake Simcoe Watershed (July 2007) identifies components of the Natural Heritage System (NHS) across the study areas including significant habitats for endangered and threatened species, wetland, woodlands, valley lands, wildlife and fish habitats, areas of natural and scientific interest and linkages.

The NHS land covering each study area was created using the NHS mapping in the LSRCA Natural Heritage System for the Lake Simcoe Watershed Phase 1: Components and Policy Templates (LSRCA, June 2007) document. The NHS throughout the study area is illustrated on Figure 4. A four-tiered policy approach was utilized to direct the protection of the natural features of the NHS where Levels 1 and 2 are assigned a "provincially significant" designation and considered to be those features that would be identified if following the guidelines and intent of the Provincial Policy Statement (2005). Level 3 applies to features with significance at the watershed level. Level 4 applies to supporting features that support elements of the natural heritage system within the watershed. The Recommended Policy Levels (Level 1 to 4) and the implications on development or land use change are defined in the Natural Heritage System for the Lake Simcoe Watershed document. All new development proposed within the settlement expansion areas is to be accompanied by an updated Natural Heritage Investigation.

See Table 1 for a breakdown of the Levels 1 to 4 features in the Innisfil Creeks, Lovers Creek and Hewitt's Creek subwatersheds. Table 2 provides a brief summary of natural heritage features by study area.

Table 1: Natural Heritage Features by Subwatershed

	Area of Subwatershed (ha)	Percent of Subwatershed in NHS	Percent of Subwatershed by Level			
			Level 1	Level 2	Level 3	Level 4
Hewitt’s Creek	1751	22.3	10.5	3.1	6.9	1.8
Innisfil Creeks	10757	33.3	17.4	5.6	6.0	4.3
Lovers Creek	5995	34.0	21.8	5.2	3.4	3.6

Table 2: Summary Description of Natural Heritage Features by Study Area

Study Area	Summary of Natural Heritage Features
Alcona	Areas of all 4 Levels (1-4). Total NHS area is 379.62 ha. 33% is woodlot, 34% is meadow/thicket, 33% is wetland.
Big Bay Point	The majority of the study area is covered in Level 1 NHS features as well as a few areas designated as Level 2. Total NHS area is 157.78 ha. 64% is woodlot, 28% is wetland, 8% is meadow/thicket.
Fennell’s Corners	No NHS features.
Gilford	The Gilford settlement area has very few areas of NHS features, which are classified as Levels 3 and 4. However, the expanded study area consists almost entirely of NHS Level 2, 3 and 4 features. Total NHS area is 63.41 ha. 35% is woodlot, 56% is meadow/thicket, 9% is wetland.
Innisfil Heights	Small areas of Levels 2-4. Total NHS area is 59.82 ha. 36% is woodlot, 64% is meadow/thicket.
Lefroy	Study area is covered by numerous NHS Level 1 features throughout the entire study area. There are also a few small areas with Level 2, 3 and 4 features. Total NHS area is 185.48 ha. 37% is woodlot, 11% is meadow/thicket, 52% is wetland.
Sandy Cove	Study area consists of a number of larger NHS Level 1, 2 and 3 features, with a small area of Level 4 on the western limits of the study area boundary. Total NHS area is 163.48 ha. 80% is woodlot, 5% is meadow/thicket, 15% is wetland.
Stroud	Study area has minimal NHS features. Total NHS area is 4.37 ha. 35% is woodlot, 65% is meadow/thicket.

The natural heritage land is further divided into detailed land uses as follows:

- coniferous forest;
- coniferous swamp;
- cultural meadow;

- cultural thicket;
- cultural woodland;
- deciduous forest;
- deciduous swamp;
- meadow marsh;
- mixed forest;
- mixed shallow aquatic;
- mixed swamp;
- open water;
- shallow marsh;
- thicket swamp;
- submerged shallow aquatic; and
- cultural plantation.

5.4 Soil Conditions

Soil characterization for the Town has been provided by the Soil Survey of Simcoe County (Report 29 of the Ontario Soil Survey, Research Branch Canada Department of Agriculture and Ontario Agricultural College, 1962) and is illustrated on Figure 3. The predominant soil type in the area is sandy loam (Type AB). Please see Appendix A for the detailed soil breakdown for each study area.

5.5 Natural Hazards

The LSRCA regulates potential natural hazard lands which may present a threat to human safety and/or the environment. These include floodplains, erosion prone areas (including meander belt) and wetland areas. The natural hazard areas, which are taken from LSRCA Regulation mapping, are illustrated on Figure 6.

In most circumstances, the natural hazard areas are conservatively estimated by LSRCA, however, detailed floodplain, erosion and wetland evaluations are available for certain areas. All future development located in an area regulated by LSRCA requires permitting from the LSRCA including detailed analysis and confirmation of the natural hazard areas in accordance with the Conservation Authorities Act (O. Reg. 179/06) and the Planning Act.

In addition, the Town has identified a number of areas which are known to be prone to flooding. There are two areas in Gilford which experience flooding; one at the downstream area of White Birch Creek, and the other at the downstream end of the unnamed creek directly north of White Birch Creek. The need for a reduction of peak flows to these areas will be assessed in the hydrologic model in Section 7.1.

There is also a known flood prone area in Lefroy in the Spooner's Road and Temple Avenue area. This area is at the downstream end of Carson Creek. The effectiveness of reducing peak flows to this area for the purpose of flood reduction will be assessed in the hydrologic model in Section 7.1.

In Alcona, there is a flood prone area at the downstream end of Leonard's Creek. Reducing peak flows to this area will be assessed using the hydrologic model in Section 7.1.

5.6 Significant Groundwater Features & Functions

Following the Walkerton tragedy in 2000, the province enacted the Clean Water Act (2006) introducing source water protection for the Province's drinking water resources. The approved assessment report that governs the Town is titled Approved Lake Simcoe and Couchiching - Black River Source Protection Area, Part 1: Lake Simcoe Watershed Assessment Report (November 2011). Chapter 10 of the above document discusses source water protection areas in the Town of Innisfil.

Included in the above mentioned report is a figure (Figure 4.3-2) illustrating Significant Groundwater Recharge Areas (SGRA) and Vulnerability Scores. SGRA's are defined as areas where recharge is 15% greater than the average recharge in the Lake Simcoe Basin, which allows surface water to infiltrate into the ground and flow to an aquifer. The information from Figure 4.3-2 has been used to illustrate the SGRA's in the study areas, which are shown on Figure 5. These areas are characterized as significant in maintaining the water level in an aquifer that supplies a community with drinking water or contributes groundwater to an ecosystem that depends on recharge to maintain its ecological function (i.e. a surface watercourse). The Vulnerability Score of an SGRA is determined by its proximity to a well and how easily water can travel through it including factors such as soil type, water table elevation, contaminant concentration, and the confined/unconfined nature of the aquifer. A Vulnerability Score of 2 represents a low risk area, a Vulnerability Score of 4 represents a medium risk area, and a Vulnerability Score of 6 represents a high risk area. It is noted that the information illustrated on Figure 5 is based on a broad level assessment and the best available information at the time of this report. These will be confirmed with more detailed analysis being conducted as part of the Tier 2 water budget by the LSRCA. The SGRA's in each study area are summarized briefly in Table 3 below.

Table 3: Summary Description of Significant Groundwater Features by Study Area

Study Area	Summary of Significant Groundwater Features
Alcona	The study area has minimal SGRAs, with a few small areas of each of the three (3) levels of SGRAs.

Study Area	Summary of Significant Groundwater Features
Big Bay Point	The study area is covered by a large area of Level 2 SGRA. There are also a few small areas of Level 4 and 6.
Fennell's Corners	The study area has a very small Level 2 SGRA and no Level 4 or 6 SGRAs.
Gilford	The study area consists of a large block of Level 2 SGRA. There are no Level 4 or 6 SGRAs in Gilford.
Innisfil Heights	The study area has minimal SGRAs, with a small number of Level 2, 4 and 6 located on the outer limits of the study area boundary.
Lefroy	The study area has a few larger blocks of Level 2 and 4 SGRAs, with a very small block of Level 6 in the northwest corner of the study area boundary.
Sandy Cove	The study area is covered by a mixture of Level 2 and 6 SGRA, with a small area of Level 4.
Stroud	The study area has minimal SGRAs, only a few small areas of each of the three (3) levels of SGRAs.

5.7 Surface Water Features & Functions

Surface drainage across the study areas which are located in the Innisfil Creeks subwatershed is generally flows to the east via the numerous watercourses which drain into Lake Simcoe. In the study areas of Stroud and Innisfil Heights which are in the Lovers Creek and Hewitt's Creek subwatersheds respectively, the drainage direction is generally to the north, eventually draining into Kempenfelt Bay. Figure 10, which is appended, provides a map of all watercourses in the Town.

5.8 Known Wellhead & Intake Protection Areas

There are a number of Town supply wells located within both the LSRCA and the NVCA watersheds. There is also a surface water intake located in the south-west shore of Lake Simcoe at the inlet to Cook's Bay. This surface water intake system serves roughly 12,500 people, and the Intake Protection Zone (IPZ) extends along the shoreline of the Alcona study area and inland for a short distance along a few tributaries, including Innisfil Creek. The wellhead protection areas (WHPA) for each study area are shown on Figures 7-A through 7-K, and are briefly summarized in Table 4.

Table 4: Summary Description of Wellhead Protection Areas by Study Area

Study Area	Summary of Wellhead Protection Areas
Alcona	No WHPAs.
Big Bay Point	No WHPAs.

Study Area	Summary of Wellhead Protection Areas
Fennell's Corners	The Goldcrest well supply consists of two wells located in the Fennell's Corners study area, and services approximately 200 people. The WHPA extends in a southwest direction.
Gilford	The Golf Haven well supply consists of two wells located within the Gilford study area on the shores of Cook's Bay. The system services approximately 500 people, and the WHPA extends westward away from Lake Simcoe and the lakeshore properties.
Innisfil Heights	There are two wells located in the Innisfil Heights study area which service over 200 people. The WHPAs extend west over Highway 400.
Lefroy	No WHPAs.
Sandy Cove	No WHPAs.
Stroud	There are three wells located in the Stroud study area, which service approximately 1,900 people. The WHPAs extend slightly south east across the Stroud study area.

There are also a number of Town supply wells located within the NVCA watershed. These wells are located within Churchill and Cookstown. There are also wells located in Barrie (LSRCA watershed) and Essa (NVCA watershed) for which the WHPAs extend into the Town of Innisfil. Please refer to Figures 7-A through 7-K for a detailed map showing the supply well locations.

5.9 Existing Stormwater Management Facilities & Systems

There are a total of 41 existing SWM facilities currently providing stormwater quantity and quality control in the Town. These SWM facilities range in age, design criteria and function. Part 1 of the SWM Master Plan, completed by Hatch Mott MacDonald in 2013, compiled a list of all SWM facilities and completed an assessment of their quality and quantity controls, and identified retrofit opportunities.

Within the study areas, there are a number of SWM facilities which control stormwater runoff from existing residential and industrial/commercial developments. Where possible, the stage-storage-discharge function of these ponds has been modelled to incorporate them into the hydrologic modelling completed in this report. The existing SWM facilities for each study area are shown on Figures 7-A through 7-K. The complete list of existing SWM facilities is included in Table 5. There are also a number of SWM facilities that are either under construction for approved developments or planned for proposed development applications; these facilities are identified in Table 6.

Table 5: Existing SWM Facilities

Pond ID	Pond Name	Year of Construction	Type	Study Area (if applicable)
4-1	Valleyview	1987	Dry	NVCA
4-2	Coralwoods	1990	Dry	NVCA
9-1	Alcona Woods	1988	Dry	Alcona
9-2	Southview	1988	Dry	Stroud
9-3	Victoria Green	1986	Dry	Stroud
10-2	Village North Dempster	1988	Dry	Stroud
13-2	Monrepos	1988	Dry	
15-1	Goldcrest	1990	Dry	Fennell’s Corners
6-1	Previn Court Stage 1	2002	Wet	Alcona
7-2	Wallace Mills Phase 2	1998	Wet	Alcona
7-3	Wallace Mills Phase 1	2002	Wet	Alcona
7-4	Forest Valley	1998	Dry	Innisfil Heights
7-8	ORSI	1999	Wet	Alcona
8-1	Trillium Industrial	1993	Dry	Innisfil Heights
8-2	Taylorwoods	1996	Dry	Alcona
8-4	Crossroads #2	1993	Wet	Alcona
8-5	Skivereen Subdivision	1999	Wet	Alcona
9-4	Doral East	2002	Wet	Innisfil Heights
9-5	Doral West	2002	Wet	Innisfil Heights
10-1	Brandy Lane/Village North	1992	Wet (Retrofit)	Stroud
10-3	McKee	1999	Wet	Sandy Cove
6-2	Tepco North	2005	Wet	Alcona
6-3	Tepco South	2005	Wet	Alcona
7-1	Royal Alcona	2007	Wet	Alcona
7-5	Innisbrook Developments Phase 2	2003	Wet	

Pond ID	Pond Name	Year of Construction	Type	Study Area (if applicable)
7-6	Innisbrook Subdivision	2009	Wet	Alcona
7-7	Green Acres (South)	2004	Wet	Alcona
7-9	Green Acres (North)	2005	Wetland	Alcona
7-10	Green Acres (West)	N/A	N/A	Alcona
7-11	Woodland Park North	N/A	N/A	Alcona
7-12	Woodland Park South	N/A	N/A	Alcona
7-13	South Rec Centre	2008	Wet	
7-14	Innisfil Admin Building Back	2008	Wet	
7-15	Innisfil Admin Building Front	2008	Wet	
8-6	Pratt Alcona North	N/A	N/A	Alcona
8-3	Crossroads Ph 1 Retrofit	2011	Wet (Retrofit)	Alcona
8-7	Pratt D’Amico Phase 1	N/A	N/A	Alcona
8-9	Crossroads Addulum	N/A	Wet	Alcona
13-1	Kempenfelt Bayside Estates	2004	Wet	
13-3	South Shore Woods	2004	Wet	
10-5	RIROB	N/A	On-line	Sandy Cove

Table 6: Proposed/Under Construction SWM Facilities

Pond ID	Pond Name	Year of Construction	Type	Study Area (if applicable)
10-4	Innisfil Executive Estates	Under Construction	Wet	Stroud
3-1	LSAMI Lefroy P4	Under Construction	Wet	Lefroy
3-2	LSAMI Lefroy P3	Under Construction	Wet	Lefroy
4-3	LSAMI Lefroy P1/P2	Under Construction	Wet	Lefroy
14-1	Belpark	Under Construction	Wet	Cookstown

Pond ID	Pond Name	Year of Construction	Type	Study Area (if applicable)
15-2	Cookshill North	Under Construction	Wet	Cookstown
14-2	Cookshill South	Under Construction	Wet	Cookstown
7-16	Alcona Downs	Under Construction	Wet	Alcona
8-10	Bremont (Forest Edge)	Under Construction	Wet	Alcona
8-11	Sandy Trail	Under Construction	Wet	Alcona

Further discussion related to these SWM facilities can be found in Section 8.

5.10 Existing Land Uses

The following section describes the existing land uses for the three (3) subwatersheds which drain into Lake Simcoe in the Town of Innisfil. The land use data for areas within the LSRCA boundary was provided by the LSRCA on a digital GIS file titled "Existing Land Condition" (ELC). The existing land use is shown on Figure 2, and is summarized Appendix A.

Innisfil Creeks

The land use within the Innisfil Creeks subwatershed is dominated by undeveloped land. The two largest land uses are agriculture (45%) and natural heritage cover (33%). The natural heritage cover is described in further detail in Section 5.3. The existing land use for the individual study areas differs from that of the overall subwatershed, and has been briefly described below.

The Sandy Cove study area has seen a substantial amount of development, however there is still a large portion of natural heritage and agriculture land use (approximately 50%). The developed land consists mainly of urban and road areas, amounting to 50% of the total study area. There are no industrial or commercial land designations on the existing conditions mapping for Sandy Cove.

Alcona has also experienced a large amount of development, as approximately 71% of the study area is developed. Development consists of a mix of urban, road, institutional, industrial and commercial land uses. The undeveloped and natural areas include natural heritage cover, agriculture, open space and golf course area, which total 29% of the study area.

The Gilford study area is approximately 59% developed, consisting of a mix of urban and rural developments. There are no industrial, institutional or commercial land use designations.

The Big Bay Point study area is by far the least developed of all of the study areas. Currently, only 5% the land is developed, consisting of rural development and roadway. The remaining 95% of the area is dominated by various natural heritage and agriculture features.

The Lefroy study area has a similar ratio of development as Sandy Cove, with approximately 41% of land consisting mainly of urban developments. The remaining 59% of the area is dominated by various natural heritage and agriculture features.

Fennell's Corners is the smallest study area, and is almost entirely developed with 99.8% of land designated as urban or rural development.

Hewitt's Creek

Similar to the land use within the Innisfil Creeks subwatershed, the Hewitt's Creek subwatershed is dominated by undeveloped land. The two largest land uses are non-intensive agriculture (52%) and natural heritage cover (21%). The natural heritage cover is described in further detail above in Section 5.3. The Stroud study area is located partially within the Hewitt's Creek subwatershed, while the remaining area drains to Lovers Creek.

The Stroud study area has a similar development ratio to Alcona, with 68% of the area currently developed. The remaining 32% of the land consists mainly of agriculture as there is very little natural heritage cover in the study area.

Lovers Creek

The Lovers Creek subwatershed is also dominated by natural heritage features (35%) and agricultural land (34%). The natural heritage cover is described in further detail in Section 5.3. The Innisfil Heights study area is located partially in the Lovers Creek subwatershed, while a portion of it drains into the NVCA watershed. As previously mentioned, the Stroud study area is also located partially within the Lovers Creek subwatershed.

The Innisfil Heights study area consists of 62% of developed land, mainly consisting of industrial areas. There is a small amount of residential land present with the remaining 38% of the area consisting of various natural heritage and agriculture features.

5.11 Land Use Designation in the Official Plan & Zoning By-Law

The Town's Official Plan has designated proposed future land uses for each of the settlement areas. On average, each study area will increase in developed land by approximately 50% (excluding Big Bay Point and Fennell's Corners). The Official Plan land use is shown on Figures 7-A through 7-K, and is summarized in Appendix A.

Table 7 summarizes the difference in developed land between the existing and proposed land uses. Refer to Appendix D for assumptions made to distinguish which land use categories classified as “developed”.

It should be noted that there is an existing Official Plan Appeal (Appeal #55) to the north west of the Sandy Cove settlement area. This area has been included in the study area boundary, but as there is no current development plan for the area, it has not been considered as future developed land in any of the modelling scenarios. As such, it is not included in the total land use in Table 7.

Table 7: Developed vs. Undeveloped Land Use

	Gilford	Sandy Cove	Stroud	Lefroy	Fennels Corners	Innisfil Heights	Big Bay Point	Alcona
Existing Developed Land (ha)	109.62 (58.6%)	248.82 (49.6%)	158.68 (68.1%)	200.41 (41.4%)	18.43 (99.8%)	166.12 (62.2%)	12.40 (5.2%)	738.55 (47.1%)
Proposed Developed Land (ha)	168.51 (90.1%)	393.17 (78.4%)	220.13 (94.4%)	298.49 (61.7%)	18.23 (98.7%)	258.04 (96.6%)	239.08 (100%)	1,291.88 (82.3%)
Increase	53.7%	58.0%	38.7%	48.9%	N/A	55.3%	N/A	74.9%
Existing Undeveloped Land (ha)	77.38 (41.4%)	252.72 (50.4%)	74.49 (31.9%)	283.34 (58.6%)	0.04 (0.2%)	101.03 (37.8%	226.69 (94.8%)	830.57 (52.9%)
Proposed Undeveloped Land (ha)	18.48 (9.9%)	108.37 (21.6%)	13.04 (5.6%)	185.26 (38.3%)	0.24 (1.3%)	9.11 (3.4%)	0.00 (0%)	277.23 (17.7%)
Decrease	318.7%	133.2%	471.2%	52.9%	N/A	1009.0%	N/A	199.6%
Total Area (ha)	186.99	501.54	233.17	483.75	18.47	267.15	239.08	1,569.12

5.12 Stormwater Facility Retrofit Opportunities Previously Identified by the LSRCA or Municipality

As mentioned above, Part 1 of the SWM Master Plan by Hatch Mott MacDonald (2013) compiled a list of all SWM facilities and identified a number of retrofit opportunities. These retrofit opportunities are summarized in Section 8.

5.13 Potential Land Use Changes

The land designations provided in the OP have been used to represent the future land use scenario, which show increase in development in comparison with the existing land use categories. There are a number of OP Appeals, which may alter the OP land uses in the future. It will be expected that all future development not currently addressed in this CSWM-MP will follow Town guidelines, as well as any applicable recommendations made in this report.

6 Management Units (Step Four)

The study areas, as previously outlined, will serve as individual units for modelling and discussion purposes. The only area which is divided into Management Units is Alcona. As separate modeling has been completed for the Alcona North and South Secondary Plans, the remaining area has been included separately as Alcona Central.

7 Cumulative Environmental Impacts of Stormwater From Existing & Planned Development (Step Five)

An evaluation of the cumulative environmental impact of stormwater from existing and planned development was completed based on the anticipated changes in land use contained in the Town's OP. The average planned increase in developed land across the study areas is 29%, and will consist mainly of urban and rural residential development, as well as some commercial and industrial zones. An analysis of the impacts of stormwater in terms of peak flow, erosion, phosphorus and water budget will be assessed in the sections below.

7.1 Water Quantity

In July 2011, a hydrologic study was completed by URS which modeled the Hewitt's Creek, Sandy Cove, Mooselanka, Gilford, and Lovers Creek subwatersheds. These subwatersheds include a large portion of the CSWM-MP study areas. The URS analysis was completed using Visual OTTHYMO (VO2) hydrologic model software, and applied the Chicago and SCS Type II design storms. For the purpose of this CSWM-MP, the URS model data and catchment delineations have been used where possible. For the study area watercourses in the Innisfil Creeks subwatershed that were not covered by the URS model, we applied the most refined catchment delineation provided by the LSRCA (GIS shape file called '125 ha') and developed new VO2 models where necessary.

For the purpose of comparing flows from the study areas, a number of the URS catchments were further divided based on the study area boundaries to enable us to isolate and compare the flows from increased development within each study area. Catchments were also further divided to model the function of existing SWM facilities in the area (i.e. if the upstream catchment information for a SWM facility was available, a separate catchment was created to accurately model the function of that SWM facility).

Using the applicable URS modelling with our revised and additional catchment areas, a VO2 model was created. Peak flow rates for the 4-hour Chicago and 12-hour SCS Type II design storms were determined for the 2, 5, 10, 25, 50, and 100-year return periods. The Regional storm event (Hurricane Hazel) was also calculated for both the existing and future land use conditions.

In keeping with Town standards, rainfall data from the Barrie WPCC station has been used. For the SCS storms, a 12-hour SCS Type II mass storm file has been used, using total precipitation depths for the 12-hour storm event from the Barrie WPCC data. The 4-hour Chicago storm event has also been modeled using the Barrie WPCC rainfall data to determine the peak flows under existing and future conditions. In order to model a climate change scenario, we have chosen to use the Barrie WPCC data as our baseline, and applied a 15% increase in rainfall intensity to represent the climate change scenario. Only the 12-hour SCS storms have been modelled for climate change.

Land uses and necessary catchment parameters were established using a combination of digital land use information provided by the LSRCA and the Town, and were verified with current aerial photography. The calculated total impervious (TIMP) and directly connected impervious (XIMP) for existing developed areas and future expansion areas were derived using a number of sources including the Town's Zoning By-Law, the LSRCA SWM Guidelines and aerial photography. As the land use categories differ between the existing (ELC) and future (OP) conditions, and a number of them are common land use categories used in the LSRCA SWM Guidelines, MOECC SWM Planning and Design Manual or Town standards, conversion tables were created to equate the land use categories and define parameters for each. Appendix D outlines the corresponding hydrologic input parameters for each land use, and the source the value was derived from. These tables summarize the assumed CN numbers corresponding to each land use (existing and future), the TIMP and XIMP values, and the runoff coefficients. The tp values for the catchment areas were calculated using the Bransby-Williams Formula and Airport Method for runoff coefficients greater than and less than 0.4 respectively.

The total rainfall depths used in the hydrologic model reflect the Barrie WPCC station, utilizing rainfall data between 1979 and 2003. The climate change scenario represents an increase of approximately 15% in comparison to the non-climate change scenario. It should be recognized that there are a variety of climate change projection models available, which produce a wide range of potential future rainfall depths. The City of Barrie IDF curves adapted for climate change have been accepted for use by LSRCA and NVCA. As such, these locally accepted values have been applied to the modelling completed in this CSWM-MP. The total rainfall depths for the SCS storms are summarized in Table 8.

Table 8: Total Rainfall Depths

Storm Event	Depth (mm)	
	12-hr SCS (no climate change)	12-hr SCS (climate change)
2-year	40.8	46.8
5-year	56.4	64.8
10-year	66.0	75.6
25-year	79.2	91.2
50-year	88.8	102.0
100-year	98.4	112.8
Regional (Hazel)	212	

7.1.1 Existing Conditions Hydrology

The existing conditions model has been developed using the existing land use data provided by the LSRCA (the ELC GIS data). The existing conditions hydrologic model incorporates the major existing SWM facilities to represent the quantity controls currently provided. The stage-storage-discharge tables used in the model were derived from design or 'as-built' drawings and reports provided by the Town, and approximate existing conditions. This is an approximation of current pond conditions recognizing field confirmation or site measurements were not complete for all ponds to confirm existing conditions. Where drawings or reports were not available, the stage-storage-discharge relationship was estimated from the surveys completed in the Part 1 SWM Master Plan. The ponds included in the existing model and the contributing upstream catchment areas are listed in Table 9.

Table 9: Existing SWM Facilities for Hydrologic Model

Study Area	Pond Name	Pond ID	VO2 ID	Upstream Catchment Area (ha)	Upstream Catchment % Impervious (Existing)	Upstream Catchment % Impervious (Future)
Fennell's Corners	Goldcrest	15-1	5	12.53	45.00	59.56
Innisfil Heights	Trillium Industrial	8-1	3	30.89	32.00	51.97
Innisfil Heights	Doral East	9-4	21	21.67	37.00	79.39
Innisfil Heights	Doral West	9-5	23	7.65	43.00	84.41
Innisfil Heights	Forest Valley	7-4	29	9.86	25.00	37.44
Stroud	Southview	9-2	28	28.07	42.00	54.31
Stroud	Brandy Lane	10-1	26	15.63	46.00	58.03
Stroud	Village North	10-2	27	30.99	41.00	53.00
Stroud	Victoria Green	9-3	24	23.9	42.00	55.29
Sandy Cove	Mckee	10-3	5325	11.94	32.00	41.15
Sandy Cove	RIROB	10-5	5330	225.65	N/A	N/A
Alcona	Taylorwoods	8-2	3	13.56	46.95	60.23
Alcona	Woodland North	7-11	7	11.44	44.54	49.67
Alcona	Woodland South	7-12	4	5.9	45.00	50.00
Alcona	Pratt Alcona	8-6	1	8.39	38.94	51.93
Alcona	ORSI	7-8	6	32.53	17.13	38.02
Alcona	Royal Alcona	7-1	5	40.37	45.18	54.21

A detailed description of each of the above ponds can be found in Section 8, as well as in the Part 1 SWM Master Plan.

The existing condition catchment parameters (weighted curve numbers, runoff coefficients and total imperviousness) were calculated using ARCGIS. The detailed catchment parameters for the existing conditions can be found in Appendix D.

Existing conditions peak flows have been recorded at significant hydrologic reference points (HRPs) in the model in order for comparison with the future conditions model. The existing conditions peak flows for the 12-hour SCS Type II design storm have been summarized in Table 10 at the HRPs. Detailed model results for all study areas and for the 12-hour SCS Type II and 4-hour Chicago design storms are included in Appendix D (VO2 Output).

Table 10: Existing Condition Peak Flow Summary at Hydrologic Reference Points

Study Area	Model ID	HRP Description	12-hr SCS Type II Peak Flow (m^3/s) (no climate change)						Hazel
			2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
Sandy Cove	9255	Sandy Cove Creek	5.57	10.86	14.94	21.41	26.61	32.34	107.84
Sandy Cove	1500	Overland to Lake Simcoe	1.71	2.70	3.33	4.66	5.47	6.31	5.36
Sandy Cove	9334	Mooselanka Creek	0.50	1.71	2.49	3.86	5.23	6.92	16.72
Sandy Cove	1400	Overland to Lake Simcoe	1.81	2.91	3.91	5.16	6.76	8.02	8.17
Sandy Cove	1204	Overland to Lake Simcoe	0.26	0.51	0.69	0.96	1.17	1.39	2.44
Stroud	9125	Hewitt’s Creek Tributary	2.86	5.72	7.83	10.75	12.72	14.01	39.28
Stroud	9181	Hewitt’s Creek Tributary	1.34	2.10	2.64	3.41	4.11	4.76	8.89
Stroud	7	Lovers Creek Tributary	3.35	5.03	6.38	7.96	9.46	11.24	27.84
Stroud	5	Overland to Lovers Creek	0.87	1.70	2.30	3.21	3.93	4.68	11.14
Stroud	4	Overland to Lovers Creek	1.41	2.75	3.73	5.26	6.59	7.97	23.94
Stroud and Innisfil Heights	9230	D/S Lovers Creek	12.09	22.83	30.29	41.53	51.32	60.68	201.07
Lefroy	2118	Carson Creek	3.02	6.05	8.27	11.72	14.46	17.37	48.53
Lefroy	1600	Overland to Lake Simcoe	0.80	1.38	1.72	2.37	2.81	3.30	3.34
Lefroy	2113	Belle Aire Creek	1.36	2.73	3.73	5.28	6.52	7.84	25.21
Lefroy	2115	Overland to Lake Simcoe	3.22	5.38	7.15	9.43	11.24	14.41	16.04
Lefroy	2123	Wilson Creek	3.80	7.42	10.01	13.94	17.02	20.26	54.72
Lefroy	1801	Overland to Lake Simcoe	0.44	0.66	0.80	1.00	1.218	1.39	0.90
Gilford	9435	White Birch Creek	5.97	11.26	14.98	20.95	25.64	30.56	87.64
Gilford	9441	Gilford Creek	1.44	2.61	3.34	4.54	5.87	6.92	14.92
Gilford	9438	Overland to Lake Simcoe	2.12	3.63	4.64	6.07	7.58	8.832	11.47
Gilford	1300	Overland to Lake Simcoe	1.18	1.81	2.21	2.96	3.45	3.96	2.59
Innisfil Heights	19	Lovers Creek Tributary	3.33	5.23	6.58	8.86	10.96	12.73	31.93
Innisfil Heights	S59	Lovers Creek Tributary	0.89	1.48	1.89	2.43	2.84	3.59	2.82
Innisfil Heights	15	Lovers Creek Tributary	4.23	6.40	7.81	9.99	11.59	13.51	21.48
Innisfil Heights	13	Lovers Creek Tributary	0.88	1.41	1.92	2.70	3.32	3.98	10.24
Innisfil Heights	2	Lovers Creek Tributary	0.18	0.25	0.29	0.35	0.39	0.43	1.47
Fennell’s Corners	9451	White Birch Creek (headwaters)	0.40	0.55	0.64	0.80	0.90	1.00	1.82
Alcona	189	Bon Secours Creek	5.01	7.58	9.26	11.64	14.10	16.12	18.18
Alcona	191	Mclean Creek	3.39	5.02	6.24	7.85	9.36	10.64	9.14
Alcona	3	Banks Creek	0.03	0.07	0.09	0.12	0.14	0.160	0.37
Alcona	150	Overland to Lake Simcoe	1.83	2.71	3.49	4.43	5.10	5.79	3.93
Alcona	192	Overland to Lake Simcoe	3.16	4.74	5.86	7.36	8.80	10.10	8.18

7.1.2 Future Conditions Hydrology

The future conditions hydrologic model uses the same catchment delineation as the existing conditions model. The catchment parameters have been altered to reflect proposed changes in land use within the study areas based on the land use categories specified in the Town's OP. All upstream catchments (upstream and outside of the study area) remain the same as in the existing conditions model in order to achieve the best comparison between existing and future land uses.

In order to accurately model that future development will be provided with quantity controls (post-to-pre peak flow control) at the site level, 'synthetic' ponds, which determine the total storage required to provide post-to-pre control within a catchment, have been created. All catchments which are designated for future development as per the Town's OP have been controlled using a 'synthetic' pond. It should be noted that these 'synthetic' ponds are not representative of future real-world SWM pond size or location, as the 'synthetic' ponds assume a single SWM facility location per catchment area while there may be several SWM facility locations. The remaining catchments which do not include any future development have not been provided with future controls ('synthetic' ponds). It should be noted that the 'synthetic' ponds have been sized using the 12-hour SCS storm, as this is the governing storm in the majority of cases. For the purposes of hydrologic modelling, the 12-hour SCS storm 'synthetic' pond Route Reservoir data (pond stage storage table in the VO2 models) was also used in the 4-hour Chicago storm model to represent future quantity controls.

In some cases, the catchments which do not have any additional future development have shown increases in peak flow. This is due to the values and assumptions made in the land use conversion tables (i.e. if existing residential development is classified as a different type of residential development in the future land use categorization). In most cases this is a conservative approach, and reflects the possibility that existing lots may intensify through the construction of additional impervious surfaces.

Table 11 summarizes the future conditions peak flows at the same HRPs as the existing conditions model without the inclusion of the 'synthetic' ponds, whereas Table 12 summarizes the peak flows with the implementation of the 'synthetic ponds'.

In general, the future condition peak flows at the HRPs have been controlled to within ±5% of the existing conditions scenario peak flows with the use of 'synthetic' ponds. In some cases the controlled flow rate at the HRPs has increased by more than 5% from the existing condition. This increase is due to the 'synthetic' pond altering the time to peak, which changes the coincidence of hydrograph peaks either to create a relatively higher or lower total peak flow downstream of the site than would otherwise occur.

Table 11: Future Condition Peak Flow Summary at Hydrologic Reference Points (no ‘synthetic’ ponds)

Study Area	Model ID	HRP Description	12-hr SCS Type II Peak Flow (m^3/s) (no climate change)						Hazel
			2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
Sandy Cove	9255	Sandy Cove Creek	6.17	10.59	14.46	20.53	25.40	30.84	102.62
Sandy Cove	1500	Overland to Lake Simcoe	2.47	3.76	4.72	6.28	7.29	8.33	6.05
Sandy Cove	9334	Mooselanka Creek	0.91	3.02	5.26	7.71	9.60	11.82	17.66
Sandy Cove	1400	Overland to Lake Simcoe	3.76	5.76	7.03	9.13	10.63	12.17	9.28
Sandy Cove	1204	Overland to Lake Simcoe	1.44	2.33	2.85	3.81	4.44	5.08	3.20
Stroud	9125	Hewitt’s Creek Tributary	2.77	5.32	7.18	9.84	11.81	13.35	37.08
Stroud	9181	Hewitt’s Creek Tributary	1.62	2.48	3.08	3.92	4.67	5.36	8.99
Stroud	7	Lovers Creek Tributary	4.81	7.25	9.17	12.08	14.17	16.85	28.47
Stroud	5	Overland to Lovers Creek	0.87	1.70	2.30	3.22	3.93	4.68	11.15
Stroud	4	Overland to Lovers Creek	1.42	2.75	3.72	5.36	6.65	8.04	23.75
Stroud and Innisfil Heights	9230	D/S Lovers Creek	16.63	31.00	39.41	54.56	64.29	75.97	200.00
Lefroy	2118	Carson Creek	7.04	12.12	15.79	19.97	28.96	30.11	49.32
Lefroy	1600	Overland to Lake Simcoe	1.11	1.84	2.35	3.02	3.53	4.09	3.55
Lefroy	2113	Belle Aire Creek	1.39	2.74	3.74	5.29	6.53	7.85	25.19
Lefroy	2115	Overland to Lake Simcoe	4.59	7.35	9.39	12.10	14.21	17.57	17.01
Lefroy	2123	Wilson Creek	3.80	7.42	10.01	13.94	17.03	20.26	54.73
Lefroy	1801	Overland to Lake Simcoe	0.61	0.88	1.05	1.34	1.53	1.73	0.97
Gilford	9435	White Birch Creek	6.06	11.36	15.09	21.09	25.80	30.70	87.74
Gilford	9441	Gilford Creek	3.39	5.37	6.61	8.47	10.13	11.63	15.17
Gilford	9438	Overland to Lake Simcoe	2.88	4.59	5.94	7.62	9.22	10.62	11.75
Gilford	1300	Overland to Lake Simcoe	1.58	2.35	2.84	3.67	4.23	4.80	2.74
Innisfil Heights	19	Lovers Creek Tributary	6.70	10.43	13.08	16.51	19.20	22.89	28.31
Innisfil Heights	59	Lovers Creek Tributary	1.94	2.83	3.37	4.24	4.83	5.44	2.76
Innisfil Heights	15	Lovers Creek Tributary	7.72	11.53	13.69	17.25	20.42	24.56	20.31
Innisfil Heights	13	Lovers Creek Tributary	1.46	2.23	2.73	3.54	4.26	5.05	10.35
Innisfil Heights	2	Lovers Creek Tributary	0.26	0.34	0.40	0.50	0.69	0.88	2.04
Fennell’s Corners	9451	White Birch Creek	0.49	0.67	0.78	0.94	1.06	1.31	1.98
Alcona	189	Bon Secours Creek	8.27	12.86	15.83	20.77	24.90	28.66	24.49
Alcona	191	Mclean Creek	4.58	6.75	8.12	10.10	12.05	13.56	9.40
Alcona	6	Banks Creek	0.08	0.11	0.13	0.16	0.18	0.19	0.39
Alcona	150	Overland to Lake Simcoe	2.55	3.72	4.75	5.93	6.78	7.64	4.11
Alcona	192	Overland to Lake Simcoe	4.32	6.35	7.76	9.87	11.38	12.94	8.40

Table 12: Future Condition Peak Flow Summary at Hydrologic Reference Points (with ‘synthetic’ ponds)

Study Area	Model ID	HRP Description	12-hr SCS Type II Peak Flow (m^3/s) (no climate change)						Hazel
			2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
Sandy Cove	9255*	Sandy Cove Creek	6.14	11.45	15.56	21.91	27.06	32.78	107.39
Sandy Cove	1500	Overland to Lake Simcoe	2.47	3.76	4.72	6.28	7.29	8.33	6.05
Sandy Cove	9334*	Mooselanka Creek	0.85	2.13	2.87	3.87	5.08	6.62	17.26
Sandy Cove	1400*	Overland to Lake Simcoe	1.80	2.90	3.88	5.16	6.67	7.88	8.74
Sandy Cove	1204*	Overland to Lake Simcoe	0.26	0.51	0.69	0.96	1.78	1.38	2.32
Stroud	9125*	Hewitt’s Creek Tributary	3.01	5.78	7.81	10.68	12.71	14.10	39.00
Stroud	9181	Hewitt’s Creek Tributary	1.62	2.49	3.08	3.93	4.67	5.37	8.99
Stroud	7*	Lovers Creek Tributary	3.70	5.88	7.27	9.48	10.97	13.07	28.66
Stroud	5	Overland to Lovers Creek	0.87	1.70	2.30	3.22	3.93	4.68	11.16
Stroud	4	Overland to Lovers Creek	1.42	2.75	3.72	5.36	6.65	8.04	23.75
Stroud and Innisfil Heights	9230*	D/S Lovers Creek	12.76	23.48	31.96	43.62	52.14	61.92	180.37
Lefroy	2118*	Carson Creek	3.12	5.52	8.13	11.42	14.04	16.77	47.01
Lefroy	1600*	Overland to Lake Simcoe	0.79	1.36	1.72	2.34	2.77	3.25	3.48
Lefroy	2113	Belle Aire Creek	1.39	2.74	3.74	5.29	6.53	7.85	25.19
Lefroy	2115	Overland to Lake Simcoe	4.59	7.35	9.39	12.10	14.21	17.57	17.01
Lefroy	2123	Wilson Creek	3.80	7.42	10.01	13.94	17.02	20.26	54.73
Lefroy	1801	Overland to Lake	0.60	0.88	1.05	1.34	1.53	1.73	0.97
Gilford	9435*	White Birch Creek	6.08	11.43	15.21	21.25	26.01	30.97	88.17
Gilford	9441*	Gilford Creek	1.44	2.54	3.30	4.49	5.85	6.91	15.15
Gilford	9438*	Overland to Lake Simcoe	2.81	4.45	5.76	7.36	8.93	10.28	11.63
Gilford	1300	Overland to Lake Simcoe	1.58	2.35	2.84	3.67	4.23	4.80	2.74
Innisfil Heights	19*	Lovers Creek Tributary	3.62	5.75	7.25	9.42	11.31	13.19	28.74
Innisfil Heights	S59*	Lovers Creek Tributary	0.89	1.46	1.85	2.41	2.78	3.53	2.65
Innisfil Heights	15*	Lovers Creek Tributary	4.27	6.44	7.84	10.00	12.34	14.26	20.52
Innisfil Heights	13*	Lovers Creek Tributary	0.84	1.50	2.02	2.82	3.46	4.13	10.36
Innisfil Heights	2*	Lovers Creek Tributary	0.18	0.26	0.30	0.36	0.40	0.46	0.43
Fennell’s Corners	9451	White Birch Creek	0.49	0.67	0.78	0.94	1.06	1.31	1.98
Alcona	189*	Bon Secours Creek	5.68	8.42	10.22	12.78	15.36	17.49	17.85
Alcona	191	Mclean Creek	4.58	6.75	8.12	10.10	12.05	13.56	10.07
Alcona	6	Banks Creek	0.08	0.11	0.13	0.16	0.18	0.19	0.42
Alcona	150	Overland to Lake Simcoe	2.55	3.72	4.75	5.93	6.78	7.64	4.48
Alcona	192	Overland to Lake Simcoe	4.32	6.35	7.76	9.87	11.38	12.94	9.09

Note: (*) these nodes are receiving runoff from upstream catchments which have been modeled with synthetic ponds due to significant future development.

7.1.3 Climate Change

In order to assess the effect of climate change in connection with SWM quantity control requirements, the Barrie WPCC IDF data was used, with 15% increase in rainfall depth (as is provided in the City of Barrie SWM Guidelines). As discussed in Section 7.1, the City of Barrie's IDF curves adapted for climate change represent a moderate increase in rainfall intensity, which has been accepted for use in submissions to the LSRCA and the NVCA. It should be noted that there is a wide range of future climate change models available, each with various assumptions relating to emissions and global temperature change. These models are then applied to a number of timing horizons, in turn producing a wide variety of predictions. If future studies with varying results from the City of Barrie's adaptation become widely accepted, the local IDF curves should be re-evaluated to align with the updated information. In the meantime, a 15% increase is a prudent approach that has garnered support from local climate change experts.

The uncontrolled (no 'synthetic' ponds) future conditions VO2 models (existing IDF vs. climate change IDF) for the 12-hour SCS storm have been compared at each of the HRPs. The climate change model resulted in average increases in peak flow between 15-30%. Full model summary tables are provided in Appendix D.

This substantial increase in peak flows has the potential to increased flooding events in low lying downstream areas, if appropriate quantity controls are not implemented. As such, it is important that SWM quantity control facilities for future development are sized to account for the potential increase in storm intensities.

7.1.4 Peak Flow Over-Control

Peak flow over-control was modeled for creeks which have known downstream flooding issues. The catchments where future development is proposed were modeled to over-control peak flows by 15%, 25%, and 50%.

As previously noted, there is a flood prone area at the downstream end of Carson Creek in the Lefroy study area. It was determined that providing 50% over-control to the upstream catchments can produce a peak flow reduction of approximately 17% compared to existing conditions. However, the LSAMI developments have already been designed and approved with a peak flow reduction strategy which was determined in the Lefroy Secondary Plan Master Drainage Plan (2007), prepared by Marshall, Macklin & Monaghan. Therefore, these developments have adequately attempted to reduce peak flows to the known flood-prone areas in Lefroy.

A second flood prone area is White Birch Creek in the Gilford study area. The same over-control scenario was applied to the future developments within the study area which contribute to White Birch Creek. Due to the fact that the development area is relatively minor in comparison to the total area draining to White Birch Creek, a 50% reduction in peak flows from the developed catchments does not provide any noticeable benefits in reduction of peak flows at the downstream end of White Birch Creek.

The Alcona North Master Drainage Plan also considered SWM alternatives to reduce flooding in the downstream portion of Goodfellow Creek. The preferred alternative specified that a target of 25% peak flow over control through the downstream reaches of the system should be provided, resulting in a peak flow reduction ranging from 23-34%. This reduction can be provided by a number of methods as outlined in the report, including control of upstream lands or on-site over-control of proposed development runoff. Improvement of two culverts in the downstream reaches of Goodfellow Creek was also recommended to reduce flood levels under frequent storm events (5-year to 25-year events).

7.2 Water Balance

7.2.1 General

A water balance assessment has been completed for each study area within the LSRCA boundary, with the exception of Big Bay Point, as the water balance for the area was already completed and approved. Existing and future land uses, in combination with soil types and land topography, were analysed to calculate evapotranspiration, infiltration and runoff produced from precipitation during existing and future conditions. The overall intent of the water balance assessment is to identify the need to incorporate infiltration mechanisms into all future development with the goal of mitigating any changes in infiltration following development. Each individual assessment is to consider the significance of any groundwater feature as discussed in Section 5.6. In particular, infiltration measures are strongly encouraged in existing areas classified as SGRA's with consideration for areas with highly vulnerable aquifers. Extra precautions should be taken for infiltration in these areas.

7.2.2 Background

The development of land typically involves converting pervious surfaces such as pasture, open field, and wooded areas into impervious surfaces including roads, driveways and buildings. This results in changes to the existing hydrologic regime including increases in runoff volume and decreases in infiltration and evapotranspiration.

In accordance with Section 4.8-DP of the LSPP, all major development requires a water balance assessment including an evaluation of existing and future development conditions. Any impacts to the existing hydrologic regime are to be minimized to the extent possible.

7.2.3 Water Balance Assessment

In accordance with the Hydrogeological Assessment Submissions Guidelines, Conservation Authority Guidelines to Support Development Applications (June 2013), overall water budgets have been developed for each study area as part of the CSWM-MP. The Thornthwaite method was determined to be an appropriate method for calculating evapotranspiration based on average temperature and precipitation data from the Barrie WPCC climate normal data (1981-2010) from Environment Canada. A composite runoff coefficient has been determined for each of the study areas for the existing and future land uses, which is used to determine total runoff depth for each scenario.

In order to develop infiltration targets for future development in each study area, existing and proposed condition water balance scenarios were considered and the increased runoff depth caused by the addition of impervious surfaces was calculated. A corresponding infiltration depth is required to offset this increase in runoff and maintain an annual balance. The water balance assessment calculations are attached in Appendix C and summarized for each study area in Table 13.

Table 13: Summary of Water Balance Results by Study Area

	Sandy Cove	Stroud	Gilford	Lefroy	Innisfil Heights	Fennell's Corners	Alcona Central
Precipitation (mm)	933.1	933.1	933.1	933.1	933.1	933.1	933.1
Evapotranspiration (mm)	487.20	487.20	487.20	487.20	487.20	487.20	487.20
Surplus (mm)	445.90	445.90	445.90	445.90	445.90	445.90	445.90
Existing Infiltration (mm)	322.34	259.87	319.38	338.67	214.31	253.77	290.10
Future Infiltration (mm)	268.09	227.10	274.70	311.44	114.76	240.11	267.10
Decrease (%)	17	13	14	8	46	5	8
Existing Runoff (mm)	123.56	186.03	126.53	107.23	231.59	192.14	155.80
Future Runoff (mm)	177.81	218.80	171.20	134.46	331.14	205.79	178.80
Increase (%)	44	18	35	25	43	7	15
Infiltration Target For Future New Impervious Land (mm)	5	5	10	15	8	-	25

Big Bay Point Study Area

The Big Bay Point study area is currently undergoing development with the creation of the Friday Harbour Resort. As such, a water balance assessment has not been included in this CSWM-MP. Please refer to the development documents for the Friday Harbour Resort for a detailed water balance assessment.

Sandy Cove Study Area

Sandy Cove will experience the greatest amount of development on a percentage basis with an increase of 58% in developed land, with approximately 93.8 ha of new impervious cover and a total developed area of 144 ha. With this large increase in development, the overall runoff coefficient for the study area will increase from 0.28 to 0.40. Without measures to ensure pre-development infiltration rates are maintained, the total infiltration will decrease by 17% as shown in Table 13. In order to mitigate this deficit, the runoff volume from the 5 mm storm event produced from all future impervious land cover must be infiltrated.

Stroud Study Area

Similar to Sandy Cove, Stroud will also experience an increase in developed area of approximately 39%, with approximately 21.4 ha of new impervious cover and 61 ha total developed area. The composite runoff coefficient for this study area will increase from 0.42 to 0.49. With this increase in impervious/developed area, the total infiltration will decrease by 13% as shown in Table 13. In order to mitigate this deficit, the runoff volume from the 5 mm storm event produced from all future impervious land cover must be infiltrated.

Gilford Study Area

Gilford is forecasted to increase its developed area by approximately 54%, to a total of 59 ha, with approximately 15.6 ha of new impervious cover. This will increase the composite runoff coefficient moderately from 0.28 to 0.38. This increase in development will lead to a decrease in infiltration rates of 14% as shown in Table 13. In order to mitigate this deficit, the runoff volume from the 10 mm storm event produced from all future impervious land cover must be infiltrated.

Lefroy Study Area

The Lefroy study area is forecasted to increase its developed area by approximately 49%, to a total of 98 ha, with approximately 23.1 ha of new impervious cover. This will increase the composite runoff coefficient from 0.24 to 0.30. This increase in development will lead to a decrease in infiltration rates of 8% as shown in Table 13. In order to mitigate this deficit, the runoff volume from the 15 mm storm event produced from all future impervious land cover must be infiltrated.

Innisfil Height Study Area

The Innisfil Heights study area is forecasted to increase developed area by approximately 55%, to 92 ha total, with approximately 61 ha of new impervious cover. This will increase the composite runoff coefficient from 0.52 to 0.74. The increase in development will lead to an approximate decrease in infiltration rates of 46% as shown in Table 13. In order to mitigate this deficit, the runoff volume from the 8 mm storm event produced from all future impervious land cover must be infiltrated.

Fennell's Corners Study Area

The Fennell's Corners study area is almost entirely developed, however the land use designations in the Official Plan result in increase in runoff coefficient from 0.43 to 0.46. This assumed increase is conservative, but it is possible that some land could be redeveloped with a greater impervious cover than is present under existing conditions. This increase in runoff coefficient would lead to an approximate decrease in infiltration rates by 5% as shown in Table 13. No future infiltration target has been specified for this area, due to lack of future planned development.

Alcona Central Study Area

The Alcona Central study area is planned to increase in developed area by 18% with approximately 11.9 ha of new impervious cover and a total developed area of 125 ha. This leads to an increase in runoff coefficient from 0.35 to 0.40. This increase in runoff coefficient will lead to an approximate decrease in infiltration rates by 8%, shown in Table 13. Due to the large increase in developed area, combined with a small increase in impervious area (using the land use conversion sheets), the 25 mm storm event does not provide enough annual volume to meet the existing conditions infiltration volume. Therefore, the 25 mm storm is required to be infiltrated for all new pervious development area to provide a best efforts approach to mitigating water balance impacts, without setting an unreasonably high target.

Alcona North Study Area

The water balance assessment for the Alcona North study area is presented in the Alcona North Hydrogeological Study prepared by R. J. Burnside & Associates Ltd. The model results indicate that infiltration will decrease due to proposed development in the area. The recommended approach to water balance and infiltration mitigation is detailed below.

- In areas where soil/groundwater conditions permit, at source infiltration measures such as soakaway pits or equivalent measures should be installed at the lot level. In these areas, roof leaders and yard drainage should be directed to a soakaway pit or equivalent measure to promote infiltration.

- Road infiltration trenches should be installed where soil/groundwater conditions permit.

- End-of-pipe SWM facility infiltration and exfiltration systems should be installed where soil and groundwater conditions permit to promote infiltration and reduce thermal impacts of the proposed SWM facilities.

Alcona South Study Area

For recommendations on water balance and infiltration measures for the Alcona South study area, please refer to the Alcona South Secondary Plan Master Drainage Plan Study Report, prepared by Greenland Consulting Engineers. The water balance assessment was completed by Azimuth Environmental Consulting Inc. The model results indicate that infiltration will decrease due to proposed development in the area. The recommended approach to water balance and infiltration mitigation is detailed below.

- In areas where soil/groundwater conditions permit, at source infiltration measures such as soakaway pits or equivalent measures should be installed at the lot level. In these areas, roof leaders and yard drainage should be directed to a soakaway pit or equivalent measure to promote infiltration.
- Road infiltration trenches should be installed where soil/groundwater conditions permit.
- End-of-pipe SWM facility infiltration and exfiltration systems should be installed where soil and groundwater conditions permit to promote infiltration and reduce thermal impacts of the proposed SWM facilities.

7.2.4 Water Balance & Climate Change

In order to assess how a changing climate will affect water balance and infiltration rates, a number of scenarios have been modeled. The future water balance scenario has been used as a baseline infiltration value, and has been compared to 11 other scenarios. The scenarios account for a ±10% change in monthly precipitation, coupled with an average monthly temperature increase of up to 4°C.

The sources for the climate change values used in this CSWM-MP represent projections for the Province of Ontario. These values were referenced from the following sources:

- Climate Change - Climate Science - Trends and Forecasts, TRCA; and,
- Climate Change Projections for Ontario: Practical Information for Policymakers and Planners, Ontario Ministry of Natural Resources (2007).

As the precipitation and temperature values apply to each study area, the percent increase/decrease in infiltration compared to the baseline value is the same for each study area. As such, only the Alcona study area has been included in Appendix C of this report.

Table 14 summarizes the assumptions made in each scenario, as well as the increase/decrease in infiltration.

Table 14: Water Balance Climate Change Summary

Scenario #	Precipitation Change (%)	Temperature Change (°C)	Annual Infiltration Change (%)
1 (Baseline)	0	0	0
2	0	1	-2.36
3	0	2	-4.69
4	0	4	-10.41
5	10	0	13.43
6	10	1	11.07
7	10	2	8.73
8	10	4	3.02
9	-10	0	-13.43
10	-10	1	-15.78
11	-10	2	-17.84
12	-10	4	-21.79

The worst case scenario represents a 10% decrease in monthly precipitation, as well as a significant average monthly temperature increase of 4 °C. This scenario resulted in a 21.79% reduction in annual infiltration.

The possibility of decreased infiltration rates further stresses the importance of implementing the use of infiltration methods as part of the SWM plan implementation strategy.

7.3 Water Quality

7.3.1 Phosphorus Loading

Excessive phosphorus has been the most significant cause off water quality impairment in Lake Simcoe and its tributaries. It leads to the excessive growth of plants and algae in Lake Simcoe which contributes to the depletion of dissolved oxygen in the deep waters of the lake and degradation of the critical habitat of cold water species.

In June 2010, the MOECC released the Lake Simcoe Phosphorus Reduction Strategy. The strategy sets an aggressive phosphorus reduction target in order to improve water quality. The goal is to reduce overall annual loading to Lake Simcoe to 44 tonnes, which corresponds to a 38.9% (ultimate target) reduction over existing annual loading levels (72 tonnes per year). However, the strategy also recognizes that opportunities and technology presently exist to reduce loading to 58 tonnes annually or approximately 19.4% (feasible target reduction).

As the majority of future development within the Town is planned to occur within the boundaries of the study areas, a phosphorus budget was prepared for each study area. For the purpose of this CSWM-MP, a desktop based unit load approach (i.e. spreadsheet) was deemed appropriate for estimating the existing and future condition phosphorus loading on Lake Simcoe.

In consultation with Michalski Nielsen Associates Ltd. and LSRCA staff, it was determined that the phosphorus loading rates described in the MOECC's Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed (2012), prepared by Hutchinson Environmental Sciences Ltd., are the most appropriate rates to be applied to the study areas in Innisfil. These loading rates were developed using the approach described in *Estimation of the Phosphorus Loading to Lake Simcoe (2010)*, prepared by The Louis Berger Group, Inc., as a base but were modified to address unexplained variances in the Berger loading rates that were observed between land uses and subwatersheds in the Lake Simcoe Basin. The Berger report used the CANWET model and we understand that some of the variances are explained by the fact that the CANWET model version used to determine the Barrie Creeks loading rates differs from that used to determine the loading rates for Hewitt's Creek, Lovers Creek and Innisfil Creeks, where the latter included a loading rate reduction factor to account for best management practices. The fact that the assumptions used in determining the reduction factor are not known (i.e. what type of best management practices were assumed to apply) means that the loading rates that include these reduction factors (i.e. the Berger values for Hewitt's Creek, Lovers Creek and Innisfil Creeks) can't be effectively used to assess proposed SWM alternatives. We also considered applying the Barrie Creeks loading rates to our study area since we understood that these did not include reduction factors. However, upon further review, these values were not selected for use as loading rates for some land uses increase under future conditions while others decrease. As well, the Berger Report only utilizes High and Low Intensity Development rates, which could lead to inaccuracies when trying to assign the differing existing and future land use types to these loading rates.

In order to model existing and future conditions using the land uses categories and loading rates provided in the MOECC's Budget Tool, a 'land use conversion' sheet has been developed. This is included in Appendix B.

The loading rates for each land use applied to both the existing and future conditions land uses and are provided in Table 15.

Table 15: Existing Conditions Phosphorus Loading Rates

Land Use Category	Average Annual Phosphorus Loading Rates (kg/ha)
Hay- Pasture	0.07
Cropland	0.19
Turf-Sod	0.12
Quarry	0.08
Low Intensity Development	0.13
Unpaved Road	0.83
High Intensity Development (Commercial/Industrial)	1.82
High Intensity Development (Residential)	1.32
Transition	0.06
Polder	0
Forest	0.05
Wetland	0.05

The Hutchinson report has also provided phosphorus reduction rates for a number of different types of SWM facilities and BMP's. These rates have been applied to existing controlled areas, and have also been used to model the retrofit scenario. They have also been applied to future developed areas to help assess the potential phosphorus reduction for each option. The reduction rates applied to existing and future SWM facilities are summarized in Table 16.

Table 16: Phosphorous Removal Rates

SWM Control	Removal Efficiency
Dry Pond (proper function)	10%
Wet Pond (proper function)	63%
*Wet Pond (in need of retrofits)	30%
LID Controls	85%

Note: * denotes assumed removal efficiency value based on poor pond function

The LID controls removal rate is based on a removal rate of 87% for a perforated pipe infiltration system. The Hutchinson report also provides rates for other LID controls including vegetated filter strips, soakaway pits, green roofs, etc., however there is no removal rate for a combination of these LID controls. Our LID option assumes that new developments that include LIDs will be provided with a 'treatment train' approach incorporating multiple LID controls, most likely including a perforated pipe/infiltration system. Therefore, the value of 85% was chosen to be a conservative representation.

Table 17 summarizes the phosphorus loading for both the existing conditions with the existing SWM controls, as well as the loading for existing land use with retrofit controls.

Table 17: Existing Phosphorus Loading Summary With and Without Retrofits

Study Area	Total Area (ha)	Existing Phosphorus Loading (kg/year)	Existing Phosphorus Loading with retrofits (kg/year)	Annual Decrease in Phosphorous (kg)	% Decrease
Sandy Cove	501.5	362.2	362.2	-	-
Stroud	233.2	230.6	178.5	52.1	22.6
Innisfil Heights	267.1	265.20	235.29	29.9	11.3
Lefroy	483.8	296.2	296.2	-	-
Gilford	187.0	152.5	152.5	-	-
Fennell's Corners	18.5	17.14	17.14	-	-
Alcona Central	1,004.3	741.1	741.1	-	-

The Stroud study area phosphorous calculations included the controls of four (4) existing SWM facilities. Three of the ponds are specified as retrofit opportunities for the study area. These ponds are dry ponds, and have been assigned a removal efficiency of 10%. However they are proposed to be retrofit into wet ponds in order to improve water quality, and have been assigned a removal efficiency of 63%. These ponds are: Southview (Pond #9-2), Brandy Lane (Pond #10-1), and Village North Dempster (Pond #10-2). The Victoria Green facility (Pond #9-3), is a dry pond but is not proposed to be retrofit. Therefore it is assumed to have 10% removal efficiency for both scenarios. These retrofits are expected to provide 22% phosphorous removal compared to existing for the study area.

The Innisfil Heights study area phosphorous calculations have included the controls of four (4) existing SWM facilities. The Trillium Industrial facility (Pond #8-1) is currently a dry pond, however is proposed to be retrofit into a wet SWM facility. Therefore the reduction rates increase from 10% to 63% for the retrofit scenario. The Forest Valley facility (Pond #7-4) has 10% removal efficiency, for both scenarios.

The Doral East and West facilities (Pond #9-4 and #9-5) are wet facilities, with 63% removal efficiency for both scenarios.

The Alcona study area phosphorous calculations have included the controls of all existing SWM facilities in the area. For all assumptions, refer to the Alcona Phosphorous Budget Assessment calculation sheet in Appendix B.

In order to assess the benefit of controlling future developments with standard end-of-pipe controls (wet ponds) in comparison to LID controls, these two scenarios have been modeled. The scenarios assume that all increases in land use in the future scenarios will be provided with either LID or wet pond controls. The two scenarios have also included the removal efficiency rates of any proposed SWM facility retrofits (if applicable). Table 18 provides a summary for each study area. Detailed calculation sheets with all assumptions are provided in Appendix B.

Table 18: Future Phosphorous Loading with Wet Pond & LID Controls

Study Area	Total Area (ha)	Existing Phosphorus Loading - No Controls (kg/year)	Future Phosphorus Loading - No Controls	Future Phosphorus Loading with Retrofits and Wet Pond Controls (kg/year)	Future Phosphorus Loading with Retrofits and LID Controls (kg/year)
Sandy Cove	501.5	362.17	-	420.16	375.76
Stroud	233.2	243.58	-	169.98	157.80
Innisfil Heights	267.1	304.58	-	287.18	248.02
Lefroy	483.8	296.21	-	333.85	305.58
Gilford	187.0	152.46	-	178.02	159.95
Fennell's Corners	18.5	25.05	-	No future development	No future development
Alcona Central	1004.3	1173.81	-	798.31	759.95

7.3.2 Big Bay Point

In support of the Big Bay Point Friday Harbour Development, Gartner Lee Limited (GLL, now AECOM Canada) completed phosphorus budgets for existing and post-development conditions, to reflect the Structure Plan and the Master Concept Plan in an April 18, 2007 report, entitled, Big Bay Point Development: Revised Phosphorus Budget. This analysis showed that diversion, capture and re-use of stormwater would result in the reduction in phosphorus loadings to Lake Simcoe in comparison to the pre-development conditions.

The phosphorus budget concludes that the resort design and SWM measures proposed will afford a high level of protection to Lake Simcoe. These measures include:

- the compact form of development;
- the preservation of the EP area;
- the diversion, treatment and use of stormwater runoff from developed areas and golf courses for irrigation purposes;
- the separation of cleaner roof runoff; and
- the Golf Course and Nutrient Management Plan - Environmental Management Plan.

LSRCA completed an existing conditions phosphorus budget for the site as well as using different loading rates than those selected by GLL. Table 19 summarizes the phosphorus loading values developed by LSRCA and GLL for the Big Bay Point Friday Harbour Development (study area).

Table 19: Big Bay Point Phosphorus Loading Summary

	Result
Existing Conditions - GLL (kg/year)	104.4
Existing Conditions - LSRCA (kg/year)	64.2
Post Development Conditions - GLL (kg/year)	47.8
Reduction vs Existing GLL Rate (kg/year)	-56.6
Reduction vs Existing GLL Rate (%)	-54.2
Reduction vs Existing LSRCA Rate (kg/year)	-16.3
Reduction vs Existing LSRCA Rate (%)	-25.5

The SWM plan for the Big Bay Point study area results in a reduction in phosphorus loading to Lake Simcoe of:

- 56.6 kg/year (54.2%) using the GLL existing conditions; and
- 16.3 kg/year (25%) using the LSRCA existing conditions.

For detailed modelling and analysis, refer to original 2007 GLL report.

7.3.3 Alcona North

Phosphorous loading calculations for the Alcona North study area were completed as part of the Alcona North Master Drainage Plan. The phosphorous budget was completed by R.J Burnside & Associates Ltd., and is outlined in a technical memorandum dated August 19, 2011. This report calculated existing and future land uses for the Alcona North OPA1 Areas 1 and 2 and applied phosphorous loading values from the LSRCA Estimation of the Phosphorous Loadings to Lake Simcoe prepared by the Louis Berger Group Inc. This report found that the existing land use produced 31.23 kg of total phosphorous per year, compared to 28.31 kg for the future scenario. This represents a 9.3% decrease and can be attributed to the fact that significantly less agricultural land is present in the post-development conditions. The results are summarized in Table 20.

Table 20: Alcona North Phosphorous Loading Summary

Land Use	Phosphorous Export Coefficient (kg/ha/year)	Pre-Development		Post-Development	
		Area (ha)	Total Phosphorous (kg)	Area (ha)	Total Phosphorous (kg)
Cropland	0.25	121.70	30.43	47.92	11.98
Forest	0.06	13.35	0.80	13.10	0.79
High Intensity Development	0.21	-	-	74.03	15.55
	Totals	135.05	31.23	135.05	28.31

It should be noted that it is expected that the Alcona North Master Drainage Plan will undergo an update due to the proposed Leonard's Beach development. As such, any updates to the phosphorous loading in the updated Alcona North Master Drainage Plan report shall supersede the phosphorous loading calculations referenced above.

7.3.4 Alcona South

Phosphorous loading calculations for the Alcona South study area were completed as part of the Alcona South Master Drainage Plan. The phosphorous budget was completed by Greenland Consulting Engineers, and is outlined in a technical memorandum dated October 12, 2011. The calculations were completed using the CANWET modelling software. The land use summary applied to the model is summarized in Table 21, while the model results are summarized in Table 22.

Table 21: Alcona South Phosphorous Land Use Summary

Land Use/Source	Existing Area (ha)	Future Area (ha)
Crops	592	450
Hay/Pasture	391	336
Wetlands/Forest/Transitional Lands	649	592
Low Intensity Development	53	209
High Intensity Development	356	454
Turf/Sod/Quarries	34	34
Totals	2,075	2,075

Table 22: Alcona South Phosphorous Loading Summary

Source	Existing Scenario (kg)	Future Scenario (kg)
Point Source Increase	0	20
NPS Water Course 5 Catchment	295	289
NPS Water Crouse 6/7 Catchment	297	248
Uncontrolled Total	592	557
BMP Reduction WC5	0	(9)
BMP Reduction WC6/7	0	(3)
Controlled Total	592	518
Percent Reduction from Existing Scenario with BMPs		12%

Without the use of BMPs, the future land use will reduce phosphorous loading by an estimated 6% through change in land use and removal of septic systems, livestock populations and tile drain systems.

However, a 12% reduction in existing phosphorous loads can be achieved with the further implementation of BMPs including:

- Enhanced protection level SWM facilities for all new urban developments; and
- enhanced infiltration for the portion of the development areas west of the rail line within the secondary plan (which is recommended in the Master Drainage Plan hydrogeologic studies).

It should be noted that the Alcona South Master Drainage Plan is still being finalized, and as such it is possible that the phosphorous budget may be updated. As such, any updates to the phosphorous loading in the Final Alcona South Master Drainage Plan report shall supersede the phosphorous loading calculations referenced above.

7.4 Stream Channel Characterization & Erosion Threshold

As per the CSWM-MP guidelines, a stream channel characterization and erosion susceptibility analysis was completed. This report was completed by Aqualogic, and is included in Appendix F. This report assesses a number of channels downstream of existing development areas and recommends erosion control measures (extended detention controls) for upstream facilities. These erosion control measures are also to be applied to any future SWM facilities which would discharge to the specified creek. These recommendations are summarized in Section 10 for each Study Area. A brief summary of Aqualogic's Erosion Threshold Analysis is provided below.

A total of nine (9) watercourse locations were evaluated in the study, including Hewitt's Creek, Sandy Cove Creek, Sandy Cove Creek Tributary, Cooks Bay Tributary (Sandy Cove), Mooselanka Creek, Carson Creek, Cooks Bay Tributary B (Gilford), White Birch Tributary, and Cooks Bay Tributary C (Gilford). Field measurements were used for erosion threshold modelling, the results of which were used to determine the appropriate methodology for impact analysis. Refer to figure in Appendix F for a map displaying locations of field assessments.

The results from the Rapid Assessment Analysis show that channel stability across the entire study area is relatively good to very good. The most erosion sensitive location is Carson Creek, followed by Sandy Cove Creek and Hewitt's Creek. These areas require the greatest level of erosion control.

A unit-area analysis has been used to determine the unit-area flow rate to be maintained for erosion control at each of the nine locations. By default, the 25 mm rainfall event has been included as a controlling storm for all locations, as well as the 2-year rainfall event in order to conservatively address all frequent flows. The 2-year storm corresponds approximately to the 40 mm storm. Five (5) of the watercourses are entrenched, and require higher return period storm events (up to the 25-year storm event) to be controlled to the unit area flow rate in order to mitigate erosion. A summary of the results is provided in Table 23.

Table 23: Erosion Threshold Analysis Summary

Location	Unit Area Flow Rate Target (L/s/ha)	Entrenched (Y or N)	Storm Events to Control
Hewitt's Creek (10th Line, Stroud)	1.08	Y	25 mm 2-year to 25-year
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)	0.7	N	25 mm 2-year
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres	5.14	Y	25 mm 2-year to 25-year
Cooks Bay Tributary (Mooselanka Rd., Sandy Cove Acres)	9.23	N	25 mm 2-year
Mooselanka Creek (25th SR, Sandy Cove Acres	1.60	Y (partial)	25 mm 2-year to10-year
Carson Creek (Ewart St. Lefroy)	0.85	Y	25 mm 2-year to 25-year
Cooks Bay Tributary (Parkview Drive, Gilford)	11.17	N	25 mm 2-year
White Birch Creek Tributary (Harbourview Golf, Gilford)	6.21	N	25 mm 2-year
Cooks Bay Tributary (Shore Acres Rd. & Nelly Rd., Gilford)	4.29	Y (partial)	25 mm 2-year to10-year

As it may be impractical to control storm events larger than the 2-year storm due to excessive pond volume requirements, alternative analysis at the detailed design stage for future developments may be required. Such analysis may include comparison of pre-development and post-development hydrographs in order to determine the increase in total time (hours) of peak flows above the erosion threshold flow. If this increase in time is found to be negligible, controls for the larger storm events may not be required. It may also be possible to show that infiltration practices (LIDs) can adequately reduce the peak flows, and thus reduce the extended detention pond volume required to control larger storm events. Some examples of this additional analysis are included in AquaLogic's report.

8 Determine the Effectiveness of Existing SWM Systems (Step Six)

In February 2012, a SWM Master Plan - Part 1 (Part 1 Report) was completed for the Town by Hatch Mott MacDonald. The focus of this report was to create a detailed inventory of all SWM facilities in the Town, and assess the performance/function of each. The assessment was completed by determining the current water quality and quantity controls, sediment accumulation and phosphorus removal efficiency as determined from individual SWM facility site visits. Based on the findings from the pond assessments, a list of retrofit opportunities was developed. The complete list of retrofits can be found in the Part 1 Report by Hatch Mott MacDonald. This CSWM-MP has further prioritized the retrofit opportunities and given them a rank based on their relative benefits to the Lake Simcoe watershed (i.e. if two ponds are in need of similar retrofits, retrofitting the pond that controls the larger area will have a greater relative benefit).

Each SWM facility has been given a priority ranking between 1 and 5. Please see below for description of the ranking.

Priority 1: These facilities require a complete retrofit/re-design due to very poor function. These retrofits would have a highly beneficial impact on the receiving watercourse and the Lake Simcoe watershed within the Town.

Priority 2: These facilities require partial retrofit/maintenance work and/or installation of an upstream OGS unit. These retrofits would have significant benefits on the receiving watercourse and the Lake Simcoe watershed within the Town.

Priority 3: Similar to Level 2, these facilities require partial retrofit/maintenance work and/or installation of an upstream OGS unit. These retrofits would have moderate benefits on the receiving watercourse and the Lake Simcoe watershed within the Town.

Priority 4: Retrofits and/or maintenance work would increase the function of these facilities, however due to the low relative benefits, these retrofits are of lower priority.

Priority 5: These facilities do not require any retrofit/maintenance work. Any improvements to these facilities would have minimal benefits on the receiving watercourse and the Lake Simcoe watershed within the Town.

Table 24 provides a summary of the assessment of the existing SWM facilities. The ‘Design Level’ column details the water quality control criteria used in the design, where Level 1, 2 and 3 represent Enhanced, Normal, and Basic level of protection, as defined in the MOECC SWM Planning and Design Manual. The ‘Part 1 CSWMP-MP Assessed Level’ outlines the quality level as determined in the Part 1 CSWM-MP. The ‘CCTA Retrofit Priority Level’ is the priority level assigned to each facility based on the criteria discussed above.

Table 24: SWM Facility Quality Assessment

Pond ID	Pond Name	Type	Study Area (if applicable)	MOECC Design Level	Part 1 CSWMP-MP Assessed Level	CCTA Retrofit Priority Level
13-1	Kempenfelt Bayside Estates	Wet		Enhanced	Poorer than ‘Basic’	2014 Cleanout
7-5	Innisbrook Developments Phase 2	Wet		N/A	Poorer than ‘Basic’	2015 Cleanout
8-4	Crossroads #2	Wet	Alcona	Enhanced	‘Basic’	2015 Cleanout
8-1	Trillium Industrial	Dry	Innisfil Heights	N/A	Poorer than ‘Basic’	1
10-1	Brandy Lane/Village North	Wet (Retrofit)	Stroud	N/A	Poorer than ‘Basic’	1
10-2	Village North Dempster	Dry	Stroud	N/A	Poorer than ‘Basic’	1
9-2	Southview	Dry	Stroud	N/A	Poorer than ‘Basic’	1
13-2	Monrepos	Dry		N/A	Poorer than ‘Basic’	2
13-3	South Shore Woods	Wet		Enhanced	Poorer than ‘Basic’	2
4-2	Coralwoods	Dry	NVCA	N/A	Poorer than ‘Basic’	2
9-3	Victoria Green	Dry	Stroud	N/A	Poorer than ‘Basic’	3
9-4	Doral East	Wet	Innisfil Heights	Normal	‘Enhanced’	3
6-1	Previn Court Stage 1	Wet	Alcona	Enhanced	-	3
4-1	Valleyview	Dry	NVCA	N/A	Poorer than ‘Basic’	3
8-3	Crossroads Phase 1 Retrofit	Wet (Retrofit)	Alcona	N/A	‘Enhanced’	3
7-6	Innisbrook Subdivision	Wet	Alcona	Enhanced	‘Basic’	3
6-3	Tepco South	Wet	Alcona	Enhanced	‘Enhanced’	4
7-1	Royal Alcona	Wet	Alcona	N/A	Poorer than ‘Basic’	4
9-1	Alcona Woods	Dry	Alcona	N/A	Poorer than ‘Basic’	4
15-1	Goldcrest	Dry	Fennell’s Corners	N/A	Poorer than ‘Basic’	4
10-5	RIROB		Sandy Cove	N/A	-	4
7-3	Wallace Mills Phase 1	Wet	Alcona	Enhanced	‘Normal’	4
10-3	McKee	Wet	Sandy Cove	Enhanced	-	4
8-5	Skivereen Subdivision	Wet	Alcona	Enhanced	‘Enhanced’	4

Pond ID	Pond Name	Type	Study Area (if applicable)	MOECC Design Level	Part 1 CSWMP-MP Assessed Level	CCTA Retrofit Priority Level
6-2	Tepco North	wet	Alcona	Enhanced	'Normal'	4
7-9	Green Acres (North)	Wetland	Alcona	N/A	-	4
7-4	Forest Valley	Dry	Innisfil Heights	N/A	Poorer than 'Basic'	4
9-5	Doral West	Wet	Innisfil Heights	Enhanced	'Enhanced'	5
8-2	Taylorwoods	Dry	Alcona	Normal	2013 cleanout	5
7-2	Wallace Mills Phase 2	Wet	Alcona	Enhanced	-	5
7-8	ORSI	Wet	Alcona	Enhanced	'Enhanced'	5
7-7	Green Acres (South)	Wet	Alcona	Enhanced	-	5
7-10	Green Acres (West)		Alcona	N/A	-	5
7-11	Woodland Park North		Alcona	N/A	-	5
7-12	Woodland Park South		Alcona	N/A	-	5
7-13	South Rec Centre	Wet		N/A	-	5
7-14	Innisfil Admin Building Back	Wet		N/A	-	5
7-15	Innisfil Admin Building Front	Wet		N/A	-	5
8-6	Pratt Alcona North		Alcona	N/A	-	5
8-7	Pratt D'Amico Phase 1		Alcona	N/A	-	5
8-9	Crossroads Addulum	Wet	Alcona	N/A	-	5

8.1 Big Bay Point

There are no existing SWM facilities within the Big Bay Point study area, therefore there are no proposed retrofits. Prior to the start of construction for the Friday Harbour Resort Development, the study area was completely undeveloped.

8.2 Sandy Cove

The Sandy Cove study area currently has two SWM facilities. The McKee Pond (Pond #10-3) is located within the study area boundary, however the contributing drainage area to the facility is located south of the study area boundary. There is a second facility (Rirob Pond #10-5) located adjacent to the McKee Pond, which is an on-line SWM facility on Mooselanka Creek. As the McKee Pond is on the southern border of the study area, and provides controls for developments outside of the study area, there are no SWM controls provided for any of the existing developments in the area. This presents an opportunity to implement SWM improvements for some part of the 248.8 ha of existing uncontrolled development area. The following is a description of the current function of the two (2) existing facilities in the study area.

McKee (Pond #10-3)

The McKee pond was constructed in 1995 as a wet SWM facility to provide SWM controls for a drainage area of approximately 11.8 ha (approximate imperviousness is 35%). This appears to be functioning at an adequate level based on the total permanent pool volume and the total active storage volume. Upon field inspection, there appears to be excessive algae and vegetation growth in the pond. Removal of the algae should be the prime objective for any retrofit works.

A detailed list of retrofit opportunities are provided in the Part 1 Report which include: construction of a deepened pool area to increase sediment settling, review the grade of upstream and downstream flow paths to reduce standing water, improvements to downstream channel, and installation of an aeration device to improve the pond’s water quality function. This pond has been designated as a Priority 4 retrofit status due to the relatively high existing performance, and the relatively small contributing drainage area.

RIROB (Pond #10-5)

The RIROB pond is an on-line facility on Mooselanka Creek (Watercourse #2), and is located immediately east of the McKee pond. The RIROB pond outlets to the creek via a 1,050 mm diameter concrete outlet pipe, which then immediately discharges into Lake Simcoe. The pond was designed as a wet SWM facility to provide quality controls for the upstream drainage area of approximately 319.5 ha. The pond was proposed to undergo retrofits to its inlet and outlet during the construction of the McKee subdivision. A bypass weir was created to divert flows greater than the 25 mm storm event into a bypass channel which outlets directly to Lake Simcoe. During the retrofit, the outlet was also modified to provide a minimum draw-down time of 24 hours for the 25 mm storm event to increase siltation control.

Currently, this facility is acting as a wetland, with a visible low flow channel running from inlet to outlet. There is overgrown vegetation (cattails, small trees) throughout the pond, as well as some algae growth and oily film. There is visible sediment build-up around the perimeter of the pond as well as a beaver dam in the pond. This facility has been given a Priority 4 retrofit, as it is likely providing some quality control, however it is not designed to provide quantity control. Due to the large contributing drainage area (approximately 319.5 ha), increasing the quality control of the facility would have a moderate relative benefit.

8.3 Stroud

The Stroud study area currently has four (4) SWM facilities controlling a total of 98.5 ha of land. This represents approximately 62% of all currently developed land in the study area. The existing SWM facilities in the area are the Southview Pond (Pond #9-2), Brandy Lane Pond (Pond #10-1), the Village North Dempster Pond (Pond # 10-2), and the Victoria Green Pond (Pond #9-3). The following is a description of the current function of the ponds in the study area.

Southview (Pond #9-2)

The Southview pond was constructed in 1988 as a dry SWM facility to provide SWM controls for approximately 28 ha of low density residential land (approximate imperviousness is 43%). This pond was constructed prior to the release of the MOECC SWM Planning and Design Guidelines. As such, the quality control provided does not meet the Enhanced Level. There is currently inadequate information available to assess the facility's quantity control function.

The preferred retrofit option for this pond would be to modify it into a hybrid wetland/wet pond. This would provide improved water quality characteristics by creating a deeper permanent pool throughout the pond. Detailed recommendations are included in the Part 1 CSWM-MP. Due to the age and relatively large contributing drainage area, this pond was assigned a Level 1 retrofit status, requiring a complete retrofit which would be highly beneficial with respect to stormwater quality control.

Victoria Green (Pond #9-3)

The Victoria Green pond was constructed in 1986 as a dry SWM facility to provide SWM controls for approximately 24 ha of low density-estate residential land (approximate imperviousness of 47%). In 2012, emergency maintenance was completed to remove beaver dams which resulted in the blockage of the outlet structure and compromised the operation of the pond. The beaver dam was removed, however no further cleanout work (sediment removal) was completed.

Over the years of pond operation, sediment build up has resulted in stormwater retention in the pond, and has caused it to function more like a wet pond or hybrid pond. It is recommended that a detailed review of this pond be conducted at the same time as the Brandy Lane Pond (Pond #10-1) as there is an opportunity to split the flows between the ponds and improve the efficiency of both. This pond has been given a Priority 3 retrofit status, as only a moderate relative benefit would be achieved by any pond works.

Brandy Lane (Pond #10-1)

The Brandy Lane pond was originally constructed in 1992 as a dry SWM facility; however it was later converted into a wet SWM facility. The pond provides SWM controls for approximately 15.5 ha of developed land (approximate imperviousness of 50%). This facility has inadequate permanent pool volume resulting in inadequate quality control. There are a number of deficiencies within the pond, including erosion and sediment build-up, failing/breached berms, submerged inlet pipes and standing green, cloudy water with algae growth.

The preferred retrofit option for this pond is to do a complete re-design and re-build to increase the overall performance of the pond. This would involve installing an OGS unit immediately upstream of the SWM facility to decrease the overall sediment loading, creating a deep permanent pool, and install a media based wetland treatment system. A complete description of the proposed retrofit is included in the Part 1 CSWM-MP. Due to the poor design and performance of this SWM facility, it has been given a Priority 1 status, requiring a complete retrofit to provide increased quality and quantity or controls.

Village North Dempster (Pond #10-2)

The Village North Dempster pond was constructed in 1988 as a dry SWM facility to provide SWM controls for approximately 31.0 ha of developed land (approximate imperviousness of 49%). Based off the surveyed volumes completed in the Part 1 CSWM-MP, the pond is undersized for both extended detention and active storage; therefore neither adequate quantity nor quality controls are being provided.

Due to the relatively large upstream drainage area and the high level of imperviousness, coupled with the overall poor pond function, this facility has been given Priority 1 status, requiring a complete retrofit to provide increased quality and quantity controls.

8.4 Innisfil Heights

The Innisfil Heights study area currently has four (4) SWM facilities controlling a total of 70.1 ha of land. This represents approximately 42% of all currently developed land in the study area. The existing SWM facilities in the area are the Forest Valley pond (Pond #7-4), Trillium Industrial pond (Pond #8-1), Doral East pond (Pond #9-4) and Doral West pond (Pond #9-5). Over half of the existing developed area in the study area is uncontrolled. This presents an opportunity to implement SWM BMPs to improve both water quality and quantity controls in the area, as well as promote infiltration. The following is a description of the current function of the ponds in the study area.

Forest Valley (Pond #7-4)

The Forest Valley pond was constructed in 1998 as a dry SWM facility which provides control for approximately 9.9 ha of estate residential area (approximate imperviousness of 16%). It is assumed that the SWM facility was designed in accordance with the MOECC 1994 SWM Guidelines, however calculations from the Part 1 CSWM-MP indicate that the pond does not provide adequate extended detention or active storage volumes.

The preferred retrofit option is to improve the existing functions of the dry pond, which does not include MOECC Enhanced water quality protection. The retrofit could include some or all of the following: cleanout sediment to increase storage volumes, improve extended detention by modifying outlet structure, provide a deepened outlet with a bottom draw pipe, and install an OGS unit immediately upstream of the facility. This pond has been given Priority 4 retrofit status, due to the relatively small estate residential area that it services, as well as the fact that Enhanced water quality treatment will not be achieved. A full list of retrofit options is included in the Part 1 CSWM-MP.

Trillium Industrial (Pond #8-1)

The Trillium Industrial pond was constructed in 1993 as a dry SWM facility which provides SWM controls for approximately 31 ha of industrial land. The pond currently provides minimal water quality control, as there is no permanent pool and the extended detention volume provided is insufficient. The pond does provide the required quantity controls. However, due to the relatively large upstream catchment and the type of land use it services (industrial land use is highly impervious and often produces more pollutants), increasing the water quality control in the pond would greatly benefit the downstream water body.

The Part 1 CSWM-MP has provided a number of alternatives for retrofit of this facility, all of which will improve the quality of stormwater runoff. These alternatives include retrofitting the facility into a wetland, a hybrid facility, or a wet pond. It should also be noted that the roadside ditches servicing the area have potential for future enhancement and should be considered as part of the retrofit for this facility. Due to the relatively large upstream catchment and the type of land it is servicing, this facility has been given a Priority 1 retrofit status, requiring a complete retrofit.

Doral East (Pond #9-4)

The Doral East pond was constructed in 2002 as a wet SWM facility to provide SWM controls for an area of approximately 21.7 ha of land (approximate imperviousness of 27%). Overall, this pond is functioning at an adequate level. There is sufficient permanent pool and extended detention volumes, providing Normal water quality control as indicated in the Part 1 CSWM-MP.

There are a number of measures which could be implemented to improve the pond function. These measures include: install an OGS immediately upstream of the facility to reduce sediment loading, improve the upstream swales, repair the eastern inlet channel, and remove the accumulated sediment from the forebays. This facility has been given a Priority 3 retrofit status as improvements such as installing an upstream OGS would have moderate benefits relative to other possible facility upgrades.

Doral West (Pond #9-5)

The Doral West pond was constructed in 2002 as a wet SWM facility to provide SWM controls for an area of approximately 7.7 ha of land (approximate imperviousness of 21%). Overall, this pond is functioning at an adequate level. There is sufficient permanent pool and extended detention volumes, providing Enhanced water quality control. The only deficiency within the pond is the poor vegetation. This facility has been given a Priority 5 retrofit status, as the pond is functioning as designed and does not need any improvements.

8.5 Lefroy

There are no existing SWM facilities within the Lefroy study area. There are currently 200.4 ha of developed land in Lefroy which drain into Lake Simcoe or a neighbouring watercourse, all of which is uncontrolled with respect to stormwater runoff. This presents an opportunity for implementation of LID SWM controls within the area to increase water quality and quantity controls, and increase infiltration.

8.6 Gilford

There are no existing SWM facilities within the Gilford study area. There are currently 109.6 ha of developed land in Gilford which drain into Lake Simcoe or a neighbouring watercourse, all of which is uncontrolled with respect to stormwater runoff. This presents an opportunity for implementation of LID SWM controls within the area to increase water quality and quantity controls, and increase infiltration.

8.7 Fennell's Corners

The Fennell's Corners study area currently has only one SWM facility which controls 12.6 ha of developed land. The controlled area represents approximately 68% of the developed land in the study area. The SWM facility is the Goldcrest Pond (Pond # 15-1).

Goldcrest (Pond #15-1)

The Goldcrest pond was constructed in 1990 as a dry SWM facility which provides control for approximately 12.6 ha of upstream developed land (approximate imperviousness of 49.5%). The facility was built prior to implementation of the MOECC 1994 SWM Guidelines. This facility was determined to provide basic level quality treatment, and does not provide adequate quantity control. There is noticeable sediment deposition and organic matter build-up, with stagnant water at the outlet.

There are no retrofit measures currently proposed for this facility, however it may be beneficial to establish a maintenance schedule in consideration of the established wetland which has formed. This facility has been given Priority 4 retrofit status due to the low relative benefit any improvement would have on stormwater quality or quantity.

8.8 Alcona Central

As the North and South Alcona Secondary plan lands are not yet constructed, there are no SWM facilities within these areas. As such, the following data represents the SWM facilities included in Alcona Central. The Alcona Central study area has 21 existing SWM facilities which control approximately 353.5 ha (49.5%) of developed land in the area. A description of each SWM facility is provided below.

Alcona Woods (Pond# 9-1)

The Alcona Woods pond was constructed in 1988 as a dry SWM facility in order to provide stormwater controls for a 6.0 ha residential development located near the shores of Lake Simcoe (approximate imperviousness of 45%). The construction of the pond predates any MOECC Guidelines and thus its design components do not meet current SWM practises. Over the years the pond has developed into a wetland type feature with dense vegetation. The pond now provides higher than 'basic' level water quality treatment

A number of recommendations have been made to enhance the function of the pond. These include: removal of existing sediment near the inlet to improve existing treatment capacity, installation of an OGS unit upstream of the inlet to minimize sediment load, create a meandering low flow channel through the facility and create a deeper pool near the outlet to further enhance the wetland operation. This facility has been given a Priority 4 retrofit status due to the low relative benefit any improvement would have on stormwater quality or quantity.

Previn Court (Stage 1) (Pond# 6-1)

The Previn Court (Stage 1) pond was constructed in 2002 as an Enhanced Level wet SWM facility which provides control to an area of 74 ha (approximate imperviousness of 22%). It is assumed that the SWM facility was designed to the 1994 MOECC SWM Guidelines. It was determined that this facility currently provides adequate permanent pool and extended detention volume to provide Enhanced water quality controls, as well as sufficient active storage volume for quantity control. Potential upstream stormwater treatment features such as ponds, sediment collectors or ditches may be required to provide additional runoff control.

There are a number of maintenance and retrofit recommendations that would improve the function of this facility. The maintenance options include: repairs to the access road of the pond to reduce grit/gravel deposition into the pond, debris cleanout of the inlet culvert and sediment cleanout in the bypass channel to increase its flow depths and conveyance capacity. The retrofit options include: increasing the pond volume, installing an OGS unit upstream of the inlet, provide a deep pool area at the outlet to the storm sewer to reduce vegetation and potential blockages and install an aeration fountain to improve water quality. This facility has been given Priority 3 retrofit status, as even though the facility is functioning relatively well, the upstream drainage area contributing to this facility is the large, and improvements are expected to provide significant overall benefits.

Wallace Mills Phase 2 (Pond# 7-2)

The Wallace Mills Phase 2 pond was constructed in 1998 as a wet SWM facility and underwent a clean out in 2012 to remove accumulated sediment. It controls approximately 23.9 ha of residential land. It has been recommended that the pond be reviewed again in 5 years. Based on the sediment that was removed from the pond, the pond is operating at Level 2 (MOECC Normal protection level). This facility has been given Priority 5 retrofit status.

Wallace Mills Phase 1 (Pond# 7-3)

The Wallace Mills (Phase 1) pond was constructed in 2002 as a wet SWM facility that provides control for approximately 28 ha of low density residential development (approximate imperviousness of 40%). It is assumed that the pond was constructed according to the 1994 MOECC SWM Guidelines. The pond was recently cleaned out in 2012 to remove accumulated sediment.

There are still a number of retrofit improvements which could be made to this facility. These include: installation of an OGS unit at the inlet, improvements to the forebay design, outlet modification to improve water quality controls and the addition of an aeration fountain to increase the ponds water quality treatment function. This facility has been given Priority 4 retrofit status due to the recent cleanout.

ORSI (Pond# 7-8)

The ORSI pond was constructed in 1999 as a wet SWM facility to service an upstream catchment area of 32.5 ha (approximate imperviousness of 11%). The upstream land is mostly undeveloped. The facility was found to provide sufficient quality control but does not provide adequate quantity control. It is recommended that this facility undergo further review upon completion of any upstream development. There are no retrofit recommendations at this time, and as such has been given a Priority 5 retrofit status.

Taylorwoods (Pond# 8-2)

The Taylorwoods SWM facility was constructed in 1996 as a dry SWM facility. It is assumed that the pond was designed according to the 1994 MOECC SWM Guidelines. The pond is servicing approximately 14 ha of estate residential area in close proximity to the Lake Simcoe shoreline. The Taylorwoods SWM facility underwent a clean out in 2012 in order to remove sediment and is currently operating at an MOECC Enhanced Level treatment. This facility has been given Priority 5 retrofit status.

Crossroads (Phase 2) (Pond# 8-4)

The Crossroads pond was constructed in 1993 as a Level 1 wet SWM facility with wetland components to provide higher water quality functions. The SWM facility currently provides control for 19.9 ha (approximate imperviousness of 48%) of residential land. It was determined that this facility is currently providing inadequate water quality control due to sediment build up. This pond has been evaluated under the Town's cleanout program, and a design has been completed to remove accumulated sediment. This facility was cleaned out in the summer of 2015.

Besides the sediment cleanout, there are a number of other retrofit/cleanout possibilities which could improve the ponds function. These include: repairs to the gates/locks, removal of debris from the culverts, installation of an OGS unit upstream of the inlet to reduce sediment loading and increasing the permanent pool volume with a deep pool area at the outlet as this pond has recently been cleaned out, it has not been given a retrofit status.

Skivereen Subdivision (Pond# 8-5)

The Skivereen pond was constructed in 1999 as a wet SWM facility and is servicing an upstream area of approximately 12 ha of residential land (approximate imperviousness of 48%). The facility design predates the current MOECC SWM Guidelines, but is believed to be functioning at Enhanced Level protection. The available permanent pool volume and reduced sediment loadings from the residential area allow for proper pond functions.

It is recommended that monitoring of the sediment levels within the forebay take place to ensure that the pond continues to function as designed. Installing an OGS unit immediately upstream of the pond will help to maintain the ponds function over time. This facility has been given Priority 4 retrofit status, as it is currently providing a high level of control and improvements would provide minimal benefit.

Tepco North (Pond# 6-2)

The Tepco North pond was constructed in 2005 as a wet SWM facility according to the current MOECC SWM Guidelines. The facility services an upstream area of 8.5 ha (approximate imperviousness of 35%) in the Alcona subdivision and is part of the Bank's Creek watershed. The current permanent pool volume is slightly less than the required volume for Level 1 quality control. The active storage volume available is sufficient.

There are a number maintenance and enhancement measures that have been recommended for this site which include: sediment removal from the pond, monitoring of the planting around and within the pond and the installation of an OGS unit at the inlet. This facility has been given Priority 4 retrofit status due to the small drainage area and the relatively high functioning level of the pond. It is recommended that regular maintenance inspections be performed to monitor the sediment accumulation.

Tepco South (Pond# 6-3)

The Tepco South pond was constructed in 2005 as a wet SWM facility under the current MOECC SWM Guidelines. The facility services a total upstream area of 5.9 ha of residential land (approximate imperviousness of 42.5%). The pond appears to be performing at an adequate level; however upon inspection the forebay berm is completely submerged and the potential for short circuiting of flows from the inlet to the outlet exists.

Some retrofit and enhancement opportunities include: restoration of the forebay berm, and potential deepening of the pond permanent pool. This facility has been given Priority 4 retrofit status due to the small drainage area and relatively high level of function.

Royal Alcona (Pond# 7-1)

The Royal Alcona pond was constructed in 2007 as a wet SWM facility and is serving an upstream area of 40.4 ha (approximate imperviousness is 47.8%). The pond underwent a retrofit in 2009 to enhance the function of the facility.

There are a number of maintenance and retrofit measures that have been recommended including: additional monitoring of sedimentation during pond inspections, removal of sediment, installation of an OGS unit upstream, and an evaluation of the contributing drainage area in connection with a possible retrofit to accommodate the new area. This facility has been given Priority 4 retrofit status due to the recently completed retrofit.

Innisbrook Subdivision (Pond# 7-6)

The Innisbrook Subdivision SWM facility was constructed in 2003 and was subsequently upgraded in 2009 as a wet SWM facility. The facility is servicing an upstream area of 6.0 ha of residential area (approximate imperviousness of 50%). The pond is beginning to show signs of sedimentation especially at the outlet which could be a result of ongoing construction within the subdivision, insufficient pond depth, or insufficient length to width ratio to accommodate runoff from the contributing area.

A number of maintenance and retrofit measures have been recommended which include: sediment removal and pond clean-up, clean out of the hickenbottom chamber, increasing the permanent pool volume, addition of an OGS unit at the inlet, flow deflective barriers in order to reduce the velocity through the pond and replacement of the open grate with an infiltration grate at the hickenbottom structure in order to prevent sediment and grit migration. This facility has been given Priority 3 retrofit status due to the large accumulation of sediment in the pond.

Green Acres South (Pond# 7-7)

The Green Acres (South) SWM facility was constructed in 2004 as a wet SWM facility. 'As constructed' drawings indicate that the pond is servicing an area of 6.8 ha however the LSRCA data indicates a serviced area of only 6.4 ha. The LSRCA assessed the facility to be a Level 1 pond.

A number of improvements have been recommended which include: pond monitoring in order to ensure a healthy ecosystem is established and planting improvements to maintain native terrestrial and aquatic habitat while providing shading to the pond to allow for further naturalization of the site. This facility has been given Priority 5 retrofit status due to the small drainage area and high level of treatment.

Green Acres North (Pond# 7-9)

The Green Acres North SWM facility was constructed in 2005 and subsequently followed by a retrofit in 2009. The facility is located within a wetland complex. It is assumed that the overall 2009 retrofit/redesign considerations aimed to provide water quality and quantity controls in accordance with the current MOECC SWM Guidelines while taking into consideration the Bon Secours Creek and the Woodland Park wetland.

A site visit completed as part of the Part 1 CSWM-MP made a number of observations which may contribute to further site improvements including: enforcement of the 'onsite construction practises' within the catchment areas, monitoring of the planting strategy, cleanout of sediment deposition at the storm outlets, installation of grit capture devices and considerations for the fish habitat connectivity along the creek. This facility has been given Priority 4 retrofit status.

Green Acres West (Pond# 7-10)

The Green Acres West SWM facility is a new facility and has not yet been assessed. Some maintenance and enhancement opportunities include: pond monitoring to ensure a healthy ecosystem is established, enforcement of the 'onsite construction practises', and planting improvements to maintain native terrestrial and aquatic habitat while providing shading for the pond to allow for further naturalization of the site. This facility has been given Priority 5 retrofit status.

Woodland Park North (Pond# 7-11)

The Woodland Park North SWM facility is a new facility and has not yet been assessed. The pond controls approximately 11.4 ha of residential land. Some maintenance and enhancement opportunities include: pond monitoring to ensure a healthy ecosystem is established, enforcement of the 'onsite construction practises', and planting improvements to maintain native terrestrial and aquatic habitat while providing shading for the pond to allow for further naturalization of the site. This facility has been given Priority 5 retrofit status.

Woodland Park South (Pond# 7-12)

The Woodland Park South SWM facility is a new facility and has not yet been assessed. The pond controls approximately 5.9 ha of residential land. Some maintenance and enhancement opportunities include: pond monitoring to ensure a healthy ecosystem is established, enforcement of the ‘onsite construction practises’, and planting improvements to maintain native terrestrial and aquatic habitat while providing shading for the pond to allow for further naturalization of the site. This facility has been given Priority 5 retrofit status.

Pratt Alcona North (Pond# 8-6)

The Pratt Alcona North SWM facility is a new facility and has not yet been assessed. The pond is located in a very urban setting and has had significant construction activity around it. The pond controls approximately 8.3 ha of land. There is little to no vegetation established around the pond. It is recommended that the pond will have a cleanout prior to the acceptance and assumption to restore function. This facility has been given Priority 5 retrofit status.

Crossroads Phase 1 (Pond# 8-3)

The Crossroads Phase 1 SWM facility was originally constructed in 1991 and retrofitted to a wet pond in 2011 in accordance to the current MOECC SWM Guidelines. The facility services an upstream area of approximately 20.5 ha of primarily residential development (imperviousness of approximately 49.3%). The site is also located adjacent to a local natural wetland-woodlot area. It was determined that this facility provides adequate quantity and quality control.

A number of maintenance and retrofit enhancements have been recommended which include: removal of debris from the inlet structures, lock the main inlet structure, local sediment removal, increasing the detention time through outlet modifications, installation of an aeration device to improve water quality and the installation of flow deflective devices to elongate the flow paths within the pond. This facility has been given Priority 3 retrofit status.

Pratt D’Amico Phase 1 (Pond# 8-7)

The Pratt D’Amico SWM facility is a new facility that has not yet been assessed and was not included in the surveys or assessments in the Part 1 report. It is currently under construction and was not included in the LSRCA assessments. The pond controls approximately 10.4 ha of land. No retrofit recommendations have been made at this time. This facility has been given Priority 5 retrofit status.

Crossroads Addulum (Pond# 8-9)

The Crossroads Addulum SWM facility was constructed in 1993 as a wet SWM facility. This facility was assessed by the LSRCA and determined to provide only quantity control. The pond services a small area of 2.4 ha. This facility has been given Priority 5 retrofit status due to the small size of the upstream drainage area.

8.9 SWM Facilities Outside of the Study Areas

There are a number of SWM facilities which are not located within any of the study areas, and provide stormwater controls for various developed areas. These ponds have been included within the pond assessments to provide a complete list of retrofit opportunities within the Town.

Vallyview Pond (Pond# 4-1)

The Vallyview SWM facility was constructed in 1987 as a dry facility. It was constructed prior to the 1994 SWM Guidelines and thus its design components do not meet current SWM guidelines. It is a small pond with an upstream catchment area of approximately 7.1 ha consisting of an older residential area (approximate imperviousness of 50%). The flow path of the pond indicates short circuiting and poor use of the pond area for water quality purposes. This facility provides insufficient quality control.

The preferred retrofit option for this pond would be to convert the facility into a hybrid pond with extended detention storage. This would provide improved water quality treatment by creating a deeper permanent pool throughout the pond. Detailed recommendations are included in the Part 1 SWM-MP. This facility has been given Priority 3 retrofit status as it is in need of upgrading, however it controls a small drainage area and is not located in any of the densely developed study areas.

Coral Woods (Pond# 4-2)

The Coral Woods SWM facility was constructed in 1990 as a dry pond prior to the 1994 MOECC SWM Guidelines and thus many of its design components do not meet the current SWM Guidelines. The pond has a contributing upstream area of approximately 18.4 ha of low density residential area (approximate imperviousness of 45%).

It has been recommended that this pond be converted to a hybrid-wetland facility. This would include a number of enhancements such as: improving the wetland type pockets in the open space area, the installation of a pre-treatment sediment collector upstream of the inlet and providing additional vegetation along the channel. This facility has been given a Priority 2 retrofit status due to its poor function and medium sized contributing drainage area.

Monrepos (Pond# 13-2)

The Monrepos SWM facility was constructed in 1988 as a dry pond. It is servicing an upstream area of approximately 22 ha consisting of an estate lot subdivision (approximate imperviousness of 38%). Currently the pond is achieving quantity control only and providing insufficient quality control. There is an opportunity to improve this pond without the need for additional area.

The preferred retrofit option for this facility is to re-design the pond and maintain the existing wetland feature while adding a permanent pool. This would include a number of enhancements including: increasing the extended detention volume, providing a deep permanent pool area at the outlet and improvements to pond inlet aimed at reducing erosion. This facility has been given a Priority 2 retrofit status due to its poor function and medium sized contributing drainage area.

Innisbrook Developments Phase 2 (Pond# 7-5)

The Innisbrook Developments SWM facility was constructed in 2003 as a wet pond. The facility has an upstream area of approximately 22.4 ha of estate residential area (approximate imperviousness of 32.8%). The facility is currently providing inadequate quality control. This pond has been evaluated under the Town's cleanout program, and a retrofit was completed in the summer of 2015.

A number of retrofit recommendations have been made which include: maintenance for sediment cleanout or partial cleanout, improve shading of the facility by improving existing planting, the addition of an aeration fountain to improve water quality control and the installation of a grit removal chamber. As this facility has been recently cleaned out, the pond has not been given a retrofit status.

South Rec Centre (Pond# 7-13)

This facility was constructed in 2008, and, due to the relatively recent construction as well as the pond performance based on visual inspection, it is determined that this pond does not require further assessment. This facility has been given a Priority 5 retrofit status.

Innisfil Admin Building Back (Pond# 7-14)

This facility was constructed in 2008, and due to the relatively recent construction as well as the pond performance based on visual inspection, it is determined that this pond does not require further assessment. This facility has been given a Priority 5 retrofit status.

Innisfil Admin Building Front (Pond# 7-15)

This facility was constructed in 2008, and due to the relatively recent construction as well as the pond performance based on visual inspection, it is determined that this pond does not require further assessment. This facility has been given a Priority 5 retrofit status.

Kempenfelt Bayside Estates (Pond# 13-1)

The Kempenfelt Bayside Estates SWM facility was constructed in 2004 according to the current MOECC SWM Guidelines. The pond has an upstream area of approximately 37.4 ha (approximate imperviousness of 40%). The pond currently provides inadequate permanent pool volume. This pond has been evaluated under the Town's cleanout program, and a retrofit was completed in 2014. On this basis the pond has not been given a retrofit status.

South Shore Woods (Pond# 13-3)

The South Shore Woods SWM facility was constructed in 2004 as a wet pond. The pond has an upstream area of 37.7 ha consisting of estate residential development (approximate imperviousness of 24%). This pond is only providing quantity control. The quality control has been found to be insufficient. There is ongoing development within the contributing catchment which has resulted in excessive sediment loading in the pond.

The retrofit recommendations for this facility include: sediment removal after site development is completed, installation of an aeration fountain for water quality improvement, installation of baffles to elongate the flow path and the addition of a deep pool at the outlet. This facility has been given a Priority 2 retrofit status, requiring partial retrofits which would provide significant benefits related to stormwater quality.

8.10 Effectiveness of Existing SWM Systems in a Changing Climate

The treatment area of the existing SWM facilities in the study areas total approximately 866 ha (including 319.5 ha draining to the RIROB pond). On this basis, the majority of the study area does not rely on upstream SWM systems for either water quality or quantity controls causing the receiving watercourses or water bodies to be especially vulnerable to climate chance. The following is a list of effects of climate change that have the potential to affect the existing and future SWM systems and are to be considered for retrofit opportunities and in the design of future SWM systems:

- more frequent and intense storm events;
- more frequent and extended droughts;
- more frequent winter thaws;
- earlier spring thaws and associated freshets; and
- plant community die-offs due to the above environmental conditions.

9 Identify & Evaluate Stormwater Improvement & Retrofit Opportunities (Step Seven)

A number of alternatives have been developed in order to address the problem statement for each study area assessed in this report. Each alternative is intended to improve the overall health of the Lake Simcoe watershed. The alternatives include measures to improve stormwater runoff quality and quantity from existing developments, as well as suggest appropriate SWM measures for future developments within the study areas. For future developments, the alternatives have been divided into two categories: water quantity and water quality. The “Do Nothing” alternative has also been considered

Section 10 will select the overall preferred SWM options for the Town (Overall SWM Plan), as well as provide a detailed selection of options to implement for each individual study area.

9.1 “Do Nothing”

The “Do Nothing” alternative represents a scenario where no SWM controls are provided for any future developments, and no retrofits or maintenance is provided for any of the existing SWM facilities and development areas. This alternative is represented in the future conditions hydrologic model results. This scenario results in increased peak flows, increased flooding and increased erosion. Water quality is not addressed in this alternative. As such the phosphorus loadings to Lake Simcoe will increase. Infiltration rates in developed areas are also expected to decrease without efforts to maintain existing infiltration rates through a water budget exercise. This alternative does nothing to improve stormwater management in the Town, and is therefore not a viable option.

9.2 Existing Developments

9.2.1 Option 1: SWM Facility Retrofit or Maintenance Work

Based on the existing SWM facility analysis provided in Section 8, a number of retrofit/maintenance opportunities have been identified to increase the performance of existing SWM facilities. These opportunities include complete re-design and re-build of a facility, sediment cleanout, improvements to inlet/outlet structure, installation of an OGS unit, and improvements to the upstream or downstream watercourses. Implementing these changes provides various improvements to the existing stormwater runoff by improving water quantity and quality control, and reducing erosion. Each existing SWM facility presents different opportunities for retrofits which result in different impacts. The effectiveness of retrofits is discussed in further detail in the selection of preferred solutions in Section 10.

The Town has already begun to implement a SWM facility maintenance program to address issues in existing SWM facilities. These maintenance works mainly include general up-keep and cleaning out of sediment. Removal of sediment provides increased permanent pool and/or active storage volumes which can increase the stormwater quality and quantity functions of the facility. Regular pond inspections should aid in assessing the frequency of maintenance works. If available, SWM facility Operations and Maintenance manuals should also be used as a tool to assess pond maintenance requirements.

Completed Cleanouts

In 2013, three SWM facilities underwent cleanouts. The ponds were Wallace Mills Phase 2 (Pond #7-2), Wallace Mills Phase 1 (Pond # 7-3), and Taylorwoods (Pond #8-2). The work on these ponds is now complete, and all of the facilities are fully functioning. The functions of these ponds were not assessed during the design of the cleanout projects; the only goal was to remove accumulated sediment and flush the inlet and outlet pipes and structures.

In 2014, the Kempenfelt Bayside Estates facility (Pond #13-1) was cleaned out, reinstating the permanent pool volume and retrofitting the forebay. In 2015, the Innisbrook Developments Phase 2 (Pond #7-5), and Crossroads #2 (Pond #8-4) facilities were also cleaned out. The goal of these cleanout projects is to reinstate the permanent pool volume to the intended design volume.

9.2.2 Option 2: Improve Existing Stormwater Runoff: LID Measures

LID measures can be implemented, in areas where runoff is controlled or uncontrolled, to provide additional stormwater runoff quality and quantity controls. There are many existing developed areas in the study areas which release stormwater completely uncontrolled into neighbouring watercourses or directly into Lake Simcoe. These uncontrolled areas present opportunities for SWM BMPs to be implemented to increase quality and quantity control, as well as promote infiltration and groundwater recharge.

For existing developments which are controlled by traditional end-of-pipe SWM facilities, it is also possible to incorporate LID measures to increase runoff quality. LID opportunities will depend on available space, development type and soil and groundwater conditions. A detailed description of the various LID controls is provided in Section 9.4, however a short list is provided below. Further discussion of applicable LID measures on a study area basis is provided in Section 10.2, including:

- bioretention;
- soakaway/infiltration pits and trenches;
- green roofs;
- rainwater harvesting;
- downspout disconnection;
- permeable pavement;

- vegetated filter strips;
- perforated pipe systems; and
- enhanced grass swales.

9.2.3 Option 3: Improve Existing Stormwater Runoff: OGS Units

Where existing infrastructure permits, there may be opportunities to install OGS units to increase water quality treatment of stormwater runoff from existing developments. OGS units are able to remove sediment and hydrocarbons from stormwater runoff, and are ideal for treating runoff from parking lots and commercial/industrial developments. They can also be applied to residential developments. OGS units have much simpler maintenance requirements in comparison to standard end-of-pipe facilities.

There are two main locations where the installation of an OGS unit would improve existing stormwater runoff quality, including:

1. Installation of an OGS unit immediately upstream of an existing SWM facility, if the existing storm sewer system can accommodate this addition. An OGS installed in this manner will reduce the frequency of pond cleanouts, improving the lifespan of the pond and increasing its function.
2. Installation of an OGS unit on existing commercial or industrial developments which discharge into Town storm sewers. This is ideal for treating runoff from parking lots. OGS units should be considered during the reconstruction of any existing development.

9.2.4 Option 4: Improve Existing Uncontrolled Stormwater: End-of-pipe controls

It may be possible to construct new end-of-pipe SWM facilities (dry pond, wet pond, constructed wetland) downstream of existing developed areas to provide water quality and/or quantity control of stormwater runoff This option is dependent on the availability of land downstream of existing developments. The traditional end-of-pipe facilities are described below.

Wet SWM Pond

Wet ponds are the most common end-of-pipe SWM facility employed in Ontario. They are less land-intensive than wetland systems and are normally reliable in operation, especially during adverse conditions (winter/spring). A few benefits of wet SWM ponds are:

- performance does not depend on soil characteristics;
- the permanent pool minimizes re-suspension;
- the permanent pool minimizes blockage of the outlet;
- the permanent pool provides for extended settling;

- MOECC Enhanced Stormwater Quality control can be achieved with proper design; and
- can attenuate stormwater runoff with proper orifice/outlet design.

Dry SWM Pond

Dry SWM ponds have no permanent pool of water. While they can be effectively used for erosion and flood (quantity) control, the removal of sediments is a function of the detention time in the pond. For a 24 hour retention period, this normally means a lower contaminant removal, as inter event settling time does not exist. Dry SWM ponds cannot achieve MOECC Enhanced stormwater quality control; they are only capable of providing Basic Level control. They should be used where other SWM options are not feasible, or as part of a treatment train approach.

Constructed Wetlands

The constructed wetland is one of the preferred end-of-pipe SWM facilities for water quality enhancement. Wetlands are normally more land-intensive than wet ponds because of their shallower depth (both in permanent pool and active storage). They are suitable for providing the storage needed for erosion control purposes, but will generally be limited in their quantity control capabilities due to restricted active storage depth.

The benefits of constructed wetlands are similar to wet ponds and include:

- performance does not depend on soil characteristics;
- the permanent pool minimizes re-suspension;
- the permanent pool minimizes blockage of the outlet;
- the biological removal of pollutants (enhanced nutrient removal) occurs; and
- the permanent pool provides extended settling.

9.3 Future Development (Quantity Controls)

The following options have been assessed in regards to providing stormwater quantity controls for future development.

9.3.1 Option 5: Standard Post-to-Pre Control

This option would require all future developments to control the post development runoff to the pre development peak flow rate using a standard end-of-pipe SWM facility (wet/dry pond or wetland) for each proposed new development. This option will reduce the peak flow rates for the 2-100 year storm events; however the Regional Storm event will not be controlled. This option has been modeled in the future conditions hydrologic model in Section 7.1.2. This option does not address existing flooding problems or erosion control. This option may also lead to increased peak flow in some watercourses due to coincident peak flows from multiple pond outlets.

9.3.2 Option 6: Peak Flow Over-control

This option involves reducing the post development peak flows to less than the pre development peak flow rates. This will contribute to the reduction of peak flows in a number of watercourses and potentially reduce flooding in flood-prone areas. This option was modeled in future conditions hydrologic model in section 7.1.4. This would be accomplished using standard end-of-pipe controls (wet pond, dry pond or wetland), and would require a larger active storage volumes than the typical end-of-pipe controls described Option 4.

9.3.3 Option 7: Extended Detention Over-control

This option involves increasing the extended detention draw-down time to either 48 or 72 hours. This will provide increased time for particle settling, reducing the total sediment transported to the receiving watercourse.

9.3.4 Option 8: Water Balance & Infiltration Measures (LID Measures)

This option involves implementing LID measures to increase infiltration rates for new developments. In this scenario, new developments must match the pre development infiltration rates. Recommended approaches are listed below.

- In areas where soil/groundwater conditions permit, at source infiltration measures such as soakaway pits or equivalent measures installed at the lot level are recommended. In these areas, roof leaders and other impervious surfaces are to be directed towards pervious surfaces including lawns, side and rear yard swales, boulevards, parks and other open space areas throughout the development to promote infiltration.
- Road infiltration trenches should be installed where soil/groundwater conditions permit.
- End-of-pipe infiltration and exfiltration systems should be installed where soil and groundwater conditions permit.

A complete list of LID options is provided in Section 9.4.2.

9.3.5 Option 9: Over-control Infiltration Rates

This option requires that post-development infiltration rates for future developments be increased beyond the pre-development infiltration rate. This increase in infiltration at a site level will help to offset the vast amount of existing development which did not consider any infiltration measures. This increase in infiltration rate may also help to offset the potential decrease in infiltration due to climate change.

9.4 Future Development (Quality Controls)

9.4.1 Option 10: Standard Wet Pond

This option involves all future development providing MOECC Enhanced Level stormwater quality control by means of a wet pond.

9.4.2 Option 11: Implement LID Source Controls

The following sections describe the various LID source control measures which are recommended for consideration in the Town. These alternatives involve measures that are located at the source where runoff is generated and are often on private property. Source controls will improve stormwater runoff quality by promoting filtration and infiltration, as well as reducing stormwater runoff volumes and peak flows generated from impervious surfaces which, for the most part, originate in urban areas. Source controls can be used in a variety of different land uses including residential, industrial and commercial. Source controls can be retrofitted in existing developments, and should be implemented in all new proposed developments.

Roof Downspout Disconnection

Downspout disconnection involves directing flow from roof downspouts to a pervious area that drains away from a building. This prevents stormwater from directly entering the storm sewer system or flowing across a directly connected impervious surface, such as a driveway, and into a storm sewer. Downspout disconnection requires a minimum flow path length of 5 m across a pervious area.

When the infiltration rate of the soil in the pervious area is less than 15 mm/hour (i.e. hydraulic conductivity of less than $1x10^{-6}$ cm/s), the area should be tilled to a depth of 300 mm and supplemented with compost to achieve an organic content in the range of 8 to 15% by weight or 30 to 40% by volume.

Bioretention/Rainwater Gardens

As a stormwater filtration and infiltration practice, rainwater gardens use a bioretention system to temporarily store, treat and infiltrate stormwater runoff. Depending on the native soil infiltration rate, the system may be designed without an underdrain for full infiltration, with an underdrain for partial infiltration, or with an impermeable liner and underdrain for filtration only, which can also be referred to as a biofilter. The primary component of a bioretention practice is the filter bed with a mixture of sand, fines and organic material. Other important elements of bioretention include a mulch ground cover and plants adapted to the conditions of the stormwater practice. Pre-treatment, such as a settling forebay, vegetated filter strip, or stone diaphragm, often precedes the bioretention to remove particles that would otherwise clog the filter bed. Bioretention is designed to capture small storm events or the water quality storage requirements. An overflow bypass is necessary to pass large storm events.

Bioretention can be adapted to fit into many different development contexts and provides a convenient area for snow storage and treatment. In a low density development, it might have a soft edge and gentle slopes, while a high density application might have a hard edge with vertical slopes.

Green Roofs (Roof Gardens)

Green roofs consist of a thin layer of vegetation and growing medium installed on top of a conventional flat or sloped roof. Green roofs are publicized for their benefits to cities, as they improve energy efficiency, reduce urban heat island effects, and create greenspace for passive recreation or aesthetic enjoyment. To a water resource manager, they are attractive for their water quality, water balance, and peak flow control benefits. From a hydrologic perspective, the green roof acts like a lawn or meadow by storing rainwater in the growing medium and ponding areas. Excess rainfall enters underdrains and overflow is conveyed in the building drainage system. After the storm, a large portion of the stored water is evapotranspirated by the plants, evaporates or slowly drains away.

Soakaway Pits, Infiltration Trenches & Chambers

On sites suitable for underground stormwater infiltration practices, there are a variety of facility design options to consider, such as soakaway pits, infiltration trenches and infiltration chambers. Soakaway pits are rectangular or circular excavations lined with geotextile fabric and filled with clean granular stone or other void forming material, which receives runoff from a perforated pipe inlet and allows it to infiltrate into the native soil. They typically service individual lots and receive only roof and walkway runoff, but can also be designed to receive flows from other sources. Soakaway pits can also be referred to as infiltration galleries or dry wells.

Infiltration trenches are rectangular trenches lined with geotextile fabric and filled with clean granular stone or other void forming material. Like soakaway pits, they typically service an individual lot and receive only roof and walkway runoff. This design variation is well suited to sites where available space for infiltration is limited to narrow strips of land between buildings or properties, or along road right of ways. They can also be referred to as infiltration galleries or linear soakaways.

Infiltration chambers are another design variation of soakaway pits. They include a range of proprietary manufactured modular structures installed underground, typically under parking or landscaped areas that create large void spaces for temporary storage of stormwater runoff and allow it to infiltrate into the underlying native soil. Structures typically have open bottoms, perforated side walls, and optional underlying granular stone reservoirs. They can be installed individually or in series in trench or bed configurations. They can infiltrate roof, walkway, parking lot and road runoff with adequate pre-treatment. Due to the large volume of underground void space they create in comparison to a soakaway of the same dimensions, and the modular nature of their design, they are well suited to sites where available space for other types of LID practices are limited, or where it is desirable for the facility to have little or no surface footprint (high density developments).

Permeable Pavement

Permeable pavement, an alternative to traditional impervious pavement, allow stormwater to drain through them into a stone reservoir where it is infiltrated into the underlying native soil or temporarily detained. They can be used for low traffic roads, parking lots, driveways, pedestrian plazas and walkways. Permeable pavement is ideal for sites with limited space for other surface stormwater BMPs. Depending on the native soils and physical constraints, the system may be designed with no underdrain for full infiltration, with an underdrain for partial infiltration, or with an impermeable liner and underdrain to provide filtration only. Permeable paving allows for filtration, storage, or infiltration of runoff, and can reduce or eliminate surface stormwater flows compared to traditional impervious paving surfaces.

Rainwater Harvesting

Rainwater harvesting is the process of intercepting, conveying and storing rainfall for future use. Harvesting rainwater for domestic uses has proved to be practical in rural Ontario for over a century. Interest in adapting this practice to urban areas is increasing as it provides combined benefits of conserving potable water and reducing stormwater runoff. When harvested rainwater is used to irrigate landscaped areas, the water is either evapotranspirated by vegetation or infiltrated into the soil, thereby helping to maintain predevelopment water balance.

9.4.3 Option 12: Implement LID Conveyance Controls

Conveyance controls involve controlling the stormwater runoff as it travels along a designed drainage path. There are a variety of existing drainage features within the Town which could be retrofitted to provide specific LID treatment targets for stormwater runoff. These LID measures increase water quality by promoting filtration and infiltration, as well as reducing the stormwater runoff volume and peak flows. The proposed LID conveyance controls are listed in the following section.

Vegetated Filter Strips

Vegetated filter strips (also known as buffer strips and grassed filter strips) are gently sloping, densely vegetated areas that treat runoff as sheet flow from adjacent impervious areas. They function by slowing runoff velocity and filtering out suspended sediment and associated pollutants, and by providing some infiltration into underlying soils. Originally used as an agricultural treatment practice, filter strips have evolved into an urban SWM practice. Vegetation may be comprised of a variety of trees, shrubs and native plants to add aesthetic value as well as water quality benefits. With proper design and maintenance, filter strips can provide relatively high pollutant removal. Maintaining sheet flow into the filter strip through the use of a level spreading device is essential. Using vegetated filter strips as pre-treatment practices to other BMPs is highly recommended. They also provide a convenient area for snow storage and treatment, and are particularly valuable due to their capacity for snowmelt infiltration. If used for snow storage, the area should be planted with salt-tolerant, non-woody plant species.

Because of the simplicity of filter strip designs, physical changes to the practice are not needed for winter operation.

Enhanced Grass Swales

Enhanced Grass Swales are vegetated open channels designed to convey, treat and attenuate stormwater runoff (also known as enhanced vegetated swales). Check dams and vegetation in the swale slows the water to allow sedimentation, filtration through the root zone and soil matrix, evapotransipration, and infiltration into the underlying native soil. Simple grass channels or ditches have long been used for stormwater conveyance, particularly for roadway drainage. Enhanced Grass Swales incorporate design features such as modified geometry and check dams that improve the contaminant removal and runoff reduction functions of simple grass channel and roadside ditch designs.

A dry swale is a design variation that incorporates an engineered soil media bed and optional perforated pipe underdrain system. Enhanced Grass Swales are not capable of providing the same water balance and water quality benefits as dry swales, as they lack the engineered soil media and storage capacity of that best management practice.

Where development density, topography and depth to water table permit, Enhanced Grass Swales are a preferred alternative to both curb and gutter and storm drains as a stormwater conveyance system. When incorporated into a site design, they can reduce impervious cover, accent natural landscape, and provide aesthetic benefits.

Dry Swales

A dry swale can be thought of as an enhanced grass swale that incorporates an engineered soil bed and optional perforated pipe underdrain or a bioretention cell configured as a linear open channel. They can also be referred to as infiltration swales or bio-swales. Dry swales are similar to enhanced grassed swales in terms of the design of their surface geometry, slope, check dams and pre-treatment devices. They are similar to bioretention cells in terms of the design of the filter media bed, gravel storage layer and optional underdrain components. In general, they are open channels designed to convey, treat and attenuate stormwater runoff. Vegetation or aggregate material on the surface of the swales slows the runoff water to allow sedimentation, filtration through the root zone and engineered soil bed, evapotranspiration, and infiltration into the underlying native soil. Dry swales may be planted with grasses or have more elaborate landscaping.

Perforated Pipe Systems

Perforated pipe systems can be thought of as long infiltration trenches or linear soakaway pits that are designed for both conveyance and infiltration of stormwater runoff. They are underground stormwater conveyance systems designed to attenuate runoff volume and reduce contaminant loads to receiving waters. They are composed of perforated pipes installed in gently sloping granular stone beds that are lined with geotextile fabric that allow infiltration of runoff into the gravel bed and underlying native soil while it is being conveyed from source areas or other BMPs to an end-of pipe facility or receiving water body. Perforated pipe systems can be used in place of conventional storm sewer pipes, where topography, water table depth, and runoff quality conditions are suitable. They are suitable for treating runoff from roofs, walkways, parking lots and low to medium traffic roads, with adequate pre-treatment. A design variation can include perforated catch basins, where the catch basin sump is perforated to allow for runoff to infiltrate into the underlying native soil. Perforated pipe systems can also be referred to as pervious pipe systems, exfiltration systems, clean water collector systems and percolation drainage systems.

9.5 General Stormwater Improvement Opportunities

The following alternatives represent a number of implementable options, all of which can be implemented concurrently.

9.5.1 Option 13: Alter SWM System Design Rainfall to Account for Climate Change

Town Engineering Guides and standards should provide design intensity-duration-frequency (IDF) curve parameters and rainfall depths for all design storms (2- year through 100-year). These values should be adjusted to account for increased rainfall intensities due to climate change.

9.5.2 Option 14: Implement Landscape Program: Drought & Flood Tolerant Plant Species

SWM facilities including: wet ponds, dry ponds, wetlands, bio swales, bioretention cells, etc. play a vital role in water quality treatment throughout a number of biological and physical mechanisms. Nutrient uptake by plants and sediment filtering by vegetation are incorporated into the above SWM facilities to improve water quality and treatment of runoff. Landscape plans that consider native plant species able to tolerate extended wet and dry conditions are to be prepared with all proposed SWM systems. Selection of appropriate vegetation will ensure long term water quality treatment of runoff in all proposed SWM facilities. Efforts by the Town to replace unhealthy or dead vegetation in existing SWM facilities or along existing drainage paths etc. should be incorporated in the Town’s operation and maintenance plans and should also consider proper selection of plants to encourage water quality treatment and to avoid the need for repeated re-planting.

9.5.3 Option 15: Convert Roadside Ditches to Enhanced Grass Swales

As a vast majority of the developed land in the study areas is uncontrolled, as previously mentioned, this presents an opportunity to implement LID controls in appropriate areas to treat runoff from existing developments. An existing feature that the Town has no shortage of is roadside ditches. These ditches convey runoff from a variety of developments including residential, commercial and industrial. Converting these ditches to Enhanced Grass Swales provides an opportunity to increase the quality of stormwater runoff, as well as promote infiltration. Enhanced Grass Swales are discussed in detail in the TRCA and CVC's LID SWM Planning and Design Guide (2010), and are summarized below.

Enhanced Grass Swales are vegetated open channels designed to convey, treat and attenuate stormwater runoff. Check dams and vegetation in the swale slows the water to allow sedimentation, filtrating, evapotranspiration and infiltration. It is estimated that a volumetric runoff reduction of between 10-20% can be achieved by Enhanced Grass Swales, depending on soil type (20% for Type A or B, 10% for Type C or D). It is also estimated that these swales can remove 76% of Total Suspended Solids, and can reduce phosphorus by up to 55%. Some design considerations are listed below.

- Longitudinal swale slope should be between 0.5 and 4%. For slopes steeper than 3%, check dams should be used. Slopes less than 1% enhance the removal rate of pollutants.
- Bottom width of swales should be between 0.75 and 3.0 m.
- A maximum flow depth of 100 mm is recommended during a 4-hour, 25 mm Chicago storm event.
- Bottom of swale should be separated from the seasonally high water table or top of bedrock by at least 1 m.
- Grass swales can be applied on any soil type, however increased soil infiltration rates (greater than 15 mm/hr) will enhance the removal of pollutants.
- Pre-treatment with vegetated filter strips or sediment forebays enhance the pollutant removal rate.
- A planting strategy for enhanced grass swales is provided in the TRCA/CVC guide. Salt tolerant species are preferred as road salt often enters ditch.
- Feasibility with respect to current road use. Roads with high ATV and snowmobile traffic are not suitable for this type of retrofit.

Cost considerations for the construction of these swales are provided in the TRCA/CVC guide, however these costs are for full construction and not just retrofitting existing ditches. The retrofit of existing ditches would have costs limited to installing additional vegetation, and providing check dams where appropriate. Therefore, this is a very cost effective option of increasing stormwater runoff quality.

9.5.4 Option 16: Require 'As Constructed' Drawings for All New SWM Facilities

In order to assess sediment accumulation in SWM facilities, it is important to have an accurate as-built survey of each future pond to confirm the original pond design volumes exist.

The developer should be responsible for completing a pond cleanout and a post pond clean out topographic survey, confirming the pond has been constructed as designed and with the pond volumes intended. It is recommended that the post pond cleanout survey take place at the end of the maintenance period prior to assumption by the Town.

9.5.5 Option 17: Implement Town SWM Facility Maintenance Program

Existing Certificates of Approval (now Environmental Compliance Approvals) issued under Section 53 of the Water Resources Act, require that the owners of all SWM facilities maintain the facilities to ensure they operate continuously and effectively as originally designed.

After construction, the maintenance responsibilities of SWM facilities are sometimes neglected and resources are not set aside for ongoing and future maintenance activities. The Town has a total of 42 existing SWM facilities, with several more to be constructed due to increased development. As a minimum, it is recommended that an operation and maintenance manual be submitted by the SWM facility designer (the developer) prior to final approval and assumption of all future SWM facilities. The manuals are to identify the frequent and infrequent maintenance requirements for the SWM facility and are to be kept on file by the operating authority for reference.

A Town SWM facility maintenance program is recommended for the purposes of documenting SWM facility operating characteristics on a regular basis. Detailed annual field assessments are recommended to record:

1. sediment accumulation depth;
2. signs of erosion;
3. excessive debris;
4. excessive vegetation which may be obstruction flow, access, blocking inlets or outlets etc.;
5. prolonged ponding; and
6. damage to either the inlet/outlet.

Photos are to be logged during each visit and kept on file to track SWM facility features from year to year. For a standard end-of-pipe SWM facility, the key photos include: the pond inlet, outlet, emergency overflow and the sediment forebay and forebay berm.

A proper maintenance plan, with regular inspections/reporting and an ongoing analysis of data can be useful to assist with prioritizing SWM maintenance capital works projects (including outlet adjustments/retrofits, bank stabilization, sediment clean-outs etc.) and reduce liabilities and overall long term costs. An operation and maintenance plan can be used to determine the anticipated maintenance needs for each facility based on past records and to allocate long range budget resources as part of the Town's 5-year, 10-year and 15-year capital budgets. A Town SWM Facility Inspection and Maintenance Manual has been prepared as a component of this CSWM MP and will be submitted under separate cover (refer to Appendix G). The proper adoption and implementation of this program plays a vital role in increasing stormwater quality control.

We also recommend that the results of all completed pond condition assessments be compiled in a database which would be readily available to Town staff (ideally linked to the Town's GIS pond database). If possible, we also recommend topographic surveys be completed for existing ponds every 5 years in order to determine sediment accumulation. This data would become a useful tool for determining pond cleanout priority, and assigning capital budget based on sediment volumes to be removed.

10 Evaluation & Selection of Options (Step Eight)

The preferred alternative is meant to provide detailed SWM recommendations for the study areas defined in this report. These recommendations will guide development of future areas as outlined in the Town's OP. The following sections outline the general strategies for the Town to implement, as well as a detailed SWM strategy for each of the study areas.

The selection of the preferred alternative for this CSWM-MP has been divided into two categories. Firstly, a preferred solution has been selected for the Town as a whole. This alternative provides a general guideline for SWM practices for future development, as well as the creation of a retrofit program. However, each study area has been assessed with respect to the list of alternatives provided, and a more detailed SWM plan has been created on an individual basis.

This CSWM-MP has also identified a number of existing areas, consisting of mainly commercial and institutional developments, with large uncontrolled impervious areas which should be targeted for quality control. These areas should be investigated on a site specific basis to determine how to best implement controls (likely LID controls or OGS unit) to increase the runoff quality. These areas are explained in detail in section 10.2.

10.1 Overall SWM Plan

10.1.1 Existing Developments

With regard to selecting a SWM plan for existing developments (controlled and uncontrolled areas), implementing a combination of the options has been determined to provide the greatest benefit to the Lake Simcoe watershed. Based on the existing SWM facility analysis described in Section 8, a number of facilities that are in need of a retrofit have been identified. This retrofit work is expected to provide significant improvement to the existing water quality and quantity controls. The retrofits include converting existing dry ponds into wet facilities or including a bioretention cell upstream of the dry pond, as well as the possibility of installing OGS units upstream of existing SWM facilities. It is recommended that a detailed retrofit program be put into place. A list of retrofit opportunities organized by priority and proposed implementation timeline is provided in Section 11.1.2, while retrofit options are further discussed in detail in the study area SWM plans below.

Along with the retrofit program, it is also recommended that an operation and maintenance program is put in place to provide general up-keep and sediment accumulation removal on a regular basis to ensure that existing and future ponds continue to function at a high level. The four ponds which have been specified for retrofits in the preferred alternative selections below represent the retrofit options which would provide the greatest relative benefit to improving stormwater quality and quantity. This does not mean that the other retrofit/maintenance works required in the other ponds should be ignored. Please refer to Section 11.1.2, which details an implementation plan and timeline for the retrofit plans, as well as maintenance works for further ponds.

It is also recommended that improvements in management of existing stormwater runoff be implemented by installing SWM LID measures, where appropriate. This should be kept in consideration whenever reconstruction/improvement works are proposed to any existing development (road reconstruction, underground utility work, etc.). Specific LID measures are recommended in the study area SWM plans.

As a general SWM plan measure for the Town to implement, the conversion of existing roadside ditches into Enhanced Grass Swales is recommended where feasible (limited ATV and snowmobile traffic). This presents a relatively low cost solution to increase water quality runoff, including phosphorus reduction from existing developments. Possible locations for implementation have been included on the study area Figures 7-A through 7-K.

10.1.2 Future Development

With regard to selecting a SWM plan for future developments, an overall preferred option has been selected. However, it should be noted that within each study area, this plan may deviate slightly based on specific needs of the area. In general, the recommendations for SWM in future developments within the Town are detailed below.

- In areas where soil/groundwater conditions permit, implementation of LID source controls (soakaway pits, infiltration trenches, bioretention, green roofs, rainwater harvesting, rainwater gardens) and conveyance LIDs (enhanced grass swales, perforated pipe systems, vegetated filter strips) should be provided to improve water quality and promote infiltration.
- A treatment train or multi-layer approach to stormwater management should be utilized. For example, where at-source and conveyance LIDs are utilized for quality control and infiltration, a dry pond can also be used to provide the required post-to-pre quantity controls.
- Where required, over control of the peak flows should be provided in on-site SWM ponds in order to reduce downstream peak flows and reduce flooding.
- As-built surveys are required as part of all newly constructed SWM facilities for the purposes of confirming the design storage volumes exist and for determining sediment accumulation throughout the lifespan of the facility.

10.1.3 Evaluation of LID Options

The preferred LID controls to be utilized within the Town have been selected based on effectiveness, and relative cost. The implementation of these LID controls should be included in the Town's OP, and the Town's Engineering Design Standards and Specifications.

Rainwater harvesting cannot be included at the design level for new developments, however the Town should provide an incentive program, or provide/promote rain barrels for residents. This is a simple and effective solution to increasing infiltration and water balance, reducing peak flows for smaller storm events, and is a cost saving tool for residents who can re-use the harvested rainwater for landscaping and gardening.

Roof downspout disconnection also provides a cost effective method of increasing infiltration and reducing peak flows for smaller storm events. This LID practice should be continued to be a requirement for new developments. The Town should also promote this practice for existing residences.

Bioretention, rainwater gardens, soakaway pits, infiltration trenches and chambers should all be encouraged and/or required for implementation in new developments and reconstruction projects. These practices provide water quality controls, promote infiltration, and reduce peak runoff rates for smaller storm events. These practices are not practical for inclusion in existing developments. These practices should be included in the Town's Engineering Design Standards and Specifications as allowable SWM practices.

Green roofs and permeable pavement should be included in the Town's Engineering Design Standards and Specifications as allowable design options, however they should be left to the discretion of the developer/ developer's engineer.

The use of conveyance LID controls including vegetated filter strips, enhanced grass swales, dry swales and perforated pipe systems should all be included in the Town's Engineering Design Standards and Specifications, and should be required for implementation, where soils and site conditions permit.

It should be noted that at present, the LSRCA's Technical Guidelines for SWM Submissions are currently being revised, with an updated version expected to be released in September, 2016. The updated version will provide additional information on LID requirements.

10.2 Study Area SWM Plans

With the exception of Big Bay Point, Alcona North and Alcona South, this report has assessed all study areas for suitability of the proposed SWM alternatives, which have been listed below for reference:

1. "Do Nothing";
2. SWM Facility Retrofit or Maintenance Work;
3. Improve Existing Stormwater Runoff through LID Measures;
4. Improve Existing Stormwater Runoff through OGS Units;
5. Improve Existing Uncontrolled Stormwater through End-of-pipe Controls;
6. Standard Post-to-Pre Control;
7. Peak Flow Over-control;

8. Extended Detention Over-control;
9. Water Balance and Infiltration Measures (LID Measures);
10. Over-control Infiltration rates;
11. Standard Wet Pond;
12. Implement LID Source Controls; and
13. Implement LID Conveyance Controls.

The alternatives have been assessed using a number of criteria to determine the preferred solution for existing and future development. A detailed description of the criteria and the associated scoring for each is provided in Appendix H. A summary of the criteria is provided in Table 25.

Table 25: Evaluation Criteria and Weighting System

Criteria	Scoring	Weighting
Soil Suitability	0-2	1
Wellhead Protection Areas	0-2	1
Hazard Area	0-2	0.5
Operation and Maintenance	0-2	1
Cost	0-3	1
Social Suitability	0-2	0.5
Water Quality Benefit	0-3	3
Water Quantity Benefit	0-3	2
Suitability of Development Type	0-2	1
Land Availability	0-2	1

All developments within the Town should consider the thermal impacts to warm/cold water fisheries that may be affected.

10.2.1 Big Bay Point

The Big Bay Point study area is to be entirely developed into the Friday Harbour Resort development. This development has been approved by the Town and LSRCA, and has an accompanying Stormwater Management and Monitoring Plan completed by SCS Consulting Group Ltd., Hutchinson Environmental and Stonybrook Consulting in 2012 which provides stormwater quantity and quality controls, as well as measures to provide adequate water balance and reduce phosphorus loading. A summary of the proposed SWM plan is discussed below.

Table 26: Big Bay Point Requirement Summary

Requirement	Existing Development	Future Development
Stormwater Quality	▪ N/A	▪ Implement LID measures including pervious pavement, rain garden, enhanced roadside ditches and bioswales ▪ Direct runoff from the 25 mm storm from 30.6 ha of the marina village to an Enhanced Level SWM facility
Stormwater Quantity	▪ N/A	▪ Quantity controls not required due to direct discharge to Lake Simcoe
Water Balance/Infiltration	▪ N/A	▪ Promote infiltration using enhanced roadside ditch sections, re-use rainwater for irrigation, and implement LID infiltration measures.
Phosphorous Loading	▪ N/A	▪ N/A
Erosion Control	▪ N/A	▪ N/A

The resort development includes a mix of resort units, recreational uses (including a golf course and marina) and commercial areas. The resort has been designed to achieve a variety of objectives:

- to minimize its built footprint and thus reduce land consumption (as well as stormwater runoff);
- to ensure no increase in phosphorus loads to Lake Simcoe (beyond existing levels on the site); and
- to preserve large blocks of wetland and woodland areas.

These objectives will be achieved by incorporating the use of a treatment train of SWM practices and LID techniques to manage the quality and quantity of surface runoff from the developed resort and promote infiltration and evapotranspiration as detailed below.

- Concentrated developed resort area using higher density configurations around the marina, thereby maintain approximately 87 ha of woodlot/wetland area and 84 ha of golf course.

- Best management practices such as street sweeping and "stoop and scoop" practices, recommended to provide at source treatment and collection of sediment and potential contaminants.

- Utilization of underground parking garages for the apartment buildings and higher density marina townhomes to minimize the development footprint as well as the resulting impervious asphalt areas.

- Use of a rural road cross section for the new collector road. Road drainage will be directed to roadside swales on both sides of the road to manage drainage (i.e. slow down, filter and promote infiltration and evapotranspiration) prior to its release through the EP lands and eventually to the marina basin. These swales have been designed with rock check dams which will enhance water quality control through settlement, decreasing velocity and allowing more sediment uptake in the vegetation within the swales.

- Minimization of manicured lawns; the preference is for landscaped gardens and pervious pavements in courtyard areas and landscaped areas in and surrounding the marina.

- Direct roof runoff from 6.4 ha of townhouse, apartment and hotel roofs within the marina village directly into the marina basin. This approach will keep cleaner roof runoff separate from urban drainage. It will also reduce the runoff volumes for storage, pumping and treatment.

- Collection and conveyance of drainage from rooftops, roads, landscaped areas and courtyards from the resort development north and immediately west of the marina basin to a pumping station. This represents 30.6 ha (61% of the developed area within the marina village). Drainage from the 25 mm rainfall event will be pumped to an Enhanced Level SWM facility. An underground storage facility or cistern will be required at the pumping station location(s) to reduce the peak pumping rate required. This approach will manage "first flush" flows or runoff produced during a 25 mm storm (which accounts for up to 95% of all storm events) for reuse on the golf course. Flows in excess of the 25 mm event will outlet to the marina basin.

- Runoff to the SWM facility will be used for golf course irrigation during the season from April to October. The soils in the golf course are much more granular that in the resort area and are therefore more appropriate for promoting infiltration of stormwater runoff. During other months, outflows from the SWM facility will be directed easterly to an intermittent drainage feature through the EP lands. The SWM facility is larger than needed for Enhanced Level quality control as required by the MOECC as it is also to be used for irrigation and aesthetic purposes. Minimal pond outflows are expected during the golf season unless deemed appropriate through a water budget evaluation to be completed prior to the detail design of the facilities.

- First flush runoff from roads and landscaped areas in resorts areas south and east of the marina will be collected and pumped to the SWM facility for golf course use. Flows in excess of a 25 mm storm will outlet to the marina basin. Due to grading conditions surrounding the marina, alternative measures including pervious pavement, rain garden, bioswales and OGS units may be recommended at detailed design as alternatives to pumping to the SWM facility.

- Golf course driveways will be rural road cross sections.

- Municipal sanitary services will be provided to the clubhouse as opposed to a traditional septic system.
- Drainage from the Civic use area in the south-west corner of the site will be directed to the SWM facility. Municipal sanitary services will be provided to the Civic use area.
- A Golf Course and Nutrient Management Plan - Environmental Management Plan has been prepared as part of the golf course design.
- A Marina Basin Monitoring and Adaptive Management Plan has been prepared that integrates all golf course, resort, marina and SWM plans into a master Adaptive Management Plan to maintain water quality in the marina basin.
- During non-irrigation seasons, excess stormwater pumped from the resort area to the SWM facility at the golf course will be discharged to the existing intermittent swales which will allow a significant opportunity for infiltration, filtration and evapotranspiration though the EP lands prior to discharging to the marina basin.

10.2.2 Alcona North Secondary Plan

A SWM plan for the Alcona North study area has been previously determined in the Alcona North Master Drainage Plan (Draft). This information was reviewed and used in this study based on the SWM options provided in this CSWM-MP. The recommendations from the MDP report are summarized below.

It should be noted it is expected that the Alcona North Master Drainage Plan will undergo an update due to the proposed Leonard's Beach development. As such, any updated recommendations in the updated Alcona North Master Drainage Plan report shall supersede the recommendations discussed below.

Table 27: Alcona North Requirement Summary

Requirement	Existing Development	Future Development
Stormwater Quality	▪ N/A	▪ Implement LID at source and conveyance controls, including road infiltration trenches ▪ Implement end-of pipe infiltration and exfiltration systems where soil and groundwater conditions permit
Stormwater Quantity	▪ N/A	▪ Provide 25% peak flow over-control
Water Balance/Infiltration	▪ N/A	▪ Promote infiltration using enhanced roadside ditch sections, re-use rainwater for irrigation, and implement LID infiltration measures.

Requirement	Existing Development	Future Development
Phosphorous Loading	▪ N/A	▪ Best efforts post-to-pre phosphorous loading matching
Erosion Control	▪ N/A	▪ Provide 24-hour extended detention for the 25 mm storm event
Thermal Impacts	▪ N/A	▪ N/A

Water Balance & Infiltration

- In areas where soil/groundwater conditions permit, at source infiltration measures such as soakaway pits or equivalent measures installed at the lot level are recommended. In these areas, roof leaders and yard drainage should be directed towards lawns, side and rear yard swales, boulevards, parks and other open spaces throughout the development where possible to promote infiltration.

- Road infiltration trenches should be installed where soil/groundwater conditions permit.

- End-of-pipe SWM facility infiltration and exfiltration systems should be installed where soil and groundwater conditions permit to promote infiltration and reduce thermal impacts of the proposed SWM facilities.

- The aforementioned approach is the only feasible approach to water balance maintenance for the study area.

- Improvements to two specific downstream culverts were identified as being particularly beneficial for the mid-range of storm events (2-year through 25-year). Specifically, the twinning of the culvert at Sandy Trail and Somers Boulevard will reduce the 2-year flood levels by more than 0.3 m at these locations. These culvert improvements should be considered as part of the preferred SWM plan.

Stormwater & Floodplain Management

- All SWM facilities proposed in the MDP provide a minimum 24-hour extended detention of the 25 mm storm.

- The target of 25% flow over-control through the downstream reaches of the system should be met through the implementation of the development. As the modelling has confirmed, this can be achieved using several different SWM pond over-control scenarios.

- All SWM facilities are located outside the Regional storm flood elevation, erosion hazard limits and wetland boundaries.

- SWM alternatives will reduce peak flows downstream for the 2-year to 100-year storm events but will not reduce the Regional Storm flows. Each alternative will be evaluated considering its ability to reduce the potential for flooding in areas currently susceptible.

Erosion & Stream Morphology

The hydrologic and hydraulic assessments completed also considered the basic stream channel and erosion characteristics of Leonard's Creek downstream of the study area.

A stream erosion assessment was conducted by RJBA in accordance with the Section 2.5 of the LSRCA Technical Guidelines for Stormwater Management Submissions (November 2010). The study limits spanned from approximately 1 km west of the 25th Sideroad to the Lake Simcoe Shoreline.

The study characterized the watercourse as a low-gradient channel with relatively low bank angles and shallow bank heights which indicates a low probability of bank failure. The shear strength of the banks is increased by the presence of herbaceous and woody root material. In several areas, a wide floodplain on either side of the channel helps to dissipate energy during the less-frequent storm events.

This analysis concluded there was no evidence of long lengths of mass wasting the bank material, head cutting, nor channel incising. Indications that runoff produced across the future Secondary Plan development area from a 25 mm design storm detained and released over a period of 24 hours is sufficient erosion control for the site.

Water Quality Control

Water quality control to Enhanced Level must be achieved in all end-of-pipe SWM facilities to meet 80% TSS removal, as well as phosphorus removal targets. Where soil and development conditions permit, the use of LID techniques should also be considered for implementation.

10.2.3 Alcona South Secondary Plan

A SWM plan for the Alcona South study area has been previously determined in the Alcona South Master Drainage Plan (Draft) prepared by Greenland International Consulting Ltd. This area has not been assessed based on the SWM options provided in this CSWM-MP. The recommendations from the MDP are summarized below.

It should be noted it is expected that the Alcona South Master Drainage Plan is currently being finalized. As such, any updated recommendations in final Alcona South Master Drainage Plan report shall supersede the recommendations discussed below.

Table 28: Alcona South Requirement Summary

Requirement	Existing Development	Future Development
Stormwater Quality	▪ N/A	▪ Implement LID at source and conveyance controls, including road infiltration trenches ▪ Implement end-of pipe infiltration and exfiltration systems where soil and groundwater conditions permit
Stormwater Quantity	▪ N/A	▪ Flow diversion between Belle Aire Creek and Cedar Creek ▪ Post-to-pre peak flow matching
Water Balance/Infiltration	▪ N/A	▪ Promote infiltration using enhanced roadside ditch sections, re-use rainwater for irrigation, and implement LID infiltration measures.
Phosphorous Loading	▪ N/A	▪ Best efforts post-to-pre phosphorous loading matching
Erosion Control	▪ N/A	▪ Provide standard 24-hour extended detention for the 25 mm storm event

- Eight (8) regional SWM facilities are proposed to provide storm water quality and quantity control. The final location and sizing of all proposed SWM facilities is subject to more detailed land use planning (i.e. draft plan and final design).

- Each SWM facility is proposed as an extended detention wet pond facility that meets MOECC Enhanced water quality control criteria.

- Each proposed SWM facility will provide 24 hour detention of the 25 mm storm for erosion control purposes.

- Each proposed SWM facility is to provide post-to-pre development peak flow water quantity control for storms events up to and including the 100-year event.

- End-of-pipe SWM facility infiltration and exfiltration systems to promote infiltration and reduce thermal impacts are proposed in the MDP where soil and groundwater conditions permit.

- All development including SWM facilities are proposed outside the Natural Environment Areas, including the Regional Storm flood elevation, the erosion hazard set-back limit, wetland areas and the 15 m natural heritage/fisheries setback from the study area watercourses. One exception is SWM facility 8, which is proposed to be located between the Regional and 100-year floodplain if the compensating cut proposed in Option 5 for flood flow reduction purposes occurs.

- The use of LID techniques should be considered for all SWM plans in addition to providing end-of-pipe flood control where appropriate conditions exist.

- In areas where soil/groundwater conditions permit, at source infiltration measures such as soakaway pits or equivalent measures are to be installed at the lot level.

- Road infiltration trenches should be installed where soil/groundwater conditions permit.

- The proposed development of the Alcona South Secondary Plan lands with implementation of MDP mitigating features will reduce annual phosphorus loading of Lake Simcoe by at least 12% over existing conditions. Additional measures (such as LID techniques) should be implemented where possible to increase phosphorous removal. For the purpose of downstream flood damage reduction, a diversion of flow from Belle Aire Creek to Cedar Creek is proposed as part of the preferred solution. The diversion has the following features:

  - All Belle Aire Creek flows greater than the 25 mm peak flow and up to the 25-year flow, will be conveyed downstream of the former CNR Line to a constructed SWM facility to be located west of the Little Cedar Wetland with discharge ultimately to the Little Cedar Wetland and Cedar Creek. The conveyance of Belle Aire Creek flows to Cedar Creek has been estimated to reduce annual flood damages in existing developed areas of Belle Aire Creek by 85% over existing conditions.

  - The Belle Aire Creek flow conveyance SWM facility upstream of the Little Cedar Wetland (at the western edge of the existing wetland) will include both water quality and quantity controls.

  - A conveyance channel between the former CN Rail Line and the Belle Aire Creek flow SWM facility is proposed. The natural channel design will also be a component of the water quality/stormwater quantity control feature.

  - The flow diversion being considered is a flood control project with perceived public benefit and should be implemented through the Town of Innisfil. Implementation must include the additional study on the Little Cedar Wetland as stipulated by North-South environmental Inc. and also must consider the potential for increased flow durations and other potential changes to Cedar Creek that may occur. Currently, approximately 12 landowners could be affected in this regard (see Figure 5) and the acquisition of an easement over the Watercourse for maintenance/channel improvements should be considered.

Depending on the scope of the diversion from Belle Aire Creek to Cedar Creek that occurs, the preferred plan can also include a secondary flood storage option to achieve a similar same flood control benefit if necessary. We note that additional study, including a Municipal Class EA, would be required to allow the diversion work to proceed. Approval from LSRCA, Ministry of Natural Resources and Forestry and Fisheries & Oceans Canada would be required to construct the diversion.

10.2.4 Alcona Central

All twelve (12) study area SWM alternatives have been assessed for implementation in the Alcona Central study area. Table 29 provides a summary of the scoring for each alternative in relation to the scoring criteria. Where possible, alternatives within the same category (i.e. existing development) have been compared against each other to determine the relative scoring of each.

Table 29 summarizes the SWM requirements for the Alcona Central study area.

Table 29: Alcona Central Alternative Scoring Summary

Criteria	Weighting	Scoring											
		Existing Development Alternatives				Future Development Alternatives (Quantity Control)				Future Development Alternatives (Quality Control)			
		1	2	3	4	5	6	7	8	9	10	11	12
Soil Suitability	1	2	2	2	2	2	2	2	2	2	2	2	2
Wellhead Protection Areas	1	2	2	2	2	2	2	2	2	2	2	2	2
Hazard Area	0.5	2	2	2	2	2	2	2	2	2	2	2	2
Operation and Maintenance	1	0	1	1	0	1	1	1	2	2	1	2	2
Cost	1	1	1	2	1	1	1	1	2	1	1	2	2
Social Suitability	0.5	1	2	2	0	1	1	1	2	2	1	2	2
Water Quality Benefit	3	1	2	2	1	N/A	N/A	N/A	N/A	N/A	3	2	2
Water Quantity Benefit	2	1	1	0	1	3	3	3	3	2	N/A	N/A	N/A
Suitability of Development Type	1	2	2	2	2	2	2	2	2	2	2	2	2
Land Availability	1	2	2	2	0	2	2	2	2	2	1	1	1
Total		15.5	20	19	13	17.5	17.5	17.5	18	17	19.5	19	19

Table 30: Alcona Central Requirement Summary

Requirement	Existing Development	Future Development
Stormwater Quality	▪ Retrofit developments listed below with LID controls and/or OGS units	▪ New developments to incorporate at-source and conveyance LID controls
Stormwater Quantity	▪ N/A	▪ Post-to-pre peak flow matching
Water Balance/Infiltration	▪ Promote infiltration with LID retrofits	▪ Must infiltrate a minimum of the 25 mm storm event from all new impervious surface area
Phosphorous Loading	▪ Provide phosphorous reduction with LID retrofits	▪ Best efforts post-to-pre phosphorous loading matching
Erosion Control	▪ N/A	▪ Provide 24-hour extended detention for the 25 mm storm event

Existing Development

Currently, the Alcona Central study area has approximately 714.2 ha of developed land, representing 71.1% of the total area. As discussed above, the Alcona Central study area currently has 21 existing SWM facilities controlling a total of 353.5 ha or 49.5% of current development lands.

The majority of the ponds in the study area are functioning adequately and are not in immediate need of retrofit/maintenance works. However, we do recommend installing OGS units at Ponds #7-1 and #6-1 to increase the water quality function of the facilities.

The following list provides a number of uncontrolled, highly impervious developments, for which further detailed assessment should be completed to determine how to implement quality control measures for the existing stormwater runoff. These measures would likely be LID controls or OGS units, as follows:

- Alcona Glen Elementary School;
- commercial development at Innisfil Beach Road and Jans Boulevard;
- Goodfellow Public School;
- Holy Cross Catholic School;
- commercial development at Innisfil Beach Road and 20th Sideroad; and
- commercial development at Innisfil Beach Road and St. Johns Road.

Future Development

The Alcona study area is planned to increase in developed area by approximately 17.5% according to the Town OP. The majority of the development will be urban residential areas. The following recommendations have been made for future developments:

- Implement lot level LID measures such as downspout disconnection to pervious areas, porous pavement, rainwater gardens and soakaway areas to improve water balance, reduce phosphorus loading, and reduce peak flows from the site where groundwater levels permit;
- Provide conveyance LID measures such as enhanced grass swales, perforated pipe systems, vegetated filter strips to improve water quality and reduce phosphorus loading where groundwater levels permit;
- Soakaway/infiltration pits should be implemented in all new development areas, where appropriate where groundwater levels permit;
- A treatment train of LID approaches should be provided to achieve the required water quality control where groundwater levels permit;
- Where LID measures do not provide the adequate quantity controls, dry ponds should be utilized to provide these controls;
- Where site conditions do not allow the implementation of LID measures to provide quality control, standard wet ponds should be designed to provide both quality and quantity control. Standard post-to-pre water quantity controls are appropriate for future development; and
- Standard 24-hour detention time for the 25 mm 4-hour Chicago storm event is required.

10.2.5 Sandy Cove

All twelve (12) study area SWM alternatives have been assessed for implementation in the Sandy Cove study area. Table 31 provides a summary of the scoring for each alternative in relation to the scoring criteria. Where possible, alternatives within the same category (i.e. Existing Development) have been compared against each other to determine the relative scoring of each.

Table 31: Sandy Cove Alternative Scoring Summary

Criteria	Weighting	Scoring											
		Existing Development Alternatives				Future Development Alternatives (Quantity Control)				Future Development Alternatives (Quality Control)			
		1	2	3	4	5	6	7	8	9	10	11	12
Soil Suitability	1	2	2	2	2	2	2	2	2	2	2	2	2
Wellhead Protection Areas	1	2	2	2	2	2	2	2	2	2	2	2	2
Hazard Area	0.5	2	2	2	2	2	2	2	2	2	2	2	2
Operation and Maintenance	1	0	1	1	0	1	1	1	2	2	1	2	2
Cost	1	1	1	2	1	1	1	1	2	1	1	2	2
Social Suitability	0.5	1	2	2	0	1	1	1	2	2	1	2	2
Water Quality Benefit	3	0	2	0	1	N/A	N/A	N/A	N/A	N/A	3	2	2
Water Quantity Benefit	2	0	1	0	1	3	3	3	2	2	N/A	N/A	N/A
Suitability of Development Type	1	2	2	0	2	2	2	2	2	2	2	2	2
Land Availability	1	2	2	0	1	2	2	2	2	2	1	1	1
Total		10.5	20	9	14	17.5	17.5	17.5	17.5	18	19.5	19	19

The following table summarizes the stormwater management requirements for the Sandy Cove study area.

Table 32: Sandy Cove Requirement Summary

Requirement	Existing Development	Future Development
Stormwater Quality	▪ Retrofit with LID Conveyance controls	▪ New developments to incorporate at-source and conveyance LID controls
Stormwater Quantity	▪ N/A	▪ Post-to-pre peak flow matching
Water Balance/Infiltration	▪ Promote infiltration with LID retrofits	▪ Must infiltrate a minimum of the 5 mm storm event from all new impervious surface area
Phosphorous Loading	▪ Provide phosphorous reduction with LID retrofits	▪ Best efforts post-to-pre Phosphorous Loading Matching
Erosion Control	▪ N/A	▪ Provide 24-hour extended detention for the 2-year storm event (controlled to the unit-area flow rate) for all development draining into Sandy Cove Creek and Mooselanka Creek

Existing Development

Currently, the Sandy Cove study area has approximately 248.8 ha of developed land, which represents 49.6% of the total area. Stormwater runoff from this developed area is largely uncontrolled. The two existing SWM facilities appear to be functioning at an adequate level, and are not in need of retrofit. It is recommended that regular maintenance and inspections be carried out for these facilities.

The recommended approach to improve stormwater runoff quality in the uncontrolled developed areas is to implement LID measures into the existing developments. The soil in Sandy Cove is generally sand and sandy loam, which provides good characteristics for infiltration practices. The following is a list of recommendations:

- where appropriate, convert existing roadside ditches, swales and conveyance routes into enhanced grass swales to provide increased stormwater quality and infiltration;
- where appropriate, install check dams in existing roadside ditches, swales and conveyance routes in order to promote infiltration; and
- promote the use of rain barrels for existing houses, and encourage roof-downspout disconnection into pervious areas.

Future Development

The Sandy Cove study area is planned to increase in developed area by approximately 58%. This increase is almost entirely zoned as Residential under the OP. Recommendations have been made for the future developments where groundwater levels permit as detailed below.

- Implement lot level LID measures such as downspout disconnection to pervious areas, porous pavement, rainwater gardens and soakaway areas to improve water balance, reduce phosphorus loading, and reduce peak flows from the site where groundwater levels permit.
- Provide conveyance LID measures such as enhanced grass swales, perforated pipe systems, vegetated filter strips to improve water quality and reduce phosphorus loading where groundwater levels permit.
- Soakaway/infiltration pits should be implemented in all new development areas that are suitable for underground stormwater infiltration practices where groundwater levels permit.
- A treatment train of LID approaches should be provided to achieve the required water quality control.
- Where LID measures do not provide the adequate quantity controls, dry ponds should be utilized to provide these controls.
- Where site conditions do not allow the implementation of LID measures to provide quality control, standard wet ponds should be designed to provide both quality and quantity control. Standard post-to-pre water quantity controls are appropriate for future development.
- Provide 24-hour detention time for the 2-year storm event, controlled to the unit-area rate as specified in Table 23 in Section 7.4 of this report for all development draining into Sandy Cove Creek and Mooselanka Creek.
- Provide best efforts to control the 2-year to 25-year storm events to the unit-area flow rate as specified in Table 23 in Section 7.4 of this report.

10.2.6 Stroud

All twelve (12) study area SWM alternatives have been assessed for implementation in the Stroud study area. Table 33 provides a summary of the scoring for each alternative in relation to the scoring criteria. Where possible, alternatives within the same category (i.e. Existing Development) have been compared against each other to determine the relative scoring of each.

Table 33: Stroud Alternative Scoring Summary

Criteria	Weighting	Scoring											
		Existing Development Alternatives				Future Development Alternatives (Quantity Control)				Future Development Alternatives (Quality Control)			
		1	2	3	4	5	6	7	8	9	10	11	12
Soil Suitability	1	2	2	2	2	2	2	2	2	2	2	2	2
Wellhead Protection Areas	1	2	1	2	2	2	2	2	2	2	1	2	2
Hazard Area	0.5	2	2	2	2	2	2	2	2	2	2	2	2
Operation and Maintenance	1	0	1	1	0	1	1	1	2	2	1	2	2
Cost	1	0	1	2	0	1	1	1	2	1	1	2	2
Social Suitability	0.5	1	2	1	0	1	1	1	2	2	1	2	2
Water Quality Benefit	3	3	2	2	0	N/A	N/A	N/A	N/A	N/A	3	2	2
Water Quantity Benefit	2	2	2	0	0	3	3	3	2	2	N/A	N/A	N/A
Suitability of Development Type	1	2	2	2	2	2	2	2	2	2	2	2	2
Land Availability	1	2	1	2	0	2	2	2	2	2	1	1	1
Total		22.5	20	18.5	7	17.5	17.5	17.5	18	17	18.5	19	19

The following table summarizes the SWM requirements for the Stroud study area.

Table 34: Stroud Requirement Summary

Requirement	Existing Development	Future Development
Stormwater Quality	▪ Retrofit Existing SWM Ponds ▪ Implement OGS units ▪ Promote rain barrel and downspout disconnection for existing homes	▪ New developments to incorporate at-source and conveyance LID controls
Stormwater Quantity	▪ N/A	▪ Post-to-pre peak flow matching using combination of LID controls and dry ponds
Water Balance/Infiltration	▪ Promote infiltration with LID retrofits	▪ Must infiltrate a minimum of the 5 mm storm event from all new impervious surface area
Phosphorous Loading	▪ Provide phosphorous reduction with LID retrofits	▪ Best efforts post-to-pre phosphorous loading matching
Erosion Control	▪ N/A	▪ Provide 24-hour extended detention for the 2-year storm event (controlled to the unit-area flow rate) for all development draining into Hewitt's Creek ▪ Provide 24-hour extended detention for the 25 mm storm event for all development draining into Lovers Creek

Existing Developments

Currently, the Stroud study area has approximately 158.7 ha of developed land, representing 68.1% of the total area. As discussed above, the Stroud study area currently has four (4) existing SWM facilities controlling a total of 98.5 ha, or 62% of the existing developed land.

Three ponds in the study area have been given a Priority 1 retrofit status, meaning that these facilities require a complete retrofit/re-design due to very poor function. The retrofits could have a substantial benefit to improving stormwater quality within the Stroud study area. The three (3) ponds have a total combined contributing drainage area of 74.5 ha. It has been determined that the retrofit of these ponds will have the potential for 22% reduction of total phosphorous loading from the Stroud study area. The ponds are:

- Brandy Lane (Pond# 10-1) - 1st priority;

- Village North Dempster (Pond #10-2) - 2nd priority; and
- Southview (Pond #9-2) - 3rd priority.

It is also recommended that during the re-design phase, an assessment of installing OGS units immediately upstream of the ponds be completed to determine the relative benefit.

It is recommended that a detailed assessment of each of these ponds be completed, with the ultimate goal of creating retrofit/construction plans which would provide the required MOECC Enhanced Level water quality control.

A second recommendation to improve stormwater runoff quality for any developed and uncontrolled areas is to implement LID measures. The soil in Stroud is entirely sandy loam, which provides good characteristics for infiltration practices. The following is a list of recommendations:

- where appropriate, convert existing roadside ditches, swales and conveyance routes into enhanced grass swales to provide increased stormwater quality and infiltration;
- where appropriate, install check dams in existing roadside ditches, swales and conveyance routes in order to promote infiltration;
- where appropriate and where groundwater levels permit, install infiltration trenches/soakaway pits on Town land at downstream ends of storm pipes or conveyance channels to promote infiltration; and
- promote the use of rain barrels (rainwater harvesting) for existing houses, and encourage roof-downspout disconnection into pervious areas.

The following list provides a number of uncontrolled, highly impervious developments, for which further detailed assessment should be completed to determine how to implement quality control measures for the existing stormwater runoff. These measures would likely be LID controls or OGS units, as follows:

- Sunnybrae Public School;
- Stroud Community Centre;
- commercial development at Yonge Street and Lynn Street; and
- commercial development at Yonge and Glenn Avenue.

Future Developments

If all lands designated for development in the Town OP are built out, the developed land in the Stroud study area will increase by approximately 38.7%. The future development will consist almost entirely of Village Residential development, as designated in the OP. The majority of this area will be located in the east half of the study area boundary, and will drain into the Hewitt's Creek subwatershed. The recommendations presented below have been made for the future developments where groundwater levels permit.

- Implement Lot level LID measures such as downspout disconnection to pervious areas, porous pavement, rainwater gardens and soakaway areas to improve water balance, reduce phosphorus loading, and reduce peak flows from the site where groundwater levels permit.
- Provide Conveyance LID measures such as enhanced grass swales, perforated pipe systems, vegetated filter strips to improve water quality and reduce phosphorus loading where groundwater levels permit.
- Soakaway/infiltration pits should be implemented in all new development areas, where groundwater levels permit.
- A treatment train of LID approaches should be provided to achieve the required water quality control where groundwater levels permit.
- Where LID measures do not provide the adequate quantity controls, dry ponds should be utilized to provide these controls.
- Where site conditions do not allow the implementation of LID measures to provide quality control, standard wet ponds should be designed to provide both quality and quantity control. Standard post-to-pre water quantity controls are appropriate for future development.
- Provide 24-hour detention time for the 2-year storm event, controlled to the unit-area rate as specified in Table 23 in Section 7.4 of this report for all development draining into Hewitt's Creek.
- Provide best efforts to control the 2-year to 25-year storm events to the unit-area flow rate as specified in Table 23 in Section 7.4 of this report for all development draining into Hewitt's Creek.
- Provide standard 24-hour detention time for the 25 mm 4-hour Chicago storm event for all development areas draining into Lovers Creek.

10.2.7 Innisfil Heights

All twelve (12) study area SWM alternatives have been assessed for implementation in the Innisfil Heights study area. Table 35 provides a summary of the scoring for each alternative in relation to the scoring criteria. Where possible, alternatives within the same category (i.e. Existing Development) have been compared against each other to determine the relative scoring of each.

Table 35: Innisfil Heights Alternative Scoring Summary

Criteria	Weighting	Scoring											
		Existing Development Alternatives				Future Development Alternatives (Quantity Control)				Future Development Alternatives (Quality Control)			
		1	2	3	4	5	6	7	8	9	10	11	12
Soil Suitability	1	2	2	2	2	2	2	2	2	2	2	2	2
Wellhead Protection Areas	1	2	1	2	2	2	2	2	1	1	2	1	1
Hazard Area	0.5	2	2	2	2	2	2	2	2	2	2	2	2
Operation and Maintenance	1	0	1	1	0	1	1	1	2	2	1	2	2
Cost	1	1	1	2	0	1	1	1	2	1	1	2	2
Social Suitability	0.5	2	2	2	0	1	1	1	2	2	1	2	2
Water Quality Benefit	3	2	1	1	0	N/A	N/A	N/A	N/A	N/A	3	2	2
Water Quantity Benefit	2	2	1	0	0	3	3	3	2	2	N/A	N/A	N/A
Suitability of Development Type	1	2	1	2	2	2	2	2	1	1	2	1	1
Land Availability	1	2	1	2	0	2	2	2	1	1	2	1	1
Total		20.5	14	16	7	17.5	17.5	17.5	15	14	20.50	17	17

The following table summarizes the SWM requirements for the Innisfil Heights study area.

Table 36: Innisfil Heights Requirement Summary

Requirement	Existing Development	Future Development
Stormwater Quality	▪ Retrofit Pond #8-1 ▪ Install OGS or LID measures for existing developments listed below	▪ LID controls where land-use allows (i.e. residential and commercial land) ▪ OGS units for industrial runoff
Stormwater Quantity	▪ N/A	▪ Post-to-pre peak flow matching using combination of LID controls and dry ponds
Water Balance/Infiltration	▪ Promote infiltration with LID retrofits	▪ Must infiltrate a minimum of the 8 mm storm event from all new impervious surface area
Phosphorous Loading	▪ Provide phosphorous reduction with LID retrofits	▪ Best efforts post-to-pre phosphorous loading matching
Erosion Control	▪ N/A	▪ Provide 24-hour extended detention for the 25 mm storm event

Existing Developments

Currently, the Innisfil Heights study area has approximately 166.1 ha of developed land, representing 62.2% of the total area. As discussed above, the Innisfil Heights study area currently has four (4) existing SWM facilities controlling a total of 103 ha, or 62% of the developed land.

Out of the four ponds in the area, the Trillium Industrial pond (Pond #8-1) has been given a Priority 1 retrofit status. The facility controls approximately 31 ha of mainly industrial land. Due to the type of land use in the contributing catchment area and the potential for contamination of runoff, increasing the quality control of this pond will greatly benefit the stormwater runoff in the Innisfil Heights study area. It is recommended that a detailed assessment of this pond be completed, with the ultimate goal of creating retrofit/construction plans which would provide the required MOECC Enhanced Level water quality controls. It is recommended that the pond be retrofit within two years of implementing this CSWM-MP. The retrofit of this facility has been shown to provide a 10% reduction in total phosphorus loading from the Innisfil Heights study area.

With regard to the Doral East facility (Pond #9-4), it is recommended that this facility undergo maintenance works, including mitigating of erosion at the south east corner and sediment removal.

As over half of the existing developed area in the study area is uncontrolled, this presents an opportunity to implement SWM BMPs to improve both water quality and quantity controls in the area, as well as promote infiltration.

In the northern section of the study area the streets of Doral Drive, Bowman Street, Thomas Street and Clifford Court all drain into existing SWM facilities, and have a defined roadside ditch drainage system. These ditches could be upgraded with the following options:

- upgrade to an enhanced grassed swale to promote infiltration and reduce pollutant and sediment loading to the ponds; and
- install strategically placed rock check dams to slow down the flow is also recommended.

Other recommendations include:

- promote the use of rain barrels for existing houses, and encourage roof-downspout disconnection into pervious areas.

The following list provides a number of uncontrolled, highly impervious developments, for which further detailed assessment should be completed to determine opportunities for water quality treatment of runoff. These measures would likely be LID controls or OGS units, as follows:

- The 400 Market;
- development area including Duivenvoorden Haulage, Steel Tire Co., and Legend Boats; and
- development area including the Mercedes Dealership, Subaru Dealership, and Chaparel Boats.

Future Developments

The Innisfil Heights study area is planned to increase in developed area by approximately 55.3%. The majority of this land is zoned as Industrial, Commercial and Business Park under the Official Plan. The following recommendations have been made for future developments where ground water levels permit:

- integrate LID lot level and conveyance practices for new commercial developments to promote infiltration, improve water quality and achieve water balance, which is particularly important to headwater areas such as Innisfil Heights, where groundwater levels permit;
- for industrial developments, use of traditional end-of-pipe SWM facilities (wet/dry pond) with OGS units at the upstream end to reduce maintenance costs and for spill control;
- for industrial developments, clean rooftop drainage should be isolated and pass through LID controls to promote infiltration, improve water quality and achieve a post –to-pre development water balance where groundwater levels permit;

- for industrial developments, surface water should be conveyed through non-infiltration based LID controls before being treated by an OGS;
- standard post-to-pre water quantity controls are appropriate for future development; and
- standard 24-hour detention time for the 25 mm 4-hour Chicago storm event is required.

10.2.8 Gilford

All twelve (12) study area SWM alternatives have been assessed for implementation in the Gilford study area. Table 37 provides a summary of the scoring for each alternative in relation to the scoring criteria. Where possible, alternatives within the same category (i.e. Existing Development) have been compared against each other to determine the relative scoring of each

Table 37: Gilford Alternative Scoring Summary

Criteria	Weighting	Scoring											
		Existing Development Alternatives				Future Development Alternatives (Quantity Control)				Future Development Alternatives (Quality Control)			
		1	2	3	4	5	6	7	8	9	10	11	12
Soil Suitability	1	2	2	2	2	2	2	2	2	2	2	2	2
Wellhead Protection Areas	1	1	2	2	2	2	2	2	2	1	2	2	2
Hazard Area	0.5	2	2	2	2	2	2	2	2	2	2	2	2
Operation and Maintenance	1	0	1	0	0	1	1	1	2	2	1	2	2
Cost	1	0	1	0	0	1	1	1	2	1	1	2	2
Social Suitability	0.5	0	2	0	0	1	1	1	2	2	1	2	2
Water Quality Benefit	3	0	2	0	0	N/A	N/A	N/A	N/A	N/A	3	2	2
Water Quantity Benefit	2	0	1	0	0	3	3	3	2	2	N/A	N/A	N/A
Suitability of Development Type	1	0	2	0	0	2	2	2	2	2	2	2	2
Land Availability	1	0	1	0	0	2	2	2	2	2	1	1	1
Total		5	19	5	5	17.5	17.5	17.5	18	16	19.5	19	19

The following table summarizes the SWM requirements for the Gilford study area.

Table 38: Gilford Requirement Summary

Requirement	Existing Development	Future Development
Stormwater Quality	▪ Retrofit existing roadside ditches with LID controls ▪ Promote use of rain barrels and encourage downspout disconnection	▪ New developments to incorporate at-source and conveyance LID controls
Stormwater Quantity	▪ N/A	▪ Post-to-pre peak flow matching using combination of LID controls and dry ponds
Water Balance/Infiltration	▪ Promote infiltration with LID retrofits	▪ Must infiltrate a minimum of the 10 mm storm event from all new impervious surface area
Phosphorous Loading	▪ Provide phosphorous reduction with LID retrofits	▪ Best efforts post-to-pre phosphorous loading matching
Erosion Control	▪ N/A	▪ Provide 24-hour extended detention for the 2-year storm event (controlled to the unit-area flow rate)

Existing Developments

Currently, the Gilford study area has approximately 109.6 ha of developed land (representing 58.6% of the total area). Since there are no existing SWM facilities in the Gilford study area, the retrofit/maintenance alternative is not an option. Implementing LID controls should be the focus on improving existing stormwater runoff in the area. Specific recommendations are listed below.

- The two residential areas immediately north and south of White Birch Creek have defined drainage ditches (roadside ditches) which outlet either to White Birch Creek or the unnamed creek to the north. These residential roadside ditches should be retrofit into enhanced grass swales to improve water quality and promote infiltration.

- Promote the use of rain barrels (rainwater harvesting) for existing houses, and encourage roof-downspout disconnection into pervious areas.

Future Developments

If all potential development identified in the Town OP were built, the developed area in the Gilford study area would increase by approximately 53.7%. This future development is designated as Village

Residential in the OP. The following recommendations have been made for the future developments where ground water levels permit.

- Implement lot level LID measures such as downspout disconnection to pervious areas, porous pavement, rainwater gardens and soakaway areas to improve water balance, reduce phosphorus loading, and reduce peak flows from the site where groundwater levels permit.
- Provide conveyance LID measures such as enhanced grass swales, perforated pipe systems, vegetated filter strips to improve water quality and reduce phosphorus loading where groundwater levels permit.
- Soakaway/infiltration pits should be implemented in all new development areas, where appropriate where groundwater levels permit.
- A treatment train of LID approaches should be provided to achieve the required water quality control where groundwater levels permit.
- Where LID measures do not provide the adequate quantity controls, dry ponds should be utilized to provide these controls.
- Where site conditions do not allow the implementation of LID measures to provide quality control, standard wet ponds should be designed to provide both quality and quantity control. Standard post-to-pre water quantity controls are appropriate for future development.
- Provide 24-hour detention time for the 2-year storm event, controlled to the unit-area rate as specified in Table 23 in Section 7.4 of this report for all development draining into White Birch Creek Tributary and Cook's Bay Tributaries.
- Provide best efforts to control the 2-year to 25-year storm events to the unit-area flow rate as specified in Table 23 in Section 7.4 of this report for all development draining into White Birch Creek Tributary and Cook's Bay Tributaries.

10.2.9 Lefroy

All twelve (12) study area SWM alternatives have been assessed for implementation in the Lefroy study area. Table 39 provides a summary of the scoring for each alternative in relation to the scoring criteria. Where possible, alternatives within the same category (i.e. Existing Development) have been compared against each other to determine the relative scoring of each.

Table 39: Lefroy Alternative Scoring Summary

Criteria	Weighting	Scoring											
		Existing Development Alternatives				Future Development Alternatives (Quantity Control)				Future Development Alternatives (Quality Control)			
		1	2	3	4	5	6	7	8	9	10	11	12
Soil Suitability	1	2	2	2	2	2	2	2	2	2	2	2	2
Wellhead Protection Areas	1	2	2	2	2	2	2	2	2	2	2	2	2
Hazard Area	0.5	2	2	2	2	2	2	2	2	2	2	2	2
Operation and Maintenance	1	0	1	0	0	1	1	1	2	2	1	1	1
Cost	1	0	1	0	1	1	1	1	2	1	1	1	1
Social Suitability	0.5	0	2	0	0	1	1	1	2	2	1	1	1
Water Quality Benefit	3	0	2	0	1	NA	NA	NA	NA	NA	3	3	3
Water Quantity Benefit	2	0	1	0	1	3	3	3	2	2	NA	NA	NA
Suitability of Development Type	1	0	2	0	2	2	2	2	2	2	2	2	2
Land Availability	1	0	2	0	1	2	1	1	2	2	1	1	1
Total		5	20	5	14	17.5	17.5	17.5	18	17	19.5	19.5	19.5

The following table summarizes the SWM requirements for the Lefroy study area.

Table 40: Lefroy Requirement Summary

Requirement	Existing Development	Future Development
Stormwater Quality	▪ Retrofit existing roadside ditches with LID controls ▪ Promote use of rain barrels and encourage downspout disconnection	▪ New developments to incorporate at-source and conveyance LID controls
Stormwater Quantity	▪ N/A	▪ Post-to-pre peak flow matching using combination of LID controls and dry ponds
Water Balance/Infiltration	▪ Promote infiltration with LID retrofits	▪ Must infiltrate a minimum of the 15 mm storm event from all new impervious surface area
Phosphorous Loading	▪ Provide phosphorous reduction with LID retrofits	▪ Best efforts post-to-pre phosphorous loading matching
Erosion Control	▪ N/A	▪ Provide 24-hour extended detention for the 2-year storm event (controlled to the unit-area flow rate) for all development draining into Carson Creek ▪ Provide 24-hour extended detention for the 25 mm storm event for all other development areas

Existing Developments

Currently, the Lefroy study area has approximately 200.4 ha of developed land, representing 41.4% of the total area. Since there are no existing SWM facilities in the Lefroy study area, the retrofit/maintenance alternative is not an option. Implementing LID controls should be the focus on improving existing stormwater runoff in the area. Specific recommendations are listed below.

- There are two main residential areas which have existing roadside ditches, where it would be beneficial to retrofit these ditches into enhanced grass swales. The first area encompasses the streets of Corner Avenue, Gilmore Avenue, Ferrier Avenue and Squire Street (see Figure 7-F). The second main area is in the north east corner of the study area, encompassing all streets north of Belle Aire Beach Road. There are a number of other streets within the study area which have ditches with the potential for retrofit (refer to Figure 7-F).

- Promote the use of rain barrels (rainwater harvesting) for existing houses, and encourage roof-downspout disconnection into pervious areas.

The Lefroy South Innisfil Community Centre development has been recognized as an uncontrolled, highly impervious development, for which further detailed assessment should be completed to determine how to implement quality control measures for the existing stormwater runoff. These measures would likely be LID controls or OGS units.

Future Developments

The Lefroy study area is planned to increase in developed area by approximately 53.7%. The majority of this increased development area is the LSAMI development. This increase is almost entirely zoned as Village Residential under the Official Plan. As previously discussed, the LSAMI developments provide peak flow over control as specified in the Lefroy Secondary Plan Master Drainage Plan to assist in reducing peak flows to the downstream flood-prone areas. As such, the following recommendations have been made for additional future developments in Lefroy, where ground water levels permit.

- Implement lot level LID measures such as downspout disconnection to pervious areas, porous pavement, rainwater gardens and soakaway areas to improve water balance, reduce phosphorus loading, and reduce peak flows from the site where groundwater levels permit.
- Provide conveyance LID measures such as enhanced grass swales, perforated pipe systems, vegetated filter strips to improve water quality and reduce phosphorus loading where groundwater levels permit.
- Soakaway/infiltration pits should be implemented in all new development areas, where groundwater levels permit.
- A treatment train of LID approaches should be provided to achieve the required water quality control where groundwater levels permit.
- Where LID measures do not provide the adequate quantity controls, dry ponds should be utilized to provide these controls.
- Where site conditions do not allow the implementation of LID measures to provide quality control, standard wet ponds should be designed to provide both quality and quantity control. Standard post-to-pre water quantity controls are appropriate for future development.
- Provide 24-hour detention time for the 2-year storm event, controlled to the unit-area rate as specified in Table 23 in Section 7.4 of this report for all development draining into Carson Creek.
- Provide best efforts to control the 2-year to 25-year storm events to the unit-area flow rate as specified in Table 23 in Section 7.4 of this report for all development draining into Carson Creek
- Standard 24-hour detention time for the 25 mm 4-hour Chicago storm even for all areas not draining into Carson Creek.

10.2.10 Fennell's Corners

Due to the small size of Fennell's Corners and the fact that the study area is completely developed, it was impractical to provide a scoring summary for each alternative. However, a number of recommendations have been made for any re-development in the area. The following table summarizes the stormwater management requirements for the Fennell's Corners study area.

Table 41: Fennell's Corners Requirement Summary

Requirement	Existing Development	Future Development / Redevelopment
Stormwater Quality	▪ N/A	▪ New developments to incorporate at-source and conveyance LID controls
Stormwater Quantity	▪ N/A	▪ Post-to-pre peak flow matching using combination of LID controls and dry ponds
Water Balance/Infiltration	▪ Encourage rain barrel use and downspout disconnection	▪ Match existing
Phosphorous Loading	▪ N/A	▪ Best efforts post-to-pre phosphorous loading matching
Erosion Control	▪ N/A	▪ Provide 24-hour extended detention for the 40 mm storm event

Existing Developments

Currently, the Fennell's Corners study area of 18.4 ha is completely developed. There is one SWM facility located within the study area (Pond #15-1), which provides adequate controls; however we recommend installing an OGS unit upstream of the inlet to increase water quality function of the facility. Implementing LID controls should be the focus for improving existing stormwater runoff in the area. Specific recommendations are listed below:

- Promote the use of rain barrels (rainwater harvesting) for existing houses, and encourage roof-downspout disconnection into pervious areas.

Future Developments

As Fennell's Corners is already fully developed, the future development SWM plan only applies to any re-development. The recommendations for any re-development works in areas where groundwater levels permit are listed below.

- Implement lot level LID measures such as downspout disconnection to pervious areas, porous pavement, rainwater gardens and soakaway areas to improve water balance, reduce phosphorus loading, and reduce peak flows from the site where groundwater levels permit.

- Provide conveyance LID measures such as enhanced grass swales, perforated pipe systems, vegetated filter strips to improve water quality and reduce phosphorus loading where groundwater levels permit.

- Soakaway/infiltration pits should be implemented in all new development areas, where groundwater levels permit.

- A treatment train of LID approaches should be provided to achieve the required water quality control where groundwater levels permit.

- Where LID measures do not provide the adequate quantity controls, dry ponds should be utilized to provide these controls.

- Where site conditions do not allow the implementation of LID measures to provide quality control, standard Wet Ponds should be designed to provide both quality and quantity control. Standard post-to-pre water quantity controls are appropriate for future development.

- Standard 24-hour detention time for the 25 mm 4-hour Chicago storm event is required.

11 Implementation Plan (Step Nine)

In order to ensure that the preferred alternatives selected in the previous section can be carried out, it is necessary to create a detailed implementation plan to outline implementation strategies, determine the responsibilities of various stakeholders, determine potential funding sources, and create a primary implementation schedule. The implementation plan places responsibility with the Town, as well as developers, residents and other government agencies.

11.1 Implementation Strategies

11.1.1 Initiate Joint Public & Private Awareness Programs

As noted above, runoff from the majority of existing residential developments with the Town discharges uncontrolled either to a tributary watercourse or to Lake Simcoe directly. To assist in reducing the impacts of runoff produced during frequent storms, including the anticipated increases in storm intensity, frequency and duration caused by climate change, a joint public/private awareness program is recommended. The program should promote the use of lot level LID practices including rainwater harvesting, reducing fertilizer usage, rainwater gardens, roof downspout directed to pervious areas etc. A program offering subsidized rain barrels to individual households is recommended as a starting point, as rain barrels are relatively inexpensive, simple to use, and occupy very little space on a lot. As part of the rain barrel campaign, public education materials related to other at-source SWM opportunities can be provided. Stormwater initiatives aimed at individual property owners can be very effective at the site level, and if they are widely adopted, the cumulative effect can be a significant improvement in stormwater quality and quantity at a very low cost to the Town.

11.1.2 Implement LID Pilot Projects

Further to the joint public private awareness program, opportunities to undertake LID pilot projects should be considered. Some of the Town properties previously identified in Section 10, such as the Stroud Community Centre, could be considered for LID retrofit. We understand that LSRCA is looking to partner with Municipalities to undertake LID pilot projects and they may be willing to share some of the expense and offer support with ongoing monitoring. In addition, partnerships with SCDSB or private landowners could be developed to undertake LID pilot projects either for new development or as a retrofit measure. The establishment of pilot projects will demonstrate the Town's commitment to the use of LID and provide valuable information about how such facilities perform within the Town. This information can guide the development of design, operation and maintenance standards for LID facilities. The following table presents a complete list of possible locations for LID retrofits. The proposed construction dates are subject to revision based on further studies.

Table 42: Town LID Retrofit Project List

Study Area	Site Location	Projected Date of Construction
Stroud	Stroud Community Centre	2019
Alcona Central	Alcona Glen Elementary School	2020
Alcona Central	Commercial Development at Innisfil Beach Road and Jans Boulevard	2021
Alcona Central	Goodfellow Public School	2022
Alcona Central	Holy Cross Catholic School	2023
Alcona Central	Commercial Development at Innisfil Beach Road and 20th Sideroad	2024
Alcona Central	Commercial Development at Innisfil Beach Road and St. Johns Road	2025
Stroud	Sunnybrae Public School	2026
Stroud	Commercial Development at Yonge Street and Lynn Street	2027
Stroud	Commercial Development at Yonge and Glenn Avenue	2028
Innisfil Heights	The 400 Market	2029
Innisfil Heights	Development area including the Duivenvoorden Haulage, Steel Tire Co., and Legend Boats	2030

Note: Potential funding sources for all LID projects listed in Table 42 are provided in Section 11.2.

We have estimated a cost of $100,000 per LID pilot project (including construction and design). This estimate will fluctuate depending on the complexity of the LID retrofit. We recommend implementing one LID pilot project per year. This is included in the total annual capital costs in Table 43, below.

11.1.3 Implement Enhanced Grass Swale Retrofit Program

It is recommended that a program to retrofit existing roadside ditches into enhanced grass swales be adopted by the Town. A number of areas where this retrofit option would be feasible have been discussed in previous sections. However, there are likely many more existing ditches where this retrofit would provide stormwater enhancements. Using the cost estimate from the Part 1 Report of $10 per linear meter, we propose that a 5-year budget of $125,000 be made available, with the goal of implementing 2,500 m of enhanced grass swale per year. A number of possible locations have been identified, and are summarized in Table 43.

Table 43: Enhanced Grass Swale Opportunities

Study Area	Road	Projected Date of Construction
Innisfil Heights	Innisfil Heights Crescent	TBD
Innisfil Heights	Innisbrook Street	TBD
Sandy Cove	Mason Drive	TBD
Gilford	Shore Acres Drive	TBD

11.1.4 Implement SWM Pond Retrofit Program

It has been recommended that a complete SWM rehabilitation (clean-out of accumulated sediment and restoration back to original as-constructed conditions) should be completed for a minimum of one pond each year. There are also a number of other ponds which would benefit from maintenance work, but do not require a full rehabilitation design. These maintenance works should be taken on by the Town, and should be prioritized by Town staff based on the findings from regular pond inspections. The installation of a number of OGS units has also been proposed to improve water quality, and reduce the frequency of future maintenance and retrofit work required. In addition to the rehabilitation work identified above, a number of ponds have also been recommended for complete retrofit works as they do not provide a level of water quality control that is consistent with current standards. The retrofit works would involve redesign of the facility to address the underlying deficiency (i.e. providing additional storage volume, converting a dry pond into a wet pond or hybrid LID/dry pond facility).

For the purpose of determining capital and operations budgets, we have summarized all required SWM infrastructure works in Tables 44, 45 and 46. Table 44 summarizes the annual capital costs for proposed complete SWM facility retrofits, and provides a comparison between estimated cost and the Town's current SWM facility cleanout/retrofit budget.

Table 44: 10-Year Annual Capital Cost Summary: SWM Facility Retrofits/ Rehabilitations

Construction Year	Complete SWM Facility Retrofits/ Rehabilitations	Projected Capital Cost	Approved 2016/2017 Capital Budget Allocation
2017 (Year 1)	Trillium Industrial (#8-1)	$300,000	$300,000
2018 (Year 2)	Brandy Lane (#10-1)	$244,000	$244,000
Construction Year	Complete SWM Facility Retrofits/ Rehabilitations	Projected Capital Cost	Recommended Capital Budget Allocation
2019 (Year 3)	Village North (#10-2) and another priority facility TBD	$366,000	$366,000
2020 (Year 4)	Southview (#9-2) and another priority facility TBD	$366,000	$366,000
2021 (Year 5)	Monrepos (#13-2) and another priority facility TBD	$366,000	$366,000
2022 (Year 6)	South Shore Woods (#13-3) and another priority facility TBD	$366,000	$366,000
2023 (Year 7)	Coralwoods (#4-2) and another priority facility TBD	$366,000	$366,000
2024 (Year 8)	Victoria Green (#9-3) and another priority facility TBD	$366,000	$366,000
2025 (Year 9)	Doral East (#9-4) and another priority facility TBD	$366,000	$366,000
2026 (Year 10)	Previn Court Stage 1 (#6-1) and another priority facility TBD	$366,000	$366,000
	10-Year Total	$3,472,000	$3,472,000

As shown in Table 44, the Town's current 2016 capital budget allocation for SWM facility cleanout/retrofit meets our estimated costs for the 2017 and 2018 construction years. Our total 2017 cost estimate has been developed using a detailed cost estimate for the Trillium Industrial retrofit project, for which the design has already been completed. The 2018 cost estimate of $244,000 has been developed with the following assumptions:

- Construction Cost for one large cleanout or one complete retrofit = $200,000 (determined from the Part 1 Report and average tender prices from previous facility cleanouts);
- Engineering Consulting Fees - Design & Construction Services = $34,000 (17% of Construction Cost);
- Town Staff Charges = $10,000 (5% of Construction Cost).

For construction years 2019 to 2026, we recommend the Town complete two rehabilitation/retrofit projects each year. The 2019 to 2026 cost estimate of $366,000 has been developed with the following assumptions:

- Construction Cost for one large cleanout or one complete retrofit = $200,000 (determined from the Part 1 Report and average tender prices from previous facility cleanouts);
- Construction Cost for one small cleanout or one small retrofit project = $100,000
- Engineering Consulting Fees - Design & Construction Services = $51,000 (17% of Construction Cost);
- Town Staff Charges = $15,000 (5% of Construction Cost).

It should be noted that the construction cost will vary depending on the specifics of each design and the sediment/earth work removals required. As such, the Town has taken the approach of contracting out the design of three rehabilitation/retrofit designs at a time, which allows for more detailed construction cost estimates to be developed.

The estimated remaining annual budget which has been allocated to SWM facility retrofit/cleanouts as calculated in Table 44 has been carried over to Table 45 which summarizes the estimated annual capital cost for SWM improvement works The SWM improvement works include LID pilot projects, OGS unit installation and enhanced grass swale construction to be selected as the Town sees fit.

We have provided an annual estimated budget of $100,000 for SWM improvement works which should cover one LID retrofit project per year, or a combination of OGS and enhanced grass swale construction. The cost of OGS units vary depending on manufacturer and size. For the purpose of this CSWM-MP, we have used the cost of a mid-sized unit (Stormceptor STC3000). The approximate cost (supply and installation) of this unit is $50,000.

Table 45: 10-Year Annual Capital Cost Summary: SWM Improvement Works

Construction Year	SWM Improvement Works	Projected Capital Cost[1]	Approved 2016/2017 Capital Budget Allocation
2017 (Year 1)	LID Pilot Project, OGS or enhanced grass swales	$17,200	$17,200
2018 (Year 2)	LID Pilot Project, OGS or enhanced grass swales	$73,200	$73,200
Construction Year	SWM Improvement Works	Projected Capital Cost	Recommended Capital Budget Allocation
2019 (Year 3)	LID Pilot Project, OGS or enhanced grass swales	$100,000	$100,000
2020 (Year 4)	LID Pilot Project, OGS or enhanced grass swales	$100,000	$100,000
2021 (Year 5)	LID Pilot Project, OGS or enhanced grass swales	$100,000	$100,000
2022 (Year 6)	LID Pilot Project, OGS or enhanced grass swales	$100,000	$100,000
2023 (Year 7)	LID Pilot Project, OGS or enhanced grass swales	$100,000	$100,000
2024 (Year 8)	LID Pilot Project, OGS or enhanced grass swales	$100,000	$100,000
2025 (Year 9)	LID Pilot Project, OGS or enhanced grass swales	$100,000	$100,000
2026 (Year 10)	LID Pilot Project, OGS or enhanced grass swales	$100,000	$100,000
	10-Year Total	$890,400	$890,400

For construction years 2017 and 2018, the projected capital cost is equal to the remaining budget allocation based on the 2016 approved budget. A best efforts approach should be taken by the Town to implement SWM improvement works with this remaining budget, until additional budget becomes available in 2019.

A number of potential SWM facilities which would benefit from the installation of an OGS unit have been identified in Table 46. The table prioritizes the SWM facilities from 1-9 based on which would receive the greatest benefit from the installation of an OGS unit.

Table 46: OGS Unit Installation Opportunities

Study Area	SWM Facility	Priority
Alcona	7-1: Royal Alcona	1
Stroud	10-1: Brandy Lane	2
Stroud	10-2: Village North Dempster	3
Fennell’s Corners	15-1: Goldcrest	4
Alcona	6-1: Previn Court Stage 1	5
Stroud	9-2: Southview	6
Alcona	8-5: Skivereen	7
Alcona	6-1: Tepco	8
Alcona	7-6: Innisbrook	9

Table 47 provides a summary of the required annual SWM facility maintenance works, and summarizes the current Town Operation budget allocation to SWM facility works. Annual SWM facility maintenance works include, but are not limited to the following:

- Beaver dam removal;
- Outlet structure replacement/rehab;
- Headwall replacement;
- Repair of access road;
- Replanting dead vegetation; and
- Minor cleanout works (forebay).

The intent of these minor maintenance activities is to prolong the useful life of the SWM facility without the need for complete rehabilitation. The required maintenance activities should be determined from the regular inspections which are to be completed by Town staff.

Table 47: 10-year Annual Operational Cost Summary: SWM Facility Maintenance Works

Year	SWM Facility Maintenance Works	Projected Operations Cost	2016/2017 Operations Budget Allocation
2017 (Year 1)	As Required	$100,000	$25,000
2018 (Year 2)	As Required	$100,000	$25,000
Year	**SWM Facility Maintenance Works**	**Projected Operations Cost**	**Recommended Operations Budget Allocation**
2019 (Year 3)	As Required	$100,000	$100,000
2020 (Year 4)	As Required	$100,000	$100,000
2021 (Year 5)	As Required	$100,000	$100,000
2022 (Year 6)	As Required	$100,000	$100,000
2023 (Year 7)	As Required	$100,000	$100,000
2024 (Year 8)	As Required	$100,000	$100,000
2025 (Year 9)	As Required	$100,000	$100,000
2026 (Year 10)	As Required	$100,000	$100,000
	10-Year Total	$1,000,000	$850,000

The cost of maintenance works will vary depending on the actual work required; as such we have estimated an annual budget of $100,000 for years 2019 to 2026 for the purpose of this CSWM-MP. The scope of work shall be determined by Town staff on an as-needed basis.

11.1.5 Develop LID Cross Sections for Urban Developments

It is recommended that the Town undertake a project to develop a standard urban cross-section design which incorporates LID controls. This standard could be then be applied for all new developments.

11.2 Potential Funding Sources

In order to implement the numerous SWM Recommendations made in this CSWM-MP, it maybe be necessary for funding to be provided from a number of stakeholders. The majority of funds required for the improvements should be provided for by the Town, however other sources should include:

- LSRCA;
- MOECC;

- Ministry of Transportation (for roadside ditch enhancements);
- provincial government (grants for sustainability and asset management); and
- private sector/developers.

A handful of potential funding sources are discussed below.

11.2.1 Landowner Environmental Assistance Program (LEAP)

The LEAP program has been developed to assist landowners with funding and technical assistance for environmental projects on their land. LEAP is administered by the LSRCA and made possible by funding from municipal partners and the support of the York, Durham, and Simcoe chapters of the Ontario Federation of Agriculture. The program covers a variety of environmental projects, some of which involve SWM improvements. For more information on the program, please refer to http://www.lsrca.on.ca/leap/.

11.2.2 Lake Simcoe/South-eastern Georgian Bay Clean-up Fund

The Lake Simcoe Clean-up Fund (LSCUF) is a program funded by Environment Canada, and was created in 2007. From 2001-2012 it was successful in accelerating the adoption of beneficial management practices in the watershed, reducing phosphorous loads from urban and rural sources, and improving information and monitoring for decision making. The Government of Canada renewed and expanded the program for 2012-2017 with a $29 million funding budget. This program has recently expanded to include the South-eastern Georgian Bay area. The main objectives are:

- to improve environmental monitoring, assessment and scientific information required to measure the effectiveness of control strategies, and identify and assess alternative approaches to reducing phosphorous discharges;
- to conserve critical aquatic habitat and associated species through targeted aquatic habitat protection, restoration and creation projects;
- to reduce rural and urban non-point sources of phosphorous/nutrients, including implementation of BMPs for the management of soil, crops, livestock, and water use, septic systems and creating and rehabilitating wetlands and naturalizing watercourses to attenuate phosphorous discharges; and
- to reduce discharge of phosphorous from point sources including sewage, combined sewer overflows and urban stormwater systems including support to development and testing of innovative approaches to manage urban stormwater and wastewater.

The fund is open to applications from the following groups:

- landowners;
- environmental groups;

- community groups (e.g. youth and seniors groups, community-based associations, service clubs);
- small and medium sized business (e.g. developers, industries etc.);
- aboriginal organizations (e.g. First Nations Councils, Métis Associations);
- conservation authorities;
- stewardship networks;
- agriculture associations;
- non-governmental organizations;
- educational institutions;
- industry; and
- provincial/territorial/municipal governments

For more information on the program, please refer to http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=85C54DAE-1#Purpose.

11.2.3 Green Municipal Fund

The Green Municipal Fund (GMF) is an initiative program run by the Federation of Canadian Municipalities (FCM) with the goal of funding municipal environmental initiatives including plans, studies and projects. The GMF funds a variety of project including works related to water conservation, SWM, wastewater systems and septic systems. For more information on the program, please refer to http://www.fcm.ca/home/programs/green-municipal-fund/about-gmf.htm.

11.2.4 RBC Blue Water Project

The focus of the RBC Blue Water Project is to support initiatives that help protect and preserve water in towns, cities and urbanized areas with populations of more than 10,000 people that focus on:

- improved control and management of urban storm or rain water;
- efficient and innovative use (or capture and reuse) of water in towns and cities;
- protection and restoration of urban waterways; and
- improved urban water quality.

Funded projects are expected to achieve measureable outcomes such as:

- increased riparian space and aquatic habitat;

- reduced damage from flooding;
- reduced rate of water runoff;
- increased water absorption through natural landscape or infiltration;
- reduced water pollution; and

For more information about this program, please refer to http://www.rbc.com/community-sustainability/apply-for-funding/guidelines-and-eligibility/blue-water-project.html.

11.2.5 Enbridge Savings by Design

Created by Enbridge Gas Distribution with integrated design support from Sustainable Buildings Canada and their network of sustainable experts, the Savings by Design program was developed to facilitate an easier transition to green housing innovation. This program is available for both residential and commercial developments. Enbridge and their support team assist in LID designs, which incorporate LID SWM controls, as well as other various energy saving designs. For more information, please refer to http://residential.savingsbydesign.ca/incentives.html for the residential program, and http://commercial.savingsbydesign.ca/programoverview.html for the commercial program.

11.2.6 Lake Simcoe Phosphorous Offset Program

The Lake Simcoe Phosphorus Offset Program (LSPOP) was developed to promote greater phosphorus reductions to offset the increases from future urban expansion. This project was initiated by the Lake Simcoe Region Conservation Authority (LSRCA) and was partially funded through a grant from the Province of Ontario's Showcasing Water Innovation program, the City of Barrie, and the Regional Municipality of York. The LSPOP is presently designed to offset any residual phosphorous loads from growth related urban stormwater after the best available control technology is applied within the development itself. The offsetting measures consist of phosphorous load reduction through the retrofit of existing stormwater discharges elsewhere in the subwatershed or adjacent subwatersheds. In order to ensure the highest environmental benefit from the retrofits, the phosphorous load reduction is over controlled to some multiple of the required loading.

11.3 Policy Considerations

It is recommended that a number of additions/alterations be made to the Town’s policies and guidelines in regards to stormwater management. The alterations/additions to these documents are as follows.

11.3.1 Town of Innisfil Official Plan

In recognizing that the Town has recently begun a review of their current approved OP, it is recommended that the following be included in Section 7.2.

- In areas where soil/groundwater conditions permit, the installation of lot level infiltration measures such as bioretention cells, soakaway pits or equivalent measures is recommended. In these areas, roof leaders and yard drainage should be disconnected and directed towards lawns, side and rear yard swales, boulevards, parks and other open spaces throughout the development where possible to promote infiltration.

- Road infiltration trenches and perforated pipe systems should be installed where soil/groundwater conditions permit.

- Enhanced Grass Swales should be implemented as conveyance channels where soil/groundwater conditions permit.

- Infiltration and exfiltration systems for end-of-pipe stormwater facilities should be installed where soil and groundwater conditions permit to promote infiltration and reduce thermal impacts.

11.3.2 Town of Innisfil Engineering Design Standards & Specifications

Section 4.0: includes a brief section on LID. It is recommended that this section be updated to require the implementation of LID controls (source, conveyance and end-of-pipe controls) for new developments and retrofit/reconstruction projects. The same list of policies should be included in the following standards:

- In areas where soil/groundwater conditions permit, the installation of lot level infiltration measures such as bioretention cells, soakaway pits or equivalent measures is recommended. In these areas, roof leaders and yard drainage should be disconnected and directed towards lawns, side and rear yard swales, boulevards, parks and other open spaces throughout the development where possible to promote infiltration.

- Where site soils are less conducive to infiltration, underdrains can be included to encourage drainage but still provide a filtration benefit.

- Road infiltration trenches and perforated pipe systems should be installed where soil/groundwater conditions permit.

- Enhanced Grass Swales should be implemented as conveyance channels where soil/groundwater conditions permit.

- Infiltration and exfiltration systems for end-of-pipe stormwater facilities should be installed where soil and groundwater conditions permit to promote infiltration and reduce thermal impacts.

It will also be beneficial to include a more detailed list of LID controls which have been approved by the Town for implementation. This list may include design guidelines and detail drawings, or may reference other sources for design guidelines (i.e. the TRCA/CVC Low Impact Development Stormwater Management Planning and Design Guide). We suggest that the Town develop a list of approved LID controls which can be used by developers and their design engineers.

The Town's Engineering Design Standards & Specifications should also address the effect of climate change on rainfall events by adopting IDF curves which are adapted to account for an increase in rainfall intensities. Additional studies/investigations may be required to determine the most appropriate increase in intensities.

11.3.3 Lake Simcoe Watershed Model By-Law and LID SWM Guidelines for Municipalities (Draft)

It is recommended the Town consider the adoption of the draft LSRCA Lake Simcoe Watershed Model By-law and LID SWM Guidelines for Municipalities (April, 2015). These draft guidelines provide a model framework for LID SWM requirements to be defined within the Town's legislative framework. The Town has the option to adopt some, all, or none of these requirements into their standards.

The draft Lake Simcoe LID SWM Guidelines for Municipalities (2015) includes guidelines and standards regarding site design, stormwater volume reduction goals, SWM rate controls, LID design, and permanent SWM systems. It should be noted that the quality and quantity control approach to be implemented in the Lake Simcoe watershed by the LSRCA will be based on Section 2.2.2 of the Authority's new Technical Guidelines for SWM Submissions, scheduled for release in September, 2016. The requirements of this document supersede those in the draft Lake Simcoe LID SWM Guidelines for Municipalities (2015). The MOECC is also finalizing a document dealing with this matter which is scheduled for release in 2017.

The Lake Simcoe Watershed Model By-law for Municipalities provides a number of draft by-laws which can be adopted by municipalities within the LSRCA watershed. The document includes draft by-laws regarding site alteration and fill placement, stormwater management permits, and erosion and sediment control permits.

12 Inspection & Maintenance Program (Step Ten)

A SWM Facility Inspection and Maintenance Manual document has been provided under separate cover, and is included in Appendix G.

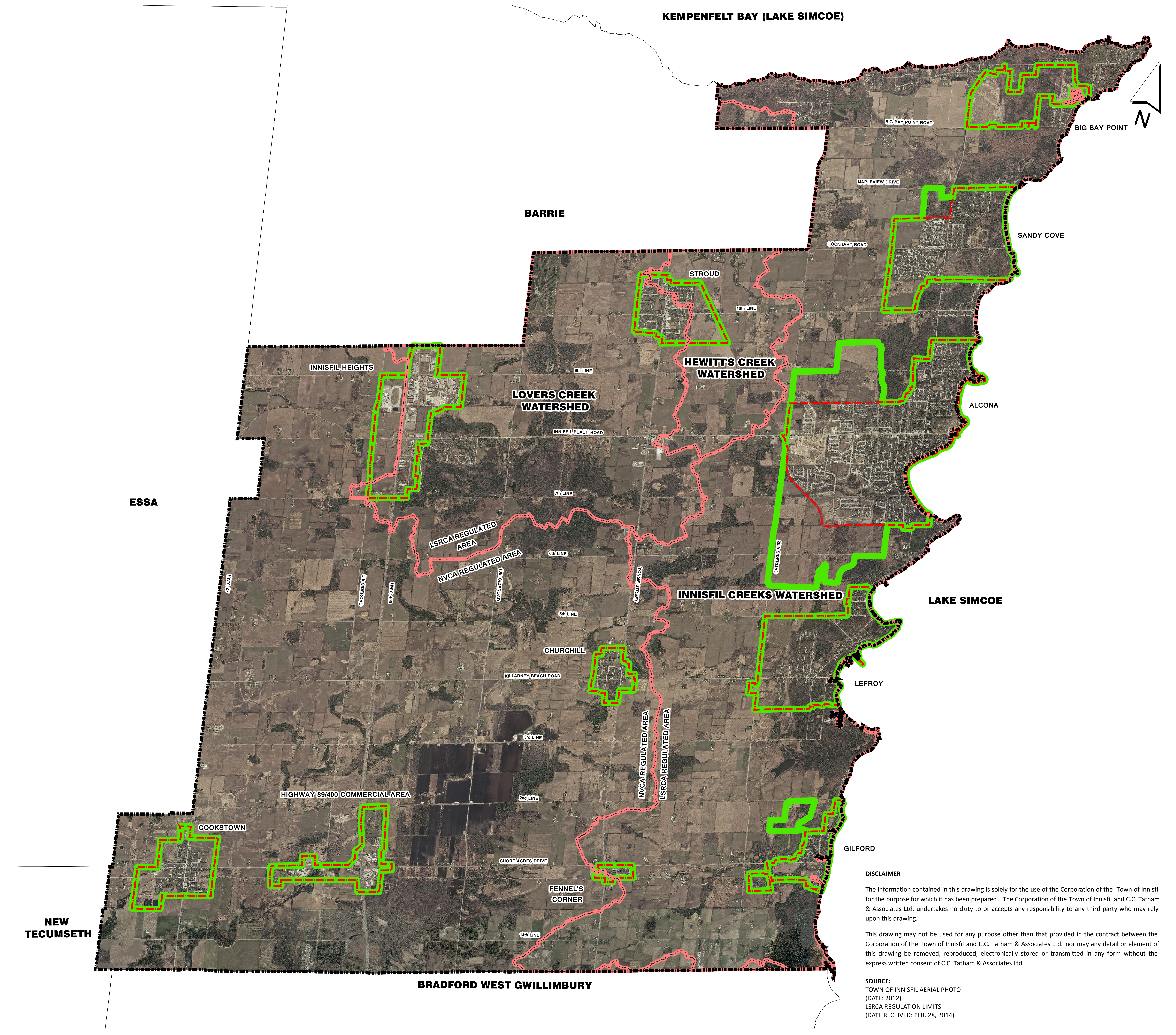
LICENSED PROFESSIONAL ENGINEER
A Kellett
A. L. KELLETT
100123897
Oct 21, 2016
PROVINCE OF ONTARIO

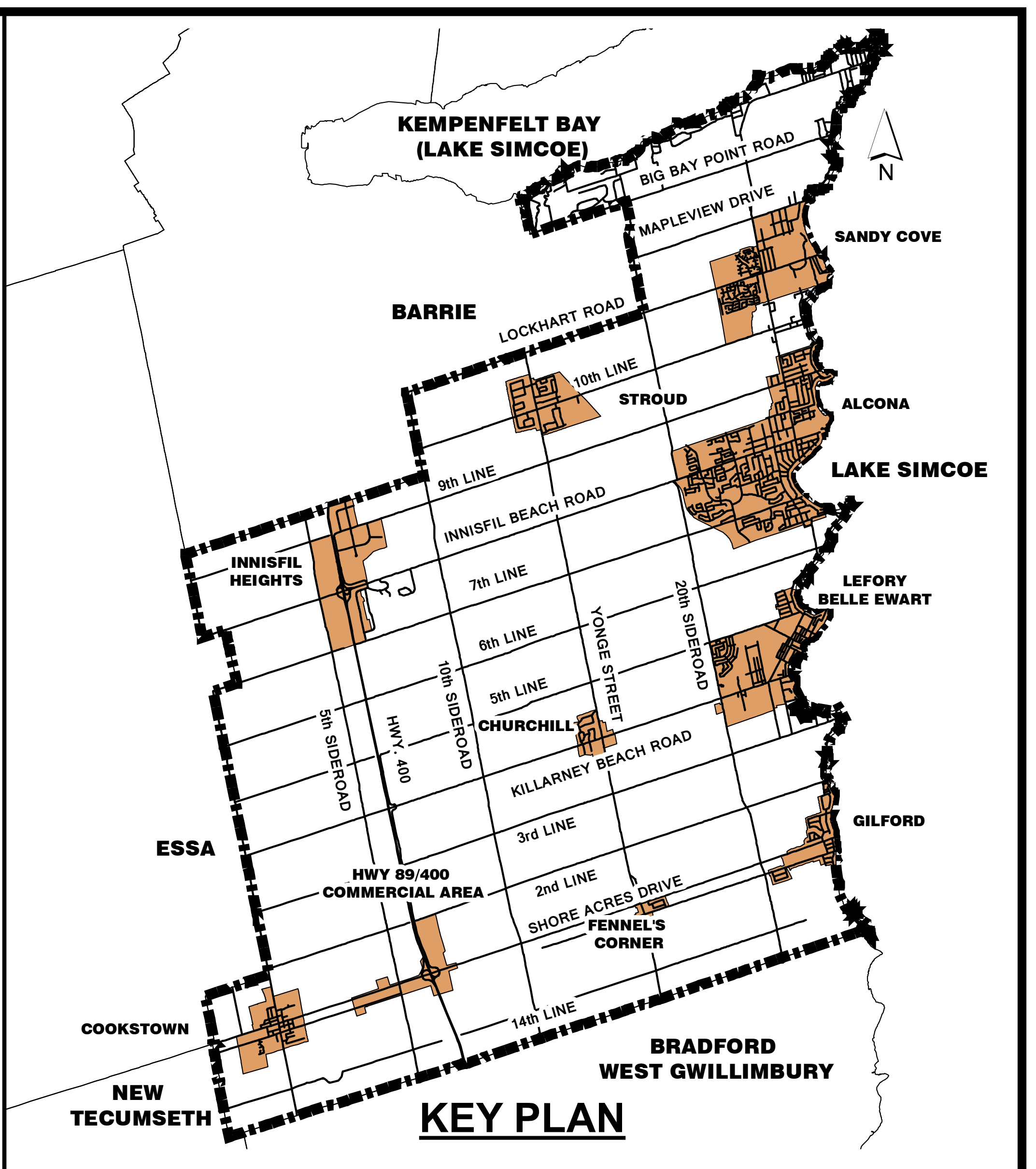
Dan Hurley

Authored by: Amanda Kellett, B.Sc.Eng., P.Eng.
Project Manager

Reviewed by: Dan Hurley, B.A.Sc., P.Eng., LEED AP
Vice President,
Manager - Water Resources Engineering

FIGURES





KEY PLAN

Legend

- 🟥 WATERSHED BOUNDARY
- 🟥 SETTLEMENT AREAS
- ⬛ MUNICIPAL BOUNDARY
- 🟩 STUDY AREAS

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SOURCE:
TOWN OF INNISFIL AERIAL PHOTO
(DATE: 2012)
LSRCA REGULATION LIMITS
(DATE RECEIVED: FEB. 28, 2014)

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Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

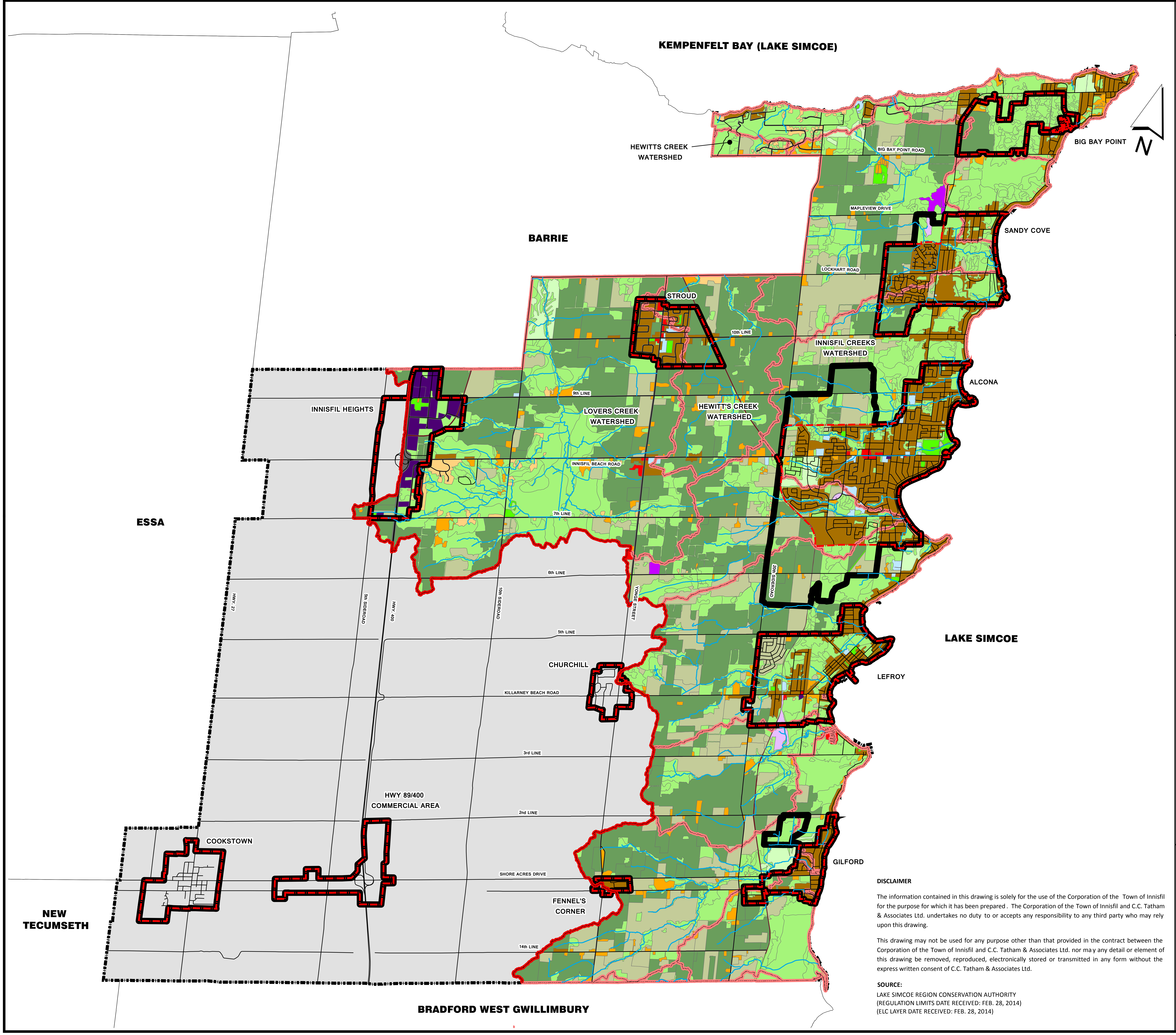
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

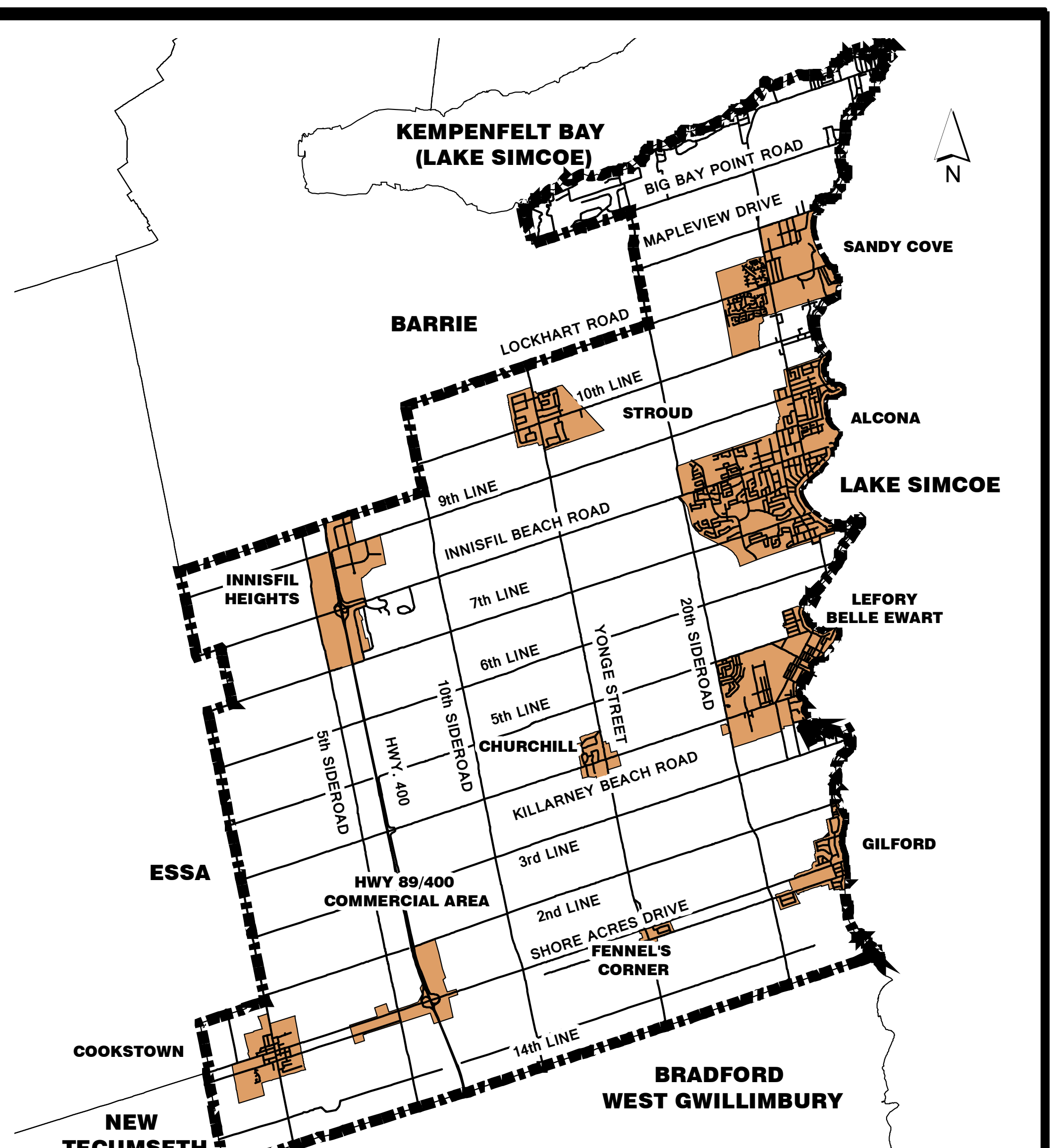
OVERALL SETTLEMENT AREA KEY PLAN

0 495 990 1,980 2,970 3,960
Meters

FIGURE 1

DATE: MARCH 2016





KEY PLAN

Legend

—	ROADS
—	WATERCOURSE
—	LSRCA LIMIT
▭	SETTLEMENT AREAS
▭	SUBCATCHMENT BOUNDARY
▭	STUDY AREAS
▭	MUNICIPAL BOUNDARY

LSRCA EXISTING LAND USE

🟪	Active Aggregate
🟪	Inactive Aggregate
🟥	Commercial
🟪	Industrial
🟦	Institutional
🟩	Intensive Agriculture
🟩	Non-intensive Agriculture
🟩	Golf Course
🟩	Manicured Open Space
🟩	Natural Heritage Feature
🟥	Rail
⬛	Road
🟨	Estate Residential
🟧	Rural Development
🟫	Urban

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SOURCE:

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(ELC LAYER DATE RECEIVED: FEB. 28, 2014)

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Innisfil

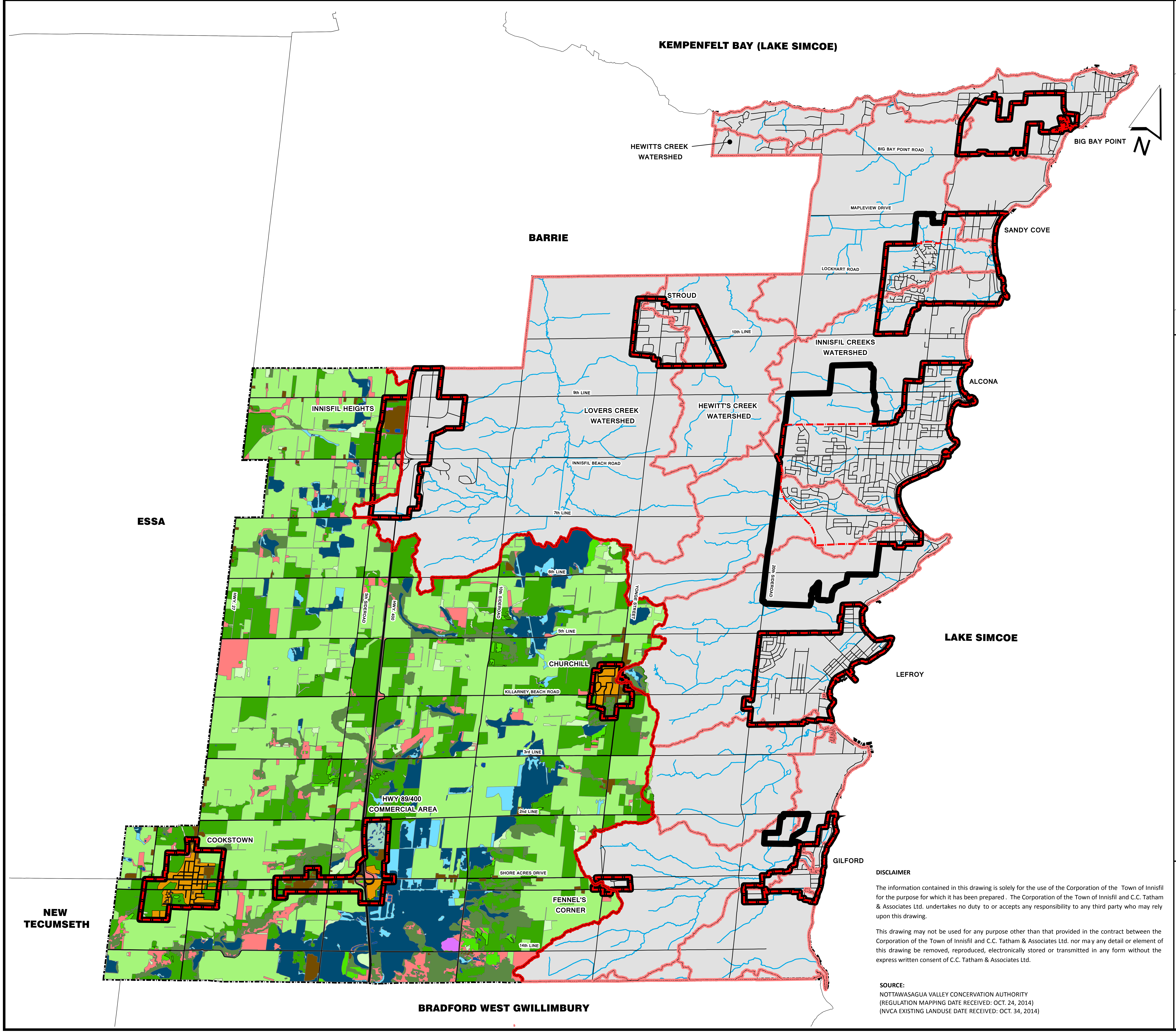
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

LSRCA EXISTING LAND USE PLAN

0 500 1,000 2,000 3,000 4,000 Meters

FIGURE 2-A

DATE: JUNE 2016



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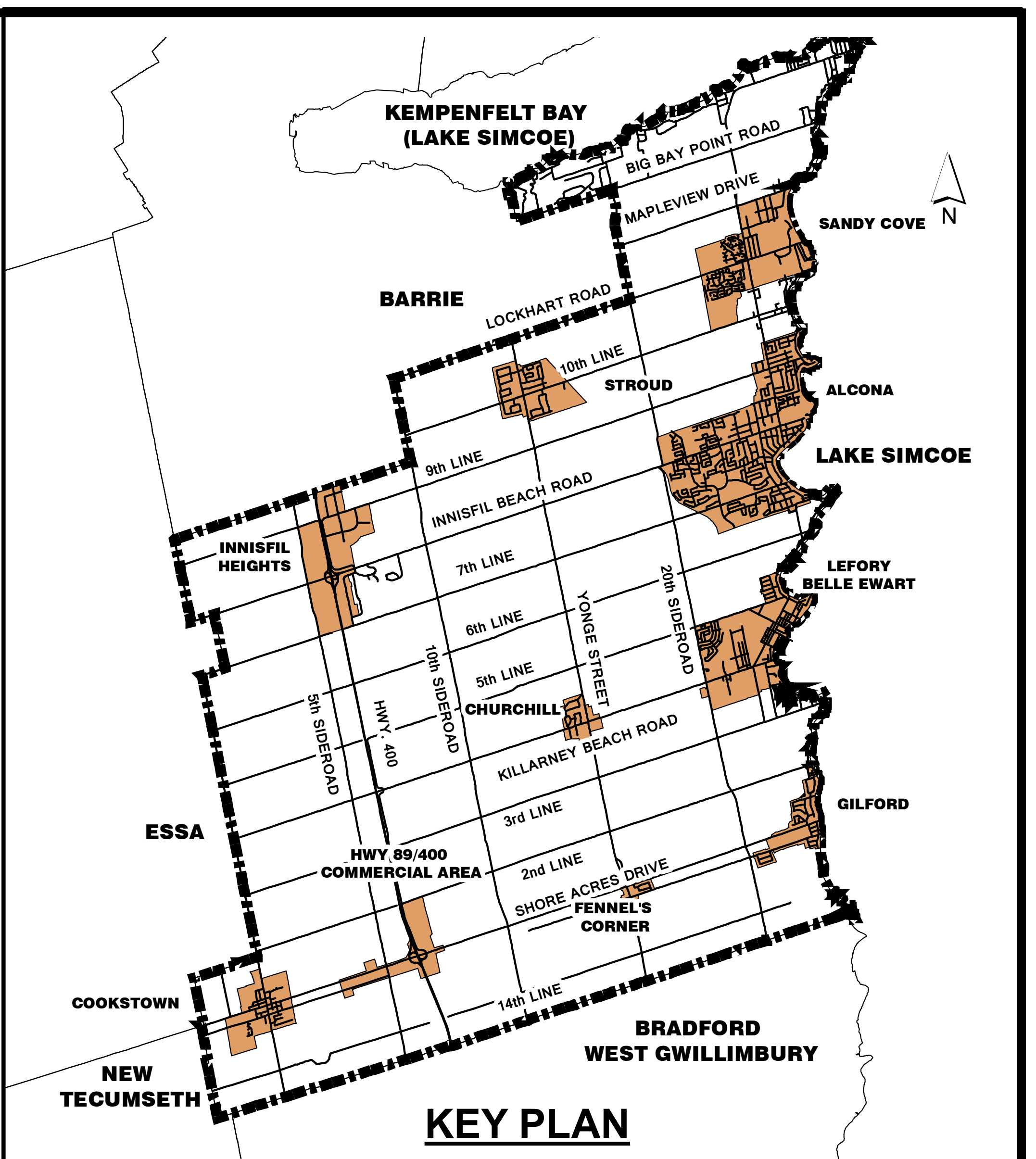
SOURCE:
NOTTAWASAGUA VALLEY CONCERVATION AUTHORITY
(REGULATION MAPPING DATE RECEIVED: OCT. 24, 2014)
(NVCA EXISTING LANDUSE DATE RECEIVED: OCT. 34, 2014)



KEY PLAN

Legend

- ROADS
- WATERCOURSE
- LSRCA LIMIT
- SUBCATCHMENT BOUNDARY
- SETTLEMENT AREAS
- STUDY AREAS
- MUNICIPAL BOUNDARY

NVCA EXISTING LANDUSE

- 🟩 CONIFEROUS FOREST
- 🟩 DECIDUOUS FOREST
- 🟩 GOLF COURSE
- 🟩 HAY/PASTURE
- 🟩 MIXED FOREST
- 🟦 OPEN WETLAND
- 🟪 QUARRY
- ⬛ ROAD
- 🟩 ROW CROP
- 🟥 TRANSITIONAL
- 🟧 URBAN IMPERVIOUS
- 🟫 URBAN PERVIOUS
- 🟦 WATER
- 🟦 WOODY WETLAND

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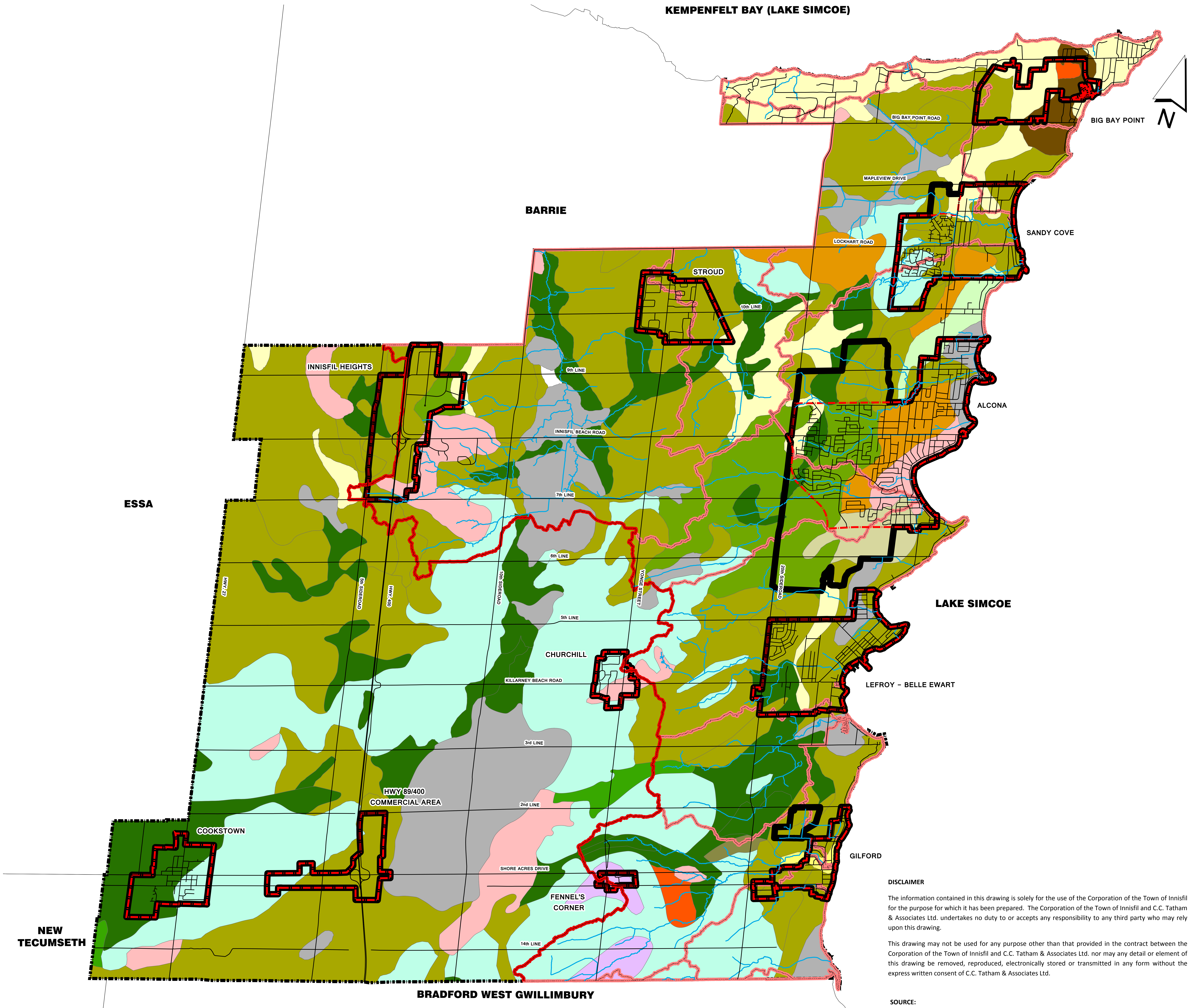
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

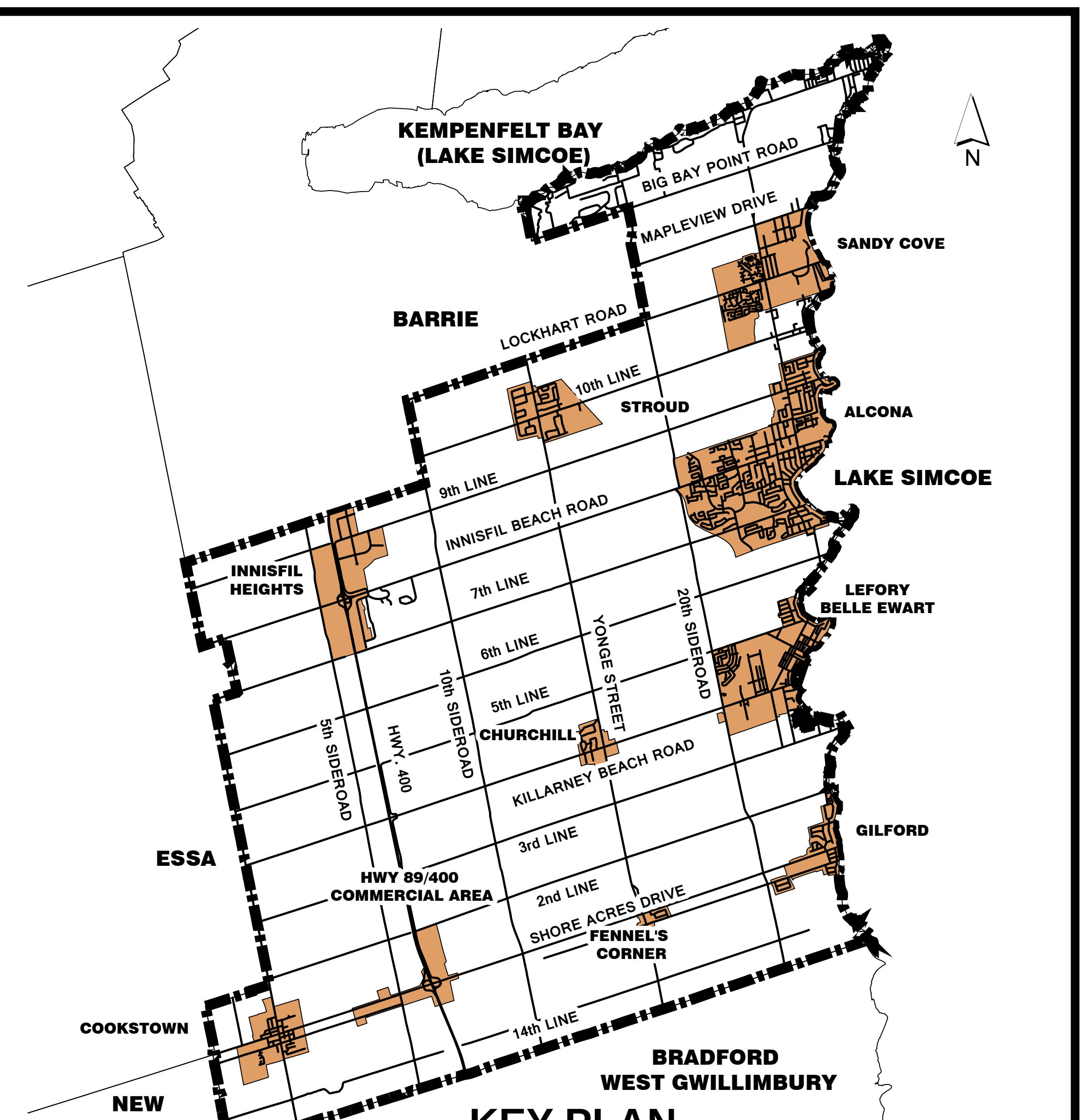
NVCA EXISTING LAND USE PLAN

0 500 1,000 2,000 3,000 4,000 Meters

FIGURE 2-B

DATE: MARCH 2016





KEY PLAN

Legend

- ROADS
- WATERCOURSE
- LSRCA LIMIT
- SETTLEMENT AREAS
- STUDY AREAS
- SUBCATCHMENT BOUNDARY
- MUNICIPAL BOUNDARY

HYDROLOGIC SOIL GROUPS

- 🟪 FINE SANDY LOAM
- 🟨 GRAVELLY SANDY LOAM
- 🟩 GRAVELLY SANDY LOAM-STONY PHASE
- 🟦 LOAM
- ▨ LOAM-STONY PHASE
- 🟥 LOAMY SAND
- 🟧 LOAMY SAND-STONY PHASE
- 🟨 MARSH
- ⬜ MUCK
- 🟫 SANDY LOAM
- 🟩 SANDY LOAM-STONY
- 🟩 SILT LOAM
- 🟩 SILTY CLAY LOAM
- 🟧 SILTY CLAY LOAM-STEEP PHASE
- 🟫 SILTY CLAY LOAM-STONY PHASE
- 🟫 VERY FINE SANDY LOAM

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SOURCE:

SOILS OF ONTARIO MAP – SIMCOE COUNTY
(HYDROLOGIC SOIL GROUPS DATE RECEIVED: OCT. 11, 2014)

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Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

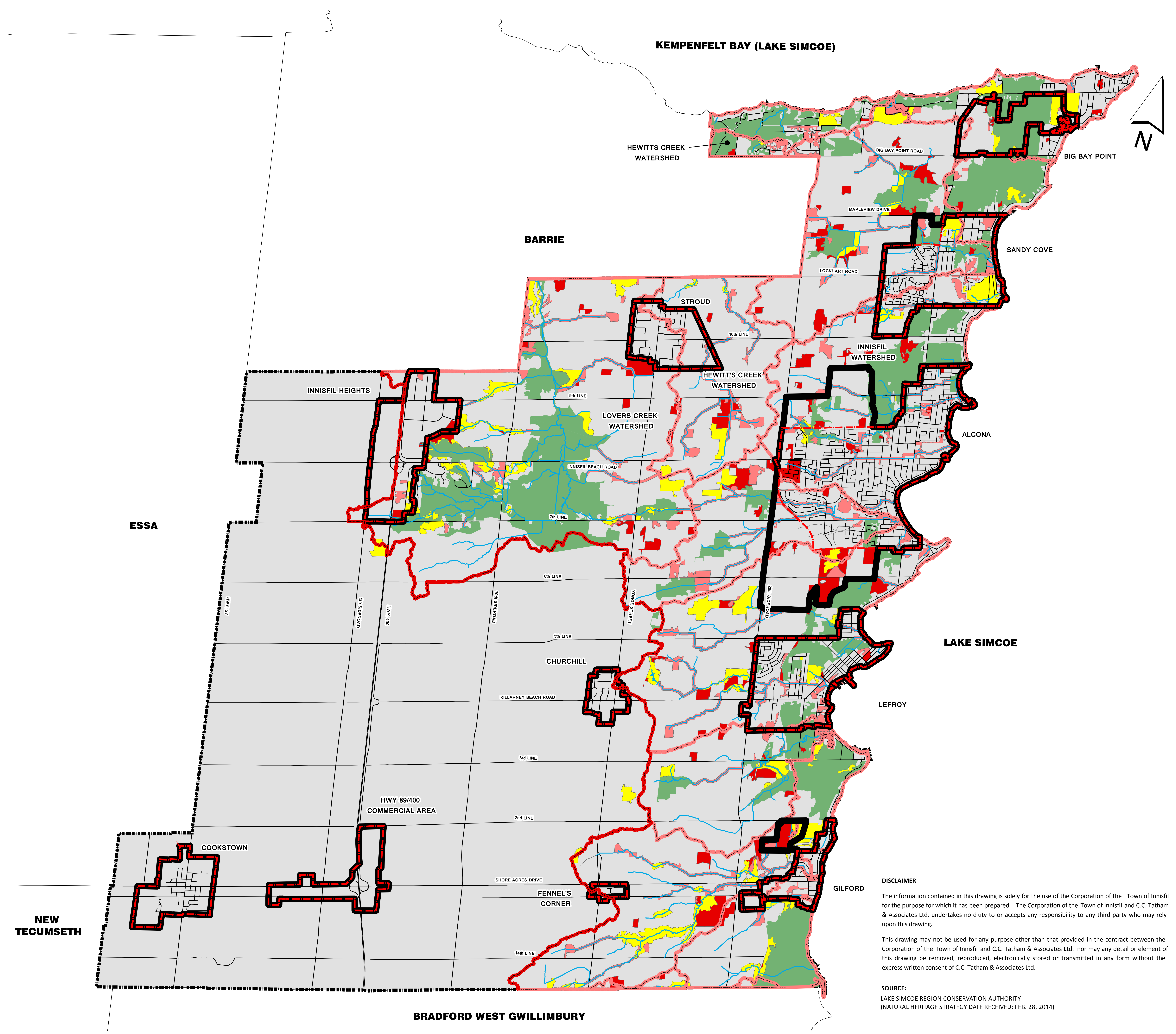
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

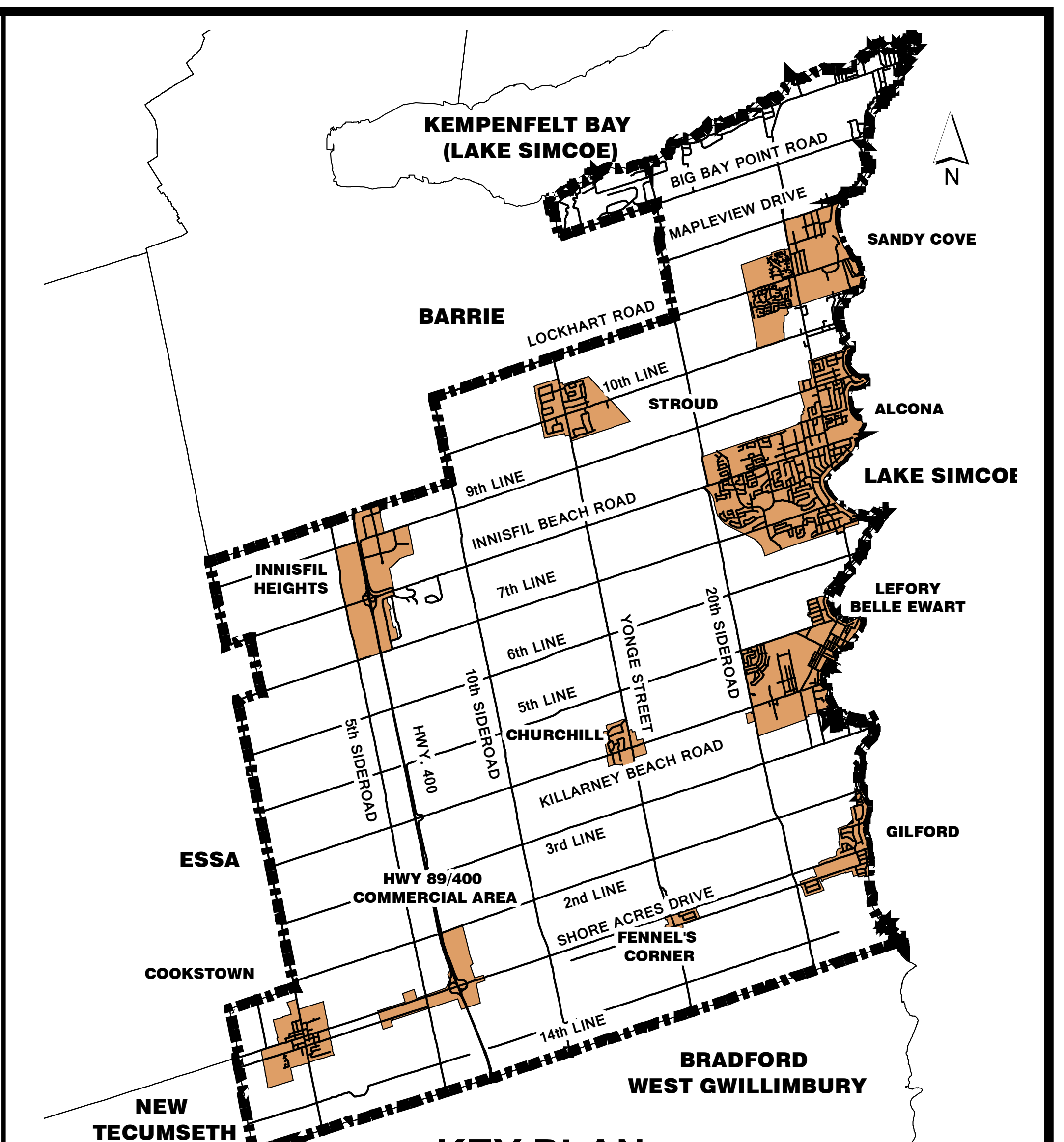
HYDROLOGIC SOIL GROUPS

0 500 1,000 2,000 3,000 4,000 Meters

FIGURE 3

DATE: MARCH 2016





KEY PLAN

Legend

—	ROADS
—	WATERCOURSE
—	LSRCA LIMIT
▭	SETTLEMENT AREAS
▭	SUBCATCHMENT BOUNDARY
▭	STUDY AREAS
▭	MUNICIPAL BOUNDARY

NHS POLICY

🟩	LEVEL 1
🟨	LEVEL 2
🟥	LEVEL 3
🟥	LEVEL 4

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SOURCE:

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(NATURAL HERITAGE STRATEGY DATE RECEIVED: FEB. 28, 2014)

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

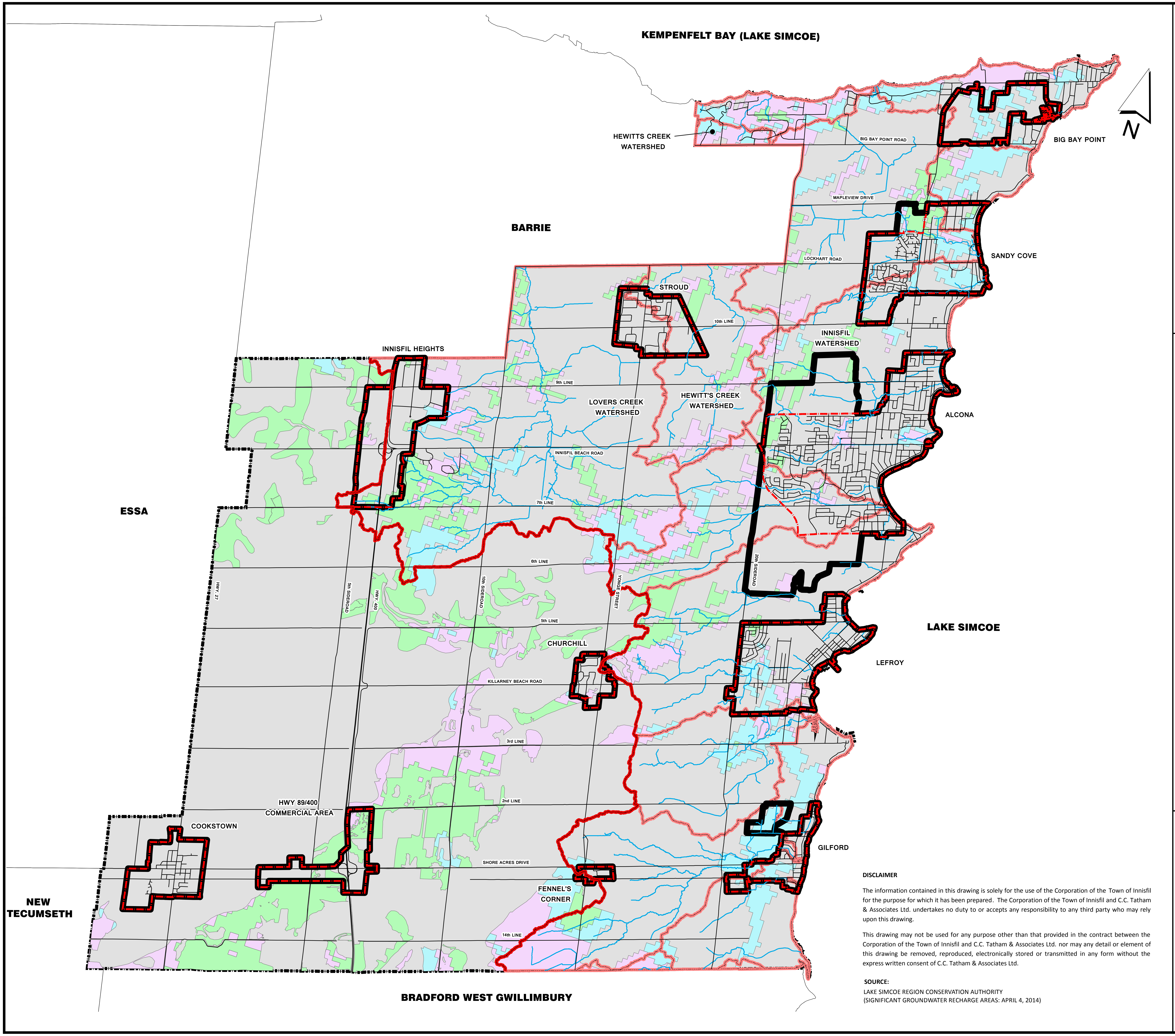
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

NATURAL HERITAGE FEATURES

0 500 1,000 2,000 3,000 4,000 Meters

FIGURE 4

DATE: JUNE 2016



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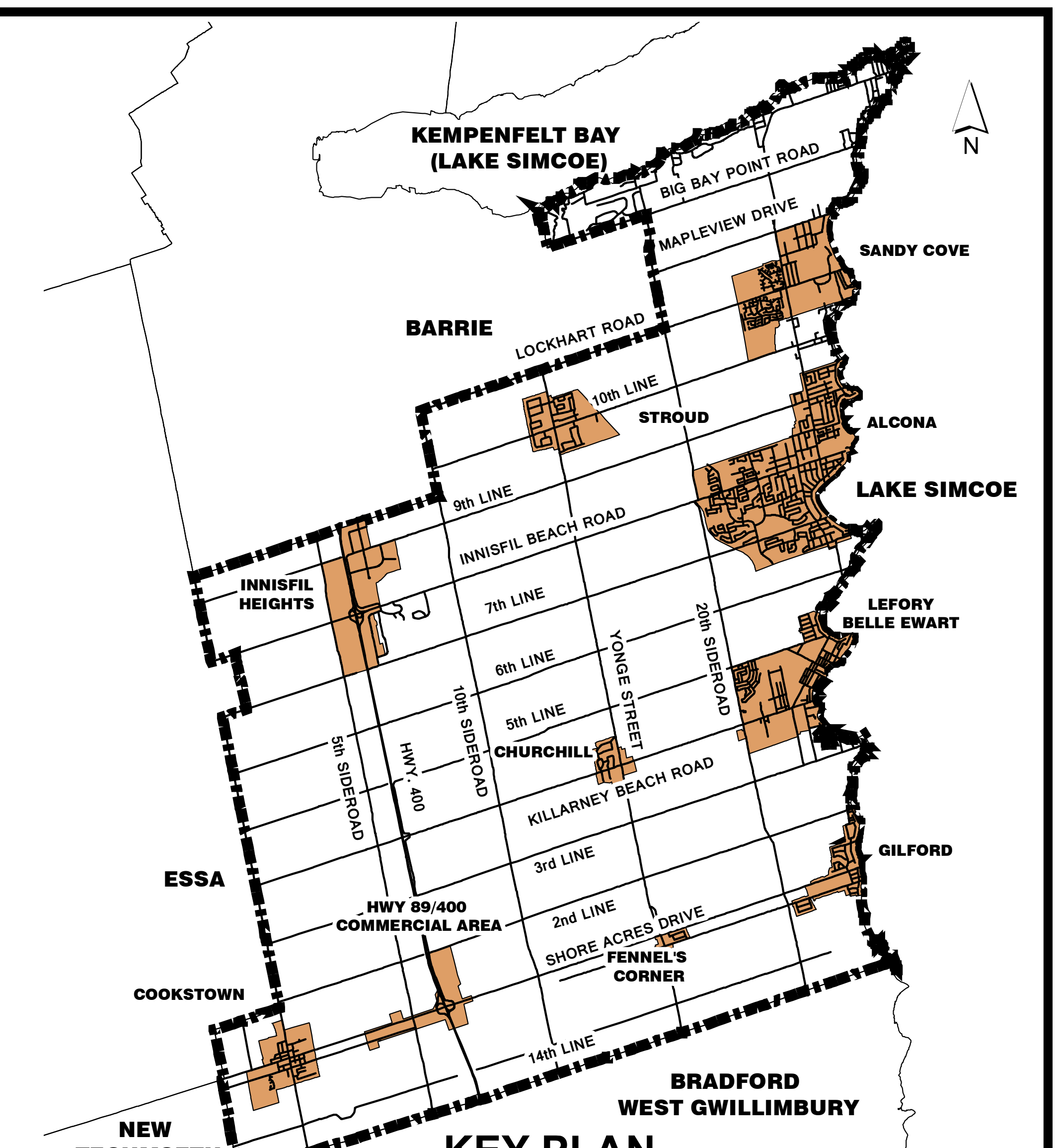
SOURCE:

LAKE SIMCOE REGION CONSERVATION AUTHORITY
(SIGNIFICANT GROUNDWATER RECHARGE AREAS: APRIL 4, 2014)



KEY PLAN

Legend

- ROADS
- WATERCOURSE
- LSRCA LIMIT
- SETTLEMENT AREAS
- SUBCATCHMENT BOUNDARY
- STUDY AREAS
- MUNICIPAL BOUNDARY

SIGNIFICANT GROUNDWATER RECHARGE AREAS

- 🟦 2 (LOW VULNERABILITY)
- 🟪 4 (MEDIUM VULNERABILITY)
- 🟩 5 (HIGH VULNERABILITY)

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

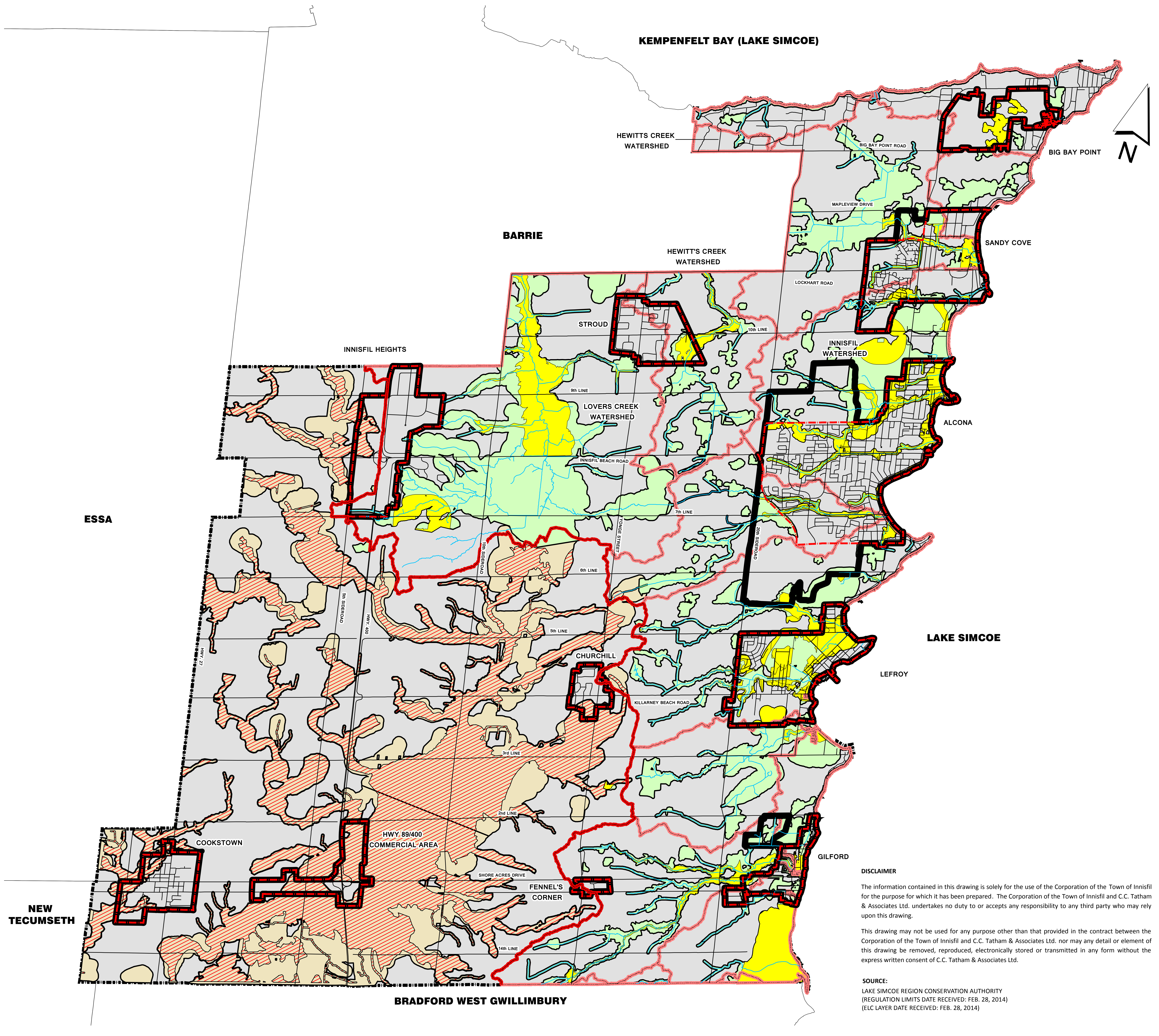
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

SIGNIFICANT GROUNDWATER RECHARGE AREAS

0 500 1,000 2,000 3,000 4,000 Meters

FIGURE 5

DATE: JUNE 2016



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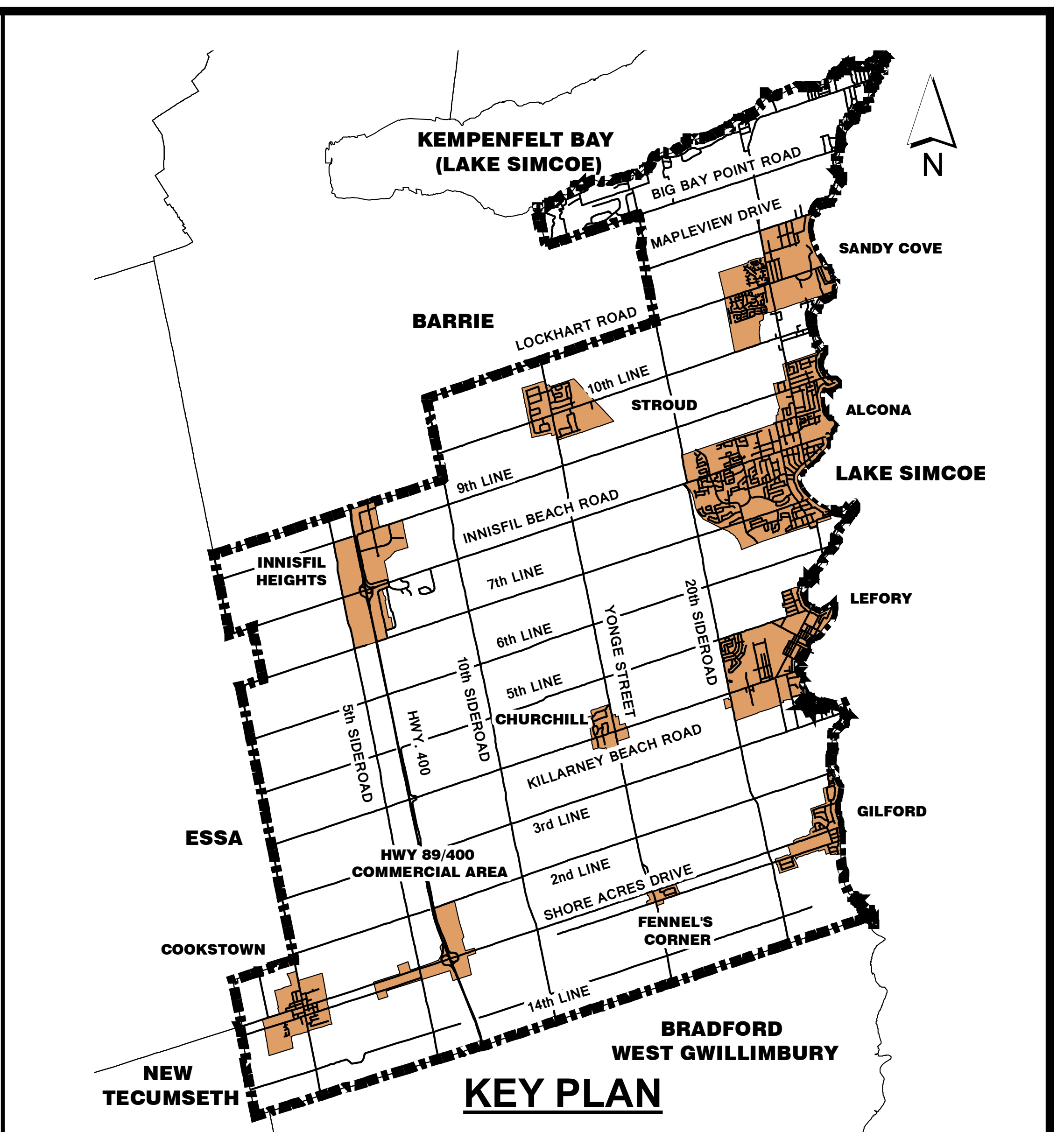
SOURCE:

LAKE SIMCOE REGION CONSERVATION AUTHORITY
(REGULATION LIMITS DATE RECEIVED: FEB. 28, 2014)
(ELC LAYER DATE RECEIVED: FEB. 28, 2014)



KEY PLAN

Legend

- 🟥 LSRCA LIMIT
- ▭ SETTLEMENT AREAS
- — ROADS
- — WATERCOURSE
- ▭ STUDY AREAS
- ▭ SUBCATCHMENT BOUNDARY
- 🟨 LSRCA HAZARD LANDS (FLOODPLAIN ONLY)
- ▨ NVCA HAZARD LANDS (INCLUDING WETLANDS, FLOODPLAINS AND EROSION PRONE AREAS)
- 🟩 LSRCA GENERIC REGULATION AREA
- 🟫 NVCA GENERIC REGULATION AREA
- ▭ MUNICIPAL BOUNDARY

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Collingwood Bracebridge Orillia Barrie

Innisfil

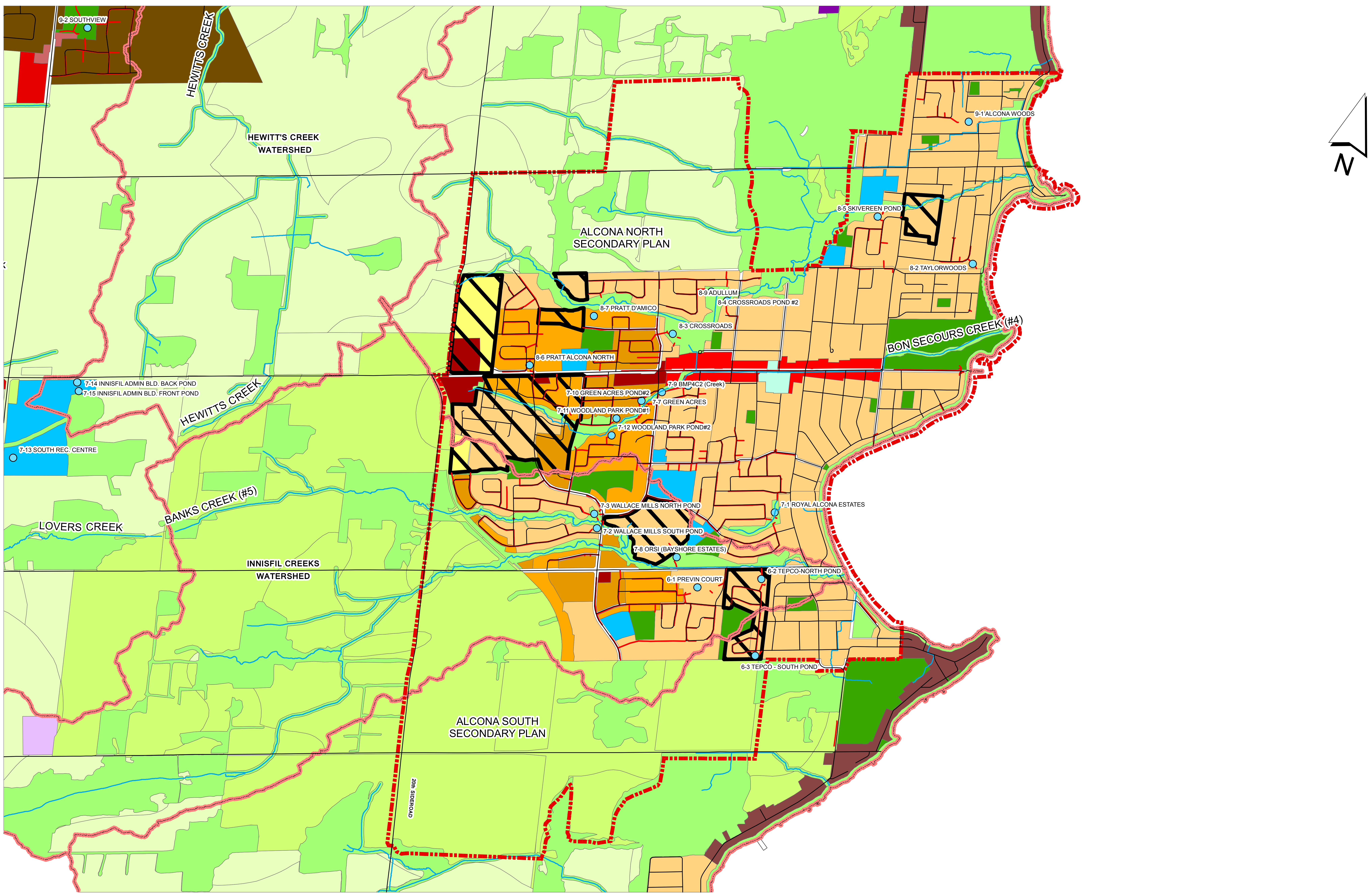
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

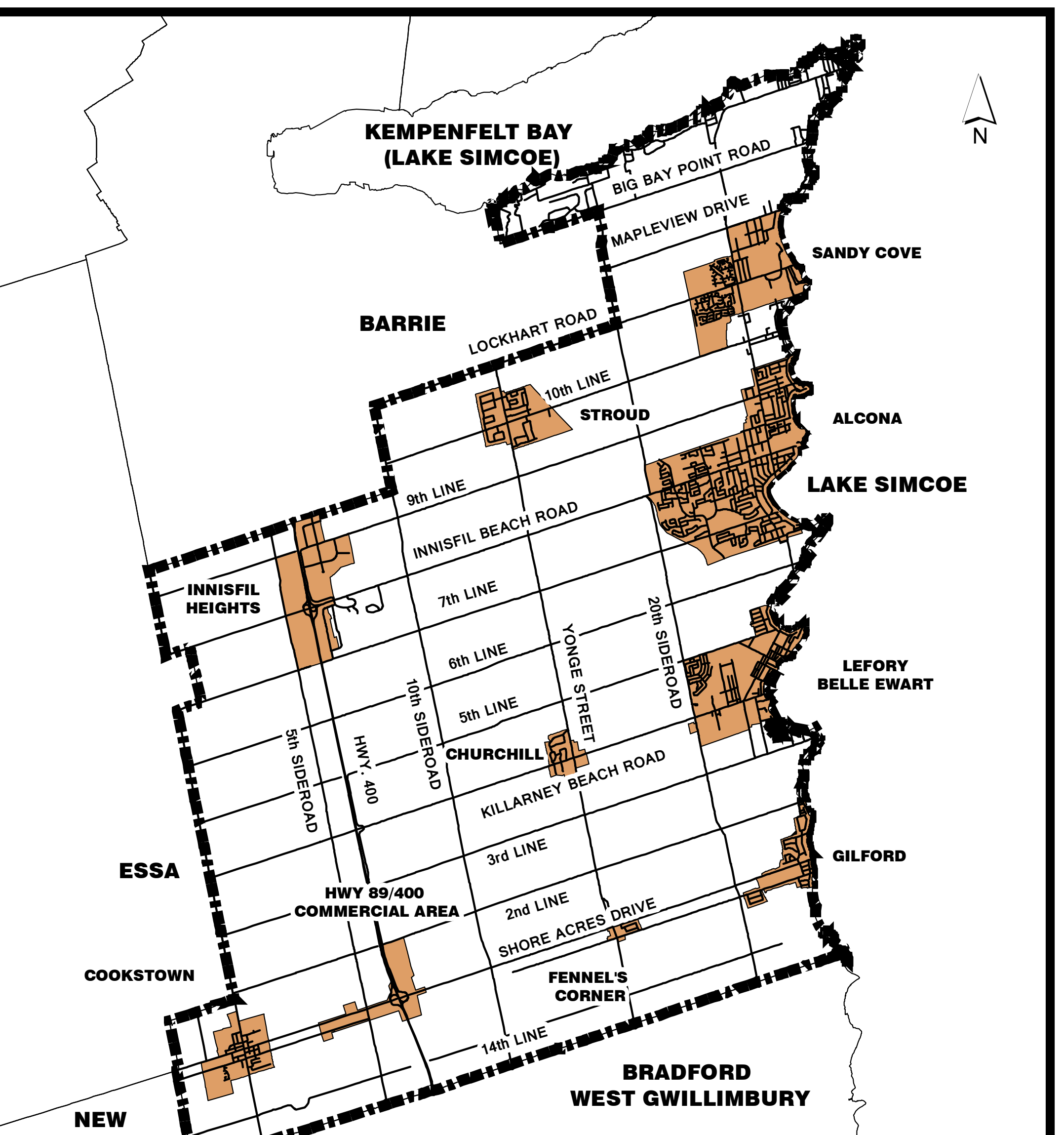
NATURAL HAZARDS PLAN

0 500 1,000 2,000 3,000 4,000 Meters

FIGURE 6

DATE: JUNE 2016





KEY PLAN

Legend

- ― ROADS
- ― STORM SEWER
- ― WATERCOURSE
- ● STORMWATER MANAGEMENT POND
- ▨ OP DESIGNATED FUTURE DEVELOPMENT AREAS
- ▭ SUBCATCHMENT BOUNDARY
- ▭ STUDY AREA

SOURCE:

TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)

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OFFICAL PLAN LAND USE

- 🟨 FUTURE URBAN
- 🟨 FUTURE RESIDENTIAL
- 🟩 AGRICULTURE AREA
- 🟩 AGRICULTURE-RURAL AREA
- 🟩 AGRICULTURE-SPECIAL RURAL AREA
- 🟥 BUSINESS PARK
- 🟥 COMMERCIAL-CONVENIENCE
- 🟥 COMMERCIAL-CORE
- 🟥 COMMERCIAL-HIGHWAY
- 🟥 COMMERCIAL-NEIGHBOURHOOD
- 🟫 COMMERCIAL-NEIGHBOURHOOD/MIXED USE
- 🟫 COMMERCIAL-SHORELINE
- 🟥 COMMERCIAL-VILLAGE
- 🟩 COMMUNITY SERVICE
- 🟪 INDUSTRIAL-EXTRACTIVE
- 🟪 INDUSTRIAL-GENERAL
- 🟦 INSTITUTIONAL
- 🟪 LANDFILL
- 🟪 LANDFILL-CLOSED
- 🟩 NATURAL ENVIRONMENTAL AREA
- 🟩 NEIGHBOURHOOD PARK
- 🟩 PARKS AND OPEN SPACE
- 🟨 RESIDENTIAL-ESTATE
- 🟧 RESIDENTIAL-LOW DENSITY 1
- 🟧 RESIDENTIAL-LOW DENSITY 2
- 🟧 RESIDENTIAL-MEDIUM DENSITY
- 🟫 RESIDENTIAL-RETIREMENT
- 🟫 RESIDENTIAL-VILLAGE
- 🟦 STORMWATER MANAGEMENT

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

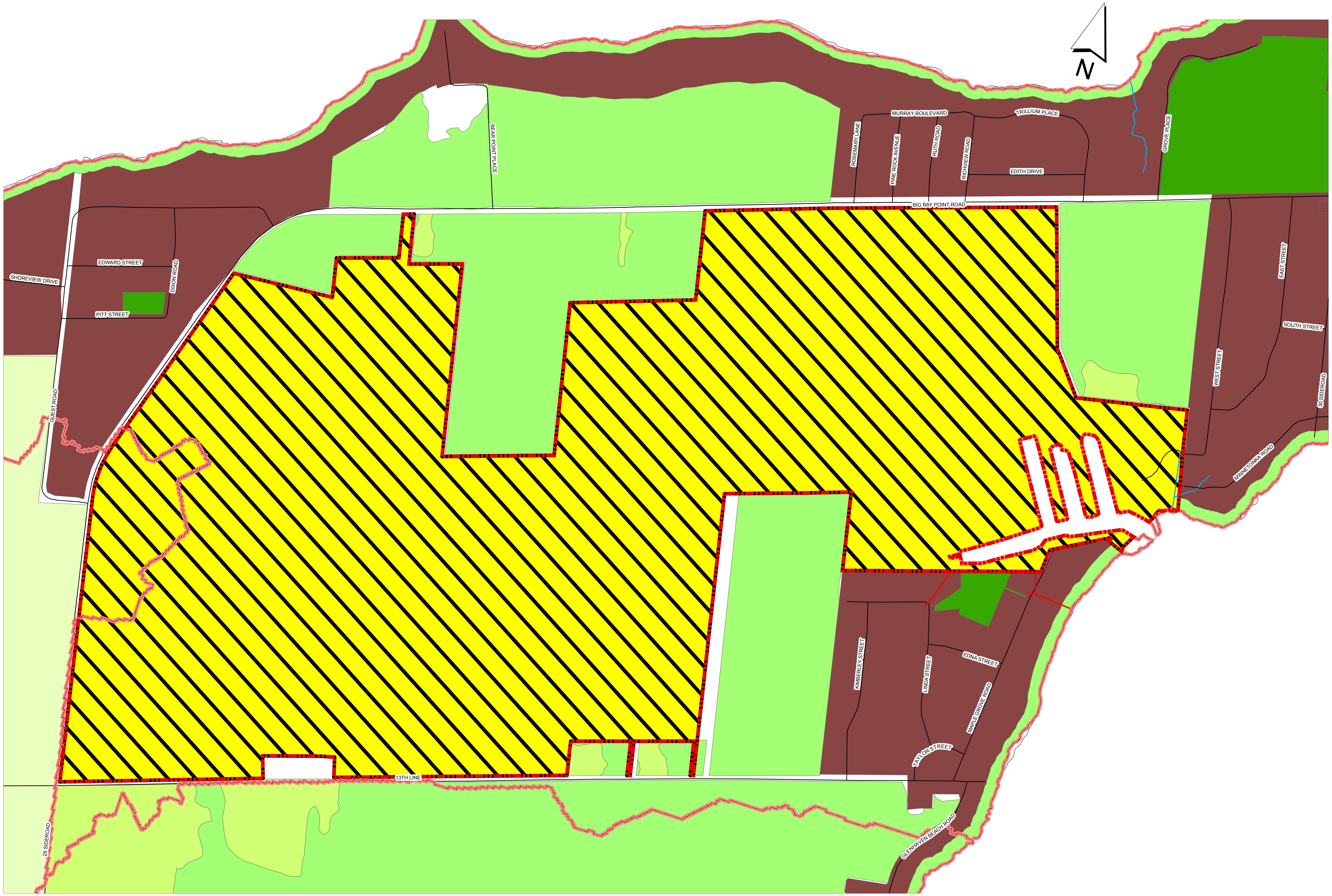
0 250 500 1,000 1,500 2,000
Meters

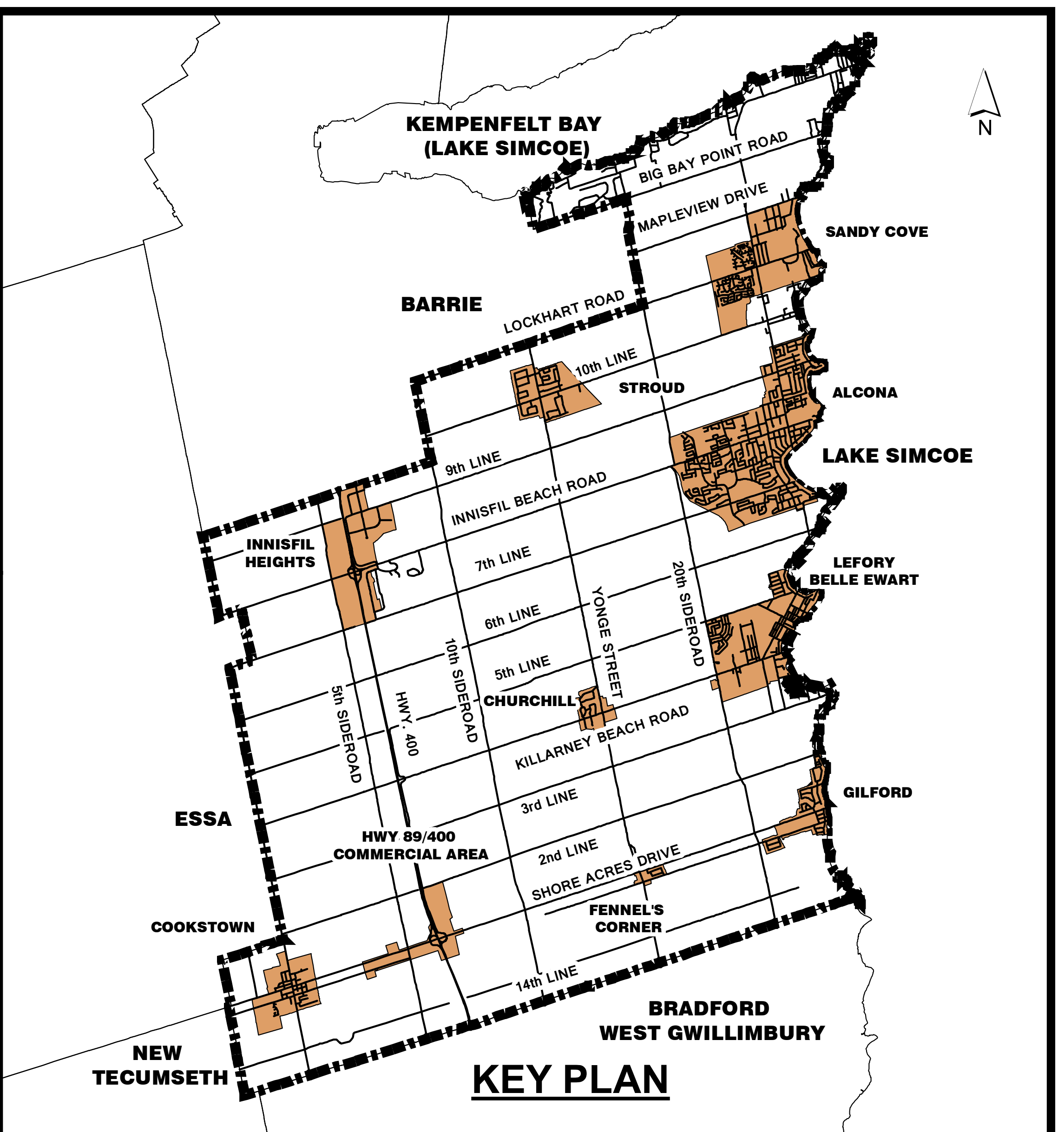
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA FIGURE ALCONA

FIGURE 7-A

DATE:MARCH 2016





KEY PLAN

Legend

- ROADS
- WATERCOURSE
- STORM SEWER
- ● STORMWATER MANAGEMENT POND
- ▨ OP DESIGNATED FUTURE DEVELOPMENT AREAS
- SUBCATCHMENT BOUNDARY
- STUDY AREA

SOURCE:

TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)

DISCLAIMER

OFFICAL PLAN LAND USE

- 🟨 FUTURE RESIDENTIAL
- ⬜ AGRICULTURE AREA
- 🟩 AGRICULTURE-RURAL AREA
- 🟩 AGRICULTURE-SPECIAL RURAL AREA
- 🟥 BUSINESS PARK
- 🟥 COMMERCIAL-CONVENIENCE
- 🟥 COMMERCIAL-CORE
- 🟥 COMMERCIAL-HIGHWAY
- 🟥 COMMERCIAL-NEIGHBOURHOOD
- 🟫 COMMERCIAL-NEIGHBOURHOOD/MIXED USE
- 🟫 COMMERCIAL-SHORELINE
- 🟥 COMMERCIAL-VILLAGE
- ⬜ COMMUNITY SERVICE
- 🟪 INDUSTRIAL-EXTRACTIVE
- 🟪 INDUSTRIAL-GENERAL
- 🟦 INSTITUTIONAL
- 🟪 LANDFILL
- 🟪 LANDFILL-CLOSED
- 🟩 NATURAL ENVIRONMENTAL AREA
- 🟩 NEIGHBOURHOOD PARK
- 🟩 PARKS AND OPEN SPACE
- 🟨 RESIDENTIAL-ESTATE
- 🟧 RESIDENTIAL-LOW DENSITY 1
- 🟧 RESIDENTIAL-LOW DENSITY 2
- 🟧 RESIDENTIAL-MEDIUM DENSITY
- 🟫 RESIDENTIAL-RETIREMENT
- 🟫 RESIDENTIAL-VILLAGE
- 🟦 STORMWATER MANAGEMENT

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Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

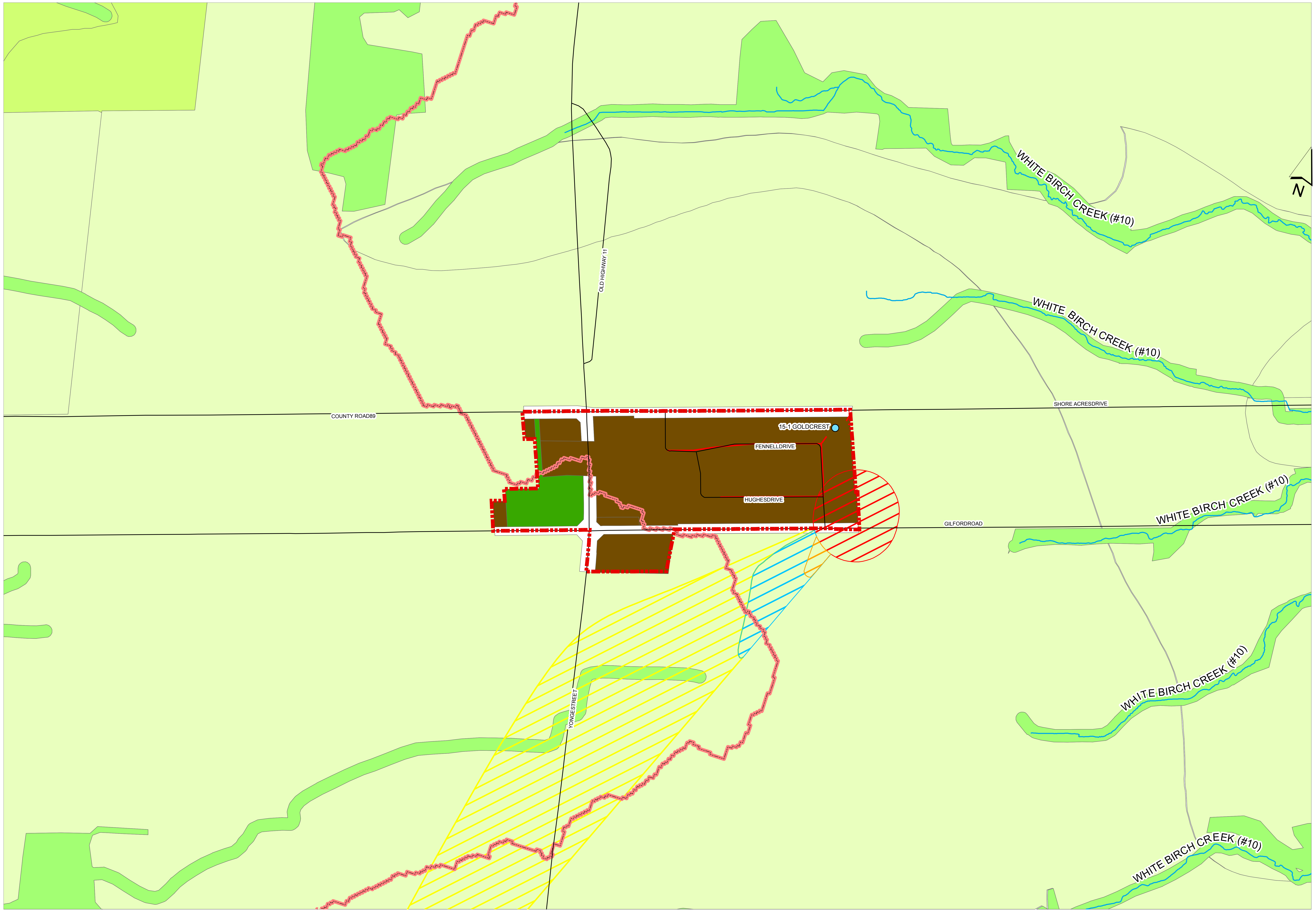
0 85 170 340 510 680
Meters

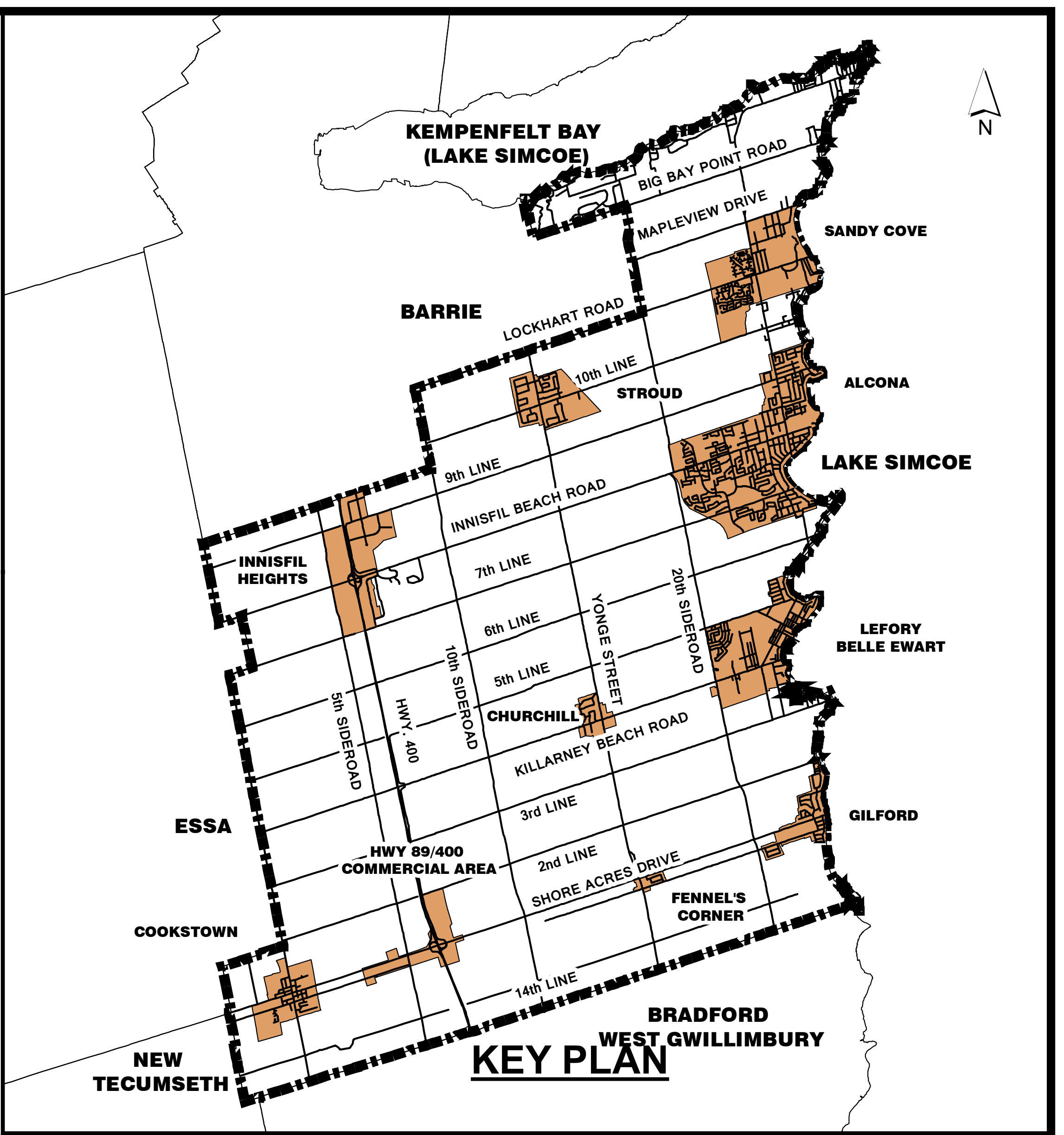
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA FIGURE BIG BAY POINT

FIGURE 7-B

DATE: MARCH 2016





KEY PLAN

Legend

- ▬ ROADS
- ▬ WATERCOURSE
- ▬ STORM SEWER
- ● STORMWATER MANAGEMENT POND
- ▭ SUBCATCHMENT BOUNDARY
- ▭ STUDY AREA

WHPA

- ▨ WHPA-A (100m RADIUS)
- ▨ WHPA-B (2yr TIME OF TRAVEL)
- ▨ WHPA-C (5yr TIME OF TRAVEL)
- ▨ WHPA-C1 (10yr TIME OF TRAVEL
- ▨ WHPA-D (25yr TIME OF TRAVEL)

SOURCE:

TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)
LAKE SIMCOE REGION CONSERVATION AUTHORITY
(WELLHEAD PROTECTION AREA DATE RECEIVED APRIL 4, 2014)

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- ■ AGRICULTURE AREA
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- ■ AGRICULTURE-SPECIAL RURAL AREA
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- ■ COMMERCIAL-CONVENIENCE
- ■ COMMERCIAL-CORE
- ■ COMMERCIAL-HIGHWAY
- ■ COMMERCIAL-NEIGHBOURHOOD
- ■ COMMERCIAL-NEIGHBOURHOOD/MIXED USE
- ■ COMMERCIAL-SHORELINE
- ■ COMMERCIAL-VILLAGE
- ■ COMMUNITY SERVICE
- ■ INDUSTRIAL-EXTRACTIVE
- ■ INDUSTRIAL-GENERAL
- ■ INSTITUTIONAL
- ■ LANDFILL
- ■ LANDFILL-CLOSED
- ■ NATURAL ENVIRONMENTAL AREA
- ■ NEIGHBOURHOOD PARK
- ■ PARKS AND OPEN SPACE
- ■ RESIDENTIAL-ESTATE
- ■ RESIDENTIAL-LOW DENSITY 1
- ■ RESIDENTIAL-LOW DENSITY 2
- ■ RESIDENTIAL-MEDIUM DENSITY
- ■ RESIDENTIAL-RETIREMENT
- ■ RESIDENTIAL-VILLAGE
- ■ STORMWATER MANAGEMENT

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

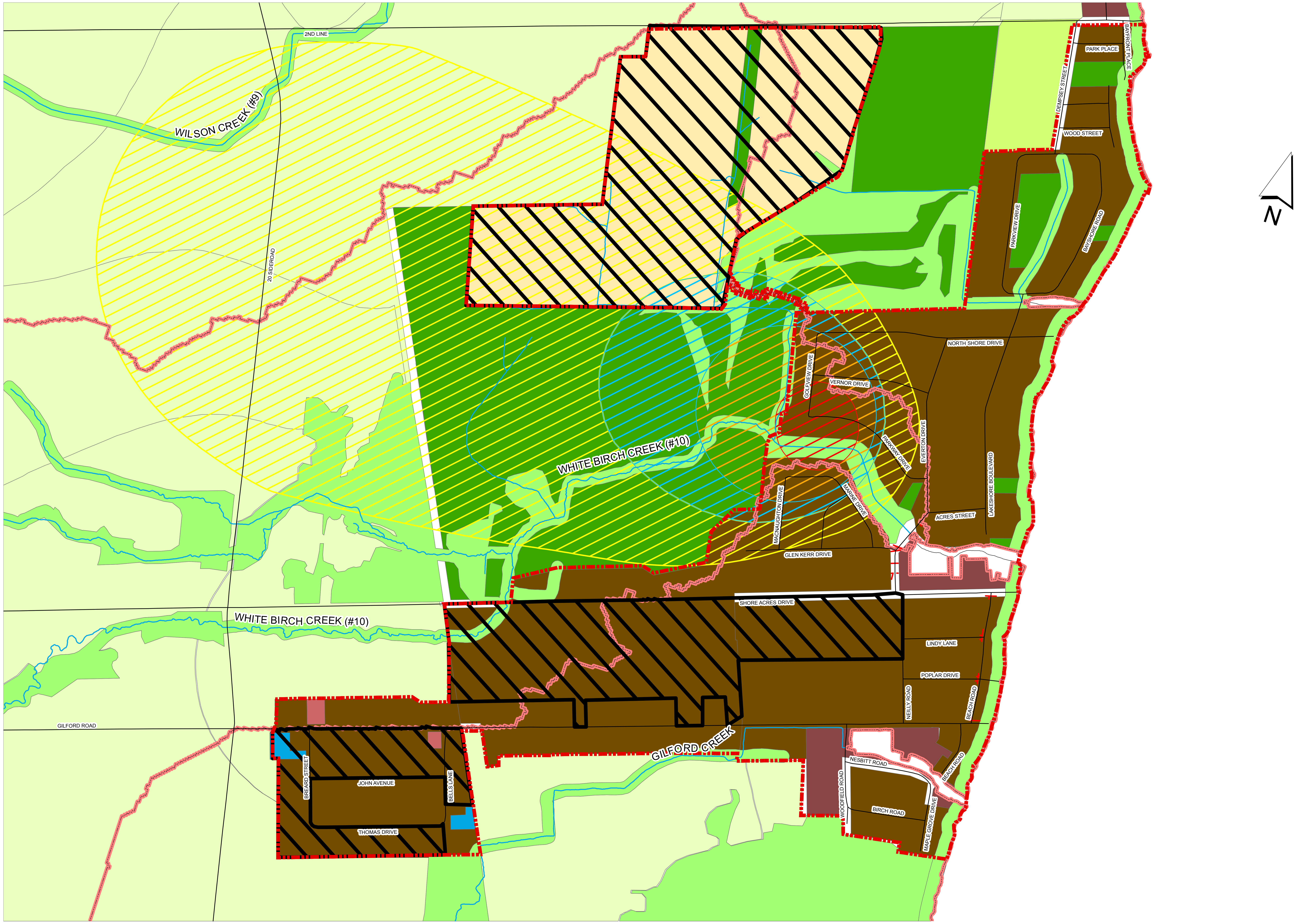
0 87.5 175 350 525 700
Meters

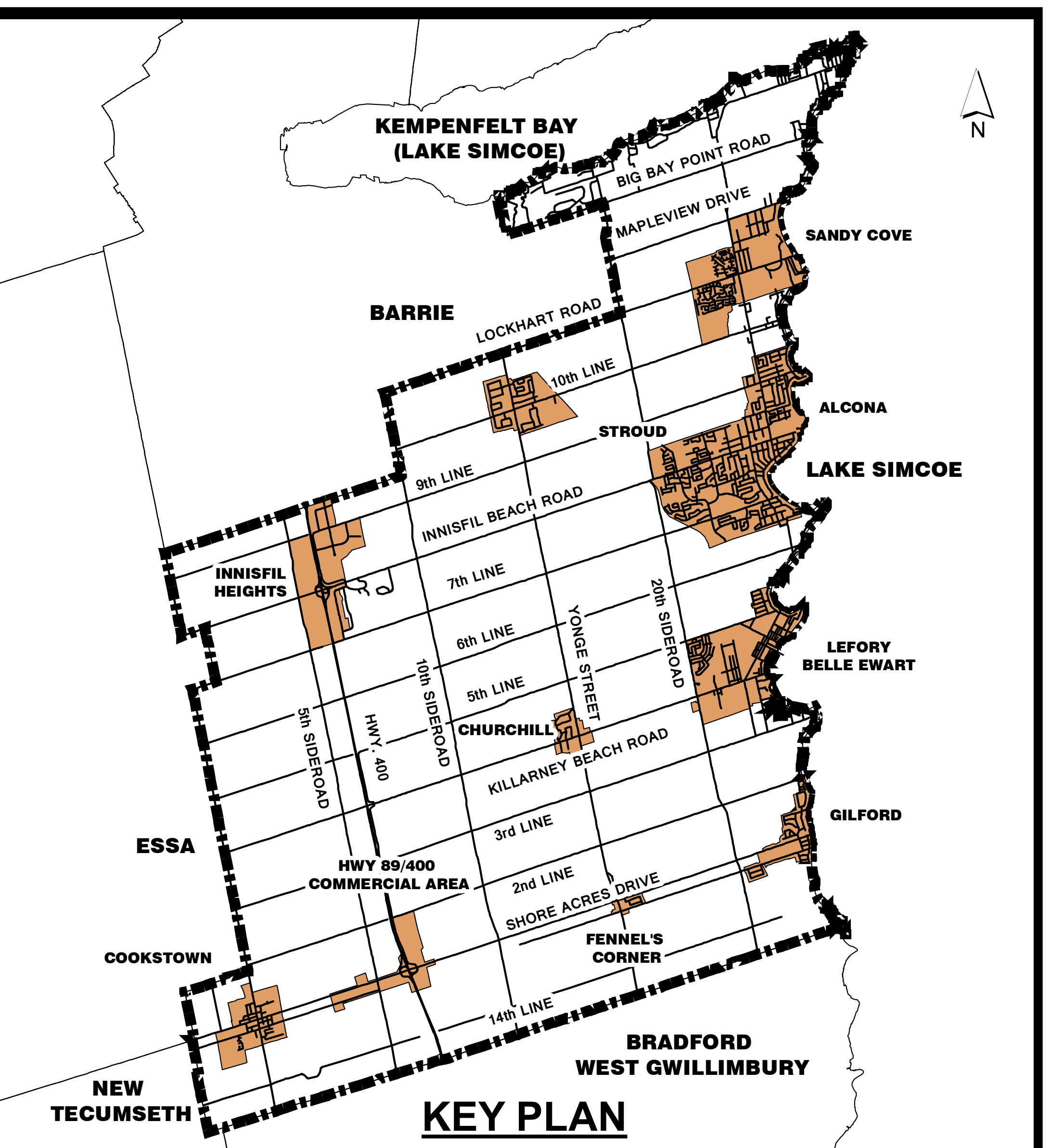
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA FIGURE FENNELL'S CORNER

FIGURE 7-C

DATE: MARCH 2016





KEY PLAN

Legend

- ROADS
- WATERCOURSE
- STORM SEWER
- ● STORMWATER MANAGEMENT POND
- OP DESIGNATED FUTURE DEVELOPMENT AREAS
- SUBCATCHMENT BOUNDARY
- STUDY AREA

WHPA

- ▨ WHPA-A (100m RADIUS)
- ▨ WHPA-B (2yr TIME OF TRAVEL)
- ▨ WHPA-C (5yr TIME OF TRAVEL)
- ▨ WHPA-C1 (10yr TIME OF TRAVEL
- ▨ WHPA-D (25yr TIME OF TRAVEL)

SOURCE:

TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)
LAKE SIMCOE REGION CONSERVATION AUTHORITY
(WELLHEAD PROTECTION AREA DATE RECEIVED APRIL 4, 2014)

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- ■ FUTURE URBAN
- ■ FUTURE RESIDENTIAL
- ■ AGRICULTURE AREA
- ■ AGRICULTURE-RURAL AREA
- ■ AGRICULTURE-SPECIAL RURAL AREA
- ■ BUSINESS PARK
- ■ COMMERCIAL-CONVENIENCE
- ■ COMMERCIAL-CORE
- ■ COMMERCIAL-HIGHWAY
- ■ COMMERCIAL-NEIGHBOURHOOD
- ■ COMMERCIAL-NEIGHBOURHOOD/MIXED USE
- ■ COMMERCIAL-SHORELINE
- ■ COMMERCIAL-VILLAGE
- ■ COMMUNITY SERVICE
- ■ INDUSTRIAL-EXTRACTIVE
- ■ INDUSTRIAL-GENERAL
- ■ INSTITUTIONAL
- ■ LANDFILL
- ■ LANDFILL-CLOSED
- ■ NATURAL ENVIRONMENTAL AREA
- ■ NEIGHBOURHOOD PARK
- ■ PARKS AND OPEN SPACE
- ■ RESIDENTIAL-ESTATE
- ■ RESIDENTIAL-LOW DENSITY 1
- ■ RESIDENTIAL-LOW DENSITY 2
- ■ RESIDENTIAL-MEDIUM DENSITY
- ■ RESIDENTIAL-RETIREMENT
- ■ RESIDENTIAL-VILLAGE
- ■ STORMWATER MANAGEMENT

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

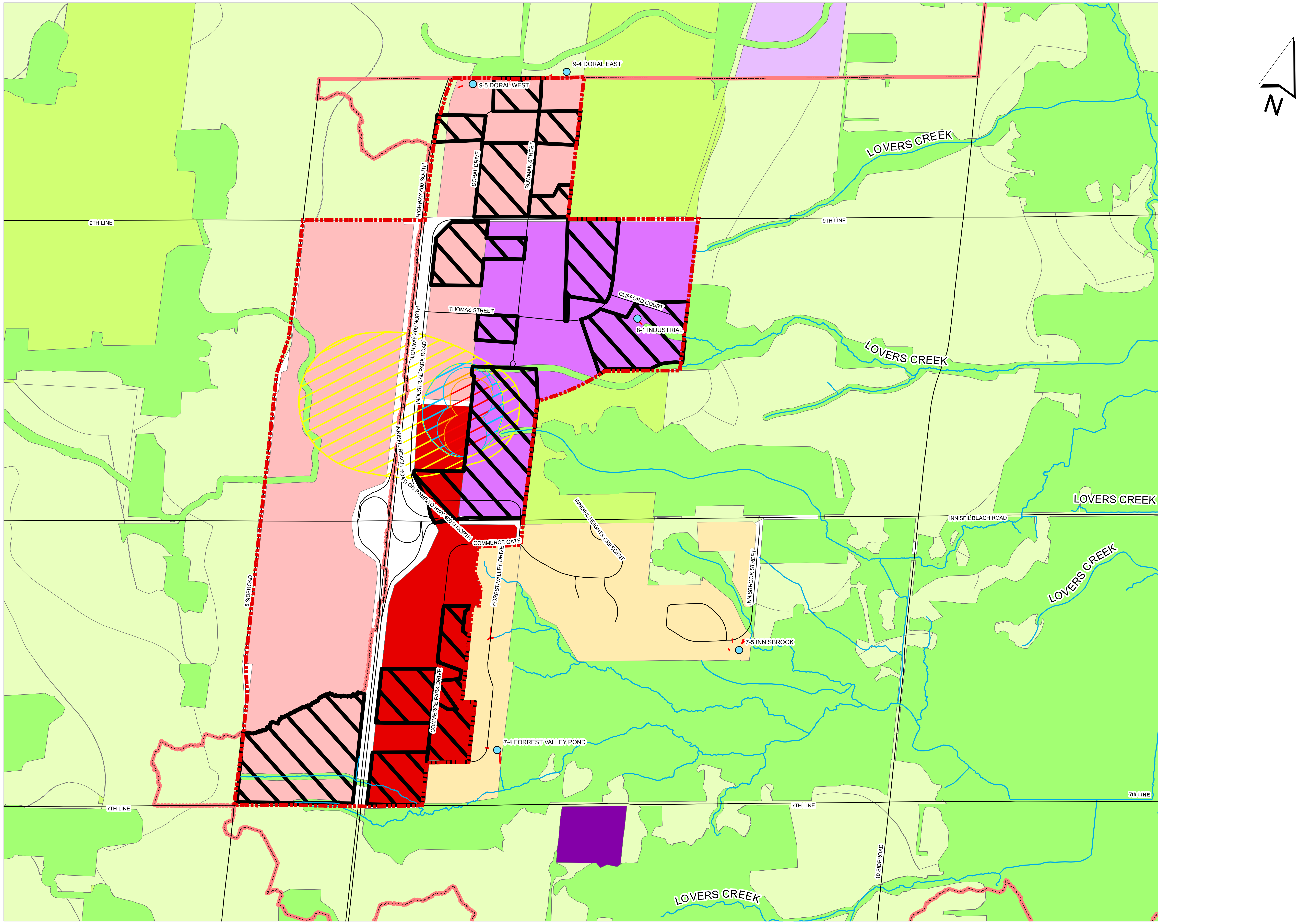
0 85 170 340 510 680 Meters

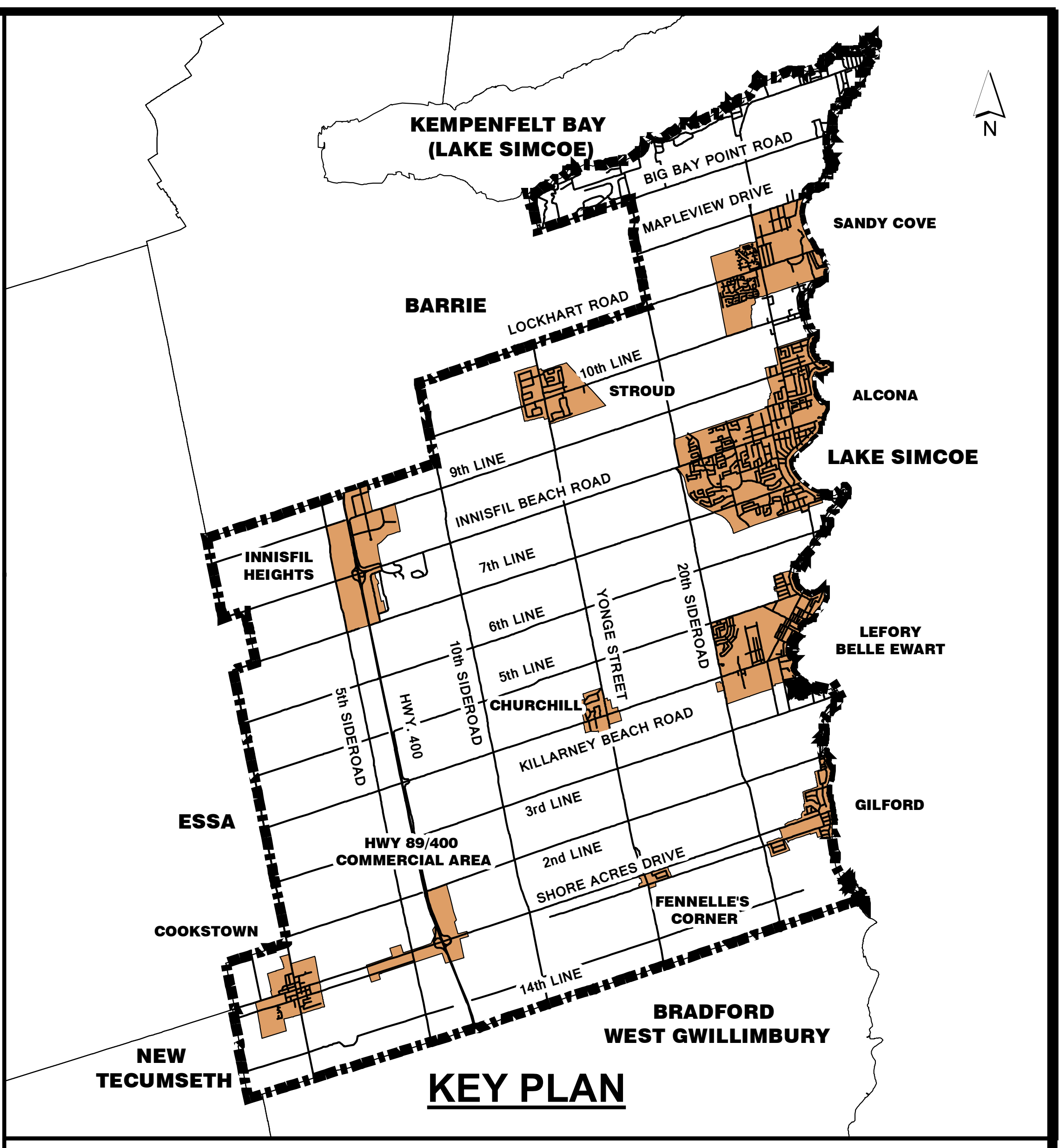
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA FIGURE GILFORD

FIGURE 7-D

DATE: MARCH 2016





KEY PLAN

Legend

— ROADS

— WATERCOURSE

— STORM SEWER

● STORMWATER MANAGEMENT POND

▨ OP DESIGNATED FUTURE DEVELOPMENT AREAS

▭ SUBCATCHMENT BOUNDARY

▭ STUDY AREA

WHPA

▨ WHPA-A (100m RADIUS)

▨ WHPA-B (2yr TIME OF TRAVEL)

▨ WHPA-C (5yr TIME OF TRAVEL)

▨ WHPA-C1 (10yr TIME OF TRAVEL

▨ WHPA-D (25yr TIME OF TRAVEL)

SOURCE:

TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)
LAKE SIMCOE REGION CONSERVATION AUTHORITY
(WELLHEAD PROTECTION AREA DATE RECEIVED APRIL 4, 2014)

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🟩 AGRICULTURE-RURAL AREA
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🟦 INSTITUTIONAL
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🟪 LANDFILL-CLOSED
🟩 NATURAL ENVIRONMENTAL AREA
🟩 NEIGHBOURHOOD PARK
🟩 PARKS AND OPEN SPACE
🟨 RESIDENTIAL-ESTATE
🟧 RESIDENTIAL-LOW DENSITY 1
🟧 RESIDENTIAL-LOW DENSITY 2
🟧 RESIDENTIAL-MEDIUM DENSITY
🟫 RESIDENTIAL-RETIREMENT
🟫 RESIDENTIAL-VILLAGE
🟦 STORMWATER MANAGEMENT

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

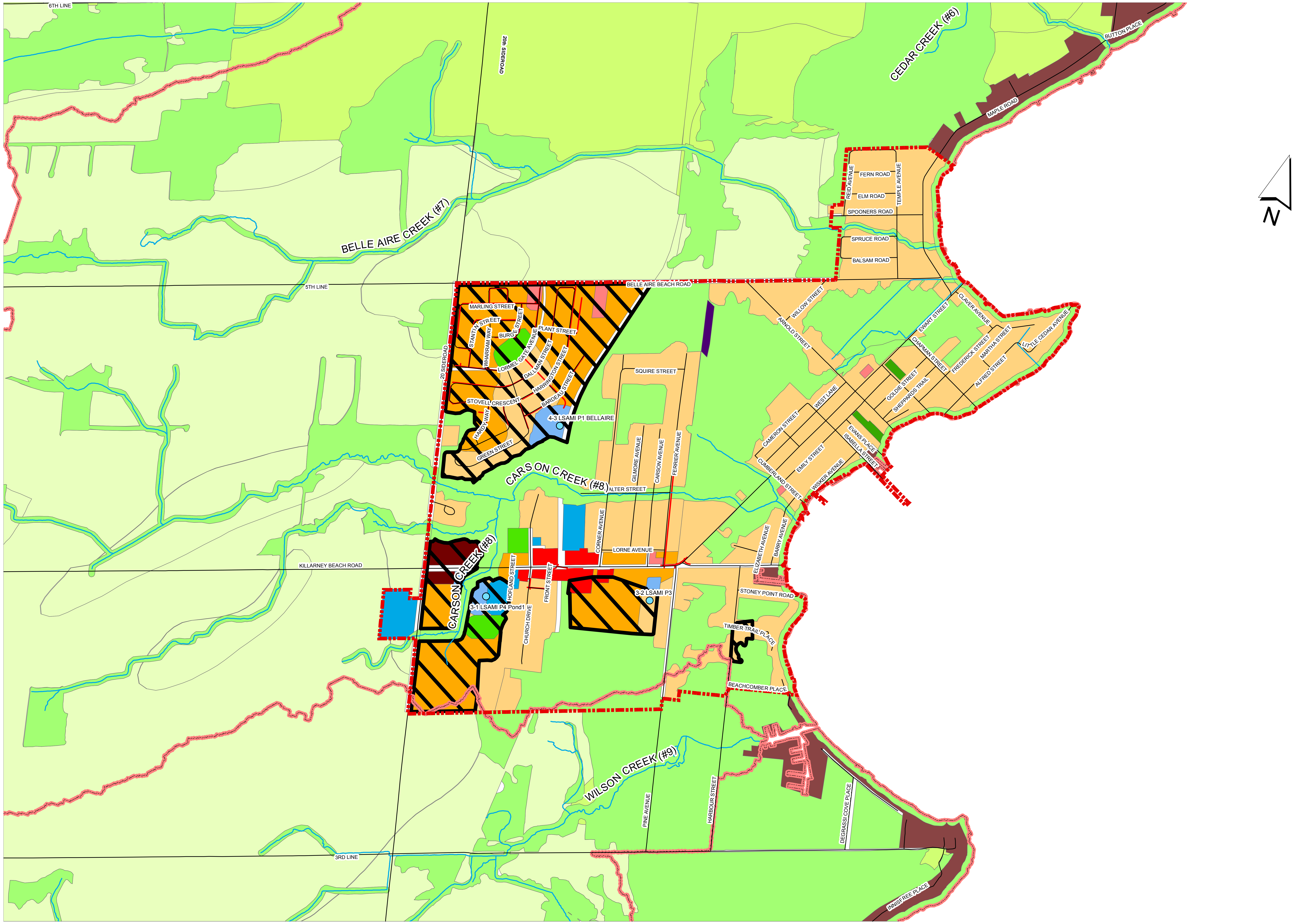
0 187.5 375 750 1,125 1,500 Meters

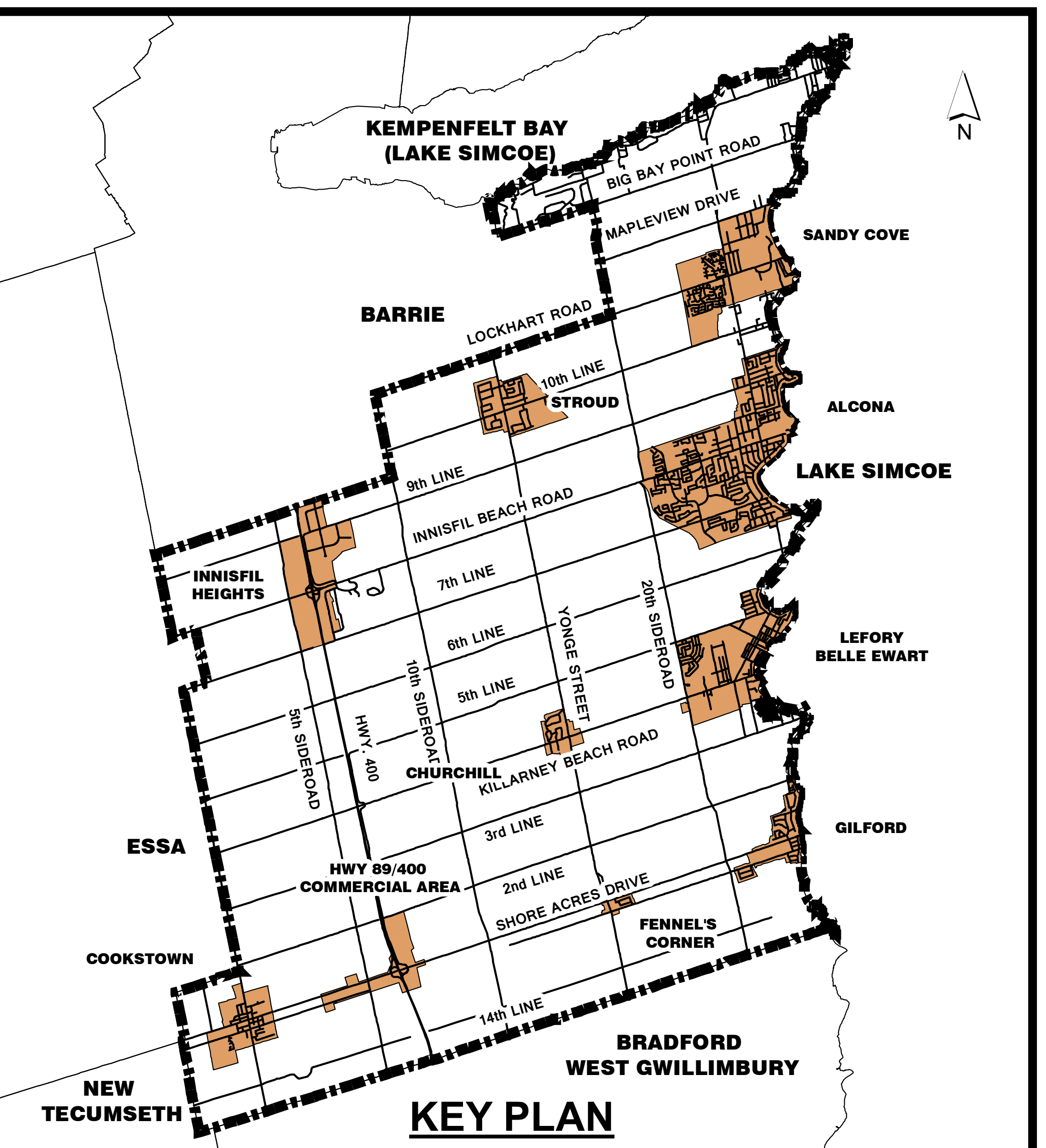
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA FIGURE INNISFIL HEIGHTS

FIGURE 7-E

DATE: MARCH 2016





KEY PLAN

Legend

- ― ROADS
- ― WATERCOURSE
- ― STORM SEWER
- ● STORMWATER MANAGEMENT POND
- ▭ SUBCATCHMENT BOUNDARY
- ▨ OP DESIGNATED FUTURE DEVELOPMENT AREAS
- ▭ STUDY AREA

SOURCE:
TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)

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- 🟥 COMMERCIAL-CONVENIENCE
- 🟥 COMMERCIAL-CORE
- 🟥 COMMERCIAL-HIGHWAY
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- 🟫 COMMERCIAL-NEIGHBOURHOOD/MIXED USE
- 🟫 COMMERCIAL-SHORELINE
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- 🟪 LANDFILL-CLOSED
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- 🟩 PARKS AND OPEN SPACE
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- 🟧 RESIDENTIAL-LOW DENSITY 2
- 🟧 RESIDENTIAL-MEDIUM DENSITY
- 🟫 RESIDENTIAL-RETIREMENT
- 🟫 RESIDENTIAL-VILLAGE
- 🟦 STORMWATER MANAGEMENT

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

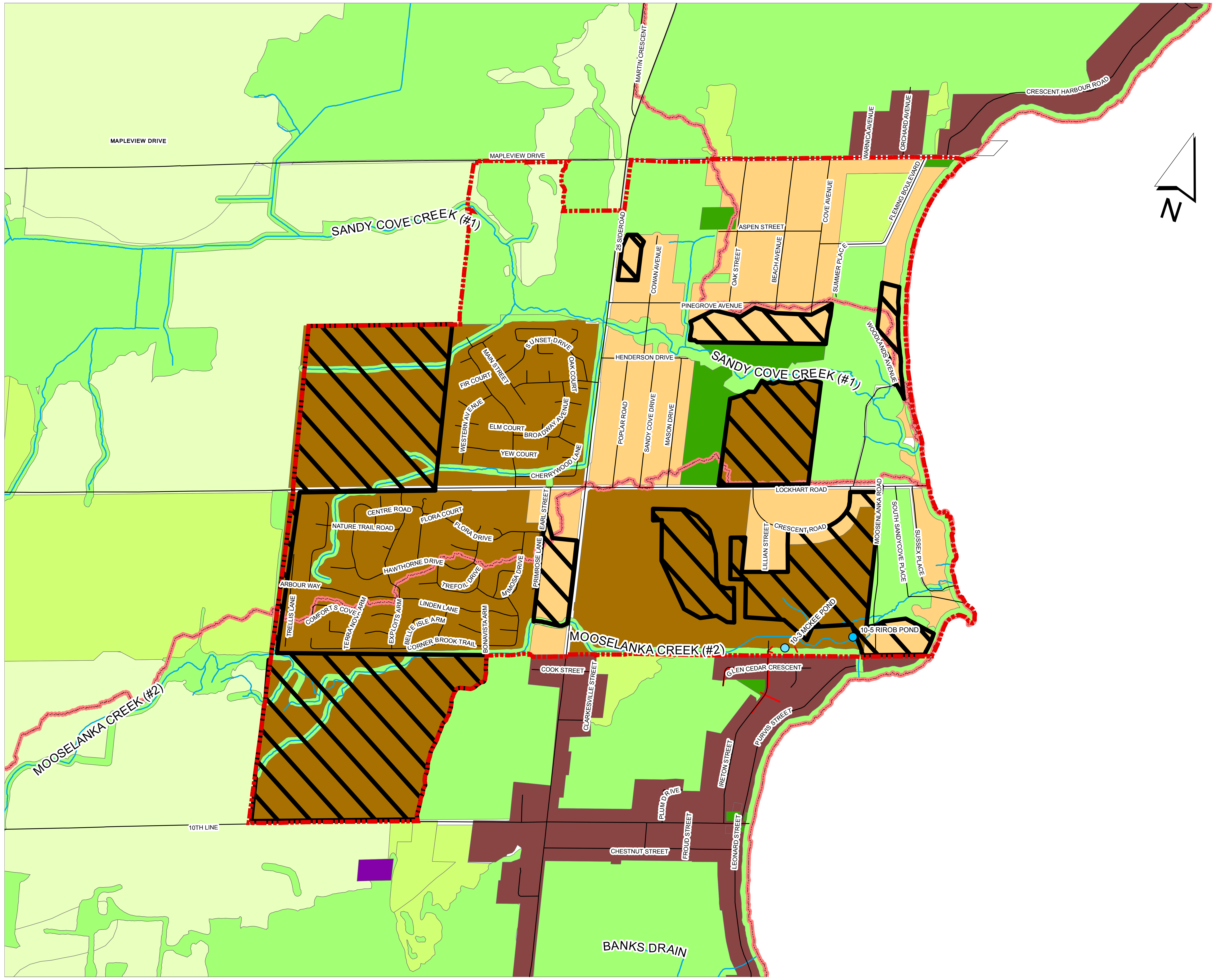
0 185 370 740 1,110 1,480
Meters

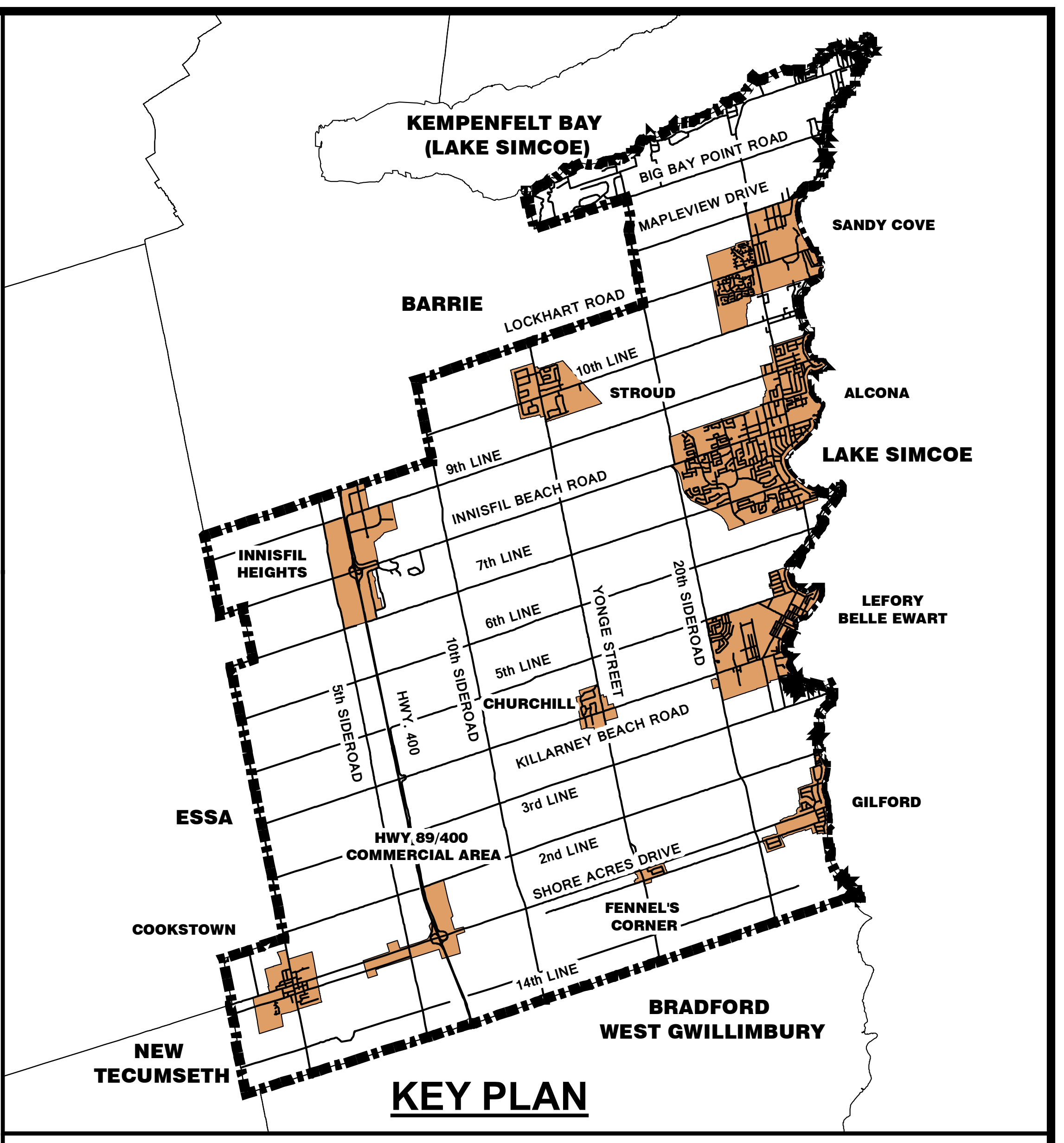
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA FIGURE LEFROY

FIGURE 7-F

DATE: MARCH 2016





KEY PLAN

Legend

— ROADS
— WATERCOURSE
— STORM SEWER
● STORMWATER MANAGEMENT POND
▨ OP DESIGNATED FUTURE DEVELOPMENT AREAS
☐ SUBCATCHMENT BOUNDARY
☐ STUDY AREA

SOURCE:
TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)

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- 🟥 COMMERCIAL-CORE
- 🟥 COMMERCIAL-HIGHWAY
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- 🟫 COMMERCIAL-NEIGHBOURHOOD/MIXED USE
- 🟫 COMMERCIAL-SHORELINE
- 🟥 COMMERCIAL-VILLAGE
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- 🟫 RESIDENTIAL-VILLAGE
- 🟦 STORMWATER MANAGEMENT

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

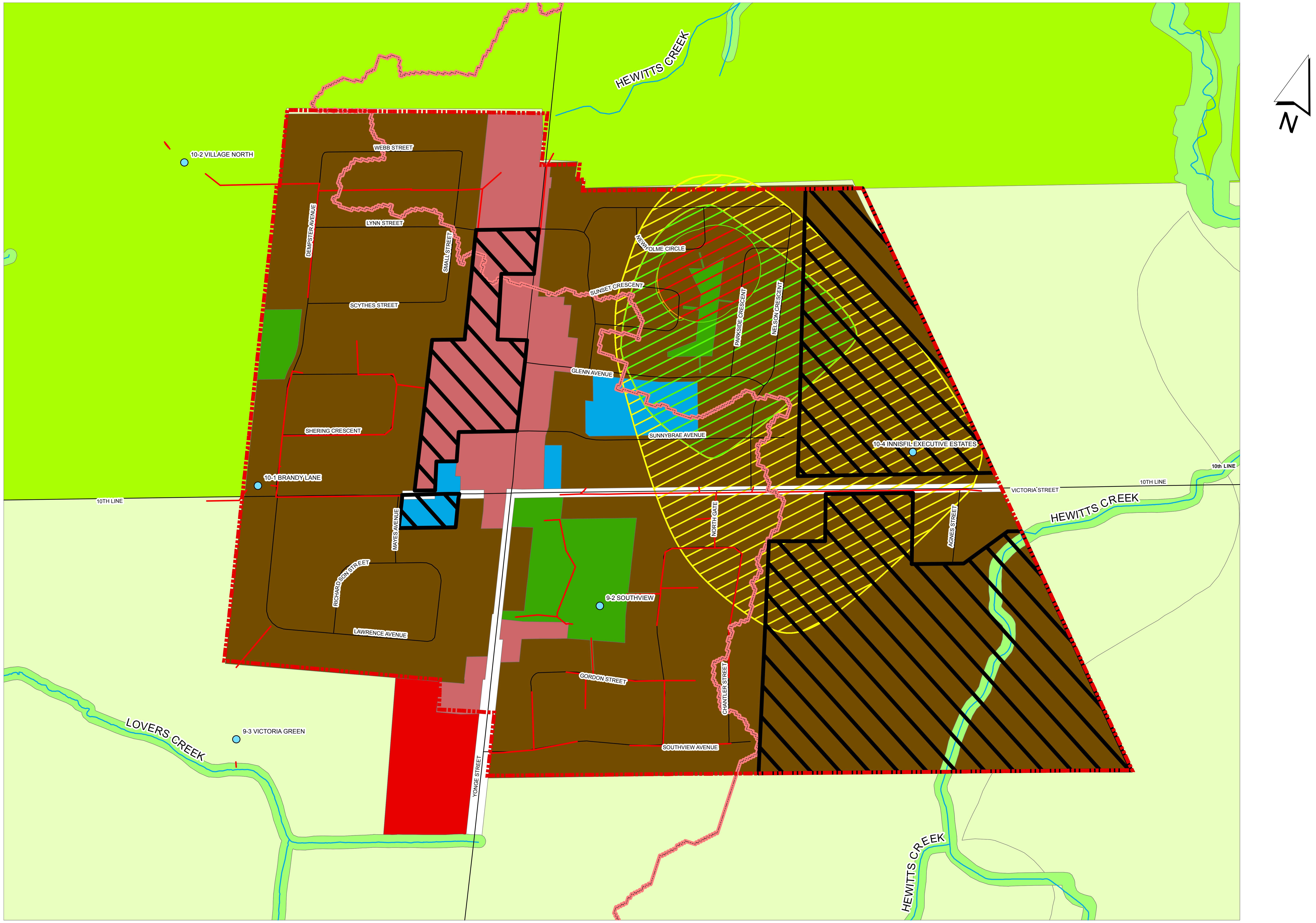
0 185 370 740 1,110 1,480 Meters

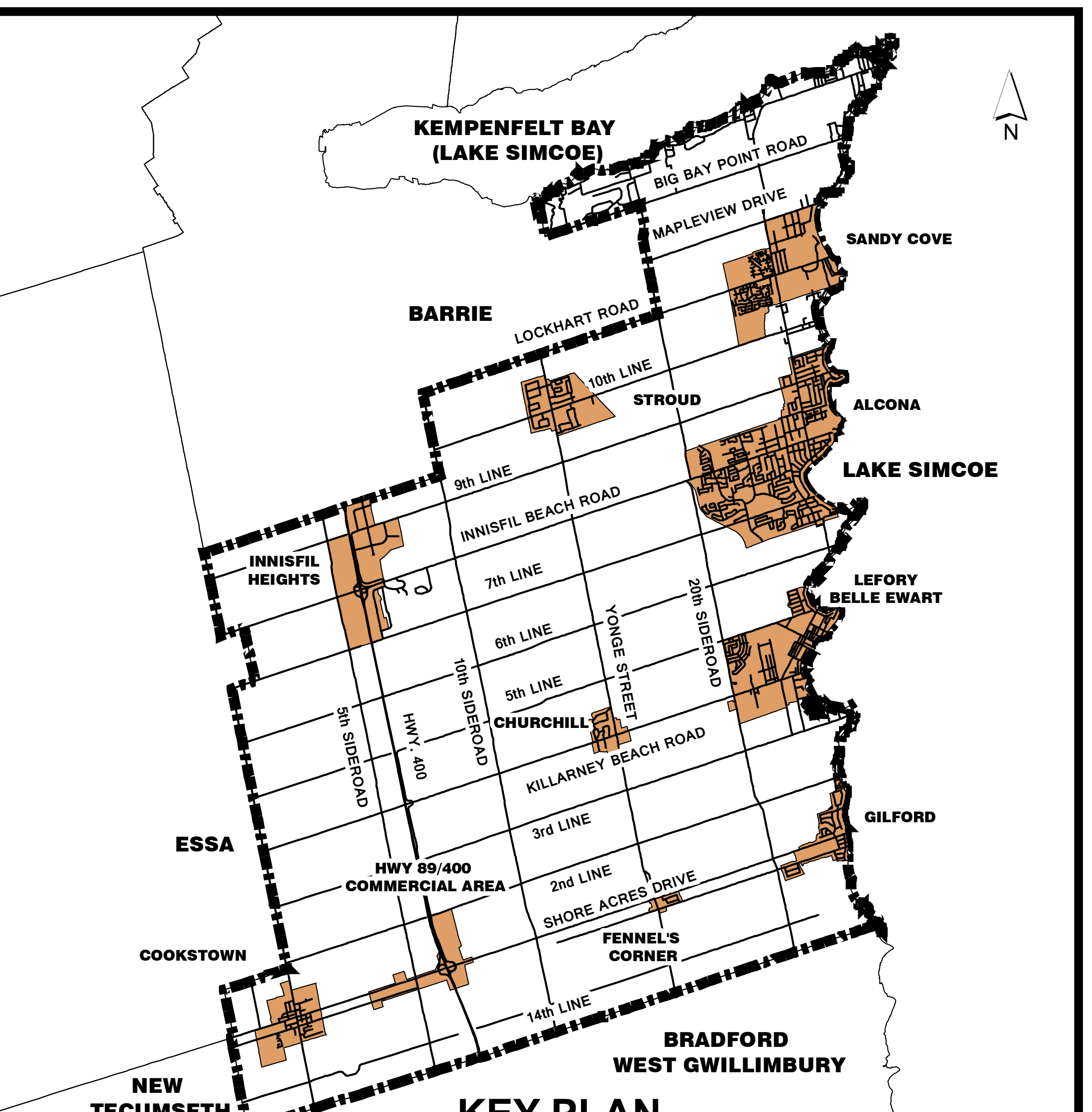
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA FIGURE SANDY COVE

FIGURE 7-G

DATE: MARCH 2016





KEY PLAN

Legend

— ROADS

— WATERCOURSE

— STORM SEWER

● STORMWATER MANAGEMENT POND

▨ OP DESIGNATED FUTURE DEVELOPMENT AREAS

▭ SUBCATCHMENT BOUNDARY

▭ STUDY AREA

WHPA

▨ WHPA-A (100m RADIUS)

▨ WHPA-B (2yr TIME OF TRAVEL)

▨ WHPA-C (5yr TIME OF TRAVEL)

▨ WHPA-C1 (10yr TIME OF TRAVEL

▨ WHPA-D (25yr TIME OF TRAVEL)

SOURCE:

TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)
LAKE SIMCOE REGION CONSERVATION AUTHORITY
(WELLHEAD PROTECTION AREA DATE RECEIVED APRIL 4, 2014)

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OFFICAL PLAN LAND USE

🟨 FUTURE URBAN
🟨 FUTURE RESIDENTIAL
🟩 AGRICULTURE AREA
🟩 AGRICULTURE-RURAL AREA
🟩 AGRICULTURE-SPECIAL RURAL AREA
🟥 BUSINESS PARK
🟥 COMMERCIAL-CONVENIENCE
🟥 COMMERCIAL-CORE
🟥 COMMERCIAL-HIGHWAY
🟥 COMMERCIAL-NEIGHBOURHOOD
🟫 COMMERCIAL-NEIGHBOURHOOD/MIXED USE
🟫 COMMERCIAL-SHORELINE
🟥 COMMERCIAL-VILLAGE
🟦 COMMUNITY SERVICE
🟪 INDUSTRIAL-EXTRACTIVE
🟪 INDUSTRIAL-GENERAL
🟦 INSTITUTIONAL
🟪 LANDFILL
🟪 LANDFILL-CLOSED
🟩 NATURAL ENVIRONMENTAL AREA
🟩 NEIGHBOURHOOD PARK
🟩 PARKS AND OPEN SPACE
🟨 RESIDENTIAL-ESTATE
🟧 RESIDENTIAL-LOW DENSITY 1
🟧 RESIDENTIAL-LOW DENSITY 2
🟧 RESIDENTIAL-MEDIUM DENSITY
🟫 RESIDENTIAL-RETIREMENT
🟫 RESIDENTIAL-VILLAGE
🟦 STORMWATER MANAGEMENT

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

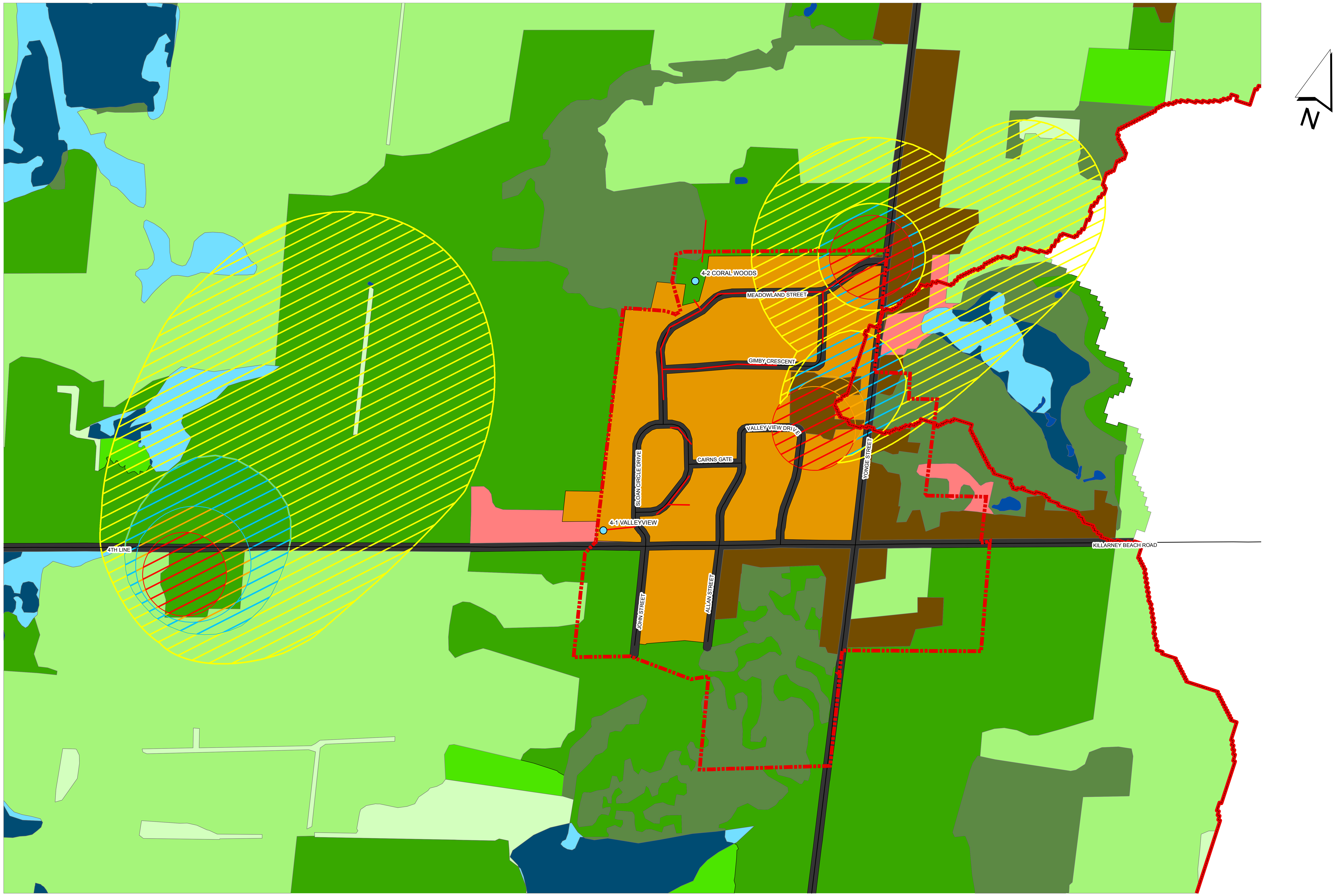
0 90 180 360 540 720 Meters

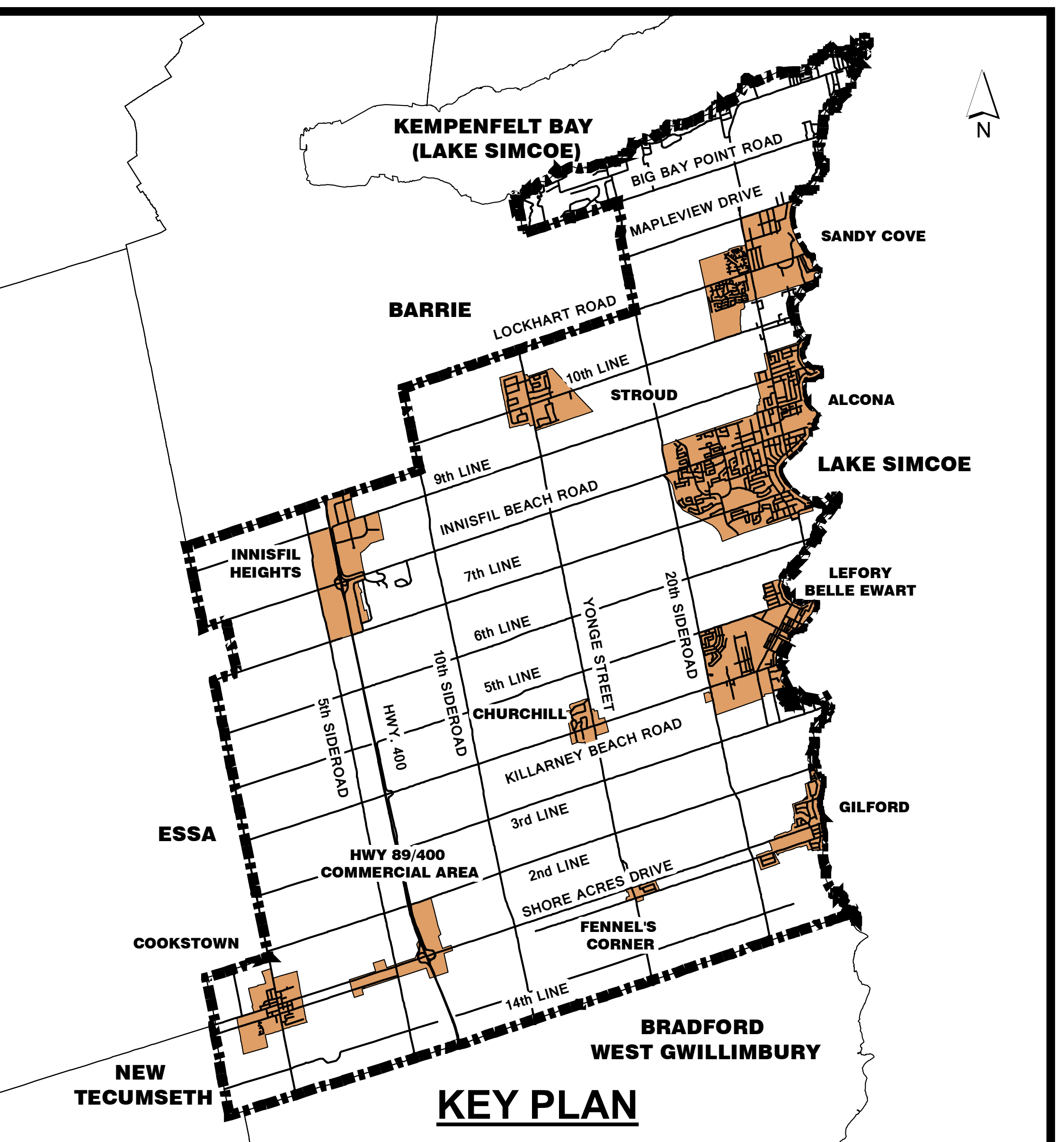
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA FIGURE STROUD

FIGURE 7-H

DATE: MARCH 2016





KEY PLAN

Legend

- — ROADS
- — STORM SEWER
- ● STORMWATER MANAGEMENT POND
- ☐ LSRCA LIMIT
- ☐ SUBCATCHMENT BOUNDARY
- ☐ STUDY AREA

WHPA

- ▨ WHPA-A (100m RADIUS)
- ▨ WHPA-B (2yr TIME OF TRAVEL)
- ▨ WHPA-C (5yr TIME OF TRAVEL)
- ▨ WHPA-C1 (10yr TIME OF TRAVEL
- ▨ WHPA-D (25yr TIME OF TRAVEL)

SOURCE:

NOTTAWASAGA VALLEY CONSERVATION AUTHORITY REGULATION MAPPING
(NVCA EXISTING LANDUSE DATE: JANUARY, 2014)
LAKE SIMCOE REGION CONSERVATION AUTHORITY
(WELLHEAD PROTECTION AREA DATE RECEIVED APRIL 4, 2014)

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NVCA EXISTING LANDUSE

🟩 CONIFEROUS FOREST	🟦 OPEN WETLAND	🟧 URBAN IMPERVIOUS
🟩 DECIDUOUS FOREST	🟪 QUARRY	🟫 URBAN PERVIOUS
🟩 GOLF COURSE	⬛ ROAD	🟦 WATER
🟩 HAY/PASTURE	🟩 ROW CROP	🟦 WOODY WETLAND
🟩 MIXED FOREST	🟥 TRANSITIONAL	

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

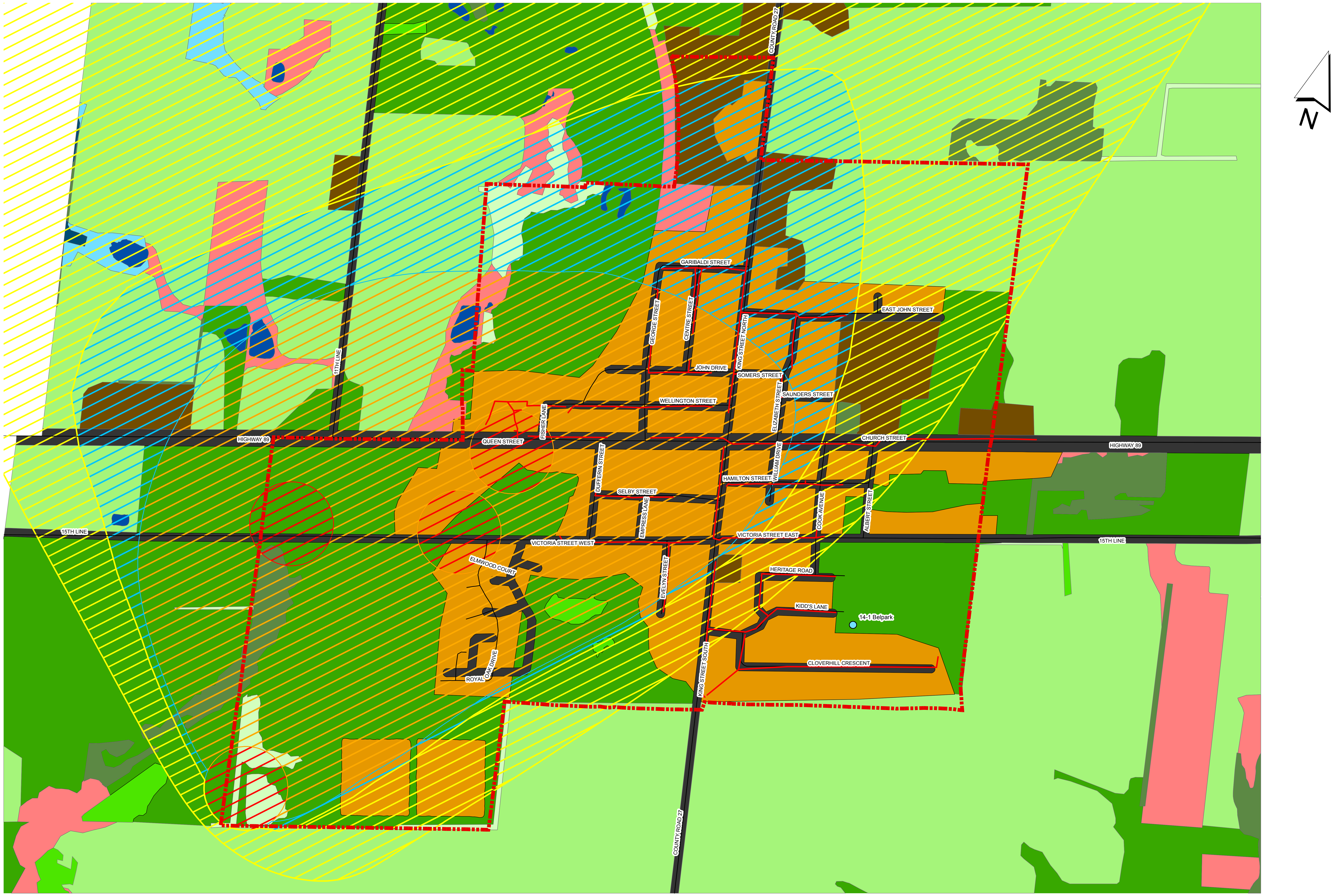
0 90 180 360 540 720
Meters

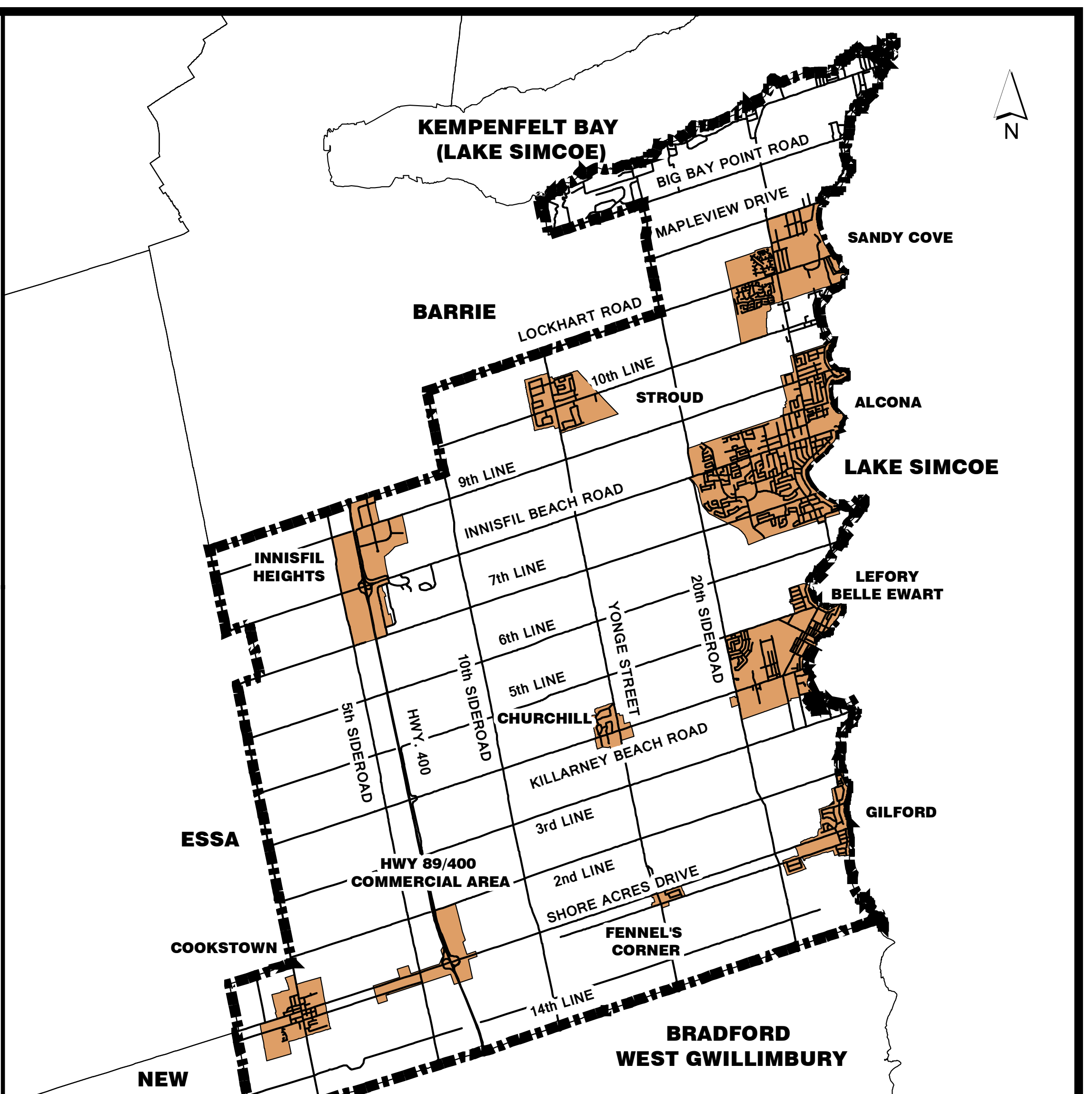
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA FIGURE CHURCHILL

FIGURE 7-I

DATE: MARCH 2016





KEY PLAN

Legend

—	ROADS
—	STORM SEWER
●	STORMWATER MANAGEMENT POND
▭	SUBCATCHMENT BOUNDARY
▭	SETTLEMENT AREA

WHPA

▨	WHPA-A (100m RADIUS)
▨	WHPA-B (2yr TIME OF TRAVEL)
▨	WHPA-C (5yr TIME OF TRAVEL)
▨	WHPA-C1 (10yr TIME OF TRAVEL
▨	WHPA-D (25yr TIME OF TRAVEL)

SOURCE:
NOTTAWASAGA VALLEY CONSERVATION AUTHORITY REGULATION MAPPING
(NVCA EXISTING LANDUSE DATE: JANUARY, 2014)
LAKE SIMCOE REGION CONSERVATION AUTHORITY
(WELLHEAD PROTECTION AREA DATE RECEIVED APRIL 4, 2014)

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NVCA EXISTING LANDUSE

🟩	CONIFEROUS FOREST	🟦	OPEN WETLAND	🟧	URBAN IMPERVIOUS
🟩	DECIDUOUS FOREST	🟪	QUARRY	🟫	URBAN PERVIOUS
🟩	GOLF COURSE	⬛	ROAD	🟦	WATER
🟩	HAY/PASTURE	🟩	ROW CROP	🟦	WOODY WETLAND
🟩	MIXED FOREST	🟥	TRANSITIONAL		

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

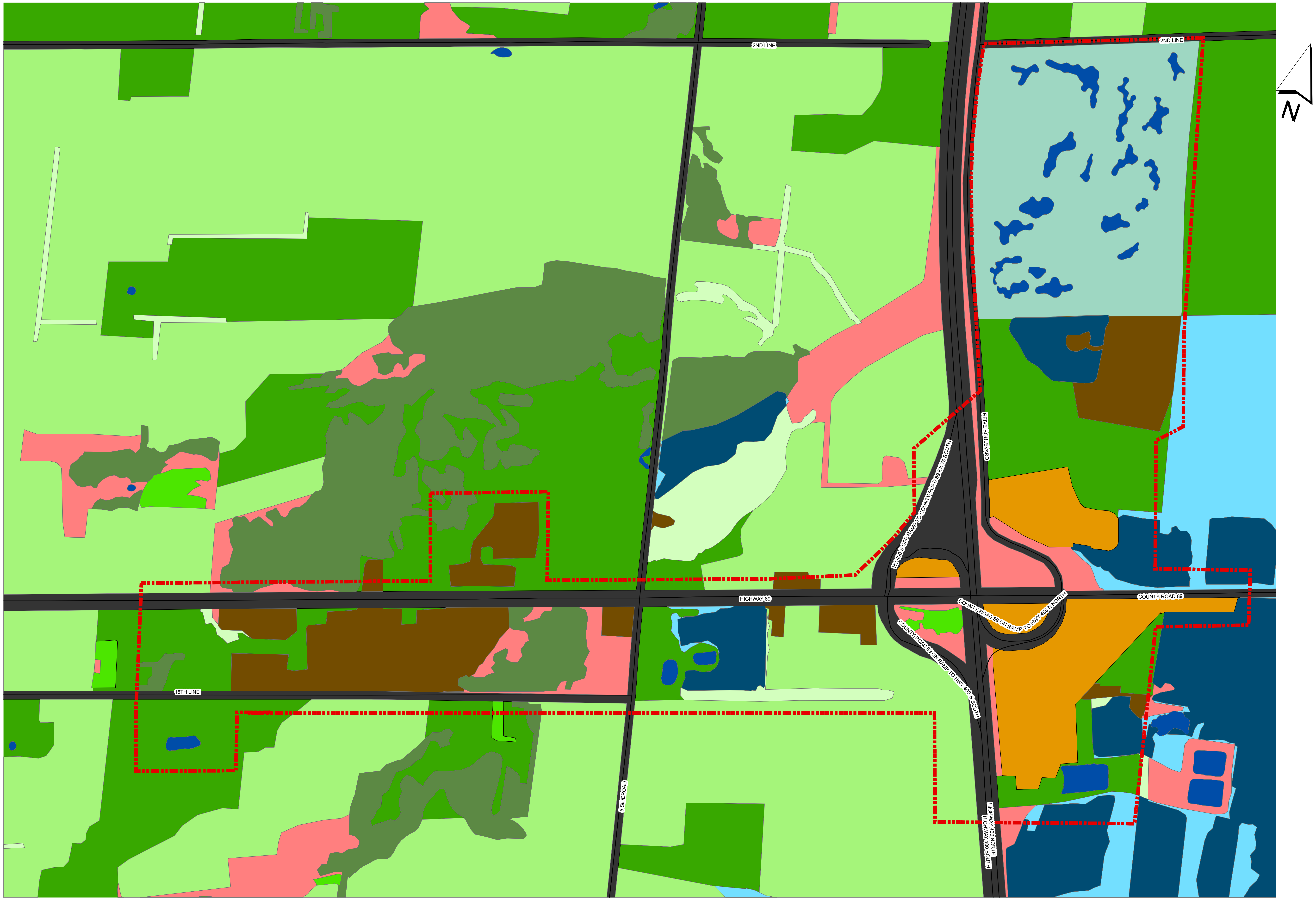
0 90 180 360 540 720
Meters

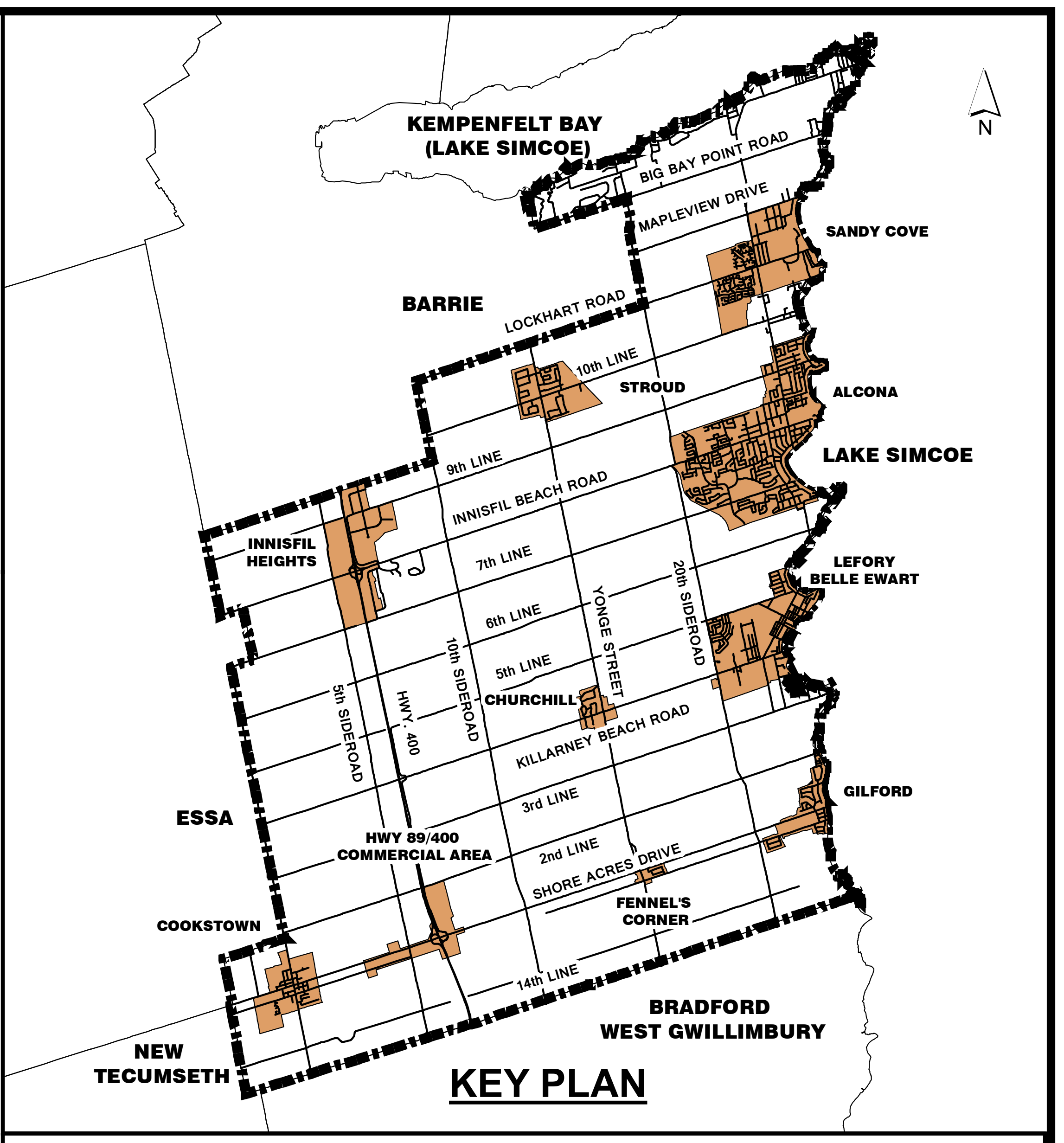
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA FIGURE COOKSTOWN

FIGURE 7-J

DATE: MARCH 2016





KEY PLAN

Legend

- — ROADS
- — STORM SEWER
- ● STORMWATER MANAGEMENT POND
- ▭ STUDY AREA
- ▭ SUBCATCHMENT BOUNDARY

SOURCE:

NOTTAWASAGA VALLEY CONSERVATION AUTHORITY REGULATION MAPPING
(NVCA EXISTING LANDUSE DATE: JANUARY, 2014)

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NVCA EXISTING LANDUSE

- 🟩 CONIFEROUS FOREST
- 🟩 DECIDUOUS FOREST
- 🟩 GOLF COURSE
- 🟩 HAY/PASTURE
- 🟩 MIXED FOREST
- 🟦 OPEN WETLAND
- 🟪 QUARRY
- ⬛ ROAD
- 🟩 ROW CROP
- 🟥 TRANSITIONAL
- 🟧 URBAN IMPERVIOUS
- 🟫 URBAN PERVIOUS
- 🟦 WATER
- 🟦 WOODY WETLAND

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Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

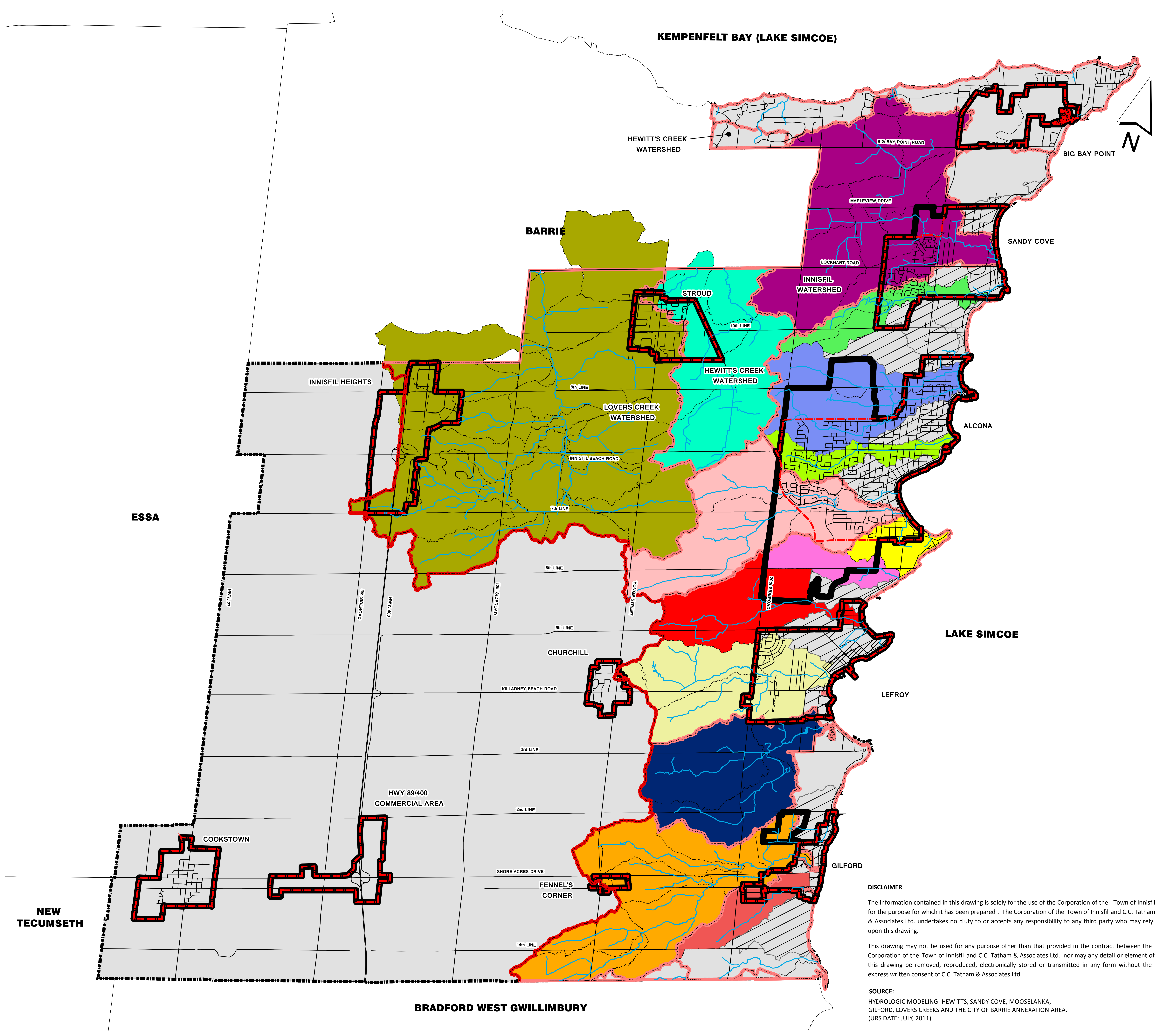
0 90 180 360 540 720 Meters

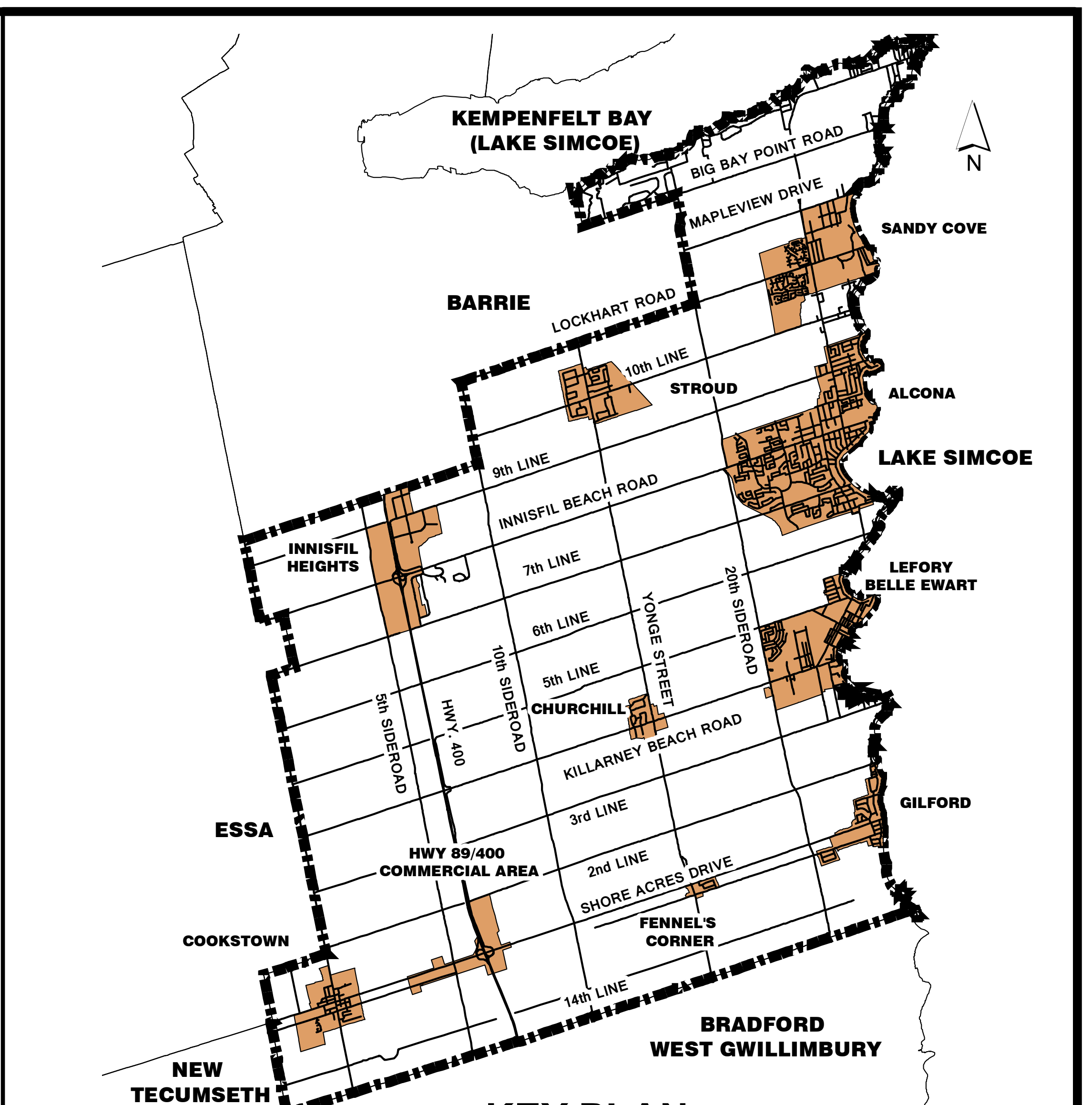
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA FIGURE HWY 89 AND 400

FIGURE 7-K

DATE: MARCH 2016





KEY PLAN

Legend

- ▬ LSRCA LIMIT
- ▭ SETTLEMENT AREAS
- ─ WATERCOURSE
- ─ ROADS
- ▭ STUDY AREAS
- ▭ SUBCATCHMENT BOUNDARY
- ▨ MUNICIPAL BOUNDARY

HYDROLOGIC MODEL CATCHMENTS WITHIN SETTLEMENT AREAS

- 🟥 BELLE AIRE CREEK
- ▭ CARSON CREEK
- 🟥 GILFORD CREEK
- 🟩 HEWITTS CREEK
- 🟫 LOVERS CREEK
- 🟩 MOOSELANKA CREEK
- 🟨 MOYER CREEK
- ▨ OVERLAND TO LAKE SIMCOE
- 🟪 SANDY COVE CREEK
- 🟧 WHITE BIRCH CREEK
- 🟦 WILSON CREEK
- 🟦 LEONARD'S CREEK
- ▭ BANK'S CREEK
- 🟪 CEDAR CREEK

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SOURCE:

HYDROLOGIC MODELING: HEWITTS, SANDY COVE, MOOSELANKA,
GILFORD, LOVERS CREEKS AND THE CITY OF BARRIE ANNEXATION AREA.
(URS DATE: JULY, 2011)

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Innisfil

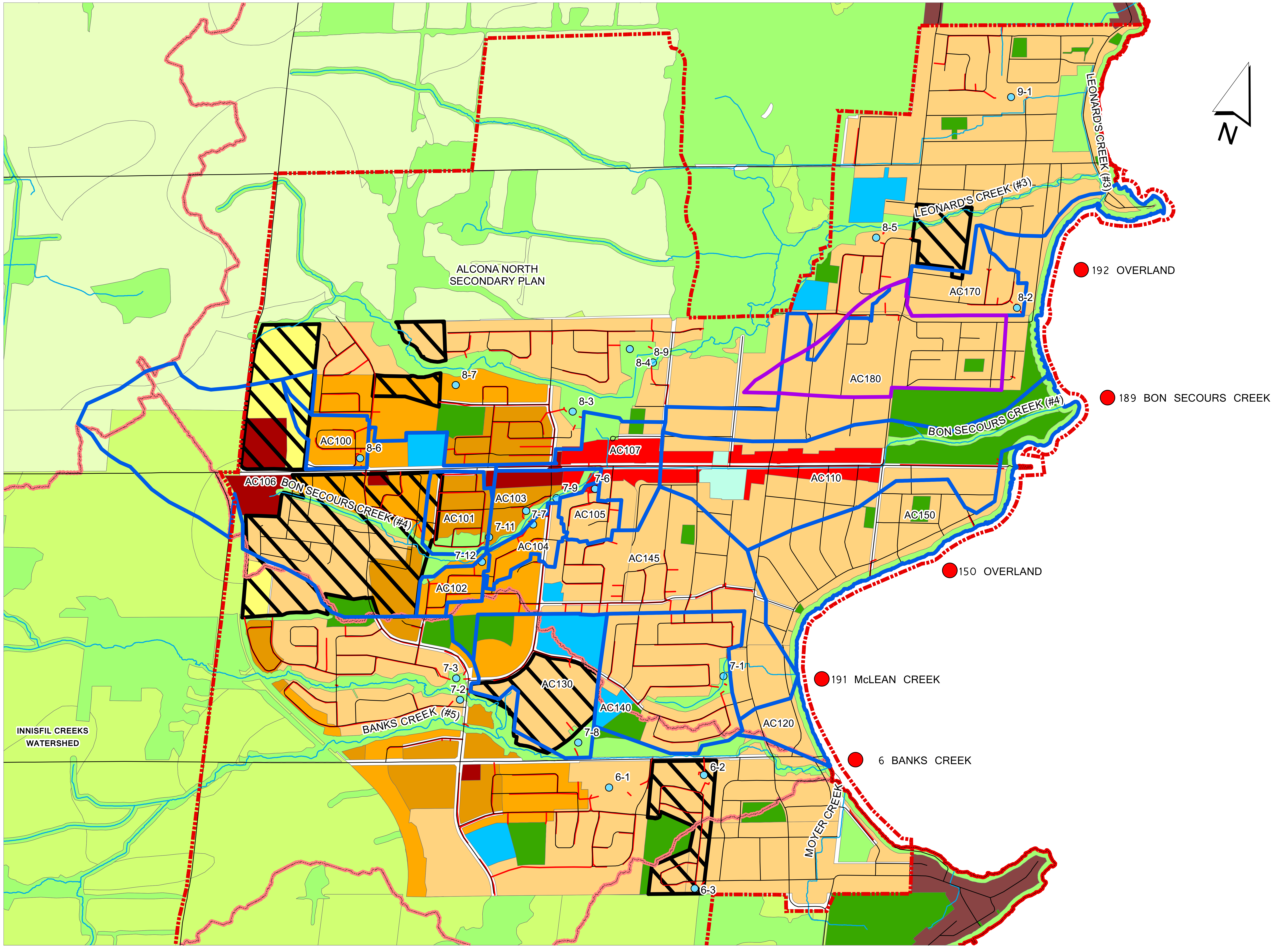
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

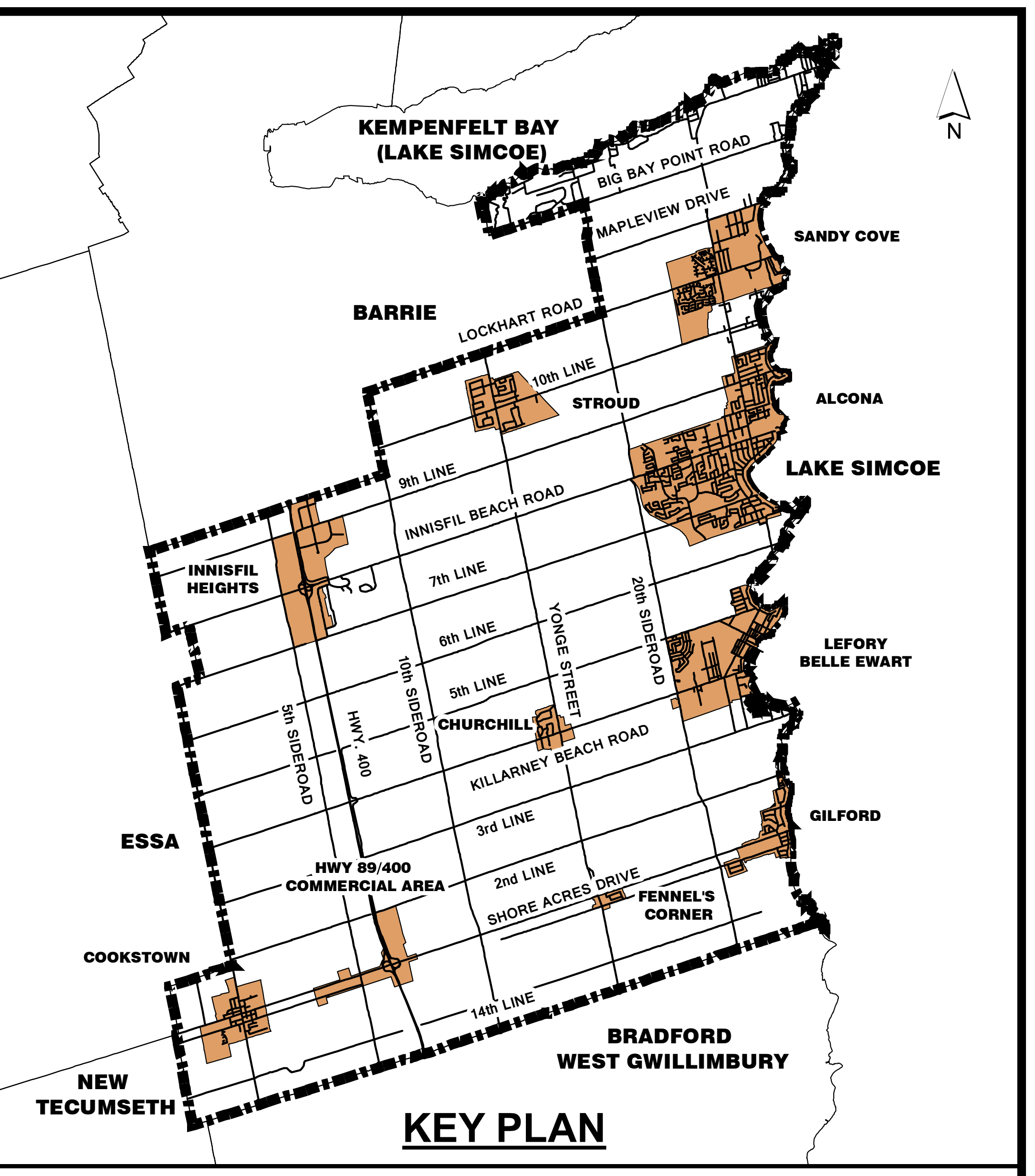
HYDROLOGIC MODEL CATCHMENTS

0 500 1,000 2,000 3,000 4,000
Meters

FIGURE 8

DATE: JUNE 2016





KEY PLAN

Legend

- ― ROADS
- ― WATERCOURSE
- ― STORM SEWER
- ● STORMWATER MANAGEMENT POND
- AC150 VO2 CATCHMENT ID
- ▨ OP DESIGNATED FUTURE DEVELOPMENT AREAS
- ☐ SUBCATCHMENT BOUNDARY
- ☐ STUDY AREA
- ● HYDROLOGIC REFERENCE POINT

SOURCE:
TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)

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OFFICAL PLAN LAND USE

- 🟨 FUTURE URBAN
- 🟨 FUTURE RESIDENTIAL
- 🟩 AGRICULTURE AREA
- 🟩 AGRICULTURE-RURAL AREA
- 🟩 AGRICULTURE-SPECIAL RURAL AREA
- 🟥 BUSINESS PARK
- 🟥 COMMERCIAL-CONVENIENCE
- 🟥 COMMERCIAL-CORE
- 🟥 COMMERCIAL-HIGHWAY
- 🟥 COMMERCIAL-NEIGHBOURHOOD
- 🟥 COMMERCIAL-NEIGHBOURHOOD/MIXED USE
- 🟫 COMMERCIAL-SHORELINE
- 🟥 COMMERCIAL-VILLAGE
- 🟩 COMMUNITY SERVICE
- 🟪 INDUSTRIAL-EXTRACTIVE
- 🟪 INDUSTRIAL-GENERAL
- 🟦 INSTITUTIONAL
- 🟪 LANDFILL
- 🟪 LANDFILL-CLOSED
- 🟩 NATURAL ENVIRONMENTAL AREA
- 🟩 NEIGHBOURHOOD PARK
- 🟩 PARKS AND OPEN SPACE
- 🟨 RESIDENTIAL-ESTATE
- 🟧 RESIDENTIAL-LOW DENSITY 1
- 🟧 RESIDENTIAL-LOW DENSITY 2
- 🟧 RESIDENTIAL-MEDIUM DENSITY
- 🟫 RESIDENTIAL-RETIREMENT
- 🟫 RESIDENTIAL-VILLAGE
- 🟦 STORMWATER MANAGEMENT

C.C. Tatham & Associates Ltd.
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Collingwood Bracebridge Orillia Barrie

Innisfil

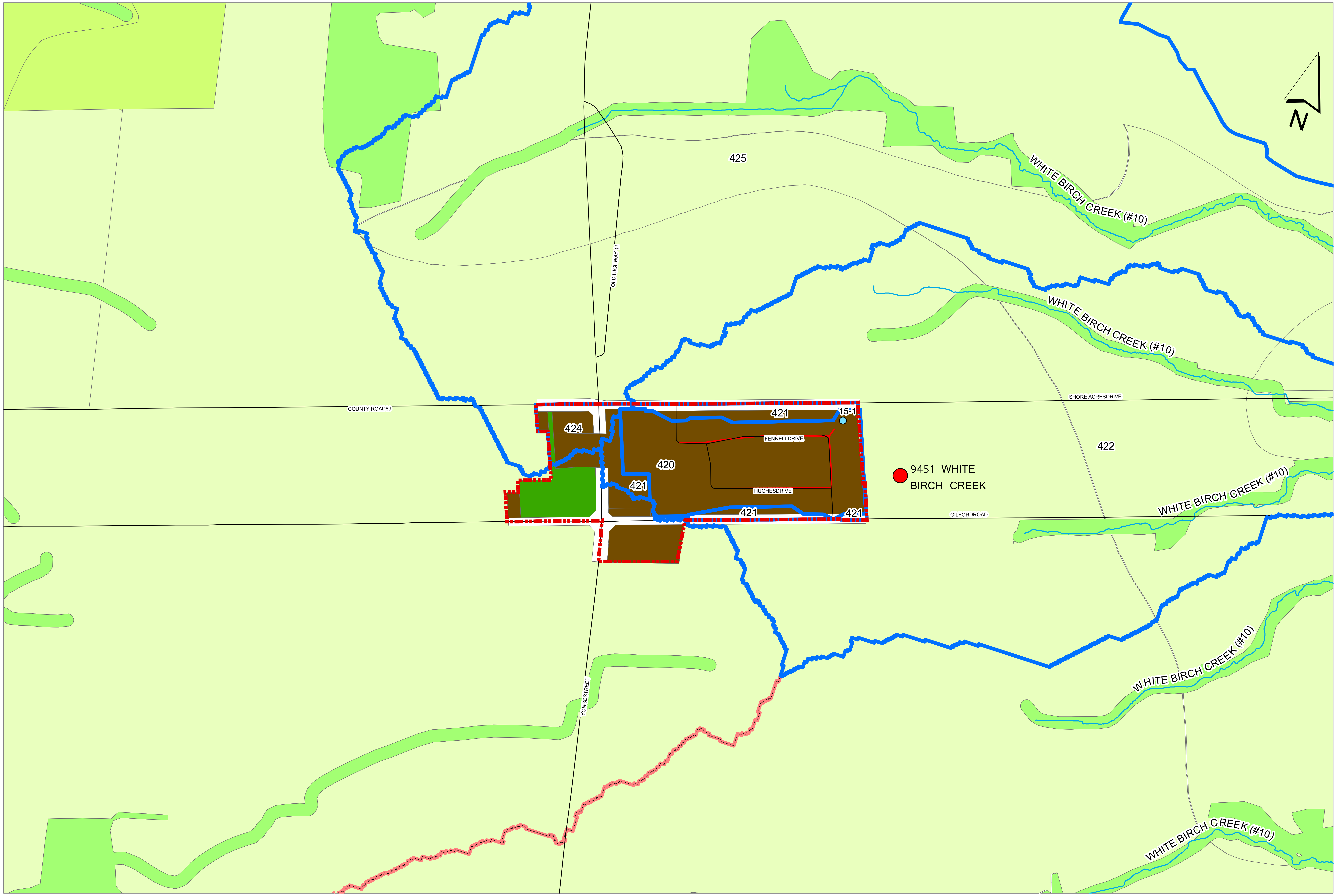
0 187.5 375 750 1,125 1,500
Meters

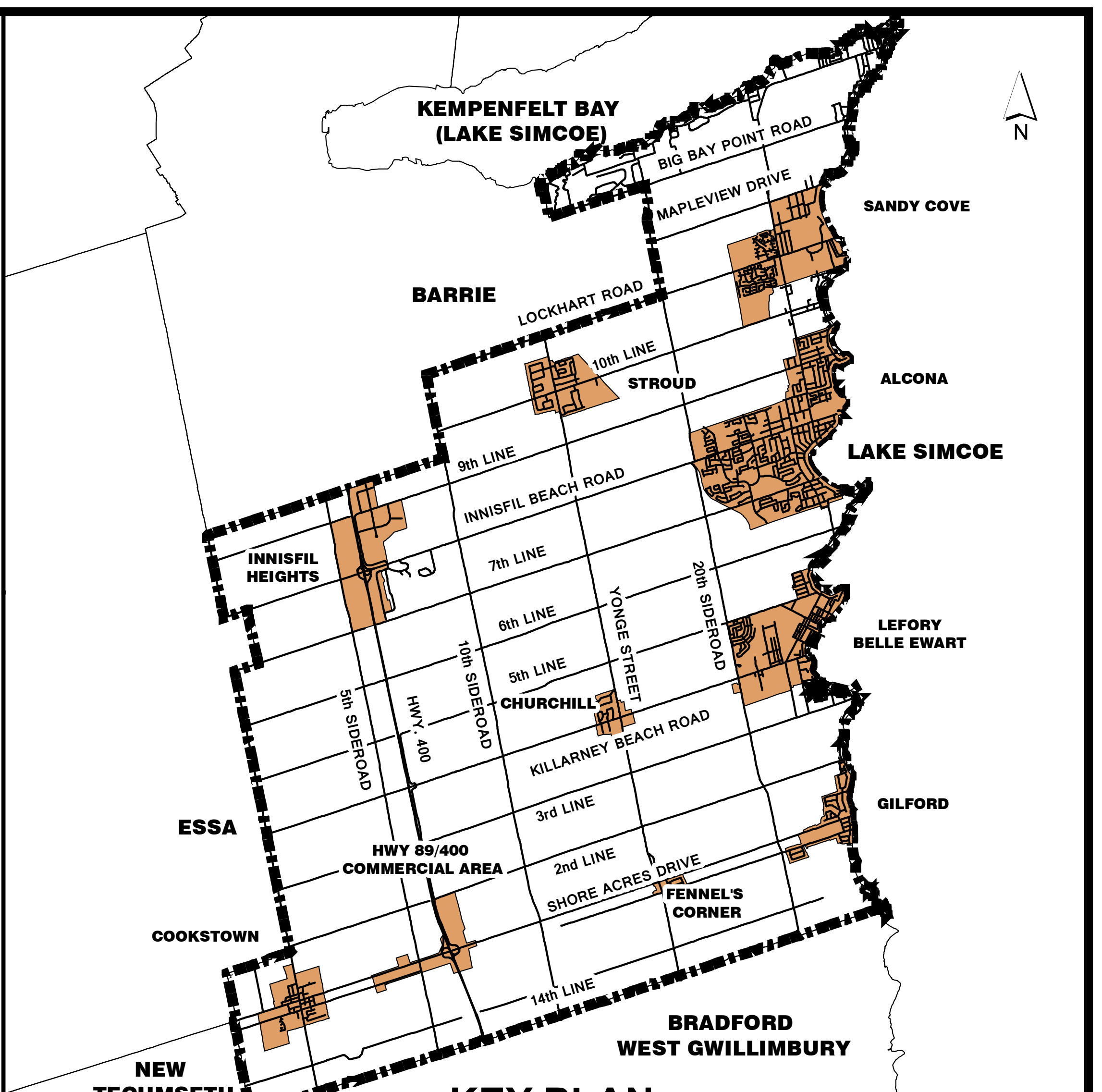
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA CATCHMENT FIGURE- ALCONA CENTRAL

FIGURE 9-A

DATE: MARCH 2016





KEY PLAN

Legend

- ROADS
- WATERCOURSE
- STORM SEWER
- STORMWATER MANAGEMENT POND
- STUDY AREA
- 422 V02 CATCHMENT BOUNDARY
- SUBCATCHMENT BOUNDARY
- ● HYDROLOGIC REFERENCE POINT

SOURCE:
TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)

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- 🟨 FUTURE URBAN
- 🟨 FUTURE RESIDENTIAL
- 🟩 AGRICULTURE AREA
- 🟩 AGRICULTURE-RURAL AREA
- 🟩 AGRICULTURE-SPECIAL RURAL AREA
- 🟥 BUSINESS PARK
- 🟥 COMMERCIAL-CONVENIENCE
- 🟥 COMMERCIAL-CORE
- 🟥 COMMERCIAL-HIGHWAY
- 🟥 COMMERCIAL-NEIGHBOURHOOD
- 🟫 COMMERCIAL-NEIGHBOURHOOD/MIXED USE
- 🟫 COMMERCIAL-SHORELINE
- 🟥 COMMERCIAL-VILLAGE
- 🟩 COMMUNITY SERVICE
- 🟪 INDUSTRIAL-EXTRACTIVE
- 🟪 INDUSTRIAL-GENERAL
- 🟦 INSTITUTIONAL
- 🟪 LANDFILL
- 🟪 LANDFILL-CLOSED
- 🟩 NATURAL ENVIRONMENTAL AREA
- 🟩 NEIGHBOURHOOD PARK
- 🟩 PARKS AND OPEN SPACE
- 🟨 RESIDENTIAL-ESTATE
- 🟧 RESIDENTIAL-LOW DENSITY 1
- 🟧 RESIDENTIAL-LOW DENSITY 2
- 🟧 RESIDENTIAL-MEDIUM DENSITY
- 🟫 RESIDENTIAL-RETIREMENT
- 🟫 RESIDENTIAL-VILLAGE
- 🟦 STORMWATER MANAGEMENT

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Collingwood Bracebridge Orillia Barrie

Innisfil

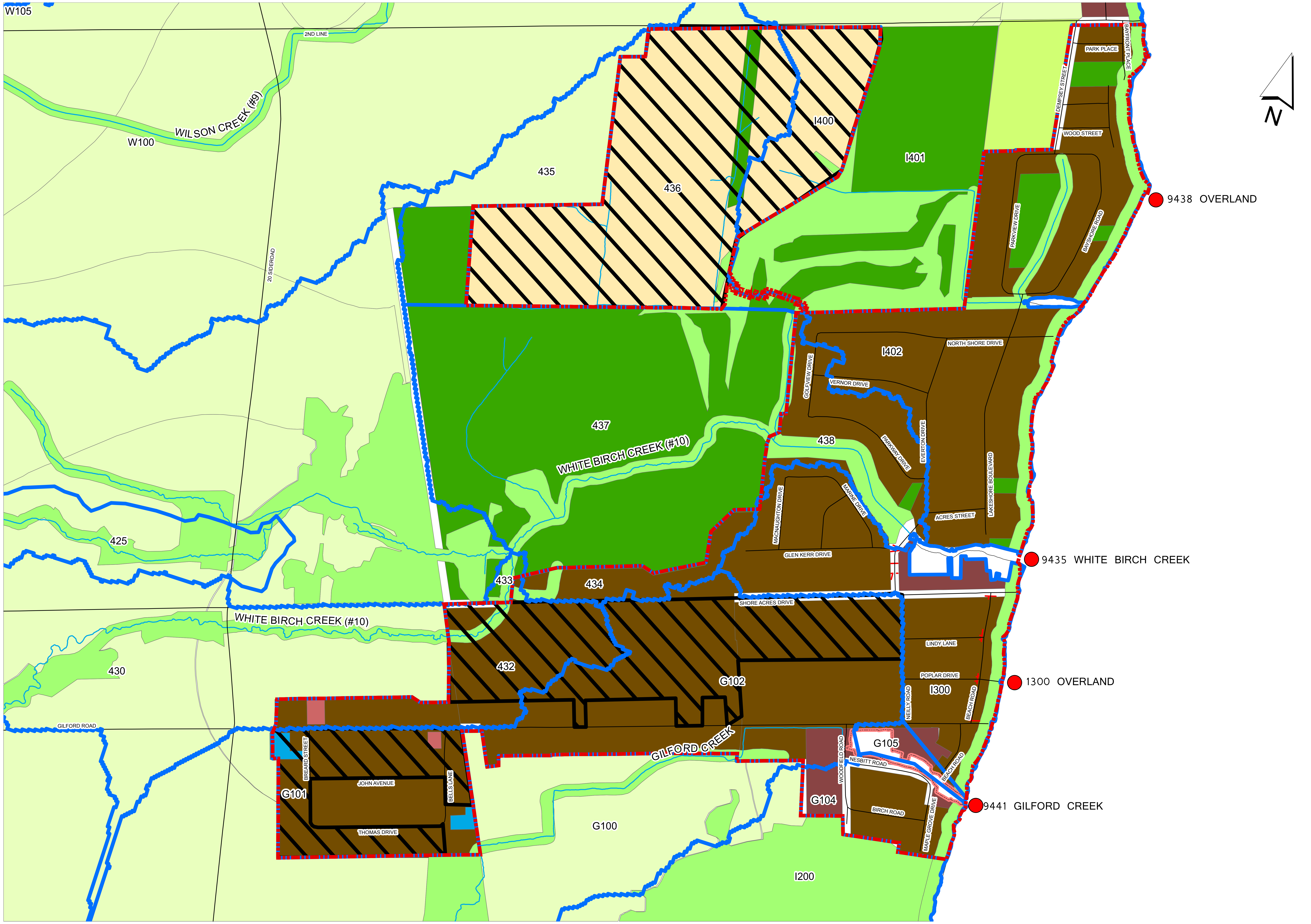
0 85 170 340 510 680 Meters

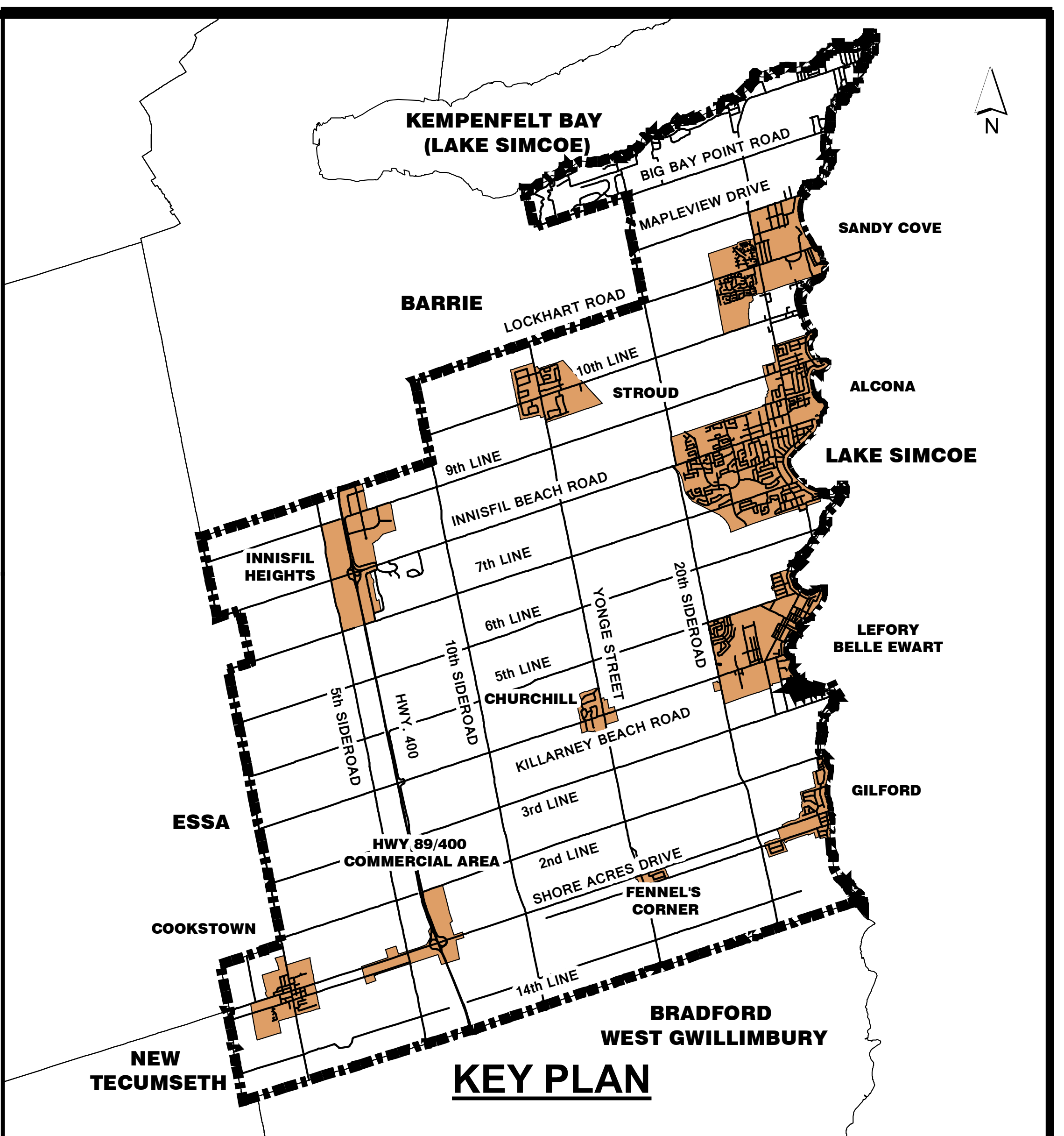
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA CATCHMENT FIGURE
FENNEL'S CORNER

FIGURE 9-B

DATE: MARCH 2016





KEY PLAN

Legend

- — ROADS
- — WATERCOURSE
- — STORM SEWER
- ● STORMWATER MANAGEMENT POND
- G102 V02 CATCHMENT BOUNDARY
- ▭ STUDY AREA
- ▨ OP DESIGNATED FUTURE DEVELOPMENT AREAS
- ▭ SUBCATCHMENT BOUNDARY
- ● HYDROLOGIC REFERENCE POINT

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- 🟨 FUTURE URBAN
- 🟨 FUTURE RESIDENTIAL
- 🟩 AGRICULTURE AREA
- 🟩 AGRICULTURE-RURAL AREA
- 🟩 AGRICULTURE-SPECIAL RURAL AREA
- 🟥 BUSINESS PARK
- 🟥 COMMERCIAL-CONVENIENCE
- 🟥 COMMERCIAL-CORE
- 🟥 COMMERCIAL-HIGHWAY
- 🟥 COMMERCIAL-NEIGHBOURHOOD
- 🟥 COMMERCIAL-NEIGHBOURHOOD/MIXED USE
- 🟫 COMMERCIAL-SHORELINE
- 🟥 COMMERCIAL-VILLAGE
- 🟦 COMMUNITY SERVICE
- 🟪 INDUSTRIAL-EXTRACTIVE
- 🟪 INDUSTRIAL-GENERAL
- 🟦 INSTITUTIONAL
- 🟪 LANDFILL
- 🟪 LANDFILL-CLOSED
- 🟩 NATURAL ENVIRONMENTAL AREA
- 🟩 NEIGHBOURHOOD PARK
- 🟩 PARKS AND OPEN SPACE
- 🟨 RESIDENTIAL-ESTATE
- 🟧 RESIDENTIAL-LOW DENSITY 1
- 🟧 RESIDENTIAL-LOW DENSITY 2
- 🟧 RESIDENTIAL-MEDIUM DENSITY
- 🟫 RESIDENTIAL-RETIREMENT
- 🟫 RESIDENTIAL-VILLAGE
- 🟦 STORMWATER MANAGEMENT

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

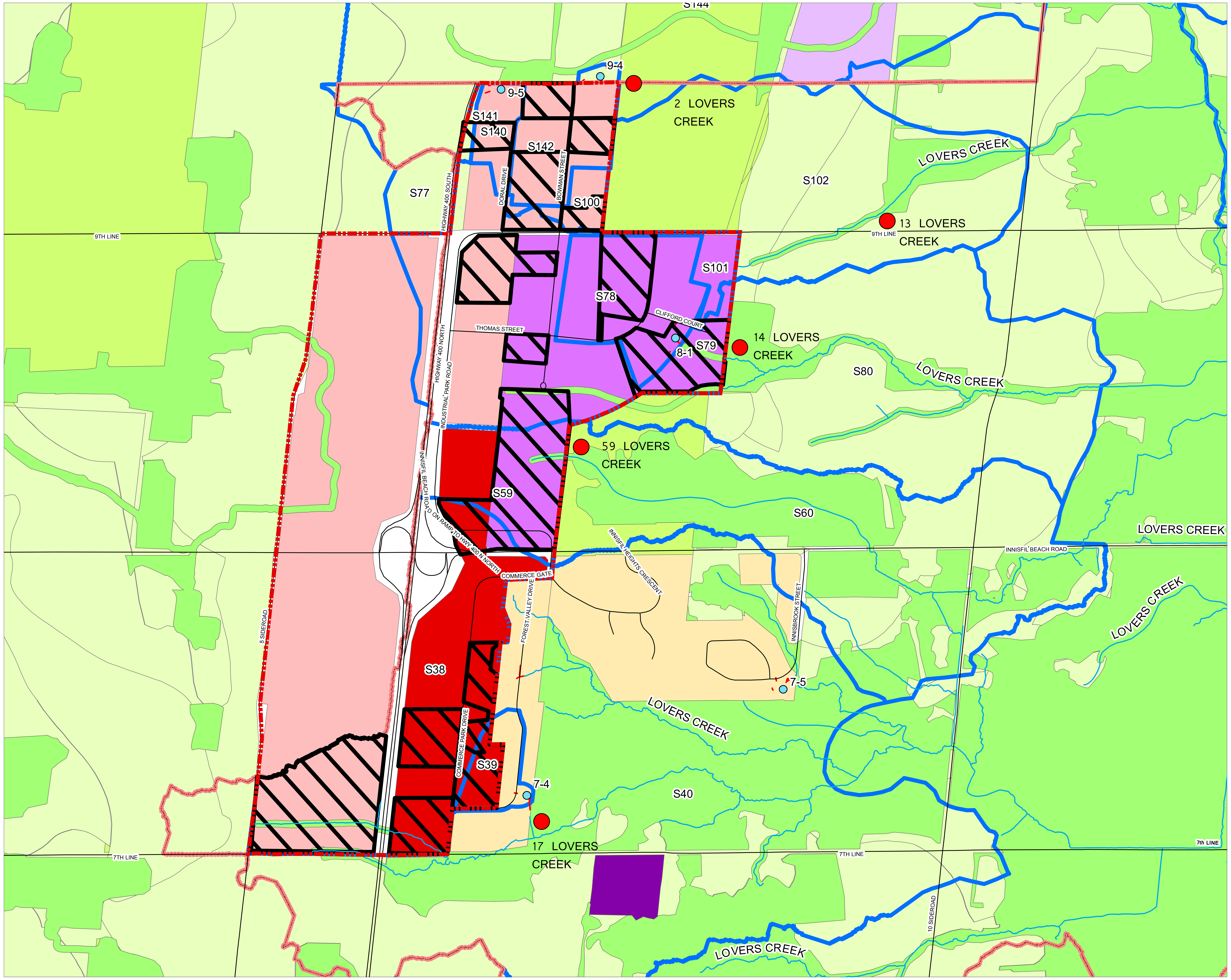
0 90 180 360 540 720 Meters

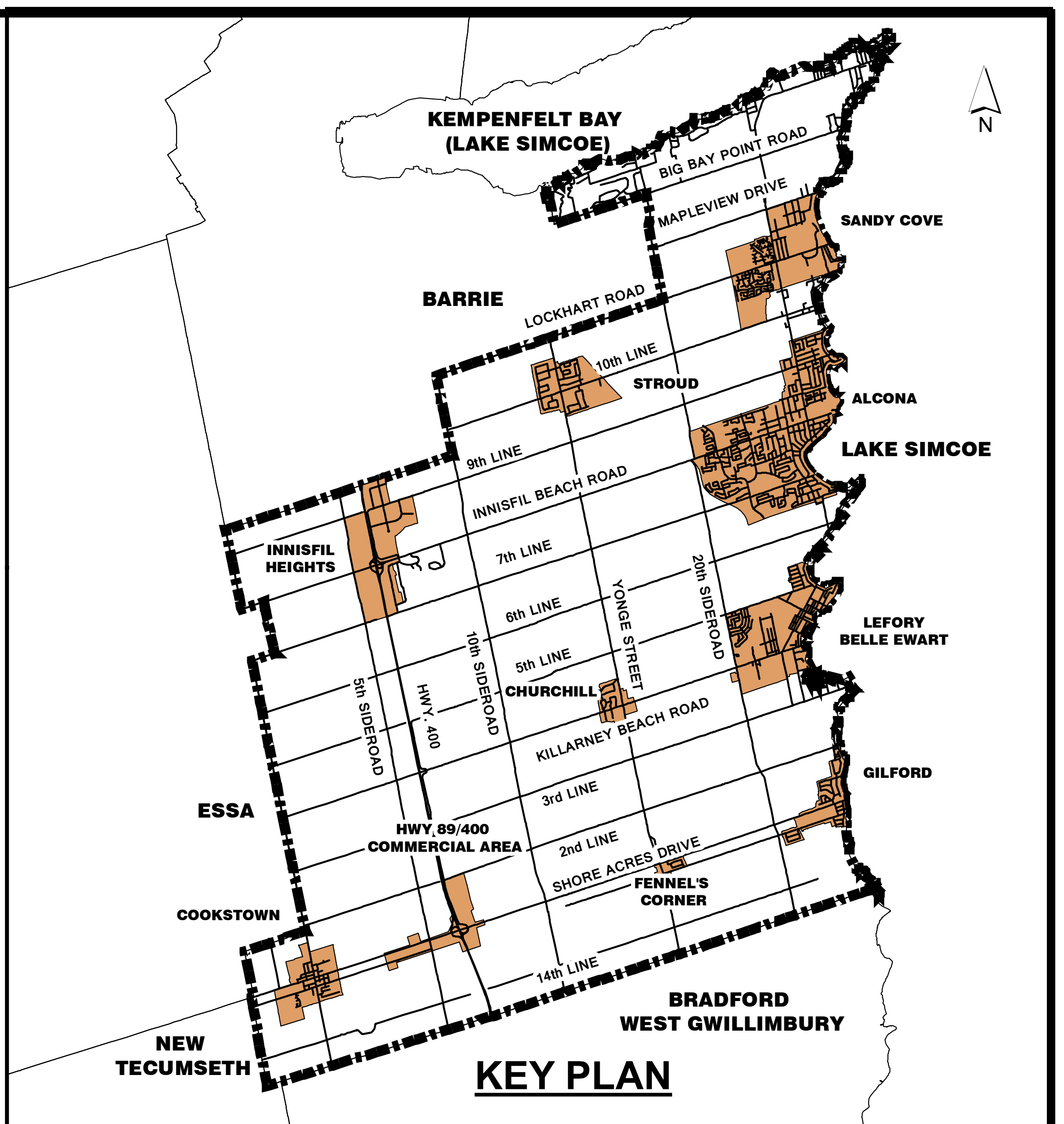
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA CATCHMENT FIGURE GILFORD

FIGURE 9-C

DATE: MARCH 2016





KEY PLAN

Legend

- — ROADS
- — WATERCOURSE
- — STORM SEWER
- ● STORMWATER MANAGEMENT POND
- S40 V02 CATCHMENT BOUNDARY
- ▭ STUDY AREA
- ▭ SUBCATCHMENT BOUNDARY
- ▨ OP DESIGNATED FUTURE DEVELOPMENT AREAS
- ● HYDROLOGIC REFERENCE POINT

SOURCE:
TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)

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OFFICAL PLAN LAND USE

- ■ FUTURE URBAN
- ■ FUTURE RESIDENTIAL
- ■ AGRICULTURE AREA
- ■ AGRICULTURE-RURAL AREA
- ■ AGRICULTURE-SPECIAL RURAL AREA
- ■ BUSINESS PARK
- ■ COMMERCIAL-CONVENIENCE
- ■ COMMERCIAL-CORE
- ■ COMMERCIAL-HIGHWAY
- ■ COMMERCIAL-NEIGHBOURHOOD
- ■ COMMERCIAL-NEIGHBOURHOOD/MIXED USE
- ■ COMMERCIAL-SHORELINE
- ■ COMMERCIAL-VILLAGE
- ■ COMMUNITY SERVICE
- ■ INDUSTRIAL-EXTRACTIVE
- ■ INDUSTRIAL-GENERAL
- ■ INSTITUTIONAL
- ■ LANDFILL
- ■ LANDFILL-CLOSED
- ■ NATURAL ENVIRONMENTAL AREA
- ■ NEIGHBOURHOOD PARK
- ■ PARKS AND OPEN SPACE
- ■ RESIDENTIAL-ESTATE
- ■ RESIDENTIAL-LOW DENSITY 1
- ■ RESIDENTIAL-LOW DENSITY 2
- ■ RESIDENTIAL-MEDIUM DENSITY
- ■ RESIDENTIAL-RETIREMENT
- ■ RESIDENTIAL-VILLAGE
- ■ STORMWATER MANAGEMENT

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

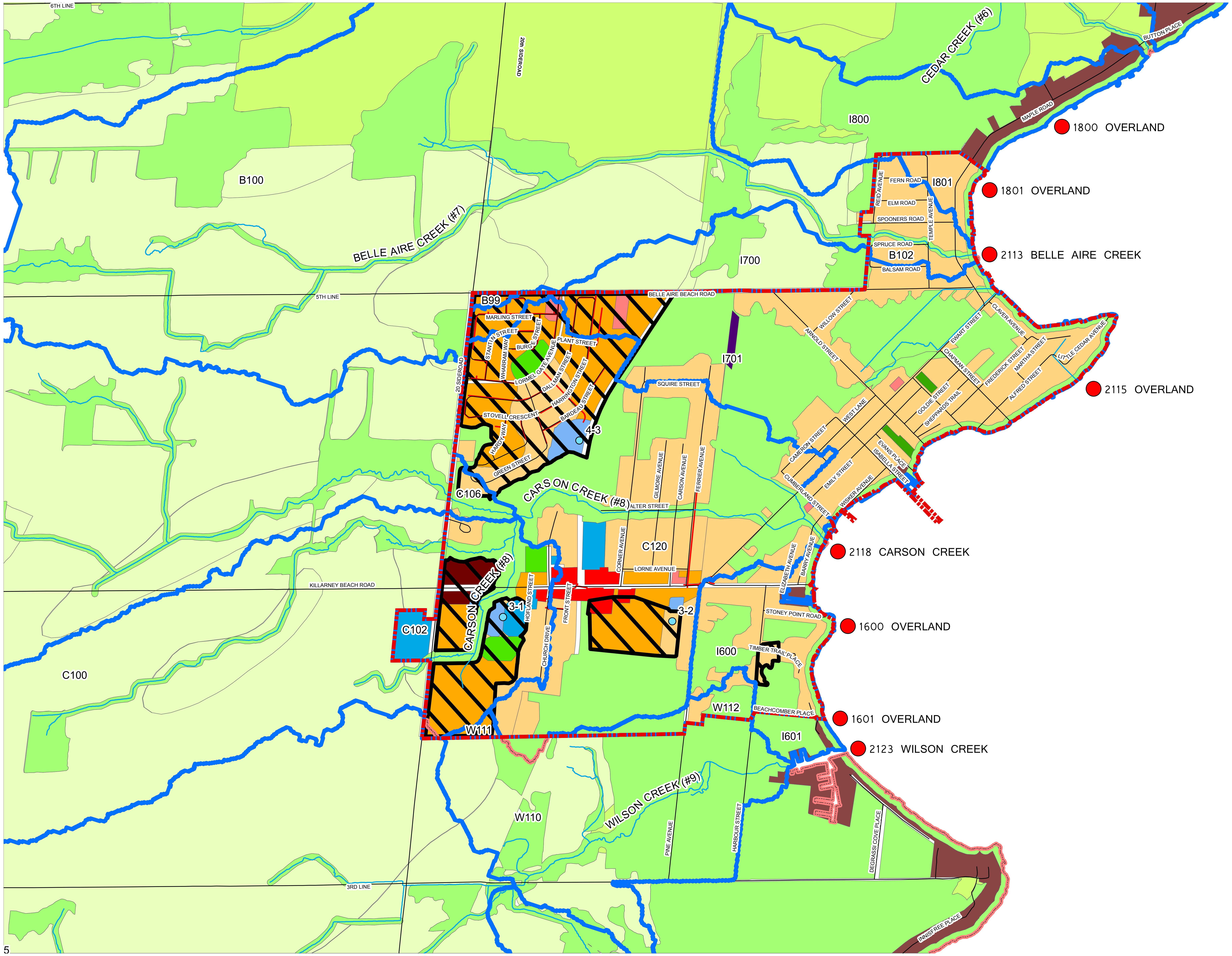
0 187.5 375 750 1,125 1,500 Meters

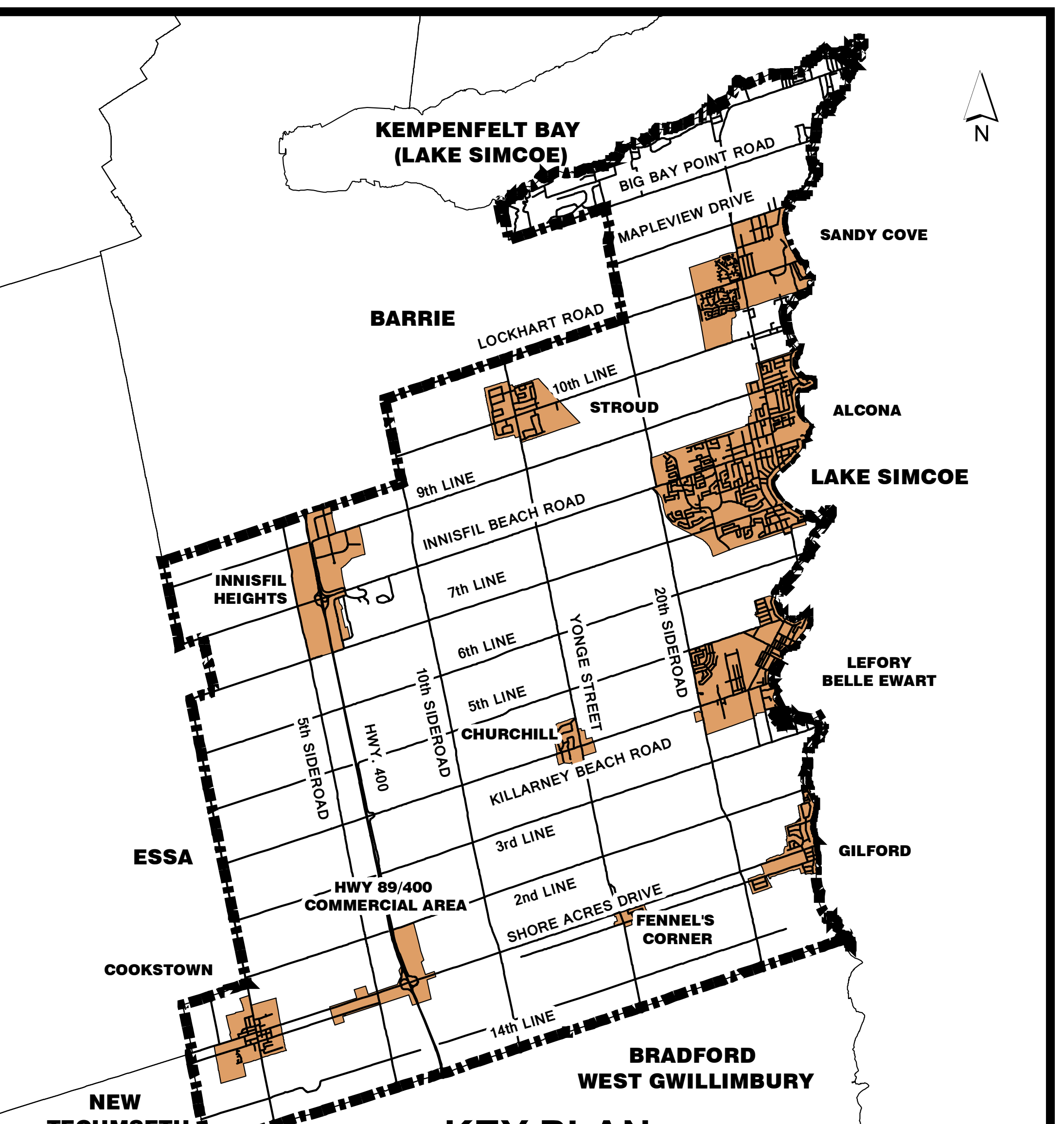
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA CATCHMENT FIGURE INNISFIL HEIGHTS

FIGURE 9-D

DATE: MARCH 2016





KEY PLAN

Legend

- ROADS
- WATERCOURSE
- STORM SEWER
- ● STORMWATER MANAGEMENT POND
- C120 V02 CATCHMENT BOUNDARY
- ▨ OP DESIGNATED FUTURE DEVELOPMENT AREAS
- SUBCATCHMENT BOUNDARY
- STUDY AREA
- ● HYDROLOGIC REFERANCE POINT

SOURCE:
TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)

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OFFICAL PLAN LAND USE

- 🟨 FUTURE URBAN
- 🟨 FUTURE RESIDENTIAL
- 🟩 AGRICULTURE AREA
- 🟩 AGRICULTURE-RURAL AREA
- 🟩 AGRICULTURE-SPECIAL RURAL AREA
- 🟥 BUSINESS PARK
- 🟥 COMMERCIAL-CONVENIENCE
- 🟥 COMMERCIAL-CORE
- 🟥 COMMERCIAL-HIGHWAY
- 🟥 COMMERCIAL-NEIGHBOURHOOD
- 🟫 COMMERCIAL-NEIGHBOURHOOD/MIXED USE
- 🟫 COMMERCIAL-SHORELINE
- 🟥 COMMERCIAL-VILLAGE
- 🟩 COMMUNITY SERVICE
- 🟪 INDUSTRIAL-EXTRACTIVE
- 🟪 INDUSTRIAL-GENERAL
- 🟦 INSTITUTIONAL
- 🟪 LANDFILL
- 🟪 LANDFILL-CLOSED
- 🟩 NATURAL ENVIRONMENTAL AREA
- 🟩 NEIGHBOURHOOD PARK
- 🟩 PARKS AND OPEN SPACE
- 🟨 RESIDENTIAL-ESTATE
- 🟧 RESIDENTIAL-LOW DENSITY 1
- 🟧 RESIDENTIAL-LOW DENSITY 2
- 🟧 RESIDENTIAL-MEDIUM DENSITY
- 🟫 RESIDENTIAL-RETIREMENT
- 🟫 RESIDENTIAL-VILLAGE
- 🟦 STORMWATER MANAGEMENT

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

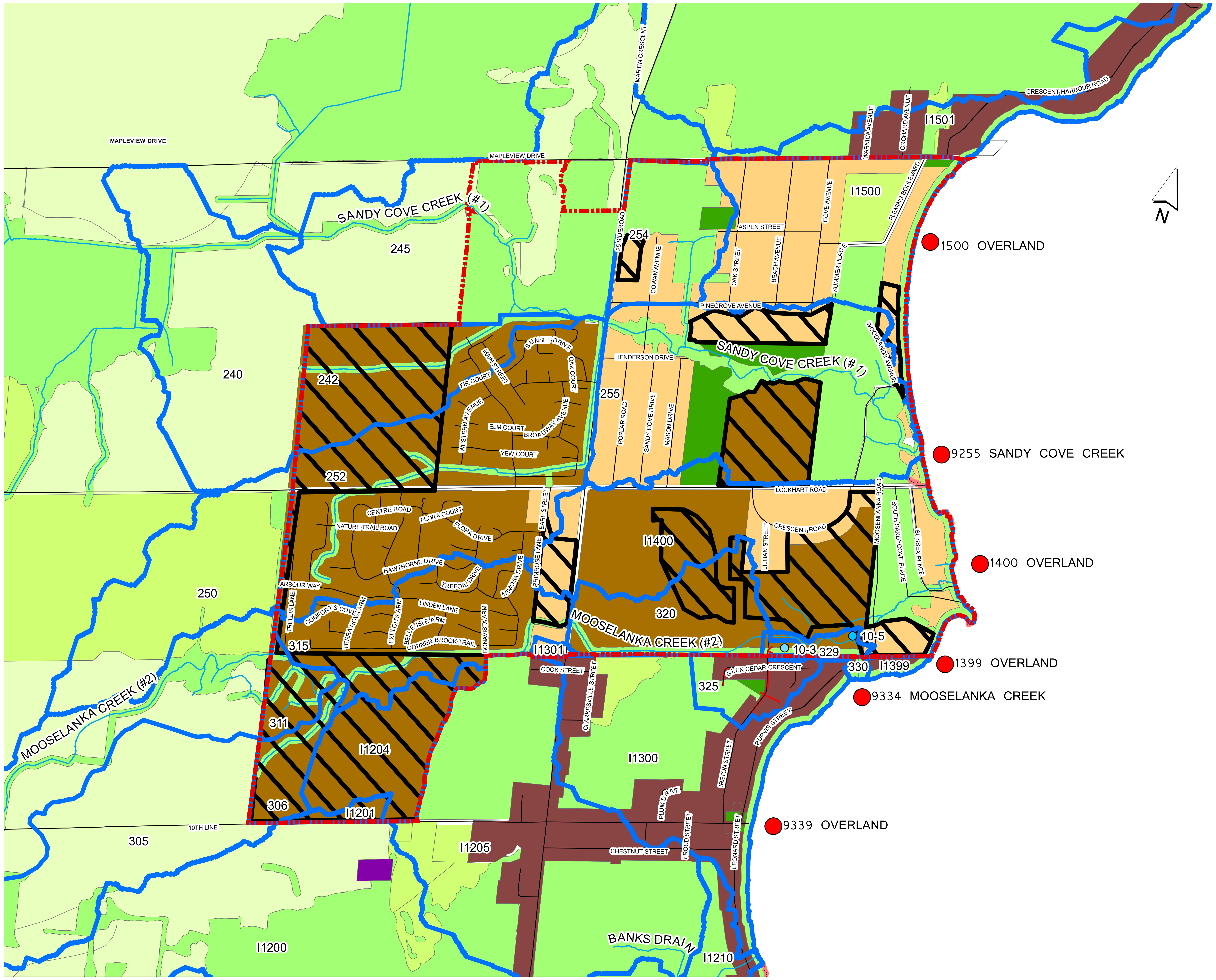
0 187.5 375 750 1,125 1,500 Meters

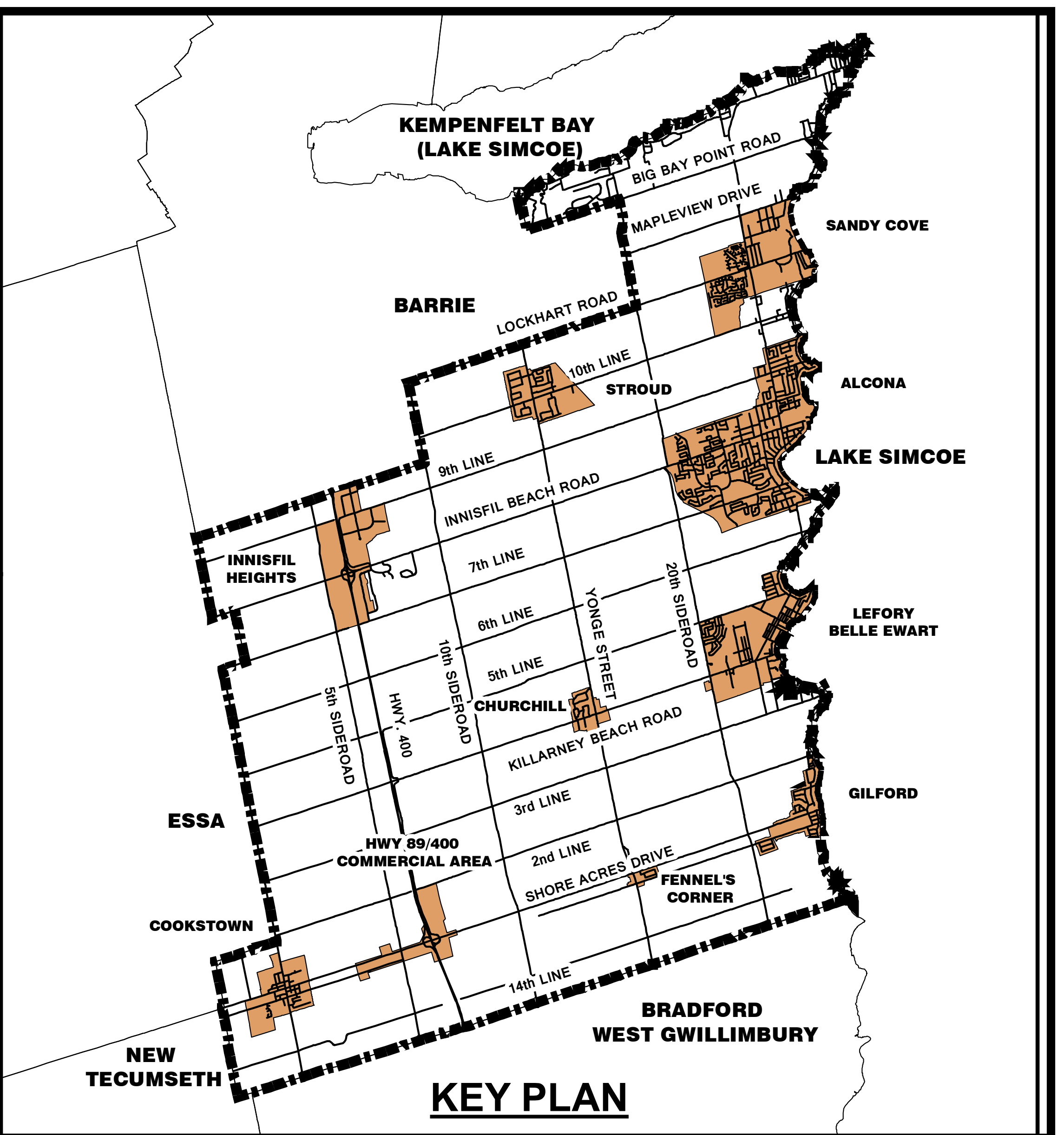
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA CATCHMENT FIGURE LEFROY

FIGURE 9-E

DATE: MARCH 2016





KEY PLAN

Legend

— ROADS
— WATERCOURSE
— STORM SEWER
● STORMWATER MANAGEMENT POND
320 V02 CATCHMENT BOUNDARY
▨ OP DESIGNATED FUTURE DEVELOPMENT AREAS
☐ SUBCATCHMENT BOUNDARY
☐ STUDY AREA
● HYDROLOGIC REFERENCE POINT

SOURCE:
TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)

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OFFICAL PLAN LAND USE

🟨 FUTURE URBAN
🟨 FUTURE RESIDENTIAL
🟩 AGRICULTURE AREA
🟩 AGRICULTURE-RURAL AREA
🟩 AGRICULTURE-SPECIAL RURAL AREA
🟥 BUSINESS PARK
🟥 COMMERCIAL-CONVENIENCE
🟥 COMMERCIAL-CORE
🟥 COMMERCIAL-HIGHWAY
🟥 COMMERCIAL-NEIGHBOURHOOD
🟫 COMMERCIAL-NEIGHBOURHOOD/MIXED USE
🟫 COMMERCIAL-SHORELINE
🟥 COMMERCIAL-VILLAGE
🟩 COMMUNITY SERVICE
🟪 INDUSTRIAL-EXTRACTIVE
🟪 INDUSTRIAL-GENERAL
🟦 INSTITUTIONAL
🟪 LANDFILL
🟪 LANDFILL-CLOSED
🟩 NATURAL ENVIRONMENTAL AREA
🟩 NEIGHBOURHOOD PARK
🟩 PARKS AND OPEN SPACE
🟨 RESIDENTIAL-ESTATE
🟧 RESIDENTIAL-LOW DENSITY 1
🟧 RESIDENTIAL-LOW DENSITY 2
🟧 RESIDENTIAL-MEDIUM DENSITY
🟫 RESIDENTIAL-RETIREMENT
🟫 RESIDENTIAL-VILLAGE
🟦 STORMWATER MANAGEMENT

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

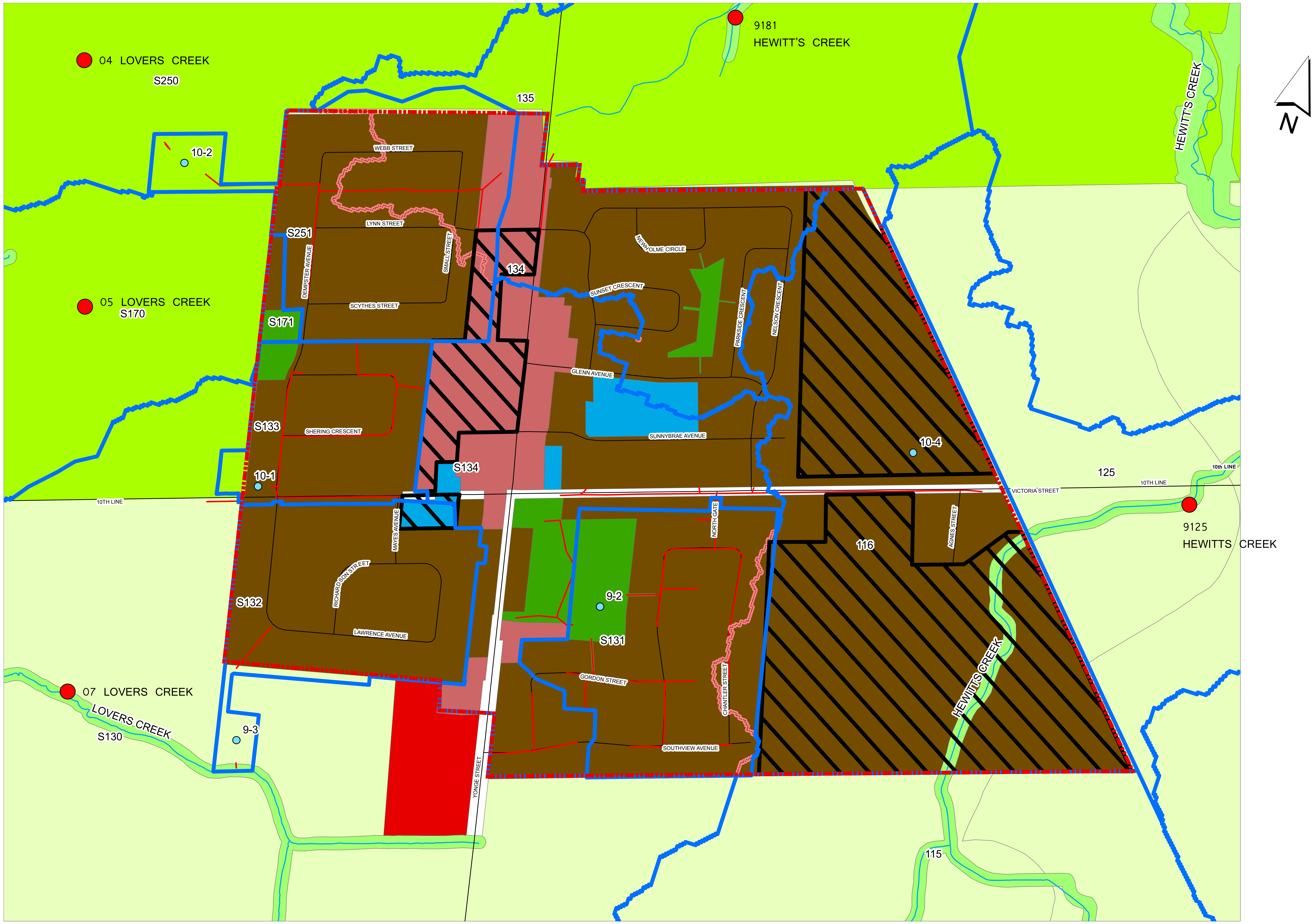
0 185 370 740 1,110 1,480
Meters

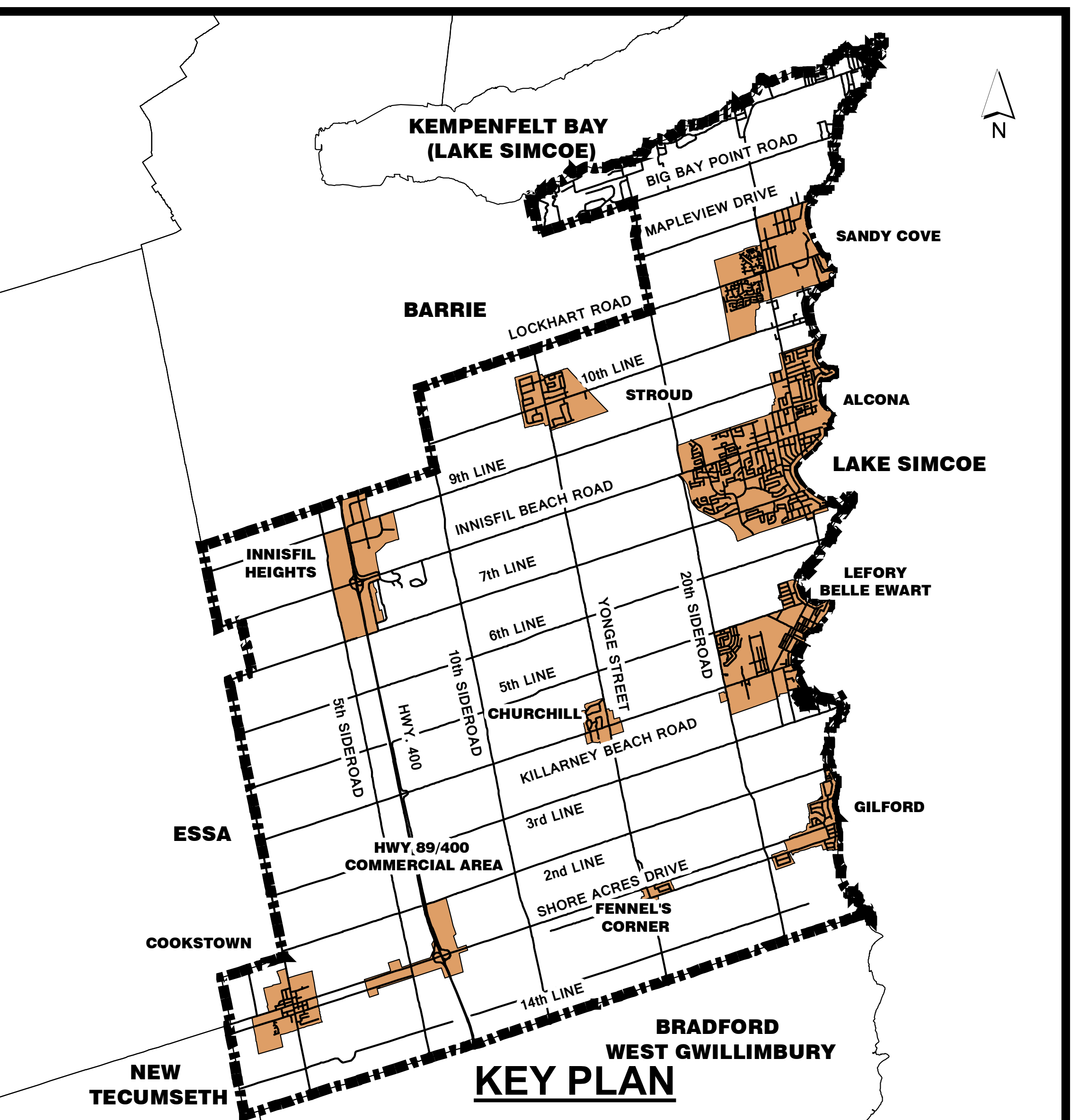
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA CATCHMENT FIGURE SANDY COVE

FIGURE 9-F

DATE: MARCH 2016





KEY PLAN

Legend

- ▭ STUDY AREA
- ▭ 125 V02 CATCHMENT BOUNDARY
- ▨ OP DESIGNATED FUTURE DEVELOPMENT AREAS
- ▭ SUBCATCHMENT BOUNDARY
- ● STORMWATER MANAGEMENT POND
- — STORM SEWER
- — ROADS
- — WATERCOURSE
- ● HYDROLOGIC REFERENCE POINT

SOURCE:
TOWN OF INNISFIL
(OFFICIAL PLAN TOWN OF INNISFIL DATE: JULY, 2006)

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OFFICAL PLAN LAND USE

- FUTURE URBAN
- FUTURE RESIDENTIAL
- AGRICULTURE AREA
- AGRICULTURE-RURAL AREA
- AGRICULTURE-SPECIAL RURAL AREA
- BUSINESS PARK
- COMMERCIAL-CONVENIENCE
- COMMERCIAL-CORE
- COMMERCIAL-HIGHWAY
- COMMERCIAL-NEIGHBOURHOOD
- COMMERCIAL-NEIGHBOURHOOD/MIXED USE
- COMMERCIAL-SHORELINE
- COMMERCIAL-VILLAGE
- COMMUNITY SERVICE
- INDUSTRIAL-EXTRACTIVE
- INDUSTRIAL-GENERAL
- INSTITUTIONAL
- LANDFILL
- LANDFILL-CLOSED
- NATURAL ENVIRONMENTAL AREA
- NEIGHBOURHOOD PARK
- PARKS AND OPEN SPACE
- RESIDENTIAL-ESTATE
- RESIDENTIAL-LOW DENSITY 1
- RESIDENTIAL-LOW DENSITY 2
- RESIDENTIAL-MEDIUM DENSITY
- RESIDENTIAL-RETIREMENT
- RESIDENTIAL-VILLAGE
- STORMWATER MANAGEMENT

C.C. Tatham & Associates Ltd.
Consulting Engineers
Collingwood Bracebridge Orillia Barrie

Innisfil

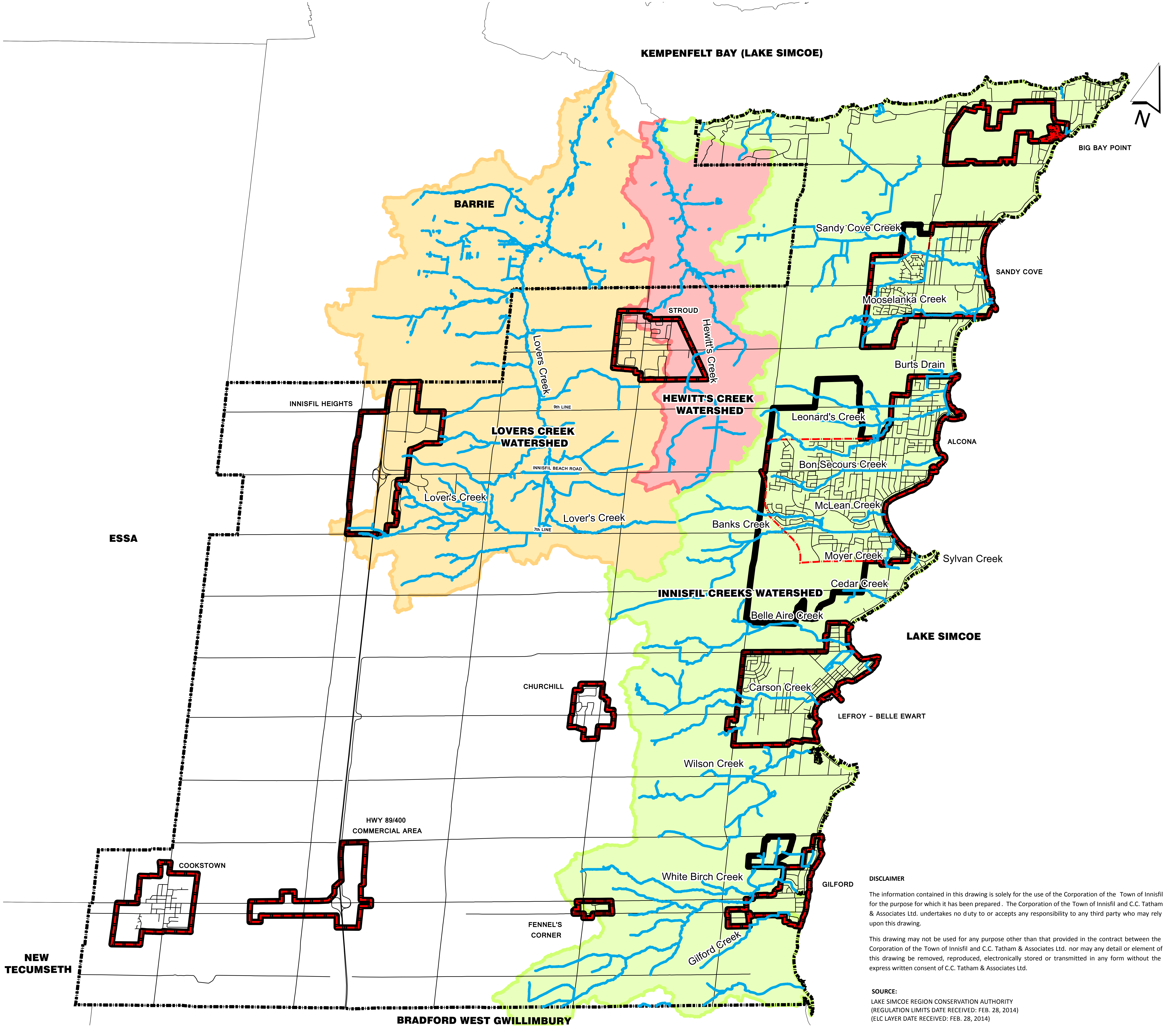
0 87.5 175 350 525 700 Meters

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

STUDY AREA CATCHMENT FIGURE STROUD

FIGURE - 9-G

DATE: MARCH 2016



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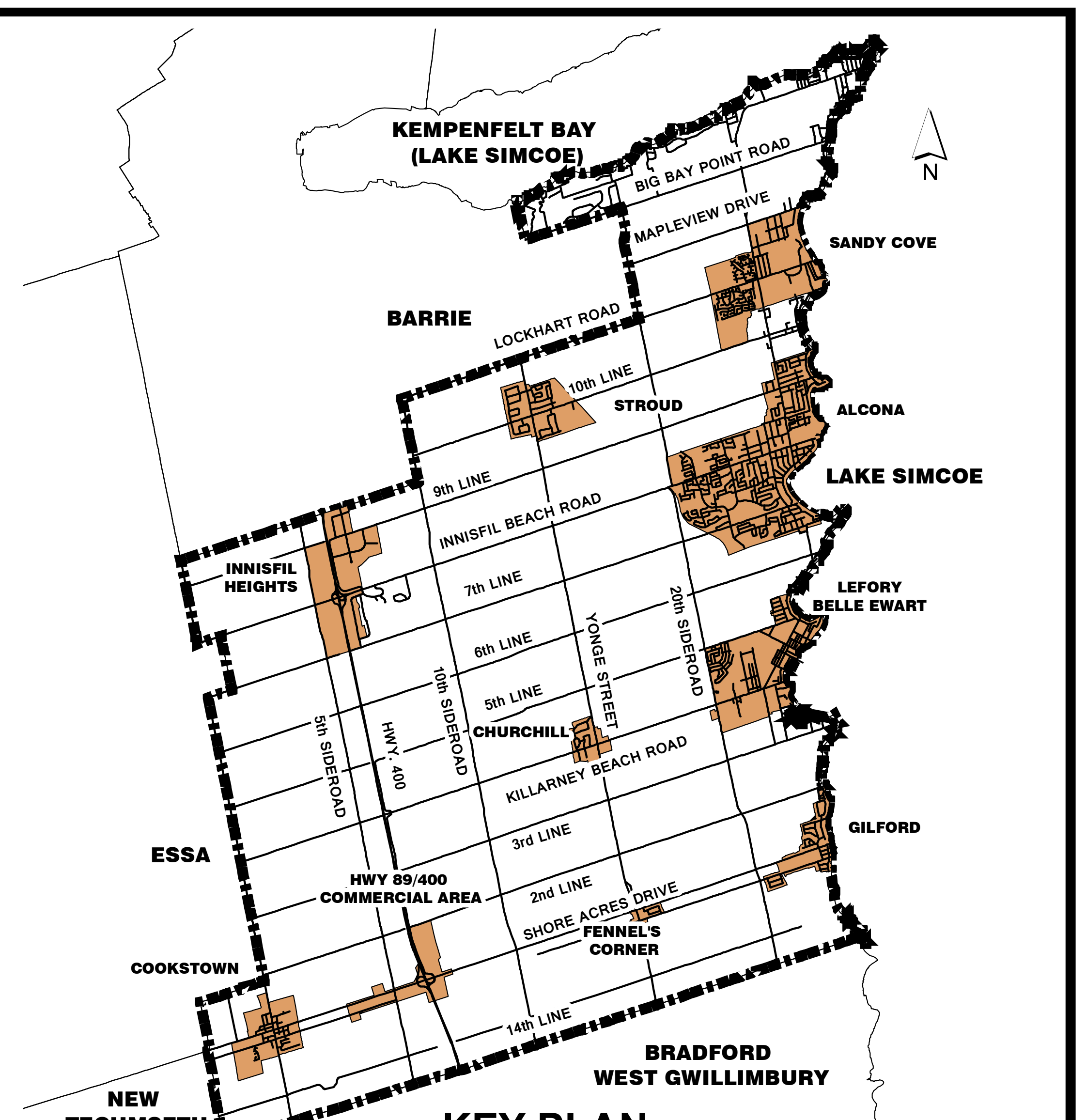
SOURCE:
LAKE SIMCOE REGION CONSERVATION AUTHORITY
(REGULATION LIMITS DATE RECEIVED: FEB. 28, 2014)
(ELC LAYER DATE RECEIVED: FEB. 28, 2014)



KEY PLAN

Legend

━	WATERCOURSE
—	ROADS
▭	SETTLEMENT AREAS
▭	STUDY AREAS
▭	MUNICIPAL BOUNDARY
🟧	LOVER'S CREEK WATERSHED
🟥	HEWITTS CREEK WATERSHED
🟩	INNISFIL WATERSHED

C.C. Tatham & Associates Ltd.
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Collingwood Bracebridge Orillia Barrie

Innisfil

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

WATERCOURSE IDENTIFICATION PLAN

0 500 1,000 2,000 3,000 4,000
Meters

FIGURE 10

DATE: JUNE 2016

APPENDIX A:
STUDY AREA INFORMATION

Table 1: Existing Land Use Breakdown (ELC Layer)

Land Use	Gilford	Sandy Cove	Stroud	Lefroy	Fennell's Corners	Innisfil Heights	Big Bay Point	Alcona
Active Aggregate		-	-	-	-	-	-	-
Commercial *	-	-	6.82	3.01	-	2.59	3.98	7.84
Estate Residential *	0.43	0.75	-	0.66	-	0.99	0.57	1.59
Golf Course	0.82	-	-	-	-	-	-	32.79
Inactive Aggregate	-	-	-	5.38	-	-	-	1.58
Industrial *	-	-	-	2.32	-	116.94	-	0.76
Institutional *	-	0.22	7.75	7.54	0.12	-	0.04	31.34
Intensive Agriculture	13.15	76.83	63.01	26.30	-	28.24	67.18	0.76
Manicured Open Space	-	0.11	7.11	3.36	-	7.75	1.72	28.33
NH- Coniferous Forest	3.20	4.26	-	3.53	-	-	9.77	11.11
NH- Coniferous Swamp	-	-	-	9.93	-	-	13.81	3.55
NH- Cultural Meadow	12.43	4.97	2.86	0.66	-	33.35	5.50	25.60
NH- Cultural Thicket	22.93	2.67	-	19.89	-	4.98	7.35	17.32
NH- Cultural Woodland	1.00	2.37	-	2.61	-	6.57	2.20	4.45
NH- Deciduous Forest	5.32	62.26	1.51	13.68	-	13.52	62.27	13.89
NH- Deciduous Swamp	1.02	5.39	-	41.19	-	-	20.65	16.40
NH- Meadow marsh	-	14.15	-	-	-	-	0.42	2.98
NH- Mixed Forest	12.59	61.73	-	48.47	-	1.40	26.21	36.60
NH- Mixed Shallow Aquatic	-	-	-	0.41	-	-	0.18	-
NH- Mixed Swamp	0.01	1.20	-	22.27	-	-	4.89	28.89
NH- Open Water	3.59	1.06	-	1.38	-	-	-	22.57
NH- Shallow Marsh	0.04	1.66	-	5.70	-	-	-	0.43
NH- Thicket Swamp	1.29	1.44	-	15.75	-	-	-	11.42
NH- Submerged Shallow Aquatic	-	0.33	-	-	-	-	4.52	0.11
NH- Cultural Plantation	-	-	-	-	-	-	-	5.51
Non-intensive Agriculture (Hay)	-	-	-	48.17	0.04	5.23	-	23.23
Non-intensive Agriculture (Pasture)	-	12.30	-	14.66	-		-	2.66
Rail *	0.47	-	0.32	2.01	-	4.06	-	2.19
Road *	4.41	19.78	28.16	15.77	1.34	40.52	2.59	53.14
Rural Development *	4.64	3.94	-	15.62	1.26	1.02	4.91	10.52
Urban *	99.67	224.13	115.62	153.49	15.71	-	0.30	606.78
Total	186.99	501.54	233.17	483.75	18.47	267.15	239.08	1004.33

Note: * denotes the land use is a 'developed' land use type

Table 2: Future Land Use (OP Layer)

Land Use	Gilford	Sandy Cove	Stroud	Lefroy	Fennell's Corners	Innisfil Heights	Big Bay Point	Alcona Central
Agriculture area	0.24	0.09	0.79	0.45	0.10	3.40	-	0.25
Agriculture-rural area	0.02	6.58	-	-	-	0.15	-	4.48
Agriculture-special rural area	-	-	0.40	-	-	-	-	-
Business park *	-	-	-	-	-	80.58	-	-
Commercial-convenience *	-	-	-	2.45	-	-	-	-
Commercial-core *	-	-	-	5.05	-	-	-	19.29
Commercial-highway *	-	-	-	-	-	59.34	-	-
Commercial-neighbourhood *	-	-	-	-	-	-	-	13.82
Commercial-neighbourhood/mixed use *	-	-	-	3.72	-	-	-	-
Commercial-shoreline *	6.71	-	-	1.45	-	-	-	-
Commercial village *	0.39	-	21.13	-	0.51	-	-	-
Community service *	-	-	-	-	-	-	-	3.34
Estate-residential *	39.11	-	-	-	-	0.18	-	-
Industrial-extractive *	-	-	-	-	-	-	-	-
Industrial-general *	-	-	-	-	-	88.21	-	-
Landfill *	-	-	-	-	-	-	-	-
Landfill-closed *	-	-	-	0.91	-	-	-	-
Institutional *	0.59	-	5.00	8.17	-	-	-	22.02
Natural environmental area	13.09	88.09	1.86	178.49	-	5.56	-	105.06
Neighbourhood park	-	-	-	5.21	-	-	-	-
Parks and open space	5.13	13.62	9.99	1.11	0.14	-	-	55.61
Residential village *	117.49	-	190.56	-	15.60	-	-	-
Residential-low density *	-	-	-	-	-	-	-	-
Residential-low density 1 *	-	111.77	-	193.14	-	-	-	573.90
Residential-low density 2 *	-	-	-	63.99	-	-	-	86.78
Residential-medium density *	-	-	-	-	-	-	-	49.42
Residential-retirement *	-	269.70	-	-	-	-	-	-
Residential-shoreline *	-	0.25	-	-	-	-	-	0.07
Stormwater management *	-	-	-	4.58	-	-	-	-
Future urban *	-	-	-	-	-	-	239.08	18.74
Roads (assumption) *	4.22	11.45	3.43	15.03	2.12	29.72	-	51.54
Total	186.99	501.54	233.17	483.75	18.47	267.15	239.08	1004.33

Note: * denotes the land use is a 'developed' land use type

Table 3: ELC Land Use Conversion for Water Balance (Runoff coefficient)

Existing (ELC) Land Use Category		TOI/ MTO Land use category
Active Aggregate	*modeled as*	Industrial- light
Commercial	*modeled as*	Business- heavy
Estate Residential	*modeled as*	Residential- suburban
Golf Course	*modeled as*	Parks, cemeteries
Inactive Aggregate	*modeled as*	Industrial- light
Industrial	*modeled as*	Industrial- Heavy
Institutional	*modeled as*	Business- heavy
Intensive Agriculture	*modeled as*	Cultivated Land, 0 - 5% grade
Manicured Open Space	*modeled as*	Parks, cemeteries
NH- Coniferous Forest	*modeled as*	Woodlot or Cutover, 0 - 5% grade
NH- Coniferous Swamp	*modeled as*	Lakes and Wetlands
NH- Cultural Meadow	*modeled as*	Pasture Land, 0 - 5% grade
NH- Cultural Thicket	*modeled as*	Woodlot or Cutover, 0 - 5% grade
NH- Cultural Woodland	*modeled as*	Woodlot or Cutover, 0 - 5% grade
NH- Deciduous Forest	*modeled as*	Woodlot or Cutover, 0 - 5% grade
NH- Deciduous Swamp	*modeled as*	Lakes and Wetlands
NH- Meadow marsh	*modeled as*	Lakes and Wetlands
NH- Mixed Forest	*modeled as*	Woodlot or Cutover, 0 - 5% grade
NH- Mixed Shallow Aquatic	*modeled as*	Lakes and Wetlands
NH- Mixed Swamp	*modeled as*	Lakes and Wetlands
NH- Open Water	*modeled as*	Lakes and Wetlands
NH- Shallow Marsh	*modeled as*	Lakes and Wetlands
NH- Thicket Swamp	*modeled as*	Lakes and Wetlands
NH- Submerged Shallow Aquatic	*modeled as*	Lakes and Wetlands
NH- Cultural Plantation	*modeled as*	Cultivated Land, 0 - 5% grade
Non-intensive Agriculture (Hay)	*modeled as*	Pasture Land, 0 - 5% grade
Non-intensive Agriculture (Pasture)	*modeled as*	Pasture Land, 0 - 5% grade
Rail	*modeled as*	Pasture Land, 0 - 5% grade
Road	*modeled as*	Railroad yards
Rural Development	*modeled as*	Pavement (asphalt or concrete)
Urban	*modeled as*	Residential- suburban
		Residential- single family urban

Table 4: OP Land Use Conversion for Water Balance (Runoff Coefficient)

Future (OP) Land Use Category		TOI/ MTO Land use category
Future Urban	*modeled as*	Residential- single family urban
Agriculture Area	*modeled as*	Cultivated Land, 0 - 5% grade
Agriculture Rural Area	*modeled as*	Cultivated Land, 0 - 5% grade
Agriculture Special Rural Area	*modeled as*	Cultivated Land, 0 - 5% grade
Business Park	*modeled as*	Business- heavy
Commercial Convenience	*modeled as*	Business- heavy
Commercial Core	*modeled as*	Business- heavy
Commercial Highway	*modeled as*	Business- heavy
Commercial Neighbourhood	*modeled as*	Business- heavy
Commercial Neighbourhood/Mixed Use	*modeled as*	Business- heavy
Commercial Shoreline	*modeled as*	Business- heavy
Commercial Village	*modeled as*	Business- heavy
Community Service	*modeled as*	business - light
Estate Residential	*modeled as*	Residential- suburban
Industrial Extractive	*modeled as*	Industrial- Heavy
Industrial General	*modeled as*	Industrial- Heavy
Landfill	*modeled as*	Unimproved areas
Landfill Closed	*modeled as*	Unimproved areas
Institutional	*modeled as*	Business- heavy
Natural Environment Area	*modeled as*	Varies- Woodlot, Parks/Cemeteries or wetland
Neighbourhood Park	*modeled as*	Parks, cemeteries
Parks and Open Space	*modeled as*	Parks, cemeteries
Residential Village	*modeled as*	Residential- single family urban
Residential Low Density	*modeled as*	Residential- single family urban
Residential Low Density 1	*modeled as*	Residential- single family urban
Residential Low Density 2	*modeled as*	Residential- single family urban
Residential Medium Density	*modeled as*	residential- multiple, detached
Residential Retirement	*modeled as*	Residential- multiple, attached
Residential Shoreline	*modeled as*	residential- multiple, detached
Stormwater Management	*modeled as*	Lakes and Wetlands
Roads	*modeled as*	Pavement (asphalt or concrete)

Table 5: Existing Condition Land Use Conversion (Phosphorus Loading)

Existing (ELC) Land Use Category		MOE Land Use Category
Active Aggregate	*modeled as*	Quarry
Commercial	*modeled as*	High Intensity Development – Commercial/Industrial
Estate Residential	*modeled as*	High Intensity Development - Residential
Golf Course	*modeled as*	Sod Farm/ Golf Course
Inactive Aggregate	*modeled as*	Quarry
Industrial	*modeled as*	High Intensity Development – Commercial/Industrial
Institutional	*modeled as*	High Intensity Development – Commercial/Industrial
Intensive Agriculture	*modeled as*	Cropland
Manicured Open Space	*modeled as*	Low Intensity Development
NH- Coniferous Forest	*modeled as*	Forest
NH- Coniferous Swamp	*modeled as*	Wetland
NH- Cultural Meadow	*modeled as*	Transitional
NH- Cultural Thicket	*modeled as*	Transitional
NH- Cultural Woodland	*modeled as*	Forest
NH- Deciduous Forest	*modeled as*	Forest
NH- Deciduous Swamp	*modeled as*	Wetland
NH- Meadow marsh	*modeled as*	Wetland
NH- Mixed Forest	*modeled as*	Forest
NH- Mixed Shallow Aquatic	*modeled as*	Wetland
NH- Mixed Swamp	*modeled as*	Wetland
NH- Open Water	*modeled as*	Wetland
NH- Shallow Marsh	*modeled as*	Wetland
NH- Thicket Swamp	*modeled as*	Wetland
NH- Submerged Shallow Aquatic	*modeled as*	Wetland
NH- Cultural Plantation	*modeled as*	Forest
Non-intensive Agriculture	*modeled as*	Hay-pasture
Rail	*modeled as*	Low Intensity Development
Road	*modeled as*	High Intensity Development – Commercial/Industrial
Rural Development	*modeled as*	High Intensity Development - Residential
Urban	*modeled as*	High Intensity Development - Residential

Table 6: Future Conditions Land Use Conversion (Phosphorus Loading)

Future (OP) Land Use Category		MOE Land Use Category
Future Urban	*modeled as*	High Intensity Development - Residential
Future Residential	*modeled as*	High Intensity Development - Residential
Agriculture Area	*modeled as*	50% Hay - Pasture, 50% Cropland
Agriculture Rural Area	*modeled as*	50% Hay - Pasture, 50% Cropland
Agriculture Special Rural Area	*modeled as*	50% Hay - Pasture, 50% Cropland
Business Park	*modeled as*	High Intensity Development – Commercial/Industrial
Commercial Convenience	*modeled as*	High Intensity Development – Commercial/Industrial
Commercial Core	*modeled as*	High Intensity Development – Commercial/Industrial
Commercial Highway	*modeled as*	High Intensity Development – Commercial/Industrial
Commercial Neighbourhood	*modeled as*	High Intensity Development – Commercial/Industrial
Commercial Neighbourhood/Mixed Use	*modeled as*	High Intensity Development – Commercial/Industrial
Commercial Shoreline	*modeled as*	High Intensity Development – Commercial/Industrial
Commercial Village	*modeled as*	High Intensity Development – Commercial/Industrial
Community Service	*modeled as*	High Intensity Development - Residential
Estate Residential	*modeled as*	High Intensity Development - Residential
Industrial Extractive	*modeled as*	High Intensity Development – Commercial/Industrial
Industrial General	*modeled as*	High Intensity Development – Commercial/Industrial
Landfill	*modeled as*	Quarry
Landfill Closed	*modeled as*	Quarry
Institutional	*modeled as*	High Intensity Development – Commercial/Industrial
Natural Environment Area*	*modeled as*	Varies- Wetland, Forest or Turf-Sod
Neighbourhood Park	*modeled as*	Low Intensity Development
Parks and Open Space	*modeled as*	Low Intensity Development
Residential Village	*modeled as*	High Intensity Development - Residential
Residential Low Density	*modeled as*	High Intensity Development - Residential
Residential Low Density 1	*modeled as*	High Intensity Development - Residential
Residential Low Density 2	*modeled as*	High Intensity Development - Residential
Residential Medium Density	*modeled as*	High Intensity Development - Residential
Residential Retirement	*modeled as*	High Intensity Development - Residential
Residential Shoreline	*modeled as*	High Intensity Development - Residential
Stormwater Management	*modeled as*	Wetland
Roads	*modeled as*	High Intensity Development – Commercial/Industrial

SOILS INFORMATION

Lefroy- Soils Breakdown					
Soil Series	Symbol	Soil Type	Class	Area (ha)	% of Total
BERRIEN	Bas	SANDY LOAM	AB	4.35	1%
DUNDONALD	Ds	SANDY LOAM	AB	12.01	2%
ALLISTON	Ans	SANDY LOAM	AB	12.27	3%
MUCK	M	MUCK	B	42.78	9%
ALLISTON	Ans	SANDY LOAM	AB	219.22	45%
GWILLIMBURY	Gg	GRAVELLY SANDY LOAM	AB	40.07	8%
BONDHEAD	Bs	SANDY LOAM	AB	74.83	16%
SCHOMBERG	Shsc	SILTY CLAY LOAM	C	76.58	16%
		TOTAL		482.09	

Sum of AB	362.74	75.2%
Sum of C	76.58	16%
Sum of B	42.78	9%

Innisfil Heights Soils Breakdown					
Soil Series	Symbol	Soil Type	Class	Area (ha)	% of Total
BONDHEAD	Bs	SANDY LOAM	AB	15.15	5.7%
BONDHEAD	Bs-b	SANDY LOAM-STONY	AB	51.87	19.4%
SARGENT	Stsl	GRAVELLY SANDY LOAM	AB	13.41	5.0%
TIOGA	Tisl	SANDY LOAM	A	147.68	55.3%
TIOGA	Tis-Vasi	LOAMY SAND	A	33.82	12.7%
DUNDONALD	Ds	SANDY LOAM	AB	4.07	1.5%
TIOGA	Tisl	SANDY LOAM	A	1.15	0.4%
		TOTAL		267.15	

sum of AB (ha)	84.50	32%
sum of A (ha)	182.65	68%

Stroud Soils Breakdown					
Soil Series	Symbol	Soil Type	Class	Area (ha)	% of Total
BONDHEAD	Bs	SANDY LOAM	AB	228.08	97.8%
SARGENT	Stsl	GRAVELLY SANDY LOAM	AB	4.21	1.8%
SMITHFIELD	Smsc	SILTY CLAY LOAM	CD	0.88	0.4%
		TOTAL		233.17	

Sum of AB	232.29	99.6%

Sandy Cove Soils Breakdown					
Soil Series	Symbol	Soil Type	Class	Area (ha)	% of Total
SARGENT	Stsl	GRAVELLY SANDY LOAM	AB	52.27	10%
ALLISTON	Ans	SANDY LOAM	AB	144.39	29%
BONDHEAD	Bs	SANDY LOAM	AB	21.51	4%
BONDHEAD	Bl	LOAM	B	103.28	21%
VASEY	Vasl	SANDY LOAM	AB	32.07	6%
TIOGA	Tisl	SANDY LOAM	A	59.13	12%
GRANBY	Gsl	SANDY LOAM	B	26.32	5%
TIOGA	Tis-b	LOAMY SAND-STONY PHASE	A	46.44	9%
GWILLIMBURY	Gg-b	GRAVELLY SANDY LOAM-STONY PHASE	AB	10.10	2%
BONDHEAD	Bs	SANDY LOAM	AB	5.68	1%
		TOTAL		501.20	

Sum of A	105.57	21.1%
Sum of AB	266.03	53.1%
Sum of B	129.61	25.9%

Fennell's Corners Soils Breakdown					
Soil Series	Symbol	Soil Type	Class	Area (ha)	% of Total
BONDHEAD	Bl	LOAM	B	2.91	15.8%
DUNDONALD	Df	FINE SANDY LOAM	AB	15.56	84.2%
		TOTAL		18.47	

Big Bay Point Soils Breakdown					
Soil Series	Symbol	Soil Type	Class	Area (ha)	% of Total
BONDHEAD	Bs	SANDY LOAM	AB	74.34	31.7%
SARGENT	Stsl	GRAVELLY SANDY LOAM	AB	7.15	3.0%
SCHOMBERG	Shsc-b	SILTY CLAY LOAM-STONY PHASE	C	41.98	17.9%
SARGENT	Stsl	GRAVELLY SANDY LOAM	AB	93.29	39.8%
SIMCOE	Sisc-b	SILTY CLAY LOAM-STEEP PHASE	C	17.93	7.6%
		TOTAL		234.68	

Sum of AB	174.77	74%
Sum of C	59.91	26%

Gilford Soils Breakdown

Soil Series	Symbol	Soil Type	Class	Area (ha)	% of Total
MARSH	Ma	MARSH	B	25.64	13.7%
TIOGA	Tisl	SANDY LOAM	A	9.85	5.3%
GRANBY	Gsl	SANDY LOAM	B	87.24	46.7%
GUERIN	Gul	SANDY LOAM	B	48.10	25.7%
BONDHEAD	Bl	LOAM	B	0.39	0.2%
BONDHEAD	Bs	SANDY LOAM		15.68	8.4%
		TOTAL		186.90	

Sum of A	9.85	5%
Sum of B	177.05	95%

Alcona Central

Soil Series	Symbol	Soil Type	Class	Area (ha)	% of Total
GWILLIMBURY	Gg-b	GRAVELLY SANDY LOAM-STONY PHASE	AB	11.26	1.1%
BONDHEAD	Bs	SANDY LOAM	AB	0.17	0.0%
GUERIN	Gul	SANDY LOAM	B	0.54	0.1%
SMITHFIELD	Smsc	SILTY CLAY LOAM	CD	0.91	0.1%
MUCK	M	MUCK	B	79.57	8.1%
GUERIN	Gul	SANDY LOAM	B	8.49	0.9%
ALLISTON	Ans	SANDY LOAM	AB	54.36	5.5%
TIOGA	Tis-b	LOAMY SAND-STONY PHASE	A	247.54	25.1%
TIOGA	Tis	LOAMY SAND	A	135.32	13.7%
BONDHEAD	Bs-b	SANDY LOAM-STONY	AB	279.41	28.4%
SARGENT	Stsl	GRAVELLY SANDY LOAM	AB	33.04	3.4%
SCHOMBERG	Shsc	SILTY CLAY LOAM	C	40.82	4.1%
GUERIN	Gul-b	LOAM-STONY PHASE	B	74.09	7.5%
ALLISTON	Ans	SANDY LOAM	AB	13.22	1.3%
SMITHFIELD	Smsc	SILTY CLAY LOAM	CD	5.80	0.6%
		TOTAL		984.53	

sum of AB	391.45	40%
sum of A	382.86	39%
Sum of CD	6.71	1%
Sum of B	162.68	17%
Sum of C	40.82	4%

APPENDIX B:

PHOSPHORUS BUDGET CALCULATIONS

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
PHOSPHOROUS BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: ALCONA

Total Drainage Area (ha): 1004.3

LAND USE CATEGORY	Existing Phosphorous Loading Rate (kg/ha/year)	Future Phosphorous Loading Rate (kg/ha/year)	Existing Area (ha)	Future Area (ha)	Existing Phosphorous Loadings (kg/year) (no controls)	Future Phosphorous Loadings (kg/year) (no controls)	Difference +/- (kg/year)	Difference (%) (kg/year)	Existing Phosphorous Loadings (kg/year) with existing ponds	Future Phosphorous Loadings (kg/year) with only existing ponds	Future Phosphorous Loadings (kg/year) with retrofits and controls (Wet Pond (63%))	Future Phosphorous Loadings (kg/year) with retrofits and controls (LID (85%))
Hay - Pasture	0.0700	0.0700	25.89	2.36	1.81	0.17	-1.65	-90.9%	1.81	0.17	0.17	0.17
Cropland	0.1900	0.1900	0.76	2.36	0.14	0.45	0.30	211.4%	0.14	0.45	0.45	0.45
Turf -Sod	0.1200	0.1200	32.79	0.00	3.93	0.00	-3.93	-100.0%	3.93	0.00	0.00	0.00
Quarry	0.0800	0.0800	1.58	0.00	0.13	0.00	-0.13	-100.0%	0.13	0.00	0.00	0.00
Low Intensity Development	0.1300	0.1300	30.52	55.61	3.97	7.23	3.26	82.2%	3.97	7.23	7.23	7.23
Unpaved Road	0.8300	0.8300	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00
High Intensity Development - C/I	1.8200	1.8200	93.07	106.67	169.40	194.14	24.74	14.6%	169.40	194.14	178.55	173.11
High Intensity Development - R	1.3200	1.3200	618.89	732.25	816.93	966.57	149.64	18.3%	551.30	700.94	606.66	613.59
Transition	0.0600	0.0600	42.92	0.00	2.58	0.00	-2.58	-100.0%	2.58	0.00	0.00	0.00
Polder	0.0000	0.0000	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00
Forest	0.0500	0.0500	71.55	18.70	3.58	0.94	-2.64	-73.9%	3.58	0.94	0.94	0.94
Wetland	0.0500	0.0500	86.36	86.36	4.32	4.32	0.00	0.0%	4.32	4.32	4.32	4.32
Total	▨	▨	1004.3	1004.3	1006.8	1173.81	167.0	16.6%	741.1	908.2	798.31	799.79

Notes and Information: 1) Phosphorus Loading Rates determined from MOE's Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed (2012)

Removal Efficiency Assumptions:

Alcona Woods (#9-1) Dry pond, controls 6 ha of residential. No retrofit. Assume 10% removal for for ex. and fut.
Previn Court (Stage 1) (#6-1) Wet pond, controls 74 ha of residential area. No Retrofit. Assume 63% for ex. And fut
Wallace Mills (#7-2) Wet pond, controls 23.9 ha. No retrofit. Assume 63% for ex. and fut.
Wallace Mills (#7-3) Wet pond, controls 28 ha. No retrofit. Assume 63% for ex. and fut.
ORSI (#7-8) Wet pond, controls 32.5 ha. No retrofit. 63% reduction for ex. and fut.
TaylorWoods (#8-2) Dry pond, controls 14 ha estate residential. No retrofit. Assume 10% reduction for ex. and fut.
Crossroads P2 (#8-4) Wet pond, controls 19.9 ha. Assume previously cleaned out, therefore assume 63% removal for ex. and fut.
Skivereen (#8-5) Wet pond, controls 12 ha. No retrofit. Assume 63% removal for ex. and fut.
Tepco North (#6-2) Wet pond, controls 8.5 ha. No retrofit. Assume 63% removal for for ex. and fut.
Tepco South (#6-3) Wet pond, controls 5.9 ha. No retrofit. Assume 63% removal for ex. and fut.

Royal Alcona (#7-1) Wet pond, controls 40.37 ha. Possible Retrofit, therefore assume 30% reduction for ex. and 63% fut.
Innisbrook (#7-6) Wet pond, poor performance, controls 6 ha. No Retrofit. Assume 10% ex and fut
Green AcresSouth (#7-7) Wet pond. Area included in #7-9. No retrofit. Assume 63% removal for ex. and fut.
Green acres North (#7-9) Wet pond controls 23.4 ha ha. Assume 63% removal for ex. and fut. No retrofit. (includes pond #7-7, 7-6. 7
Green Acres West (#7-10) Wet pond. Area included in #7-9. No retrofit. Assume 63% removal for ex. and fut.
Pratt Alcona North (#8-6) Wet pond, controls 8.3 ha. No retrofit. Assume 63% reduction for ex. and fut.
Crossroads P1 (Pond #8-3) Wet pond, controls 20.54 ha. No retrofit. Assume 63% for ex. and fut.
Pratt D'Amico P1 (#8-7) Wet pond, controls 10.4ha . No retrofi. Assume 63% for ex. and fut.
Crossraods Addulum (#8-9) Dry pond, controls 2.44 ha. No Retrofit. Assume 10% removal for ex. and fut.
Woodland Park North (#7-11) Wet Pond, controls 11.44 ha . Assume 63% removal
Woodland Park North (#7-12) Wet Pond, controls 5.9 ha. Assume 63% removal

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
PHOSPHOROUS BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: FENNELL'S CORNERS (LSRCA BOUNDARY

Total Drainage Area (ha): 18.5

LAND USE CATEGORY	Existing Phosphorous Loading Rate (kg/ha/year)	Future Phosphorous Loading Rate (kg/ha/year)	Existing Area (ha)	Future Area (ha)	Existing Phosphorous Loadings (kg/year)	Future Phosphorous Loadings (kg/year)	Difference +/- (kg/year)	Difference (%) (kg/year)	Existing Phosphorous Loadings (kg/year) with existing swm pond	Future Phosphorous Loadings (kg/year) with reduction factor
Hay - Pasture	0.0700	0.0700	0.04	0.05	0.00	0.00	0.00	20.5%	0.00	0.00
Cropland	0.1900	0.1900	0.00	0.05	0.00	0.01	0.01	34666.1%	0.00	0.01
Turf -Sod	0.1200	0.1200	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
Quarry	0.0800	0.0800	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
Low Intensity Development	0.1300	0.1300	0.00	0.14	0.00	0.02	0.02	0.0%	0.00	0.02
Unpaved Road	0.8300	0.8300	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
High Intensity Development - C/I	1.8200	1.8200	1.46	2.63	2.65	4.79	2.13	80.3%	2.65	3.51
High Intensity Development - R	1.3200	1.3200	16.97	15.60	22.40	20.59	-1.81	-8.1%	14.48	21.68
Transition	0.0600	0.0600	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
Polder	0.0000	0.0000	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
Forest	0.0500	0.0500	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
Wetland	0.0500	0.0500	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
Total	▨	▨	18.5	18.5	25.05	25.4	0.4	1.4%	17.14	25.21

Notes and Information:	1) Phosphorus Loading Rates determined from MOE's Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed (2012)
Removal Efficiency Assumptions:	The Goldcrest Wet Pond (#15-1) controls 12.57 ha of residential development. The pond is functioning well, and does not require retrofit. The removal efficiency is assumed to be 63% There is no future development in this area, thereore there are no proposed future controls or retrofit opportunities

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
PHOSPHOROUS BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: GILFORD

Total Drainage Area (ha): 186.99

LAND USE CATEGORY	Existing Phosphorous Loading Rate (kg/ha/year)	Future Phosphorous Loading Rate (kg/ha/year)	Existing Area (ha)	Future Area (ha)	Existing Phosphorous Loadings (kg/year) (no controls)	Future Phosphorous Loadings (kg/year) (no controls)	Difference +/-(kg/year)	Difference (%) (kg/year)	Future Phosphorous Loadings (kg/year) with controls (Wet Pond (63%))	Future Phosphorous Loadings (kg/year) with LID Controls (85% Removal Efficiency)
Hay - Pasture	0.0700	0.0700	0.00	0.13	0.00	0.01	0.01	0.0%	0.01	0.01
Cropland	0.1900	0.1900	13.15	0.13	2.50	0.02	-2.47	-99.0%	0.02	0.02
Turf -Sod	0.1200	0.1200	0.82	0.00	0.10	0.00	-0.10	-100.0%	0.00	0.00
Quarry	0.0800	0.0800	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
Low Intensity Development	0.1300	0.1300	0.47	5.13	0.06	0.67	0.61	986.6%	0.67	0.67
Unpaved Road	0.8300	0.8300	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
High Intensity Development - C/I	1.8200	1.8200	4.41	11.91	8.03	21.68	13.64	169.8%	13.08	10.08
High Intensity Development - R	1.3200	1.3200	104.73	156.60	138.25	206.71	68.47	49.5%	163.58	148.52
Transition	0.0600	0.0600	35.36	0.00	2.12	0.00	-2.12	-100.0%	0.00	0.00
Polder	0.0000	0.0000	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
Forest	0.0500	0.0500	22.11	7.16	1.11	0.36	-0.75	-67.6%	0.36	0.36
Wetland	0.0500	0.0500	5.94	5.94	0.30	0.30	0.00	0.0%	0.30	0.30
Total			186.99	186.99	152.46	229.75	77.28	50.7%	178.02	159.95

Notes and Information: 1) Phosphorus Loading Rates determined from MOE's Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed (2012)

Removal Efficiency Assumptions: Future controls assume all development will be controlled by either Wet Pond (63% Removal Efficiency) or LID controls (85% Removal Efficiency)

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
PHOSPHOROUS BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: INNISFIL HEIGHTS

Total Drainage Area (ha): 267.1

LAND USE CATEGORY	Existing Phosphorous Loading Rate (kg/ha/year)	Future Phosphorous Loading Rate (kg/ha/year)	Existing Area (ha)	Future Area (ha)	Existing Phosphorous Loadings (kg/year) (no controls)	Future Phosphorous Loadings (kg/year) (no controls)	Difference +/-(kg/year)	Difference (%) (kg/year)	Existing Phosphorous Loadings (kg/year) with existing controls	Existing Phosphorous Loadings (kg/year) with retrofit controls	Future Phosphorous Loadings (kg/year) with only existing controls	Future Phosphorous Loadings (kg/year) with retrofits and controls (Wet Pond (63%))	Future Phosphorous Loadings (kg/year) with retrofits and controls (LID (85%))
Hay - Pasture	0.0700	0.0700	5.23	1.77	0.37	0.12	-0.24	-66.1%	0.37	0.37	0.12	0.12	0.12
Cropland	0.1900	0.1900	28.24	1.77	5.36	0.34	-5.03	-93.7%	5.36	5.36	0.34	0.34	0.34
Turf -Sod	0.1200	0.1200	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00
Quarry	0.0800	0.0800	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00
Low Intensity Development	0.1300	0.1300	11.81	0.00	1.53	0.00	-1.53	-100.0%	1.41	1.41	0.00	0.00	0.00
Unpaved Road	0.8300	0.8300	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00
High Intensity Development - C/I	1.8200	1.8200	160.05	257.85	291.29	469.29	178.00	61.1%	252.03	222.13	398.33	286.19	247.03
High Intensity Development - R	1.3200	1.3200	2.01	0.18	2.65	0.24	-2.41	-90.8%	2.65	2.65	0.24	0.24	0.24
Transition	0.0600	0.0600	38.33	0.00	2.30	0.00	-2.30	-100.0%	2.30	2.30	0.00	0.00	0.00
Polder	0.0000	0.0000	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00
Forest	0.0500	0.0500	21.49	5.56	1.07	0.28	-0.80	-74.1%	1.07	1.07	0.28	0.28	0.28
Wetland	0.0500	0.0500	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00	0.00	0.00	0.00
Total	▨	▨	267.1	267.1	304.58	470.3	165.7	54.4%	265.20	235.29	399.32	287.18	248.02

Notes and Information: 1) Phosphorus Loading Rates determined from MOE's Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed (2012)

Removal Efficiency Assumptions: Forest Valley Pond (#7-4) is a dry swm facility and controls 9.86 ha of estate residential - No Retrofit (Assume 10% reduction for existing and future)
Trillium Industrial (#8-1) is a dry pond and controls 31 ha of industrial land. Prioirty 1 retorift (assume 10% existing Removal, convert to 63% for retrofit to Wet Pond)
Doral East (#9-4) is a wet pond for 21.67 ha of industrial. No retrofit. Assume 63% reduction for existing and future
Doral West (#9-5) is a wet pond, provides controls to 7.65 ha of land. No retrofit. Assume 63% reduction for existing and future

Future controls assume all development will be controlled by either Wet Pond (63% Removal Efficiency) or LID controls (85% Removal Efficiency)

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
PHOSPHOROUS BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: LEFROY

Total Drainage Area (ha): 483.8

LAND USE CATEGORY	Existing Phosphorous Loading Rate (kg/ha/year)	Future Phosphorous Loading Rate (kg/ha/year)	Existing Area (ha)	Future Area (ha)	Existing Phosphorous Loadings (kg/year) (no controls)	Future Phosphorous Loadings (kg/year) (no controls)	Difference +/- (kg/year)	Difference (%) (kg/year)	Future Phosphorous Loadings (kg/year) with controls (Wet Pond (63%))	Future Phosphorous Loadings (kg/year) with LID Controls (85%)
Hay - Pasture	0.0700	0.0700	62.83	0.22	4.40	0.02	-4.38	-99.6%	0.02	0.02
Cropland	0.1900	0.1900	26.30	0.22	5.00	0.04	-4.95	-99.1%	0.04	0.04
Turf -Sod	0.1200	0.1200	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
Quarry	0.0800	0.0800	5.38	0.91	0.43	0.07	-0.36	-83.1%	0.07	0.07
Low Intensity Development	0.1300	0.1300	5.37	6.32	0.70	0.82	0.12	17.7%	0.82	0.82
Unpaved Road	0.8300	0.8300	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
High Intensity Development - C/I	1.8200	1.8200	28.64	35.86	52.12	65.27	13.15	25.2%	56.98	54.09
High Intensity Development - R	1.3200	1.3200	169.76	257.14	224.09	339.43	115.34	51.5%	266.76	241.39
Transition	0.0600	0.0600	20.54	0.00	1.23	0.00	-1.23	-100.0%	0.00	0.00
Polder	0.0000	0.0000	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
Forest	0.0500	0.0500	68.30	81.85	3.41	4.09	0.68	19.9%	4.09	4.09
Wetland	0.0500	0.0500	96.64	101.22	4.83	5.06	0.23	4.7%	5.06	5.06
Total	▨	▨	483.8	483.8	296.21	414.8	118.6	40.0%	333.85	305.58

Notes and Information: 1) Phosphorus Loading Rates determined from MOE's Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed (2012)

Removal Efficiency Assumptions: Future controls assume all development will be controlled by either Wet Pond (63% Removal Efficiency) or LID controls (85% Removal Efficiency)

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
PHOSPHOROUS BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: SANDY COVE

Total Drainage Area (ha): 501.5

LAND USE CATEGORY	Existing Phosphorous Loading Rate (kg/ha/year)	Future Phosphorous Loading Rate (kg/ha/year)	Existing Area (ha)	Future Area (ha)	Existing Phosphorous Loadings (kg/year) (no controls)	Future Phosphorous Loadings (kg/year) (no controls)	Difference +/-(kg/year)	Difference (%) (kg/year)	Future Phosphorous Loadings (kg/year) with controls (Wet Pond (63%))	Future Phosphorous Loadings (kg/year) with controls (LID (85%))
Hay - Pasture	0.0700	0.0700	12.30	3.33	0.86	0.23	-0.63	-72.9%	0.23	0.23
Cropland	0.1900	0.1900	76.83	3.33	14.60	0.63	-13.96	-95.7%	0.63	0.63
Turf -Sod	0.1200	0.1200	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
Quarry	0.0800	0.0800	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
Low Intensity Development	0.1300	0.1300	0.11	13.62	0.01	1.77	1.76	11807.0%	1.77	1.77
Unpaved Road	0.8300	0.8300	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
High Intensity Development - C/I	1.8200	1.8200	20.00	11.45	36.40	20.84	-15.57	-42.8%	36.40	36.40
High Intensity Development - R	1.3200	1.3200	228.82	381.72	302.04	503.88	201.84	66.8%	376.72	332.31
Transition	0.0600	0.0600	7.64	0.00	0.46	0.00	-0.46	-100.0%	0.00	0.00
Polder	0.0000	0.0000	0.00	0.00	0.00	0.00	0.00	0.0%	0.00	0.00
Forest	0.0500	0.0500	130.61	68.09	6.53	3.40	-3.13	-47.9%	3.40	3.40
Wetland	0.0500	0.0500	25.23	20.00	1.26	1.00	-0.26	-20.7%	1.00	1.00
Total			501.5	501.5	362.17	531.8	169.6	46.8%	420.16	375.76

Notes and Information: 1) Phosphorus Loading Rates determined from MOE’s Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed (2012)

Removal Efficiency Assumptions: Future controls assume all development will be controlled by either Wet Pond (63% Removal Efficiency) or LID controls (85% Removal Efficiency)

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
PHOSPHOROUS BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: STROUD

Total Drainage Area (ha): 233.2

LAND USE CATEGORY	Existing Phosphorous Loading Rate (kg/ha/year)	Future Phosphorous Loading Rate (kg/ha/year)	Existing Area (ha)	Future Area (ha)	Existing Phosphorous Loadings (kg/year) (no controls)	Future Phosphorous Loadings (kg/year) (no controls)	Difference +/- (kg/year)	Difference (%) (kg/year)	Existing Phosphorous Loadings (kg/year) with existing controls	Existing Phosphorous Loadings (kg/year) with retrofit controls	Difference +/- (kg/year)	Difference (%) (kg/year)	Future Phosphorous Loadings (kg/year) with retrofits and controls (Wet Pond (63%))	Future Phosphorous Loadings (kg/year) with retrofits and controls (LID (85%))
Hay - Pasture	0.0700	0.0700	0.00	0.59	0.000	0.041	0.04	0.0%	0.000	0.000	0.000	0.0%	0.04	0.04
Cropland	0.1900	0.1900	63.01	0.59	11.972	0.112	-11.86	-99.1%	11.972	11.972	0.000	0.0%	0.11	0.11
Turf -Sod	0.1200	0.1200	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00
Quarry	0.0800	0.0800	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00
Low Intensity Development	0.1300	0.1300	7.43	9.99	0.966	1.299	0.33	34.5%	0.966	0.966	0.000	0.0%	1.66	1.35
Unpaved Road	0.8300	0.8300	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00
High Intensity Development - C/I	1.8200	1.8200	42.74	29.57	77.784	53.809	-23.98	-30.8%	77.784	77.784	0.000	0.0%	53.81	53.81
High Intensity Development - R	1.3200	1.3200	115.62	190.56	152.614	251.546	98.93	64.8%	139.621	87.550	-52.071	-37.3%	114.26	102.39
Transition	0.0600	0.0600	2.86	0.00	0.172	0.000	-0.17	-100.0%	0.172	0.172	0.000	0.0%	0.00	0.00
Polder	0.0000	0.0000	0.00	0.00	0.000	0.000	0.00	0.0%	0.000	0.000	0.000	0.0%	0.00	0.00
Forest	0.0500	0.0500	1.51	1.51	0.075	0.075	0.00	0.0%	0.075	0.075	0.000	0.0%	0.08	0.08
Wetland	0.0500	0.0500	0.00	0.36	0.000	0.018	0.02	0.0%	0.000	0.000	0.000	0.0%	0.02	0.02
Total			233.2	233.2	243.58	306.9	63.3	26.0%	230.6	178.5	-52.1	-23%	169.98	157.80

Notes and Information: 1) Phosphorus Loading Rates determined from MOE's Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed (2012)

Removal Efficiency Assumptions:
Southview pond (#9-2) is a dry pond with 28 ha of low density residential draining to it - Priority 1 Retrofit (assume 10% existing Removal, convert to 63% for retrofit to Wet Pond)
Brandy Lane pond (#10-1) is originally dry, converted to wet. Poorly functioning. 15.46 ha of developed land - Priority 1 Retrofit (assume 10% existing Removal, convert to 63% for retrofit to Wet Pond)
Village North Dempster Pond (#10-2) is dry pond with 30.97 ha of developed drainage area - Priority 1 Retrofit (assume 10% existing Removal, convert to 63% for retrofit to Wet Pond)
Victoria Green pnd (#9-3) is a dry pond with 24 ha. No urgent retrofit (assume 10% removal for ex and future)

Future controls assume all development will be controlled by either Wet Pond (63% Removal Efficiency) or LID controls (85% Removal Efficiency)

APPENDIX C:
WATER BUDGET

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)

RUNOFF COEFFICIENTS

Land Use	MIN	MEDIAN	MAX
Pavement (asphalt or concrete)	0.8	0.875	0.95
Pavement (brick)	0.7	0.775	0.85
Gravel roads and shoulders	0.4	0.5	0.6
Roofs	0.7	0.825	0.95
Business- Downtown	0.7	0.825	0.95
Business- neighbourhood	0.5	0.6	0.7
business - light	0.5	0.65	0.8
Business- heavy	0.6	0.75	0.9
Residential- single family urban	0.3	0.4	0.5
residential- multiple, detached	0.4	0.5	0.6
Residential- multiple, attached	0.6	0.675	0.75
Residential- suburban	0.25	0.325	0.4
Industrial- light	0.5	0.65	0.8
Industrial- Heavy	0.6	0.75	0.9
Apartments	0.5	0.6	0.7
Parks, cemetaries	0.1	0.175	0.25
Playgrounds (unpaved)	0.2	0.275	0.35
Railroad yards	0.2	0.275	0.35
Unimproved areas	0.1	0.2	0.3
Lawns- Sandy soil- flat to 2%	0.05	0.075	0.1
Lawns- Sandy soil- average, 2 to 7%	0.1	0.125	0.15
Lawns- Sandy soil- steep, over 7%	0.15	0.175	0.2
Lawns- Clayey soil- flat to 2%	0.13	0.15	0.17
Lawns- Clayey soil-average, 2 to 7%	0.18	0.2	0.22
Lawns- Clayey soil- steep, over 7%	0.25	0.3	0.35

Note: Runoff Coefficients from Town of Innisifl Engineering Standards, which refers to MTO Drainage chart 1.07

Land Use	Open Sand Loam	Loam or Silt Loam	Clay Loam or Clay
Cultivated Land, 0 - 5% grade	0.22	0.35	0.55
Cultivated Land, 5 -10% grade	0.3	0.45	0.6
Cultivated Land, 10 - 30% grade	0.4	0.65	0.7
Pasture Land, 0 - 5% grade	0.1	0.28	0.4
Pasture Land, 5 -10% grade	0.15	0.35	0.45
Pasture Land, 10 - 30% grade	0.22	0.4	0.55
Woodlot or Cutover, 0 - 5% grade	0.08	0.25	0.35
Woodlot or Cutover, 5 -10% grade	0.12	0.3	0.42
Woodlot or Cutover, 10 -30% grade	0.18	0.35	0.52
Lakes and Wetlands	0.05	0.05	0.05

Note: Runoff Coefficients from Town of Innisifl Engineering Standards, which refers to MTO Drainage chart 1.07

EXISTING CONDITIONS WATER BALANCE

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: ALCONA CENTRAL

RUNOFF COEFFICIENT - EXISTING CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: Min-2, Med-3, Max-4	3
Runoff Coeffcient "C" Reference No. for MTO chart: Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4	2

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	53.1	46.50
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65		0.00
Business- heavy	0.75	39.2	29.38
Residential- single family urban	0.40	606.8	242.71
residential- multiple, detached	0.50		0.00
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	12.1	3.93
Industrial- light	0.65		0.00
Industrial- Heavy	0.75	0.8	0.57
Apartments	0.60		0.00
Parks, cemetaries	0.18	61.1	10.70
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28	2.2	0.60
Unimproved areas	0.20	1.6	0.32
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	6.3	1.38
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10	25.9	2.59
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08	83.4	6.67
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05	112.0	5.60
Weighted Average	▨	1004.3	0.349

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: ALCONA CENTRAL

EXISTING CONDITIONS

Runoff Coefficient:	0.35
Thornthwaite Coefficient	1.081

Month	Temperature (^{o}C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.82	0	0	83	0	54	29
February	-6.6	61.9	0.0	0	0.82	0	0	62	0	40	22
March	-2.1	58.2	0.0	0	1.03	0	0	58	0	38	20
April	5.6	62.3	1.2	28	1.12	31	31	31	0	20	11
May	12.3	82.4	3.9	74	1.27	94	82	0	12	0	0
June	17.9	84.8	6.9	113	1.28	144	85	0	60	0	0
July	20.8	77.2	8.7	134	1.30	174	77	0	97	0	0
August	19.7	89.9	8.0	116	1.20	139	90	0	49	0	0
September	15.3	94	5.4	76	1.04	79	79	15	0	10	5
October	8.7	77.5	2.3	37	0.95	35	35	42	0	27	15
November	2.7	88.8	0.4	9	0.81	7	7	82	0	53	29
December	-3.5	73.6	0.0	0	0.78	0	0	74	0	48	26
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	290.1	155.8

Note:

1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: FENNELL'S CORNERS

RUNOFF COEFFICIENT - EXISTING CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: 3
Min-2, Med-3, Max-4

Runoff Coeffcient "C" Reference No. for MTO chart: 2
Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	1.3	1.17
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65		0.00
Business- heavy	0.75	0.1	0.09
Residential- single family urban	0.40	15.7	6.28
residential- multiple, detached	0.50		0.00
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	1.3	0.41
Industrial- light	0.65		0.00
Industrial- Heavy	0.75	0.0	0.00
Apartments	0.60		0.00
Parks, cemetaries	0.18	0.0	0.00
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28	0.0	0.00
Unimproved areas	0.20	0.0	0.00
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	0.0	0.00
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10	0.0	0.00
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08	0.0	0.00
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05	0.0	0.00
Weighted Average	▨	18.5	0.431

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: FENNELL'S CORNERS

EXISTING CONDITIONS

Runoff Coefficient:	0.43
Thornthwaite Coefficient	1.081

Month	Temperature (^{o}C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.8	0	0	83	0	47	36
February	-6.6	61.9	0.0	0	0.8	0	0	62	0	35	27
March	-2.1	58.2	0.0	0	1.0	0	0	58	0	33	25
April	5.6	62.3	1.2	28	1.1	31	31	31	0	18	13
May	12.3	82.4	3.9	74	1.3	94	82	0	12	0	0
June	17.9	84.8	6.9	113	1.3	144	85	0	60	0	0
July	20.8	77.2	8.7	134	1.3	174	77	0	97	0	0
August	19.7	89.9	8.0	116	1.2	139	90	0	49	0	0
September	15.3	94	5.4	76	1.0	79	79	15	0	9	6
October	8.7	77.5	2.3	37	1.0	35	35	42	0	24	18
November	2.7	88.8	0.4	9	0.8	7	7	82	0	46	35
December	-3.5	73.6	0.0	0	0.8	0	0	74	0	42	32
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	253.8	192.1

Note: 1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: GILFORD

RUNOFF COEFFICIENT - EXISTING CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: Min-2, Med-3, Max-4	3
Runoff Coeffcient "C" Reference No. for MTO chart: Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4	2

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	4.4	3.86
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65		0.00
Business- heavy	0.75	0.0	0.00
Residential- single family urban	0.40	99.7	39.87
residential- multiple, detached	0.50		0.00
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	5.1	1.65
Industrial- light	0.65		0.00
Industrial- Heavy	0.75	0.0	0.00
Apartments	0.60		0.00
Parks, cemetaries	0.18	0.8	0.14
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28	0.5	0.13
Unimproved areas	0.20	0.0	0.00
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	13.1	2.89
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10	0.0	0.00
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08	45.0	3.60
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05	18.4	0.92
Weighted Average		187.0	0.284

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: GILFORD

EXISTING CONDITIONS

Runoff Coefficient:	0.28
Thornthwaite Coefficient	1.081

Month	Temperature (°C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.8	0	0	83	0	59	23
February	-6.6	61.9	0.0	0	0.8	0	0	62	0	44	18
March	-2.1	58.2	0.0	0	1.0	0	0	58	0	42	17
April	5.6	62.3	1.2	28	1.1	31	31	31	0	22	9
May	12.3	82.4	3.9	74	1.3	94	82	0	12	0	0
June	17.9	84.8	6.9	113	1.3	144	85	0	60	0	0
July	20.8	77.2	8.7	134	1.3	174	77	0	97	0	0
August	19.7	89.9	8.0	116	1.2	139	90	0	49	0	0
September	15.3	94	5.4	76	1.0	79	79	15	0	11	4
October	8.7	77.5	2.3	37	1.0	35	35	42	0	30	12
November	2.7	88.8	0.4	9	0.8	7	7	82	0	58	23
December	-3.5	73.6	0.0	0	0.8	0	0	74	0	53	21
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	319.4	126.5

Note: 1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: INNISFIL HEIGHTS

RUNOFF COEFFICIENT - EXISTING CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: Min-2, Med-3, Max-4	3
Runoff Coeffcient "C" Reference No. for MTO chart: Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4	2

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	40.5	35.46
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65		0.00
Business- heavy	0.75	2.6	1.94
Residential- single family urban	0.40	0.0	0.00
residential- multiple, detached	0.50		0.00
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	2.0	0.65
Industrial- light	0.65		0.00
Industrial- Heavy	0.75	116.9	87.70
Apartments	0.60		0.00
Parks, cemetaries	0.18	7.7	1.36
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28	4.1	1.12
Unimproved areas	0.20	0.0	0.00
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	28.2	6.21
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10	5.2	0.52
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08	26.5	2.12
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05	33.4	1.67
Weighted Average	▨	267.1	0.519

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: INNISFIL HEIGHTS

EXISTING CONDITIONS

Runoff Coefficient:	0.52
Thornthwaite Coefficient	1.081

Month	Temperature (^{o}C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.8	0	0	83	0	40	43
February	-6.6	61.9	0.0	0	0.8	0	0	62	0	30	32
March	-2.1	58.2	0.0	0	1.0	0	0	58	0	28	30
April	5.6	62.3	1.2	28	1.1	31	31	31	0	15	16
May	12.3	82.4	3.9	74	1.3	94	82	0	12	0	0
June	17.9	84.8	6.9	113	1.3	144	85	0	60	0	0
July	20.8	77.2	8.7	134	1.3	174	77	0	97	0	0
August	19.7	89.9	8.0	116	1.2	139	90	0	49	0	0
September	15.3	94	5.4	76	1.0	79	79	15	0	7	8
October	8.7	77.5	2.3	37	1.0	35	35	42	0	20	22
November	2.7	88.8	0.4	9	0.8	7	7	82	0	39	42
December	-3.5	73.6	0.0	0	0.8	0	0	74	0	35	38
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	214.3	231.6

Note:
1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: LEFROY

RUNOFF COEFFICIENT - EXISTING CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: 3
Min-2, Med-3, Max-4

Runoff Coeffcient "C" Reference No. for MTO chart: 2
Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	15.8	13.80
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65		0.00
Business- heavy	0.75	10.6	7.91
Residential- single family urban	0.40	153.5	61.39
residential- multiple, detached	0.50		0.00
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	16.3	5.29
Industrial- light	0.65		0.00
Industrial- Heavy	0.75	2.3	1.74
Apartments	0.60		0.00
Parks, cemetaries	0.18	3.4	0.59
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28	2.0	0.55
Unimproved areas	0.20	5.4	1.08
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	26.3	5.79
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10	62.8	6.28
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08	88.2	7.05
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05	97.3	4.86
Weighted Average	▨	483.8	0.240

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: LEFROY

EXISTING CONDITIONS

Runoff Coefficient: 0.24
Thornthwaite Coefficient 1.081

Month	Temperature (°C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.8	0	0	83	0	63	20
February	-6.6	61.9	0.0	0	0.8	0	0	62	0	47	15
March	-2.1	58.2	0.0	0	1.0	0	0	58	0	44	14
April	5.6	62.3	1.2	28	1.1	31	31	31	0	24	7
May	12.3	82.4	3.9	74	1.3	94	82	0	12	0	0
June	17.9	84.8	6.9	113	1.3	144	85	0	60	0	0
July	20.8	77.2	8.7	134	1.3	174	77	0	97	0	0
August	19.7	89.9	8.0	116	1.2	139	90	0	49	0	0
September	15.3	94	5.4	76	1.0	79	79	15	0	11	4
October	8.7	77.5	2.3	37	1.0	35	35	42	0	32	10
November	2.7	88.8	0.4	9	0.8	7	7	82	0	62	20
December	-3.5	73.6	0.0	0	0.8	0	0	74	0	56	18
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	338.7	107.2

Note: 1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: SANDY COVE- EXISTING

RUNOFF COEFFICIENT - EXISTING CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: 3
Min-2, Med-3, Max-4

Runoff Coeffcient "C" Reference No. for MTO chart: 2
Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	19.8	17.31
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65		0.00
Business- heavy	0.75	0.2	0.17
Residential- single family urban	0.40	224.1	89.65
residential- multiple, detached	0.50		0.00
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	4.7	1.52
Industrial- light	0.65	0.0	0.00
Industrial- Heavy	0.75	0.0	0.00
Apartments	0.60		0.00
Parks, cemetaries	0.18	0.1	0.02
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28	0.0	0.00
Unimproved areas	0.20		0.00
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	76.8	16.90
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10	12.3	1.23
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08	133.3	10.66
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05	30.2	1.51
Weighted Average	▨	501.5	0.277

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: SANDY COVE- EXISTING

EXISTING CONDITIONS

Runoff Coefficient:	0.28
Thornthwaite Coefficient	1.081

Month	Temperature (°C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.8	0	0	83	0	60	23
February	-6.6	61.9	0.0	0	0.8	0	0	62	0	45	17
March	-2.1	58.2	0.0	0	1.0	0	0	58	0	42	16
April	5.6	62.3	1.2	28	1.1	31	31	31	0	22	9
May	12.3	82.4	3.9	74	1.3	94	82	0	12	0	0
June	17.9	84.8	6.9	113	1.3	144	85	0	60	0	0
July	20.8	77.2	8.7	134	1.3	174	77	0	97	0	0
August	19.7	89.9	8.0	116	1.2	139	90	0	49	0	0
September	15.3	94	5.4	76	1.0	79	79	15	0	11	4
October	8.7	77.5	2.3	37	1.0	35	35	42	0	30	12
November	2.7	88.8	0.4	9	0.8	7	7	82	0	59	23
December	-3.5	73.6	0.0	0	0.8	0	0	74	0	53	20
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	322.3	123.6

Note:
1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: STROUD

RUNOFF COEFFICIENT - EXISTING CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: 3
Min-2, Med-3, Max-4

Runoff Coeffcient "C" Reference No. for MTO chart: 2
Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	28.2	24.64
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65		0.00
Business- heavy	0.75	14.6	10.93
Residential- single family urban	0.40	115.6	46.25
residential- multiple, detached	0.50		0.00
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	0.0	0.00
Industrial- light	0.65		0.00
Industrial- Heavy	0.75	0.0	0.00
Apartments	0.60		0.00
Parks, cemetaries	0.18	7.1	1.24
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28	0.3	0.09
Unimproved areas	0.20	0.0	0.00
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	63.0	13.86
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10	0.0	0.00
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08	1.5	0.12
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05	2.9	0.14
Weighted Average	▨	233.2	0.42

Note: Natural Heritage Feature land was broken down at 50% woodlot, 50% wetlands

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: STROUD

EXISTING CONDITIONS

Runoff Coefficient:	0.42
Thornthwaite Coefficient	1.081

Month	Temperature (°C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.8	0	0	83	0	48	34
February	-6.6	61.9	0.0	0	0.8	0	0	62	0	36	26
March	-2.1	58.2	0.0	0	1.0	0	0	58	0	34	24
April	5.6	62.3	1.2	28	1.1	31	31	31	0	18	13
May	12.3	82.4	3.9	74	1.3	94	82	0	12	0	0
June	17.9	84.8	6.9	113	1.3	144	85	0	60	0	0
July	20.8	77.2	8.7	134	1.3	174	77	0	97	0	0
August	19.7	89.9	8.0	116	1.2	139	90	0	49	0	0
September	15.3	94	5.4	76	1.0	79	79	15	0	9	6
October	8.7	77.5	2.3	37	1.0	35	35	42	0	25	18
November	2.7	88.8	0.4	9	0.8	7	7	82	0	48	34
December	-3.5	73.6	0.0	0	0.8	0	0	74	0	43	31
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	259.9	186.0

Note:
1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

FUTURE CONDITIONS WATER BALANCE

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: ALCONA CENTRAL- FUTURE

RUNOFF COEFFICIENT - FUTURE CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: 3
Min-2, Med-3, Max-4

Runoff Coeffcient "C" Reference No. for MTO chart: 2
Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	51.5	45.10
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65	3.3	2.17
Business- heavy	0.75	55.1	41.35
Residential- single family urban	0.40	679.4	271.77
residential- multiple, detached	0.50	49.5	24.75
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	0.0	0.00
Industrial- light	0.65		0.00
Industrial- Heavy	0.75	0.0	0.00
Apartments	0.60		0.00
Parks, cemetaries	0.18	55.6	9.73
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28		0.00
Unimproved areas	0.20	0.0	0.00
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	4.7	1.04
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10		0.00
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08	52.5	4.20
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05	52.5	2.63
Weighted Average	▨	1004.33	0.40

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: ALCONA CENTRAL- FUTURE

FUTURE CONDITIONS

Runoff Coefficient:	0.40
Thornthwaite Coefficient	1.081

Month	Temperature (^{o}C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.8	0	0	83	0	49	33
February	-6.6	61.9	0.0	0	0.8	0	0	62	0	37	25
March	-2.1	58.2	0.0	0	1.0	0	0	58	0	35	23
April	5.6	62.3	1.2	28	1.1	31	31	31	0	19	12
May	12.3	82.4	3.9	74	1.3	94	82	0	12	0	0
June	17.9	84.8	6.9	113	1.3	144	85	0	60	0	0
July	20.8	77.2	8.7	134	1.3	174	77	0	97	0	0
August	19.7	89.9	8.0	116	1.2	139	90	0	49	0	0
September	15.3	94	5.4	76	1.0	79	79	15	0	9	6
October	8.7	77.5	2.3	37	1.0	35	35	42	0	25	17
November	2.7	88.8	0.4	9	0.8	7	7	82	0	49	33
December	-3.5	73.6	0.0	0	0.8	0	0	74	0	44	30
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	267.1	178.8

Note:
1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

SETTLEMENT AREA: ALCONA CENTRAL- FUTURE
Comparison

Total Area= 1004.33 ha

	Ex. Infiltration	Future Infiltration	Difference	Difference (%)
Annual Depth (mm)	290.09	267.10	(22.99)	-8%
Annual Volume (cu.m)	2,913,445.36	2,682,523.13	(230,922.23)	-8%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: ALCONA CENTRAL- FUTURE

Mitigation

Infiltration Design Calculations
Total Proposed Impervious Area: 11.9 ha

Note: Red cell = user input

Average Annual Rainfall (10 mm)

Design Rainfall =	25	mm
Area =	11.9	ha
Volume =	2975.0	cu.m
Provided Storage Volume =	82.2	cu.m
Average Total Yearly Depth (from 10 mm storm events and less) =	746.6	mm
Yearly Volume =	88,845.40	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	81%	
Annual Defecit =	230,922.23	cu.m
Volume check =	INNSUFFICENT	
Yearly Infiltrated volume =	88,845.40	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	25	mm
Min yearly depth		mm
Max yearly depth		mm
Average Yearly Depth	746.6	mm

Average Total Annual Rainfall 918.4 mm

Average Annual Rainfall (15 mm)

Design Rainfall =	15	mm
Area =	11.9	ha
Volume =	1785.0	cu.m
Provided Storage Volume =	64.4	cu.m
Average Total Yearly Depth =	539.7	mm
Yearly Volume =	64,224.30	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	59%	
Annual Defecit =	230,922.23	cu.m
Volume check =	INNSUFFICENT	
Yearly Infiltrated volume =	64224.3	cu.m
Net Infiltration with mitigation =	-166697.93	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	15	mm
Min yearly depth	401.1	mm
Max yearly depth	659	mm
Average Yearly Depth	539.7	mm

Average Annual Rainfall (25 mm)

Design Rainfall =	25	mm
Area =	11.9	ha
Volume =	2975.0	cu.m
Provided Storage Volume =	64.4	cu.m
Average Total Yearly Depth =	726.2	mm
Yearly Volume =	86,417.80	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	79%	
Annual Defecit =	230,922.23	cu.m
Volume check =	INNSUFFICENT	
Yearly Infiltrated volume =	86417.8	cu.m
Net Infiltration with mitigation =	-144504.43	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	25	mm
Min yearly depth	574.8	mm
Max yearly depth	935	mm
Average Yearly Depth	726.2	mm

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: GILFORD- FUTURE

RUNOFF COEFFICIENT - FUTURE CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: 3
Min-2, Med-3, Max-4

Runoff Coeffcient "C" Reference No. for MTO chart: 2
Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	4.2	3.69
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65	0.0	0.00
Business- heavy	0.75	7.7	5.77
Residential- single family urban	0.40	117.5	47.00
residential- multiple, detached	0.50	0.0	0.00
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	39.1	12.71
Industrial- light	0.65		0.00
Industrial- Heavy	0.75	0.0	0.00
Apartments	0.60		0.00
Parks, cemetaries	0.18	11.7	2.05
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28		0.00
Unimproved areas	0.20	0.0	0.00
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	0.3	0.06
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10		0.00
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08	6.5	0.52
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05		0.00
Weighted Average	▨	187.0	0.38

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: GILFORD- FUTURE

FUTURE CONDITIONS

Runoff Coefficient: 0.38
Thornthwaite Coefficient 1.081

Month	Temperature (^{o}C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.8	0	0	83	0	51	32
February	-6.6	61.9	0.0	0	0.8	0	0	62	0	38	24
March	-2.1	58.2	0.0	0	1.0	0	0	58	0	36	22
April	5.6	62.3	1.2	28	1.1	31	31	31	0	19	12
May	12.3	82.4	3.9	74	1.3	94	82	0	12	0	0
June	17.9	84.8	6.9	113	1.3	144	85	0	60	0	0
July	20.8	77.2	8.7	134	1.3	174	77	0	97	0	0
August	19.7	89.9	8.0	116	1.2	139	90	0	49	0	0
September	15.3	94	5.4	76	1.0	79	79	15	0	9	6
October	8.7	77.5	2.3	37	1.0	35	35	42	0	26	16
November	2.7	88.8	0.4	9	0.8	7	7	82	0	50	31
December	-3.5	73.6	0.0	0	0.8	0	0	74	0	45	28
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	274.7	171.2

Note:
1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

SETTLEMENT AREA: GILFORD- FUTURE
Comparison

Total Area= 187.00 ha

	Ex. Infiltration	Future Infiltration	Difference	Difference (%)
Annual Depth (mm)	319.38	274.70	(44.68)	-14%
Annual Volume (cu.m)	597,231.35	513,686.50	(83,544.86)	-14%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: GILFORD- FUTURE

Mitigation

Infiltration Design Calculations
Total Proposed Impervious Area: 15.6 ha

Note: Red cell = user input

Average Annual Rainfall (10 mm)

Design Rainfall =	10	mm
Area =	15.6	ha
Volume =	1560.0	cu.m
Provided Storage Volume =	82.2	cu.m
Average Total Yearly Depth (from 10 mm storm events and less) =	546.1	mm
Yearly Volume =	85,191.60	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	59%	
Annual Defecit =	83,544.86	cu.m
Volume check =	OK	
Yearly Infiltrated volume =	85,191.60	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	10	mm
Min yearly depth		mm
Max yearly depth		mm
Average Yearly Depth	546.1	mm

Average Total Annual Rainfall 918.4 mm

Average Annual Rainfall (15 mm)

Design Rainfall =	15	mm
Area =	15.6	ha
Volume =	2340.0	cu.m
Provided Storage Volume =	64.4	cu.m
Average Total Yearly Depth =	539.7	mm
Yearly Volume =	84,193.20	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	59%	
Annual Defecit =	83,544.86	cu.m
Volume check =	OK	
Yearly Infiltrated volume =	84193.2	cu.m
Net Infiltration with mitigation =	648.34	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	15	mm
Min yearly depth	401.1	mm
Max yearly depth	659	mm
Average Yearly Depth	539.7	mm

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: INNISFIL HEIGHTS- FUTURE

RUNOFF COEFFICIENT - FUTURE CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: 3
Min-2, Med-3, Max-4

Runoff Coeffcient "C" Reference No. for MTO chart: 2
Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	29.7	26.00
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65	0.0	0.00
Business- heavy	0.75	139.9	104.94
Residential- single family urban	0.40	0.0	0.00
residential- multiple, detached	0.50	0.0	0.00
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	0.2	0.06
Industrial- light	0.65		0.00
Industrial- Heavy	0.75	88.2	66.16
Apartments	0.60		0.00
Parks, cemetaries	0.18	0.0	0.00
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28		0.00
Unimproved areas	0.20	0.0	0.00
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	3.5	0.78
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10		0.00
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08	5.6	0.44
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05		0.00
Weighted Average	▨	267.15	0.74

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: INNISFIL HEIGHTS- FUTURE

FUTURE CONDITIONS

Runoff Coefficient:	0.74
Thornthwaite Coefficient	1.081

Month	Temperature (^{o}C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.8	0	0	83	0	21	61
February	-6.6	61.9	0.0	0	0.8	0	0	62	0	16	46
March	-2.1	58.2	0.0	0	1.0	0	0	58	0	15	43
April	5.6	62.3	1.2	28	1.1	31	31	31	0	8	23
May	12.3	82.4	3.9	74	1.3	94	82	0	12	0	0
June	17.9	84.8	6.9	113	1.3	144	85	0	60	0	0
July	20.8	77.2	8.7	134	1.3	174	77	0	97	0	0
August	19.7	89.9	8.0	116	1.2	139	90	0	49	0	0
September	15.3	94	5.4	76	1.0	79	79	15	0	4	11
October	8.7	77.5	2.3	37	1.0	35	35	42	0	11	31
November	2.7	88.8	0.4	9	0.8	7	7	82	0	21	61
December	-3.5	73.6	0.0	0	0.8	0	0	74	0	19	55
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	114.8	331.1

Note:
1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

SETTLEMENT AREA: INNISFIL HEIGHTS- FUTURE
Comparison

Total Area= 267.15 ha

	Ex. Infiltration	Future Infiltration	Difference	Difference (%)
Annual Depth (mm)	214.31	114.76	(99.55)	-46%
Annual Volume (cu.m)	572539.72	306,590.10	(265,949.63)	-46%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: INNISFIL HEIGHTS- FUTURE

Mitigation

Infiltration Design Calculations
Total Proposed Impervious Area: 61 ha

Note: Red cell = user input

Average Annual Rainfall (10 mm)

Design Rainfall =	5	mm
Area =	61	ha
Volume =	3050.0	cu.m
Provided Storage Volume =	82.2	cu.m
Average Total Yearly Depth (from 10 mm storm events and less) =	481.9	mm
Yearly Volume =	293,959.00	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	52%	
Annual Defecit =	265,949.63	cu.m
Volume check =	OK	
Yearly Infiltrated volume =	293,959.00	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	5	mm
Min yearly depth		mm
Max yearly depth		mm
Average Yearly Depth	481.9	mm

Average Total Annual Rainfall 918.4 mm

Average Annual Rainfall (15 mm)

Design Rainfall =	8	mm
Area =	61	ha
Volume =	4880.0	cu.m
Provided Storage Volume =		cu.m
Average Total Yearly Depth =	507.6	mm
Yearly Volume =	309,636.00	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	55%	
Annual Defecit =	265949.63	cu.m
Volume check =	OK	
Yearly Infiltrated volume =	309636	cu.m
Net Infiltration with mitigation =	43686.37	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	8	mm
Min yearly depth		mm
Max yearly depth		mm
Average Yearly Depth	507.6	mm

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: LEFROY FUTURE

RUNOFF COEFFICIENT - FUTURE CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: 3
Min-2, Med-3, Max-4

Runoff Coeffcient "C" Reference No. for MTO chart: 2
Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	15.0	13.15
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65	0.0	0.00
Business- heavy	0.75	20.8	15.63
Residential- single family urban	0.40	257.1	102.85
residential- multiple, detached	0.50	0.0	0.00
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	0.0	0.00
Industrial- light	0.65		0.00
Industrial- Heavy	0.75	0.0	0.00
Apartments	0.60		0.00
Parks, cemetaries	0.18	19.6	3.42
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28		0.00
Unimproved areas	0.20	0.9	0.18
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	0.4	0.10
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10		0.00
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08	68.3	5.46
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05	101.5	5.08
Weighted Average	▨	483.75	0.30

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: LEFROY FUTURE

FUTURE CONDITIONS

Runoff Coefficient:	0.30
Thornthwaite Coefficient	1.081

Month	Temperature (°C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.8	0	0.0	82.5	0.0	57.6	24.9
February	-6.6	61.9	0.0	0	0.8	0	0.0	61.9	0.0	43.2	18.7
March	-2.1	58.2	0.0	0	1.0	0	0.0	58.2	0.0	40.6	17.6
April	5.6	62.3	1.2	28	1.1	31	31.3	31.0	0.0	21.6	9.3
May	12.3	82.4	3.9	74	1.3	94	82.4	0.0	12.0	0.0	0.0
June	17.9	84.8	6.9	113	1.3	144	84.8	0.0	59.5	0.0	0.0
July	20.8	77.2	8.7	134	1.3	174	77.2	0.0	96.8	0.0	0.0
August	19.7	89.9	8.0	116	1.2	139	89.9	0.0	49.5	0.0	0.0
September	15.3	94	5.4	76	1.0	79	79.0	15.0	0.0	10.5	4.5
October	8.7	77.5	2.3	37	1.0	35	35.3	42.2	0.0	29.5	12.7
November	2.7	88.8	0.4	9	0.8	7	7.2	81.6	0.0	57.0	24.6
December	-3.5	73.6	0.0	0	0.8	0	0.0	73.6	0.0	51.4	22.2
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	311.4	134.5

Note:
1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

SETTLEMENT AREA: LEFROY FUTURE
Comparison

Total Area= 483.75 ha

	Ex. Infiltration	Future Infiltration	Difference	Difference (%)
Annual Depth (mm)	338.67	311.44	(27.23)	-8%
Annual Volume (cu.m)	1,638,298.42	1,506,577.63	(131,720.78)	-8%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: LEFROY- FUTURE

Mitigation

Infiltration Design Calculations
Total Proposed Impervious Area: 23.1 ha

Note: Red cell = user input

Average Annual Rainfall (10 mm)

Design Rainfall =	5	mm
Area =	23.1	ha
Volume =	1155.0	cu.m
Provided Storage Volume =	82.2	cu.m
Average Total Yearly Depth (from 10 mm storm events and less) =	481.9	mm
Yearly Volume =	111,318.90	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	52%	
Annual Defecit =	131,720.78	cu.m
Volume check =	INNSUFFICENT	
Yearly Infiltrated volume =	111,318.90	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	5	mm
Min yearly depth		mm
Max yearly depth		mm
Average Yearly Depth	481.9	mm

Average Total Annual Rainfall 918.4 mm

Average Annual Rainfall (15 mm)

Design Rainfall =	15	mm
Area =	23.1	ha
Volume =	3465.0	cu.m
Provided Storage Volume =	64.4	cu.m
Average Total Yearly Depth =	613.8	mm
Yearly Volume =	141,787.80	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	67%	
Annual Defecit =	131,720.78	cu.m
Volume check =	OK	
Yearly Infiltrated volume =	141787.8	cu.m
Net Infiltration with mitigation =	10067.02	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	15	mm
Min yearly depth		mm
Max yearly depth		mm
Average Yearly Depth	613.8	mm

Average Annual Rainfall (25 mm)

Design Rainfall =	25	mm
Area =	23.1	ha
Volume =	5775.0	cu.m
Provided Storage Volume =	64.4	cu.m
Average Total Yearly Depth =	726.2	mm
Yearly Volume =	167,752.20	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	79%	
Annual Defecit =	131,720.78	cu.m
Volume check =	OK	
Yearly Infiltrated volume =	167752.2	cu.m
Net Infiltration with mitigation =	36031.42	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	25	mm
Min yearly depth	574.8	mm
Max yearly depth	935	mm
Average Yearly Depth	726.2	mm

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: SANDY COVE- FUTURE

RUNOFF COEFFICIENT - FUTURE CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: 3
Min-2, Med-3, Max-4

Runoff Coeffcient "C" Reference No. for MTO chart: 2
Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	11.4	10.02
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65	0.0	0.00
Business- heavy	0.75	0.0	0.00
Residential- single family urban	0.40	111.8	44.71
residential- multiple, detached	0.50	270.0	134.98
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	0.0	0.00
Industrial- light	0.65		0.00
Industrial- Heavy	0.75	0.0	0.00
Apartments	0.60		0.00
Parks, cemetaries	0.18	13.6	2.38
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28		0.00
Unimproved areas	0.20	0.0	0.00
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	6.7	1.47
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10		0.00
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08	68.1	5.45
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05	20.0	1.00
Weighted Average		501.5	0.40

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: SANDY COVE- FUTURE

FUTURE CONDITIONS

Runoff Coefficient:	0.40
Thornthwaite Coefficient	1.081

Month	Temperature (°C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.8	0	0	83	0	50	33
February	-6.6	61.9	0.0	0	0.8	0	0	62	0	37	25
March	-2.1	58.2	0.0	0	1.0	0	0	58	0	35	23
April	5.6	62.3	1.2	28	1.1	31	31	31	0	19	12
May	12.3	82.4	3.9	74	1.3	94	82	0	12	0	0
June	17.9	84.8	6.9	113	1.3	144	85	0	60	0	0
July	20.8	77.2	8.7	134	1.3	174	77	0	97	0	0
August	19.7	89.9	8.0	116	1.2	139	90	0	49	0	0
September	15.3	94	5.4	76	1.0	79	79	15	0	9	6
October	8.7	77.5	2.3	37	1.0	35	35	42	0	25	17
November	2.7	88.8	0.4	9	0.8	7	7	82	0	49	33
December	-3.5	73.6	0.0	0	0.8	0	0	74	0	44	29
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	268.1	177.8

Note:
1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

SETTLEMENT AREA: SANDY COVE- FUTURE

Comparison

Total Area= 501.50 ha

	Ex. Infiltration	Future Infiltration	Difference	Difference (%)
Annual Depth (mm)	322.34	268.09	(54.26)	-17%
Annual Volume (cu.m)	1616558.02	1,344,467.06	(272,090.96)	-17%
Average Daily Volume (cu.m)	4428.93	3683.47	(745.45)	-17%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: SANDY COVE- FUTURE

Mitigation

Infiltration Design Calculations
Total Proposed Impervious Area: 93.8 ha

Note: Red cell = user input

Average Annual Rainfall (10 mm)

Design Rainfall =	10	mm
Area =	93.8	ha
Volume =	9380.0	cu.m
Provided Storage Volume =	82.2	cu.m
Average Total Yearly Depth (from 10 mm storm events and less) =	546.1	mm
Yearly Volume =	512,241.80	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	59%	
Annual Defecit =	272,090.96	cu.m
Volume check =	OK	
Yearly Infiltrated volume =	512,241.80	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	10	mm
Min yearly depth		mm
Max yearly depth		mm
Average Yearly Depth	546.1	mm

Average Total Annual Rainfall 918.4 mm

Average Annual Rainfall (5 mm)

Design Rainfall =	5	mm
Area =	93.8	ha
Volume =	4690.0	cu.m
Provided Storage Volume =	64.4	cu.m
Average Total Yearly Depth =	481.9	mm
Yearly Volume =	452,022.20	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	52%	
Annual Defecit =	272090.96	cu.m
Volume check =	OK	
Yearly Infiltrated volume =	452022.2	cu.m
Net Infiltration with mitigation =	179931.24	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	5	mm
Min yearly depth		mm
Max yearly depth		mm
Average Yearly Depth	481.9	mm

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: STROUD- FUTURE

RUNOFF COEFFICIENT - FUTURE CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: 3
Min-2, Med-3, Max-4

Runoff Coeffcient "C" Reference No. for MTO chart: 2
Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	31.6	27.67
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65	0.0	0.00
Business- heavy	0.75	26.1	19.60
Residential- single family urban	0.40	162.4	64.95
residential- multiple, detached	0.50	0.0	0.00
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	0.0	0.00
Industrial- light	0.65		0.00
Industrial- Heavy	0.75	0.0	0.00
Apartments	0.60		0.00
Parks, cemetaries	0.18	10.3	1.81
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28		0.00
Unimproved areas	0.20	0.0	0.00
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	1.2	0.26
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10		0.00
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08	1.5	0.12
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05		0.00
Weighted Average	▨	233.2	0.49

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: STROUD- FUTURE

FUTURE CONDITIONS

Runoff Coefficient:	0.49
Thornthwaite Coefficient	1.081

Month	Temperature (^{o}C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.8	0	0	83	0	42	40
February	-6.6	61.9	0.0	0	0.8	0	0	62	0	32	30
March	-2.1	58.2	0.0	0	1.0	0	0	58	0	30	29
April	5.6	62.3	1.2	28	1.1	31	31	31	0	16	15
May	12.3	82.4	3.9	74	1.3	94	82	0	12	0	0
June	17.9	84.8	6.9	113	1.3	144	85	0	60	0	0
July	20.8	77.2	8.7	134	1.3	174	77	0	97	0	0
August	19.7	89.9	8.0	116	1.2	139	90	0	49	0	0
September	15.3	94	5.4	76	1.0	79	79	15	0	8	7
October	8.7	77.5	2.3	37	1.0	35	35	42	0	21	21
November	2.7	88.8	0.4	9	0.8	7	7	82	0	42	40
December	-3.5	73.6	0.0	0	0.8	0	0	74	0	37	36
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	227.1	218.8

Note:
1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

SETTLEMENT AREA: STROUD- FUTURE

Comparison

Total Area= 233.20 ha

	Ex. Infiltration	Future Infiltration	Difference	Difference (%)
Annual Depth (mm)	259.87	227.10	(32.77)	-13%
Annual Volume (cu.m)	606010.13	529,597.19	(76,412.94)	-13%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: STROUD- FUTURE

Mitigation

Infiltration Design Calculations
Total Proposed Impervious Area: 21.4 ha

Note: Red cell = user input

Average Annual Rainfall (10 mm)

Design Rainfall =	10	mm
Area =	21.4	ha
Volume =	2140.0	cu.m
Provided Storage Volume =	82.2	cu.m
Average Total Yearly Depth (from 10 mm storm events and less) =	546.1	mm
Yearly Volume =	116,865.40	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	59%	
Annual Defecit =	76,412.94	cu.m
Volume check =	OK	
Yearly Infiltrated volume =	116,865.40	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	10	mm
Min yearly depth		mm
Max yearly depth		mm
Average Yearly Depth	546.1	mm

Average Total Annual Rainfall 918.4 mm

Average Annual Rainfall (5 mm)

Design Rainfall =	5	mm
Area =	21.4	ha
Volume =	1070.0	cu.m
Provided Storage Volume =	64.4	cu.m
Average Total Yearly Depth =	481.9	mm
Yearly Volume =	103,126.60	cu.m
Average Total Yearly Depth =	918.4	mm
Percentage of total yearly rainfall =	52%	
Annual Defecit =	76412.94	cu.m
Volume check =	OK	
Yearly Infiltrated volume =	103126.6	cu.m
Net Infiltration with mitigation =	26713.66	cu.m

Rainfall Data summary: Barrie WPCC (1998-2008)		
Design Rainfall	5	mm
Min yearly depth		mm
Max yearly depth		mm
Average Yearly Depth	481.9	mm

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: FENNELL'S CORNERS- FUTURE

RUNOFF COEFFICIENT - FUTURE CONDITIONS

Runoff Coeffcient "C" Reference No. for TOI: 3
Min-2, Med-3, Max-4

Runoff Coeffcient "C" Reference No. for MTO chart: 2
Open Sand Loam-2, Loam or Silt Loam-3, Clay Loam or Clay-4

(Soils Group A - 2; AB - 3, B - 4, BC - 5, C - 6, CD - 7, D - 8)

Land Use	Runoff Coeffcient "C"	Total Area (Ha)	A*C
Town of Innisifl Eng. Standards			
Pavement (asphalt or concrete)	0.88	2.1	1.86
Pavement (brick)	0.78		0.00
Gravel roads and shoulders	0.50		0.00
Roofs	0.83		0.00
Business- Downtown	0.83		0.00
Business- neighbourhood	0.60		0.00
business - light	0.65	0.0	0.00
Business- heavy	0.75	0.5	0.38
Residential- single family urban	0.40	15.6	6.24
residential- multiple, detached	0.50	0.0	0.00
Residential- multiple, attached	0.68		0.00
Residential- suburban	0.33	0.0	0.00
Industrial- light	0.65		0.00
Industrial- Heavy	0.75	0.0	0.00
Apartments	0.60		0.00
Parks, cemetaries	0.18	0.1	0.02
Playgrounds (unpaved)	0.28		0.00
Railroad yards	0.28		0.00
Unimproved areas	0.20	0.0	0.00
Lawns- Sandy soil- flat to 2%	0.08		0.00
Lawns- Sandy soil- average, 2 to 7%	0.13		0.00
Lawns- Sandy soil- steep, over 7%	0.18		0.00
Lawns- Clayey soil- flat to 2%	0.15		0.00
Lawns- Clayey soil-average, 2 to 7%	0.20		0.00
Lawns- Clayey soil- steep, over 7%	0.30		0.00
MTO Drainage Manual			
Cultivated Land, 0 - 5% grade	0.22	0.1	0.02
Cultivated Land, 5 -10% grade	0.30		0.00
Cultivated Land, 10 - 30% grade	0.40		0.00
Pasture Land, 0 - 5% grade	0.10		0.00
Pasture Land, 5 -10% grade	0.15		0.00
Pasture Land, 10 - 30% grade	0.22		0.00
Woodlot or Cutover, 0 - 5% grade	0.08		0.00
Woodlot or Cutover, 5 -10% grade	0.12		0.00
Woodlot or Cutover, 10 -30% grade	0.18		0.00
Lakes and Wetlands	0.05		0.00
Weighted Average	▨	18.5	0.46

Note: Soil type was assumed to be AB (sandy loam) from GIS data

Note: for all runoff coefficients taken from TOI standards, the Medium recommended C value was used

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT
STEP 5 - CSWM-MP GUIDELINES (LSRCA, April 2011)
SETTLEMENT AREA: FENNELL'S CORNERS- FUTURE

FUTURE CONDITIONS

Runoff Coefficient:	0.46
Thornthwaite Coefficient	1.081

Month	Temperature (^{o}C)	Precipitation (mm)	Heat Index	PET (mm)	Daylight Factor	Adjusted PET (mm)	AET (mm)	Surplus (mm)	Deficit (mm)	Infiltration (mm)	Runoff (mm)
January	-7.7	82.5	0.0	0	0.8	0	0	83	0	44	38
February	-6.6	61.9	0.0	0	0.8	0	0	62	0	33	29
March	-2.1	58.2	0.0	0	1.0	0	0	58	0	31	27
April	5.6	62.3	1.2	28	1.1	31	31	31	0	17	14
May	12.3	82.4	3.9	74	1.3	94	82	0	12	0	0
June	17.9	84.8	6.9	113	1.3	144	85	0	60	0	0
July	20.8	77.2	8.7	134	1.3	174	77	0	97	0	0
August	19.7	89.9	8.0	116	1.2	139	90	0	49	0	0
September	15.3	94	5.4	76	1.0	79	79	15	0	8	7
October	8.7	77.5	2.3	37	1.0	35	35	42	0	23	19
November	2.7	88.8	0.4	9	0.8	7	7	82	0	44	38
December	-3.5	73.6	0.0	0	0.8	0	0	74	0	40	34
Total	▨	933.1	36.8	587.2	▨	705.1	487.2	445.9	217.9	240.1	205.8

Note:
1) Source - Barrie WPCC Climate Normal Data for 1981 - 2010 (Environment Canada).
2) Thornthwaite method used to determine the potential Evapotranspiration.
3) PET - potential evapotranspiration; AET - actual evapotranspiration.

CLIMATE CHANGE WATER BALANCE EXAMPLE

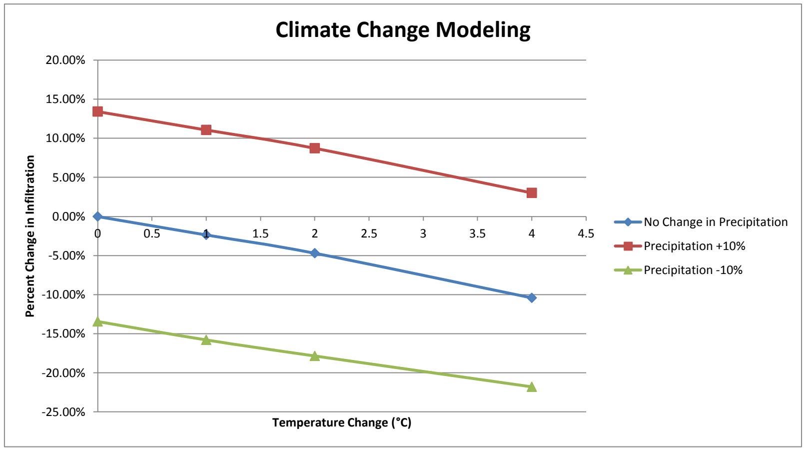
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
WATER BUDGET ASSESSMENT FOR CLIMATE CHANGE
SETTLEMENT AREA: ALCONA- FUTURE

FUTURE CONDITIONS
COMBINATION OF TEMPERATURE AND PRECIPITATION CHANGE

Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		Scenario 6		Scenario 7		Scenario 8		Scenario 9		Scenario 10		Scenario 11		Scenario 12	
Existing Temp, Precip.		(+1C, No change Precip)		(+2C, No change Precip)		(+4C, No change Precip)		(No Temp change , -10% Precip)		(+1C, -10% Precip)		(+2, -10 Precip)		(+4C, -10 Precip)		(No Temp change, +10% Precip)		(+1C, +10 Precip)		(+2C, +10 Precip)		(+4C, +10 Precip)	
Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)	Infiltration (mm)	Runoff (mm)
49.42	33.08	49	33	49	33	49	33	44	30	44	30	44	30	44	30	54	36	54	36	54	36	54	36
37.08	24.82	37	25	37	25	37	25	33	22	33	22	33	22	33	22	41	27	41	27	41	27	41	27
34.86	23.34	35	23	35	23	32	22	31	21	31	21	31	21	29	19	38	26	38	26	38	26	36	24
18.55	12.42	17	11	15	10	11	8	15	10	13	9	11	7	8	5	22	15	20	14	19	12	15	10
0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.96	6.00	7	5	5	3	0	0	3	2	1	1	0	0	0	0	15	10	13	8	11	7	6	4
25.26	16.91	24	16	23	15	20	13	21	14	19	13	18	12	15	10	30	20	29	19	27	18	25	16
48.87	32.71	48	32	47	31	45	30	44	29	42	28	41	28	40	27	54	36	53	36	52	35	50	34
44.09	29.51	44	30	44	30	44	29	40	27	40	27	40	27	39	26	48	32	48	32	48	32	48	32
267.10	**178.80**	**260.8**	**174.6**	**254.6**	**170.4**	**239.3**	**160.2**	**231.2**	**154.8**	**224.9**	**150.6**	**219.4**	**146.9**	**208.9**	**139.8**	**303.0**	**202.8**	**296.7**	**198.6**	**290.4**	**194.4**	**275.2**	**184.2**

Scenario #	Precipitation Change (%)	Temp Change (°C)	Infiltration (mm)	Percent Change
1	0	0	267.10	0.00%
2	0	1	260.8	-2.36%
3	0	2	254.6	-4.69%
4	0	4	239.3	-10.41%
5	10	0	303.0	13.43%
6	10	1	296.7	11.07%
7	10	2	290.4	8.73%
8	10	4	275.2	3.02%
9	-10	0	231.2	-13.43%
10	-10	1	224.9	-15.78%
11	-10	2	219.4	-17.84%
12	-10	4	208.9	-21.79%

Note: Percent change for infiltration assumed to be the same for all study areas



APPENDIX D:
HYDROLOGY

ELC Land Use

Landuse	TIMP	XIMP	CN Category	Curve Number (AMC II) Whole area				Curve Number (AMC II) Pervious area				Runoff Coefficient				
				Soil Group				Soil Group				Soil Group				
				A	B	C	D	A	B	C	D	All	A	B	C	D
Active Aggregate	0	0	newly graded area	77	86	91	94	39	61	74	80	0.65	0.65	0.65	0.65	0.65
Commercial	50	50	Commercial	69	80	86	89	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Estate Residential	15	10	Residential Half acre	48	67	78	83	39	61	74	80	0.33	0.33	0.33	0.33	0.33
Golf Course	0	0	Open Space- Good	39	61	74	80	39	61	74	80	0.18	0.18	0.18	0.18	0.18
Inactive Aggregate	0	0	newly graded area	77	86	91	94	39	61	74	80	0.65	0.65	0.65	0.65	0.65
Industrial	50	50	Industrial	69	80	86	89	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Institutional	50	50	Commercial	69	80	86	89	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Intensive Agriculture	0	0	Straight row crops- good	67	78	85	89	67	78	85	89		0.22	0.35	0.42	0.55
Manicured Open Space	0	0	Open space-fair	49	69	79	84	39	61	74	80	0.18	0.18	0.18	0.18	0.18
NH- Coniferous Forest	0	0	Wood fair	36	60	73	79	36	60	73	79		0.10	0.28	0.34	0.40
NH- Coniferous Swamp	0	0	Lakes and Wetlands	50	50	50	50	50	50	50	50	0.05	0.05	0.05	0.05	0.05
NH- Cultural Meadow	0	0	Meadow	30	58	71	78	30	58	71	78		0.10	0.28	0.34	0.40
NH- Cultural Thicket	0	0	Brush- good	30	48	65	73	30	48	65	73		0.08	0.25	0.30	0.35
NH- Cultural Woodland	0	0	Wood-Fair	43	65	76	82	43	65	76	82		0.08	0.25	0.30	0.35
NH- Deciduous Forest	0	0	Wood-Fair	43	65	76	82	43	65	76	82		0.08	0.25	0.30	0.35
NH- Deciduous Swamp	0	0	Lakes and Wetlands	50	50	50	50	50	50	50	50	0.05	0.05	0.05	0.05	0.05
NH- Meadow marsh	0	0	Lakes and Wetlands	50	50	50	50	50	50	50	50	0.05	0.05	0.05	0.05	0.05
NH- Mixed Forest	0	0	Wood-Fair	43	65	76	82	43	65	76	82		0.08	0.25	0.30	0.35
NH- Mixed Shallow Aquatic	0	0	Lakes and Wetlands	50	50	50	50	50	50	50	50	0.05	0.05	0.05	0.05	0.05
NH- Mixed Swamp	0	0	Lakes and Wetlands	50	50	50	50	50	50	50	50	0.05	0.05	0.05	0.05	0.05
NH- Open Water	0	0	Lakes and Wetlands	50	50	50	50	50	50	50	50	0.05	0.05	0.05	0.05	0.05
NH- Shallow Marsh	0	0	Lakes and Wetlands	50	50	50	50	50	50	50	50	0.05	0.05	0.05	0.05	0.05
NH- Thicket Swamp	0	0	Lakes and Wetlands	50	50	50	50	50	50	50	50	0.05	0.05	0.05	0.05	0.05
NH- Submerged Shallow Aquatic	0	0	Lakes and Wetlands	50	50	50	50	50	50	50	50	0.05	0.05	0.05	0.05	0.05
NH- Cultural Plantation	0	0	Brush- Fair	35	56	70	77	35	56	70	77		0.22	0.35	0.42	0.55
Non-intensive Agriculture- Hay	0	0	Meadow	30	58	71	78	30	58	71	78		0.10	0.28	0.34	0.40
Non-intensive Agriculture- Pasture	0	0	Pasture- Fair	49	69	79	84	49	69	79	84		0.10	0.28	0.34	0.40
Rail	30	30	Roads-gravel	76	85	89	91	76	85	89	91	0.28	0.28	0.28	0.28	0.28
Road	75	75	Road-Paved (inlcuding ROW)	83	89	92	93	39	61	74	80	0.88	0.88	0.88	0.88	0.88
Rural Development	15	10	Residential Half acre	48	67	78	83	39	61	74	80	0.33	0.33	0.33	0.33	0.33
Urban	45	35	Residential 1/4 acre	66	78	85	88	39	61	74	80	0.40	0.40	0.40	0.40	0.40

References

CN- Whole Area
🟦 TR-55 Curve Number Table 2.2a
🟥 MTO Design Chart 1.09
🟩 Composite CN based of TIMP (CN=98), remainder = Open Space

CN- Pervious Area
🟧 tr-55 Open Space good condition
🟦 TR-55 Curve Number Table 2.2a
🟥 MTO Design Chart 1.09

TIMP/XIMP
⬜ TOI Zoning - Direct Category
🟪 TOI Zoning - Assumed Category
🟦 Assumed
🟥 LSRCA SWM Guidelines XIMP/TIMP Table Appendix C
🟨 Assumed from City of Barrie SWM Guidelines
🟥 Calculated from Aerial Photography

Runoff Coefficient
🟦 Adapted from MTO Table 1.07
🟫 Adapted from TOI RC Table (Median Value)

OP Land Use

Landuse	TIMP	XIMP	CN Category	Curve Number Whole area				Curve Number Pervious area				Runoff Coefficient				
				Soil Group				Soil Group				Soil Group				
				A	B	C	D	A	B	C	D	All	A	B	C	D
Agriculture Area	0	0	Straight Row Crops- good	67	78	85	89	67	78	85	89		0.22	0.35	0.42	0.55
Agriculture-Rural Area	0	0	Straight Row Crops- good	67	78	85	89	67	78	85	89		0.22	0.35	0.42	0.55
Agriculture-Special Rural Area	0	0	Straight Row Crops- good	67	78	85	89	67	78	85	89		0.22	0.35	0.42	0.55
Business Park	85	85	Commercial and Business	89	92	94	95	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Commercial-Convenience	50	50	Commercial and Business	69	80	86	89	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Commercial-Core	85	85	Commercial and Business	89	92	94	95	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Commercial-Highway	30	30	Commercial and Business	57	72	81	85	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Commercial-Neighbourhood	50	50	Commercial and Business	69	80	86	89	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Commercial-Neighbourhood/Mixed Use	50	50	Commercial and Business	69	80	86	89	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Commercial-Shoreline	30	30	Commercial and Business	57	72	81	85	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Commercial Village	50	50	Commercial and Business	69	80	86	89	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Community Service	55	55	Commercial and Business	71	81	87	90	39	61	74	80	0.65	0.65	0.65	0.65	0.65
Estate-Residential	15	10	Residential Half acre	48	67	78	83	39	61	74	80	0.33	0.33	0.33	0.33	0.33
Industrial-Extractive	50	50	Industrial	69	80	86	89	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Industrial-General	50	50	Industrial	69	80	86	89	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Landfill	0	0	Open space-fair	49	69	79	84	39	61	74	80	0.20	0.20	0.20	0.20	0.20
Landfill-Closed	0	0	Open space-fair	49	69	79	84	39	61	74	80	0.20	0.20	0.20	0.20	0.20
Institutional	50	50	Commercial	69	80	86	89	39	61	74	80	0.75	0.75	0.75	0.75	0.75
Natural Environmental Area	0	0	Brush- fair	35	56	70	77	35	56	70	77	0.20	0.20	0.20	0.20	0.20
Neighbourhood Park	5	3	Open Space-fair	49	69	79	84	39	61	74	80	0.18	0.18	0.18	0.18	0.18
Parks And Open Space	5	3	Open Space- Good	39	61	74	80	39	61	74	80	0.18	0.18	0.18	0.18	0.18
Residential Village	45	35	Residential 1/3 acre	66	78	85	88	39	61	74	80	0.40	0.40	0.40	0.40	0.40
Residential-Low Density	35	20	Residential 1/3 acre	60	74	82	86	39	61	74	80	0.40	0.40	0.40	0.40	0.40
Residential-Low Density 1	35	20	Residential 1/3 acre	60	74	82	86	39	61	74	80	0.40	0.40	0.40	0.40	0.40
Residential-Low Density 2	35	20	Residential 1/3 acre	60	74	82	86	39	61	74	80	0.40	0.40	0.40	0.40	0.40
Residential-Medium Density	55	35	Residential 1/4 acre	71	81	87	90	39	61	74	80	0.50	0.50	0.50	0.50	0.50
Residential-Retirement	60	40	Residential 1/8 acre or less	74	83	88	91	39	61	74	80	0.68	0.68	0.68	0.68	0.68
Residential-Shoreline	35	20	Residential 1/3 acre	60	74	82	86	39	61	74	80	0.50	0.50	0.50	0.50	0.50
Stormwater Management	0	0	Lakes and Wetlands	50	50	50	50	50	50	50	50	0.05	0.05	0.05	0.05	0.05
Future Urban	60	50	Residential 1/8 acre or less	74	83	88	91	39	61	74	80	0.40	0.40	0.40	0.40	0.40
Roads	75	75	Road-Paved (inlcuding ROW)	83	89	92	93	39	61	74	80	0.88	0.88	0.88	0.88	0.88

References

CN- Whole Area

🟦 TR-55 Curve Number Table 2.2a
🟥 MTO Design Chart 1.09
🟩 Composite CN based of TIMP (CN=98), remainder = Open Space

CN- Pervious Area

🟧 tr-55 Open Space good condition
🟦 TR-55 Curve Number Table 2.2a
🟥 MTO Design Chart 1.09

TIMP/XIMP

⬜ TOI Zoning - Direct Category
🟪 TOI Zoning - Assumed Category
🟦 Assumed
🟥 LSRCA SWM Guidelines XIMP/TIMP Table Appendix C
🟨 Assumed from City of Barrie SWM Guidelines
🟥 Calculated from Aerial Photography

Runoff Coefficient

🟦 Adapted from MTO Table 1.07
🟫 Adapted from TOI RC Table (Median Value)

Barrie WPCC Rainfall Intensity (mm/hr) + 15% for Climate Change						
Duration (min)	Return Period					
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5	115.5	150	173	201.8	223.3	244.7
10	81.5	107.9	125.5	147.4	163.9	180.1
15	67.4	89.9	104.9	123.7	137.7	151.6
30	43.1	56.2	65.1	76	84.3	92.3
60	25.3	32.8	37.6	43.8	48.4	53
120	15.5	21.9	26.1	31.4	35.4	39.3
360	7	9.9	11.8	14.3	16	17.7
720	3.9	5.4	6.3	7.6	8.5	9.4
1440	2.3	3.2	3.8	4.5	5.1	5.5
6-hour P Total (mm)	42	59.4	70.8	85.8	96	106.2
12-hour P Total (mm)	46.8	64.8	75.6	91.2	102	112.8
24-hour P Total (mm)	55.2	76.8	91.2	108	122.4	132

Barrie WPCC Rainfall Intensity (mm/hr)						
Duration (min)	Return Period					
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5	100.4	130.4	150.4	175.5	194.2	212.8
10	70.9	93.8	109.1	128.2	142.5	156.6
15	58.6	78.2	91.2	107.6	119.7	131.8
30	37.5	48.9	56.6	66.1	73.3	80.3
60	22	28.5	32.7	38.1	42.1	46.1
120	13.5	19	22.7	27.3	30.8	34.2
360	6.1	8.6	10.3	12.4	13.9	15.4
720	3.4	4.7	5.5	6.6	7.4	8.2
1440	2	2.8	3.3	3.9	4.4	4.8
6-hour P Total (mm)	36.6	51.6	61.8	74.4	83.4	92.4
12-hour P Total (mm)	40.8	56.4	66	79.2	88.8	98.4
24-hour P Total (mm)	48	67.2	79.2	93.6	105.6	115.2

Barrie WPCC IDF Curve Parameters - Adjusted For Climate Change						
Parameter	Return Period					
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
A	678.085	853.608	975.865	1146.275	1236.152	1426.408
B	4.699	4.699	4.699	4.922	4.699	5.273
C	0.781	0.766	0.76	0.757	0.751	0.759

EXISTING CONDITIONS VO2 PARAMETERS

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 PARAMETERS FOR EXISTING CONDITIONS
HEWITTS CREEK

VO2 ID	AREA (ha)	CN	CN (pervious)	Ia	Timp	Ximp	Length	Minimum ele.	Maximum ele.	Slope	Rc	AIRPORT Tp	B-W Tp	SELECT Tp	Ntype select
115	111.39	74.83	74.19	6.74	2.85	2.51	1672	264	283	1.14	0.35	1.059	0.644	1.059	Nash
116	72.87	72.52	70.12	6.29	9.04	7.61	1016	263	275	1.18	0.31	0.860	0.406	0.860	Nash
125	62.02	74.38	73.06	6.57	5.65	4.90	1935	261	275	0.72	0.33	1.359	0.865	1.359	Nash
134	25.62	73.74	49.84	3.16	48.79	42.76	666	272	275	0.45	0.52	0.699	0.357	0.357	Standhyd
135	83.44	66.91	65.57	6.29	4.42	3.79	1567	255	275	1.28	0.26	1.106	0.607	1.106	Nash

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 PARAMETERS FOR EXISTING CONDITIONS
LOVERS CREEK

VO2 ID	AREA (ha)	CN	CN (pervious)	Ia	Timp	Ximp	Length	Minimum ele.	Maximum ele.	Slope	Rc	AIRPORT Tp	B-W Tp	SELECT Tp	Ntype select
S100	5.83	66.05	40.25	3.73	44.68	44.67	304	301	306	1.65	0.68	0.226	0.146	0.146	standhyd
S101	5.32	76.18	57.28	3.04	48.53	48.53	277	291	295	1.44	0.68	0.225	0.138	0.138	standhyd
S102	119.62	65.90	65.12	7.12	2.50	2.49	2137	259	302	2.01	0.25	1.128	0.729	1.128	Nash
S140	7.65	63.84	38.23	3.84	42.85	42.85	521	300	306	1.15	0.66	0.351	0.262	0.262	standhyd
S141	1.32	76.67	38.80	3.20	64.23	64.23	350	300	306	1.71	0.81	0.166	0.194	0.194	standhyd
S142	21.67	65.51	46.22	4.34	37.26	37.26	782	295	306	1.41	0.60	0.453	0.340	0.340	standhyd
S144	232.42	62.72	58.41	7.09	4.44	4.38	3757	268	311	1.14	0.28	1.742	1.343	1.742	Nash
S38	89.52	62.53	46.71	5.49	30.63	30.55	683	298	305	1.02	0.48	0.583	0.275	0.275	standhyd
S39	9.86	55.50	41.76	6.46	24.50	24.09	4302	282	301	0.44	0.38	2.230	2.552	2.230	standhyd
S40	358.33	54.83	51.95	7.45	6.09	5.21	2675	257	300	1.61	0.23	1.395	0.856	1.395	Nash
S59	26.84	66.65	56.90	5.48	24.35	24.34	652	295	305	1.53	0.44	0.528	0.273	0.273	standhyd
S60	146.48	52.61	50.02	6.61	5.40	4.65	5269	255	292	0.70	0.18	2.729	2.175	2.729	Nash
S77	9.79	69.88	65.55	6.28	13.48	13.48	430	306	310	0.93	0.34	0.587	0.220	0.587	Nash
S78	30.89	62.44	45.58	4.98	32.21	32.21	552	293	305	2.18	0.54	0.371	0.212	0.212	standhyd
S79	83.16	65.97	42.78	4.01	40.29	40.27	1579	293	306	0.82	0.60	0.762	0.668	0.668	standhyd
S80	145.59	66.55	66.25	7.33	0.94	0.87	1781	255	286	0.50	0.26	1.613	0.788	1.613	Nash
115	111.39	74.83	74.19	6.74	2.85	2.51	1672	264	283	1.14	0.35	1.059	0.644	1.059	Nash
116	72.87	72.52	70.12	6.29	9.04	7.61	1016	263	275	1.18	0.31	0.860	0.406	0.860	Nash
125	62.02	74.38	73.06	6.57	5.65	4.90	1935	261	275	0.72	0.33	1.359	0.865	1.359	Nash
134	25.62	73.74	49.84	3.16	48.79	42.76	666	272	275	0.45	0.52	0.699	0.357	0.357	standhyd
135	83.44	66.91	65.57	6.29	4.42	3.79	1567	255	275	1.28	0.26	1.106	0.607	1.106	Nash
S130	343.12	72.33	71.67	7.05	2.51	2.29	4822	249	284	0.73	0.32	2.178	1.816	2.178	Nash
S131	28.07	71.86	50.69	3.33	42.26	35.05	712	266	272	0.84	0.43	0.685	0.335	0.335	standhyd
S132	23.90	72.65	53.93	3.63	41.85	34.41	950	264	270	0.63	0.44	0.862	0.480	0.480	standhyd
S133	15.63	73.67	51.73	3.26	46.53	39.22	588	270	274	0.68	0.47	0.627	0.305	0.305	standhyd
S134	43.39	74.41	54.72	3.46	45.43	40.88	1105	265	275	0.90	0.55	0.686	0.490	0.490	standhyd
S170	134.66	71.54	71.12	6.80	1.53	1.30	2090	249	275	1.24	0.29	1.252	0.776	1.252	Nash
S250	360.89	62.73	61.07	6.66	4.49	3.89	3361	242	275	0.98	0.24	1.816	1.185	1.816	Nash
S251	30.99	71.40	52.73	3.69	41.25	34.79	907	272	275	0.33	0.45	1.025	0.508	0.508	standhyd
S171	1.38	65.69	50.00	3.98	23.52	18.59	169	273	275	1.18	0.30	0.357	0.100	0.357	standhyd

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 PARAMETERS FOR EXISTING CONDITIONS
SANDY COVE AND MOOSELANKA

VO2 ID	AREA (ha)	CN	CN (pervious)	Ia	Timp	Ximp	Length	Minimum ele.	Maximum ele.	Slope	Rc	AIRPORT Tp	B-W Tp	SELECT Tp	Ntype select
240	71.05	73.00	72.94	7.15	0.24	0.23	1048	234	251	1.62	0.31	0.794	0.393	0.794	Nash
242	33.40	73.91	71.57	6.31	8.88	7.22	1103	235	247	1.09	0.33	0.896	0.484	0.896	Nash
245	111.90	63.28	56.04	6.84	1.27	1.22	3020	230	246	0.53	0.31	1.942	1.355	1.942	Nash
250	45.98	51.29	51.15	7.05	0.31	0.31	1285	249	259	0.78	0.22	1.235	0.584	1.235	Nash
252	93.30	72.63	57.26	3.92	37.72	30.85	2184	231	248	0.78	0.41	1.265	0.924	0.924	standhyd
254	24.54	60.08	53.18	7.03	15.40	12.35	673	226	234	1.19	0.25	0.752	0.299	0.752	Nash
255	90.22	59.06	51.46	6.71	16.34	12.97	1725	219	232	0.75	0.25	1.398	0.737	1.398	Nash
305	63.41	70.18	69.85	6.98	1.15	1.05	1236	252	262	0.81	0.32	1.063	0.539	1.063	Nash
306	9.85	70.59	70.54	6.73	0.17	0.17	1113	245	250	0.45	0.27	1.303	0.658	1.303	Nash
310	77.14	66.02	65.60	7.10	1.29	1.22	2626	251	275	0.91	0.29	1.553	1.097	1.553	Nash
311	7.31	53.57	53.57	6.17	0.00	0.00	344	246	251	1.45	0.09	0.600	0.166	0.600	Nash
315	42.67	72.52	57.99	3.97	36.31	29.68	1413	237	250	0.92	0.40	0.975	0.625	0.625	standhyd
320	25.27	59.63	42.73	4.86	30.57	23.89	862	225	236	1.28	0.30	0.785	0.376	0.785	standhyd
325	11.94	65.26	50.10	4.10	31.65	25.81	596	222	227	0.84	0.32	0.735	0.305	0.735	standhyd
329	2.74	67.20	50.34	3.86	35.39	27.54	427	220	225	1.17	0.33	0.546	0.237	0.546	standhyd
330	1.30	72.09	50.00	3.00	46.03	36.38	90	219.5	220	0.50	0.42	0.295	0.064	0.064	standhyd
I1201	2.42	76.40	75.92	6.89	2.15	2.15	118	255	256	0.85	0.34	0.315	0.071	0.315	Nash
I1204	24.45	73.42	73.40	6.88	0.09	0.09	739	244	255	1.49	0.30	0.691	0.314	0.691	Nash
I1205	103.38	53.38	47.74	6.05	11.22	9.03	1592	222	235	0.82	0.16	1.457	0.660	1.457	Nash
I1300	62.67	61.04	48.68	4.37	25.06	19.89	990	219	236	1.72	0.26	0.798	0.372	0.798	standhyd
I1301	1.01	65.18	40.11	3.17	43.31	34.19	183	236	239	1.64	0.39	0.294	0.105	0.294	standhyd
I1399	1.65	71.57	50.00	3.00	44.94	34.95	97	219	221	2.06	0.40	0.197	0.051	0.197	standhyd
I1400	89.13	58.90	49.06	6.74	20.09	16.09	2145	221	236	0.70	0.27	1.575	0.931	1.575	standhyd
I1500	54.02	66.10	51.70	4.97	31.09	24.78	920	219	232	1.41	0.35	0.740	0.365	0.740	standhyd
I1501	32.02	65.52	51.39	4.53	30.32	24.01	350	220	225	1.43	0.32	0.470	0.146	0.470	standhyd

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 PARAMETERS FOR EXISTING CONDITIONS
GILFORD

VO2 ID	AREA (ha)	CN	CN (pervious)	Ia	Timp	Ximp	Length	Minimum ele.	Maximum ele.	Slope	Rc	AIRPORT Tp	B-W Tp	SELECT Tp	Ntype select
420	12.53	72.57	52.03	3.03	44.67	34.76	591	288	300	2.03	0.40	0.488	0.252	0.488	standhyd
421	3.91	75.58	51.78	3.00	51.45	43.62	598	288	301	2.18	0.50	0.409	0.283	0.283	standhyd
422	127.68	70.30	69.11	6.58	4.12	3.53	2423	246	285	1.61	0.32	1.190	0.859	1.190	Nash
424	2.08	66.36	50.00	3.61	34.08	30.01	177	300	301	0.56	0.49	0.358	0.117	0.117	standhyd
425	231.14	77.38	77.13	6.91	1.17	1.06	4557	240	300	1.32	0.36	1.652	1.585	1.652	Nash
430	41.40	52.53	49.40	7.18	6.44	5.90	1153	228	237	0.78	0.25	1.135	0.529	1.135	Nash
432	12.42	63.03	55.51	5.87	18.17	15.05	850	225	237	1.41	0.31	0.749	0.391	0.749	Nash
433	0.65	42.05	39.56	4.92	4.27	4.06	154	225	225	0.00	0.20	N/A	N/A	0.100	Nash
434	4.01	74.80	59.56	3.28	39.64	31.35	587	222	225	0.51	0.38	0.785	0.370	0.785	standhyd
435	13.80	50.48	49.26	7.57	2.53	2.40	546	235	240	0.92	0.24	0.753	0.271	0.753	Nash
436	32.96	48.69	48.68	8.83	0.01	0.00	979	221	233	1.23	0.22	0.937	0.420	0.937	Nash
437	50.21	58.50	58.41	5.64	0.36	0.34	1119	220	234	1.25	0.18	1.039	0.458	1.039	Nash
438	10.31	75.92	59.92	3.19	42.02	32.69	601	219	220	0.50	0.38	0.806	0.346	0.806	standhyd
G100	152.47	69.63	68.98	6.76	2.35	1.97	3339	224	264	1.20	0.30	1.587	1.234	1.587	Nash
G101	14.62	65.39	58.73	5.88	16.99	13.31	593	228	237	1.52	0.31	0.604	0.264	0.604	Nash
G102	32.44	72.83	65.78	5.56	21.86	17.76	945	219	228	0.95	0.37	0.826	0.427	0.826	standhyd
G104	6.57	77.01	60.43	3.36	44.08	35.80	344	219	220	0.29	0.42	0.684	0.231	0.231	standhyd
G105	1.63	64.47	53.85	4.48	24.04	19.39	242	219	219	0.00	0.25	N/A	N/A	0.100	standhyd
I200	151.63	60.17	59.89	7.07	0.82	0.76	3965	219	250	0.78	0.18	2.277	1.597	2.277	Nash
I300	21.42	78.20	61.00	3.00	46.45	36.94	461	219	222	0.65	0.42	0.606	0.234	0.234	standhyd
I400	8.79	60.40	60.40	8.78	0.00	0.00	284	223	228	1.76	0.23	0.441	0.129	0.441	Nash
I401	76.00	65.96	64.07	7.12	5.54	4.62	862	220	237	1.97	0.26	0.713	0.309	0.713	Nash
I402	40.44	77.44	60.85	3.02	44.65	34.73	1109	219	220	0.09	0.40	1.876	0.785	1.876	standhyd
W100	283.22	76.40	75.95	6.85	2.14	2.01	4587	231	285	1.18	0.36	1.716	1.599	1.716	Nash
W105	409.54	68.48	68.09	6.91	1.33	1.20	3437	235	290	1.60	0.29	1.475	1.086	1.475	Nash

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 PARAMETERS FOR EXISTING CONDITIONS
LEFROY

VO2 ID	AREA (ha)	CN	CN (pervious)	Ia	Timp	Ximp	Length	Minimum ele.	Maximum ele.	Slope	Rc	AIRPORT Tp	B-W Tp	SELECT Tp	Ntype select
B100	488.48	63.42	63.15	7.27	0.80	0.78	5228	223	258	0.67	0.25	2.549	1.932	2.549	Nash
B102	18.06	76.23	58.34	3.24	45.09	36.23	547	221.8	290	12.47	0.42	0.249	0.157	0.157	standhyd
B99	1.11	53.14	46.52	5.43	12.87	10.85	79	255	256	1.27	0.31	0.235	0.047	0.235	Nash
C100	196.95	61.93	61.01	7.00	2.47	2.02	3024	240	282	1.39	0.25	1.516	1.057	1.516	Nash
C102	51.29	78.52	75.37	6.04	13.47	12.02	1140	232	251	1.67	0.39	0.737	0.440	0.737	Nash
C105	259.10	62.94	62.71	7.42	0.65	0.58	3112	242	283	1.32	0.25	1.560	1.070	1.560	Nash
C106	5.13	52.61	51.55	8.00	2.27	2.17	310	232	240	2.58	0.22	0.409	0.138	0.409	Nash
C120	198.59	59.80	52.72	5.97	14.78	12.08	2383	219	257	1.59	0.27	1.263	0.810	1.263	Nash
I600	35.47	60.86	51.53	5.93	20.08	16.53	3870	219	225	0.16	0.31	3.299	2.490	3.299	standhyd
I601	6.44	63.24	54.84	5.65	19.47	19.19	448	219	221	0.45	0.38	0.725	0.277	0.725	Nash
I700	35.31	55.71	55.01	7.44	1.75	1.67	1226	222	250.8	2.35	0.19	0.868	0.458	0.868	Nash
I701	154.99	61.45	50.90	4.85	22.14	18.01	2402	219	257	1.58	0.26	1.281	0.838	1.281	standhyd
I800	76.18	53.59	49.94	6.70	7.64	6.10	1241	225	235	0.81	0.17	1.268	0.532	1.268	Nash
I801	8.10	72.18	50.52	3.12	45.62	36.34	391	219	225	1.53	0.42	0.423	0.184	0.184	standhyd
W100	283.22	76.40	75.95	6.85	2.14	2.01	4587	231	285	1.18	0.36	1.716	1.599	1.716	Nash
W105	409.54	68.48	68.09	6.91	1.33	1.20	3437	235	290	0.50	0.29	2.166	1.370	2.166	Nash
W110	111.27	70.18	67.00	7.14	2.49	2.33	2056	222	244	1.07	0.31	1.273	0.802	1.273	Nash
W111	1.43	67.37	67.37	7.87	0.00	0.00	140	246	251	3.57	0.25	0.239	0.066	0.239	Nash
W112	8.54	59.64	54.83	7.09	8.65	8.17	337	225	230	1.48	0.28	0.476	0.159	0.476	Nash

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 PARAMETERS FOR EXISTING CONDITIONS
ALCONA

VO2 ID	AREA (ha)	CN	CN (pervious)	Ia	Timp	Ximp	Length	Minimum ele.	Maximum ele.	Slope	Rc	AIRPORT Tp	B-W Tp	SELECT Tp	Ntype select
AC100	8.39	77.03	63.66	3.64	38.94	30.29	475	260	274	2.95	0.38	0.399	0.196	0.399	standhyd
AC101	11.44	71.38	50.00	3.04	44.54	34.82	433	244	251	1.62	0.40	0.450	0.195	0.195	standhyd
AC102	5.90	71.60	50.00	3.00	45.00	35.00	459	245	248	0.65	0.40	0.626	0.265	0.626	standhyd
AC103	10.57	71.71	50.00	3.07	45.24	37.75	580	239	251	2.07	0.48	0.428	0.251	0.251	standhyd
AC104	6.79	72.69	50.00	3.00	47.28	38.04	228	244	249	2.19	0.44	0.280	0.102	0.102	standhyd
AC105	5.92	73.37	50.00	3.00	48.68	40.57	322	240	250	3.11	0.48	0.277	0.136	0.136	standhyd
AC106	111.47	61.96	59.32	6.27	7.01	6.39	2095	246	275	1.38	0.28	1.226	0.776	1.226	Nash
AC107	17.07	63.85	45.53	4.12	34.80	30.72	594	237	246	1.52	0.46	0.495	0.260	0.260	standhyd
AC110	66.75	63.57	41.91	3.67	35.21	29.83	2082	219	234	0.72	0.41	1.268	0.925	0.925	standhyd
AC120	7.09	65.94	39.30	3.04	45.39	35.89	332	219	223	1.20	0.41	0.428	0.167	0.167	standhyd
AC130	32.53	52.31	40.87	5.83	17.13	16.87	755	231	244	1.72	0.35	0.627	0.303	0.627	Nash
AC140	40.37	65.58	38.90	3.38	45.18	37.81	933	224	231	0.75	0.46	0.780	0.432	0.432	standhyd
AC145	60.89	67.97	44.00	3.42	44.40	35.76	1596	220	245	1.57	0.42	0.849	0.613	0.613	standhyd
AC150	41.64	65.72	39.01	3.09	44.53	35.51	446	220	231	2.47	0.41	0.389	0.162	0.162	standhyd
AC170	13.56	72.58	50.08	3.05	46.95	38.03	582	220	229	1.55	0.44	0.498	0.260	0.260	standhyd
AC180	82.65	66.18	44.39	3.49	38.87	31.28	1961	220	237	0.87	0.39	1.199	0.822	1.199	standhyd

FUTURE CONDITIONS VO2 PARAMETERS

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 PARAMETERS FOR FUTURE DEVELOPMENT
HEWITTS CREEK

VO2 ID	AREA (ha)	CN	CN (pervious)	Ia	Timp	Ximp	Length	Minimum ele.	Maximum ele.	Slope	Rc	AIRPORT Tp	B-W Tp	select Tp	Ntype select
115	111.39	74.83	74.19	6.74	2.85	2.51	1672	264	283	1.14	0.35	1.059	0.644	1.059	Nash
116	72.87	73.14	51.94	3.90	46.30	37.07	1016	263	275	1.18	0.41	0.759	0.406	0.406	standhyd
125	62.02	74.70	73.23	6.57	6.33	5.58	1935	261	275	0.72	0.33	1.359	0.865	1.359	Nash
134	25.64	78.51	50.12	3.10	59.51	53.35	666	272	275	0.45	0.54	0.681	0.357	0.357	standhyd
135	83.44	66.91	65.57	6.29	4.43	3.80	1567	255	275	1.28	0.26	1.106	0.607	1.106	Nash

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 PARAMETERS FOR FUTURE DEVELOPMENT
LOVERS CREEK

VO2 ID	AREA (ha)	CN	CN (pervious)	Ia	Timp	Ximp	Length	Minimum ele	Maximum elv	Slope	Rc	AIRPORT Tp	B-W Tp	select Tp	Ntype select
S100	5.83	88.92	39.06	3.02	84.59	84.59	304	301	306	1.65	0.75	0.187	0.146	0.146	standhyd
S101	5.32	76.20	56.88	3.00	49.08	49.08	277	291	295	1.44	0.68	0.222	0.138	0.138	standhyd
S102	119.62	65.90	65.12	7.12	2.50	2.49	2137	259	302	2.01	0.25	1.128	0.729	1.128	Nash
S140	7.65	88.94	39.87	3.02	84.41	84.41	521	300	306	1.15	0.75	0.278	0.262	0.262	standhyd
S141	1.32	78.14	40.01	3.05	66.02	66.02	350	300	306	1.71	0.82	0.157	0.194	0.194	standhyd
S142	21.67	87.61	47.57	3.27	79.39	79.39	782	295	306	1.41	0.71	0.349	0.340	0.340	standhyd
S144	232.42	62.72	58.41	7.09	4.44	4.38	3757	268	311	1.14	0.28	1.742	1.343	1.742	Nash
S38	89.52	71.04	40.20	3.11	53.40	53.40	683	298	305	1.02	0.77	0.315	0.275	0.275	standhyd
S39	9.86	61.42	39.58	3.71	37.44	37.08	4302	282	301	0.44	0.67	1.322	2.552	2.552	standhyd
S40	358.33	54.87	51.96	7.46	6.16	5.28	2675	257	300	1.61	0.23	1.387	0.856	1.387	Nash
S59	26.84	67.13	42.01	3.10	45.32	45.32	652	295	305	1.53	0.73	0.294	0.273	0.273	standhyd
S60	146.48	52.87	50.07	6.61	5.84	5.09	5269	255	292	0.70	0.18	2.729	2.175	2.729	Nash
S77	9.79	69.88	65.55	6.28	13.48	13.48	430	306	310	0.93	0.34	0.587	0.220	0.587	Nash
S78	30.89	74.40	48.92	3.00	51.97	51.97	552	293	305	2.18	0.76	0.225	0.212	0.212	standhyd
S79	83.16	80.13	46.17	3.08	65.81	65.81	1579	293	306	0.82	0.75	0.533	0.668	0.668	standhyd
S80	145.59	66.55	66.25	7.33	0.94	0.87	1781	255	286	0.50	0.26	1.613	0.788	1.613	Nash
115	111.39	74.83	74.19	6.74	2.85	2.51	1672	264	283	1.14	0.35	1.059	0.644	1.059	Nash
116	72.87	73.14	51.94	3.90	46.30	37.07	1016	263	275	1.18	0.41	0.759	0.406	0.406	standhyd
125	62.02	74.70	73.23	6.57	6.33	5.58	1935	261	275	0.72	0.33	1.359	0.865	1.359	Nash
134	25.64	78.51	50.12	3.10	59.51	53.35	666	272	275	0.45	0.54	0.681	0.357	0.357	standhyd
135	83.44	66.91	65.57	6.29	4.43	3.80	1567	255	275	1.28	0.26	1.106	0.607	1.106	Nash
S130	343.12	72.36	71.69	7.05	2.56	2.34	4822	249	284	0.73	0.34	2.131	1.816	2.131	Nash
S131	28.07	75.86	50.22	3.29	54.31	46.71	712	266	272	0.84	0.43	0.683	0.335	0.335	standhyd
S132	23.90	78.77	54.98	3.50	55.29	47.69	950	264	270	0.63	0.46	0.835	0.480	0.480	standhyd
S133	15.63	78.61	52.03	3.24	58.03	50.58	588	270	274	0.68	0.47	0.625	0.305	0.305	standhyd
S134	43.39	76.44	50.00	3.17	55.45	50.50	1105	265	275	0.90	0.56	0.671	0.490	0.490	standhyd
S170	134.66	71.57	71.14	6.80	1.61	1.38	2090	249	275	1.24	0.29	1.250	0.776	1.250	Nash
S250	360.89	62.95	60.98	6.66	5.32	4.72	3361	242	275	0.98	0.24	1.810	1.185	1.810	Nash
S251	30.99	77.30	53.95	3.54	53.01	46.55	907	272	275	0.33	0.47	0.989	0.508	0.508	standhyd
S171	1.38	65.76	51.11	4.04	33.54	27.62	169	273	275	1.18	0.30	0.355	0.100	0.355	standhyd

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 PARAMETERS FOR FUTURE DEVELOPMENT
SANDY COVE AND MOOSELANKA

VO2 ID	AREA (ha)	CN	CN (pervious)	Ia	Timp	Ximp	Length	Minimum ele.	Maximum elv.	Slope	Rc	AIRPORT Tp	B-W Tp	select Tp	Ntype select
240	71.05	73.00	72.94	7.15	0.24	0.23	1048	234	251	1.62	0.31	0.794	0.393	0.794	Nash
242	33.40	79.37	56.34	3.39	55.28	38.98	1103	235	247	1.09	0.60	0.588	0.484	0.484	standhyd
245	111.90	63.28	56.04	6.84	1.27	1.22	3020	230	246	0.53	0.31	1.942	1.355	1.942	Nash
250	45.98	51.29	51.15	7.05	0.31	0.31	1285	249	259	0.78	0.22	1.235	0.584	1.235	Nash
252	93.30	80.23	53.55	3.09	60.02	49.12	2184	231	248	0.78	0.49	1.113	0.924	0.924	standhyd
254	24.54	63.04	52.84	6.46	22.85	18.57	673	226	234	1.19	0.27	0.736	0.299	0.736	standhyd
255	90.22	66.82	51.08	5.22	34.05	26.15	1725	219	232	0.75	0.36	1.226	0.737	1.226	standhyd
305	63.41	70.18	69.85	6.98	1.15	1.05	1236	252	262	0.81	0.33	1.046	0.539	1.046	Nash
306	9.85	78.86	61.34	3.70	47.78	31.91	1113	245	250	0.45	0.57	0.828	0.658	0.658	standhyd
310	77.14	66.02	65.60	7.10	1.29	1.22	2626	251	275	0.91	0.29	1.553	1.097	1.553	Nash
311	7.31	74.71	57.47	3.96	42.54	28.36	344	246	251	1.45	0.51	0.353	0.166	0.166	standhyd
315	42.67	79.30	53.47	3.19	57.99	47.33	1413	237	250	0.92	0.48	0.866	0.625	0.625	standhyd
320	25.27	73.99	41.16	3.11	57.77	45.20	862	225	236	1.28	0.47	0.619	0.376	0.376	standhyd
325	11.94	69.82	50.11	4.06	41.15	35.06	596	222	227	0.84	0.32	0.728	0.305	0.728	standhyd
329	2.74	78.26	50.01	3.05	58.88	46.98	427	220	225	1.17	0.45	0.464	0.237	0.237	standhyd
330	1.30	79.04	50.00	3.00	60.49	50.85	90	219.5	220	0.50	0.42	0.295	0.064	0.064	standhyd
I1201	2.42	81.32	61.03	3.37	54.88	37.30	118	255	256	0.85	0.65	0.188	0.071	0.071	standhyd
I1204	24.45	82.19	58.61	3.01	59.86	39.94	739	244	255	1.49	0.67	0.368	0.314	0.314	standhyd
I1205	103.38	55.13	47.87	6.05	14.49	12.29	1592	222	235	0.82	0.16	1.457	0.660	1.457	Nash
I1300	62.67	64.66	48.72	4.37	32.36	27.18	990	219	236	1.72	0.26	0.798	0.372	0.798	standhyd
I1301	1.01	73.95	39.77	3.09	58.70	49.01	183	236	239	1.64	0.41	0.287	0.105	0.105	standhyd
I1399	1.65	78.76	50.00	3.00	59.92	49.93	97	219	221	2.06	0.40	0.197	0.051	0.197	standhyd
I1400	89.16	71.39	47.49	4.16	47.36	35.78	2145	221	236	0.70	0.45	1.226	0.931	0.931	standhyd
I1500	54.03	73.80	54.67	4.18	44.17	36.09	920	219	232	1.41	0.38	0.703	0.365	0.703	standhyd
I1501	32.02	69.84	51.44	4.53	39.51	33.20	350	220	225	1.43	0.32	0.470	0.146	0.470	standhyd

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 PARAMETERS FOR FUTURE DEVELOPMENT
GILFORD

VO2 ID	AREA (ha)	CN	CN (pervious)	Ia	Timp	Ximp	Length	Minimum ele.	Maximum elv.	Slope	Rc	AIRPORT Tp	B-W Tp	select Tp	Ntype select
420	12.53	79.48	52.20	3.03	59.56	49.64	591	288	300	2.03	0.40	0.488	0.252	0.488	standhyd
421	3.91	81.03	51.84	3.00	63.20	55.37	598	288	301	2.18	0.50	0.409	0.283	0.283	standhyd
422	127.68	70.32	69.11	6.58	4.16	3.57	2423	246	285	1.61	0.32	1.190	0.859	1.190	Nash
424	2.08	74.45	50.82	3.54	50.44	46.08	177	300	301	0.56	0.58	0.304	0.117	0.117	standhyd
425	231.14	77.38	77.13	6.91	1.17	1.06	4557	240	300	1.32	0.36	1.652	1.585	1.652	Nash
430	41.40	52.54	49.40	7.18	6.45	5.90	1153	228	237	0.78	0.25	1.135	0.529	1.135	Nash
432	12.46	74.56	52.86	3.71	48.51	39.69	850	225	237	1.41	0.40	0.659	0.390	0.390	standhyd
433	0.65	42.23	39.56	4.92	4.58	4.37	154	225	225	0.00	0.20	N/A	N/A	0.100	Nash
434	4.01	81.61	59.44	3.16	57.57	48.04	587	222	225	0.51	0.41	0.755	0.370	0.370	standhyd
435	13.80	50.48	49.26	7.57	2.53	2.40	546	235	240	0.92	0.24	0.753	0.271	0.753	Nash
436	32.96	61.94	56.13	8.83	14.12	9.40	979	221	233	1.23	0.22	0.937	0.420	0.832	Nash
437	50.21	58.52	58.41	5.64	0.40	0.38	1119	220	234	1.25	0.18	1.039	0.458	1.039	Nash
438	10.31	81.11	59.58	3.19	56.03	46.70	601	219	220	0.50	0.38	0.806	0.346	0.806	standhyd
G100	152.47	69.64	68.98	6.76	2.37	1.98	3339	224	264	1.20	0.30	1.587	1.234	1.587	Nash
G101	14.62	76.54	55.06	3.65	50.04	40.60	593	228	237	1.52	0.42	0.525	0.264	0.264	standhyd
G102	32.44	80.00	60.87	3.61	51.48	42.18	945	219	228	0.95	0.42	0.764	0.427	0.427	standhyd
G104	6.57	82.62	60.98	3.10	58.38	50.07	344	219	220	0.29	0.46	0.646	0.231	0.231	standhyd
G105	1.63	77.57	60.64	3.06	45.29	40.64	242	219	219	0.00	0.58	N/A	N/A	0.100	standhyd
I200	151.63	60.20	59.89	7.07	0.91	0.85	3965	219	250	0.78	0.18	2.276	1.597	2.276	Nash
I300	21.42	83.47	61.00	3.00	60.70	51.20	461	219	222	0.65	0.42	0.606	0.234	0.234	standhyd
I400	8.79	65.65	60.09	8.78	14.70	9.80	284	223	228	1.76	0.23	0.441	0.129	0.394	Nash
I401	76.00	66.44	64.12	7.12	6.84	5.92	862	220	237	1.97	0.26	0.713	0.309	0.713	Nash
I402	40.44	82.96	60.82	3.02	59.55	49.63	1109	219	220	0.09	0.40	1.875	0.785	1.875	standhyd
W100	283.22	76.40	75.95	6.85	2.14	2.01	4587	231	285	1.18	0.36	1.716	1.599	1.716	Nash
W105	409.54	68.48	68.09	6.91	1.33	1.20	3437	235	290	1.60	0.29	1.475	1.086	1.475	Nash

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 PARAMETERS FOR FUTURE DEVELOPMENT
LEFROY

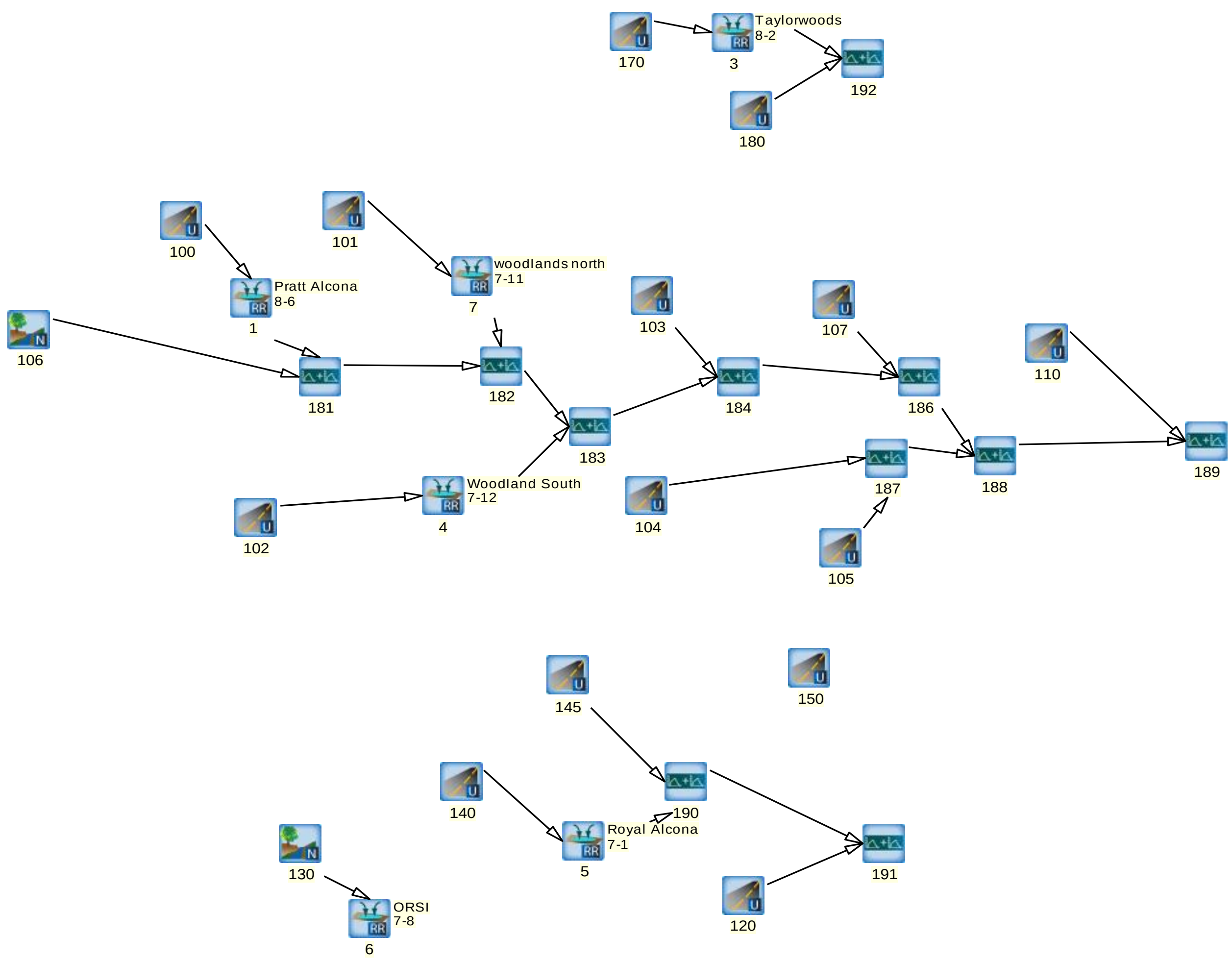
VO2 ID	AREA (ha)	CN	CN (pervious)	Ia	Timp	Ximp	Length	Minimum ele.	Maximum elv.	Slope	Rc	AIRPORT Tp	B-W Tp	select Tp	Ntype select
B100	488.48	63.42	63.15	7.27	0.80	0.78	5228	223	258	0.67	0.25	2.549	1.932	2.549	Nash
B102	18.06	81.53	58.39	3.24	58.38	49.52	547	221.8	290	12.47	0.42	0.249	0.157	0.157	standhyd
B99	1.11	65.89	49.26	4.15	34.11	22.53	79	255	256	1.27	0.42	0.202	0.047	0.047	standhyd
C100	196.95	62.05	61.01	7.00	2.82	2.37	3024	240	282	1.39	0.25	1.516	1.057	1.516	Nash
C102	51.29	78.00	68.32	4.43	32.83	26.19	1140	232	251	1.67	0.43	0.687	0.440	0.440	standhyd
C105	259.10	62.94	62.71	7.42	0.65	0.58	3112	242	283	1.32	0.26	1.557	1.070	1.557	Nash
C106	5.13	58.38	52.71	7.04	12.53	8.02	310	232	240	2.58	0.28	0.382	0.138	0.382	Nash
C120	198.59	67.09	53.49	4.84	29.78	22.48	2383	219	257	1.59	0.33	1.168	0.810	1.168	standhyd
I600	35.47	65.35	51.35	5.56	30.02	23.51	3870	219	225	0.16	0.34	3.169	2.490	3.169	standhyd
I601	6.44	63.25	54.84	6.01	19.48	19.20	448	219	221	0.45	0.38	0.725	0.277	0.725	Nash
I700	35.31	55.71	55.01	7.44	1.75	1.67	1226	222	250.8	2.35	0.21	0.850	0.458	0.850	Nash
I701	154.99	66.41	50.67	4.39	33.17	26.88	2402	219	257	1.58	0.34	1.166	0.838	1.166	standhyd
I800	76.18	54.69	49.94	6.70	9.93	8.39	1241	225	235	0.81	0.17	1.268	0.532	1.268	Nash
I801	8.10	78.83	50.61	3.12	59.54	50.26	391	219	225	1.53	0.42	0.423	0.184	0.184	standhyd
W100	283.22	76.40	75.95	6.85	2.14	2.01	4587	231	285	1.18	0.36	1.716	1.599	1.716	Nash
W105	409.54	68.48	68.09	6.91	1.33	1.20	3437	235	290	0.50	0.29	2.166	1.370	2.166	Nash
W110	111.27	70.18	67.00	7.15	2.49	2.33	2056	222	244	1.07	0.31	1.273	0.802	1.273	Nash
W111	1.43	67.51	55.00	4.58	29.10	16.63	140	246	251	3.57	0.38	0.203	0.066	0.203	standhyd
W112	8.54	59.84	54.99	7.19	9.33	6.11	337	225	230	1.48	0.25	0.494	0.159	0.494	Nash

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 PARAMETERS FOR FUTURE DEVELOPMENT
ALCONA

VO2 ID	AREA (ha)	CN	CN (pervious)	Ia	Timp	Ximp	Length	Minimum ele.	Maximum ele.	Slope	Rc	AIRPORT Tp	B-W Tp	SELECT Tp	Ntype select
AC100	8.39	80.92	62.47	3.64	51.93	43.27	475	260	274	2.95	0.38	0.399	0.196	0.399	standhyd
AC101	11.44	78.64	50.00	3.02	59.67	49.71	433	244	251	1.62	0.40	0.447	0.195	0.195	standhyd
AC102	5.90	78.80	50.00	3.00	60.00	50.00	459	245	248	0.65	0.40	0.626	0.265	0.626	standhyd
AC103	10.57	79.29	50.00	2.97	61.03	53.59	580	239	251	2.07	0.50	0.410	0.251	0.251	standhyd
AC104	6.79	79.35	50.00	3.00	61.14	51.90	228	244	249	2.19	0.44	0.280	0.102	0.102	standhyd
AC105	5.92	79.81	50.00	3.01	62.10	53.53	322	240	250	3.11	0.47	0.282	0.136	0.136	standhyd
AC106	111.47	70.79	61.49	4.96	25.77	19.37	2095	246	275	1.38	0.40	1.042	0.776	0.776	standhyd
AC107	17.07	76.03	45.33	3.62	58.41	54.39	594	237	246	1.52	0.53	0.436	0.260	0.260	standhyd
AC110	66.75	68.52	42.34	3.53	46.94	40.84	2082	219	234	0.72	0.44	1.206	0.925	0.925	standhyd
AC120	7.09	74.42	39.20	3.03	59.91	50.29	332	219	223	1.20	0.41	0.426	0.167	0.167	standhyd
AC130	32.53	63.43	42.23	3.82	38.02	28.84	755	231	244	1.72	0.49	0.506	0.303	0.303	standhyd
AC140	40.37	70.77	38.92	3.45	54.21	46.64	933	224	231	0.75	0.43	0.813	0.432	0.432	standhyd
AC145	60.89	75.29	43.62	3.10	58.43	49.32	1596	220	245	1.57	0.43	0.840	0.613	0.613	standhyd
AC150	41.64	73.48	39.01	3.08	58.45	49.27	446	220	231	2.47	0.42	0.385	0.162	0.162	standhyd
AC170	13.56	79.01	50.24	3.03	60.23	50.78	582	220	229	1.55	0.43	0.503	0.260	0.260	standhyd
AC180	82.65	72.10	44.73	3.33	51.87	43.34	1961	220	237	0.87	0.40	1.175	0.822	0.822	standhyd

EXISTING & FUTURE CONDITIONS VO2 SCHEMATICS

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
EXISTING CONDITIONS
ALCONA

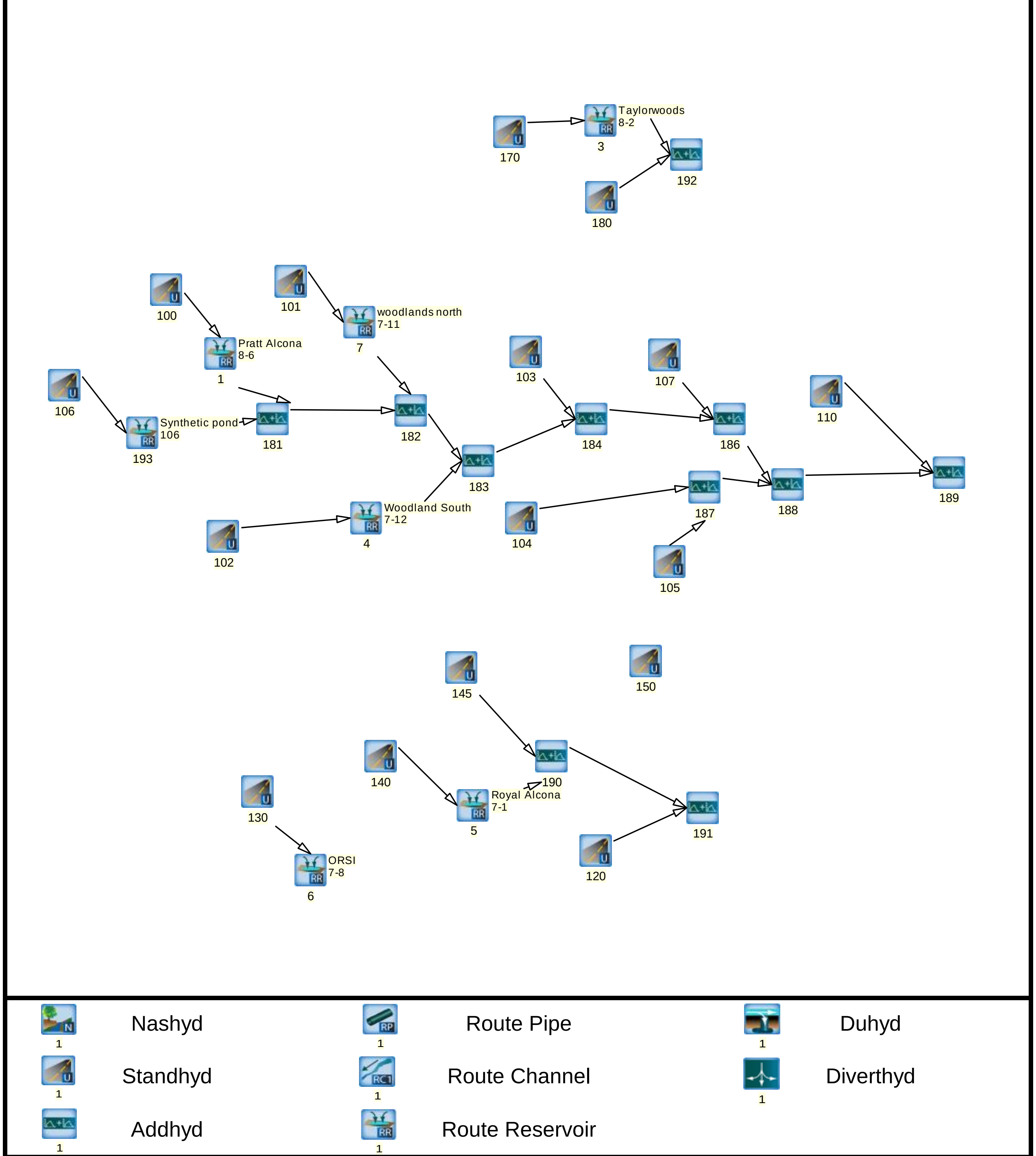


1	Nashyd	1	Route Pipe	1	Duhyd
1	Standhyd	1	Route Channel	1	Diverthyd
1	Addhyd	1	Route Reservoir		

C.C. TATHAM & ASSOCIATES LTD.
Consulting Engineers

Project:	Innisfil SWM Master Plan		
File No.:	413448		
Subject:	Otthymo Flow Schematic		
Date:	Jun-14	**Figure:**	1

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
FUTURE CONDITIONS WITH SYNTHETIC PONDS
ALCONA



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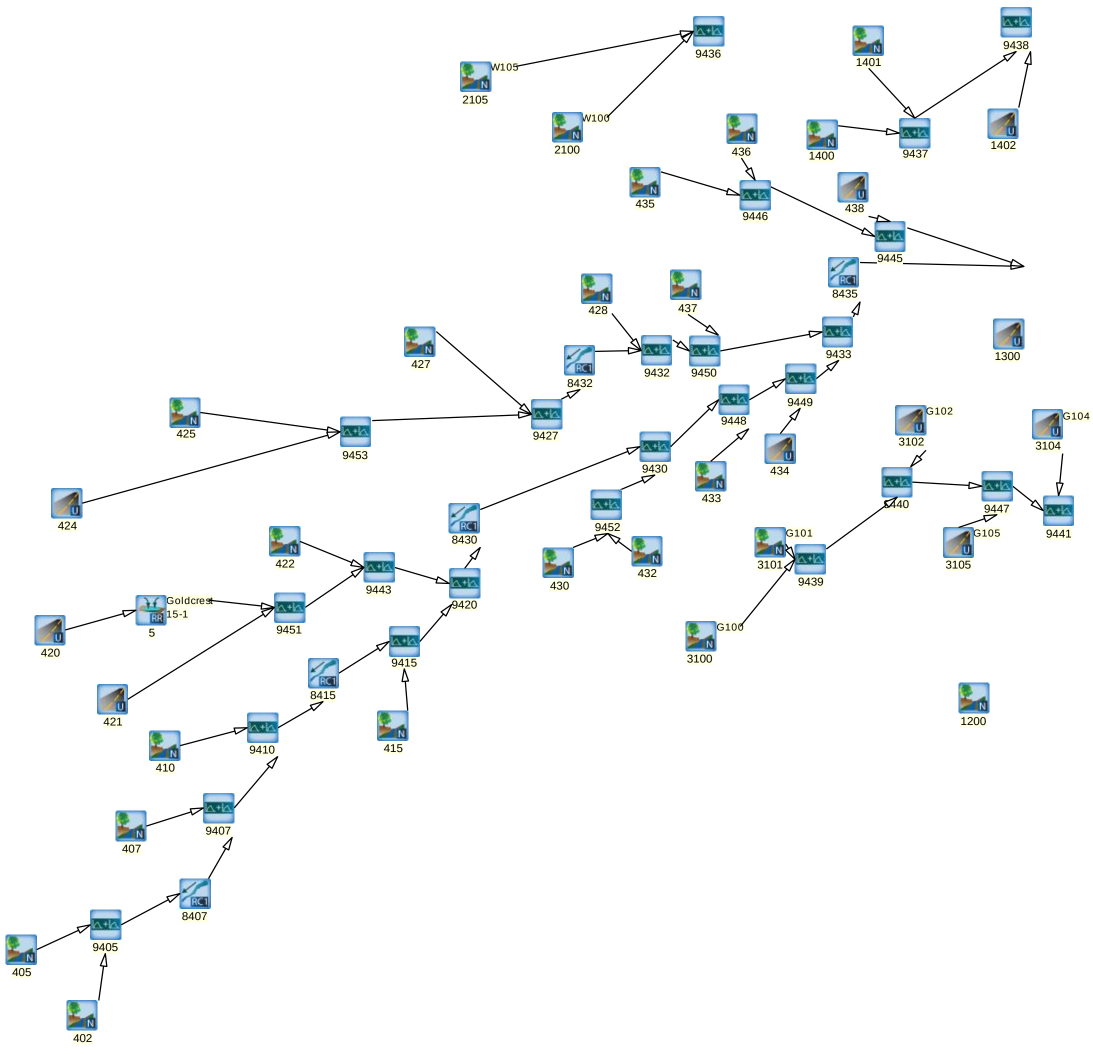
Consulting Engineers

Project:	Innisfil SWM Master Plan		
File No.:	413448		
Subject:	Otthymo Flow Schematic		
Date:	Jun-14	**Figure:**	2

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
EXISTING CONDITIONS
GILFORD

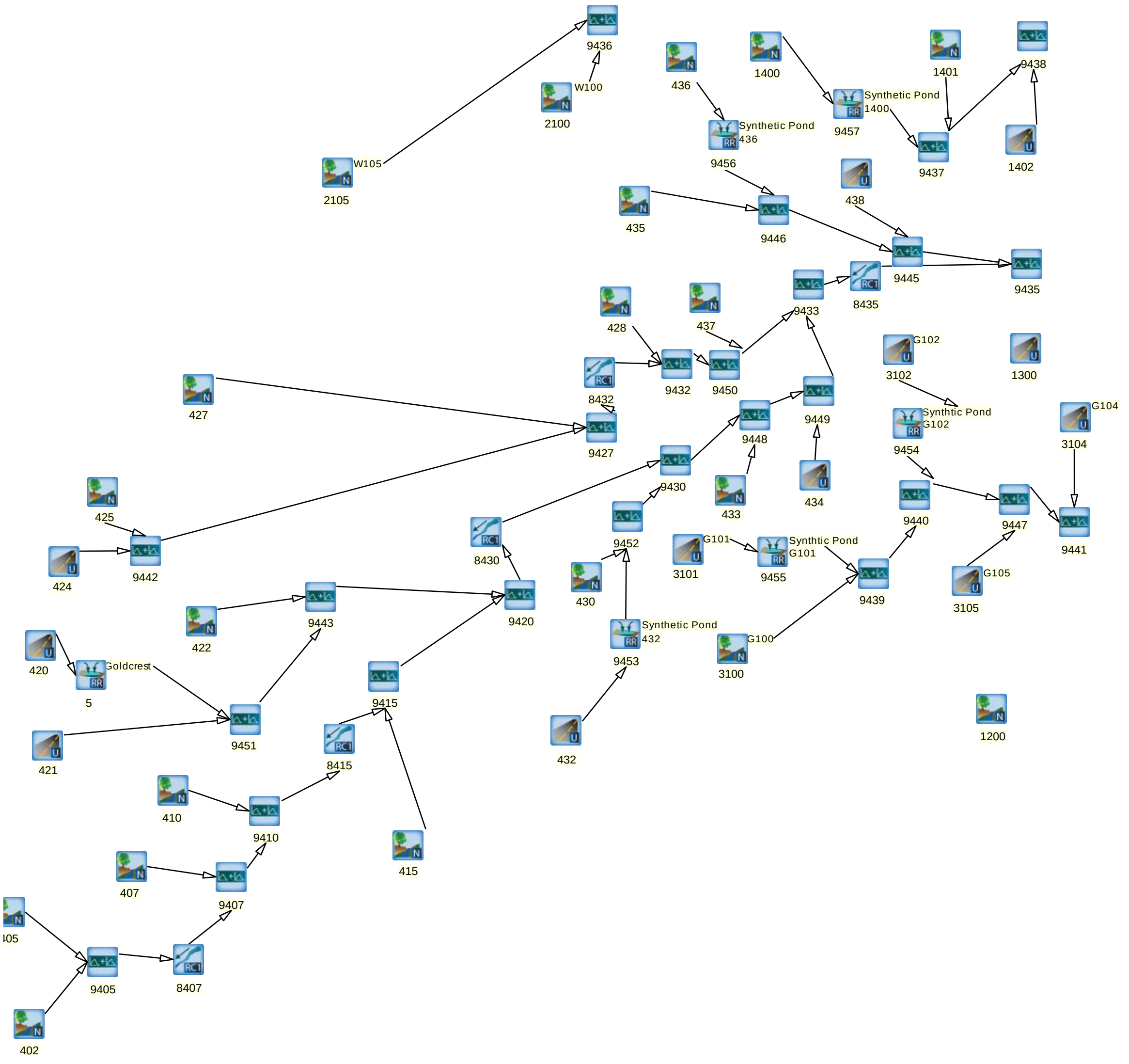


Nashyd	Route Pipe	Duhyd
Standhyd	Route Channel	Diverthyd
Addhyd	Route Reservoir	

C.C. TATHAM & ASSOCIATES LTD.
Consulting Engineers

Project: Innisfil SWM Master Plan
File No.: 413448
Subject: Otthymo Flow Schematic
Date: Jun-14 **Figure:** 3

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
FUTURE CONDITIONS WITH SYNTHETIC PONDS
GILFORD

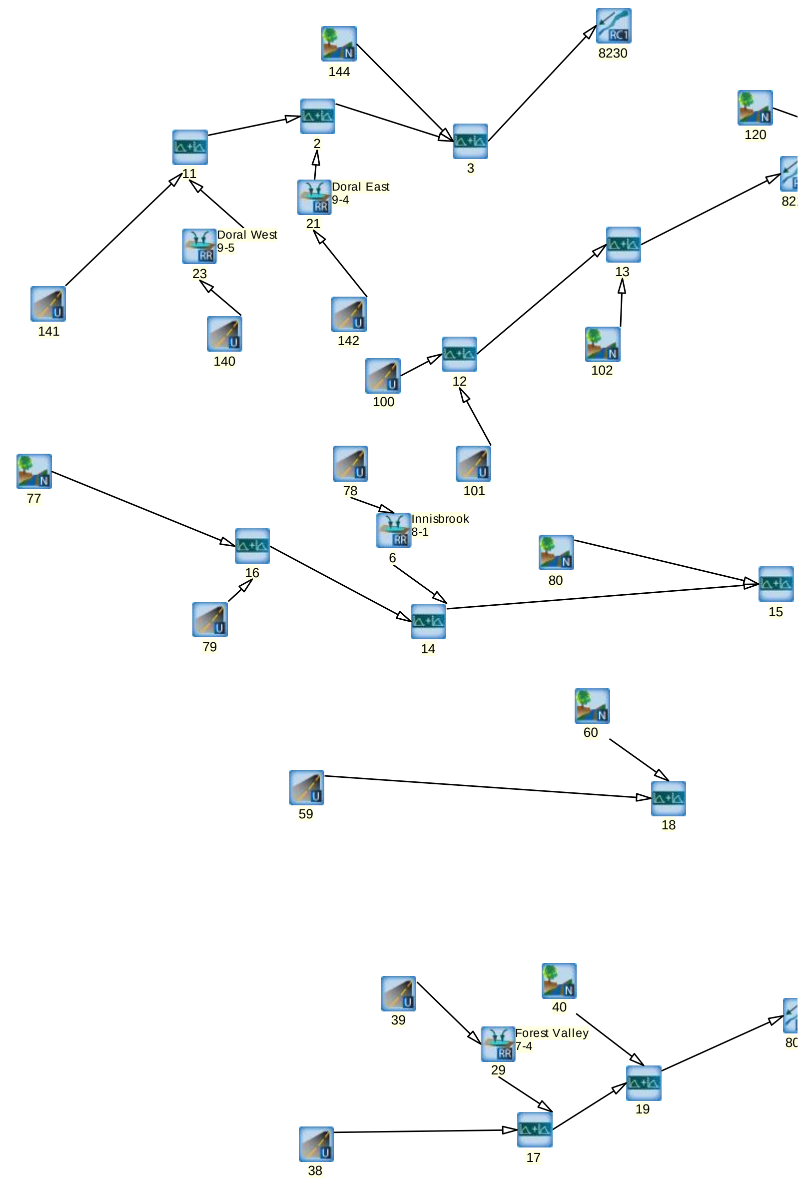


N 1	Nashyd	RP 1	Route Pipe	1	Duhyd
U 1	Standhyd	RC1 1	Route Channel	1	Diverthyd
1	Addhyd	RR 1	Route Reservoir		

C.C. TATHAM & ASSOCIATES LTD.
Consulting Engineers

Project:	Innisfil SWM Master Plan
File No.:	413448
Subject:	Otthymo Flow Schematic
Date:	Jun-14 **Figure:** 4

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
EXISTING CONDITIONS
INNISFIL HEIGHTS

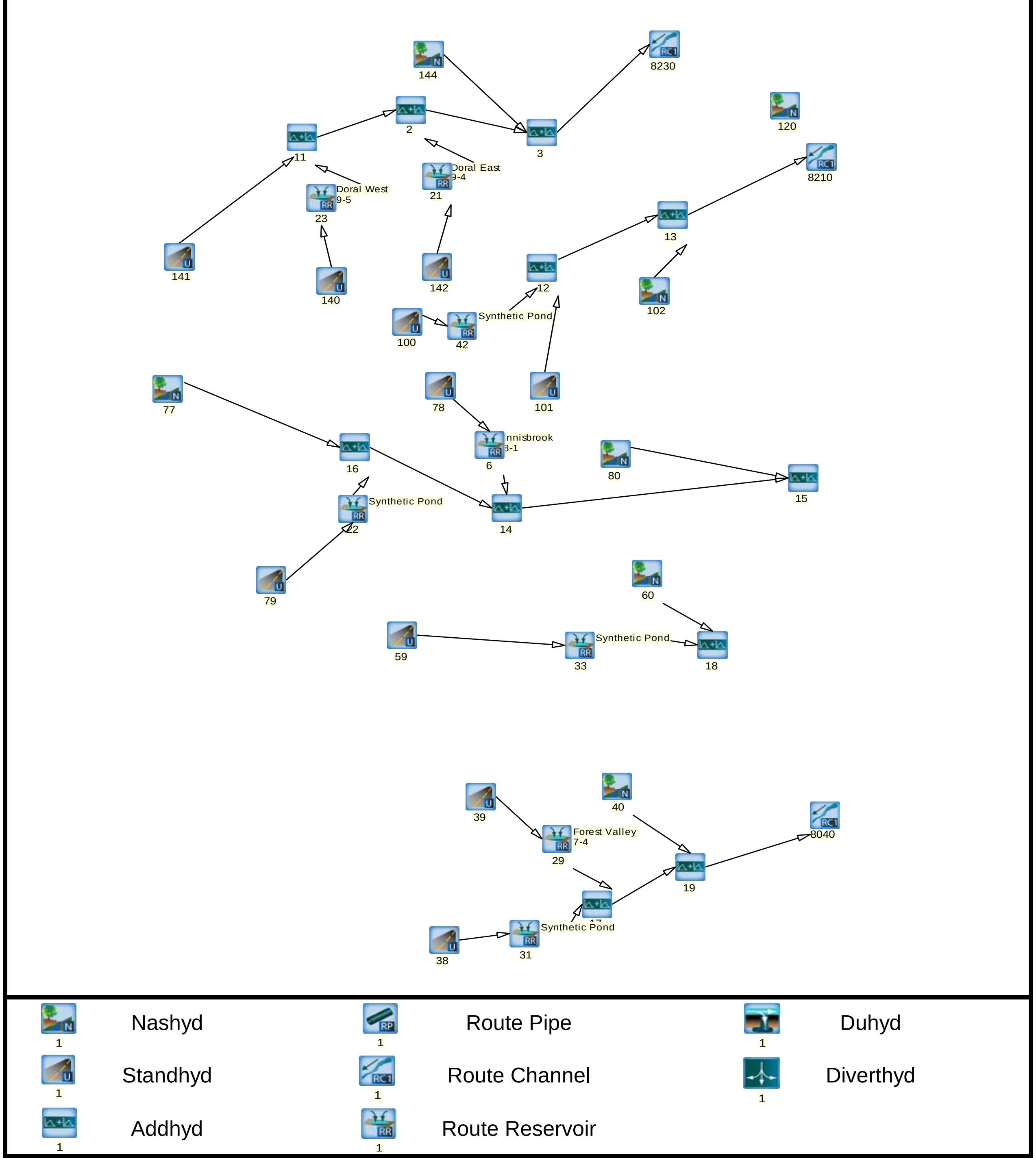


N 1	Nashyd	RP 1	Route Pipe	1	Duhyd
U 1	Standhyd	RC1 1	Route Channel	1	Diverthyd
1	Addhyd	RR 1	Route Reservoir		

C.C. TATHAM & ASSOCIATES LTD.
Consulting Engineers

Project:	Innisfil SWM Master Plan		
File No.:	413448		
Subject:	Otthymo Flow Schematic		
Date:	Jun-14	**Figure:**	5

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
FUTURE CONDITIONS WITH SYNTHETIC PONDS
INNISFIL HEIGHTS



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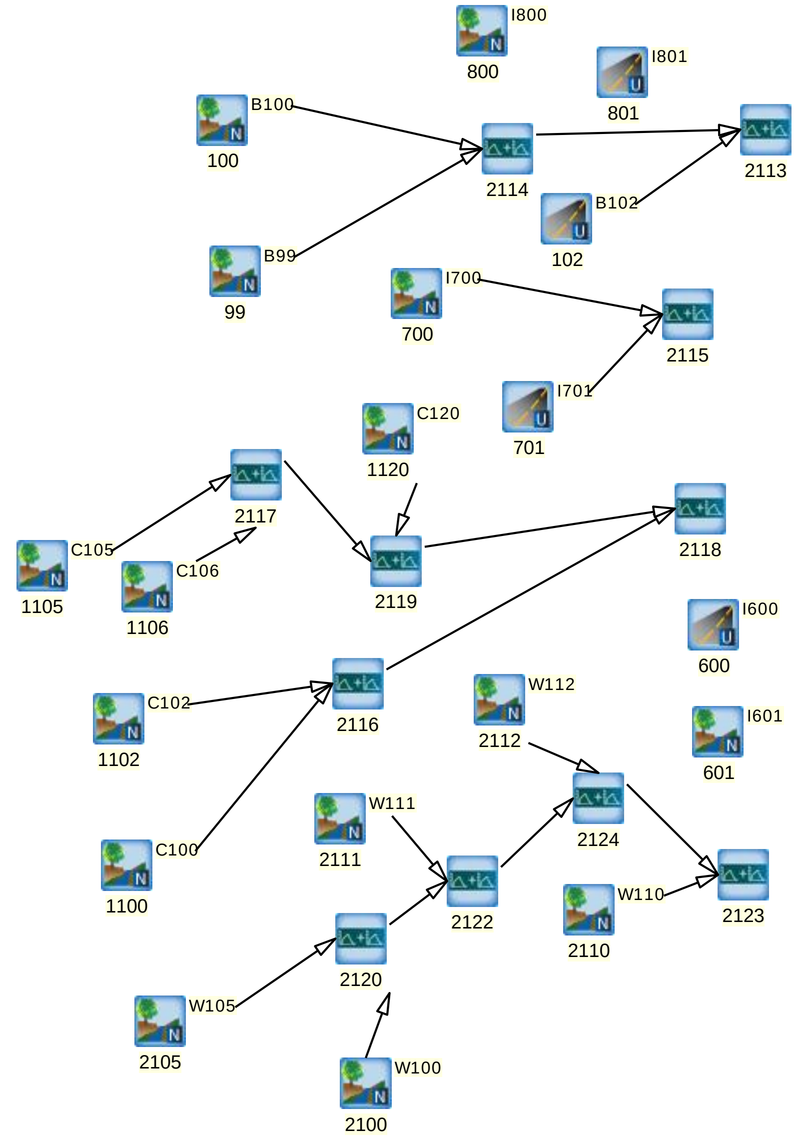
Project:	Innisfil SWM Master Plan
File No.:	413448
Subject:	Otthymo Flow Schematic
Date:	Jun-14 **Figure:** 6

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
EXISTING CONDITIONS
LEFROY



Nashyd	Route Pipe	Duhyd
Standhyd	Route Channel	Diverthyd
Addhyd	Route Reservoir	

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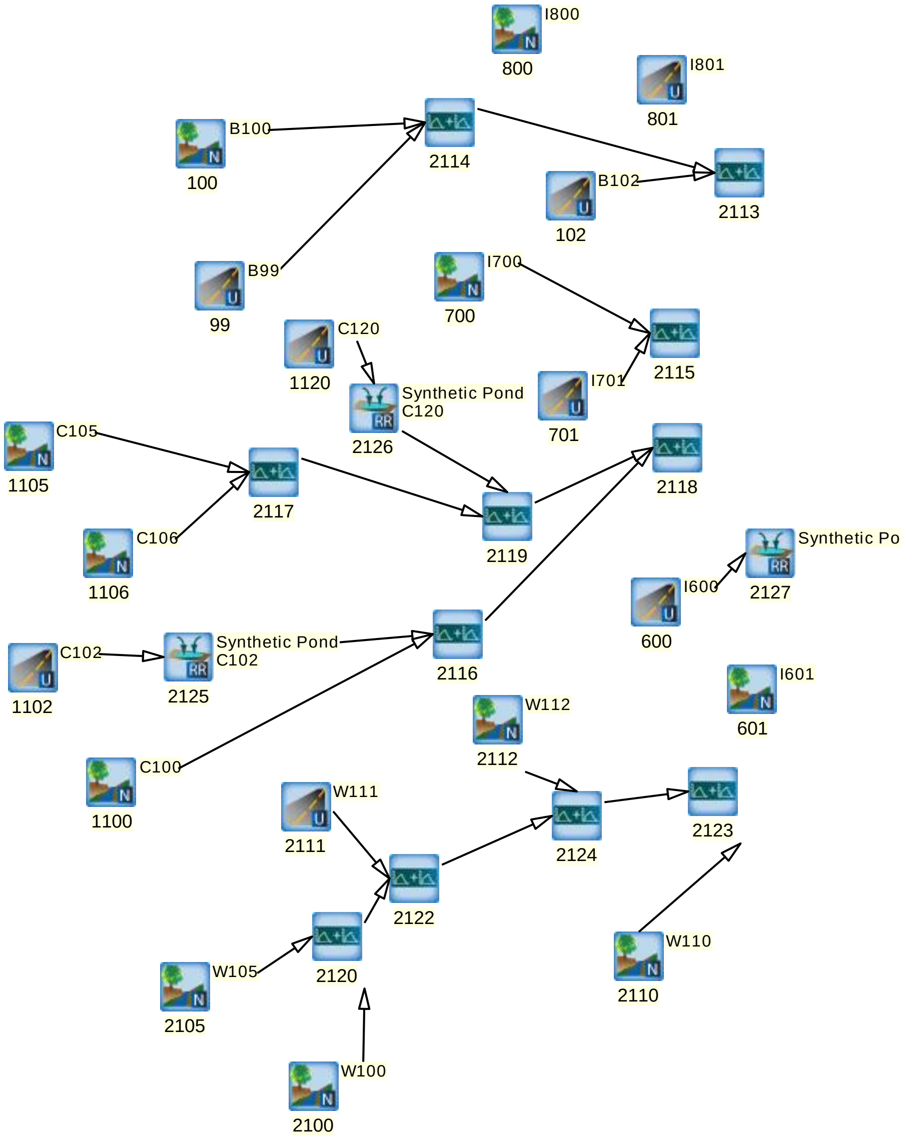
Consulting Engineers

Project:	Innisfil SWM Master Plan		
File No.:	413448		
Subject:	Otthymo Flow Schematic		
Date:	Jun-14	**Figure:**	7

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
FUTURE CONDITIONS WITH SYNTHETIC PONDS
LEFROY



N Nashyd

U Standhyd

Addhyd

RP Route Pipe

RC Route Channel

RR Route Reservoir

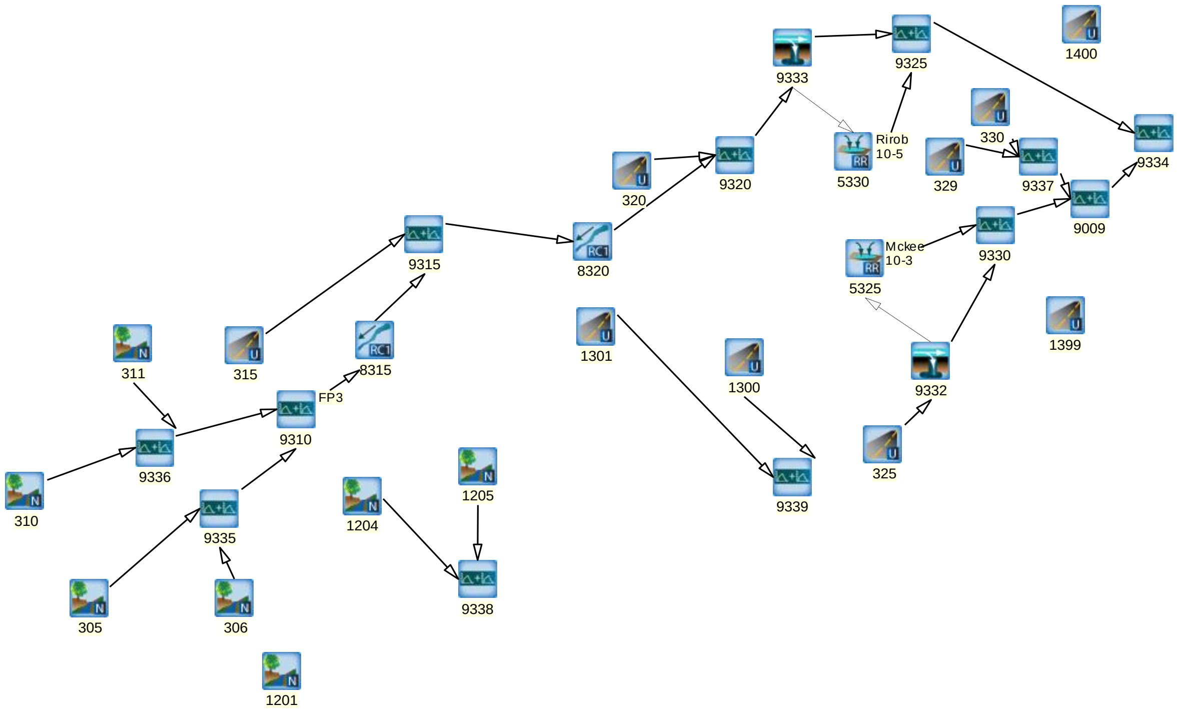
Duhyd

Diverthyd

C.C. TATHAM & ASSOCIATES LTD.
Consulting Engineers

Project:	Innisfil SWM Master Plan
File No.:	413448
Subject:	Otthymo Flow Schematic
Date:	Jun-14 **Figure:** 8

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
EXISTING CONDITIONS
MOOSELANKA

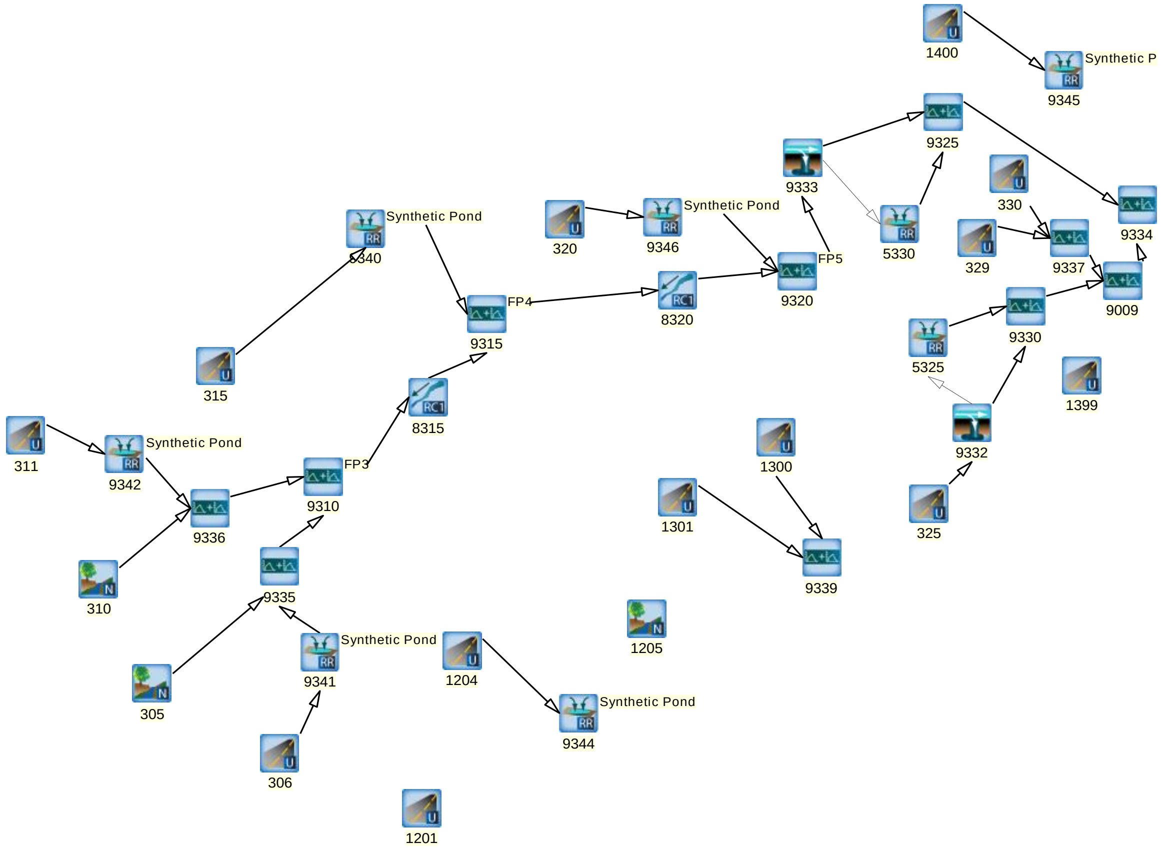


Nashyd	Route Pipe	Duhyd
Standhyd	Route Channel	Diverthyd
Addhyd	Route Reservoir	

C.C. TATHAM & ASSOCIATES LTD.
Consulting Engineers

Project:	Innisfil SWM Master Plan
File No.:	413448
Subject:	Otthymo Flow Schematic
Date:	Jun-14 **Figure:** 9

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
FUTURE CONDITIONS WITH SYNTHETIC PONDS
MOOSELANKA

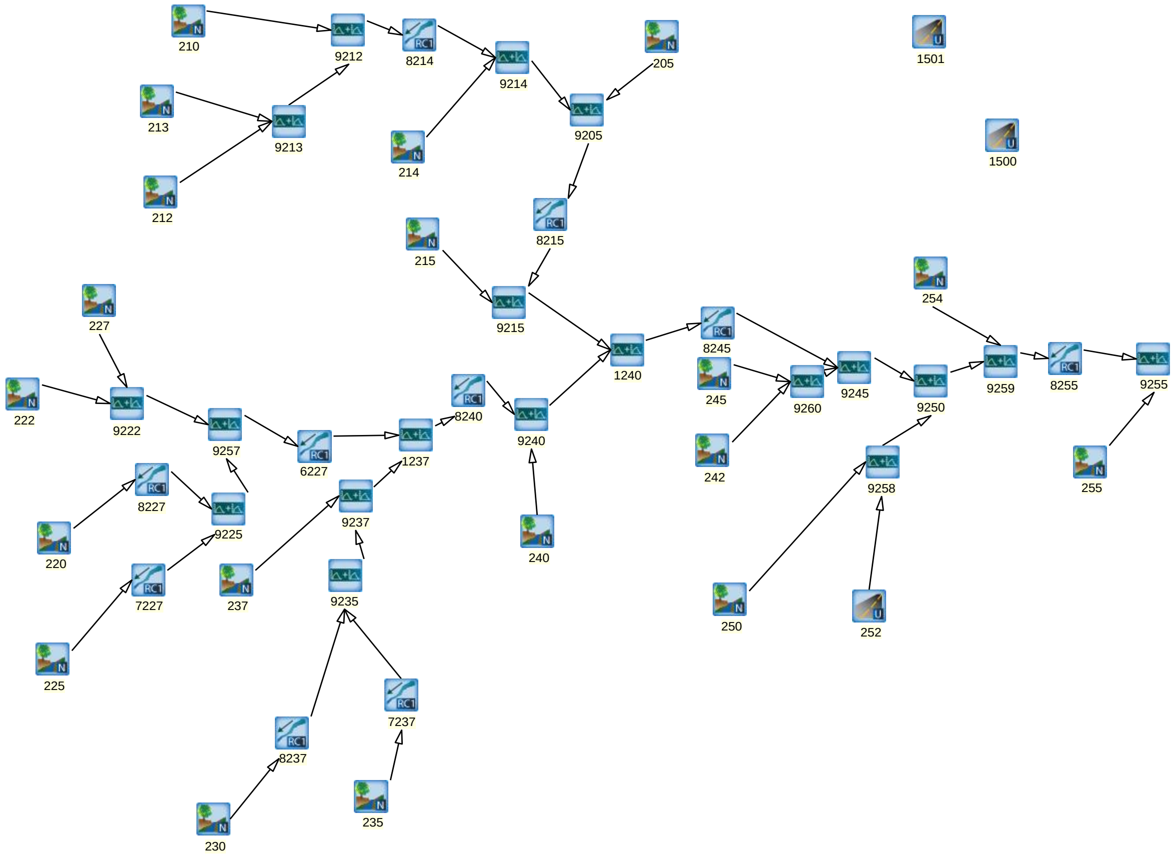


1	Nashyd	1	Route Pipe	1	Duhyd
1	Standhyd	1	Route Channel	1	Diverthyd
1	Addhyd	1	Route Reservoir		

C.C. TATHAM & ASSOCIATES LTD.
Consulting Engineers

Project:	Innisfil SWM Master Plan		
File No.:	413448		
Subject:	Otthymo Flow Schematic		
Date:	Jun-14	**Figure:**	10

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
EXISTING CONDITIONS
SANDY COVE

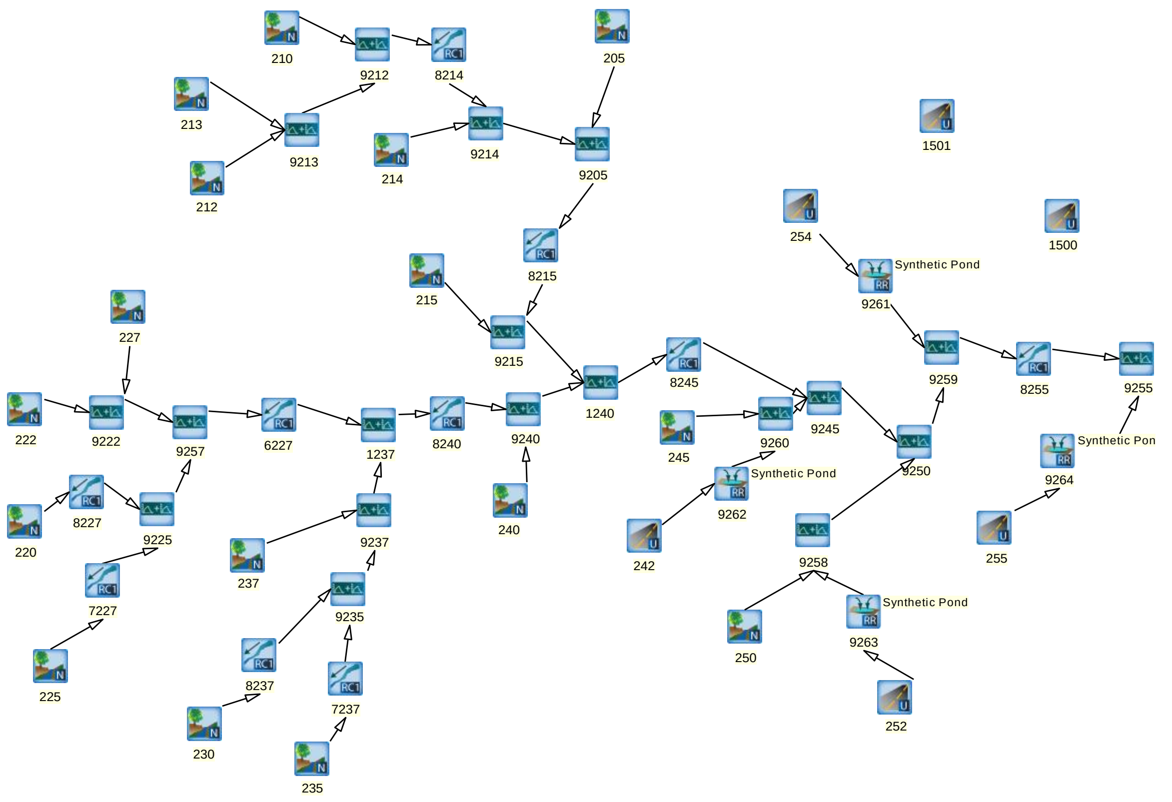


1	Nashyd	1	Route Pipe	1	Duhyd
1	Standhyd	1	Route Channel	1	Diverthyd
1	Addhyd	1	Route Reservoir		

C.C. TATHAM & ASSOCIATES LTD.
Consulting Engineers

Project:	Innisfil SWM Master Plan		
File No.:	413448		
Subject:	Otthymo Flow Schematic		
Date:	Jun-14	**Figure:**	11

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
FUTURE CONDITIONS WITH SYNTHETIC PONDS
SANDY COVE

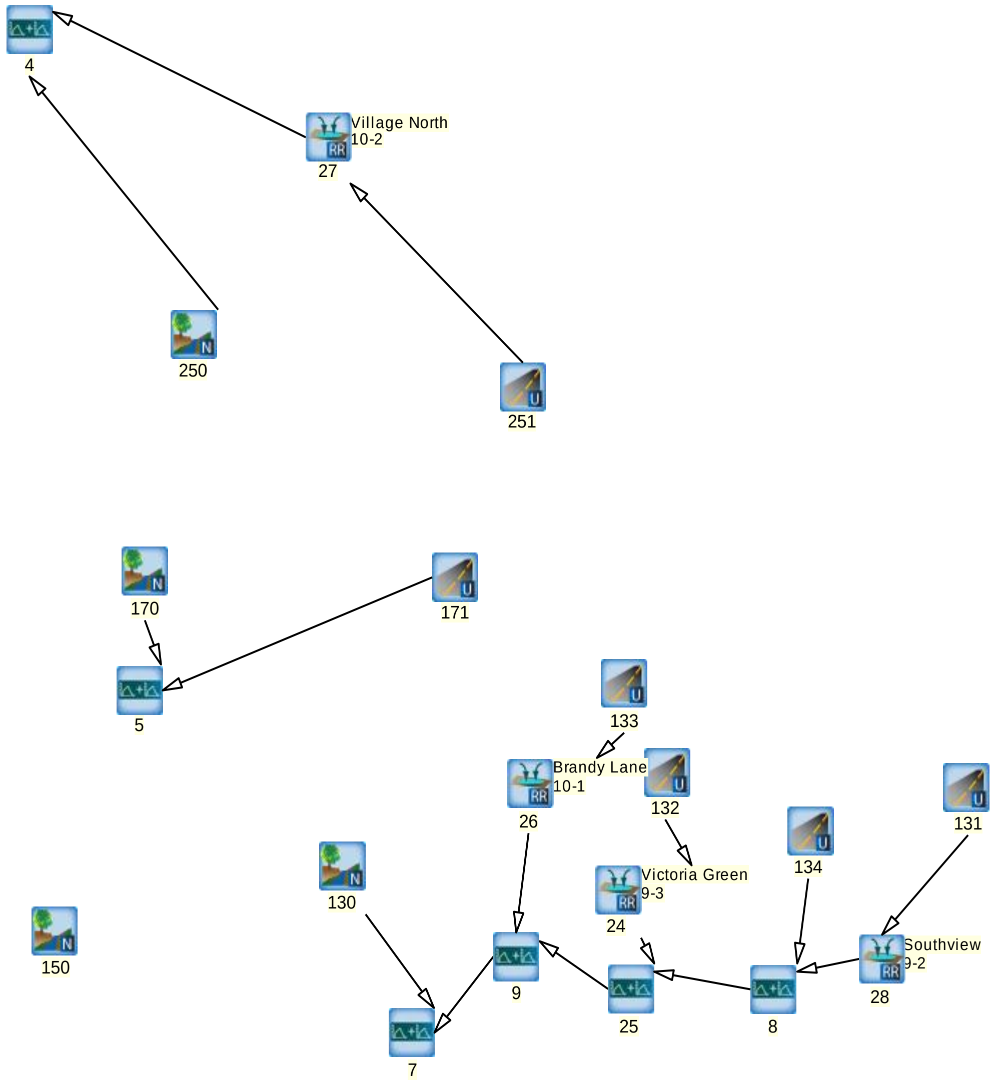


1	Nashyd	1	Route Pipe	1	Duhyd
1	Standhyd	1	Route Channel	1	Diverthyd
1	Addhyd	1	Route Reservoir		

C.C. TATHAM & ASSOCIATES LTD.
Consulting Engineers

Project:	Innisfil SWM Master Plan		
File No.:	413448		
Subject:	Otthymo Flow Schematic		
Date:	Jun-14	**Figure:**	12

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
EXISTING CONDITIONS
STROUD - LOVER'S CREEK

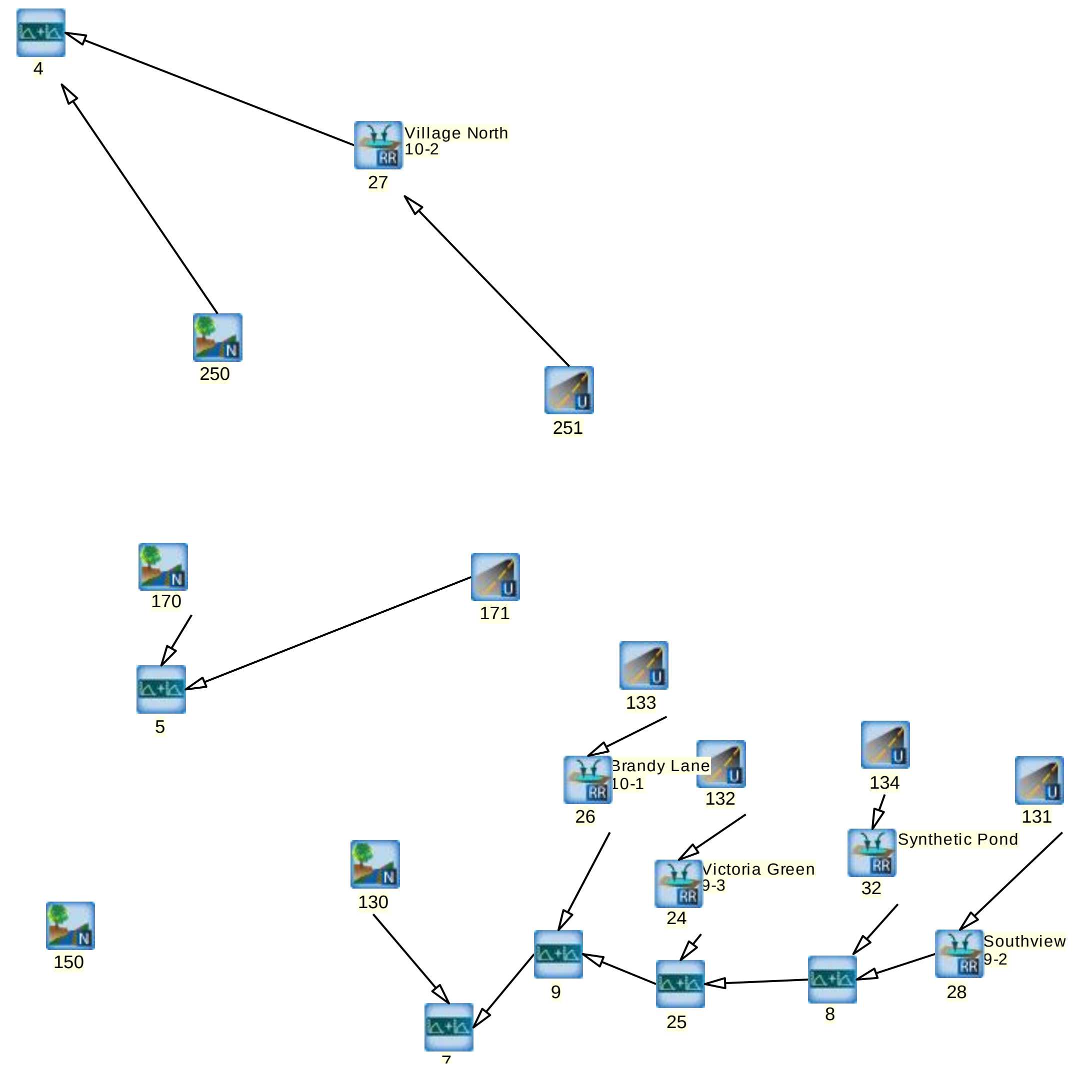


Nashyd	Route Pipe	Duhyd
Standhyd	Route Channel	Diverthyd
Addhyd	Route Reservoir	

C.C. TATHAM & ASSOCIATES LTD.
Consulting Engineers

Project: Innisfil SWM Master Plan
File No.: 413448
Subject: Otthymo Flow Schematic
Date: Jun-14 **Figure:** 13

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
FUTURE CONDITIONS WITH SYNTHETIC PONDS
STROUD - LOVER'S CREEK



Nashyd	Route Pipe	Duhyd
Standhyd	Route Channel	Diverthyd
Addhyd	Route Reservoir	

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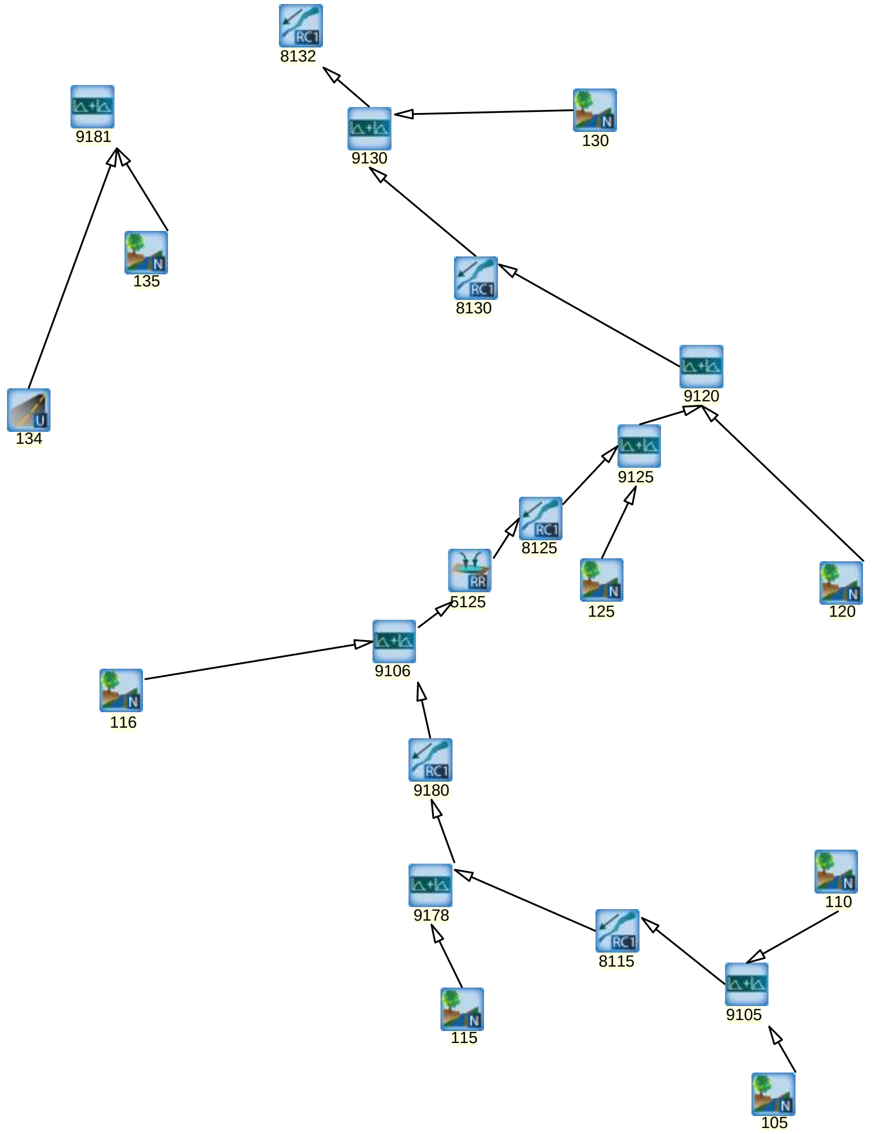
Consulting Engineers

Project:	Innisfil SWM Master Plan		
File No.:	413448		
Subject:	Otthymo Flow Schematic		
Date:	Jun-14	**Figure:**	14

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
EXISTING CONDITIONS
STROUD - HEWITTS CREEK

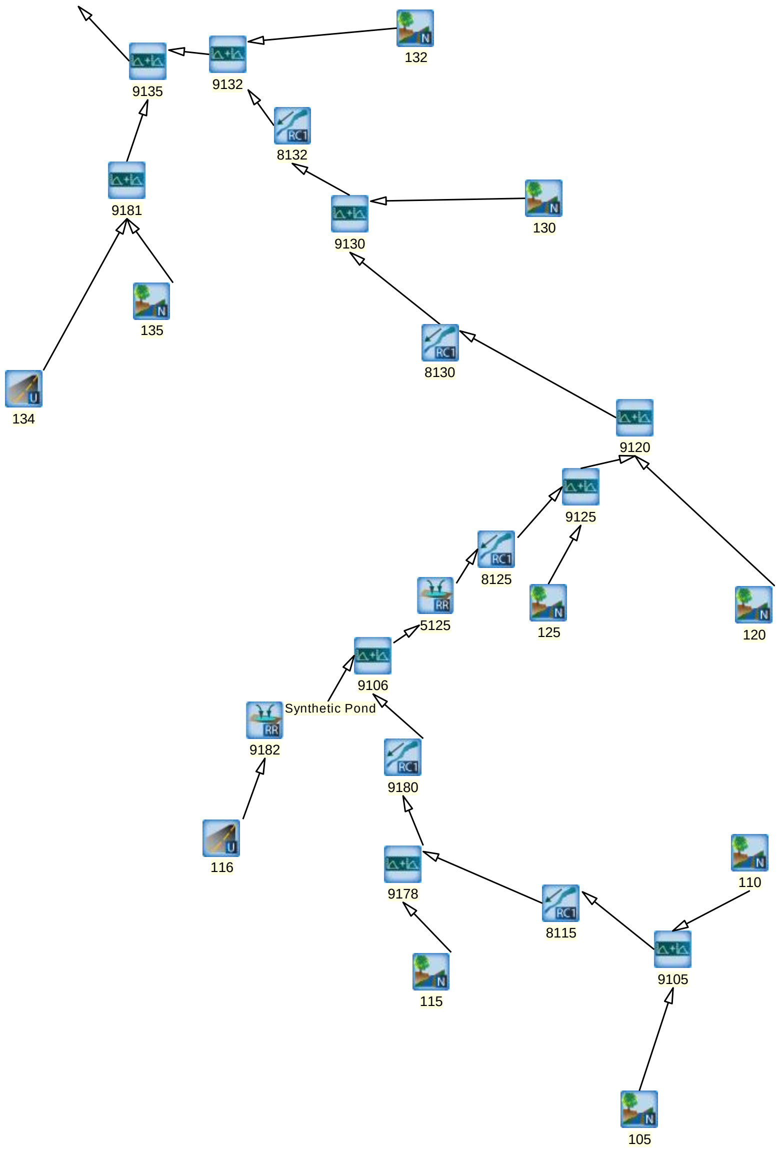


Nashyd
Standhyd
Addhyd
Route Pipe
Route Channel
Route Reservoir
Duhyd
Diverthyd

C.C. TATHAM & ASSOCIATES LTD.
Consulting Engineers

Project:	Innisfil SWM Master Plan
File No.:	413448
Subject:	Otthymo Flow Schematic
Date:	Jun-14 **Figure:** 15

INNISFIL COMPREHENSIVE STORMWATER MANAGEMENT MASTERPLAN
FUTURE CONDITIONS WITH SYNTHETIC PONDS
STROUD - HEWITTS CREEK



1 Nashyd	1 Route Pipe	1 Duhyd
1 Standhyd	1 Route Channel	1 Diverthyd
1 Addhyd	1 Route Reservoir	

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Project:	Innisfil SWM Master Plan
File No.:	413448
Subject:	Otthymo Flow Schematic
Date:	Jun-14 **Figure:** 16

VO2 RESULTS

Uncertainties with VO2 Results

Due to the high level modelling completed for report and the use of the provided GIS land use files, a number of inconsistencies are present in the hydrologic model. Although the model has these inconsistencies, it is still representative of the peak flows in the Study Areas. The following section provides explanation for a number of these inconsistencies.

Mooselanka Creek

With regards to the Mooselanka VO2, node 9334 produced inconsistent results. The difference between existing and future development models varied between 70.54% to -4.28% for the 2yr - 100yr 12hr SCS storms. Similar problems occurred while modeling the 4hr Chicago Storm. The cause of this problem is due to the two flow splitters placed in front the Mckee pond and the Rirob pond. These flow splitters are needed as these ponds were only designed for the 25mm storm, and due to the likelihood that these ponds were design using different storm files, the flows produced in our model do not match the original 25mm storm peak flows.

Alcona

With regards to the Alcona VO2 model, a number of the existing ponds did not control the contributing flows. The Taylorwoods (#8-2) pond began to overtop during the 5 to 100 year storm events during existing conditions. The reason for this could come from the source of the storage-discharge table of the pond. The ponds storage-discharge table was estimated from the Stage 1 Stormwater Management Master Plan, Appendix C, DWG No. 305787-8-2. This drawing does not represent the original design. Any inaccuracies in this drawing would result in a stage storage relationship not representative of the pond, thus resulting in overtopping.

According the pond design drawings for the Woodlands North pond (Pond ID 7-11), this facility was only designed to control the 5-year storm event. As such, our model produces overtopping of this pond for the larger storm events.

The ORSI pond (Pond ID 7-8) produced differences between the existing and future development models between 203% to 39.6% for the 2 - 100 year storms. The reason for the 203% increase may have resulted from the fact that the original flow for the existing conditions was only 0.033 m^3/s. Since this flow is very small an increase of only 0.067 m^3/s results in a large percent increase from existing to future conditions. This can likely be contributed to difference in design storms and/or catchment parameters.

Regional Storm

At a number of nodes the peak flows for the Regional Storm showed decreases when comparing the future developmend model to the existing land use model. As the land is undergoing intensification in all Study

Areas, it would be expected that the flows would increase. However, as the nodes represent the downstream end of each creek, the increase in development (impervious area) is altering the time to peak, which is resulting in non-coinciding peaks from a number of catchments. Therefore, the individual catchments are showing an increase, however the cumulative peak flow is showing a decrease at the downstream nodes. The time to peak is also altered by the use of Synthetic ponds. Problems occurred at a number of nodes while modeling the regional Storm. The problem was the peak flows for the existing land use was greater than the peak flows for the future land use. The hydrograph shown below shows that there are a number of peaks passing through the downstream node.

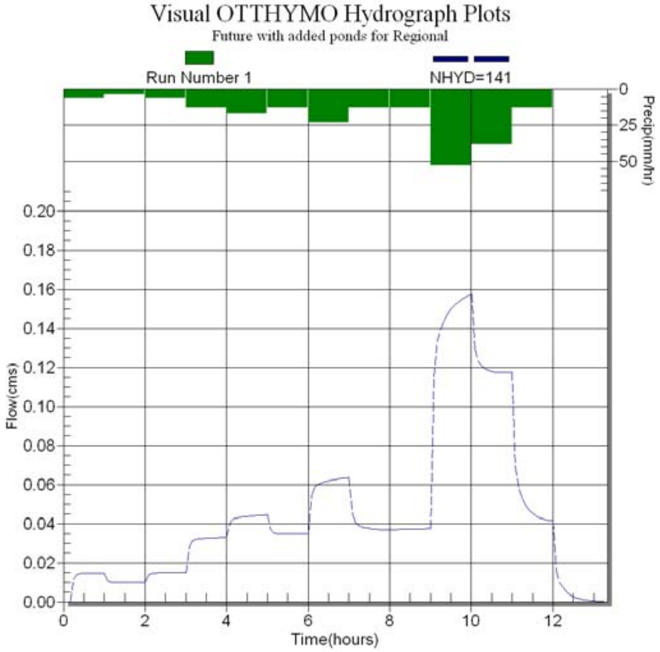

Figure 1: Example of Hydrograph

Peak Flow Increasing

Another problem occurred where the peak flow increased between existing and future land use, even though no further development was expected in the catchment. This results from land use conversions between existing and future residential land use (increase in RC, CN and TIMP). The increase in peak flows is conservative, as it would be possible to increase development on residential lots (driveways, decks, house additions etc.) which would not require additional SWM controls.

Modelling Rules

Although a land use conversion table was set up to convert the land uses provided in the ELC and OP GIS files, a number of rules were created to avoid discrepancies. The rules are as follows:

1. Only land use inside the Study Area boundary are updated for future land use (OP)
2. If the OP land use is blank, the ELC land type was applied
3. If the OP land use is Natural Heritage, the ELC land use was used, as the ELC Natural Heritage was broken down into more detailed land types, creating a more accurate model
4. If ELC land use is Urban, then use Urban land use parameters from the OP table, no matter what the OP land use is
5. If ELC land use is Road, then use Road land use parameters from the OP table, no matter what the OP land use is
6. If ELC land use is Rail, then use Rail land use parameters from the OP table, no matter what the OP land use is
7. If the OP is agriculture, but ELC is industrial, then use Industrial for OP
8. If the OP is agriculture, but ELC is Estate Residential, then use Estate Residential for OP

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 4 HOUR CHICAGO AND REGIONAL STORM
SETTLEMENT AREA: SANDY COVE

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
9255	240, 242, 245, 250, 252, 254, 255	Sandy Cove Creek	1827.06	Ex. Land Use w Ex. Rainfall	5.859	17.07	22.194	27.738	29.587	36.136	107.843
				Fut. Land Use w Ex. Rainfall	5.759	16.36	21.299	26.641	28.37	34.549	102.618
				Fut. Land use w synthetic ponds w Ex. Rainfall	6.445	17.748	22.869	28.436	30.24	36.675	107.387
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	-1.71%	-4.16%	-4.03%	-3.95%	-4.11%	-4.39%	-4.85%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	10.00%	3.97%	3.04%	2.52%	2.21%	1.49%	-0.42%

Uncontrolled areas

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
1500	1500	N/A	54.02	Ex. Land Use w Ex. Rainfall	1.667	2.728	3.567	4.202	4.73	5.454	5.632
				Fut. Land Use w Ex. Rainfall	2.407	3.839	5.064	5.902	6.629	7.61	6.053
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	44.39%	40.73%	41.97%	40.46%	40.15%	39.53%	7.48%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 4 HOUR CHICAGO AND REGIONAL STORM
SETTLEMENT AREA: MOOSELANKA CREEK

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
9334	305, 306, 310, 311, 315, 320, 325, 329, 330	Mooselanka Creek	241.63	Ex. Land Use w Ex. Rainfall	0.457	3.106	3.994	4.86	5.103	6.114	16.717
				Fut. Land Use w Ex. Rainfall	1.12	3.435	4.713	6.042	7.211	8.877	17.659
				Fut. Land use w synthetic ponds w Ex. Rainfall	0.985	3.477	4.295	5.209	5.474	6.529	17.258
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	145.08%	10.59%	18.00%	24.32%	41.31%	45.19%	5.63%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	115.54%	11.94%	7.54%	7.18%	7.27%	6.79%	3.24%

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
I400	I400	N/A	89.13	Ex. Land Use w Ex. Rainfall	1.719	2.92	3.848	4.522	5.101	6.127	8.171
				Fut. Land Use w Ex. Rainfall	3.736	5.857	7.387	8.536	9.809	11.672	9.276
				Fut. Land use w synthetic ponds w Ex. Rainfall	1.804	3.262	4.333	5.147	6.153	7.354	8.742
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	117.34%	100.58%	91.97%	88.77%	92.30%	90.50%	13.52%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	4.94%	11.71%	12.60%	13.82%	20.62%	20.03%	6.99%

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
I204	I204	N/A	25.45	Ex. Land Use w Ex. Rainfall	0.219	0.589	0.786	1.008	1.098	1.33	2.439
				Fut. Land Use w Ex. Rainfall	1.51	2.393	2.963	3.513	0.952	4.54	3.195
				Fut. Land use w synthetic ponds w Ex. Rainfall	0.259	0.639	0.831	1.056	1.15	1.362	2.319
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	589.50%	306.28%	276.97%	1.15%	-13.30%	241.35%	31.00%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	18.26%	8.49%	5.73%	4.76%	4.74%	2.41%	-4.92%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 4 HOUR CHICAGO AND REGIONAL STORM
SETTLEMENT AREA: STROUD HEWITTS CREEK

4hr Chicago and Regional Peak Flows (CMS)											
VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
9125	115, 116, 125	Hewitt's Creek	601.3	Ex. Land Use w Ex. Rainfall	2.915	8.236	10.48	12.703	13.109	14.75	39.276
				Fut. Land Use w Ex. Rainfall	2.924	8.011	10.089	12.218	12.775	14.284	37.075
				Fut. Land use w synthetic ponds w Ex. Rainfall	3.09	8.317	10.553	12.747	13.169	14.928	38.998
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	0.31%	-2.73%	-3.73%	-3.82%	-2.55%	-3.16%	-5.60%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	6.00%	0.98%	0.70%	0.35%	0.46%	1.21%	-0.71%

Uncontrolled areas

4hr Chicago and Regional Peak Flows (CMS)											
VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
9181	134, 135	Hewitt's Creek	109.06	Ex. Land Use w Ex. Rainfall	1.213	2.097	2.65	3.075	3.442	4.072	8.889
				Fut. Land Use w Ex. Rainfall	1.48	2.53	3.173	3.671	4.102	4.801	8.991
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	22.01%	20.65%	19.74%	19.38%	19.17%	17.90%	1.15%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 4 HOUR CHICAGO AND REGIONAL STORM
SETTLEMENT AREA: LEFROY

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
2118	C100, C102, C105, C106, C120	Carson Creek	711.06	Ex. Land Use w Ex. Rainfall	2.991	8.668	11.204	14.12	15.086	18.2	48.53
				Fut. Land Use w Ex. Rainfall	6.221	11.233	14.681	17.382	19.512	23.734	49.325
				Fut. Land use w synthetic ponds w Ex. Rainfall	3.169	8.861	11.252	13.996	14.892	17.827	47.011
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	107.99%	29.59%	31.03%	23.10%	29.34%	30.41%	1.64%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	5.95%	2.23%	0.43%	-0.88%	-1.29%	-2.05%	-3.13%

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
I600	I600	N/A	35.47	Ex. Land Use w Ex. Rainfall	0.768	1.361	1.697	2.031	2.292	2.664	3.343
				Fut. Land Use w Ex. Rainfall	1.078	1.872	2.319	2.731	3.073	3.54	3.553
				Fut. Land use w synthetic ponds w Ex. Rainfall	0.749	1.325	1.652	2.096	2.368	2.786	3.48
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	40.36%	37.55%	36.65%	34.47%	34.08%	32.88%	6.28%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	-2.47%	-2.65%	-2.65%	3.20%	3.32%	4.58%	4.10%

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
2113	B99, B101, B102	Belle Aire Creek	507.65	Ex. Land Use w Ex. Rainfall	1.382	4.105	5.313	6.61	7.031	8.486	25.213
				Fut. Land Use w Ex. Rainfall	1.397	4.102	5.31	6.606	7.028	8.483	25.193
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	1.09%	-0.07%	-0.06%	-0.06%	-0.04%	-0.04%	-0.08%

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
2123	W100, W105, W110, W111, W112	Wilson Creek	814	Ex. Land Use w Ex. Rainfall	3.948	11.053	14.089	14.398	18.442	21.972	54.717
				Fut. Land Use w Ex. Rainfall	3.95	11.059	14.096	17.406	18.45	21.978	54.728
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	0.05%	0.05%	0.05%	20.89%	0.04%	0.03%	0.02%

Uncontrolled

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
2115	I700, I701	N/A	190.09	Ex. Land Use w Ex. Rainfall	2.947	5.349	7.01	8.234	9.285	10.913	16.04
				Fut. Land Use w Ex. Rainfall	4.33	7.557	9.692	11.291	12.673	15.379	17.01
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	46.93%	41.28%	38.26%	37.13%	36.49%	40.92%	6.05%

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
I801	I801	N/A	8.1	Ex. Land Use w Ex. Rainfall	0.472	0.711	0.88	0.997	1.116	1.304	0.896
				Fut. Land Use w Ex. Rainfall	0.65	0.974	1.185	1.338	1.519	1.722	0.971
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	37.71%	36.99%	34.66%	34.20%	36.11%	32.06%	8.37%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 4 HOUR CHICAGO AND REGIONAL STORM
SETTLEMENT AREA: GILFORD

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
9435	420, 421, 422, 424, 425, 427, 430, 432, 433, 434, 435, 436, 437, 438	White Birch Creek	1297.62	Ex. Land Use w Ex. Rainfall	6.089	16.262	21.051	26.125	27.762	33.163	87.643
				Fut. Land Use w Ex. Rainfall	6.192	16.42	21.228	26.327	27.962	33.39	87.754
				Fut. Land use w synthetic ponds w Ex. Rainfall	6.187	16.495	21.312	26.432	28.1	33.55	88.172
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	1.69%	0.97%	0.84%	0.77%	0.72%	0.68%	0.13%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	1.61%	1.43%	1.24%	1.18%	1.22%	1.17%	0.60%

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
9441	G100, G101, G102, G104, G105	Gilford Creek	207.73	Ex. Land Use w Ex. Rainfall	1.211	2.888	3.616	4.405	4.652	5.532	14.917
				Fut. Land Use w Ex. Rainfall	3.259	5.532	6.809	7.794	8.751	10.274	15.174
				Fut. Land use w synthetic ponds w Ex. Rainfall	1.326	3.216	3.993	4.812	5.071	6.048	15.146
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	169.12%	91.55%	88.30%	76.94%	88.11%	85.72%	1.72%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	9.50%	11.36%	10.43%	9.24%	9.01%	9.33%	1.54%

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
9438	I400, I401, I402	N/A	125.23	Ex. Land Use w Ex. Rainfall	1.93	3.364	4.291	4.959	5.6	6.773	11.469
				Fut. Land Use w Ex. Rainfall	2.696	4.668	5.798	6.665	7.488	8.836	11.747
				Fut. Land use w synthetic ponds w Ex. Rainfall	2.651	4.581	5.681	6.522	7.324	8.633	11.632
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	39.69%	38.76%	35.12%	34.40%	33.71%	30.46%	2.42%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	37.36%	36.18%	32.39%	31.52%	30.79%	27.46%	1.42%

Uncontrolled

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
I300	I300	N/A	21.42	Ex. Land Use w Ex. Rainfall	1.181	1.87	2.308	2.636	3.078	3.537	2.591
				Fut. Land Use w Ex. Rainfall	1.625	2.505	3.074	3.499	4.012	4.571	2.741
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	37.60%	33.96%	33.19%	32.74%	30.34%	29.23%	5.79%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 4 HOUR CHICAGO AND REGIONAL STORM
SETTLEMENT AREA: INNISFILL HEIGHTS

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchment	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
19	S40, S39, S38	Lover's Creek	457.71	Ex. Land Use w Ex. Rainfall	3.305	5.545	7.051	8.706	9.335	11.223	31.931
				Fut. Land Use w Ex. Rainfall	5.642	8.781	11.292	13.213	14.758	17.619	28.31
				Fut. Land use w synthetic ponds w Ex. Rainfall	3.849	6.189	7.851	9.37	10.42	12.027	28.737
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	70.71%	58.36%	60.15%	51.77%	58.09%	56.99%	-11.34%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	16.46%	11.61%	11.35%	7.63%	11.62%	7.16%	-10.00%

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchment	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
S59	S59	Lover's Creek	26.84	Ex. Land Use w Ex. Rainfall	0.951	1.506	1.913	2.196	2.472	2.847	2.817
				Fut. Land Use w Ex. Rainfall	1.744	2.62	3.213	3.64	4.073	4.644	2.757
				Fut. Land use w synthetic ponds w Ex. Rainfall	0.876	1.522	1.954	2.296	2.54	3.107	2.651
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	83.39%	73.97%	67.96%	65.76%	64.77%	63.12%	-2.13%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	-7.89%	1.06%	2.14%	4.55%	2.75%	9.13%	-5.89%

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchment	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
15	S77, S78, S79, S80	Lover's Creek	269.43	Ex. Land Use w Ex. Rainfall	4.146	6.525	8.069	9.379	10.466	12.377	21.482
				Fut. Land Use w Ex. Rainfall	6.575	10.021	12.338	14.135	16.198	19.198	20.314
				Fut. Land use w synthetic ponds w Ex. Rainfall	4.216	6.818	8.463	10.111	11.759	13.454	20.525
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	58.59%	53.58%	52.91%	50.71%	54.77%	55.11%	-5.44%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	1.69%	4.49%	4.88%	7.80%	12.35%	8.70%	-4.45%

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchment	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
13	S100, S101, S102	Lover's Creek	130.77	Ex. Land Use w Ex. Rainfall	0.868	1.953	2.537	3.2	3.43	4.129	10.235
				Fut. Land Use w Ex. Rainfall	1.252	1.993	2.578	3.239	3.47	4.173	10.345
				Fut. Land use w synthetic ponds w Ex. Rainfall	0.75	2.028	2.626	3.315	3.547	4.253	10.36
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	44.24%	2.05%	1.62%	1.22%	1.17%	1.07%	1.07%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	-13.59%	3.84%	3.51%	3.59%	3.41%	3.00%	1.22%

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchment	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
2	S140, S141, S142	Lover's Creek	30.64	Ex. Land Use w Ex. Rainfall	0.173	0.263	0.314	0.348	0.383	0.438	1.474
				Fut. Land Use w Ex. Rainfall	0.22	0.319	0.417	0.528	0.563	0.703	2.043
				Fut. Land use w synthetic ponds w Ex. Rainfall	0.181	0.27	0.322	0.36	0.407	0.455	0.428
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	27.17%	21.29%	32.80%	51.72%	47.00%	60.50%	38.60%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	4.62%	2.66%	2.55%	3.45%	6.27%	3.88%	-70.96%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 4 HOUR CHICAGO AND REGIONAL STORM
SETTLEMENT AREA: STROUD - LOVERS CREEK

4hr Chicago and Regional Peak Flows (CMS)											
VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
7	S130, S131, S132, S133, S134	Lover's Creek	454.11	Ex. Land Use w Ex. Rainfall	3.312	5.767	7.16	8.616	9.007	10.63	27.84
				Fut. Land Use w Ex. Rainfall	4.06	6.185	7.454	8.936	9.331	10.931	28.473
				Fut. Land use w synthetic ponds w Ex. Rainfall	3.568	6.069	7.48	8.953	9.444	11.02	28.657
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	22.58%	7.25%	4.11%	3.71%	3.60%	2.83%	2.27%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	7.73%	5.24%	4.47%	3.91%	4.85%	3.67%	2.93%
4hr Chicago and Regional Peak Flows (CMS)											
VO2 ID	Catchment	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
9230	All of Stroud and Innisfil Heights	Lover's Creek	5050.171	Ex. Land Use w Ex. Rainfall	12.877	35.267	44.632	55.401	56.72	68.911	201.074
				Fut. Land Use w Ex. Rainfall	13.606	36.305	45.743	55.965	56.32	70.752	200.004
				Fut. Land use w synthetic ponds w Ex. Rainfall	13.438	36.157	45.703	55.25	58.068	66.831	180.37
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	5.66%	2.94%	2.49%	1.02%	-0.71%	2.67%	-0.53%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	4.36%	2.52%	2.40%	-0.27%	2.38%	-3.02%	-10.30%
Uncontrolled areas											
4hr Chicago and Regional Peak Flows (CMS)											
VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
5	S170, S171	N/A	136.04	Ex. Land Use w Ex. Rainfall	0.837	2.32	3.001	3.774	4.034	4.833	11.145
				Fut. Land Use w Ex. Rainfall	0.839	2.324	3.006	3.78	4.039	4.839	11.159
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	0.24%	0.17%	0.17%	0.16%	0.12%	0.12%	0.13%
4hr Chicago and Regional Peak Flows (CMS)											
VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
4 (S250, S251)	S250, S251	N/A	391.88	Ex. Land Use w Ex. Rainfall	1.468	4.125	5.417	6.842	7.28	8.792	23.938
				Fut. Land Use w Ex. Rainfall	1.48	4.25	5.544	6.924	7.353	8.89	23.754
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	0.82%	3.03%	2.34%	1.20%	1.00%	1.11%	-0.77%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 4 HOUR CHICAGO AND REGIONAL STORM
SETTLEMENT AREA: FENNELL'S CORNERS

Uncontrolled areas											
4hr Chicago and Regional Peak Flows (CMS)											
VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
9451	420, 421	White Birch Creek	16.44	Ex. Land Use w Ex. Rainfall	0.517	0.746	0.888	0.989	1.104	1.251	1.823
				Fut. Land Use w Ex. Rainfall	0.508	0.722	0.85	0.95	1.043	1.418	1.981
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	-1.74%	-3.22%	-4.28%	-3.94%	-5.53%	13.35%	8.67%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 4 HOUR CHICAGO AND REGIONAL STORM
SETTLEMENT AREA: ALCONA

4hr Chicago and Regional Peak flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
189	100, 101, 102, 103, 104, 105, 106, 107, 110	Bon Secours Creek	244.3	Ex. Land Use w Ex. Rainfall	4.893	7.569	9.283	11.235	12.518	14.441	18.181
				Fut. Land Use w Ex. Rainfall	7.815	12.466	15.402	18.699	20.939	24.344	24.489
				Fut. Land use w synthetic ponds w Ex. Rainfall	5.589	8.556	10.442	12.553	13.986	16.09	17.028
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	59.72%	64.70%	65.92%	66.44%	67.27%	68.58%	34.70%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	14.22%	13.04%	12.49%	11.73%	11.73%	11.42%	-6.34%

Uncontrolled areas

4hr Chicago and Regional Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
191	120, 140, 145	Mclean creek	108.35	Ex. Land Use	3.231	5.122	6.296	7.791	8.769	9.939	9.145
				Fut. Land Use	3.553	5.579	6.837	8.489	9.543	10.806	9.402
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	9.97%	8.92%	8.59%	8.96%	8.83%	8.72%	2.81%

4hr Chicago and Regional Peak flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
6	130	Banks Creek	32.53	Ex. Land Use w Ex. Rainfall	0.034	0.097	0.12	0.142	0.148	0.169	0.369
				Fut. Land Use w Ex. Rainfall	0.082	0.147	0.168	0.187	0.193	0.211	0.39
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	141.18%	51.55%	40.00%	31.69%	30.41%	24.85%	5.69%

4hr Chicago and Regional Peak flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
150	150	N/A	41.64	Ex. Land Use w Ex. Rainfall	1.82	3.059	3.778	4.3	4.876	5.551	3.927
				Fut. Land Use w Ex. Rainfall	2.033	3.41	4.204	4.781	5.41	6.15	4.113
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	11.70%	11.47%	11.28%	11.19%	10.95%	10.79%	4.74%

4hr Chicago and Regional Peak flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr	Regional
192	170, 180	N/A	96.21	Ex. Land Use w Ex. Rainfall	3.138	4.895	6.136	7.081	7.903	9.649	8.183
				Fut. Land Use w Ex. Rainfall	3.34	5.197	6.513	7.505	8.374	10.233	8.41
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	6.44%	6.17%	6.14%	5.99%	5.96%	6.05%	2.77%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 12 HOUR SCS STORM
SETTLEMENT AREA: SANDY COVE

12hr SCS Peak Flows (CMS)										
VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
9255	240, 242, 245, 250, 252, 254, 255	Sandy Cove Creek	1827.06	Ex. Land Use w ex. Rainfall	5.57	10.855	14.94	21.409	26.607	32.341
				Fut. Land Use w ex. Rainfall	6.175	10.594	14.456	20.527	25.396	30.841
				Fut. Land use w Climate Change Rainfall	7.479	13.948	18.824	26.693	33.035	39.607
				Fut. Land use w synthetic ponds w ex. Rainfall	6.138	11.452	15.555	21.911	27.061	32.783
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	10.86%	-2.40%	-3.24%	-4.12%	-4.55%	-4.64%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	21.12%	31.66%	30.22%	30.04%	30.08%	28.42%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	10.20%	5.50%	4.12%	2.34%	1.71%	1.37%

Uncontrolled areas										
12hr SCS Peak flows (CMS)										
VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
1500	1500	N/A	54.02	Ex. Land Use w ex. Rainfall	1.708	2.701	3.329	4.66	5.47	6.306
				Fut. Land Use w ex. Rainfall	2.469	3.758	4.721	6.281	7.293	8.33
				Fut. Land use w Climate Change Rainfall	2.921	4.48	5.916	7.549	8.728	10.625
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	44.56%	39.13%	41.81%	34.79%	33.33%	32.10%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	18.31%	19.21%	25.31%	20.19%	19.68%	27.55%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 12 HOUR SCS STORM
SETTLEMENT AREA: MOOSELANKA CREEK

12hr SCS Peak Flows (CMS)										
VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
9334	305, 306, 310, 311, 315, 320, 325, 329, 330	Mooselanka Creek	241.63	Ex. Land Use w ex. Rainfall	0.499	1.712	2.486	3.856	5.234	6.918
				Fut. Land Use w ex. Rainfall	0.913	3.016	5.261	7.709	9.603	11.829
				Fut. Land use w Climate Change Rainfall	1.559	5.03	7.043	10.075	12.574	15.09
				Fut. Land use w synthetic ponds w ex. Rainfall	0.851	2.126	2.868	3.872	5.083	6.622
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	82.97%	76.17%	111.63%	99.92%	83.47%	70.99%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	70.76%	66.78%	33.87%	30.69%	30.94%	27.57%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	70.54%	24.18%	15.37%	0.41%	-2.88%	-4.28%

Uncontrolled areas										
12hr SCS Peak flows (CMS)										
VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
I400	I400	N/A	89.13	Ex. Land Use w ex. Rainfall	1.809	2.912	3.907	5.162	6.76	8.018
				Fut. Land Use w ex. Rainfall	3.76	5.76	7.026	9.132	10.629	12.169
				Fut. Land use w Climate Change Rainfall	4.492	6.864	8.35	11.009	12.761	15.257
				Fut. Land use w synthetic ponds w ex. Rainfall	1.805	2.899	3.884	5.156	6.667	7.878
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	107.85%	97.80%	79.83%	76.91%	57.23%	51.77%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	19.47%	19.17%	18.84%	20.55%	20.06%	25.38%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	-0.22%	-0.45%	-0.59%	-0.12%	-1.38%	-1.75%
12hr SCS Peak flows (CMS)										
VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
I204	I204	N/A	25.45	Ex. Land Use w ex. Rainfall	0.262	0.513	0.691	0.959	1.17	1.392
				Fut. Land Use w ex. Rainfall	1.442	2.331	2.848	3.814	4.435	5.079
				Fut. Land use w Climate Change Rainfall	1.845	2.783	3.587	4.594	5.325	6.081
				Fut. Land use w synthetic ponds w ex. Rainfall	0.262	0.512	0.687	0.955	1.177	1.384
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	450.38%	354.39%	312.16%	297.71%	279.06%	264.87%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	27.95%	19.39%	25.95%	20.45%	20.07%	19.73%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	0.00%	-0.19%	-0.58%	-0.42%	0.60%	-0.57%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 12 HOUR SCS STORM
SETTLEMENT AREA: STROUD - HEWITTS CREEK

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
9125	115, 116, 125	Hewitt's Creek	601.3	Ex. Land Use w ex. Rainfall	2.86	5.722	7.83	10.753	12.723	14.014
				Fut. Land Use w ex. Rainfall	2.775	5.322	7.185	9.841	11.812	13.349
				Fut. Land use w Climate Change Rainfall	3.703	6.963	9.079	12.311	13.869	15.665
				Fut. Land use w synthetic ponds w ex. Rainfall	3.014	5.778	7.806	10.683	12.706	14.096
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	-2.97%	-6.99%	-8.24%	-8.48%	-7.16%	-4.75%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	33.44%	30.83%	26.36%	25.10%	17.41%	17.35%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	4.16%	0.80%	-0.26%	-0.57%	-0.12%	0.52%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
9181	134, 135	Hewitt's Creek	109.06	Ex. Land Use w ex. Rainfall	1.342	2.099	2.644	3.408	4.112	4.765
				Fut. Land Use w ex. Rainfall	1.622	2.486	3.083	3.926	4.671	5.367
				Fut. Land use w Climate Change Rainfall	1.945	3.007	3.689	4.84	5.631	6.454
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	20.86%	18.44%	16.60%	15.20%	13.59%	12.63%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	19.91%	20.96%	19.66%	23.28%	20.55%	20.25%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 12 HOUR SCS STORM
SETTLEMENT AREA: STROUD - LOVERS CREEK

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
7	S130, S131, S132, S133, S134	Lover's Creek	454.11	Ex. Land Use w ex. Rainfall	3.351	5.03	6.382	7.963	9.458	11.244
				Fut. Land Use w ex. Rainfall	4.083	5.947	7.412	9.812	11.63	13.493
				Fut. Land use w Climate Change Rainfall	4.809	7.254	9.171	12.078	14.172	16.851
				Fut. Land use w synthetic ponds w ex. Rainfall	3.697	5.882	7.266	9.475	10.971	13.068
				Fut. Land use w syn pond (15% overcontrolled) w ex. Rainfall	3.408	5.472	6.944	8.904	10.305	12.132
				Fut. Land use w syn pond (25% overcontrolled) w ex. Rainfall	3.187	5.141	6.577	8.527	9.924	11.642
				Fut. Land use w syn pond (50% overcontrolled) w ex. Rainfall	2.604	4.488	5.819	7.56	8.856	10.29
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	21.84%	18.23%	16.14%	23.22%	22.96%	20.00%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	17.78%	21.98%	23.73%	23.09%	21.86%	24.89%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	10.33%	16.94%	13.85%	18.99%	16.00%	16.22%
				% Increase (15% overcontrolled) w ex. Rainfall	1.70%	8.79%	8.81%	11.82%	8.96%	7.90%
				% Increase (25% overcontrolled) w ex. Rainfall	-4.89%	2.21%	3.06%	7.08%	4.93%	3.54%
				% Increase (50% overcontrolled) w ex. Rainfall	-22.29%	-10.78%	-8.82%	-5.06%	-6.36%	-8.48%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchment	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
9230	All of Stroud and Innisfil Heights	Lover's Creek	5050.171	Ex. Land Use w ex. Rainfall	12.087	22.827	30.293	41.526	51.321	60.678
				Fut. Land Use w ex. Rainfall	12.869	23.523	31.563	42.153	52.085	62.877
				Fut. Land use w Climate Change Rainfall	16.628	30.997	39.406	54.555	64.29	75.965
				Fut. Land use w synthetic ponds w ex. Rainfall	12.764	23.481	31.96	43.615	52.143	61.924
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	6.47%	3.05%	4.19%	1.51%	1.49%	3.62%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	29.21%	31.77%	24.85%	29.42%	23.43%	20.82%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	5.60%	2.87%	5.50%	5.03%	1.60%	2.05%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
5	S170, S171	N/A	136.04	Ex. Land Use w ex. Rainfall	0.868	1.701	2.3	3.211	3.928	4.681
				Fut. Land Use w ex. Rainfall	0.869	1.703	2.303	3.215	3.932	4.686
				Fut. Land use w Climate Change Rainfall	1.167	2.225	2.957	4.118	4.977	5.873
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	0.12%	0.12%	0.13%	0.12%	0.10%	0.11%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	34.29%	30.65%	28.40%	28.09%	26.58%	25.33%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
4 (S250, S251)	S250, S251	N/A	391.88	Ex. Land Use w ex. Rainfall	1.412	2.749	3.728	5.257	6.591	7.973
				Fut. Land Use w ex. Rainfall	1.424	2.746	3.715	5.362	6.653	8.039
				Fut. Land use w Climate Change Rainfall	1.89	3.588	4.9	6.989	8.598	10.258
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	0.85%	-0.11%	-0.35%	2.00%	0.94%	0.83%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	32.72%	30.66%	31.90%	30.34%	29.23%	27.60%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 12 HOUR SCS STORM
SETTLEMENT AREA: LEFROY

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
2118	C100, C102, C105, C106, C120	Carson Creek	711.06	Ex. Land Use	3.023	6.047	8.274	11.715	14.455	17.37
				Fut. Land Use	7.042	12.119	15.794	19.974	23.865	30.113
				Fut. Land use w Climate Change	8.803	15.36	18.17	26.722	31.861	37.302
				Fut. Land use w synthetic ponds	3.123	5.515	8.126	11.416	14.043	16.774
				Fut. Land use w syn pond (15% overcontrolled) w ex. Rainfall	2.958	5.328	7.818	11.011	13.552	16.205
				Fut. Land use w syn pond (25% overcontrolled) w ex. Rainfall	2.841	5.172	7.571	10.652	13.147	15.747
				Fut. Land use w syn pond (50% overcontrolled) w ex. Rainfall	2.491	4.721	6.812	9.654	11.925	14.321
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	132.95%	100.41%	90.89%	70.50%	65.10%	73.36%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	25.01%	26.74%	15.04%	33.78%	33.51%	23.87%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	3.31%	-8.80%	-1.79%	-2.55%	-2.85%	-3.43%
				% Increase (15% overcontrolled) w ex. Rainfall	-2.15%	-11.89%	-5.51%	-6.01%	-6.25%	-6.71%
				% Increase (25% overcontrolled) w ex. Rainfall	-6.02%	-14.47%	-8.50%	-9.07%	-9.05%	-9.34%
				% Increase (50% overcontrolled) w ex. Rainfall	-17.60%	-21.93%	-17.67%	-17.59%	-17.50%	-17.55%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
I600	I600	N/A	35.47	Ex. Land Use w ex. Rainfall	0.804	1.376	1.723	2.374	2.814	3.295
				Fut. Land Use w ex. Rainfall	1.11	1.845	2.355	3.019	3.535	4.09
				Fut. Land use w Climate Change Rainfall	1.341	2.209	2.832	3.679	4.682	5.426
				Fut. Land use w synthetic ponds w ex. Rainfall	0.793	1.356	1.719	2.34	2.772	3.246
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	38.06%	34.08%	36.68%	27.17%	25.62%	24.13%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	20.81%	19.73%	20.25%	21.86%	32.45%	32.67%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	-1.37%	-1.45%	-0.23%	-1.43%	-1.49%	-1.49%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
2113	B99, B101, B102	Belle Aire Creek	507.65	Ex. Land Use w ex. Rainfall	1.365	2.727	3.73	5.282	6.521	7.839
				Fut. Land Use w ex. Rainfall	1.391	2.736	3.74	5.293	6.532	7.851
				Fut. Land use w Climate Change Rainfall	1.854	3.608	4.851	6.855	8.363	9.956
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	1.90%	0.33%	0.27%	0.21%	0.17%	0.15%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	33.29%	31.87%	29.71%	29.51%	28.03%	26.81%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
2123	W100, W105, W110, W111, W112	Wilson Creek	814	Ex. Land Use w ex. Rainfall	3.803	7.419	10.01	13.941	17.022	20.255
				Fut. Land Use w ex. Rainfall	3.804	7.42	10.011	13.943	17.025	20.257
				Fut. Land use w Climate Change Rainfall	5.095	9.675	12.832	17.82	21.504	25.343
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	0.03%	0.01%	0.01%	0.01%	0.02%	0.01%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	33.94%	30.39%	28.18%	27.81%	26.31%	25.11%

Uncontrolled

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
2115	I700, I701	N/A	190.09	Ex. Land Use w ex. Rainfall	3.223	5.384	7.152	9.429	11.236	14.408
				Fut. Land Use w ex. Rainfall	4.59	7.35	9.389	12.098	14.208	17.573
				Fut. Land use w Climate Change Rainfall	5.65	9.154	11.337	15.726	18.524	21.476
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	42.41%	36.52%	31.28%	28.31%	26.45%	21.97%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	23.09%	24.54%	20.75%	29.99%	30.38%	22.21%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
I801	I801	N/A	8.1	Ex. Land Use w ex. Rainfall	0.443	0.665	0.803	1.002	1.218	1.391
				Fut. Land Use w ex. Rainfall	0.605	0.88	1.052	1.336	1.533	1.733
				Fut. Land use w Climate Change Rainfall	0.704	1.03	1.229	1.582	1.809	2.042
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	36.57%	32.33%	31.01%	33.33%	25.86%	24.59%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	16.36%	17.05%	16.83%	18.41%	18.00%	17.83%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 12 HOUR SCS STORM
SETTLEMENT AREA: GILFORD

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
9435	420, 421, 422, 424, 425, 427, 430, 432, 433, 434, 435, 436, 437, 438	White Birch Creek	1297.62	Ex. Land Use	5.973	11.255	14.982	20.948	25.635	30.563
				Fut. Land Use	6.065	11.369	15.095	21.093	25.802	30.708
				Fut. Land use w Climate Change	7.923	14.617	19.378	27.014	32.601	38.797
				Fut. Land use w synthetic ponds	6.08	11.431	15.207	21.254	26.011	30.971
				Fut. Land use w syn pond (15% overcontrolled) w ex. Rainfall	6.057	11.39	15.156	21.181	25.919	30.867
				Fut. Land use w syn pond (25% overcontrolled) w ex. Rainfall	6.04	11.357	15.117	21.121	25.844	30.778
				Fut. Land use w syn pond (50% overcontrolled) w ex. Rainfall	5.998	11.27	15.003	20.951	25.631	30.524
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	1.54%	1.01%	0.75%	0.69%	0.65%	0.47%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	30.63%	28.57%	28.37%	28.07%	26.35%	26.34%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	1.79%	1.56%	1.50%	1.46%	1.47%	1.33%
				% Increase (15% overcontrolled) w ex. Rainfall	1.41%	1.20%	1.16%	1.11%	1.11%	0.99%
				% Increase (25% overcontrolled) w ex. Rainfall	1.12%	0.91%	0.90%	0.83%	0.82%	0.70%
				% Increase (50% overcontrolled) w ex. Rainfall	0.42%	0.13%	0.14%	0.01%	-0.02%	-0.13%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
9441	G100, G101, G102, G104, G105	Gilford Creek	207.73	Ex. Land Use w ex. Rainfall	1.439	2.613	3.344	4.537	5.872	6.928
				Fut. Land Use w ex. Rainfall	3.386	5.375	6.606	8.47	10.135	11.628
				Fut. Land use w Climate Change Rainfall	4.059	6.423	7.882	10.503	12.201	13.987
				Fut. Land use w synthetic ponds w ex. Rainfall	1.442	2.545	3.302	4.494	5.851	6.913
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	135.30%	105.70%	97.55%	86.69%	72.60%	67.84%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	19.88%	19.50%	19.32%	24.00%	20.38%	20.29%
				% Increase (Fut. w synthetic ponds vs Ex. w Ex. Rainfall)	0.21%	-2.60%	-1.26%	-0.95%	-0.36%	-0.22%

Uncontrolled

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
9438	I400, I401, I402	N/A	125.23	Ex. Land Use w ex. Rainfall	2.115	3.627	4.645	6.073	7.579	8.832
				Fut. Land Use w ex. Rainfall	2.877	4.588	5.943	7.616	9.219	10.621
				Fut. Land use w Climate Change Rainfall	3.5	5.797	7.151	9.565	11.259	12.814
				Fut. Land use w synthetic ponds w ex. Rainfall	2.806	4.453	5.761	7.365	8.926	10.281
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	36.03%	26.50%	27.94%	25.41%	21.64%	20.26%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	21.65%	26.35%	20.33%	25.59%	22.13%	20.65%
				% Increase (Fut. w synthetic ponds vs Fut. w Climate Change Rainfall)	32.67%	22.77%	24.03%	21.27%	17.77%	16.41%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
I300	I300	N/A	21.42	Ex. Land Use w ex. Rainfall	1.181	1.81	2.209	2.965	3.454	3.962
				Fut. Land Use w ex. Rainfall	1.583	2.354	2.838	3.672	4.229	4.8
				Fut. Land use w Climate Change Rainfall	1.86	2.777	3.468	4.37	5.019	5.684
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	34.04%	30.06%	28.47%	23.84%	22.44%	21.15%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	17.50%	17.97%	22.20%	19.01%	18.68%	18.42%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 12 HOUR SCS STORM
SETTLEMENT AREA: INNISFIL HEIGHTS

12hr SCS Peak Flows (CMS)

VO2 ID	Catchment	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
19	S40, S39, S38	Lover's Creek	457.71	Ex. Land Use w ex. Rainfall	3.327	5.23	6.584	8.865	10.957	12.733
				Fut. Land Use w ex. Rainfall	5.667	8.45	10.73	13.852	15.971	18.351
				Fut. Land use w Climate Change Rainfall	6.701	10.428	13.075	16.512	19.204	22.85
				Fut. Land use w synthetic ponds w ex. Rainfall	3.616	5.754	7.249	9.419	11.312	13.187
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	70.33%	61.57%	62.97%	56.25%	45.76%	44.12%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	18.25%	23.41%	21.85%	19.20%	20.24%	24.52%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	8.69%	10.02%	10.10%	6.25%	3.24%	3.57%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchment	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
S59	S59	Lover's Creek	26.84	Ex. Land Use w ex. Rainfall	0.892	1.479	1.893	2.428	2.844	3.586
				Fut. Land Use w ex. Rainfall	1.564	2.4	2.884	3.601	4.11	4.632
				Fut. Land use w Climate Change Rainfall	1.939	2.825	3.37	4.24	4.831	5.435
				Fut. Land use w synthetic ponds w ex. Rainfall	0.888	1.465	1.852	2.406	2.779	3.534
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	75.34%	62.27%	52.35%	48.31%	44.51%	29.17%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	23.98%	17.71%	16.85%	17.75%	17.54%	17.34%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	-0.45%	-0.95%	-2.17%	-0.91%	-2.29%	-1.45%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchment	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
15	S77, S78, S79, S80	Lover's Creek	269.43	Ex. Land Use w ex. Rainfall	4.231	6.395	7.806	9.987	11.587	13.506
				Fut. Land Use w ex. Rainfall	6.564	9.641	11.657	14.471	16.711	19.487
				Fut. Land use w Climate Change Rainfall	7.716	11.353	13.693	17.253	20.416	24.561
				Fut. Land use w synthetic ponds w ex. Rainfall	4.266	6.443	7.835	10.001	12.345	14.258
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	55.14%	50.76%	49.33%	44.90%	44.22%	44.28%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	17.55%	17.76%	17.47%	19.22%	22.17%	26.04%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	0.83%	0.75%	0.37%	0.14%	6.54%	5.57%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchment	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
13	S100, S101, S102	Lover's Creek	130.77	Ex. Land Use w ex. Rainfall	0.881	1.408	1.918	2.697	3.318	3.977
				Fut. Land Use w ex. Rainfall	1.226	1.86	2.283	2.929	3.413	4.001
				Fut. Land use w Climate Change Rainfall	1.459	2.229	2.73	3.54	4.257	5.051
				Fut. Land use w synthetic ponds w ex. Rainfall	0.843	1.501	2.025	2.825	3.459	4.129
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	39.16%	32.10%	19.03%	8.60%	2.86%	0.60%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	19.00%	19.84%	19.58%	20.86%	24.73%	26.24%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	-4.31%	6.61%	5.58%	4.75%	4.25%	3.82%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchment	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
2	S140, S141, S142	Lover's Creek	30.64	Ex. Land Use w ex. Rainfall	0.177	0.248	0.289	0.348	0.388	0.432
				Fut. Land Use w ex. Rainfall	0.227	0.304	0.349	0.413	0.46	0.627
				Fut. Land use w Climate Change Rainfall	0.258	0.343	0.396	0.499	0.692	0.883
				Fut. Land use w synthetic ponds w ex. Rainfall	0.181	0.255	0.299	0.361	0.404	0.462
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	28.25%	22.58%	20.76%	18.68%	18.56%	45.14%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	13.66%	12.83%	13.47%	20.82%	50.43%	40.83%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	2.26%	2.82%	3.46%	3.74%	4.12%	6.94%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 12 HOUR SCS STORM
SETTLEMENT AREA: FENNELL'S CORNERS

12hr SCS Peak Flows (CMS)										
VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
9451	420, 421	White Birch Creek	16.44	Ex. Land Use w ex. Rainfall	0.403	0.553	0.644	0.795	0.901	1.005
				Fut. Land Use w ex. Rainfall	0.494	0.669	0.776	0.943	1.059	1.311
				Fut. Land use w Climate Change Rainfall	0.558	0.762	0.899	1.088	1.471	2.153
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	22.58%	20.98%	20.50%	18.62%	17.54%	30.45%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	12.96%	13.90%	15.85%	15.38%	38.90%	64.23%

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
VO2 RESULTS FOR 12 HOUR SCS STORM
SETTLEMENT AREA: ALCONA

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
189	100, 101, 102, 103, 104, 105, 106, 107, 110	Bon Secours Creek	244.3	Ex. Land Use w ex. Rainfall	5.008	7.575	9.259	11.644	14.099	16.117
				Fut. Land Use w ex. Rainfall	8.27	12.863	15.832	20.769	24.902	28.659
				Fut. Land use w Climate Change Rainfall	9.95	15.44	19.418	25.826	30.243	34.752
				Fut. Land use w synthetic ponds w ex. Rainfall	5.678	8.418	10.218	12.78	15.365	17.486
				Fut. Land use w syn pond (15% overcontrolled) w ex. Rainfall	5.651	8.375	10.163	12.707	15.278	17.382
				Fut. Land use w syn pond (25% overcontrolled) w ex. Rainfall	5.634	8.348	10.129	12.66	15.222	17.316
				Fut. Land use w syn pond (50% overcontrolled) w ex. Rainfall	5.593	8.282	10.047	12.548	15.09	17.16
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	65.14%	69.81%	70.99%	78.37%	76.62%	77.82%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	20.31%	20.03%	22.65%	24.35%	21.45%	21.26%
				% Increase (Fut. Land Use w synthetic ponds vs Ex. Land Use w Ex. Rainfall)	13.38%	11.13%	10.36%	9.76%	8.98%	8.49%
				% Increase (15% overcontrolled) w ex. Rainfall	12.84%	10.56%	9.76%	9.13%	8.36%	7.85%
				% Increase (25% overcontrolled) w ex. Rainfall	12.50%	10.20%	9.40%	8.73%	7.97%	7.44%
				% Increase (50% overcontrolled) w ex. Rainfall	11.68%	9.33%	8.51%	7.76%	7.03%	6.47%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
191	120, 140, 145	Mclean Creek	108.35	Ex. Land Use w ex. Rainfall	3.389	5.02	6.236	7.85	9.36	10.64
				Fut. Land Use w ex. Rainfall	3.721	5.488	6.748	8.46	10.079	11.43
				Fut. Land use w Climate Change Rainfall	4.398	6.61	7.875	10.435	11.933	13.485
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	9.80%	9.32%	8.21%	7.77%	7.68%	7.42%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	18.19%	20.44%	16.70%	23.35%	18.39%	17.98%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
6	130	Banks Creek	32.53	Ex. Land Use w ex. Rainfall	0.033	0.066	0.087	0.117	0.139	0.159
				Fut. Land Use w ex. Rainfall	0.078	0.113	0.135	0.161	0.179	0.196
				Fut. Land use w Climate Change Rainfall	0.091	0.133	0.154	0.183	0.202	0.221
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	136.36%	71.21%	55.17%	37.61%	28.78%	23.27%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	16.67%	17.70%	14.07%	13.66%	12.85%	12.76%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
150	150	N/A	41.64	Ex. Land Use w ex. Rainfall	1.827	2.707	3.494	4.432	5.098	5.786
				Fut. Land Use w ex. Rainfall	2.037	3.004	3.863	4.872	5.59	6.328
				Fut. Land use w Climate Change Rainfall	2.398	3.781	4.608	5.772	6.61	7.483
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	11.49%	10.97%	10.56%	9.93%	9.65%	9.37%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	17.72%	25.87%	19.29%	18.47%	18.25%	18.25%

12hr SCS Peak Flows (CMS)

VO2 ID	Catchments	Creek Name	Area (ha)		2yr	5yr	10yr	25yr	50yr	100yr
192	170, 180	N/A	96.21	Ex. Land Use w ex. Rainfall	3.155	4.735	5.856	7.365	8.804	10.096
				Fut. Land Use w ex. Rainfall	3.373	5.023	6.201	7.787	9.285	10.633
				Fut. Land use w Climate Change Rainfall	4.011	6.061	7.346	9.612	11.145	13.296
				% Increase (Fut. Land Use vs Ex. Land Use w Ex. Rainfall)	6.91%	6.08%	5.89%	5.73%	5.46%	5.32%
				% Increase (Fut. Land Use w Climate Change Rainfall vs. Fut. Land Use w Ex. Rainfall)	18.91%	20.66%	18.46%	23.44%	20.03%	25.04%

EXISTING AND SYNTHETIC POND SUMMARY

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
LIST OF EXISTING PONDS INCLUDED IN VO2 MODEL

Pond Name	Pond ID	Study Area	VO2 ID	Upstream Area (ha)	Existing Imperviousness	Future Imperviousness	Source for Storage Table
Doral West	9-5	Innisfil Heights	23	7.65	43.00%	84.41%	Stage 1 Report - Appendix C, DWG No. 305787 - 9 - 5E/ W
Doral East	9-4	Innisfil Heights	21	21.67	37.00%	79.39%	Stage 1 Report - Appendix C, DWG No. 305787 - 9 - 4W
Trillium Industrial	8-1	Innisfil Heights	3	30.89	32.00%	51.97%	Drawing provided by The Town of Innisfil by Reid and Associates Limited (Aug, 1989) DWG No. 20
Forest Valley	7-4	Innisfil Heights	29	9.86	25.00%	37.44%	Drawing provided by The Town of Innisfil by Burnside Development Services (June 97) DWG No. S3
Southview	9-2	Stroud	28	28.07	42.00%	54.31%	Stage 1 Report - Appendix C, DWG No. 305787 - 9 - 4W
Victoria Green	9-3	Stroud	24	23.9	42.00%	55.29%	Drawing provided the Town of Innisfil by F.J. Reinders and Associates Limited (Nov, 86) Project No. DWG No. 2568-9
Brandy Lane	10-1	Stroud	26	15.63	46.00%	58.03%	Drawing provided by the Town of Innisfil, DWG No. 47-8896-21
Village North	10-2	Stroud	27	30.99	41.00%	53.00%	Drawing provided by theTown of Innisfil by Rand Engineering Corporation (Oct, 1991) DWG No. 20
Goldcrest	10-3	Fennel's Corners	5	12.53	45.00%	59.56%	Drawing provided by the Town of Innisfil by Anton Kikas Limited (June 1988) DWG No. 8
Mckee	10-4	Sandy Cove	5325	11.94	32.00%	41.15%	URS Hydrology Final Report, Appendix D.3
Rirob	10-5	Sandy Cove	5330	225.65	N/A	N/A	URS Hydrology Final Report, Appendix D.3
Taylorwoods	8-2	Alcona	3	13.56	46.95%	60.23%	Stage 1 Report - Appendix C, DWG No. 305787-8-2
Woodland North	7-11	Alcona	7	11.44	44.54%	59.67%	Drawing provided by the Town of Innisfil by A.M. Candaras Associates inc. (Oct 2004) DWG No. C-5
Woodland South	7-12	Alcona	4	5.9	45.00%	60.00%	Drawing provided by the Town of Innisfil by A.M. Candaras Associates inc. (Oct 2004) DWG No. C-6
Pratt Alcona	8-6	Alcona	1	8.39	38.94%	51.93%	Drawing provided by the Town of Innisfil by Totten Sims Hubicki Associates (July 2005) DWG No. PND 1 and PND 2
ORSI	7-8	Alcona	6	32.53	17.13%	38.02%	Stage 1 Report - Appendix C, DWG No. 305787-7-8N
Royal Alcona	7-1	Alcona	5	40.37	45.18%	54.21%	BMP4C3 Stormwater Management Pond design Addendum, Town of Innisfil, Appendix B

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN
TOWN OF INNISFIL
LIST OF SYNTHETIC PONDS FOR FUTURE DEVELOPMENT

Study Area	VO2 ID for Catchment	VO2 ID of Pond	Area (ha)	VO2 Node
Sandy Cove	242	9262	33.4	9255
	252	9263	93.9	9255
	254	9261	24.54	9255
	255	9264	90.22	9255
Mooselanka	1400	9345	89.16	1400
	306	9341	9.85	9334
	311	9342	7.13	9334
	315	9340	42.67	9334
	320	9343	320	9334
	I204	9344	25.45	1204
Stroud - Hewitts	116	9182	72.81	9125
Lefroy	C102	2125	51.29	2118
	C120	2126	298.59	2118
	I600	2127	35.47	1600
Gilford	G101	9455	14.62	9441
	G102	9454	32.44	9441
	432	9453	12.42	9435
	436	9456	32.96	9435
	I400	9457	8.79	9438
Innisfil Heights	S59	33	26.84	18
	S140	37	7.65	2
	S142	41	21.67	2
	S38	31	89.52	19
	S79	22	83.16	15
Stroud - Lovers	S134	32	43.39	7
Alcona	106	193	111.47	189

APPENDIX E:
POND INSPECTIONS

Innisfil Pond Inspection May 13, 2014

RIBOB Pond (Pond # 10-5)

Surrounding Area

- Low density residential to the south. Marshy land to the northwest.
- Creek running parallel to pond between pond berm and southern houses.
- Access
    - Maintenance access from Purvis St, path from end of street
    - Trail runs around the north side of the pond
- Grass berm surrounds the perimeter of the pond covered in long grass
- Wildlife: Fish, frogs, beaver dam in pond
- Vegetation overgrowth in pond (Cattails, small trees, algae growth on perimeter of pond)
- Possible overflow structure at southeast end of pond
- Southeast outlet structure : approximately 1m concrete pipe with steel gate

Pond Conditions

- Wetland with stream running through it
- Visible sediment build up around outside areas of pond
- Overgrown vegetation throughout pond
- Algae growth around perimeter of pond
- Oily film on top of the water at parts
- No visible inlet structure

Outlet Structure

Influent to outlet
- Approximately 2.6m perforated riser pipe surrounded by stone and secured by wire

Outfluent from outlet
- Discharge into creek to the south through submerged pipe
- Stone retaining wall
- Creek has signs of standing water with algae growth

Innisfil Pond Inspections – May 11, 2012

Pond Inspection Results

1.0 General

a) Pond Name	Crossroads #2
b) Pond ID	8-4
c) Pond Address	1041 Corrie Street
d) Name of Inspector	Renata Sadowska & Sabina Martyn
e) Date of Inspection	May 11, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Table land
- Access:
    - 2 access points, not gated. Main access and asphalt overland flow path from Corrie St.
    - Gravel path along perimeter of pond
    - Mowed along west end of pond, and mowed only along maintenance path on south end of pond. Trails from west end and south end of pond into woodlot
    - No trespassing signs, signs have street name and pond ID
    - Pond can be accessed via the emergency spillway for maintenance. Could be possibility for improvement
- Guardrail at pond inlet and at culverts downstream of outlet. No guardrail at pond outlet
- Woodlot (creek) at south end of pond, low-density residential along all other sides
- Empty easement across the street on north side of Leslie Drive
- Vegetation
    - Woodlot to the south and grass around perimeter of pond
    - Within crest, there are small trees, shrubs, bulrushes
- Wildlife: small fish in forebay, goldfinches, blackbirds
- Grassed spillway off the south end of pond towards creek. Shrubs growing in spillway.
- Space available for expansion/regrading at east, north and west ends.
- Possibility for sediment storage in the middle of peninsula at northwest side of pond

3.0 Pond Conditions:

- Wet pond or wetland → verify with design
- Offline facility
- Deep pool in forebay but no difference in water levels between forebay and pond
- Forebay earth berm not visible, overflow from deep pool into pond (possibly washed out, or pond filled with sediment)
- No visible low-flow channel – might be filled with sediment
- Shallow water along west side of pond after forebay, algae growth
- Bypass structure – to be confirmed – there is a second concrete pipe to Leslie Street at the east end of pond.
- Cleanup of some trash debris required
- Flow path along inside (north edge) of pool. Possible minor adjustments can be made, including addition of baffles to increase flow path to outside edge

- Unidentified PVC pipe (?) submerged in plunge pool at north end of pond near outlet.
- Algae growth in plunge pool near outlet

4.0 Inlet Structure:

Inlet ID: 8-4-I1

- 41” Concrete pipe, not submerged
- No erosion
- Broken/unlocked grate
- Concrete interlocking Terrafix chute blocks (approx. 5cm height)
- Concrete headwall with guardrail, stone wingwalls
- Small deep pool area at forebay, no visibile forebay berm
- Small fish
- Debris at end of forebay
- Murky forebay water (SS)

5.0 Outlet Structure:

Outlet ID: 8-4-O1

Influent to outlet:

- Concrete chamber with overflow grate on top – 74” wide, 86” long, 7” thick concrete slab
- Inside of concrete chamber has a defined low-flow path - benching
- Partially submerged low-flow orifice (concrete, 10” diameter opening to chamber at WL)
- Wooden debris trapped at orifice
- Weir above orifice (not submerged), 31.5” height by 12” width
- 3 x 2-bar grates. Top one locked, two are open.
- Large stone headwalls on both sides of chamber
- Possibility to improve outlet structure must be assessed

Outfluent from outlet:

- Outlet of pipe leaving concrete chamber is located further east. 32” diameter concrete pipe with closed bar grate (no lock), bucket lodged inside pipe, standing/slow moving water
- At that location there is also another 41” concrete pipe with a locked grate that extends under easement towards Leslie Drive

Pond Inspection Results

1.0 General

a)	Pond Name	Crossroads
b)	Pond ID	8-3
c)	Pond Address	2163 Jans Boulevard
d)	Name of Inspector	Renata Sadowska & Sabina Martyn
e)	Date of Inspection	May 11, 2012
f)	Weather	Sunny

2.0 Surrounding Area

- Table land
- Access:
  - Pedestrian access from Jans Boulevard easement, asphalt overland flow path, no gate, no signs. Pond can be accessed this way for maintenance
  - Defined perimeter berm width indicates use for maintenance access.
  - Fenced off from inlet at Ashley Court, sign that says no trespassing.
- Low-density residential around half of pond, rest is woodlot
- Vegetation
  - Sparse young trees around perimeter of the pond
  - Small shrubs on inside of embankment
- Wildlife: turtles, ducks, geese, sparrows, goldfinch. Probably fish in pond because there are seagulls
- Dumping near access from Jans Blvd.
- Emergency spillway from Jans with interlocking stones on top of berm near Inlet 2. External embankment downstream – riprap protection
- Another spillway at northeast corner of pond, leading to marsh. Concrete blocks on embankment. Low-flow culvert (250mm?) partially submerged, and concrete headwall.
- Space available for expansion/regrading to the north and east (woodlot).
- Cattails growing on berm west of Inlet 1 forebay. Saw the nearby house dumping from their backyard pool.

3.0 Pond Conditions:

- Wet pond or wetland → verify with design
- Offline facility
- Subermerged earth berm visible at end of forebay for I2. Sag in the middle. Lifted pipe just upstream of earth berm.
- Berm slopes are slightly eroded in this area. Animal habitat in berm (burrows).
- No visible low-flow channel – might be filled with sediment

4.0 Inlet Structure:

Inlet ID: 8-3-I1

- Grassed overland flow path from Ashley Court, and double catchbasins in cul-de-sac. Fenced off from residential area + cedar hedge along fence.
- 10.5" PVC pipe, not submerged, grate tightly closed, not locked
- Guardrail
- Sediment in pipe
- Toe of headwall reinforced with filter sock and riprap at base of inlet
- Forebay with visible earth berm. Cattails at edges of forebay
- 37" height concrete headwall
- Two 2" PVC drains from headwall

Inlet ID: 8-3-I2

- From Jans – minor system flow route
- 29-30" concrete pipe. 45" to top of headwall, 15 degree concrete wingwalls
- Stilling blocks 15" height and 10" long
- Unlocked bar grate
- Guardrails
- No difference in water level between forebay and pond
- Forebay filled with sediment (as designed?). Very shallow.
- LRiprap protection immediately downstream of inlet headwall, 21" step height of slab at base of headwall. Exposed filter cloth.
- Sediment deposition bar visible above water surface

Inlet ID: 8-3-I3

- Emergency bypass from Jans Blvd – riprap lined
- 55" concrete pipe with 31" height bar grate (locked)
- Concrete headwall and wingwalls
- Evidence of seepage within concrete structure at wingwall
- Filter sock trapped in grate
- Evidence of human access (graffiti)
- 6" x 10" stilling blocks, some eroded
- 10" height step from slab at base of headwall
- Riprap downstream
- Heavy algae growth downstream

5.0 Outlet Structure:

Outlet ID: 8-3-O1

Influent to outlet:
- Concrete chamber with guardrail
- Overflow weir 12" high and 48" wide, with steel bars (2" spacing)

Outfluent from outlet:

- Downstream of outlet pipe, the 26” concrete pipe outlets into a marshy area to the north east of the pond. Concrete headwall with wingwalls, 46” height. Stilling blocks 8” high by 12” wide. Sediment at bottom 1” and algae growth. Locked grate.
- Evidence of animal habitat downstream of outlet in southwest direction – dam outside of the marsh.

Innisfil Pond Inspections – May 11, 2012

Pond Inspection Results

1.0 General

a) Pond Name	BMP4C2
b) Pond ID	7-9
c) Pond Address	
d) Name of Inspector	Renata Sadowska & Sabina Martyn
e) Date of Inspection	May 11, 2012
f) Weather	Sunny

BMP4C2 is a very large facility with several small pond cell inlets. Observations at these pond cells as well as through the main channel of BMP4C2 are listed below.

Main Channel:

2.0 Surrounding Area

- Located at a lower elevation than surrounding development, pond cells, etc.
- Roads to the north (Corm Street at west end, Innisfil Beach Road at east end, Jans Boulevard passes through it). Commercial land use also to the north (Plaza with Sobeys, Shoppers Drug Mart, etc.) Low-density residential to the south and construction along Mary Lou Street. “Woodland Park Wetlands” upstream (southwest) of the beginning of the wetland (more natural) and bridge. Retaining wall north of wetland south of west of bridge indicates that the houses were built too close to it.
- Flow from natural wetland disappears under the bridge, and seeps out at the 4th basin downstream of the bridge (potentially from a partially submerged pipe at the bottom of the large steps). Large basins/steps are covered in riverstone downstream of bridge.
- Remaining old silt fences along main channel of wetland
- Ongoing residential construction on the south side of the wetland, open space on the north side. (no sediment controls, broken fence)
- Concrete pedestrian access and overland spillway from Mary Lou Drive which has new construction and no sediment controls in place.
- Is development too close to wetland? (Is there supposed to be a 30m setback?)
- Access:
  - Access from Swan Street: Easement to gravel path on top of berm and along south edge of wetland, pedestrian bridge at end of wetland near Swan Street. Exposed geotextile near entrance to bridge from Swan Street.
  - Maintenance access via easement from Mary Lou Street (also pedestrian access)
  - Gravel path, maintenance access across wetland across from Pond 7-7.
  - Gravel path crossing the wetland, near Pond 7-7.
  - Pedestrian and maintenance from Gina Street at north end of wetland. Maintenance area north of Pond 6-6 and pedestrian gravel path along south end of wetland.
  - Signs indicating that it is a stormwater management facility
- Wildlife: Blackbirds, geese, ducks
- Possible dumping near Swan Street (garbage bag).
- Garbage near inlet of outlet of wetland near Innisfil Beach Road

- Vegetation:
  - At southern half, long grasses to wetland top of bank, sparse new trees along bank.
  - At northern half, large rocks on embankment on north side across from Pond 7-7. There is also a maintenance access grassed path here and overland flow path (grassed swale and riverstone). Shrubs within crest at gravel path south of wetland. New trees on south side of gravel path, outside of crest, as part of trail. Tree lined on residential side, long grasses and small shrubs on wetland side.

3.0 Pond Conditions:

- Wetland? Looks like a wet pond in some areas.
- Inline facility
- Riverstone berm located in the middle of wetland downstream of Cell #1. Surrounded by debris and cattails.
- Wetland connection from north side of pedestrian gravel berm to south side is an 18" concrete pipe, with concrete wingwalls and 36" high headwall and closed grate. Stilling blocks are 3.5" high, 12" wide and 8" long.
- Cattails and algae growth between two rocks berms in section of facility between Gina Street entrance and Jans Boulevard.

4.0 Inlet Structure:

Inlet ID: 7-9-I1

- Outlet from Cell #1 – described below

Inlet ID: 7-9-I2

- Outlet from Cell #2 – described below

Inlet ID: 7-9-I3

- Downstream of riverstone berm, west of Pond 7-7
- 21" concrete pipe with concrete headwall, no guardrails – for overland flow from Mary Lou?
- Rocks in pipe
- Deep pool formation immediately downstream of pipe, evidence of erosion downstream of pipe
- Cattails and sediment downstream in forebay.
- Riverstone on either side of inlet

Inlet ID: 7-9-I4

- Outlet from Cell #4 – described below

Inlet ID: 7-9-I5

- From the direction of the north end of Pond 7-7, not sure where it drains from
- Concrete box culvert 37" high, 61" wide, 67" tall. Concrete headwall and wingwalls, guardrail.
- Sediment deposition at inlet
- 4" high stilling blocks that are covered in sediment
- Debris deposition

Inlet ID: 7-9-I6

- From pipe running under Gina Street easement
- Large boulders to dissipate energy, large boulders for headwall
- 33” pipe with 47” concrete headwall, locked grate, guardrail
- Stone berms downstream of inlet
- Sediment deposition and overgrown cattails, murky water,
- Outlet channel with stone berms

Inlet ID: 7-9-I7

- Some slope erosion from outlet from Shoppers Drug Mart Parking lot

Inlet ID: 7-9-I8

- From Sobeys parking lot to the middle of the berm

5.0 Outlet Structure:

Outlet ID: 7-9-O1

Influent to outlet:
- Watercress near outlet, sparse pine trees and long grasses on pond banks
- Concrete box culvert 50” high and 72” wide, width of headwall is 67”
- Guardrail
- Parking lot (no fence) at north end of wetland

Cell #1:
- Located northwest of the west end of wetland, off Swan Street.
- Overland flow path (curb cut) from Swan Street
- Berm with gravel path on top separates it from the wetland. Riverstone protection on berm.
- Overflow spillway to main channel of wetland, reinforced with interlocking stones.
- Forebay berm is reinforced with riprap stones
- New vegetation on the inside perimeter of pond (shrubs and small trees)
- Cattails in the forebay and pond
- No visible low-flow pipe

Inlet:
- 33” concrete pipe, grate removed from hinges, 50.5” concrete headwall and concrete wingwalls
- Stilling blocks 8” height by 12” length by 7” width.
- Step from concrete pad is 14” high
- Riprap downstream
- Invert of inlet pipe is much lower than spillway –flow could back up into storm sewer

Outlet:
Influent to outlet:
- Concrete box with two chambers in the berm

- Overflow grate
- Concrete pipe into first chamber from pond is approximately 1000mm(?). Connected to a perforated riser pipe. Conveyance through a 450-500" PVC pipe for low flows to the second chamber. There is a weir in the dividing concrete slab between the two chambers.

Outfluent from outlet:

- Pipe out of the second chamber is 18" concrete.
- At downstream connection to wetland, there is a 56" long headwall with a grate.
- Deep pool with cattails and riverstone berm protection
- Some floating debris

Cell #2

- Located southwest of wetland
- Perimeter fence, houses are very close to pond, manicured lawns and new vegetation up to the fence.
- Pedestrian access from Lowrie Street easement, or via the pedestrian bridge from Swan Street
- Overland flow from Lowrie Street
- For 1/3 the length of the pond, starting from the forebay, there is a maintenance access road to the pond reinforced with interlocking stones. Interlocking stones are eroding and road is covered in grit.
- In main pond: dead turtle, lots of algae
- At forebay berm: bicycle, shopping cart, artificial plants
- Sediment forebay filled with sediment
- Shrubs and long grasses inside crest, cattails along perimeter

Inlet:

- 29" concrete pipe with headwalls, wingwalls and locked grate.
- Stilling blocks – 12" long, and 8" high.
- Shrubs blocking the inlet, trapped debris.
- Sediment deposition to the left of the pipe, facing downstream.

Outlet:

- Connected to main channel through control structure similar to Cell #1.
- Overflow grate located in centre of asphalt trail. Top of weir eroding in the chamber.
- Inclined overflow grate near northern corner of cell, but no visible pipe. Sealed? Or filled with sediment?

Cell #4

- Across the wetland from Pond 7-7 (north of wetland, south of Sobeys parking lot, south of Corm Street)
- Riprap berm separating forebay from main cell
- Cattail growth along perimeter of pond along forebay berm
- Long grasses and small shrubs, a few pine trees
- No suspended solids

Inlet:

- Concrete 18” pipe, concrete headwall with grate
- No guardrails, just dense shrubs around inlet.
- Slight erosion, sediment deposition in front of inlet

Outlet:

Influent to outlet:

- Concrete chamber 65” long with an overflow grate, standing water inside
- Weir inside chamber cut out of concrete slab (30“ high, 4” wide)
- 12” PVC pipe leaving the concrete chamber, no flow through it, pipe filled with sediment
- Riprap upstream of outlet

Outfluent from outlet to wetland:

- 35” pipe, closed grate, no guardrails. 26” step height
- Grassy vegetation at outlet point into wetland
- Eroded concrete seal between headwall and pipe

Cell #5

- Located at north side of Corm Street, west of Sobeys. Likely private property, and services the nearby commercial area.
- Pond is fenced, dirty.
- Cells #4 and #5 flow to the same outlet into the wetland.

Innisfil Pond Inspections – May 11, 2012

Pond Inspection Results

1.0 General

a) Pond Name	Green Acres
b) Pond ID	7-7
c) Pond Address	2050 Jans Boulevard
d) Name of Inspector	Renata Sadowska & Sabina Martyn
e) Date of Inspection	May 11, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Table land
- Access:
    - Pedestrian and maintenance access along west side of pond between pond and wetland BMP4C2. Gravel path.
- Low density residential to the south and east, wetland to the north and west.
- No room for expansion.
- Vegetation
    - Grass outside of pond crest, a couple of trees
    - Within crest, grass and cattails, dogwood. Cattails around perimeter and in the middle of pond, along berms
- Overflow spillway on west side of pond, around outlet.

3.0 Pond Conditions:

- Wet pond or wetland
- Offline facility
- Algae growth in main part of pond
- Main area of pond: Meant to be shallow or is it filled with sediment?
- Beaver dam in the middle of main pond

4.0 Inlet Structure:

Inlet ID: 7-7-I1

- Concrete headwalls, grate, no guardrails, shrubs around inlet
- Boulders around inlet for velocity protection
- Bank erosion on right side of inlet
- Partially submerged 11” concrete pipe
- Rip-rap lined forebay berm
- Suspended solids in forebay, murky water

Inlet ID: 7-7-I2

- Partially submerged concrete pipe, grate, concrete headwall

- Not open – future pipe connection?
- Forebay is much cleaner, with some cattails near berm
- Forebay berm at surface
- Riprap

5.0 Outlet Structure:

Outlet ID: 7-7-O1

Influent to outlet:

- No lock on cover (met Innisfil engineering co-op students at 2pm, who put a lock on it. Also told them about sediment from construction site, and they documented it)
- Filter fabric and pea gravel
- 44” CSP pipe
- Inside, there is a 11” diameter, 44” height PVC perforated rise, and pea gravel and sediment

Outfluent from outlet:

- 9.5” diameter PVC pipe to wetland
- Exposed geotextile, small forebay with riverstone lining
- Cattails after the deep pool area
- Grate closed
- Sediment deposition from the pond outlet – outlet should be protected with filter cloth.

Pond Inspection Results

1.0 General

a) Pond Name	Innisbrook Developments (Innisbrook Heights)
b) Pond ID	7-6
c) Pond Address	1295 Gina Street
d) Name of Inspector	Renata Sadowska & Sabina Martyn
e) Date of Inspection	May 11, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Table land
- Access:
    - 1 access point from easement from Gina Street, gated but open.
    - Concrete overland path from Gina Street easement goes into Wetland BMP4C2.
    - Circular maintenance area at north end of pond, interlocking stones
    - Asphalt path (part of trail system) along berm at western edge of pond, between pond and wetland.
- Low-density residential to the east and south, Innisfil Beach Road to the north, Sobeys parking lot and wetland BMP4C2 to the west.
- Sediment fence along southern edge – should be removed
- Wildlife: beaver dam in pond
- Vegetation
    - Grass and small trees shrubs around perimeter of pond
    - Within crest, bulrushes around perimeter and in the middle of pond.

3.0 Pond Conditions:

- Wet pond
- Offline facility
- Mildew and chemical smell, possible evidence of fertilizer/pesticides
- Brown floating organics, no suspended solids
- Mattress in forebay
- Evidence of dumping – cleanup required
- Rip-rap lined spillway to wetland on west side of pond, exposed geotextile in the riprap

4.0 Inlet Structure:

Inlet ID: 7-6-I1

- 36” concrete pipe with concrete headwall of 118” width
- No guardrail

5.0 Outlet Structure:

Innisfil Pond Inspections – May 11, 2012

Outlet ID: 7-6-O1

Influent to outlet:

- Submerged pipe, concrete headwall
- Looks like pipe might be clogged because of backflow of sediment back into pond
- Inclined overflow grate with concrete chamber. Top 60” width by 38”. Concrete width is 6”.
- Riser in the chamber is approximately 8” in diameter, perforated PVC, partially submerged.
- Water level in chamber is higher than in the pond

Outfluent from outlet:

- Towards creek running to Innisfil Beach Road.
- 12” PVC pipe with concrete headwall 73” long and 42” wide.
- Debris and sediment deposition, overgrown vegetation is shifting the channel towards the road embankment.
- Signs of sediment load in main channel
- Ongoing road construction to the north, silt fence in place
- Watercress → sign of groundwater seepage?
- Shrubs around outlet
- Riprap in an undefined path

Innisfil Pond Inspections – May 11, 2012

Pond Inspection Results

1.0 General

a)	Pond Name	Wallace Mills #2
b)	Pond ID	7-3
c)	Pond Address	1896 Webster Boulevard
d)	Name of Inspector	Renata Sadowska & Sabina Martyn
e)	Date of Inspection	May 11, 2012
f)	Weather	Sunny

2.0 Surrounding Area

- Table land
- Access:
  - Perimeter fencing around entire pond.
  - 2 access points, one from the south near woodlot/creek, and one from the west through easement from Emerald Court. Both gated and locked. Keys did not work on west gate, but worked on south gate. Difficult to access pond from the west side because path is overgrown.
  - Vehicle access from south.
  - Pedestrian walkway along south end of pond outside of the fence, from Webster Blvd to Emerald Ct.
  - "Use at own risk" signs, sign with Pond ID and street name, sign explaining SWM facility
- Guardrail at Inlet 1 but no guardrails at Inlets 2 and 3.
- Woodlot (creek) at south end of pond, low-density residential at north and west, road along east.
- Open spaces on east side of Webster Road on either side of Jans Bouleard.
- Some open space west of pond, but expansion is unlikely because existing vegetation is dense and mature.
- Vegetation
  - Woodlot to the south
  - Internal slope is well vegetated. Dense mature trees, shrubs and long grasses within crest of pond. Dense bulrushes near the water.
- Wildlife: did not see wildlife, but evidence of animal burrows in pond slope.
- Spillway off the south end of pond towards creek. Covered in concrete mat.

3.0 Pond Conditions:

- Wet pond
- Offline facility
- Murky water and algae growth

4.0 Inlet Structure:

Inlet ID: 7-3-I1

- From Emerald Court

- 48” Concrete pipe with concrete headwall and wingwalls and grate
- Stilling blocks, 5” high by 9” long by 13” wide
- Riprap downstream of inlet
- Shallow water, sediment deposition
- Partially submerged

Inlet ID: 7-3-I2

- At northeast corner
- 22” concrete pipe with concrete headwall 152” in length.
- Riprap at inlet
- Clear, still water, no SS
- Partially submerged

Inlet ID: 7-3-I3

- From east, under Webster Blvd.
- 12” concrete pipe, concrete headwall 78” long, with grate
- Riprap downstream of inlet
- Lots of algae
- Partially submerged

5.0 Outlet Structure:

Outlet ID: 7-3-O1

- Hickenbottom manhole on berm at south end near spillway, but could not see it. Outlet into pond probably submerged (could not see it on pond slope).

Innisfil Pond Inspections – May 11, 2012

Pond Inspection Results

1.0 General

a)	Pond Name	Wallace Mills #1
b)	Pond ID	7-2
c)	Pond Address	1218 Forest Street
d)	Name of Inspector	Renata Sadowska & Sabina Martyn
e)	Date of Inspection	May 11, 2012
f)	Weather	Sunny

2.0 Surrounding Area

- Table land
- Access:
  - Perimeter fence
  - Locked, gated access from Webster Blvd. Vehicle access from Webster Blvd to northeast corner of pond
  - Grassed Pedestrian access along west side of pond outside of fence, from Forest Street
  - "Use at own risk" signs, sign with Pond ID and street name, sign explaining SWM facility
- Vegetation
  - Woodlot to the south
  - Internal slope is well vegetated. Dense mature trees, shrubs and long grasses within crest of pond. Dense bulrushes near the water.
- No space for expansion, vegetation is dense and mature.
- Spillway at north end of pond towards woodlot (creek). Asphalt and concrete mat on spillway, but it is overgrown with vegetation.
- Creek is partially blocked by wood & debris

3.0 Pond Conditions:

- Wet pond
- Offline facility
- Perimeter dense vegetation, but there is not much algae growth or suspended solids.

4.0 Inlet Structure:

Inlet ID: 7-2-I1

- Dense vegetation (cedar and other trees) near inlet – difficult to assess

5.0 Outlet Structure:

Outlet ID: 7-2-O1

- Inaccessible, not assessed

Pond Inspection Results

1.0 General

a) Pond Name	Orsi (Bayshore Estates)
b) Pond ID	7-8
c) Pond Address	West of 1097 Anna Maria Avenue
d) Name of Inspector	Renata Sadowska & Sabina Martyn
e) Date of Inspection	May 11, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Table land
- Access:
  - Gravel trail through proposed subdivision (pedestrian and vehicle access)
  - Pond is fenced, but gate is open/broken
  - No signs
  - Berm also along west side of pond for access – maintenance access road from nearby subdivision to the west of pond.
- Guardrail at pond inlet(?) at northwest end of pond.
- Currently land is still a woodlot, wetland area. Road to the south (7th Line).
- Vegetation
  - Woodlot and wetland around perimeter of pond
  - Within crest, cattails and long grasses, sparse very young trees
- Wildlife: turtle, beaver dam at east end of pond, small fish near inlet
- Spillway at south end of pond towards 7th line, covered in concrete mat
- Space available for expansion to the west, north, east.
- Gravel trail is a woodlot/marsh on one side, and a wet channel/creek/swale? on the other side. Unsure of where the outlet of the channel is – into pond? Or away from pond? Standing water. End of creek near high school on Anna Maria has an inlet (?) structure with a grate, concrete headwall and guardrails – filmy water, high sediment load.
- Entry point of this creek/swale to the pond has a spillway with concrete mat, and goes under the fence. Debris trapped under fence.
- Evidence of interfering with natural drainage paths, because there is significant seepage across the trail in several areas.

3.0 Pond Conditions:

- Wet pond
- Offline facility
- Bank erosion (rill) south of inlet (from wetland to pond). Pond slope could be regraded or could plant vegetation to stabilize the slopes.

4.0 Inlet Structure:

Inlet ID: 7-8-I1 (not sure if this is inlet – drainage to and from pond needs to be confirmed)

- Erosion on left side of inlet (facing downstream into pond)
- Concrete headwalls and wingwalls
- Bicycle submerged at inlet
- Partially submerged 53” concrete pipe
- 41” Concrete pipe, not submerged
- Guardrail
- Grate fallen in
- Goes to wetland? Comes from wetland?

5.0 Outlet Structure:

Outlet ID: 7-8-O1

Influent to outlet:

- 10-11” PVC pipe, sediment deposition in pipe.
- Not submerged – in the middle of berm, a lot higher than water level
- Surrounded by long grasses, cattails upstream of pipe.

Outfluent from pipe:

- Downstream outlet of pipe to creek running parallel to 7th line. 300mm pipe? Concrete headwall, grate. Illegal dumping nearby.

Pond Inspection Results

1.0 General

a) Pond Name	Royal Alcona
b) Pond ID	7-1
c) Pond Address	971 Garden Avenue
d) Name of Inspector	Renata Sadowska & Sabina Martyn
e) Date of Inspection	May 11, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Houses on slope at higher elevation on west side of pond, houses on slope at lower elevation on east side of pond
- Access:
    - Chainlink fence around perimeter of facility
    - 3 asphalt access points, not gated. One along easement from Anna Maria Avenue, one along easement from MacLean Street, and one along easement from Garden Avenue. Grassed overland flow path from Garden Ave.
    - Gravel path between forebays and pond connecting all access points – pedestrian and maintenance.
    - Gravel maintenance access to outlet structure from pond
- Beginning of a wooded area at south end, surrounded by low-density residential on all other sides
- Vegetation
    - Woodlot to the south and grass and small shrubs around perimeter of pond. Established trees and dense brush on east side of facility, on slope.
    - Within crest, there are small trees, shrubs, a lot of bulrushes
- Emergency spillway south of I4 lined with riprap along both slopes of berm and concrete plath on top of berm.
- Very little space available for expansion, residential units back directly onto facility.
- Two large overflow grates with depressed curb upstream of easement from Maclean Street.

3.0 Pond Conditions:

- Wet pond or wetland → verify with design
- Inline facility?
- Three forebays
- Forebay for I3 has some bank erosion – there is some space available for regarding. Spillway from forebay for I3 is overgrown with cattails, as is the area it spills to before outletting into main pond. Outlet to main pond is twin 23” CSP culverts with riprap at inlet
- A lot of algae growth and cattails in area between forebay for I1 and the outlet
- Forebay for I4 has a riprap-lined berm, flowing
- Water at outlet is filmy at surface (possible presence of gasoline, oil)

4.0 Inlet Structure:

Inlet ID: 7-1-I1

- Inlet from MacLean
- 40" Concrete pipe, with concrete headwall and grate
- Partially submerged
- Riprap downstream
- Guardrail

Inlet ID: 7-1-I2

- Influent to inlet from woodlot (intermittent stream?)
- Not submerged, some sediment in pipe
- 16" CSP culvert
- Grassed swale upstream, lots of cattail growth

Inlet ID: 7-1-I3

- Inlet from Anna Maria
- Partially submerged, 32" concrete pipe with concrete headwall and grate
- Some sediment and organic matter
- Riprap downstream
- Guardrail

Inlet ID: 7-1-I4

- Concrete elliptical pipe with concrete headwall and wingwalls.
- Guardrail
- Gabion retaining walls downstream of inlet on south side
- Rip rap protection downstream

5.0 Outlet Structure:

Outlet ID: 7-1-O1

Influent to outlet:
- 50" peforated CSP with riser pipe
- Concrete chamber with steel-plated weir and inclined overflow grate
- Gabion basket wingwalls
- Fenced in with locked maintenance gate.

Outfluent from outlet:
- Concrete pipe with headwalls and wingwalls with grate
- Debris inside pipe (tire, etc.)
- Stilling blocks
- Discharge to creek/open channel.
- Fenced on both sides of outlet.

Pond Inspection Results

1.0 General

a) Pond Name	Previn Court
b) Pond ID	6-1
c) Pond Address	1006 Quarry Drive
d) Name of Inspector	Renata Sadowska & Sabina Martyn
e) Date of Inspection	May 11, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Table land
- Access:
  - Fence around entire facility. 2 access points, not gated. Asphalt overland flow path from Booth Avenue to end of forebay is also a maintenance and pedestrian access. Maintenance and pedestrian access from Quarry Road, gravel road.
  - Gravel path around pond at the top of perimeter berm
- Inlet and quantity control (second in-line) outlet are fenced
- Surrounded by low-density residential
- Open channel flow along south end of pond, flowing west to east. Possibly serves as a conveyance for re-directed creek. Channel covered in cattails. Inlet is fenced. Flows to quantity control outlet.
- Vegetation
  - Shrubs and small trees outside crest, a lot of cattails in swale along south end of pond.
  - Shrubs and small trees inside crest, and cattails near water surface
- Spillway at east end of pond, covered in concrete mat at top of berm. Cattails growing in dry basin downstream of spillway towards quality control (second in-line) outlet. Another spillway covered in concrete mat around second outlet.

3.0 Pond Conditions:

- Wet pond
- Offline facility? Pond runs parallel to open channel which could be the creek that was diverted when the subdivision was constructed.
- Forebay is murky, suspended solids
- Berm separating forebay from main pond is submerged.
- Low-flow channel/pools not visible

4.0 Inlet Structure:

Inlet ID: 6-1-I1

- Concrete box with concrete headwalls and wingwalls
- Fenced
- Murky water in forebay

5.0 Outlet Structure:

Outlet ID: 6-1-O1

Influent to outlet:
- 72” diameter concrete perforated riser pipe. Filter stones around it.

Outfluent from outlet:
- Flows through ditch – rerouted creek.

Influent to quantity control (second in-line) outlet
- Concrete pipe with concrete head walls and wingwalls (fenced). Cattails upstream.
- Two overflow grates downstream – two concrete chambers 60” by 36” grates, concrete width 6.5”
- Emergency spillway covered in concrete mat around overflow grates.

Outfluent from quantity control (second in-line) outlet:
- Outflow pipe inside chamber.

Pond Inspection Results

1.0 General

a)	Pond Name	Tepco North
b)	Pond ID	6-2
c)	Pond Address	East of 930 Booth Avenue
d)	Name of Inspector	Renata Sadowska & Sabina Martyn
e)	Date of Inspection	May 11, 2012
f)	Weather	Sunny

2.0 Surrounding Area

- Table land, valley with creek to the north
- Low-density residential on three sides, woodlot to the north
- Access:
    - Perimeter fence around facility but no gate. Pedestrian and maintenance access through asphalt easement from Booth Ave. This is also the overland flow path. There is a spillway into the pond, lined with riprap. Recommend that grit in asphalt easement be replaced with sod.
    - Another pedestrian walkway from 7th Line through woodlot to pond, gravel trail.
    - Gravel/grassed path along perimeter of pond
- Vegetation
    - Woodlot/marsh to the north, small shrubs and trees around facility.
    - Cattails and brush within crest
- Spillway near outlet is covered in down the slope into the valley/woodlot. Interlocking stones at the top of the berm.
- Some evidence of dumping
- Broken, old silt fence still exists along chainlink fence at north end of facility. Steel bars should be removed.

3.0 Pond Conditions:

- Wet pond
- Offline facility

4.0 Inlet Structure:

Inlet ID: 6-2-I1

- Concrete 24” pipe with concrete headwalls and grate
- Earth berm from forebay is not visibile, covered in cattails

5.0 Outlet Structure:

Outlet ID: 6-2-O1

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Influent to outlet:

- Quantity control structure
- DICB (48” wide by 36” long) drains to PVC Pipe into concrete chamber

Outfluent from outlet:

- Overflow grate (2 chamber concrete box)
- Rectangular weir cut into concrete wall between the chambers. Concrete is 10” thick, weir is 38” in height, 11” in width.
- PVC pipe from quality control outlet (O2) drains into second chamber.
- Twin concrete pipes outlet from the concrete chamber to the creek/marsh

Outlet ID: 6-2-O2

Influent to outlet:

- Quality control structure
- Submerged outlet
- Concrete headwall
- Gravel pad around it

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Pond Inspection Results

1.0 General

a)	Pond Name	Forest Valley
b)	Pond ID	7-4
c)	Pond Address	1891 Forest Valley Drive
d)	Name of Inspector	Paul Marsh & Sabina Martyn
e)	Date of Inspection	May 18, 2012
f)	Weather	Overcast

2.0 Surrounding Area

- Forest to the north, south and east sides of the pond. Low density residential to the south-west.
- It is believe that a berm was built around the pond to create it, rather than excavation. Woodlot east of the pond has a lower elevation, and there is a higher elevation to the west closer to the road.
- Access:
    - Perimeter fence with locked gate
    - Paved access from the road becomes a grassed (or gravel covered in vegetation)access path inside the perimeter fence
- Vegetation:
    - Within pond crest: yellow birch, Manitoba maple. Middle of pond is completely overgrown with unknown long grasses
    - Outside pond crest: Ferns, horsetails, sumach. Mixed hardwoods outside the fence (70% cedar)
- Wildlife: Animal path on slope around outfluent of 300mm pipe.
- Inflow to pond is conveyed via concrete mat channel. Concrete mat has some vegetation growing between the squares.
- Overflow spillway near the outlet to the stream. Concrete mat with riprap at base
- Room for expansion around the outlet ditch and downstream of the outlet ditch, but should avoid the mature cedar on east side of the channel.
- A lot of algae growth and small plants around outfluent point of Outlet 1. Riprap around outlet and shallow pool.
- Unidentified contribution from nearby home into outlet channel near Outlet 1. Could explain the growth there that is not found upstream.
- Roadside ditch located parallel to access road, outside fence. Ditch has some small trees and vegetation growing in it. 200mm PVC culvert outlets from roadside ditch to channel near outfluent point of Outlet 2.

3.0 Pond Conditions:

- Wet pond with no permanent pool
- Water in main pond is not visible because of growth of long grasses, but can hear water flowing
- Inline facility
- No visible forebay

4.0 Inlet Structure:

Inlet ID: 7-4-I1

- 600mm CSP under Forest Valley Drive, shovel and leaves lodged inside pipe
- Wooden headwall, no guardrail
- Discharge to concrete mat channel that conveys towards the pond. The mat is surrounded by riprap. Low flow travel under the concrete mat.

Inlet ID: 7-4-I2

- 400mm CSP culvert with wooden headwall under access road from south, leaves inside, wooden headwall
- Discharge to concrete mat channel that conveys towards the pond. The mat is surrounded by riprap. Low flow travel under the concrete mat.

5.0 Outlet Structure:

Outlet ID: 7-4-O1

Influent to outlet:
- 100 mm circular orifice plate on outlet in a CSP riser with overflow grate (partially submerged)

Outfluent from outlet:
- 230 mm CSP outlets into ditch
- Partially submerged
- There is a fallen tree in the middle of the ditch

Outlet ID: 7-4-O2

Influent to outlet:
- 300mm PVC
- Manitoba maple growing directly in front of outlet

Outfluent from outlet:
- Outlet is just outside of perimeter fence, into ditch. Outfluent point is relatively flat and covered with leaves. Growth of small trees, brush at outfluent point.

Pond Inspection Results

1.0 General

a)	Pond Name	Innisbrook Estates
b)	Pond ID	7-5
c)	Pond Address	East of 1949 Innisbrook St.
d)	Name of Inspector	Paul Marsh & Sabina Martyn
e)	Date of Inspection	May 18, 2012
f)	Weather	Overcast

2.0 Surrounding Area

- Sign with Pond Name and ID, No Trespassing sign, and sign explaining purpose of Stormwater Facility
- Access:
  - Perimeter fence, gated, locked
  - Gravel maintenance access road around perimeter of facility
- Large residential lots to the north and west. Woodlot to the south and east.
- Pond built up higher than surrounding area
- Vegetation:
  - Within crest: cattails, small trees, shrubs (sumach, dogwood)
  - Outside crest: White pine plantings, spruce. Plantings of unknown small shrubs.
- Wildlife: red-winged blackbird, frogs, animal slide near the forebay
- Room for expansion to the west of forebay

3.0 Pond Conditions:

- Wet pond
- Inline facility
- Overflow spillway (riprap) near twin outlet pipes
- Very murky water, algae
- A lot of algae in the forebay
- Algae especially in southwest corner of forebay – probably an anoxic zone, stagnant water, not part of flow path.
- Dense cattail growth through upstream half of forebay.
- Forebay has same water level as main pond
- Forebay connection to main pond:
  - Riprap spillway
  - Influent from forebay: submerged pipe, concrete headwall, guardrail, grate closed
  - Outfluent to pond: submerged pipe, concrete headwall, guardrail
- In forebay: submerged pipe, concrete headwall with guardrail – Is there another inlet from the adjoining lot? Drawing shows a ditch inlet.

4.0 Inlet Structure:

Inlet ID: 7-5-I1

- 600mm CSP, partially submerged, lots of growth around it.
- Steady flow from Innisbrook Street, flows out of culvert through space under fence. Plants bend downstream (evidence of high flow from culvert).
- Upstream there is a lot of growth in the nearby ditches.
- Riprap in ditch outside of fence. Room for pretreatment (grit chamber) here.
- Riprap downstream of inlet. Grass and algae established on top of rocks.

5.0 Outlet Structure:

Outlet ID: 7-5-O1

Influent to outlet:

- Algae growth
- Hickenbottom outlet, surrounded by riprap. Where do the holes start? Assume at the same level as the bottom of the twin pipes

Outfluent from outlet:

- 250mm corrugated PE pipe

Outlet ID: 7-5-O2

Influent to outlet:

- Twin 450mm PE pipes with smooth inside walls, partially submerged
- Concrete headwall, grate and guardrails

Outfluent from outlet:

- Southern pipe is filled with debris
- All outlets drain to common ponding area east of pond.

Pond Inspection Results

1.0 General

a)	Pond Name	Industrial
b)	Pond ID	8-1
c)	Pond Address	3277 Clifford Court
d)	Name of Inspector	Paul Marsh & Sabina Martyn
e)	Date of Inspection	May 18, 2012
f)	Weather	Overcast

2.0 Surrounding Area

- Tableland
- Access:
    - Perimeter fence, gated, locked
    - Maintenance access along berm along perimeter of site.
    - Sign with Pond Name and ID, No Trespassing sign
- Industrial area surrounding the pond. Road to the north. Connection to creek at east side. Neighbouring property has Port-a-Pottys.
- Vegetation:
    - Within crest: cattail growth in the middle of pond. Mostly grass vegetation
    - Outside crest: grass and a few sparse trees
- Wildlife: snakes near the outlet, around where cattails are located. Saw a rabbit

3.0 Pond Conditions:

- Dry pond
- Inline facility
- Gabion basket spillway into pond. Grass grows along flow path.
- Lots of sediment deposition along flow path, especially between inlet and wetter spot in the middle.
- Low flow swale is not well defined except for the vegetation that grows along it.

4.0 Inlet Structure:

Inlet ID: 8-1-I1

- 500mm CSP under Clifford Court
- Riprap at outlet of pipe, flow over gabion basket spillway, overland conveyance through low-flow swale

Inlet ID: 8-1-I2

- Inlet from industrial property to the south.
- Adjoining property has a 50m x 50 m dry pond which outlets to a smaller area (10 mm X 10m) enclosed by a rock berm. There is a CB in the middle with a 50mm perforated pipe that outlets to a 375mm PVC pipe leading to Pond 8-1. 375mm PVC surrounded by riprap down the berm slope into pond.

5.0 Outlet Structure:

Outlet ID: 8-1-O1

Influent to outlet:

- Filter fabric around the outlet pipe (diameter?), riprap and grass on top.
- Opening at the top of berm with gabion basket spillway. Geotextile exposed at the bottom of the berm.

Pond Inspection Results

1.0 General

a)	Pond Name	Doral Business Park
b)	Pond ID	9-4
c)	Pond Address	North of 2521 Bowman Street
d)	Name of Inspector	Paul Marsh & Sabina Martyn
e)	Date of Inspection	May 18, 2012
f)	Weather	Overcast

2.0 Surrounding Area

- Tableland
- Access:
  - Perimeter fence, gated, locked
  - Sign with Pond Name and ID, No Trespassing sign, and sign with explanation of stormwater facility
  - Grassed access path around pond.
- Industrial land to the south, north and west. Woodlot to the east.
- Vegetation: Some evergreens growing outside the pond crest. Short grasses and poor condition young oaks/maples within the pond crest.
- Wildlife: Animal burrows within crest, snakes, raccoons, deer, geese, toads, snails, swallows
- Riprap overflow spillway at outlet
- Small ditch along east side of pond, inside perimeter fence

3.0 Pond Conditions:

- Wet pond
- Offline facility?
- Well-established pond edge
- Pond bottom membrane exposed in some places
- Lily pads in main pond downstream of western forebay
- No cattails in western forebay and only a little algae upstream of the riprap berm at the downstream end of the forebay
- Small defined flow path on north division between eastern forebay and main pond.
- Forebay water levels lower than in the main pond.
- Need to control all the B-gravel at the inlets. Recommend a vortex chamber.

4.0 Inlet Structure:

Inlet ID: 9-4-I1

- Influent to western inlet: 1 m CSP in roadside ditch, no sediment deposition inside
- There is also a CSP under the pond access road, that drains into the same ditch. This CSP is half filled with sediment, and there is bank erosion beside it.
- A lot of sediment deposition out of the inlet into the western forebay.

Inlet ID: 9-4-I2

- Eastern inlet: concrete pipe, concrete headwall, closed grate, high sediment deposition. Riprap on either side of the pipe, long grasses along the flow path.
- Dense cattail growth at the end of open channel from I2.
- Evidence of erosion in this open channel, downstream of the rock check dam.

5.0 Outlet Structure:

Outlet ID: 9-4-O1

Influent to outlet:

- 300mm PVC with 230mm orifice steel plate flowing into 600 mm long by 750 mm wide concrete chamber with inclined overflow grate.
- Water in the chamber is lower than the pond
- Inside the chamber, 450mm PVC pipe with 450mm steel plate orifice.

Outfluent from outlet:

- 500mm PVC with concrete headwall with grate and guardrail.

Pond Inspection Results

1.0 General

a) Pond Name	Doral Business Park
b) Pond ID	9-5
c) Pond Address	Doral Drive
d) Name of Inspector	Paul Marsh & Sabina Martyn
e) Date of Inspection	May 18, 2012
f) Weather	Overcast

2.0 Surrounding Area

- Table land
- Access:
    - Perimeter fence, gated, locked
    - Access from Doral Rd.
    - Sign with Pond Name and ID, No Trespassing sign, and sign providing explanation of stormwater facility
- Industrial land all around, Highway 400 to the west
- Vegetation: long grasses along wide ditch leading to eastern inlet – same vegetation in ditch as found on the parallel pedestrian path. Cattail growth along perimeter of forebays. Dying trees facing the highway.
- Rock check dams along the ditch are intact
- Wildlife: Geese, ducks, muskrats, dead toad.
- Overflow spillway (riprap) at outlet
- Some space available for facility expansion

3.0 Pond Conditions:

- Wet pond
- Offline facility
- Pond lining exposed near eastern forebay
- Riprap berms between western and eastern forebays and the main pond. Grass growing on western berm.
- Difficult to tell whether forebay water level is higher than main pond – looks lower??

4.0 Inlet Structure:

Inlet ID: 9-5-I1

- Eastern inlet
- Corrugated PE pipe surrounded by riprap (diameter?)

Inlet ID: 9-5-I2

- Western inlet

- 900mm CSP, riprap downstream, some sediment deposition inside
- Rock check dams visible upstream of inlet

5.0 Outlet Structure:

Outlet ID: 9-5-O1

Influent to outlet:
- Low flow outlet
- Inclined overflow grate to concrete chamber
- Inside chamber, there is a steel orifice on a PVC pipe, submerged to the invert of the pipe

Outfluent from outlet:
- Flows to O2 concrete chamber.

Outlet ID: 9-5-O2

Influent to outlet:
- High flow outlet
- Inclined overflow grate to concrete chamber
- Inside chamber, outflow through a 150mm steel orifice on a PVC pipe, submerged to the invert of the pipe. Larvae in pipe

Outfluent from outlet:
- PVC pipe, concrete headwall with guardrail
- Riprap downstream to fence, then ditch beyond

Pond Inspection Results

1.0 General

a) Pond Name	Southview
b) Pond ID	9-2
c) Pond Address	7883 Yonge Street
d) Name of Inspector	Paul Marsh & Sabina Martyn
e) Date of Inspection	May 18, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Table land
- Residential on south and east sides. Open space to the north, parks and recreation (arena, library) to the west. Evidence of recreational use (bikes).
- Access:
    - Perimeter fencing but no gate/locks.
    - Signs prohibiting use of motorbikes and skidoos.
    - From Gordon: Pedestrian paved easement with mowed grass on the sides. Wooden planks at the end of the easement. Double catchbasin and depressed curb at road
    - From Chantler: Pedestrian paved easement, double catchbasin and depressed curb at road
- Vegetation: Bulrushes around the perimeter of the site, trees and a stream through the middle just south of the Chantler easement
- Wildlife: Leopard frog
- Partway down the easement from Gordon, there is a small backyard drain discharging onto the path from property to the west. Erosion at discharge point.
- Recommendation: reshape the linear perimeter conveyance channels into smaller disconnected ponds, and make the area into mountain bike park (there is a skateboard park to the west)
- Recommendation: Grit chamber at Gordon.

3.0 Pond Conditions:

- Dry pond
- Offline facility?
- No forebays, just a wet channel around perimeter of the site and through the middle.
- Mowed path extending west from Chandler easement to the west.
- Bullrushes in the centre of the field north of Chantler easement

4.0 Inlet Structure:

Inlet ID: 9-2-I1

- Inlet from Gordon
- Concrete pipe with concrete headwall with grate, partially submerged
- Lots of sediment, algae

- Opportunity for renaturalization east of this point.

Inlet ID: 9-2-I2

- Inlet from Chantler
- 600mm concrete pipe with concrete headwall with grate, clogged with debris, partially submerged
- There is also a 450mm CSP that extends under the easement and outlets at the same place as I2.

5.0 Outlet Structure:

Outlet ID: 9-2-O1

- Near the southwest corner.
- 250mm influent pipe into concrete chamber with inclined overflow grate. 700mm outfluent pipe (no sediment deposition) from concrete chamber.
- Standing water and lots of algae growth directly upstream (east) of outlet. 350mm concrete pipe out of standing water pool. Sediment deposition in front of this pipe.
- Swale with long grasses between the outlet grate and the standing water pool.

Innisfil Pond Inspections – May 18, 2012

Pond Inspection Results

1.0 General

a) Pond Name	Brandy Lane
b) Pond ID	10-1
c) Pond Address	2706 Dempster Avenue
d) Name of Inspector	Paul Marsh & Sabina Martyn
e) Date of Inspection	May 18, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Table land
- Access:
    - Perimeter fence (located on the pond crest)
    - Locked, gated access from Dempster Avenue
    - Sign with Pond Name and ID, No Trespassing sign
- Vegetation:
    - Within crest: long grasses, choke cherry, some horsetails growing in shade of fence, peas, duckweed, pond completely overgrown with bulrushes, big tree in the middle of pond (willow?)
- Wildlife: Blackbirds, bullfrog, rabbit, dead fish
- No room for expansion
- Roads on the south and east, residential on the north and west.

3.0 Pond Conditions:

- Wet pond
- Offline facility
- Riprap upstream of outlet
- Can’t tell if there is a low-flow channel
- Drainage from the first lot on the north east corner has resulted in an eroded channel formation towards the pond
- Water level in western forebay is slightly higher than in the main pond
- Berm between pond and western forebay has been breached in several areas by animals.

4.0 Inlet Structure:

Inlet ID: 10-1-I1

- East side of pond
- No guardrail (one is recommended)
- Partially submerged, with grate.
- Lots of bird droppings near inlet.
- Deep pool, lots of sediment deposition

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Inlet ID: 10-1-I2

- West side of pond, from Fire Station
- A-gravel path down the pond slope towards outlet

Inlet ID: 10-1-I3

- Western forebay inlet
- Completely submerged, concrete headwall with grate.
- Algae, green and murky, with cattails around perimeter of forebay.

Inlet ID: 10-1-I4

- Ditch from someone's backyard at the north end of the pond – very small contribution
- 6m east of northwest corner of fence

5.0 Outlet Structure:

Outlet ID: 10-1-O1

- 850mm concrete pipe into concrete chamber with inclined overflow grate. Chamber also has a pre-cast opening of 250mm but this probably because it is a reused piece from something else.
- Hickenbottom riser located just south of forebay inlet (in forebay). Surrounded by dense vegetation and cattails. Likely connected to the outlet somehow.

Innisfil Pond Inspections – May 18, 2012

Pond Inspection Results

1.0 General

a)	Pond Name	Village North
b)	Pond ID	10-2
c)	Pond Address	2856 Dempster Avenue
d)	Name of Inspector	Paul Marsh & Sabina Martyn
e)	Date of Inspection	May 18, 2012
f)	Weather	Sunny

2.0 Surrounding Area

- Valley land – former quarry?
- Farms to the west and south, open space valley lands to the east and north. Evidence of recreational use (ATVs)
- Access:
  - Sign with Pond Name and ID
  - Perimeter fence, gated, locked
  - Mowed easement from residential area, then B-gravel pathway near pond
  - ATV path at southeast corner
  - Maintenance access path along south end, from top of berm to bottom
  - Gravel path and open gate from farm to the west.
- Overland riprap spillway at the southeast corner
- Emergency gabion basket spillway around outlet structure
- Vegetation:
  - Outside of crest – ash, birch, poplar, sumach, one American elm
  - Inside crest – mostly grass, one tree near influent of outlet – willow? Poplar?. Cattails in the low-flow channel
- Wildlife: Deer, chipmunk, monarch butterfly

3.0 Pond Conditions:

- Wet pond
- Offline facility
- Low-flow channel evident, wet, cattails
- Debris in the middle of pond
- Propose planting along the low-flow channel to prevent ATVs from disrupting the flow.

4.0 Inlet Structure:

Inlet ID: 10-2-I1

- 1200mm concrete, concrete headwall, grate
- Sediment in the bottom of pipe

5.0 Outlet Structure:

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Outlet ID: 10-2-O1

Influent to outlet:
- Low flow outlet
- 300mm CSP with entrance collar

Outfluent from pipe:
- Pipes go under gravel path (used by ATVs?). Gabion baskets downstream on north side of gravel path

Outlet ID: 10-2-O2

Influent to outlet:
- High flow outlet
- Twin 500mm CSP pipes

Outfluent from pipe:
- Pipes go under gravel path (used by ATVs?). Gabion baskets downstream on north side of gravel path

Innisfil Pond Inspections – May 18, 2012

Pond Inspection Results

1.0 General

a) Pond Name	Monrepos (Bay Point Estates)
b) Pond ID	13-1
c) Pond Address	1720 Wilkinson Street
d) Name of Inspector	Paul Marsh & Sabina Martyn
e) Date of Inspection	May 18, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Access:
  - Barbed wire fence, locked gate
  - Grassed maintenance access path on berm around pond
  - Sign with Pond Name and ID, sign with explanation of stormwater facility
  - There is a well established path from forest on the north side of pond, the fence is cut down at that spot
- Crest of pond is higher than surrounding land – indication it was built up?
- Road on north and south sides, low density residential to the east and west
- Vegetation:
  - Within crest: horsetails, cattails
  - Outside of crest: milkweed, grass, aspen?, mixed hardwood
- Wildlife: fish (perch and another species), dragonflies, abandoned homes of burrowing animals, monarchs, frogs, lots of tadpoles, skull of a small animal

3.0 Pond Conditions:

- Pond is not as shown in drawing
- Wet pond
- Connects to creek. In-line facility
- Pond is very shallow around perimeter, but middle looks deep
- Water level dropping? Burrows visible
- Algae downstream of outlet
- Riprap overflow spillway at pond outlet with concrete square weir on top

4.0 Inlet Structure:

Inlet ID: 13-1-I1

- Southeast inlet
- 900mm concrete pipe, concrete headwall, grate. Sediment deposition in 1/3 of the pipe.
- Riprap on either side of inlet
- Some debris near the inlet
- Oily sheen in the water and brown scum in cattails
- Inlet 1 forebay is functioning well as a pretreatment method – lots of sediment

Inlet ID: 13-1-I2

- 400mm CSP culvert on east side of Inlet 1, draining from southern road

Inlet ID: 13-1-I3

- 400mm CSP culvert on west side of Inlet 1, draining from southern road

Inlet ID: 13-1-I4

- Southwest inlet drains from roadside ditch over riprap into pond
- 600mm corrugated PE pipe goes under the southern road, services ditch across the road (wet, algae and vegetation in the ditch)
- Inlet 4 forebay is covered with algae. Trickles into main pond from higher elevation.

5.0 Outlet Structure:

Outlet ID: 13-1-O1

- High flow outlet
- 600mm CSP from pond (not submerged on either end)

Outlet ID: 13-1-O2

Influent to outlet:
- Low flow outlet
- Assume a submerged pipe from pond to manhole on top of berm

Outfluent from outlet:
- 300mm PVC from manhole to downstream creek
- Half submerged at outfluent point

Innisfil Pond Inspections – May 18, 2012

Pond Inspection Results

1.0 General

a) Pond Name	Monrepos (Bay Point Estates)
b) Pond ID	13-2
c) Pond Address	W of 1708, Wilkinson Street
d) Name of Inspector	Paul Marsh & Sabina Martyn
e) Date of Inspection	May 18, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Access:
    - Locked, barbed wire perimeter fence
    - Access via easement from Wilkinson – gravel path
    - Fence around easement is torn for snowmobile trail
    - Gate into actual facility is broken
    - Vehicle access around perimeter of pond
- A lot of room for expansion
- Forest surrounding pond on all sides, some low-density residential land use further away. Some evidence of recreational use.
- Vegetation:
    - Within crest: cattails, long grasses, small trees
    - Outside crest: mature hardwoods (maple, oak, etc.) To the east, iris & Solomon's seal (planted?), maple, ash, oak
- Wildlife: monarch butterfly, raccoon

3.0 Pond Conditions:

- Wet pond
- Inline facility
- 2/3 of pond is bulrushes, 1/3 is tall grass
- Cattails and algae and murky water downstream of outlet
- Overflow spillway (riprap) on top and around outlet

4.0 Inlet Structure:

Inlet ID: 13-2-I1

- Channel inlet? Can't see a pipe
- Geotextile exposed
- Channel is not a stable bank (evidence of erosion)
- Riprap downstream is covered in vegetation.

5.0 Outlet Structure:

Innisfil Pond Inspections – May 18, 2012

Outlet ID: 13-2-O1

- Western pipe: 525mm CSP
- Influent point is inline with pond
- Partially submerged with some sediment deposition at outfluent point
- No control on outlet

Outlet ID: 13-2-O2

Influent to outlet:

- Eastern pipe: 750mm CSP
- Influent point is at northeast corner of pond
- Not submerged at influent point but partially submerged with some sediment deposition at outfluent point
- No control on outlet

Pond Inspection Results

6.0 General

g) Pond Name	South Shore Woods
h) Pond ID	13-3
i) Pond Address	East of Dalkab, Shoreview Drive
j) Name of Inspector	Paul Marsh & Sabina Martyn
k) Date of Inspection	May 18, 2012
l) Weather	Sunny

7.0 Surrounding Area

- Access:
  - Perimeter chainlink fence along road only, gated, locked.
  - Sign explaining purpose of stormwater facility
- Road to the north, woodlot on all other sides
- Vegetation:
  - Within crest: sparse cedars and shrubs
  - Outside crest: woodlot
- Wildlife: frogs, blackbirds, ducks, newt, leech, dragonflies

8.0 Pond Conditions:

- Wet pond
- Inline facility
- Possible groundwater entrance into westernmost corner of western forebay (sand buildup around it).
- Western forebay has cattail growth at water level. Lots of brown algae at western-most quarter of forebay. Visible forebay riprap berm with cattails on the main pond side.
- Main pond has some algae on western side and a lot less algae on eastern side. Lilypads on eastern side.
- Eastern forebay has brown algae? on western side. Cattails on western side of forebay.
- Riprap spillways near Inlet 1 and Inlet 2

9.0 Inlet Structure:

Inlet ID: 13-3-I1

- Eastern inlet
- Influent into inlet pipe is 900mm CSP with grate, concrete headwall, guardrail, fed by roadside ditch
- Outfluent into pond has enlarged opening (1.15m diameter), grate bars on top, lots of sediment deposition, riprap on both sides.

Inlet ID: 13-3-I2

- Western inlet
- Influent into inlet pipe is 1m CSP with grate, concrete headwall, guardrail, fed by roadside ditch. Some vines growing over the grate.
- Outfluent into pond: 900mm pipe expands to 1.15m enlarged opening. Grate bars on top of enlarged opening, riprap on both sides.

10.0 Outlet Structure:

Outlet ID: 13-3-O1

- Influent: Outlet riser pipe in the middle of wet pond – inaccessible. Surrounded by riverstone. Conveyance to the manhole east of Outlet 2 headwall.
- Outfluent: Outlets through 250mm pipe (with concrete headwall and guardrail) into channel on the other side of the street and goes north to the Lake. Riprap on both sides of headwall and downstream. Almost entire surface is covered with algae. Riprap spillway on east side of headwall.

Outlet ID: 13-3-O2
- Influent: 450mm stainless steel orifice place, concrete headwall with guardrail
- Outfluent: 600mm pipe filled with debris and cattails because it is the surface outlet from the pond. Pipe is in the same concrete headwall (with guardrail) as Outlet 1. Outlets into channel on the other side of the street and goes north to the Lake. Riprap on both sides of headwall and downstream. Almost entire surface is covered with algae. Riprap spillway on east side of headwall.

Innisfil Pond Inspections – May 25, 2012

Pond Inspection Results

1.0 General

a) Pond Name	McKee
b) Pond ID	10-3
c) Pond Address	2877 Ireton Street
d) Name of Inspector	Renata Sadowska & Sabina Martyn
e) Date of Inspection	May 25, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Table land
- Low density residential to the south, woodlot on all other sides. Marshy land to the northwest
- Creek running parallel to pond, between southern pond berm and houses
- Access:
    - Maintenance access from Ireton, gravel path from road
    - Sign with Pond ID and name, SWM facility explanation sign
    - No pedestrian access: “No Trespassing” sign, perimeter fence, gated, locked
- Grass berm around perimeter of pond covered in long grasses
- Wildlife: Fish, frogs, droppings from an larger animal
- Vegetation:
    - Small evergreens on south end of pond, and cedar, willow within crest.
    - Algae and foamy vegetation in forebay
    - Cattails in forebay perimeter
- Possible overflow spillway channel on top of berm west of outlet structure (unconfirmed, not well defined, but there is different vegetation there).
- Signs of organic dumping in easement outside of western perimeter fence
- Manhole connection from street, located outside fence upstream of inlet
- Western outlet to creek: 45” concrete pipe with grate.
- Downstream creek (to the west) is sandy and filled with algae

3.0 Pond Conditions:

- Offline, wet pond
- Visible sediment in forebay, localized shallow areas
- Gentle pond slopes
- No visible forebay berm
- Algae around perimeter of main pond, cattails

4.0 Inlet Structure:

Inlet ID: 10-3-I1

- 33” concrete pipe, half submerged

- Concrete headwall, stone wingwalls, grate

5.0 Outlet Structure:

Outlet ID: 10-3-O1

Influent to outlet:
- 62” perforated CSP riser surrounded by stone, secured by wire

Outfluent from outlet:
- Discharge to southern creek: submerged pipe and grate, partially filled with sediment or vegetation. 9” from the top of sediment to the top of the grate.
- Concrete headwall and stone retaining walls.
- Bank erosion downstream of outlet (to the west) in the stream
- Perimeter fence goes across the creek at the east end
- Creek has standing water with algae, watercress and other submerged vegetation

Pond Inspection Results

1.0 General

a) Pond Name	Alcona Woods
b) Pond ID	9-1
c) Pond Address	698 Trinity Street
d) Name of Inspector	Renata Sadowska & Sabina Martyn
e) Date of Inspection	May 25, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Table land
- Access:
    - Maintenance access to east side of pond via Kildare gravel access road
    - Locked perimeter fence, no pedestrian access
    - Sign with Pond ID, name, address
    - Maintenance access to west side of pond through backyard of 745 Calderas, which is fenced. What is the access agreement between the Town and the homeowner?
    - Difficult to get around the perimeter of pond – very thick vegetation
- Easement access to the west side has a lot of items piled in the swale. Resident indicated that this is temporary storage and owner has ordered a bin for disposal.
- Wildlife: frogs, minnows in channels on Kildare (but fish don't go in the pond)
- Vegetation: Birch trees, various mature trees within the crest of pond, long grasses, cattails, horsetails, lots of mosquitoes
- Wet ditches on both sides of Kildare, contains sandy soil with minnows. Western ditch is conveyed under road to the creek on the east side via twin 28" CSP culverts. On the east side, the CSPs are partially buried (14" from top of sediment to top of pipe)
- Shading in the ditches is beneficial for the fish habitat
- CSPs drain to a 50" wide swale (top measurement) on the east side of the pond
- Roadside ditches along Trinity Street – likely contribute sediment

3.0 Pond Conditions:

- Wet pond (wetland?)
- Low-flow channel not visible
- Offline facility

4.0 Inlet Structure:

Inlet ID: 9-1-I1

- Resident said the inlet gets cleaned out every year
- Submerged grate, standing water, surrounded by leaves. Concrete headwall
- 12" pipe, distance of 4" from surface of water to top of grate, rest is filled with sediment.
- Evidence of dumping of leaves

5.0 Outlet Structure:

Outlet ID: 9-1-O1

Influent to outlet:

- 6” collapsed pipe – gabion collapsed on top.

Outfluent from outlet:

- Outlet pipe from the pond is below emergency spillway. 7” height x 9” width CSP pipe partially submerged and partially (10%) filled with sediment.

Outlet ID: 9-1-O2

- Gabion basket spillway – sinking in places, riprap on top

Innisfil Pond Inspections – May 25, 2012

Pond Inspection Results

1.0 General

a)	Pond Name	Skivereen
b)	Pond ID	8-5
c)	Pond Address	2324 Jack Crescent
d)	Name of Inspector	Renata Sadowska & Sabina Martyn
e)	Date of Inspection	May 25, 2012
f)	Weather	Sunny

2.0 Surrounding Area

- Access:
  - Fenced, locked
  - Signs explaining purpose of pond, Pond ID and address
  - No pedestrian access, except gate from some of the backyards of houses to the south.
- Wooded areas to the north and west, street to the east, residential to the south
- Wildlife: frogs, animal burrows, blackbirds, butterflies
- Vegetation:
  - Inside crest: Cattail growth, mature trees and diverse vegetation
  - Outside crest: Mature trees and diverse vegetation, arrowheads
- Berm around perimeter of pond, vegetated.
- Tree growth in ditch between woodlot and berm
- Berm is mowed in one area in front of the second from the street. Drain from the first house beside the road, and the third house has a buried French drain with a grate. There is a depression between the berm and the backyard of those houses.
- Open area north of pond can be used for expansion or sediment storage. Suggest filling in eastern end of pond to reduce pond slope, move the spillway to the west end of the pond, and excavate more at the west end to increase the flow path.

3.0 Pond Conditions:

- Wet pond, inline?
- Forebay is circular, well-vegetated with trees and grasses
- Some algae growth in forebay, and standing water near west end of forebay
- Forebay berm is covered in soil and vegetated with small trees
- Spillway over forebay berm – flowing
- Some debris in pond
- Oily sheen in water near outlet
- No algae, except some brown surficial vegetation near the outlet

4.0 Inlet Structure:

Inlet ID: 8-5-I1

- 26.5” concrete pipe, concrete headwall and wingwalls, guardrail
- Stilling blocks 4” high, 12” long, 8” wide
- Layer of sediment and algae growth between wingwalls

- Water flowing through pipe
- Signs of algae within pipe
- Downstream of inlet there is a short apron with concrete link
- Lots of sediment deposition on the left and right of inlet

5.0 Outlet Structure:

Outlet ID: 8-5-O1

- Outlet: Double CB – overflow grate
- Overflow – PVC pipe out – not submerged, clear of sediment, 19”
- Standing water below
- Emergency spillway reinforced with concrete mat – vegetation growing on it
- Erosion on pond bank is right across from spillway
- Outlet pipe from pond is either submerged or under debris
- Outlet downstream – one headwall, concrete with guardrail, grates over both pipes.
- Concrete mat downstream of headwall – outlets to creek
- Low flow – some water flowing, clean, 12” PVC

Outlet ID: 8-5-O2

- High flow pipe – empty, PVC 21”

Pond Inspection Results

1.0 General

a) Pond Name	Taylorwoods
b) Pond ID	8-2
c) Pond Address	2259 Taylorwoods Blvd.
d) Name of Inspector	Renata Sadowska & Sabina Martyn
e) Date of Inspection	May 25, 2012
f) Weather	Sunny

2.0 General Observations

- Pond is scheduled to be cleaned out. Is there a retrofit study?
- Access: Fenced, locked, with “No Trespassing” sign, Sign with Pond ID and Name
- Pedestrian walkway in easement outside of pond fence
- On Roberts Road, there is rust coloured water and different vegetation in roadside ditch just west of pedestrian walkway (#682). Source of iron? Discharge is clean on the east side of the easement (#674).

Pond Inspection Results

1.0 General

a) Pond Name	Victoria Green
b) Pond ID	9-3
c) Pond Address	2600 Lawrence Avenue
d) Name of Inspector	Renata Sadowska & Sabina Martyn
e) Date of Inspection	May 25, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Access from Lawrence Ave, behind houses
- Boat storage in the middle of swale (un-fenced easement) behind one of the houses
- Open space with new tree plantings to the north and east. Agricultural use (farmland) to the west. Creek to the south.
- Grassed maintenance access berm along all sides except the farm side.
- Berm at the south end has been re-shaped with mud.
- Ditch north of pond near residential area is filled with debris. Water in ditch, cattails along edge, evidence of animal burrows and deer tracks along the N-S ditch
- Wildlife: lots of animal burrows around pond, killdeer, snake, giant beaver dam, small animal skull, bits of fur around beaver dam, butterflies
- Vegetation: thick layer of algae on top of mud in pond, cattails and some small trees in the middle of the pond. Tree stumps around the pond show evidence of beaver presence

3.0 Pond Conditions:

- Wet pond
- In-line facility
- Strong odour
- Evidence that water level was quite high, near the top of the berm. Has since been dewatered by the Town by a few feet, due to the presence of beavers.
- Asphalt spillway at south end at outlet

4.0 Inlet Structure:

Inlet ID: 9-3-I1

- Influent to inlet at Lawrence Ave. is a 24” CSP culvert under the road that feeds to a 23” concrete pipe with grate, concrete headwall and wingwalls. Concrete pipe is not submerged (<1 cm flow), has a lot of leaves collected at the inlet.
- Open-channel (ditch) conveyance from south of the Lawrence Ave houses to the north west corner of the pond.

5.0 Outlet Structure:

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Outlet ID: 9-3-O1

Influent to outlet:

- Inflow to the outlet CSP is all torn up

Outfluent from outlet:

- 24” CSP, gabion baskets around it, step down into stream
- Evidence of iron (groundwater inflow?) on the stream bank
- Fallen birch over the outfluent of the outlet

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Pond Inspection Results

1.0 General

a)	Pond Name	Tepco South
b)	Pond ID	6-3
c)	Pond Address	West of 965 Nantyr Drive
d)	Name of Inspector	Renata Sadowska & Sabina Martyn
e)	Date of Inspection	May 25, 2012
f)	Weather	Sunny

2.0 Surrounding Area

- Access:
  - No perimeter fence
  - Sign explaining purpose of facility, “Danger, water level may fluctuate” sign, “Do not enter” sign
- Low density residential to the north, east and west. Woodlot to the south.
- Construction to the north. Double catchbasin with filter cloth on one catchbasin (clogged) and no protection on the other catchbasin
- Wildlife: Turtles, minnows, tadpoles, frogs, blue dragonflies. Frog and a dead fish in the concrete outlet chamber
- Vegetation:
  - Outside crest: mowed lawn and street tree planting
  - Small trees, young cedars, maples, shrubs, long grasses, cattails along perimeter of pond

3.0 Pond Conditions:

- Wet pond
- Offline Facility
- Interlocking brick spillway from road to pond
- Rock reinforced forebay berm is completely submerged
- Silt bar very evident outside inlet – 5m, above forebay berm

4.0 Inlet Structure:

Inlet ID: 6-3-I1

- Concrete 19” pipe, concrete headwall and grate (locked)
- Thin layer of sediment in pipe, partially submerged (5” water)

5.0 Outlet Structure:

Outlet ID: 6-3-O1

Influent to outlet:
- Inlet protection: riser, rip rap on top is washed away, filter cloth exposed

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- Downstream there is a little pooling area for the outlet which is filled with algae and cattails
- Concrete chamber (2 chambers) with overflow grate.
- Weir in concrete chamber is 5” wide and 46” high. Bar on the weir but debris on top of weir. Suggest protection on top
- Gate valve to close the outlet from the pond
- Perforated PVC riser in concrete chamber
- Concrete pipes into and out of chamber
- PVC pipe between two cells of chamber

Outlet ID: 6-3-O2

- Emergency overflow of interlocking bricks

Pond Inspection Results

1.0 General

a) Pond Name	Coralwoods
b) Pond ID	4-2
c) Pond Address	2304 Meadowland Street
d) Name of Inspector	Renata Sadowska & Sabina Martyn
e) Date of Inspection	May 25, 2012
f) Weather	Sunny

2.0 Surrounding Area

- Low-density residential to the east and south, estate residential to the west, woodlot/agricultural? to the north.
- Vegetation:
  - New trees within outer edge of crest, more mature trees closer to the water
  - Long grasses, horsetails within the crest.
  - Low flow channel is well-shaded with mature trees. Dense cattails.
  - Trees mainly on the east side and not on the west.
- Access:
  - Gated and locked at south end, perimeter fence
  - Maintenance gate at north end
  - Signs with "No Trespassing", pond ID and address
- Recommend – perimeter shading, trail access
- Evidence of dumping near I1.

3.0 Pond Conditions:

- Dry pond with low-flow channel and ponding area at outlet
- Recommend – a deeper channel, splitting flow – wetland?
- Steep slopes on pond bank
- Recommend - terracing the berm?

4.0 Inlet Structure:

Inlet ID: 4-2-I1

- Overland flow – open channel from the west becomes gabion basket spillway downstream of fence. *Gabion baskets could be a human tripping/slipping hazard
- Space under the fence between fence and gabion spillway is covered by more fence, but it is broken. Suggest a grate for the space under the fence.
- Lots of vegetation at the bottom of I1, dry.

Inlet ID: 4-2-I2

- South end of pond: 33" concrete pipe with concrete headwall and wingwalls, closed grate

- Utility wire passing in front of I2.
- Stilling blocks 5” high, 12” wide and 10” long. Partially submerged inlet with some sediment.
- Should have a guardrail (steep drop)
- White foam in water (organics?)

Inlet ID: 4-2-I3

- Inlet from adjoining property at north-east.
- Swale near the top is barely visible.
- Can’t find inlet to pipe
- Outlet into pond is 18” CSP

5.0 Outlet Structure:

Outlet ID: 4-2-O1

- Rock berm in front of outlet (protective pool), filter fabric exposed
- 18” CSP is built into gabion basket. Gabion rocks act as obstruction to flow
- Wires for the baskets are hazards

Outlet ID: 4-2-O2

- Gabion basket outflow spillway – shrubs growing out of it.

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Pond Inspection Results

1.0 General

a)	Pond Name	Valleyview
b)	Pond ID	4-1
c)	Pond Address	2380 4th Line
d)	Name of Inspector	Renata Sadowska & Sabina Martyn
e)	Date of Inspection	May 25, 2012
f)	Weather	Sunny

2.0 Surrounding Area

- Access:
  - Fenced along the pond crest, gated, locked
  - Difficult to access for maintenance, because of vegetation growth
- Vegetation:
  - Lots of mature vegetation around the pond, within crest, and throughout main channel.
  - Mature trees shading the pond are on private property
  - Pond area is like a wetland, covered in cattails
- Estate properties on all sides, road to the south

3.0 Pond Conditions:

- Wet pond / wetland?
- Offline facility

4.0 Inlet Structure:

Inlet ID: 4-1-I1

- 21” concrete pipe, concrete headwalls and wingwalls.
- Pipe partially submerged (7” of standing water)
- Stilling blocks – 2.5” high, 12” long, 7-8” wide.
- Riprap protection around inlet
- Thin layer of sediment and some sort of grease (organic?)
- Small pond in front of inlet

5.0 Outlet Structure:

Outlet ID: 4-1-O1

- 18” Concrete pipe
- Rock protection at influent point, sediment buildup

Outlet ID: 4-1-O2

- Rock-protected spillway

Pond Inspection Results

1.0 General

a)	Pond Name	Goldcrest
b)	Pond ID	15-1
c)	Pond Address	2098 Fennel Drive
d)	Name of Inspector	Renata Sadowska & Sabina Martyn
e)	Date of Inspection	May 18, 2012
f)	Weather	Sunny

2.0 Surrounding Area

- Access:
  - Perimeter fence is along the crest of pond, gated, locked
  - Trees right in front of the gate
  - No trespassing sign, Pond name and ID
  - Steep pond slopes – 3:1 or greater
  - No safe access to inlet – suggest terracing of slopes?
- Vegetation:
  - Tree in the middle of pond, cattails throughout the middle of pond, horsetails, long grasses and some trees on the pond slope.
  - Watercress near outlet – evidence of cool groundwater?
- Wildlife: goldfinches
- Enbridge utility on north side of fence along Shore Acres Drive
- No room for expansion

3.0 Pond Conditions:

- Wet pond / wetland?
- Offline
- Pond does not seem to have a permanent pool but there is water at the bottom
- Flowing water
- Concrete mat slope protection at south west corner.
- Seems to have a defined low-flow channel

4.0 Inlet Structure:

Inlet ID: 15-1-I1

- Inlet spillway channel from Fennel Drive (southeast) – vegetated, works well
- Conveyance under the fence, but the space under the fence is blocked by leaves. Recommend that there should be a gap under the fence.
- Low flow channel from inlet to main pond

Inlet ID: 15-1-I2

- 21”concrete pipe from southwest, vertical bar grates (screwed on), concrete headwall and wingwalls
- Rock protection downstream but it is not distributed properly so it is acting as an obstruction to flow

Inlet ID: 15-1-I3

- 15” CSP from swale that goes along private property to the south. 11” high, the rest is buried and filled with rocks. Surrounded by asphalt (cracked, broken, eroded)
- Broken fence, 2 small trees in front of the inlet
- Dry

5.0 Outlet Structure:

Outlet ID: 15-1-O1

- 15” concrete pipe with concrete headwall, with grate, but no wingwalls or guardrail.
- Partially submerged (only 4” of pipe is above water).
- Lots of organic matter and sediment deposition. About 3” of water, the rest is sediment.
- Stagnant water at the outlet – like a wetland
- Receiving channel is the roadside channel along Shore Acres Drive

Outlet ID: 15-1-O2

- Emergency spillway - rock riprap with asphalt poured on top

APPENDIX F:

STREAMBANK EROSION REPORT (AQUALOGIC)

Erosion Threshold Analysis
Sandy Cove Creek & Tributary, Mooselanka Creek, Carson Creek, White Birch Creek Tributary, and Cooks Bay Tributaries
Town of Innisfil Stormwater Management Master Plan

Carson Creek

Submitted to:

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August 8, 2014

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Erosion Threshold Analysis
Sandy Cove Creek & Tributary, Mooselanka Creek, Carson Creek, White Birch Creek Tributary, and Cooks Bay Tributaries
Town of Innisfil Stormwater Management Master Plan

Erosion threshold analysis has been undertaken for nine watercourse locations that will receive stormwater discharge from future proposed development in the Town of Innisfil. The study area and specific watercourse locations identified in this report are shown in Figure 1, as appended.

Analysis has been done based on field review of channel sensitivity below proposed stormwater (SWM) pond outlets, with detailed cross-section surveys of selected locations that will receive future development flows. Field measurements were used for erosion threshold modelling and the results were then used to determine the appropriate methodology for impact analysis. Unit-area flow analysis was identified as appropriate for the larger channels with thresholds identified below channel forming flows. Many of the smaller channels were deemed stable at channel forming flows and for consistency across the region, unit-area flow targets were thus set at the channel forming flow rate determined for bankfull conditions.

Watercourse Characterization

Table 1 presents of summary of the watershed context for each watercourse location selected for detailed analysis.

Table 1: Watershed Context Summary

	Stream Order	Manmade Drain	Catchment Area (km^2)	Physiog. Region
Hewitts Creek (10th Line, Stroud)	3	Y	5.02	PD
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)	3	N	15.69	SL
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres)	1	Y	0.42	SL
Cooks Bay Tributary (Moosenlanka Rd., Sandy Cove Acres)	1	N	0.17	SL
Mooselanka Creek (25th Sideroad, Sandy Cove Acres)	2	Y	2.72	SL
Carson Creek (Ewart St., Lefroy)	3	N	6.15	SL
Cooks Bay Tributary (Parkview Drive, Gilford)	1	Y	0.06	SL
White Birch Creek Tributary (Harborview Golf, Gilford)	1	Y	0.47	SL
Cooks Bay Tributary (Shore Acres Rd. & Nelly Rd., Gilford)	1	Y	0.48	SL

Y -yes / N - no
SL - Simcoe Lowlands physiographic region
PD - Peterborough Drumlin Fields physiographic region

Hewitts Creek is tributary to Kempenfelt Bay while all other locations are tributary to Cooks Bay. The Sandy Cove Creek Tributary (Main St., Sandy Cove Acres) location is tributary to the main branch Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres) location further downstream, while all other watercourse locations are standalone without other detailed analysis sites on the same system.

All of the area watercourse sites, except Hewitts Creek, are in the Simcoe Lowlands physiographic region that borders the Cooks Bay shoreline, while Hewitts Creek is in the region known as the Peterborough Drumlin Field, further inland from Cooks Bay. Sandy soils with gravel and cobble are dominant along all features with the two largest watercourses, Carson Creek in Lefroy and Sandy Cove Creek in Sandy Cove Acres showing some exposure of hardpan clay till along their channel beds. Flow response varies from ephemeral in the two smallest features to intermittent or drought susceptible in the next four larger systems and permanent baseflow assumed in the three largest drainage area systems.

Summary descriptions for each location are as follows.

Hewitts Creek (10th Line, Stroud)

Hewitts Creek is an entrenched manmade drain realignment, characterized by a triangular to trapezoidal cross-section up to approximately 2.5-3m deep and 10-15m wide at the top of slope. The riparian zone is lined with dense tall grass groundcover and occasional shrubs and small trees. Channel stability appears fair with some areas showing minor incision and localized aggradation that obscures the low flow. Bedforms are indistinct and the low flow feature is generally defined as a continuous run flowing through heterogeneous deposits of sand, some gravel, and some silt-clay. Base flows appear permanent but may be at the threshold of being occasionally influent or intermittent in summer. Straightening has decreased natural sinuosity and channel slope is very low.

Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)

The Sandy Cove Creek study site is a relatively unaltered location within a forested tract close to Cooks Bay. The watercourse is relatively wide, up to 6-7m across pools, and displays a diverse mix of stability conditions from stable to actively adjusting. Channel stability is influenced by variable levels of biotechnical reinforcement, lower in tree canopy and higher where sunlight penetration and groundcover is denser. Bedforms are relatively distinct with riffle-pool sequences, intervening runs, and some backwater influence from Cooks Bay downstream of the study site. Deposits of sand, gravel, and cobble dominate the bed, and riffles are distinctly formed by larger material while pools can show veneers of consistent sand. Channel slope varies from moderately high upstream of Woodlands Avenue to low as the channel passes under the crossing and meanders downstream. Flows are permanent and physical fish habitat is diverse.

Sandy Cove Creek Tributary (Main St., Sandy Cove Acres)

The Sandy Cove Creek Tributary site transitions from a historic agricultural drain to a manmade drain through residential land use. The channel becomes entrenched in a triangular shape in the residential area and leads to an inlet and enclosure structure. Through the agricultural area the feature is highly obscured by dense groundcover and shrub-tree thicket which abruptly transitions to formal lawn grass in the residential area. The feature is intermittent and has no low flow definition within the residential area while the upstream agricultural feature has discontinuous small shallow pools. The feature is stable at moderate gradient.

Cooks Bay Tributary (Moosenlanka Rd., Sandy Cove Acres)

The Cooks Bay Tributary that flows under Moosenlanka Road is a small ephemeral feature within a fully forested drainage area. Defined channel forming widths vary to approximately 1.5m and the feature is shallow and well connected to overbank areas. Despite lower levels of rooting density protection in the dominant forest conditions the feature appears stable at moderate to high gradient.

Mooselanka Creek (25th Sideroad, Sandy Cove Acres)

The Mooselanka Creek study site is a permanent flowing watercourse that falls within a well vegetated corridor that varies from unconfined to partially confined immediately upstream of 25th Sideroad. Minor realignment may have occurred in the past to meet the 25th Sideroad crossing. Groundcover reinforcement creates reasonable channel stability and watercress is evident within the low flow. Bankfull width varies around 3.5m with groundcover and swamp thicket shrub and tree rooting within bankfull limits along a 0.5-1m wide low flow. Bed forms are modest and some poorly sorted deposits of gravel seen in the channel may be a result of inputs from a parking lot to the south and the adjacent road shoulder.

Carson Creek (Ewart St., Lefroy)

Carson Creek is a permanent watercourse that displays partially to fully entrenched geometry as it flows through forested conditions downstream of Ewart St. The channel appears to have incised through topsoil and sand dominant soils, both as a historic channel evolution process and as a response to the invert depth of the Ewart Street crossing (which may be a replacement to have met the depth of the channel). Incision has occurred down to a hardpan clay till layer and the resultant resistance on the bed has shifted erosion into a channel widening process. Deposits of gravel and cobble are evident as winnowed from the historically eroded bed and banks and these materials form riffle and bar structures through the reach. Woody debris, exposed roots, and failed trees are common. The reach is in a condition of self repair as it attempts to cut a new channel forming width in the range of 4-5m wide between terraces of a wider entrenched flood plain.

Cooks Bay Tributary B (Parkview Drive, Gilford)

The Cooks Bay Tributary that begins as a drain west of Parkview Drive is a minor ephemeral swale through swamp forest conditions. The feature has obscure definition and no distinct evidence of channel bed features. Bankfull definition is difficult to interpret except for minor indicators of debris from past flow events. The drainage feature is fully stable by biotechnical reinforcement.

White Birch Creek Tributary (Harbourview Golf, Gilford)

The White Birch Creek Tributary in Gilford is a small defined drain that flows through well vegetated groundcover and thicket conditions on the east edge of the Harbourview Golf & Country Club before entering a dredged confluence feature that sits at the backwater elevation of Cooks Bay. The channel is a continuous run with lack of bed form features and has variable levels of aquatic vegetation encroachment that contribute to flow attenuation and localized stagnant backwater. At the time of field work the feature appeared to have permanent water but may be susceptible to intermittent conditions in the peak of summer.

Cooks Bay Tributary C (Shore Acres Rd. & Nelly Rd., Gilford)

The Cooks Bay Tributary that exists essentially as a roadside ditch along Shore Acres Road in Gilford is manmade and partially confined and entrenched. Close to Cooks Bay it is confluent with backwater conditions that can extend inland past Beach Rd. The edges of the feature are well vegetated with groundcover and shrub and tree thicket, but it appears the channel may be subject to occasional maintenance clean outs. A narrow ~0.5m wide defined low flow run was observed at the time of field work in the upper portion of the feature below the intersection with Nelly Road but no flow was evident.

Rapid Assessment Analysis

Three rapid assessment protocols were undertaken for each of the features in the reaches in proximity to proposed SWM pond outlets. Background review and field reconnaissance generally suggested that the reaches closest to proposed stormwater facilities will have the greatest sensitivity to future flow changes, except for two sites with unique characteristics. The selected Mooselanka Creek site is downstream of an enclosure that already exists as the potential tie in for future SWM, and the selected site is in proximity to a road and nearby commercial land use that would be deemed more sensitive than intervening natural areas. The Carson Creek location was selected on the assumption that future development flows would need to be piped to the closest free flowing outlet in lieu of roadside ditching on Killarney Beach Road, which would potentially need to be enlarged and reinstated. By comparison, the outlet for the Cooks Bay Tributary at Shore Acres Rd. & Nelly Rd. was selected as the roadside ditch on Shore Acres Rd. instead of Everton Drive. The Everton ditch appeared to have limited grade and would likely need to be cleaned out of fully encroaching vegetation and have its cross-section reinstated. It would also likely be more desirable to discharge to Cooks Bay directly, rather than the head of the marina basin that the Everton ditch leads to. For all other locations, areas further downstream than close proximity to future potential SWM outlets would have drainage area increases and/or subsequent confluent tributaries adding flow, and thus a dilution effect is achieved to the flow contribution from future ponds.

Field observations were used to score relative geomorphic and environmental attributes. Rapid Geomorphic Assessment (RGA) was used to rate channel stability and infrastructure impact. Rapid Habitat Assessment (RHA) was used to define in-stream and riparian habitat. Rapid Stream Assessment Technique (RSAT) was used to test broad indicators of channel stability, aquatic habitat, and water quality. A prorated score out of 100 was transposed from the results of each protocol and a combined average score was determined from the three tests. Four qualifying ranges of poor, fair, good, and optimal are maintained in the RHA and RSAT protocols, between the original scoring and the weighted scoring out of 100, while the three original ranges in RGA scoring are reflected as poor, fair, and good. The combined average score is qualified by poor to optimal ranges designed as a best fit of the individual protocol ranges. The detailed results are appended and included with each are photographs of typical reach conditions. **Table 2** presents a summary of the rapid assessment results.

Table 2: Rapid Assessment Summary Results

	RGA Score	RHA Score	RSAT Score	Combined Score
Hewitts Creek (10th Line, Stroud)	79.6	54.0	60.0	65.0
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)	79.3	80.0	80.0	79.8
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres)	97.5	48.5	60.0	69.0
Cooks Bay Tributary (Mossenlanka Rd., Sandy Cove Acres)	85.4	62.0	60.0	69.0
Mooselanka Creek (25th Sideroad, Sandy Cove Acres)	85.4	62.5	72.0	73.3
Carson Creek (Ewart St., Lefroy)	77.9	70.0	76.0	74.6
Cooks Bay Tributary (Parkview Drive, Gilford)	84.3	55.5	70.0	70.0
White Birch Creek Tributary (Harborview Golf, Gilford)	84.3	51.0	64.0	66.0
Cooks Bay Tributary (Shore Acres Rd. & Nelly Rd., Gilford)	86.8	32.5	48.0	56.0

RGA - Rapid Geomorphic Assessment
RHA - Rapid Habitat Assessment
RSAT - Rapid Stream Assessment Technique
All scores are prorated to be out of 100.

The smallest watercourse features tend to have the lowest habitat scores and low combined scores due to a lack of permanent flow and due to impacts of past alteration. All of the features with less than 1km^2 drainage area are assumed to be dry or drought susceptible between rain events in the summer, thus limiting aquatic habitat function.

Sandy Cove Creek scores the highest combined rating due to the very good habitat and biological indicators observed during the spring season.

Channel stability is relatively good to very good across the study area with the most erosion sensitive location being Carson Creek due to high levels of entrenchment and lack of flood plain flow relief. Entrenchment levels are also high on Sandy Cove Creek and Hewitts Creek and thus these three locations are will require the greatest level of erosion potential control.

Erosion Threshold Characterization

Erosion threshold characterization was undertaken to establish benchmark targets for discharge control provided by stormwater management treatment of the proposed development blocks. Sensitivity was measured and modeled at either three or five surveyed bankfull or channel forming cross-sections. Three sections were done based on field estimation of high levels of stability in the smaller features while five were done at the larger sites that appeared less stable. Backwater influences caused by large woody debris were avoided. Channel forming debris flow lines, fallen and matted groundcover vegetation lines, and well defined scour lines were used as field indicators as deemed appropriate to identify cross-section width under a variety of conditions. Deeper channel capacity geometry for locations that were entrenched was not surveyed but rather the depth of entrenchment was judged with respect to what range of return event flows might be captured below the top of bank capacity level. This was subsequently used as a target for the type of hydrology analysis, as described further below. Channel geometry was measured laterally at each cross-section and the longitudinal profile was shot using bankfull and channel bed indicators. Channel bed substrates were measured through random-step Wolman pebble counts and recorded using the Wentworth sediment distribution scale.

Open channel flow models were created for each cross-section location. Each model required input of channel bed substrate data, cross-section dimensions, gradient, and bank geometry. Modeling tests were done for each cross-section and erosion indicators and thresholds were reviewed.

Subsequent checks were done to determine the critical stability threshold discharge. This discharge represents a reach based average point at which channel instability begins to occur with rising flow stage and rising discharge, or conversely when instability stops with falling flow stage and falling discharge. This discharge then becomes the comparative flow regime target for detailed analysis of stormwater management hydrology. Iterative flow stage adjustments were made in each cross-section model until appropriate stability criteria were judged to have been achieved over the primary shear stress and velocity threshold tests, with secondary checks made of stream power and Froude number. **Table 3** presents the threshold criteria used for this analysis based on ‘small’ watercourse channel typology which display the influence of vegetation control.

Table 3: Critical stability threshold criteria

	low flow morphology		
	riffle	run	pool / glide
semi-alluvial firm to dense till channels	D_{84} pavement	D_{84} pavement or vegetation control*	D_{100} pavement or vegetation control*
alluvial cohesionless channels	D_{50} pavement	D_{50} pavement or vegetation control*	D_{84} pavement or vegetation control*

*vegetation control criteria varies depending on vegetation type and density
note: step-pool and cascade-step-pool channels require case by case study

The second row criteria are applied for this study case, based on soil conditions and channel type. A mix of low flow morphology types, wide ranging sediment sizing, and degrees of vegetation control exist over the scale of surveyed channels. Conservative vegetation control criteria are identified as 40N m^{-2} for shear stress and 1.2m s^{-1} for channel velocity. Higher thresholds for vegetation control are common and viable under very high levels of vegetative encroachment and this could be argued as applicable for some of the smaller channels. Channel run and pool sections that have partial vegetation control but are not judged to be fully protected are deemed to have thresholds of approximately 0.4-0.7m s^{-1} for velocities acting on pure sand to graded sediments, with shear stress values approximately 10-15N m^{-1} being acceptable when large volumes of sub coarse sand sized sediment forms both the channel pavement and subpavement (individual sand particle size values would be too low to be practical). More cohesive gradations of silt-clay or gradations that include some gravel with sand were deemed to have thresholds of approximately 30N m^{-2} and 0.8m s^{-1} respectively for shear stress and velocity (ranges summarized in Fischenich 2001). Several references vary on specific erosion threshold levels for sediment sizing, mixes of sizes, vegetative influence, entrenchment risk, and duration of flow effects, but notwithstanding the multiplicity of methods, the noted targets have proven practical over several similar studies and modelling efforts. Detailed results of stable conditions modelling are appended after the existing conditions bankfull flow modelling.

Four of nine watercourse locations were determined to require downward adjustment in flow rate to meet dynamic stability on a balance of vegetation control and particle size transport. Existing condition shear and velocity results reviewed for all nine locations were seen to meet the criteria for vegetation control, however the depth and density of observed vegetation is not consistent over all sites nor does it influence the full cross-section of the larger sites, i.e. rooting and stem density does not cover full bank height and/or does not fully traverse under the bed. Directly supporting checks of stream power and indirectly of Froude number, also suggest that although channel adjustment is seen in some locations, it is not aggressively adverse. All stream power results are below a stability threshold of 400 watts m^{-1} (Sear et. al. 2003) and all Froude numbers are less than one, confirming subcritical and tranquil flow. All locations other than Carson Creek are deemed to have smooth beds and low turbulence based on particle sizing related to hydraulic roughness and Reynolds number. The results show that both dynamic stability and adjustment are concurrent in each of the locations needing flow rate adjustment. This may corroborate the already noted channel evolution observations of late stage incision with subsequent widening leading towards a more stable long term geometry, for these locations.

The four locations requiring flow stage and flow rate adjustment are the four largest drainage areas at point of measurement, including Hewitts Creek, Sandy Cove Creek, Mosselanka Creek, and Carson Creek. Each site was adjusted based on the above discussed velocity and shear targets, reflecting both particle gradation levels for the D_{50}-D_{100} range and judgement of the depth and volume of coarse sand to smaller sediments lining the channel bed. The detailed results of stable conditions modelling are appended after the channel forming / bankfull conditions modelling. Appended after the stable conditions models are summary models that show the comparisons of key variables between the respective conditions cross-section models. The summary models include the breakdown of three conditions of dynamic stability, cautionary dynamic stability, and potential instability. The adjustments made to achieve stability reflect bump ups from cautionary dynamic stability to full dynamic stability and from potential instability to cautionary dynamic stability, with an averaged final condition judged to be a realistic stable regime in the watercourse.

The remaining five watercourse locations were judged to require no iterations in adjusted flow stage for dynamic stability. These reaches are deemed fully stable at channel capacity flows with appreciably low velocity, shear, and supporting indicators, corroborating good levels of biotechnical reinforcement through respective cross-section conditions.

Based on the results of erosion threshold characterization, the method of subsequent hydrology analysis was considered. Three general approaches are available including exceedance-duration analysis, unit-area flow rate analysis, and vegetation-hydroperiod analysis. The latter, vegetation-hydroperiod analysis would not be applicable for the larger watercourse locations and would thus not be comparable to or consistent with applying this to the smaller sites. Nonetheless, given the small drainage areas and relatively low flow rates for each of the five smaller and stable sites with biotechnical reinforcement, there would be no anticipated issues or restraints from a hydroperiod perspective on just these locations. Exceedance-duration analysis is best applied when continuous hydrology modelling is undertaken although a variant is possible with event modelling. In this study, the variation in entrenchment levels would mean having to specifically determine the top of channel capacity for entrenched locations and then correlate this to the selected period of time used in the continuous analysis. Invariably some long term inaccuracy results in this analysis because of potential differences in return event flows and actual flow frequency recurrence that would be available from continuous modelling. The alternative way to address this variability is to apply unit-area flow rate targets for the receiving reaches and then identify a reasonable range of frequent flow events that are qualitatively judged to be contained within channel capacity. This is deemed appropriate when the receiving reach locations are close to the ultimate receiver (e.g. Cooks Bay) or the receiver locations are essentially the only isolated location receiving future development flows (or there are a very limited number of locations in the system, e.g. Sandy Cove Creek). This method also provides long term flexibility because the target is not modified by types of land use change which may ultimately be modified from current planning (which by comparison to exceedance-duration analysis would specifically affect continuous modelling efforts of future conditions, i.e. the need to redo modelling for any modified proposal change in land use). The unit-area flow target qualifying criteria are therefore felt to be the best fit across the study area for consistent application.

Unit-Area Flow Rate Targets

The results of erosion threshold analysis were used to establish unit-area flow rate targets for each watercourse location. **Table 4** summarizes the channel forming flow rates and erosion threshold flow rates for all locations.

Table 4: Unit-Area Flow Rate Summary

	Q_{cf} $m^3 s^{-1}$	Q_{ds} $m^3 s^{-1}$	Q_{ua} $l s^{-1} ha^{-1}$	entr.	control events
Hewitts Creek (10th Line, Stroud)	0.865	0.540	1.08	Y	25mm, 2-25yr
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)	2.150	1.103	0.70	N	25mm, 2yr
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres)	0.216	0.216	5.14	Y	25mm, 2-25yr
Cooks Bay Tributary (Moosenlanka Rd., Sandy Cove Acres)	0.157	0.157	9.23	N	25mm, 2yr
Moosenlanka Creek (25 SR, Sandy Cove Acres)	0.595	0.434	1.60	Y (P)	25mm, 2-10yr
Carson Creek (Ewart St., Lefroy)	1.135	0.525	0.85	Y	25mm, 2-25yr
Cooks Bay Tributary (Parkview Drive, Gilford)	0.067	0.067	11.17	N	25mm, 2yr
White Birch Creek Tributary (Harbourview Golf, Gilford)	0.292	0.292	6.21	N	25mm, 2yr
Cooks Bay Tributary (Shore Acres Rd. & Nelly Rd., Gilford)	0.206	0.206	4.29	Y (P)	25mm, 2-10yr

Q_{cf} - channel forming discharge
Q_{ds} - dynamic stability discharge
Q_{ua} – unit-area flow rate target for SWM
entr. - entrenched: Y – yes / N – no / Y(P) – yes, partial

The unit-area flow rates are included based on the erosion threshold rate divided by the total drainage area to the point of field measurement. Entrenchment qualification is noted and the suggested events that will require analysis for unit-area target compliance are listed. All locations require the 25mm event by default to be included. The 2yr is listed for all sites to conservatively address and include all frequent flows from the thresholds below bankfull and those at bankfull. For sites that are not entrenched, the peak of flood flows entering the flood plain do not need to be over-controlled but for those that are entrenched, best efforts should be made to over-control to the unit-area flow rate. If these events prove problematic from a volume perspective, a modified exceedance-duration analysis check could be made to identify the time component of flows over and under the threshold, based on some level of over-control or standard peak matching control.

The unit-area flow rate targets were subsequently used to model storage and outflow requirements based on the 25mm event, with a secondary scenario of volume control reduction. The secondary scenario was based on the sandy dominant soils in the study area and possible application of LID practices that would infiltrate the first 20mm, which reduces volume to runoff from 5mm. Volume control will be required to meet the more stringent unit-area flow rates and this can be either addressed through variable levels of infiltration or adjustment in land use and weighted runoff. The modelling results thus demonstrate what storage levels and extended detention rates might be achieved by a high level of infiltration application. Detailed results of this exercise are appended. Each modelling summary shows a range of weighted runoff coefficients and the resultant storage and hours of extended detention at the target rate for the whole drainage area. Individual development applications will need to meet relevant control rates based on specific land use drainage areas and runoff coefficients.

The target rate for the Sandy Cove Creek Tributary (Main St., Sandy Cove Acres) is significantly higher than the main branch Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres) location. If development proceeds in the watershed with drainage to just the tributary location, without any development further downstream, then the higher rate is acceptable. Should development proceed below the tributary site, draining to the main branch site, then the tributary target is voided and all development would be required to control to the main branch constraint target. As an interim measure, lands above the tributary site could drain to the tributary target if no development has occurred downstream, but when and if new development proceeds downstream the controls for lands draining to the tributary would need to be retrofitted.

Conclusions

Erosion threshold analysis has been undertaken for nine watercourse locations that will receive stormwater discharge from future proposed development in the Town of Innisfil. Analysis has been done based on field review of channel sensitivity below proposed SWM outlets, with detailed cross-section surveys of selected locations. Erosion threshold modelling and the results were then used to determine the appropriate methodology for impact analysis. Unit-area flow analysis was identified as appropriate for the larger channels with thresholds identified below channel forming flows. Many of the smaller channels were deemed stable at channel forming flows and for consistency across the region, unit-area flow targets were thus set at the channel forming flow rate determined for bankfull conditions.

The methods of analysis presented in this report do not preclude a catastrophic event potentially causing some erosion due to unforeseen circumstances (e.g. SWM pond failure, culvert failures, major debris jam scour, beaver dam construction/breaching, or combinations thereof, etc.). The results presented here are also contingent on long term preservation and maintenance of natural vegetation conditions within the respective corridors, and maintenance of drainage areas without diversions between watersheds.

Prepared by,

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Figure 1: Study Area (N▲, not to scale, base map: http://atlas.gc.ca/site/english/toporama/)

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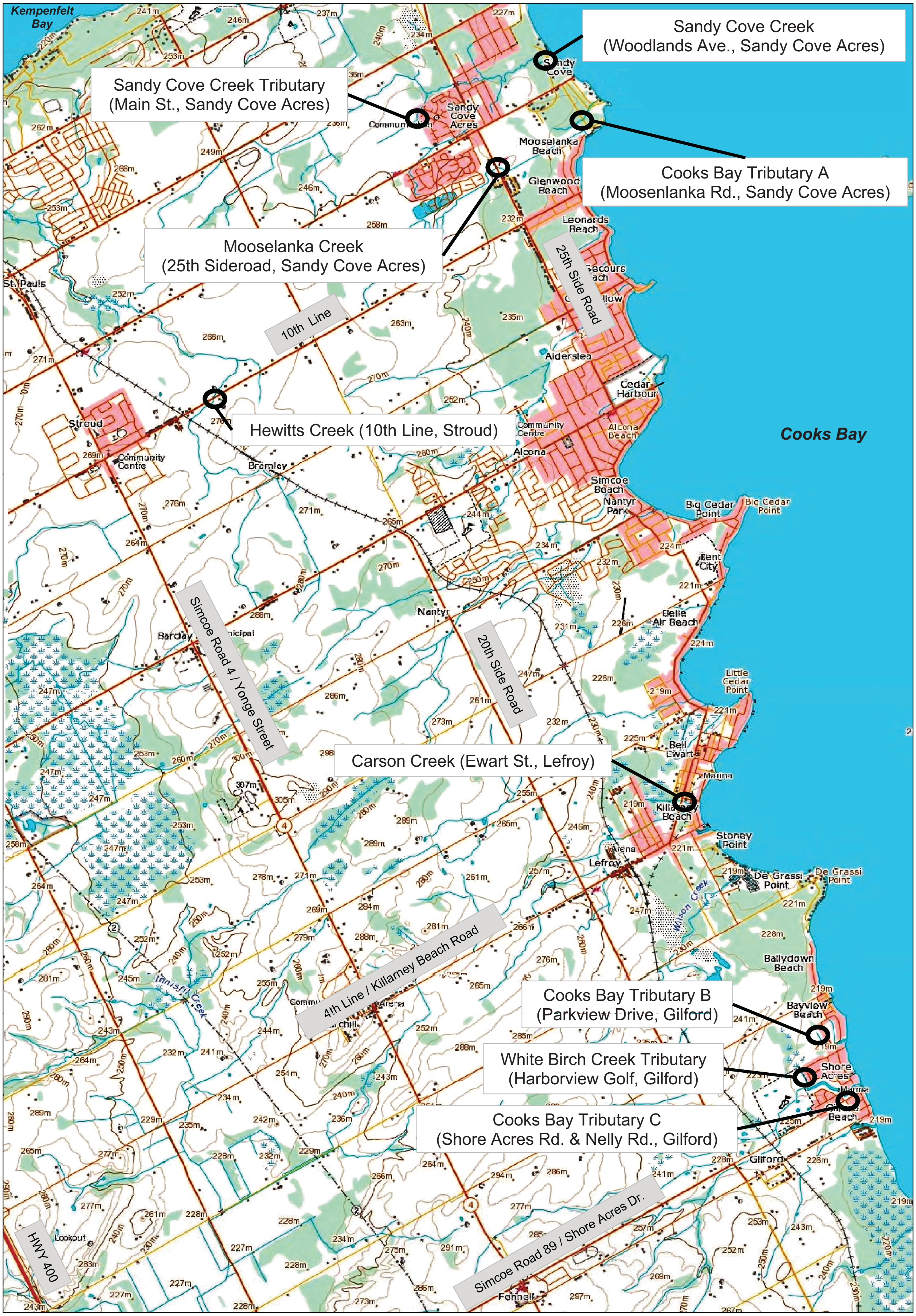

GEO-RAP v.1.2 Rapid Assessment Protocol Models

Hewitts Creek (10th Line, Stroud)
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres)
Cooks Bay Tributary A (Moosenlanka Rd., Sandy Cove Acres)
Mooselanka Creek (25th Sideroad, Sandy Cove Acres)
Carson Creek (Ewart St., Lefroy)
Cooks Bay Tributary B (Parkview Drive, Gilford)
White Birch Creek Tributary (Harborview Golf, Gilford)
Cooks Bay Tributary C (Shore Acres Rd. & Nelly Rd., Gilford)

Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

AquaLogic

GEO-RAP v.1.2 Rapid Assessment Protocol Model

B. de Geus 03.12

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Hewitts Creek (10th Line, Stroud)

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	1
	Siltation in pools	1
	Medial bars	1
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.43
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	1
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.10
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	1
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	1
	n/7 =	0.29

STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.20**
SI < 0.2	In Regime
0.2 < SI < 0.4	Transitional
SI > 0.4	In Adjustment
100 - (100*SI) =	**79.6**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	14	20--16	15-11	10-6	5-0
Pool Substrate Characterization	10	20--16	15-11	10-6	5-0
Pool Variability	10	20--16	15-11	10-6	5-0
Sediment Deposition	7	20--16	15-11	10-6	5-0
Channel Flow Status	12	20--16	15-11	10-6	5-0
Channel Alteration	5	20--16	15-11	10-6	5-0
Channel Sinuosity	6	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	7	10-8	7-6	5-3	2-0
u/s R	7	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	7	10-8	7-6	5-3	2-0
u/s R	7	10-8	7-6	5-3	2-0
/200	108				
/100	**54**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	4	8-7	6-5	4-3	2-0
Physical Instream Habitat	6	8-7	6-5	4-3	2-0
Water Quality	5	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	4	7-6	5-4	3-2	1-0
Biological Indicators	3	8-7	6-5	4-3	2-0
/50	30				
/100	**60.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =					
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**65**				
		100-80	80-56	55-30	29-0

▲ Overview looking downstream from 10th Line

▼ Overview looking upstream from 10th Line

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

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Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	1
	n/7 =	0.29
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	1
	n/10 =	0.10

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	1
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.14

STABILITY INDEX (SI) = (A + D + W + P) / 4 = **0.21**

SI < 0.2	In Regime
0.2 < SI < 0.4	Transitional
SI > 0.4	In Adjustment

100 - (100*SI) = **79.3**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Embeddedness	17	20--16	15-11	10-6	5-0
Velocity / Depth Regime	17	20--16	15-11	10-6	5-0
Sediment Deposition	12	20--16	15-11	10-6	5-0
Channel Flow Status	20	20--16	15-11	10-6	5-0
Channel Alteration	17	20--16	15-11	10-6	5-0
Frequency of Riffles	17	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	6	10-8	7-6	5-3	2-0
u/s R	6	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
/200	160				
/100	**80.0**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	6	8-7	6-5	4-3	2-0
Physical Instream Habitat	6	8-7	6-5	4-3	2-0
Water Quality	6	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	8	8-7	6-5	4-3	2-0
/50	40				
/100	**80.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

(RGA + RHA + RSAT) / 3 =	**79.8**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

▲ Looking downstream from Woodlands Ave. showing low gradient pool conditions

▼ Looking upstream from a point above Woodlands Ave. showing transition into steeper gradient and confined conditions

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

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Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres)

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.00
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	1
	Exposed tree roots	
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.10
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00

STABILITY INDEX (SI) = (A + D + W + P) / 4 = **0.03**

SI < 0.2	In Regime
0.2 < SI < 0.4	Transitional
SI > 0.4	In Adjustment
100 - (100*SI) =	**97.5**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	11	20--16	15-11	10-6	5-0
Pool Substrate Characterization	11	20--16	15-11	10-6	5-0
Pool Variability	6	20--16	15-11	10-6	5-0
Sediment Deposition	16	20--16	15-11	10-6	5-0
Channel Flow Status	0	20--16	15-11	10-6	5-0
Channel Alteration	5	20--16	15-11	10-6	5-0
Channel Sinuosity	6	20--16	15-11	10-6	5-0
Bank Stability u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	7	10-8	7-6	5-3	2-0
u/s R	7	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	4	10-8	7-6	5-3	2-0
u/s R	4	10-8	7-6	5-3	2-0
/200	97				
/100	**48.5**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	11	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	7	8-7	6-5	4-3	2-0
Physical Instream Habitat	3	8-7	6-5	4-3	2-0
Water Quality	5	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	4	7-6	5-4	3-2	1-0
Biological Indicators	0	8-7	6-5	4-3	2-0
/50	30				
/100	**60.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

(RGA + RHA + RSAT) / 3 =	69	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

▲ Overview looking upstream showing riparian conditions and limits

▼ Looking downstream through channelized section leading to headwall and enclosure

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.

2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.

3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

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Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary (Mossenlanka Rd., Sandy Cove Acres)

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	1
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.29
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00

STABILITY INDEX (SI) = (A + D + W + P) / 4 = **0.15**

SI < 0.2 In Regime
0.2 < SI < 0.4 Transitional
SI > 0.4 In Adjustment
100 - (100*SI) = **85.4**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	11	20--16	15-11	10-6	5-0
Pool Substrate Characterization	11	20--16	15-11	10-6	5-0
Pool Variability	7	20--16	15-11	10-6	5-0
Sediment Deposition	10	20--16	15-11	10-6	5-0
Channel Flow Status	3	20--16	15-11	10-6	5-0
Channel Alteration	14	20--16	15-11	10-6	5-0
Channel Sinuosity	14	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	10	10-8	7-6	5-3	2-0
u/s R	10	10-8	7-6	5-3	2-0
/200	124				
/100	**62**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	4	8-7	6-5	4-3	2-0
Physical Instream Habitat	4	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	0	8-7	6-5	4-3	2-0
/50	30				
/100	**60.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =		100-80	80-56	55-30	29-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
(RGA + RHA + RSAT) / 3 =	**69**	100-80	80-56	55-30	29-0

▲ Overview looking downstream from a point below Moosenlanka Rd.

▼ Looking upstream at Moosenlanka Rd. crossing

References
1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

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Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Mooselanka Creek (25th Sideroad, Sandy Cove Acres)

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	1
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.14
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.30
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	1
	n/7 =	0.14

STABILITY INDEX (SI) = (A + D + W + P) / 4 =	0.15
SI < 0.2	In Regime
0.2 < SI < 0.4	Transitional
SI > 0.4	In Adjustment
100 - (100*SI) =	85.4

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	15	20--16	15-11	10-6	5-0
Embeddedness	12	20--16	15-11	10-6	5-0
Velocity / Depth Regime	10	20--16	15-11	10-6	5-0
Sediment Deposition	10	20--16	15-11	10-6	5-0
Channel Flow Status	11	20--16	15-11	10-6	5-0
Channel Alteration	11	20--16	15-11	10-6	5-0
Frequency of Riffles	11	20--16	15-11	10-6	5-0
Bank Stability u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	6	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	4	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
/200	125				
/100	62.5	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200	0				
/100	0	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	8	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	5	8-7	6-5	4-3	2-0
Physical Instream Habitat	6	8-7	6-5	4-3	2-0
Water Quality	6	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	5	8-7	6-5	4-3	2-0
/50	36				
/100	72.0	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

(RGA + RHA + RSAT) / 3 =	73.3	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

▲ Overview looking downstream from 25th

▼ Overview looking upstream from a point above 25th Sideroad

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.

2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.

3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

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Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Carson Creek (Earl St., Lefroy)

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	
	Siltation in pools	
	Medial bars	
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.00
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	1
	n/10 =	0.10

Widening	Fallen/leaning trees/fence posts etc.	1
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	1
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	1
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.50
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	1
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	1
	n/7 =	0.29

STABILITY INDEX (SI) = (A + D + W + P) / 4 = **0.22**

SI < 0.2	In Regime
0.2 < SI < 0.4	Transitional
SI > 0.4	In Adjustment
100 - (100*SI) =	**77.9**

2) Rapid Habitat Assessment (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	17	20--16	15-11	10-6	5-0
Embeddedness	14	20--16	15-11	10-6	5-0
Velocity / Depth Regime	17	20--16	15-11	10-6	5-0
Sediment Deposition	6	20--16	15-11	10-6	5-0
Channel Flow Status	18	20--16	15-11	10-6	5-0
Channel Alteration	14	20--16	15-11	10-6	5-0
Frequency of Riffles	14	20--16	15-11	10-6	5-0
Bank Stability u/s L	6	10-8	7-6	5-3	2-0
u/s R	6	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	5	10-8	7-6	5-3	2-0
u/s R	5	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
/200	140				
/100	**70.0**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Pool Substrate Characterization		20--16	15-11	10-6	5-0
Pool Variability		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Channel Sinuosity		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200	0				
/100	**0**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	7	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	4	8-7	6-5	4-3	2-0
Physical Instream Habitat	6	8-7	6-5	4-3	2-0
Water Quality	7	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	6	7-6	5-4	3-2	1-0
Biological Indicators	8	8-7	6-5	4-3	2-0
/50	38				
/100	**76.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

(RGA + RHA + RSAT) / 3 =	**74.6**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

▲ Looking upstream through Earl St. crossing

▼ Overview looking upstream from Barry Ave.

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-RAP v.1.2 Rapid Assessment Protocol Model

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Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary (Parkview Drive, Gilford)

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	1
	Siltation in pools	1
	Medial bars	1
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.43
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.20
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00

STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.16**
SI < 0.2	In Regime
0.2 < SI < 0.4	Transitional
SI > 0.4	In Adjustment
100 - (100*SI) =	**84.3**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	16	20--16	15-11	10-6	5-0
Pool Substrate Characterization	6	20--16	15-11	10-6	5-0
Pool Variability	9	20--16	15-11	10-6	5-0
Sediment Deposition	6	20--16	15-11	10-6	5-0
Channel Flow Status	10	20--16	15-11	10-6	5-0
Channel Alteration	6	20--16	15-11	10-6	5-0
Channel Sinuosity	6	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	9	10-8	7-6	5-3	2-0
u/s R	9	10-8	7-6	5-3	2-0
/200	111				
/100	**55.5**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	4	8-7	6-5	4-3	2-0
Physical Instream Habitat	6	8-7	6-5	4-3	2-0
Water Quality	6	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	7	7-6	5-4	3-2	1-0
Biological Indicators	3	8-7	6-5	4-3	2-0
/50	35				
/100	**70.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

(RGA + RHA + RSAT) / 3 =	**70**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Typical swamp thicket corridor conditions with weakly defined channel characteristics

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.

2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.

3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

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Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
White Birch Creek Tributary (Harborview Golf, Gilford)

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	1
	Siltation in pools	1
	Medial bars	1
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.43
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	1
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.20
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00

STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.16**
SI < 0.2	In Regime
0.2 < SI < 0.4	Transitional
SI > 0.4	In Adjustment
100 - (100*SI) =	**84.3**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	15	20--16	15-11	10-6	5-0
Pool Substrate Characterization	6	20--16	15-11	10-6	5-0
Pool Variability	7	20--16	15-11	10-6	5-0
Sediment Deposition	6	20--16	15-11	10-6	5-0
Channel Flow Status	12	20--16	15-11	10-6	5-0
Channel Alteration	6	20--16	15-11	10-6	5-0
Channel Sinuosity	6	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	6	10-8	7-6	5-3	2-0
u/s R	6	10-8	7-6	5-3	2-0
/200	102				
/100	**51**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	4	8-7	6-5	4-3	2-0
Physical Instream Habitat	6	8-7	6-5	4-3	2-0
Water Quality	5	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	5	7-6	5-4	3-2	1-0
Biological Indicators	3	8-7	6-5	4-3	2-0
/50	32				
/100	**64.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

(RGA + RHA + RSAT) / 3 =	**66**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

▲ Looking upstream through typical thicket conditions

▼ Detail of riparian groundcover and standing water to slow moving low flow conditions

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.

2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.

3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

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Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary (Shore Acres Rd. & Nelly Rd., Gilford)

1) Rapid Geomorphic Assessment (RGA)

Aggradation	Lobate bar	
	Coarse material in riffles embedded	1
	Siltation in pools	1
	Medial bars	1
	Accretion on point bars	
	Poor longitudinal sorting of bed materials	
	Deposition in the overbank zone	
	n/7 =	0.43
Degradation	Exposed bridge footing(s)	
	Exposed sanitary/storm sewer/pipeline etc.	
	Elevated stormsewer outfall(s)	
	Undermined gabion baskets/concrete aprons etc.	
	Scour pools d/s of culverts/stormsewer outlets	
	Cut face on bar forms	
	Head cutting due to knick point migration	
	Terrace cut through older bar material	
	Suspended armour layer visible in bank	
	Channel worn into undisturbed overburden/bedrock	
	n/10 =	0.00

Widening	Fallen/leaning trees/fence posts etc.	
	Occurrence of Large Organic Debris	
	Exposed tree roots	1
	Basal scour on inside meander bends	
	Basal scour on both sides of channel through riffle	
	Gabion baskets/concrete walls etc. out flanked	
	Length of basal scour >50% through subject reach	
	Exposed length of previously buried pipe/cable etc.	
	Fracture lines along top of bank	
	Exposed building foundation	
	n/10 =	0.10
Planimetric Form	Formation of chute(s)	
	Single thread channel to multiple channel	
	Evolution of pool-riffle form to low bed relief form	
	Cut-off channel(s)	
	Formation of island(s)	
	Thalweg alignment out of phase meander form	
	Bar forms poorly formed/reworked/removed	
	n/7 =	0.00

STABILITY INDEX (SI) = (A + D + W + P) / 4 =	**0.13**
SI < 0.2	In Regime
0.2 < SI < 0.4	Transitional
SI > 0.4	In Adjustment
100 - (100*SI) =	**86.8**

2) Rapid Habitat Assessmemt (RHA)

Riffle Run Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover		20--16	15-11	10-6	5-0
Embeddedness		20--16	15-11	10-6	5-0
Velocity / Depth Regime		20--16	15-11	10-6	5-0
Sediment Deposition		20--16	15-11	10-6	5-0
Channel Flow Status		20--16	15-11	10-6	5-0
Channel Alteration		20--16	15-11	10-6	5-0
Frequency of Riffles		20--16	15-11	10-6	5-0
Bank Stability u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Vegetative Protection u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L		10-8	7-6	5-3	2-0
u/s R		10-8	7-6	5-3	2-0
/200					
/100		Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

Glide Pool Channel Type

		Optimal	Good	Fair	Poor
Epifaunal Substrate / Available Cover	7	20--16	15-11	10-6	5-0
Pool Substrate Characterization	7	20--16	15-11	10-6	5-0
Pool Variability	5	20--16	15-11	10-6	5-0
Sediment Deposition	5	20--16	15-11	10-6	5-0
Channel Flow Status	2	20--16	15-11	10-6	5-0
Channel Alteration	2	20--16	15-11	10-6	5-0
Channel Sinuosity	1	20--16	15-11	10-6	5-0
Bank Stability u/s L	8	10-8	7-6	5-3	2-0
u/s R	8	10-8	7-6	5-3	2-0
Vegetative Protection u/s L	7	10-8	7-6	5-3	2-0
u/s R	7	10-8	7-6	5-3	2-0
Riparian Vegetation Zone Width u/s L	3	10-8	7-6	5-3	2-0
u/s R	3	10-8	7-6	5-3	2-0
/200	65				
/100	**32.5**	Optimal	Good	Fair	Poor
		100-78	77-53	52-28	27-0

3) Rapid Stream Assessment Technique (RSAT)

		Optimal	Good	Fair	Poor
Channel Stability	9	11-9	8-6	5-3	2-0
Channel Scouring/Deposition	4	8-7	6-5	4-3	2-0
Physical Instream Habitat	4	8-7	6-5	4-3	2-0
Water Quality	3	8-7	6-5	4-3	2-0
Riparian Habitat Conditions	4	7-6	5-4	3-2	1-0
Biological Indicators	0	8-7	6-5	4-3	2-0
/50	24				
/100	**48.0**	Optimal	Good	Fair	Poor
		100-83	82-59	58-31	30-0

Combined Assessment

Riffle Run Channel Type

(RGA + RHA + RSAT) / 3 =		Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

Glide Pool Channel Type

(RGA + RHA + RSAT) / 3 =	**56**	Optimal	Good	Fair	Poor
		100-80	80-56	55-30	29-0

▲ Overview looking downstream from upstream start of channel at the intersection of Shore Acres Rd. and Nelly Rd.; no flow

▼ Overview looking downstream near confluence with Cooks Bay; standing water and minor flow

References

1) Ontario Ministry of Environment and Energy. 2003. Stormwater Management Planning and Design Manual. Appendix C.
2) USEPA. 2004. Wadeable Stream Assessment: Field Operations Manual. EPA841-B-04-004. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.
3) Galli, J., 1996. Rapid stream assessment technique, field methods. Metropolitan Washington Council of Governments.

GEO-X v.5.1 Geomorphic Cross-Section Analysis Models
Channel Forming / Bankfull Conditions

Hewitts Creek (10th Line, Stroud)
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres)
Cooks Bay Tributary A (Moosenlanka Rd., Sandy Cove Acres)
Mooselanka Creek (25th Sideroad, Sandy Cove Acres)
Carson Creek (Ewart St., Lefroy)
Cooks Bay Tributary B (Parkview Drive, Gilford)
White Birch Creek Tributary (Harborview Golf, Gilford)
Cooks Bay Tributary C (Shore Acres Rd. & Nelly Rd., Gilford)

Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

AquaLogic

Hewitts Creek (10th Line, Stroud)
Channel Forming / Bankfull Conditions Cross-Section Models

Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Hewitts Creek (10th Line, Stroud) - Section 1

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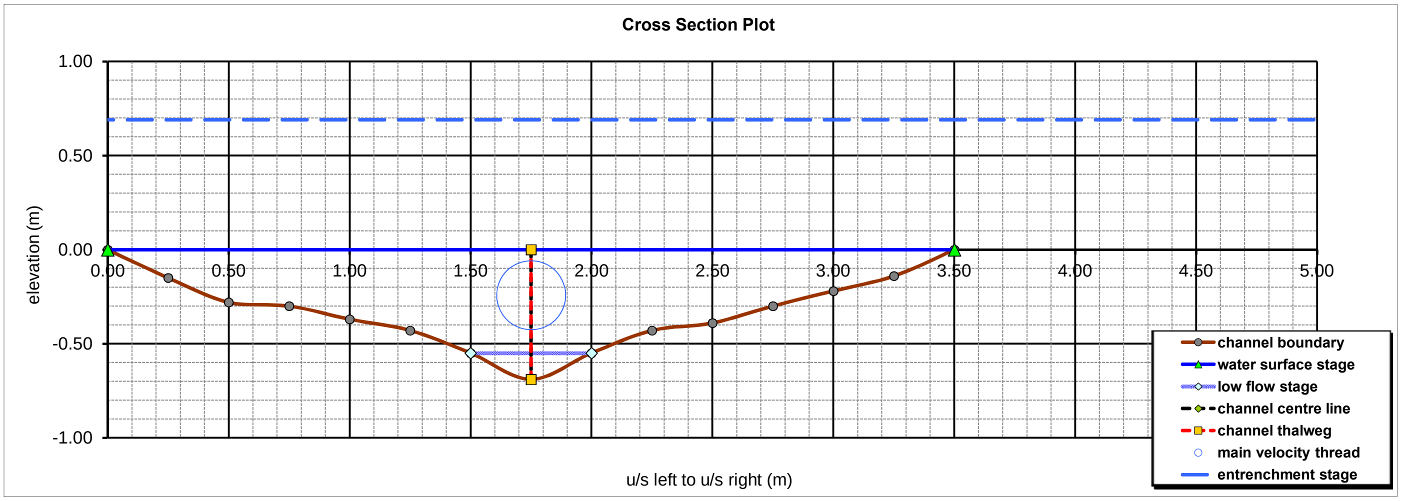

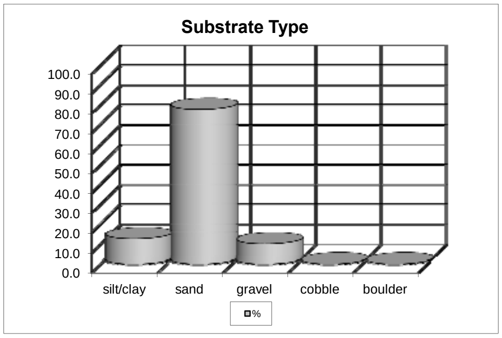

Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.20
R (m)	0.32
TW (m)	3.50
WP (m)	3.80
max d (m)	0.69
mean d (m)	0.34
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	315.88
ff V mean/V*	12.34
ff D_{84}	17.28
ff mean	14.81
SMOOTH BED	

Hydraulic Ratios	
ER max d	2.29
r_c / TW	
TW / Lf_w	7.00
TW/max d	5.1
TW/mean d	10.2

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.42	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.044	D_{50}	0.023	1.30	NO	NO	YES	YES
		D_{84}	0.126	7.07	NO	NO	NO	YES

Section Data					
ER_e (m)	0.69	ER stations L / R	-2.00	6.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.50	3.50
Lf_e (m)	-0.550	Lf stations L / R	1.50	2.00	
W_{fp} (m)	8.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.69	1.75	
E_g ($m\ m^{-1}$)	0.0030				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	95.7	47.9	9.6
B3	0.0018	0.0023	saltation	YES	YES	YES
C3	0.0002	0.0011	rolling	YES	YES	YES
C4	0.0061	0.0090	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	1.00	10.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				0.97	9.70
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.868	Q (cms)	
V ($m\ s^{-1}$)	0.72	V ($m\ s^{-1}$)	
n	0.035	n	
Fr	0.39	*Fr*	
D_c rectangular (m)	0.19	D_c rectangular (m)	
D_c trapezoidal (m)	0.30	D_c trapezoidal (m)	
D_c triangular (m)	0.44	D_c triangular (m)	
D_c parabolic (m)	0.26	D_c parabolic (m)	
D_c mean (m)	0.30	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	25.51	Ω (watts m^{-1})	
ω_a (watts m^{-2})	6.71	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.92	ω_a/TW (watts m^{-1})	
*Re**	0.3	*Re**	
Re	200350	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds			
τ_{calc} ($kg\ m^{-2}$)	0.95		
τ_{calc} ($N\ m^{-2}$)	9.29	V_c / V_b	
τ D_{crit} (gr-co) (mm)	9.57	Strickler	Limerinos
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.07	0.14	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.16	0.31	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
12.5	77.5	10.0	0.0	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

AquaLogic

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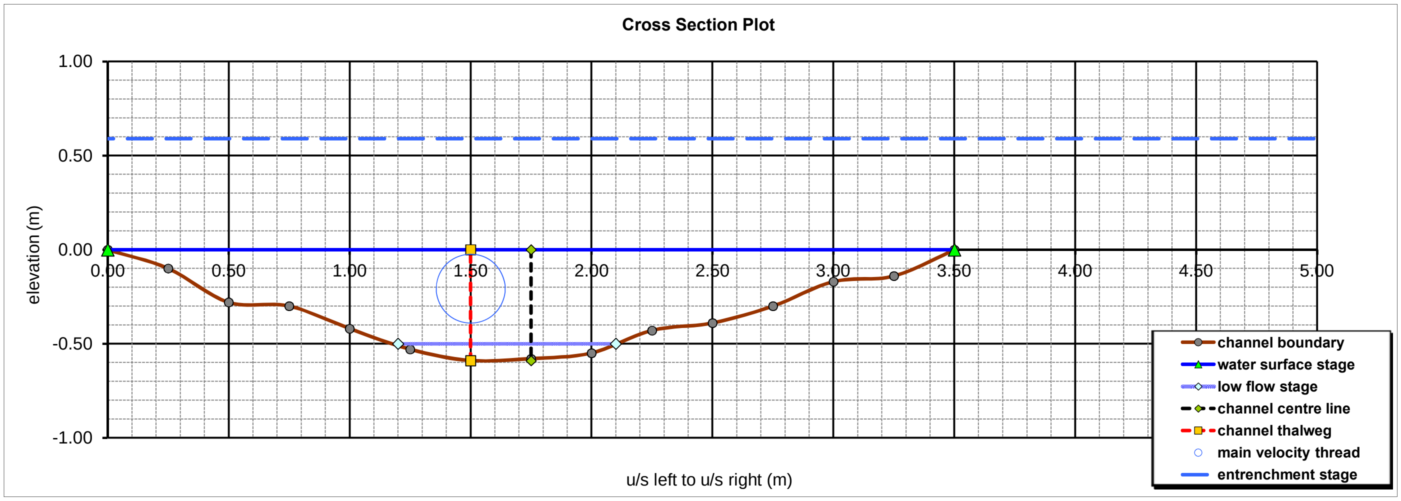
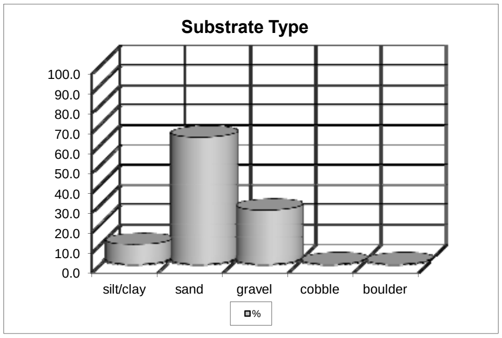
Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Hewitts Creek (10th Line, Stroud) - Section 2





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.20
R (m)	0.32
TW (m)	3.50
WP (m)	3.75
max d (m)	0.59
mean d (m)	0.34
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	39.79
ff V mean/V*	9.86
ff D_{84}	12.12
ff mean	10.99
	SMOOTH BED

Hydraulic Ratios	
ER max d	2.29
r_c / TW	
TW / Lf_w	3.89
TW/max d	5.9
TW/mean d	10.3

Sediment Transport Mode						high	low	
			w_s ($m\ s^{-1}$)	P	wash load	sus. load	sus. load	bedload
k	0.41	D_{30}	0.023	1.30	NO	NO	YES	YES
V_* ($m\ s^{-1}$)	0.044	D_{50}	0.071	3.96	NO	NO	NO	YES
		D_{84}	0.412	23.00	NO	NO	NO	NO

Section Data					
ER_e (m)	0.59	ER stations L / R	-2.00	6.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.50	3.50
Lf_e (m)	-0.500	Lf stations L / R	1.20	2.10	
W_{fp} (m)	8.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.59	1.50	
E_g ($m\ m^{-1}$)	0.0030				

Bedload Transport Data						
	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	48.2	19.3	1.2
B3	0.0018	0.0021	saltation	YES	YES	NO
C3	0.0002	0.0006	rolling	YES	YES	YES
C4	0.0061	0.0077	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.20	0.50	8.00	50.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				7.76	48.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	0.869	Q (cms)	
V ($m\ s^{-1}$)	0.73	V ($m\ s^{-1}$)	
n	0.035	n	
Fr	0.40	*Fr*	
D_c rectangular (m)	0.19	D_c rectangular (m)	
D_c trapezoidal (m)	0.30	D_c trapezoidal (m)	
D_c triangular (m)	0.44	D_c triangular (m)	
D_c parabolic (m)	0.26	D_c parabolic (m)	
D_c mean (m)	0.30	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	25.54	Ω (watts m^{-1})	
ω_a (watts m^{-2})	6.80	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.94	ω_a/TW (watts m^{-1})	
*Re**	0.7	*Re**	
Re	202954	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds			
τ_{calc} ($kg\ m^{-2}$)	0.95		
τ_{calc} ($N\ m^{-2}$)	9.36	V_c / V_b	
$\tau\ D_{crit}$ (gr-co) (mm)	9.65	Strickler	Limerinos
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.11	0.22	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.44	0.86	

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
9.6	63.5	26.9	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

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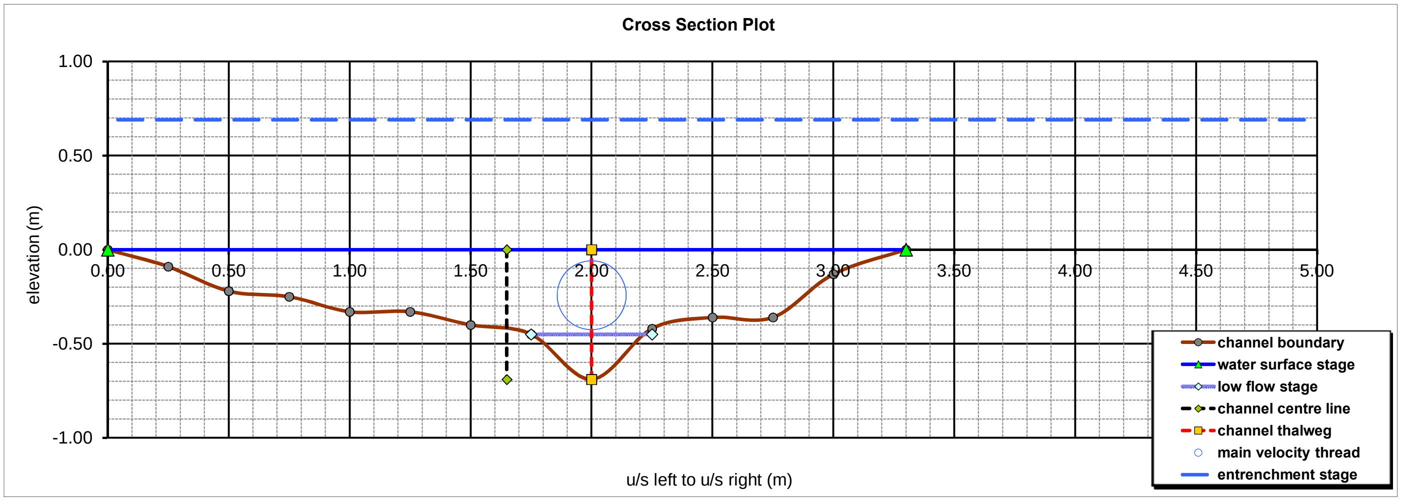
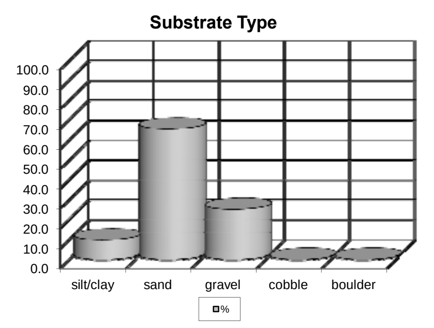
Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Hewitts Creek (10th Line, Stroud) - Section 3





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.01
R (m)	0.27
TW (m)	3.30
WP (m)	3.71
max d (m)	0.69
mean d (m)	0.31
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	34.01
ff V mean/V*	9.58
ff D_{84}	11.85
ff mean	10.71
SMOOTH BED	

Hydraulic Ratios	
ER max d	2.42
r_c / TW	
TW / Lf_w	6.60
TW/max d	4.8
TW/mean d	10.8

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.35	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.052	D_{50}	0.071	3.32	NO	NO	NO	YES
		D_{84}	0.412	19.27	NO	NO	NO	NO

Section Data

ER_e (m)	0.69	ER stations L / R	-3.00	5.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.30	3.30
Lf_e (m)	-0.450	Lf stations L / R	1.75	2.25	
W_{fp} (m)	8.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.69	2.00	
E_g ($m\ m^{-1}$)	0.0050				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} ($kg\ sec^{-1}$)	Limerinos Q Q_{sb} ($kg\ sec^{-1}$)		D_{30}	D_{50}	D_{84}
			T_*	137.5	27.5	1.7
B3	0.0018	0.0021	saltation	YES	YES	NO
C3	0.0002	0.0006	rolling	YES	YES	YES
C4	0.0060	0.0076	Ø	NO	NO	NO

Substrate Gradation

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.50	8.00	40.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				7.76	38.80
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	0.854	Q (cms)	
V ($m\ s^{-1}$)	0.84	V ($m\ s^{-1}$)	
n	0.035	n	
Fr	0.49	*Fr*	
D_c rectangular (m)	0.19	D_c rectangular (m)	
D_c trapezoidal (m)	0.30	D_c trapezoidal (m)	
D_c triangular (m)	0.44	D_c triangular (m)	
D_c parabolic (m)	0.27	D_c parabolic (m)	
D_c mean (m)	0.30	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω ($watts\ m^{-1}$)	41.83	Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	11.26	ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	3.41	ω_a/TW ($watts\ m^{-1}$)	
*Re**	0.7	*Re**	
Re	201609	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	V_c / V_b Limerinos
τ_{calc} ($kg\ m^{-2}$)	1.36		
τ_{calc} ($N\ m^{-2}$)	13.33		
τ D_{crit} (gr-co) (mm)	13.75		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.11	0.19	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.44	0.74	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
9.6	65.4	25.0	0.0	0.0

Bank Data

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Hewitts Creek (10th Line, Stroud) - Section 4

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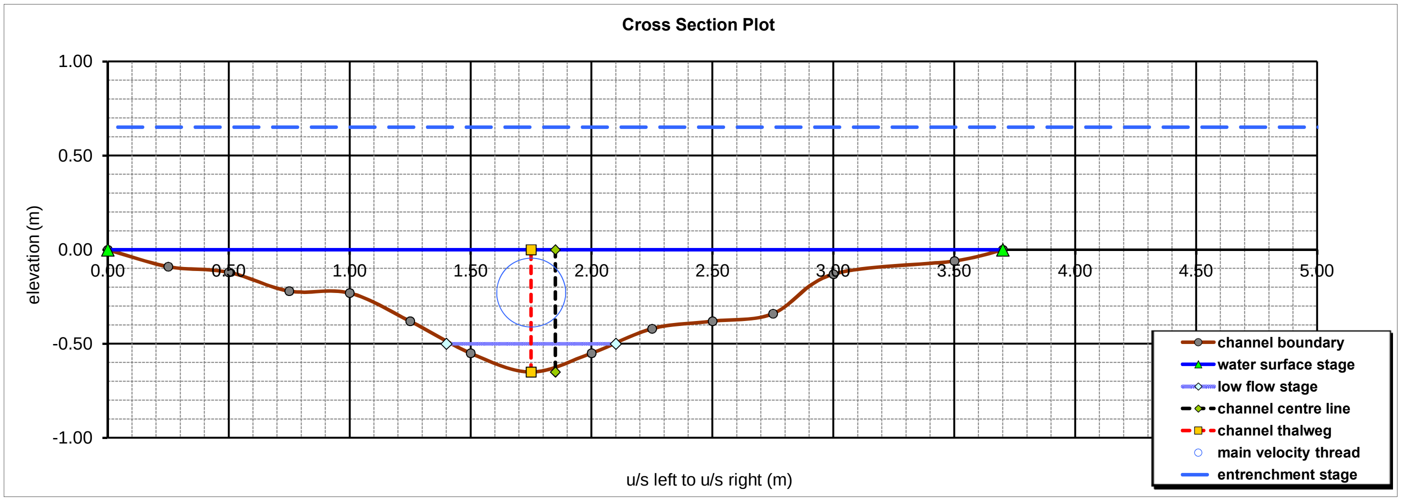

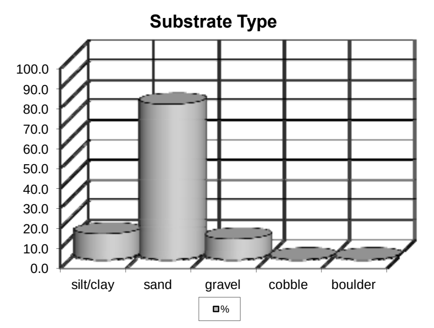

Morphology Type		Hydraulic Geometry	
cascade		A (m^2)	1.05
step		*R* (m)	0.26
riffle		TW (m)	3.70
run	●	WP (m)	4.00
glide		max d (m)	0.65
pool		mean d (m)	0.28
thalweg out of phase		$E_{s\ (Limerinos)}$ (m) [+]	
		$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness		Hydraulic Ratios	
rr R/D_{84}	526.43		
ff V mean/V*	12.82	ER max d	2.70
ff D_{84}	18.53	r_c / TW	
ff mean	15.68	TW / Lf_w	5.29
SMOOTH BED		TW/max d	5.7
		TW/mean d	13.0

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.36	YES	YES	YES	YES
V_* (m s^{-1})	0.051	D_{50}	0.023	1.10	NO	YES	YES	YES
		D_{84}	0.071	3.37	NO	NO	NO	YES

Section Data

ER_e (m)	0.65	ER stations L / R	-3.00	7.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.70	3.70
Lf_e (m)	-0.500	Lf stations L / R	1.40	2.10	
W_{fp} (m)	10.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.65	1.75	
E_g (m m^{-1})	0.0050				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	133.0	66.5	26.6
B3	0.0018	0.0024	saltation	YES	YES	YES
C3	0.0002	0.0014	rolling	YES	YES	YES
C4	0.0061	0.0094	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	0.50	20.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})					19.40
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	0.869	Q (cms)	
V (m s^{-1})	0.83	V (m s^{-1})	
n	0.035	n	
Fr	0.49	*Fr*	
D_c rectangular (m)	0.18	D_c rectangular (m)	
D_c trapezoidal (m)	0.30	D_c trapezoidal (m)	
D_c triangular (m)	0.44	D_c triangular (m)	
D_c parabolic (m)	0.27	D_c parabolic (m)	
D_c mean (m)	0.30	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	42.59	Ω (watts m^{-1})	
ω_a (watts m^{-2})	10.65	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	2.88	ω_a/TW (watts m^{-1})	
*Re**	0.3	*Re**	
Re	190737	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	V_c / V_b Limerinos
τ_{calc} (kg m^{-2})	1.32		
τ_{calc} (N m^{-2})	12.90		
τ D_{crit} (gr-co) (mm)	13.30		
D_{50} V_c (vcs +) (m s^{-1})	0.07	0.12	
D_{84} V_c (vcs +) (m s^{-1})	0.11	0.19	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
12.5	77.5	10.0	0.0	0.0

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Hewitts Creek (10th Line, Stroud) - Section 5

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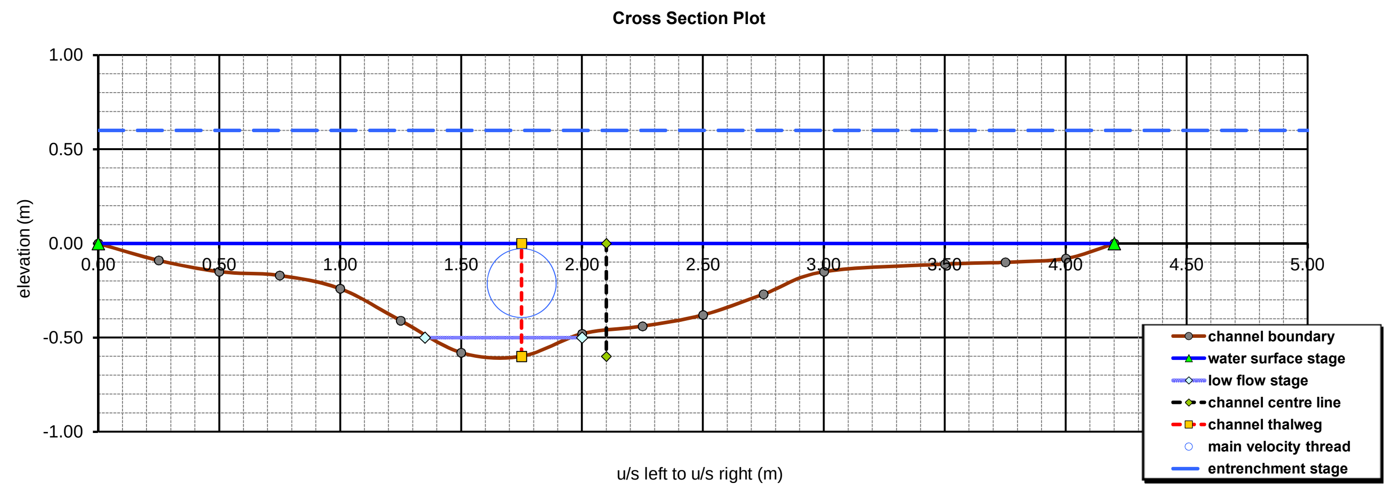
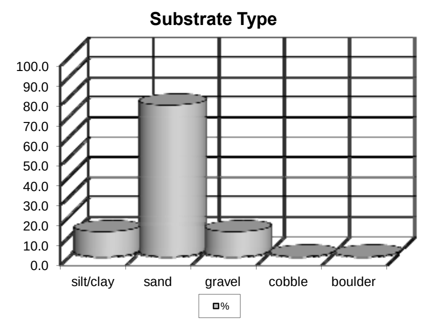




Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.09
R (m)	0.25
TW (m)	4.20
WP (m)	4.44
max d (m)	0.60
mean d (m)	0.26
$E_{S\ (Limerinos)}$ (m) [+]	
$E_{S\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	245.91
ff V mean/V*	11.86
ff D_{84}	16.60
ff mean	14.23
	SMOOTH BED

Hydraulic Ratios	
ER max d	3.10
r_c / TW	
TW / Lf_w	6.46
TW/max d	7.0
TW/mean d	16.1

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.37	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.050	D_{50}	0.023	1.14	NO	YES	YES	YES
		D_{84}	0.126	6.20	NO	NO	NO	YES

Section Data					
ER_e (m)	0.60	ER stations L / R	-4.00	9.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	4.20	4.20
Lf_e (m)	-0.500	Lf stations L / R	1.35	2.00	
W_{fp} (m)	13.00	E_S sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_S sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.60	1.75	
E_g ($m\ m^{-1}$)	0.0050				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen type	Q_{sb} ($kg\ sec^{-1}$)	Q_{sb} ($kg\ sec^{-1}$)		D_{30}	D_{50}	D_{84}
			T_*	124.2	62.1	12.4
B3	0.0018	0.0023	saltation	YES	YES	YES
C3	0.0002	0.0011	rolling	YES	YES	YES
C4	0.0061	0.0090	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	1.00	10.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				0.97	9.70
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	0.863	Q (cms)	
V ($m\ s^{-1}$)	0.79	V ($m\ s^{-1}$)	
n	0.035	n	
Fr	0.49	*Fr*	
D_c rectangular (m)	0.17	D_c rectangular (m)	
D_c trapezoidal (m)	0.30	D_c trapezoidal (m)	
D_c triangular (m)	0.44	D_c triangular (m)	
D_c parabolic (m)	0.28	D_c parabolic (m)	
D_c mean (m)	0.30	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω ($watts\ m^{-1}$)	42.27	Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	9.51	ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	2.26	ω_a/TW ($watts\ m^{-1}$)	
*Re**	0.3	*Re**	
Re	170260	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds		V_c / V_b Strickler	V_c / V_b Limerinos
τ_{calc} ($kg\ m^{-2}$)	1.23		
τ_{calc} ($N\ m^{-2}$)	12.05		
τ D_{crit} (gr-co) (mm)	12.42		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.07	0.13	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.16	0.28	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
12.2	75.6	12.2	0.0	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Hewitts Creek (10th Line, Stroud)
Stable Conditions Cross-Section Models

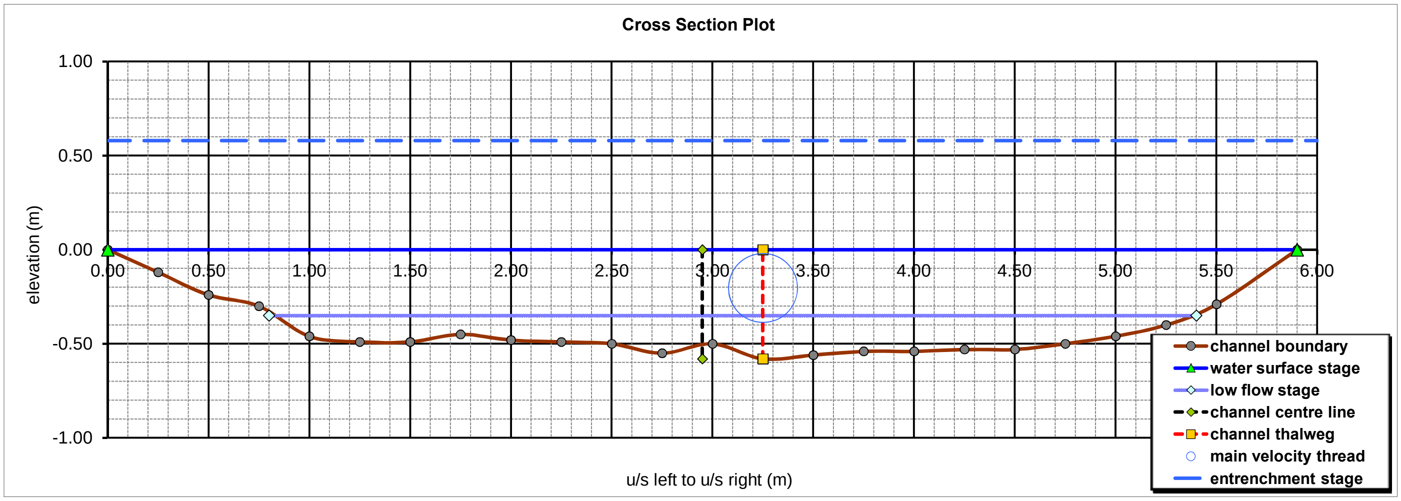
Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

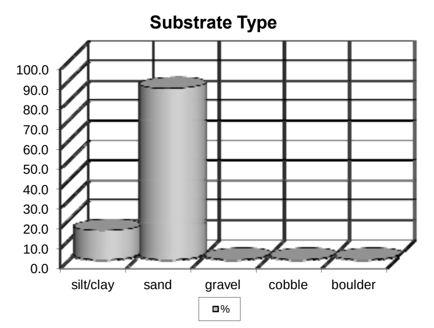
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

AquaLogic

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres) - Section 1





Morphology Type	
cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	2.52
R (m)	0.41
TW (m)	5.90
WP (m)	6.17
max d (m)	0.58
mean d (m)	0.43
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R /D_{84}	817.54
ff V mean/V*	13.68
ff D_{84}	19.54
ff mean	16.61
SMOOTH BED	

Hydraulic Ratios	
ER max d	3.05
r_c / TW	
TW / Lf_w	1.28
TW/max d	10.2
TW/mean d	13.8

Sediment Transport Mode						high	low	
			w_s (m s^{-1})	P	wash load	sus. load	sus. load	bedload
k	0.41	D_{30}	0.008	0.37	YES	YES	YES	YES
V_* (m s^{-1})	0.050	D_{50}	0.023	1.14	NO	YES	YES	YES
		D_{84}	0.071	3.50	NO	NO	NO	YES

Section Data					
ER_e (m)	0.58	ER stations L / R	-10.00	8.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	5.90	5.90
Lf_e (m)	-0.350	Lf stations L / R	0.80	5.40	
W_{fp} (m)	18.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.58	3.25	
E_g (m m^{-1})	0.0030				

Bedload Transport Data						
	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	123.9	61.9	24.8
B3	0.0024	0.0031	saltation	YES	YES	YES
C3	0.0014	0.0080	rolling	YES	YES	YES
C4	0.0094	0.0144	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	0.50	1.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})					0.97
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	2.167	Q (cms)	
V (m s^{-1})	0.86	V (m s^{-1})	
n	0.035	n	
Fr	0.42	*Fr*	
D_c rectangular (m)	0.24	D_c rectangular (m)	
D_c trapezoidal (m)	0.42	D_c trapezoidal (m)	
D_c triangular (m)	0.64	D_c triangular (m)	
D_c parabolic (m)	0.39	D_c parabolic (m)	
D_c mean (m)	0.42	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	63.71	Ω (watts m^{-1})	
ω_a (watts m^{-2})	10.33	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.75	ω_a/TW (watts m^{-1})	
*Re**	0.3	*Re**	
Re	308144	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds		V_c / V_b	
τ_{calc} (kg m^{-2})	1.23		
τ_{calc} (N m^{-2})	12.02		
τ D_{crit} (gr-co) (mm)	12.39	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.07	0.12	
D_{84} V_c (vcs +) (m s^{-1})	0.11	0.18	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

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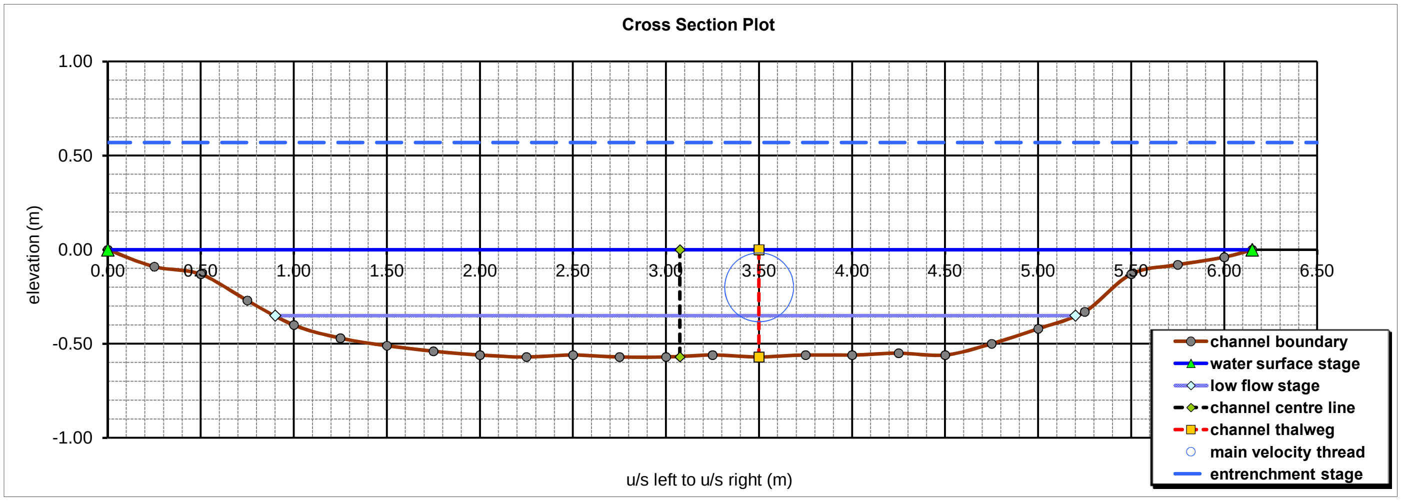
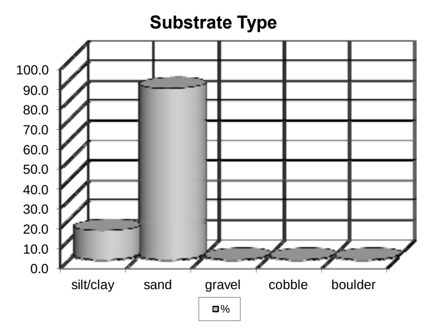
Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres) - Section 2





Morphology Type	
cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	2.52
R (m)	0.40
TW (m)	6.15
WP (m)	6.37
max d (m)	0.57
mean d (m)	0.41
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	791.78
ff V mean/V*	13.62
ff D_{84}	19.44
ff mean	16.53
SMOOTH BED	

Hydraulic Ratios	
ER max d	2.93
r_c / TW	
TW / Lf_w	1.43
TW/max d	10.8
TW/mean d	15.0

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.38	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.049	D_{50}	0.023	1.16	NO	YES	YES	YES
		D_{84}	0.071	3.55	NO	NO	NO	YES

Section Data					
ER_e (m)	0.57	ER stations L / R	-10.00	8.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	6.15	6.15
Lf_e (m)	-0.350	Lf stations L / R	0.90	5.20	
W_{fp} (m)	18.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.57	3.50	
E_g ($m\ m^{-1}$)	0.0030				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	($kg\ sec^{-1}$)	($kg\ sec^{-1}$)	T_*	120.0	60.0	24.0
B3	0.0024	0.0031	saltation	YES	YES	YES
C3	0.0013	0.0077	rolling	YES	YES	YES
C4	0.0093	0.0143	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	0.50	1.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)					0.97
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds		V_c / V_b	
τ_{calc} ($kg\ m^{-2}$)	1.19		
τ_{calc} ($N\ m^{-2}$)	11.64		
τ D_{crit} (gr-co) (mm)	12.00	Strickler	Limerinos
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.07	0.12	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.11	0.19	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	2.122	Q (cms)	
V ($m\ s^{-1}$)	0.84	V ($m\ s^{-1}$)	
n	0.035	n	
Fr	0.42	*Fr*	
D_c rectangular (m)	0.23	D_c rectangular (m)	
D_c trapezoidal (m)	0.42	D_c trapezoidal (m)	
D_c triangular (m)	0.63	D_c triangular (m)	
D_c parabolic (m)	0.39	D_c parabolic (m)	
D_c mean (m)	0.42	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω ($watts\ m^{-1}$)	62.39	Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	9.79	ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	1.59	ω_a/TW ($watts\ m^{-1}$)	
*Re**	0.3	*Re**	
Re	292102	*Re*	
turbulence	LOW	turbulence	

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres) - Section 3

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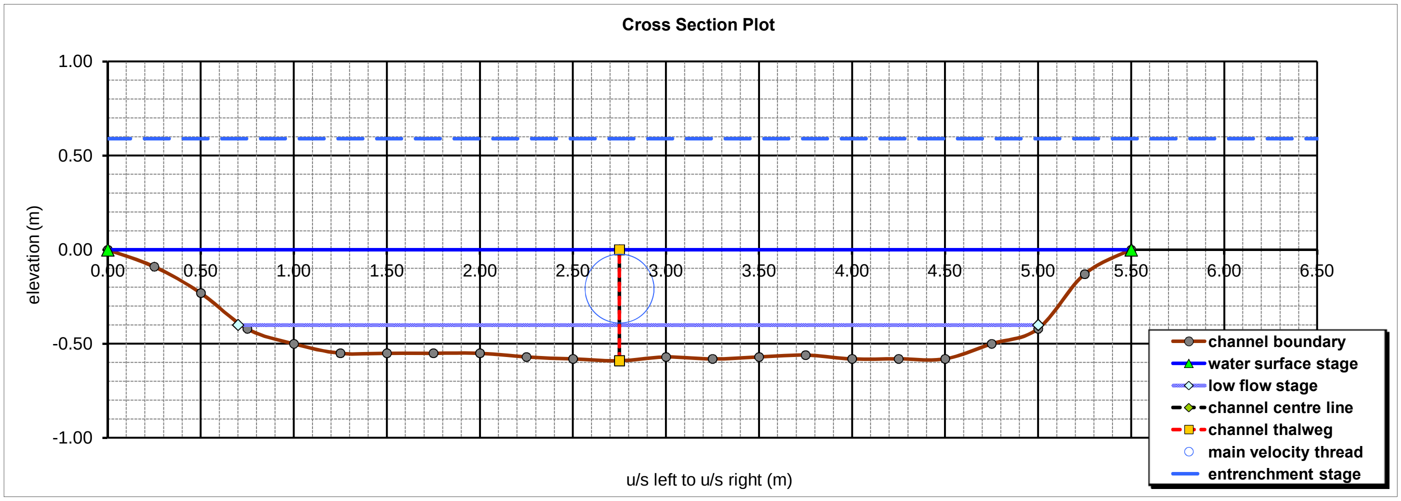
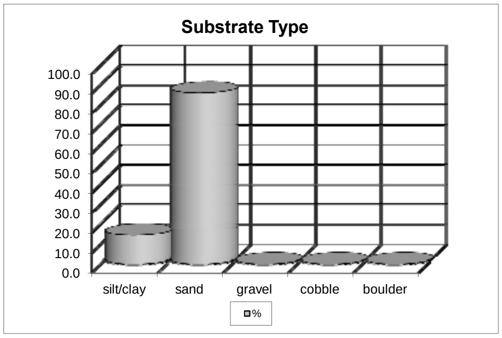




Morphology Type

cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Geometry

A (m^2)	2.56
R (m)	0.44
TW (m)	5.50
WP (m)	5.83
max d (m)	0.59
mean d (m)	0.47
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr *R* /D_{84}	879.57
ff V mean/V*	13.61
ff D_{84}	19.76
ff mean	16.68
SMOOTH BED	

Hydraulic Ratios

ER max d	3.27
r_c / TW	
TW / Lf_w	1.28
TW/max d	9.3
TW/mean d	11.8

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.36	YES	YES	YES	YES
V_* (m s^{-1})	0.051	D_{50}	0.023	1.10	NO	YES	YES	YES
		D_{84}	0.071	3.37	NO	NO	NO	YES

Section Data

ER_e (m)	0.59	ER stations L / R	-10.00	8.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	5.50	5.50
Lf_e (m)	-0.400	Lf stations L / R	0.70	5.00	
W_{fp} (m)	18.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.59	2.75	
E_g (m m^{-1})	0.0030				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	133.3	66.6	26.7
B3	0.0024	0.0032	saltation	YES	YES	YES
C3	0.0014	0.0090	rolling	YES	YES	YES
C4	0.0094	0.0148	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	0.50	1.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})					0.97
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method / Flow Regime Limerinos method

Strickler method		Limerinos method	
Q (cms)	2.188	Q (cms)	
V (m s^{-1})	0.85	V (m s^{-1})	
n	0.037	n	
Fr	0.40	*Fr*	
D_c rectangular (m)	0.26	D_c rectangular (m)	
D_c trapezoidal (m)	0.43	D_c trapezoidal (m)	
D_c triangular (m)	0.64	D_c triangular (m)	
D_c parabolic (m)	0.38	D_c parabolic (m)	
D_c mean (m)	0.43	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	64.32	Ω (watts m^{-1})	
ω_a (watts m^{-2})	11.04	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	2.01	ω_a/TW (watts m^{-1})	
*Re**	0.3	*Re**	
Re	329355	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} (kg m^{-2})	1.32		
τ_{calc} (N m^{-2})	12.93		
τ D_{crit} (gr-co) (mm)	13.33		
D_{50} V_c (vcs +) (m s^{-1})	0.07	0.12	
D_{84} V_c (vcs +) (m s^{-1})	0.11	0.18	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

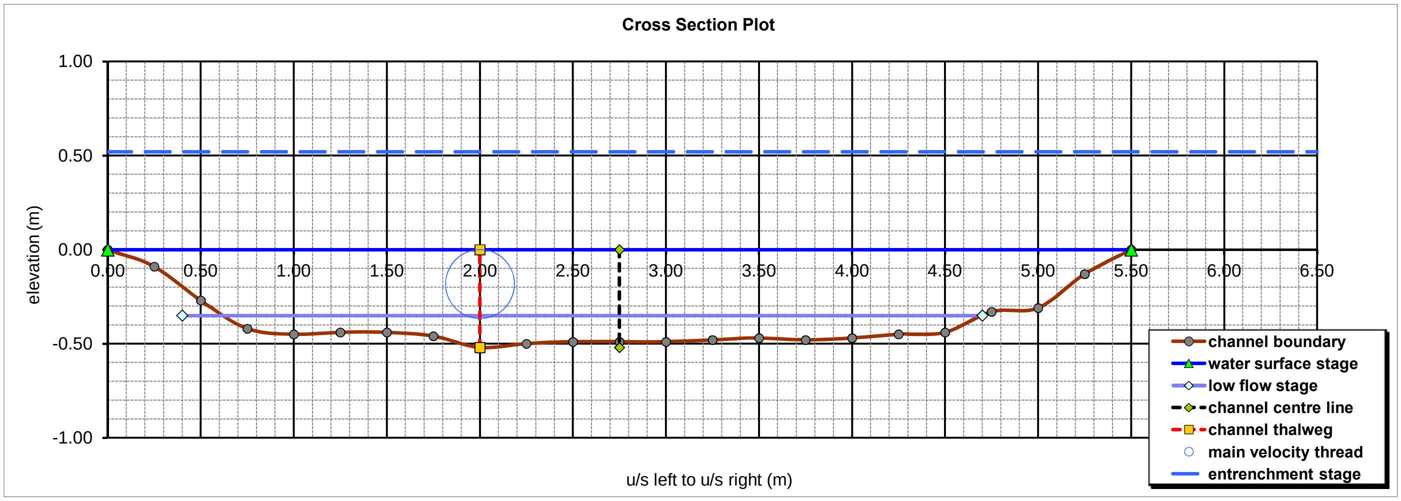
Bank Data

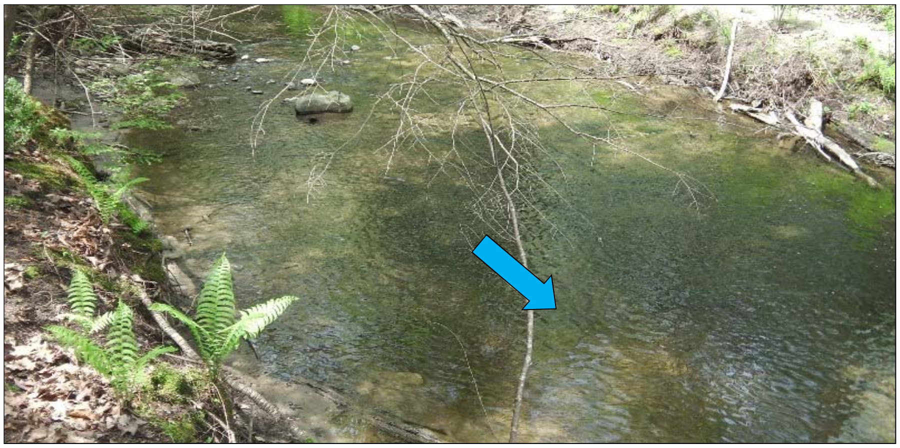
	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

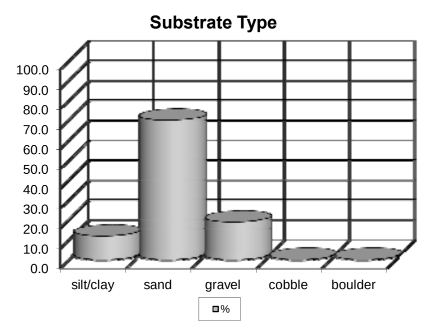
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres) - Section 4







Morphology Type	
cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	2.16
R (m)	0.38
TW (m)	5.50
WP (m)	5.74
max d (m)	0.52
mean d (m)	0.39
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	93.83
ff V mean/V*	10.80
ff D_{84}	14.18
ff mean	12.49
SMOOTH BED	

Hydraulic Ratios	
ER max d	2.73
r_c / TW	
TW / Lf_w	1.28
TW/max d	10.6
TW/mean d	14.0

Sediment Transport Mode						high	low	
			w_s (m s^{-1})	P	wash load	sus. load	sus. load	bedload
k	0.41	D_{30}	0.023	0.92	NO	YES	YES	YES
V_* (m s^{-1})	0.061	D_{50}	0.040	1.60	NO	NO	YES	YES
		D_{84}	0.288	11.45	NO	NO	NO	NO

Section Data					
ER_e (m)	0.52	ER stations L / R	-5.00	10.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	5.50	5.50
Lf_e (m)	-0.350	Lf stations L / R	0.40	4.70	
W_{fp} (m)	15.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.52	2.00	
E_g (m m^{-1})	0.0050				

Bedload Transport Data						
	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	94.8	63.2	4.7
B3	0.0024	0.0029	saltation	YES	YES	YES
C3	0.0013	0.0049	rolling	YES	YES	YES
C4	0.0093	0.0128	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.20	0.30	4.00	40.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})				3.88	38.80
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	2.136	Q (cms)	
V (m s^{-1})	0.99	V (m s^{-1})	
n	0.037	n	
Fr	0.51	*Fr*	
D_c rectangular (m)	0.25	D_c rectangular (m)	
D_c trapezoidal (m)	0.43	D_c trapezoidal (m)	
D_c triangular (m)	0.64	D_c triangular (m)	
D_c parabolic (m)	0.39	D_c parabolic (m)	
D_c mean (m)	0.43	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	104.66	Ω (watts m^{-1})	
ω_a (watts m^{-2})	18.23	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	3.31	ω_a/TW (watts m^{-1})	
*Re**	0.4	*Re**	
Re	326309	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds			
τ_{calc} (kg m^{-2})	1.88		
τ_{calc} (N m^{-2})	18.39	V_c / V_b	
τ D_{crit} (gr-co) (mm)	18.96	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.08	0.12	
D_{84} V_c (vcs +) (m s^{-1})	0.31	0.45	

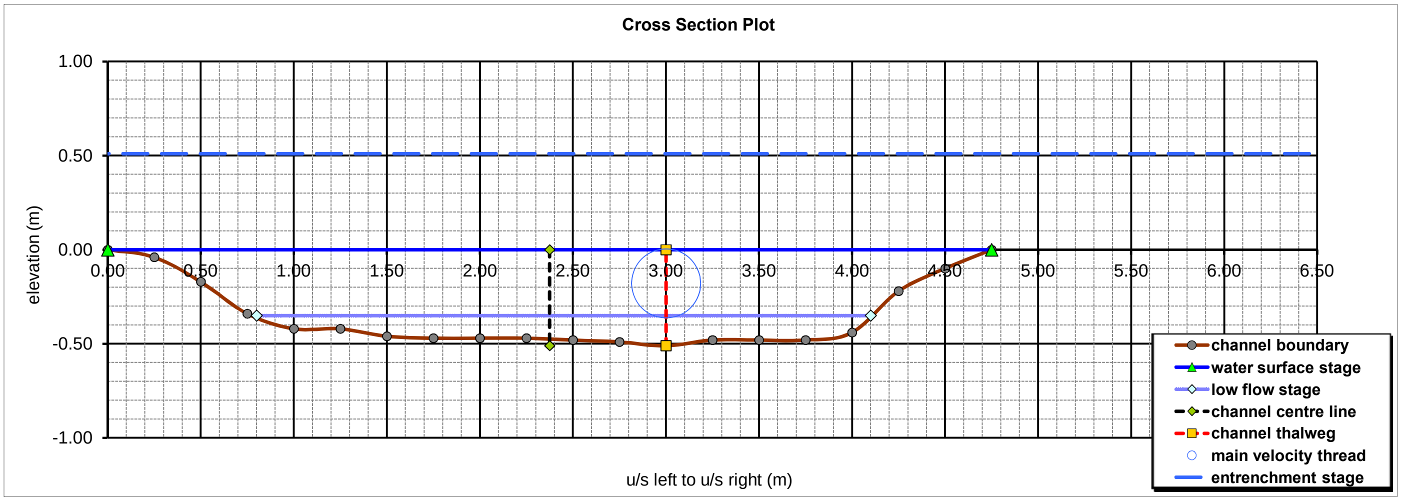
Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
11.6	69.8	18.6	0.0	0.0

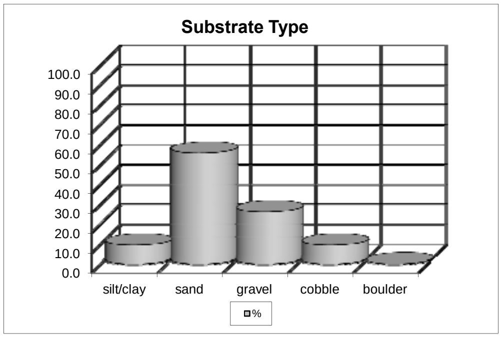
Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres) - Section 5





Morphology Type	
cascade	
step	
riffle	●
run	
glide	
pool	
thalweg out of phase	●

Hydraulic Geometry	
A (m^2)	1.74
R (m)	0.35
TW (m)	4.75
WP (m)	4.99
max d (m)	0.51
mean d (m)	0.37
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	11.59
ff V mean/V*	7.95
ff D_{84}	9.02
ff mean	8.49
SMOOTH BED	

Hydraulic Ratios	
ER max d	1.89
r_c / TW	
TW / Lf_w	1.44
TW/max d	9.3
TW/mean d	13.0

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.023	0.68	YES	YES	YES	YES
V_* (m s^{-1})	0.083	D_{50}	0.071	2.08	NO	NO	YES	YES
		D_{84}	0.803	23.48	NO	NO	NO	NO

Section Data					
ER_e (m)	0.51	ER stations L / R	-2.00	7.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	4.75	4.75
Lf_e (m)	-0.350	Lf stations L / R	0.80	4.10	
W_{fp} (m)	9.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.51	3.00	
E_g (m m^{-1})	0.0100				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	175.7	70.3	1.2
B3	0.0024	0.0026	saltation	YES	YES	NO
C3	0.0013	0.0025	rolling	YES	YES	YES
C4	0.0093	0.0109	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.20	0.50	30.00	150.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})				29.10	145.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	2.138	Q (cms)	
V (m s^{-1})	1.23	V (m s^{-1})	
n	0.040	n	
Fr	0.65	*Fr*	
D_c rectangular (m)	0.28	D_c rectangular (m)	
D_c trapezoidal (m)	0.44	D_c trapezoidal (m)	
D_c triangular (m)	0.64	D_c triangular (m)	
D_c parabolic (m)	0.40	D_c parabolic (m)	
D_c mean (m)	0.44	D_c mean (m)	
flow type	SUBCRICTICAL	flow type	
Ω (watts m^{-1})	209.48	Ω (watts m^{-1})	
ω_a (watts m^{-2})	41.99	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	8.84	ω_a/TW (watts m^{-1})	
*Re**	0.8	*Re**	
Re	375834	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds			
τ_{calc} (kg m^{-2})	3.48		
τ_{calc} (N m^{-2})	34.08	V_c / V_b	
τ D_{crit} (gr-co) (mm)	35.14	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.11	0.13	
D_{84} V_c (vcs +) (m s^{-1})	0.85	0.98	

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
9.3	55.6	25.9	9.3	0.0

Sandy Cove Creek Tributary (Main St., Sandy Cove Acres)
Channel Forming / Bankfull Conditions Cross-Section Models

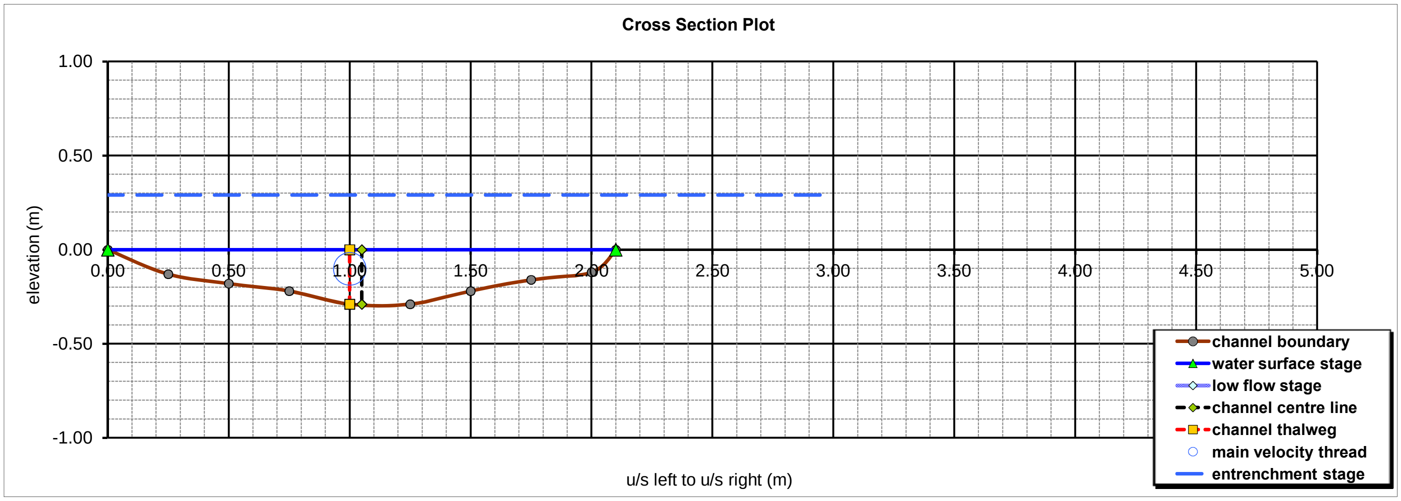
Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

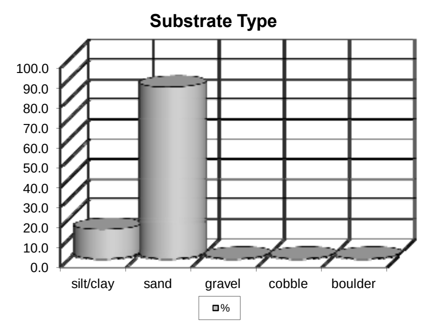
AquaLogic

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres) - Section 1





Morphology Type

cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry

A (m^2)	0.39
R (m)	0.18
TW (m)	2.10
WP (m)	2.23
max d (m)	0.29
mean d (m)	0.19
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr R /D_{84}	707.22
ff V mean/V*	12.15
ff D_{84}	19.22
ff mean	15.68
	SMOOTH BED

Hydraulic Ratios

ER max d	1.90
r_c / TW	
TW / Lf_w	
TW/max d	7.2
TW/mean d	11.2

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.003	0.16	YES	YES	YES	YES
V_* (m s^{-1})	0.046	D_{50}	0.008	0.40	YES	YES	YES	YES
		D_{84}	0.032	1.68	NO	NO	YES	YES

Section Data

					TW ck
ER_e (m)	0.29	ER stations L / R	-1.00	3.00	
WS_e (m)	0.000	WS stations L / R	0.00	2.10	2.10
Lf_e (m)	-0.290	Lf stations L / R	1.00	1.00	
W_{fp} (m)	4.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
$\underline{z}$		T_e (m) $T_{o/s}$ (m)	-0.29	1.00	
E_g (m m^{-1})	0.0060				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	178.6	107.2	42.9
B3	0.0012	0.0018	saltation	YES	YES	YES
C3	0.0000	0.0002	rolling	YES	YES	YES
C4	0.0031	0.0057	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.06	0.10	0.25	0.50
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})					
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} (kg m^{-2})	1.06		
τ_{calc} (N m^{-2})	10.40		
τ D_{crit} (gr-co) (mm)	10.72		
D_{50} V_c (vcs +) (m s^{-1})	0.05	0.13	
D_{84} V_c (vcs +) (m s^{-1})	0.08	0.21	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Flow Regime Strickler method

Q (cms)	0.212
V (m s^{-1})	0.54
n	0.045
Fr	0.40
D_c rectangular (m)	0.10
D_c trapezoidal (m)	0.17
D_c triangular (m)	0.25
D_c parabolic (m)	0.15
D_c mean (m)	0.17
flow type	SUBCRITICAL
Ω (watts m^{-1})	12.47
ω_a (watts m^{-2})	5.60
ω_a/TW (watts m^{-1})	2.67
*Re**	0.2
Re	83612
turbulence	LOW

Flow Regime Limerinos method

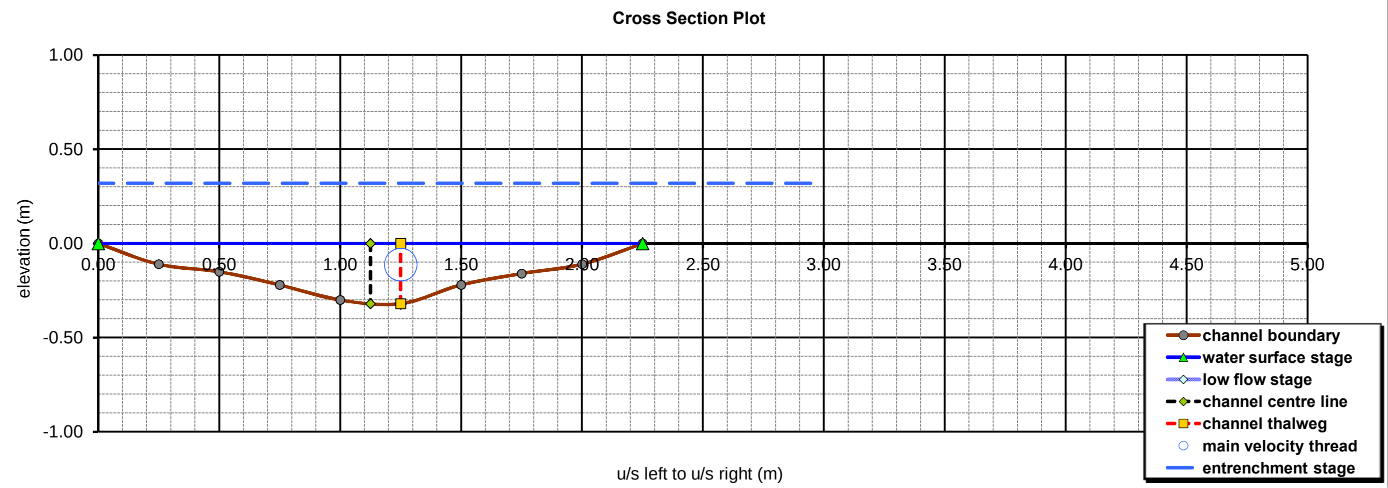
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

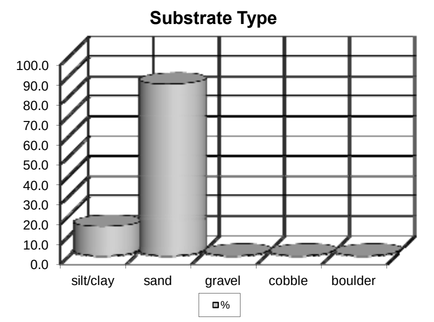
B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres) - Section 2

Cross Section Plot



Substrate Type



Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.40
R (m)	0.17
TW (m)	2.25
WP (m)	2.35
max d (m)	0.32
mean d (m)	0.18
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	675.55
ff V mean/V*	12.82
ff D_{84}	19.07
ff mean	15.95
SMOOTH BED	

Hydraulic Ratios	
ER max d	1.78
r_c / TW	
TW / Lf_w	
TW/max d	7.0
TW/mean d	12.7

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.003	0.20	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.037	D_{50}	0.008	0.50	YES	YES	YES	YES
		D_{84}	0.032	2.11	NO	NO	YES	YES

Section Data					
ER_e (m)	0.32	ER stations L / R	-1.00	3.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.25	2.25
Lf_e (m)	-0.320	Lf stations L / R	1.25	1.25	
W_{fp} (m)	4.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.32	1.25	
E_g ($m\ m^{-1}$)	0.0040				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	113.8	68.3	27.3
B3	0.0012	0.0016	saltation	YES	YES	YES
C3	0.0000	0.0001	rolling	YES	YES	YES
C4	0.0032	0.0052	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.06	0.10	0.25	0.50
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)					
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.218	Q (cms)	
V ($m\ s^{-1}$)	0.55	V ($m\ s^{-1}$)	
n	0.035	n	
Fr	0.42	*Fr*	
D_c rectangular (m)	0.10	D_c rectangular (m)	
D_c trapezoidal (m)	0.17	D_c trapezoidal (m)	
D_c triangular (m)	0.25	D_c triangular (m)	
D_c parabolic (m)	0.15	D_c parabolic (m)	
D_c mean (m)	0.17	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	8.55	Ω (watts m^{-1})	
ω_a (watts m^{-2})	3.63	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.61	ω_a/TW (watts m^{-1})	
*Re**	0.2	*Re**	
Re	81309	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds		V_c / V_b Strickler	V_c / V_b Limerinos
τ_{calc} ($kg\ m^{-2}$)	0.68		
τ_{calc} ($N\ m^{-2}$)	6.62		
τ D_{crit} (gr-co) (mm)	6.83		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.05	0.13	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.08	0.20	

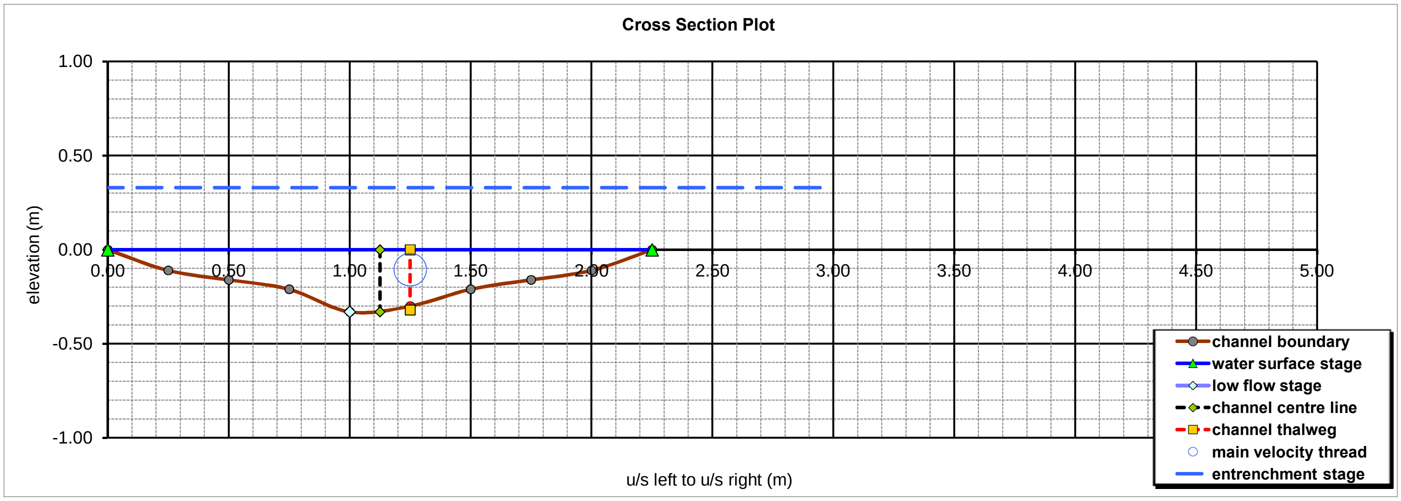
Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

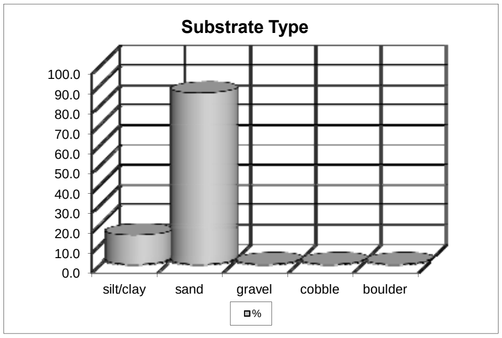
Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres) - Section 3





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.40
R (m)	0.17
TW (m)	2.25
WP (m)	2.36
max d (m)	0.33
mean d (m)	0.18
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	673.48
ff V mean/V*	12.81
ff D_{84}	19.07
ff mean	15.94
SMOOTH BED	

Hydraulic Ratios	
ER max d	1.78
r_c / TW	
TW / Lf_w	#DIV/0!
TW/max d	6.8
TW/mean d	12.7

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.003	0.20	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.037	D_{50}	0.008	0.50	YES	YES	YES	YES
		D_{84}	0.032	2.11	NO	NO	YES	YES

Section Data					
ER_e (m)	0.33	ER stations L / R	-1.00	3.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.25	2.25
Lf_e (m)	-0.330	Lf stations L / R	1.00	1.00	
W_{fp} (m)	4.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		*T* e (m) *T* o/s (m)	-0.32	1.25	
E_g ($m\ m^{-1}$)	0.0040				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	113.4	68.0	27.2
B3	0.0012	0.0016	saltation	YES	YES	YES
C3	0.0000	0.0001	rolling	YES	YES	YES
C4	0.0032	0.0051	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.06	0.10	0.25	0.50
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)					
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.218	Q (cms)	
V ($m\ s^{-1}$)	0.55	V ($m\ s^{-1}$)	
n	0.035	n	
Fr	0.42	*Fr*	
D_c rectangular (m)	0.10	D_c rectangular (m)	
D_c trapezoidal (m)	0.17	D_c trapezoidal (m)	
D_c triangular (m)	0.25	D_c triangular (m)	
D_c parabolic (m)	0.15	D_c parabolic (m)	
D_c mean (m)	0.17	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	8.53	Ω (watts m^{-1})	
ω_a (watts m^{-2})	3.62	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.61	ω_a/TW (watts m^{-1})	
*Re**	0.2	*Re**	
Re	80894	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds		V_c / V_b Strickler	V_c / V_b Limerinos
τ_{calc} ($kg\ m^{-2}$)	0.67		
τ_{calc} ($N\ m^{-2}$)	6.60		
τ D_{crit} (gr-co) (mm)	6.80		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.05	0.13	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.08	0.20	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Cooks Bay Tributary A (Moosenlanka Rd., Sandy Cove Acres)
Channel Forming / Bankfull Conditions Cross-Section Models

Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

AquaLogic

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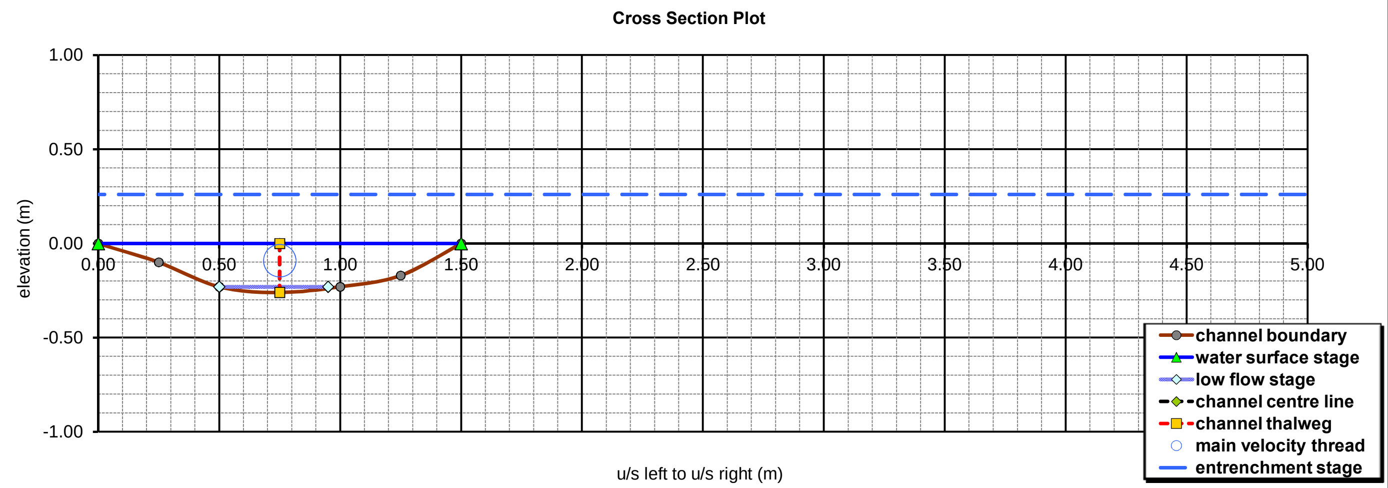
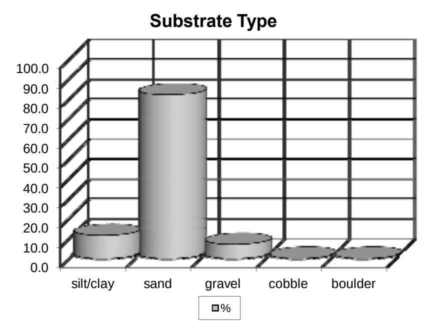
Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary A (Moosenlanka Rd., Sandy Cove Acres) - Section 1





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.25
R (m)	0.15
TW (m)	1.50
WP (m)	1.61
max d (m)	0.26
mean d (m)	0.17
E$_{s\ (Limerinos)}$ (m) [+]	
E$_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D$_{84}$	153.34
ff V mean/V*	10.57
ff D$_{84}$	15.47
ff mean	13.02
SMOOTH BED	

Hydraulic Ratios	
ER max d	13.33
r$_c$ / TW	
TW / Lf$_w$	3.33
TW/max d	5.8
TW/mean d	9.1

Sediment Transport Mode			w$_s$ (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D$_{30}$	0.008	0.37	YES	YES	YES	YES
V$_*$ (m s^{-1})	0.050	D$_{50}$	0.023	1.14	NO	YES	YES	YES
		D$_{84}$	0.126	6.21	NO	NO	NO	YES

Section Data					
ER$_e$ (m)	0.26	ER stations L / R	-10.00	10.00	TW ck
WS$_e$ (m)	0.000	WS stations L / R	0.00	1.50	1.50
Lf$_e$ (m)	-0.230	Lf stations L / R	0.50	0.95	
W$_{fp}$ (m)	20.00	E$_s$ sta. $_{(Limerinos)}$ L / R			
r$_c$ (m)		E$_s$ sta. $_{(Strickler)}$ L / R			
z		*T* $_e$ (m) *T* $_{o/s}$ (m)	-0.26	0.75	
E$_g$ (m m^{-1})	0.0080				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen	Q$_{sb}$	Q$_{sb}$		D$_{30}$	D$_{50}$	D$_{84}$
type	(kg sec^{-1})	(kg sec^{-1})	*T* $_*$	123.9	62.0	12.4
B3	0.0011	0.0015	saltation	YES	YES	YES
C3	0.0000	0.0001	rolling	YES	YES	YES
C4	0.0027	0.0043	Ø	NO	NO	NO

Substrate Gradation	D$_{15}$	D$_{30}$	D$_{50}$	D$_{84}$	D$_{100}$
Existing Conditions (mm)	0.03	0.10	0.20	1.00	15.00
Stability Design Targets (mm)					
τ$_{cr}$ (N m^{-2})				0.97	14.55
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.158	Q (cms)	
V (m s^{-1})	0.64	V (m s^{-1})	
n	0.040	n	
Fr	0.50	*Fr*	
D$_c$ rectangular (m)	0.11	D$_c$ rectangular (m)	
D$_c$ trapezoidal (m)	0.15	D$_c$ trapezoidal (m)	
D$_c$ triangular (m)	0.22	D$_c$ triangular (m)	
D$_c$ parabolic (m)	0.13	D$_c$ parabolic (m)	
D$_c$ mean (m)	0.15	D$_c$ mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	12.35	Ω (watts m^{-1})	
ω$_a$ (watts m^{-2})	7.65	ω$_a$ (watts m^{-2})	
ω$_a$/TW (watts m^{-1})	5.10	ω$_a$/TW (watts m^{-1})	
Re *	0.4	*Re* *	
Re	85631	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds		V$_c$ / V$_b$	
τ$_{calc}$ (kg m^{-2})	1.23		
τ$_{calc}$ (N m^{-2})	12.02		
τ D$_{crit}$ (gr-co) (mm)	12.39	Strickler	Limerinos
D$_{50}$ V$_c$ (vcs +) (m s^{-1})	0.07	0.16	
D$_{84}$ V$_c$ (vcs +) (m s^{-1})	0.16	0.35	

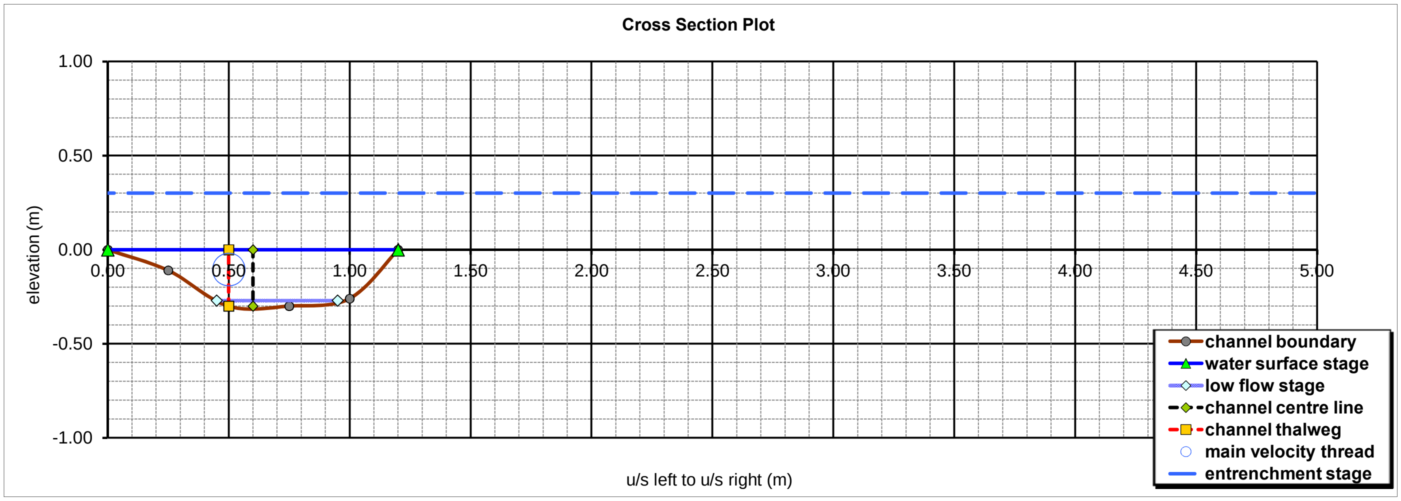
Bank Data	u/s L	u/s R
H$_b$ (m)		
Bf$_d$ (m)		
RDp (m)		
H$_b$/Bf$_d$		
RDp/H$_b$		
RDn (%)		
BA (°)		
BFP (%)		

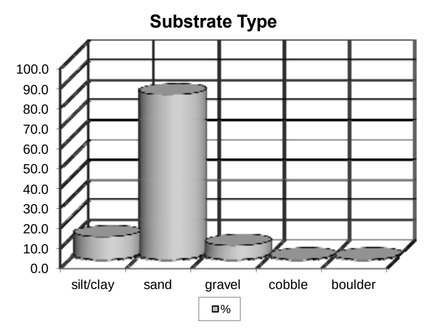
Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
11.4	81.8	6.8	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary A (Moosenlanka Rd., Sandy Cove Acres) - Section 2





Morphology Type

cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry

A (m^2)	0.24
R (m)	0.17
TW (m)	1.20
WP (m)	1.42
max d (m)	0.30
mean d (m)	0.20
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr *R* /D_{84}	166.39
ff V mean/V*	10.71
ff D_{84}	15.90
ff mean	13.31
	SMOOTH BED

Hydraulic Ratios

ER max d	16.67
r_c / TW	
TW / Lf_w	2.40
TW/max d	4.0
TW/mean d	6.1

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.36	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.052	D_{50}	0.023	1.10	NO	YES	YES	YES
		D_{84}	0.126	5.96	NO	NO	NO	YES

Section Data

ER_e (m)	0.30	ER stations L / R	-10.00	10.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	1.20	1.20
Lf_e (m)	-0.270	Lf stations L / R	0.45	0.95	
W_{fp} (m)	20.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		*T* e (m) *T* o/s (m)	-0.30	0.50	
E_g ($m\ m^{-1}$)	0.0080				

Bedload Transport Data

	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	134.5	67.2	13.4
B3	0.0011	0.0015	saltation	YES	YES	YES
C3	0.0000	0.0001	rolling	YES	YES	YES
C4	0.0027	0.0043	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	1.00	8.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				0.97	7.76
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method

Q (cms)	0.159
V ($m\ s^{-1}$)	0.67
n	0.040
Fr	0.48
D_c rectangular (m)	0.12
D_c trapezoidal (m)	0.16
D_c triangular (m)	0.22
D_c parabolic (m)	0.13
D_c mean (m)	0.16
flow type	SUBCRITICAL
Ω (watts m^{-1})	12.44
ω_a (watts m^{-2})	8.77
ω_a/TW (watts m^{-1})	7.31
*Re**	0.4
Re	98145
turbulence	LOW

Flow Regime Limerinos method

Q (cms)	
V ($m\ s^{-1}$)	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

Erosion Thresholds

		V_c / V_b	
		Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	1.33		
τ_{calc} ($N\ m^{-2}$)	13.05		
τ D_{crit} (gr-co) (mm)	13.45		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.07	0.15	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.16	0.33	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
11.1	82.2	6.7	0.0	0.0

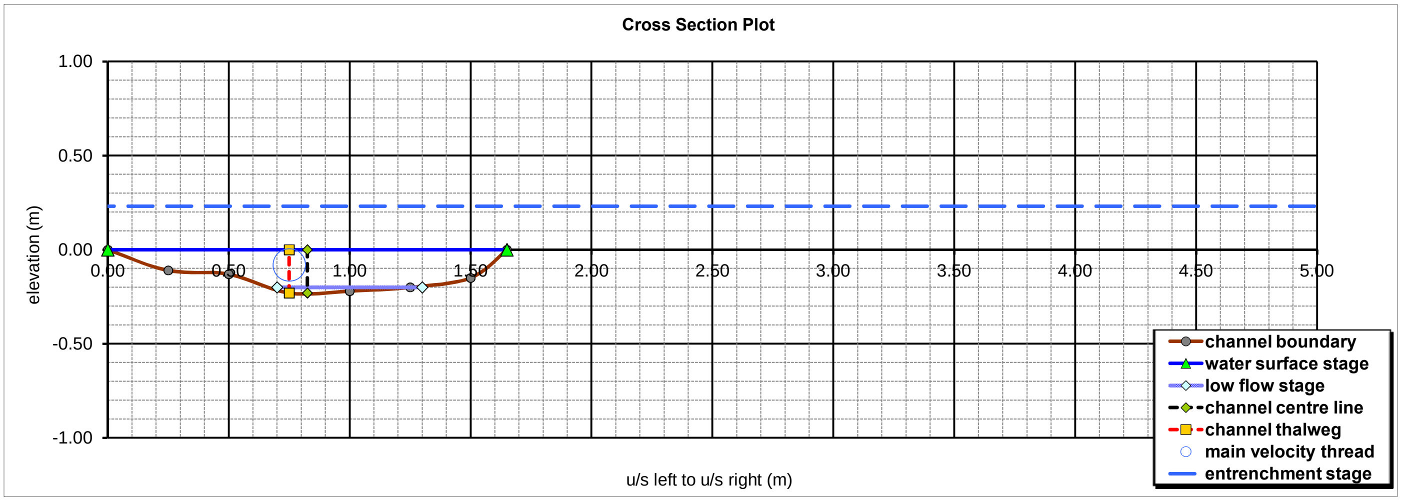
Bank Data u/s L u/s R

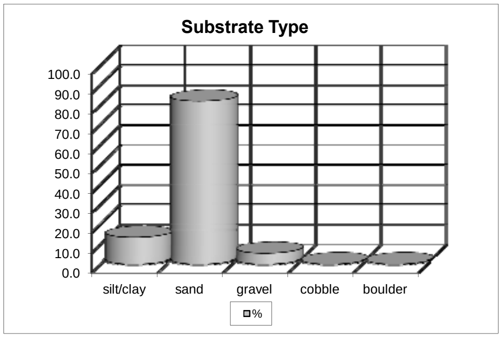
	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary A (Moosenlanka Rd., Sandy Cove Acres) - Section 3





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.25
R (m)	0.14
TW (m)	1.65
WP (m)	1.76
max d (m)	0.23
mean d (m)	0.15
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	358.41
ff V mean/V*	11.54
ff D_{84}	17.55
ff mean	14.55
	SMOOTH BED

Hydraulic Ratios	
ER max d	12.12
r_c / TW	
TW / Lf_w	2.75
TW/max d	7.2
TW/mean d	10.8

Sediment Transport Mode						high	low	
			w_s ($m\ s^{-1}$)	P	wash load	sus. load	sus. load	bedload
k	0.41	D_{30}	0.008	0.38	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.048	D_{50}	0.023	1.18	NO	YES	YES	YES
		D_{84}	0.056	2.87	NO	NO	NO	YES

Section Data					
ER_e (m)	0.23	ER stations L / R	-10.00	10.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	1.65	1.65
Lf_e (m)	-0.200	Lf stations L / R	0.70	1.30	
W_{fp} (m)	20.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.23	0.75	
E_g ($m\ m^{-1}$)	0.0080				

Bedload Transport Data						
	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	($kg\ sec^{-1}$)	($kg\ sec^{-1}$)	T_*	115.9	57.9	29.0
B3	0.0011	0.0015	saltation	YES	YES	YES
C3	0.0000	0.0001	rolling	YES	YES	YES
C4	0.0027	0.0045	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	0.40	25.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				0.39	24.25
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	0.154	Q (cms)	
V ($m\ s^{-1}$)	0.61	V ($m\ s^{-1}$)	
n	0.040	n	
Fr	0.50	*Fr*	
D_c rectangular (m)	0.10	D_c rectangular (m)	
D_c trapezoidal (m)	0.15	D_c trapezoidal (m)	
D_c triangular (m)	0.22	D_c triangular (m)	
D_c parabolic (m)	0.13	D_c parabolic (m)	
D_c mean (m)	0.15	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω ($watts\ m^{-1}$)	12.05	Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	6.84	ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	4.15	ω_a/TW ($watts\ m^{-1}$)	
*Re**	0.4	*Re**	
Re	76529	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds			
τ_{calc} ($kg\ m^{-2}$)	1.15		
τ_{calc} ($N\ m^{-2}$)	11.24	V_c / V_b	
$\tau\ D_{crit}$ (gr-co) (mm)	11.59	Strickler	Limerinos
$D_{50}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.07	0.16	
$D_{84}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.10	0.23	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
13.2	81.6	5.3	0.0	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Moosenlanka Creek (25 SR, Sandy Cove Acres)
Channel Forming / Bankfull Conditions Cross-Section Models

Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

AquaLogic

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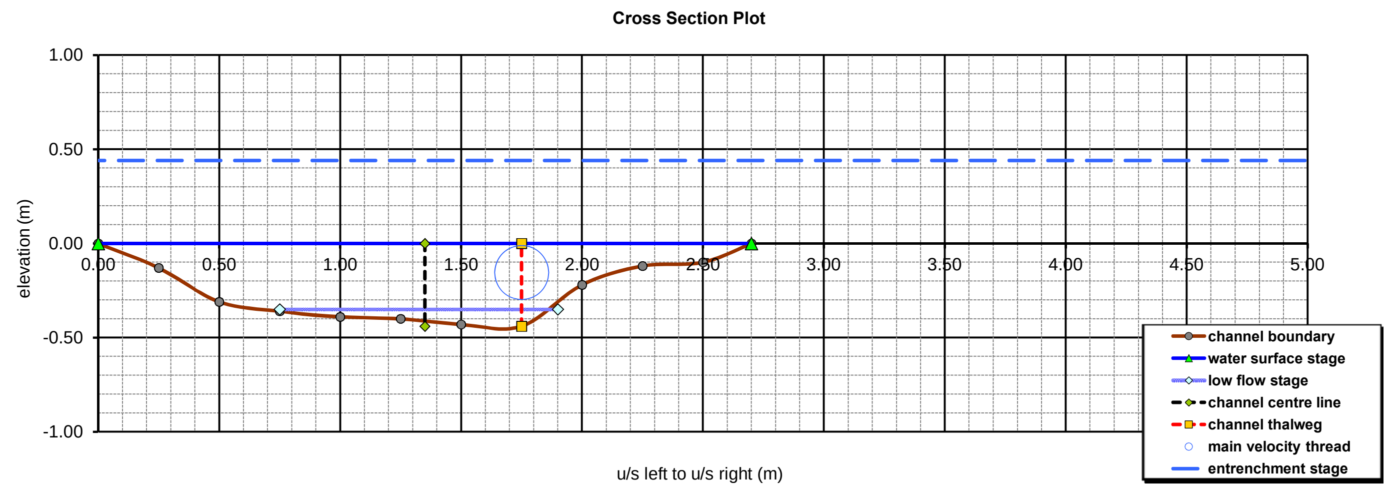
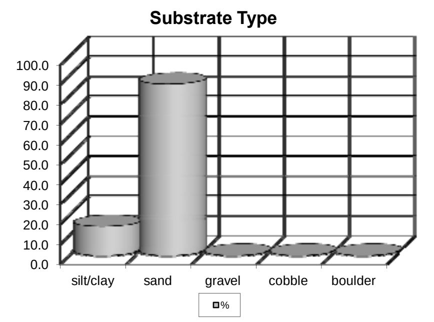
Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Moosenlanka Creek (25 SR, Sandy Cove Acres) - Section 1





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.72
R (m)	0.25
TW (m)	2.70
WP (m)	2.93
max d (m)	0.44
mean d (m)	0.27
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	493.94
ff V mean/V*	11.90
ff D_{84}	18.38
ff mean	15.14
SMOOTH BED	

Hydraulic Ratios	
ER max d	7.41
r_c / TW	
TW / Lf_w	2.35
TW/max d	6.1
TW/mean d	10.1

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.28	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.067	D_{50}	0.023	0.85	NO	YES	YES	YES
		D_{84}	0.071	2.60	NO	NO	NO	YES

Section Data					
ER_e (m)	0.44	ER stations L / R	-10.00	10.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.70	2.70
Lf_e (m)	-0.350	Lf stations L / R	0.75	1.90	
W_{fp} (m)	20.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.44	1.75	
E_g ($m\ m^{-1}$)	0.0090				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	($kg\ sec^{-1}$)	($kg\ sec^{-1}$)	T_*	224.6	112.3	44.9
B3	0.0016	0.0023	saltation	YES	YES	YES
C3	0.0001	0.0011	rolling	YES	YES	YES
C4	0.0051	0.0089	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	0.50	1.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)					0.97
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.597	Q (cms)	
V ($m\ s^{-1}$)	0.83	V ($m\ s^{-1}$)	
n	0.045	n	
Fr	0.51	*Fr*	
D_c rectangular (m)	0.17	D_c rectangular (m)	
D_c trapezoidal (m)	0.26	D_c trapezoidal (m)	
D_c triangular (m)	0.38	D_c triangular (m)	
D_c parabolic (m)	0.23	D_c parabolic (m)	
D_c mean (m)	0.26	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω ($watts\ m^{-1}$)	52.64	Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	17.99	ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	6.66	ω_a/TW ($watts\ m^{-1}$)	
*Re**	0.4	*Re**	
Re	178945	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds		V_c / V_b	
		Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	2.22		
τ_{calc} ($N\ m^{-2}$)	21.78		
τ D_{crit} (gr-co) (mm)	22.46		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.07	0.12	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.11	0.19	

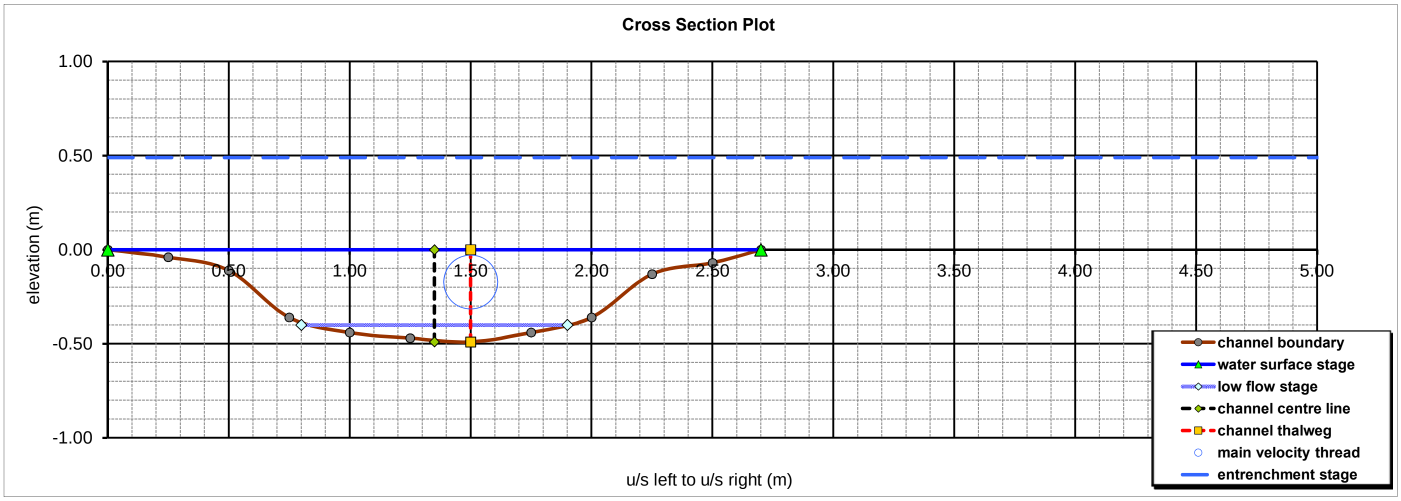
Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

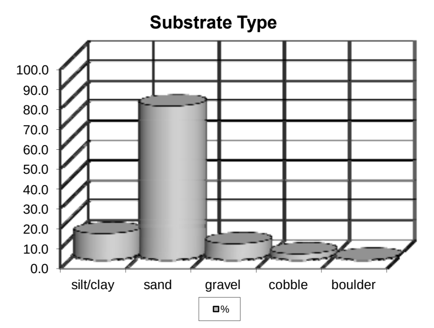
Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Moosenlanka Creek (25 SR, Sandy Cove Acres) - Section 2





Morphology Type

cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry

A (m^2)	0.73
R (m)	0.25
TW (m)	2.70
WP (m)	2.96
max d (m)	0.49
mean d (m)	0.27
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr R/D_{84}	245.39
ff V mean/V*	11.06
ff D_{84}	16.68
ff mean	13.87
	SMOOTH BED

Hydraulic Ratios

ER max d	7.04
r_c / TW	
TW / Lf_w	2.45
TW/max d	5.5
TW/mean d	10.0

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.28	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.066	D_{50}	0.023	0.85	NO	YES	YES	YES
		D_{84}	0.126	4.63	NO	NO	NO	YES

Section Data

ER_e (m)	0.49	ER stations L / R	-4.00	15.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.70	2.70
Lf_e (m)	-0.400	Lf stations L / R	0.80	1.90	
W_{fp} (m)	19.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.49	1.50	
E_g ($m\ m^{-1}$)	0.0090				

Bedload Transport Data

	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	223.1	111.6	22.3
B3	0.0016	0.0022	saltation	YES	YES	YES
C3	0.0001	0.0009	rolling	YES	YES	YES
C4	0.0051	0.0085	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	1.00	70.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				0.97	67.90
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method / Flow Regime Limerinos method

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.597	Q (cms)	
V ($m\ s^{-1}$)	0.82	V ($m\ s^{-1}$)	
n	0.045	n	
Fr	0.51	*Fr*	
D_c rectangular (m)	0.17	D_c rectangular (m)	
D_c trapezoidal (m)	0.26	D_c trapezoidal (m)	
D_c triangular (m)	0.38	D_c triangular (m)	
D_c parabolic (m)	0.23	D_c parabolic (m)	
D_c mean (m)	0.26	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	52.65	Ω (watts m^{-1})	
ω_a (watts m^{-2})	17.80	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	6.59	ω_a/TW (watts m^{-1})	
*Re**	0.4	*Re**	
Re	177034	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b	
		Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	2.21		
τ_{calc} ($N\ m^{-2}$)	21.64		
τ D_{crit} (gr-co) (mm)	22.31		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.07	0.12	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.16	0.27	

Bank Data u/s L u/s R

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

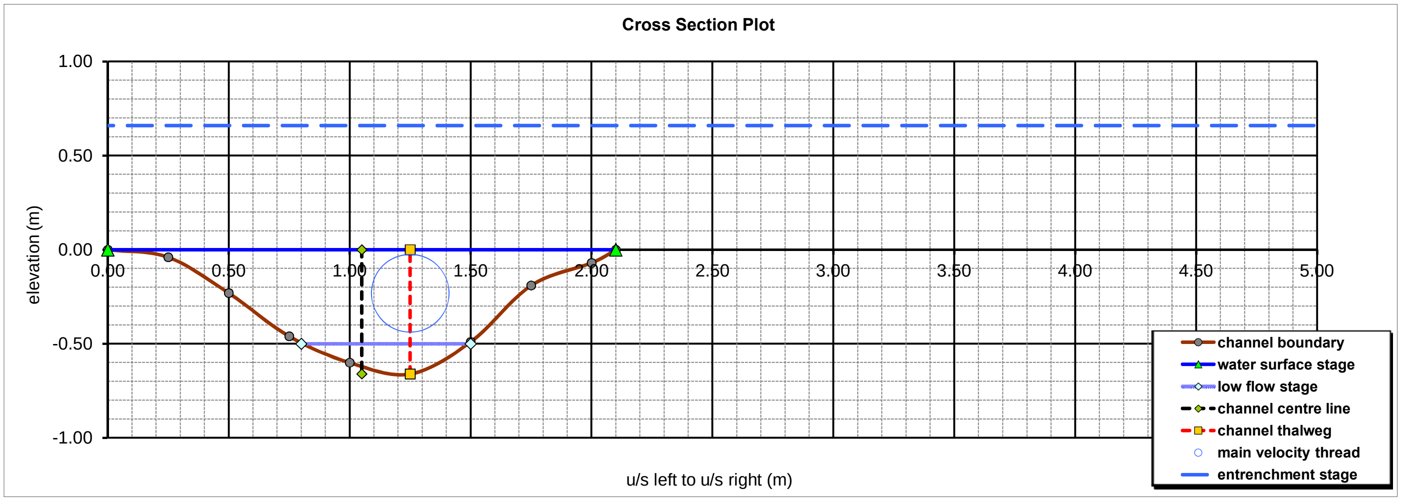
Substrate Type (%)

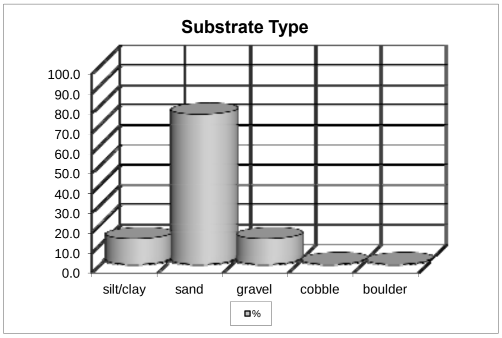
silt/clay	sand	gravel	cobble	boulder
12.8	76.9	7.7	2.6	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Moosenlanka Creek (25 SR, Sandy Cove Acres) - Section 3





Morphology Type

cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry

A (m^2)	0.68
R (m)	0.27
TW (m)	2.10
WP (m)	2.54
max d (m)	0.66
mean d (m)	0.32
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr *R* /D_{84}	267.33
ff V mean/V*	11.19
ff D_{84}	17.14
ff mean	14.16
	SMOOTH BED

Hydraulic Ratios

ER max d	5.71
r_c / TW	
TW / Lf_w	3.00
TW/max d	3.2
TW/mean d	6.5

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.26	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.069	D_{50}	0.032	1.12	NO	YES	YES	YES
		D_{84}	0.126	4.44	NO	NO	NO	YES

Section Data

ER_e (m)	0.66	ER stations L / R	-2.00	10.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.10	2.10
Lf_e (m)	-0.500	Lf stations L / R	0.80	1.50	
W_{fp} (m)	12.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.66	1.25	
E_g ($m\ m^{-1}$)	0.0090				

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.25	1.00	40.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				0.97	38.80
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	2.41		
τ_{calc} ($N\ m^{-2}$)	23.58		
$\tau\ D_{crit}$ (gr-co) (mm)	24.31		
$D_{50}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.08	0.13	
$D_{84}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.16	0.25	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
12.5	75.0	12.5	0.0	0.0

Bank Data u/s L u/s R

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} ($kg\ sec^{-1}$)	Limerinos Q Q_{sb} ($kg\ sec^{-1}$)
B3	0.0016	0.0022
C3	0.0001	0.0009
C4	0.0051	0.0085

	D_{30}	D_{50}	D_{84}
T_*	243.1	97.2	24.3
saltation	YES	YES	YES
rolling	YES	YES	YES
Ø	NO	NO	NO

Flow Regime Strickler method

Q (cms)	0.592
V ($m\ s^{-1}$)	0.87
n	0.045
Fr	0.49
D_c rectangular (m)	0.20
D_c trapezoidal (m)	0.27
D_c triangular (m)	0.38
D_c parabolic (m)	0.22
D_c mean (m)	0.27
flow type	SUBCRITICAL
Ω ($watts\ m^{-1}$)	52.22
ω_a ($watts\ m^{-2}$)	20.54
ω_a/TW ($watts\ m^{-1}$)	9.78
*Re**	0.5
Re	204256
turbulence	LOW

Flow Regime Limerinos method

Q (cms)	
V ($m\ s^{-1}$)	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	
*Re**	
Re	
turbulence	

Carson Creek (Ewart St., Lefroy)
Channel Forming / Bankfull Conditions Cross-Section Models

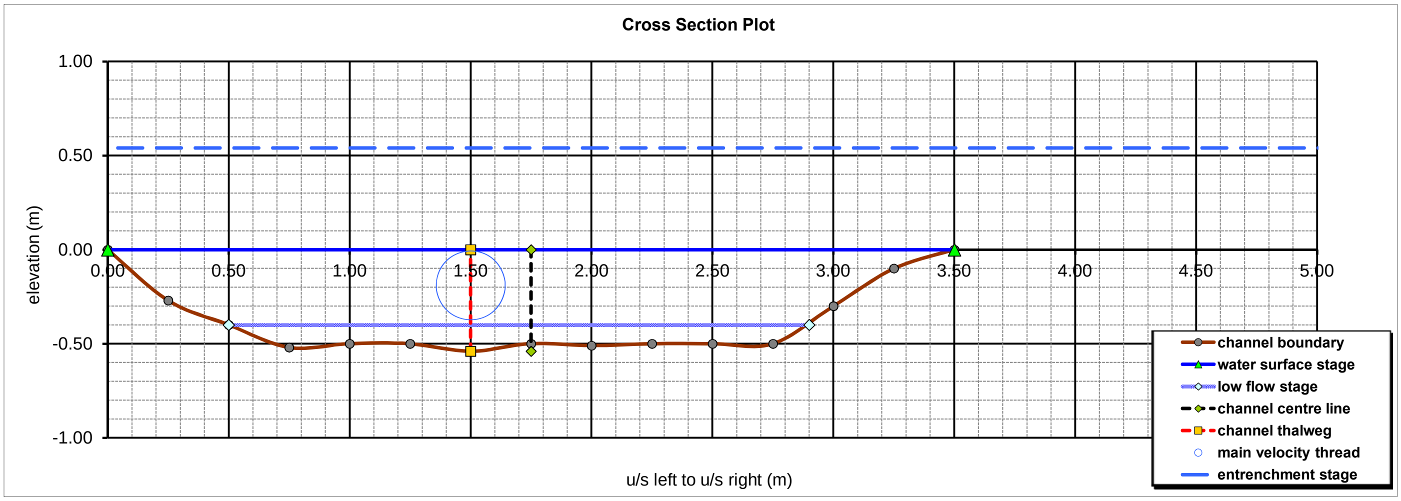
Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

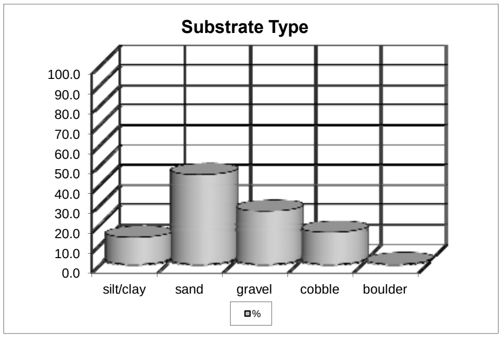
AquaLogic

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Carson Creek (Ewart St., Lefroy) - Section 1





Morphology Type

cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry

A (m^2)	1.41
R (m)	0.37
TW (m)	3.50
WP (m)	3.84
max d (m)	0.54
mean d (m)	0.40
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr *R* /D_{84}	6.11
ff V mean/V*	6.87
ff D_{84}	7.54
ff mean	7.21
ROUGH BED	

Hydraulic Ratios

ER max d	3.14
r_c / TW	
TW / Lf_w	1.46
TW/max d	6.5
TW/mean d	8.7

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.023	0.93	NO	YES	YES	YES
V_* (m s^{-1})	0.061	D_{50}	0.071	2.86	NO	NO	NO	YES
		D_{84}	1.137	45.77	NO	NO	NO	NO

Section Data

ER_e (m)	0.54	ER stations L / R	-3.00	8.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.50	3.50
Lf_e (m)	-0.400	Lf stations L / R	0.50	2.90	
W_{fp} (m)	11.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		*T* $_e$ (m) *T* $_{o/s}$ (m)	-0.54	1.50	
E_g (m m^{-1})	0.0050				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})
B3	0.0020	0.0021
C3	0.0004	0.0006
C4	0.0069	0.0078

	D_{30}	D_{50}	D_{84}
T_*	92.6	37.1	0.3
saltation	YES	YES	NO
rolling	YES	YES	NO
Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.20	0.50	60.00	150.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})				58.20	145.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method

Q (cms)	1.131
V (m s^{-1})	0.80
n	0.045
Fr	0.40
D_c rectangular (m)	0.22
D_c trapezoidal (m)	0.33
D_c triangular (m)	0.49
D_c parabolic (m)	0.29
D_c mean (m)	0.33
flow type	SUBCRITICAL
Ω (watts m^{-1})	55.44
ω_a (watts m^{-2})	14.42
ω_a/TW (watts m^{-1})	4.12
*Re**	0.9
Re	258191
turbulence	LOW

Flow Regime Limerinos method

Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

Erosion Thresholds

τ_{calc} (kg m^{-2})	1.83		
τ_{calc} (N m^{-2})	17.97	*V* $_c$ / *V* $_b$	
τ D_{crit} (gr-co) (mm)	18.53	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.11	0.20	
D_{84} V_c (vcs +) (m s^{-1})	1.20	2.14	

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

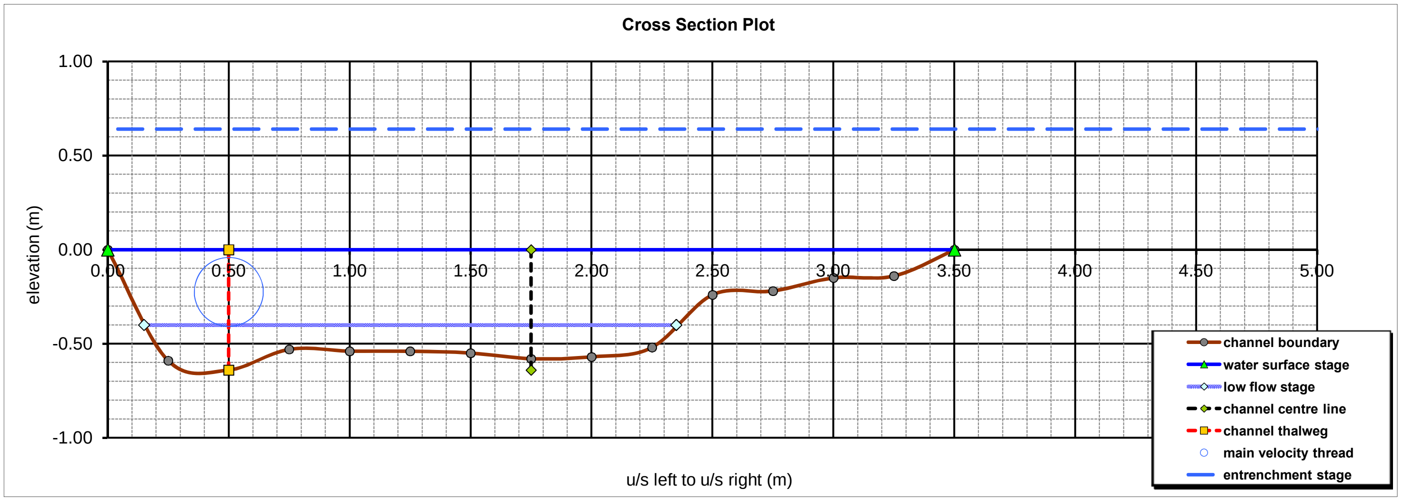
Substrate Type (%)

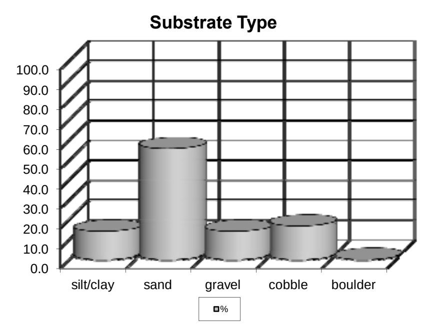
silt/clay	sand	gravel	cobble	boulder
13.2	44.7	26.3	15.8	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Carson Creek (Ewart St., Lefroy) - Section 2





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.45
R (m)	0.35
TW (m)	3.50
WP (m)	4.10
max d (m)	0.64
mean d (m)	0.42
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	3.94
ff V mean/V*	6.37
ff D_{84}	6.61
ff mean	6.49
ROUGH BED	

Hydraulic Ratios	
ER max d	3.14
r_c / TW	
TW / Lf_w	1.59
TW/max d	5.5
TW/mean d	8.4

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.023	0.95	NO	YES	YES	YES
V_* ($m\ s^{-1}$)	0.060	D_{50}	0.071	2.91	NO	NO	NO	YES
		D_{84}	1.393	57.03	NO	NO	NO	NO

Section Data					
ER_e (m)	0.64	ER stations L / R	-3.00	8.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.50	3.50
Lf_e (m)	-0.400	Lf stations L / R	0.15	2.35	
W_{fp} (m)	11.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.64	0.50	
E_g ($m\ m^{-1}$)	0.0050				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	89.5	35.8	0.2
B3	0.0020	0.0021	saltation	YES	YES	NO
C3	0.0004	0.0005	rolling	YES	YES	NO
C4	0.0069	0.0074	Ø	NO	NO	YES

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.20	0.50	90.00	110.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				87.30	106.70
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	1.139	Q (cms)	
V ($m\ s^{-1}$)	0.78	V ($m\ s^{-1}$)	
n	0.045	n	
Fr	0.39	*Fr*	
D_c rectangular (m)	0.22	D_c rectangular (m)	
D_c trapezoidal (m)	0.33	D_c trapezoidal (m)	
D_c triangular (m)	0.49	D_c triangular (m)	
D_c parabolic (m)	0.28	D_c parabolic (m)	
D_c mean (m)	0.33	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	55.81	Ω (watts m^{-1})	
ω_a (watts m^{-2})	13.62	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	3.89	ω_a/TW (watts m^{-1})	
*Re**	0.9	*Re**	
Re	243770	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds		V_c / V_b	
τ_{calc} ($kg\ m^{-2}$)	1.77		
τ_{calc} ($N\ m^{-2}$)	17.36	Strickler	Limerinos
τ D_{crit} (gr-co) (mm)	17.90		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.11	0.20	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	1.47	2.68	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
13.9	55.6	13.9	16.7	0.0

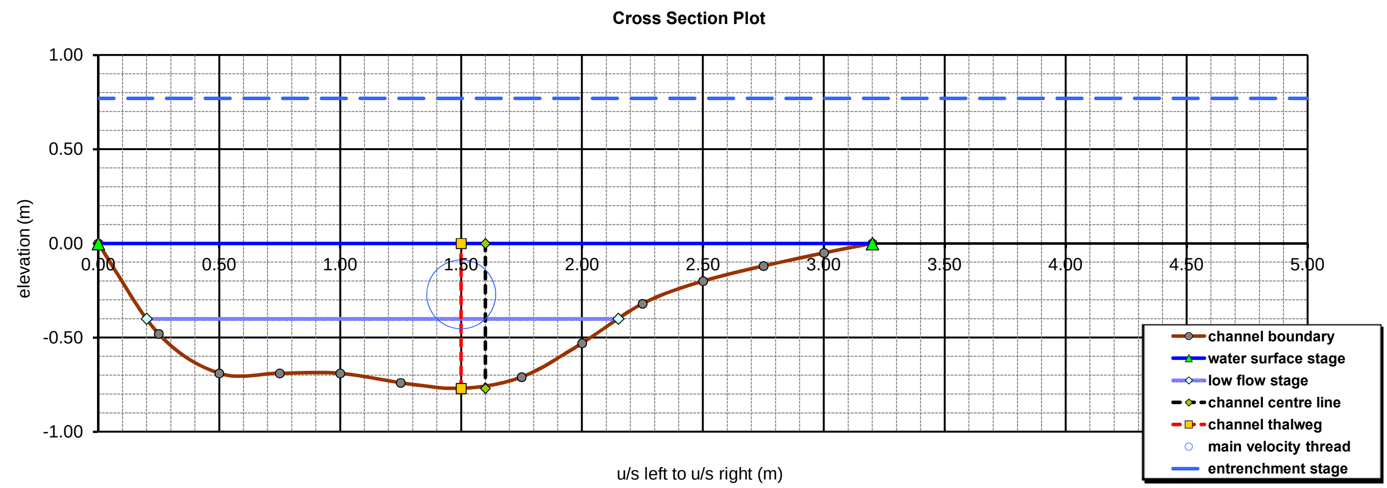
Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

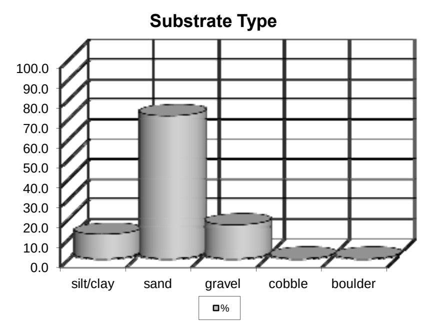
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

AquaLogic

B. de Geus 05.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Carson Creek (Ewart St., Lefroy) - Section 3





Morphology Type	
cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.50
R (m)	0.40
TW (m)	3.20
WP (m)	3.77
max d (m)	0.77
mean d (m)	0.47
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R /D_{84}	39.67
ff V mean/V*	9.17
ff D_{84}	12.35
ff mean	10.76
SMOOTH BED	

Hydraulic Ratios	
ER max d	6.25
r_c / TW	
TW / Lf_w	1.64
TW/max d	4.2
TW/mean d	6.8

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.023	1.00	NO	YES	YES	YES
V_* ($m\ s^{-1}$)	0.056	D_{50}	0.032	1.38	NO	NO	YES	YES
		D_{84}	0.462	19.99	NO	NO	NO	NO

Section Data					
ER_e (m)	0.77	ER stations L / R	-5.00	15.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.20	3.20
Lf_e (m)	-0.400	Lf stations L / R	0.20	2.15	
W_{fp} (m)	20.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.77	1.50	
E_g ($m\ m^{-1}$)	0.0040				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	($kg\ sec^{-1}$)	($kg\ sec^{-1}$)	T_*	80.2	64.1	1.6
B3	0.0020	0.0024	saltation	YES	YES	NO
C3	0.0004	0.0015	rolling	YES	YES	YES
C4	0.0069	0.0096	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.20	0.25	10.00	60.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				9.70	58.20
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	1.132	Q (cms)	
V ($m\ s^{-1}$)	0.76	V ($m\ s^{-1}$)	
n	0.045	n	
Fr	0.35	*Fr*	
D_c rectangular (m)	0.24	D_c rectangular (m)	
D_c trapezoidal (m)	0.33	D_c trapezoidal (m)	
D_c triangular (m)	0.49	D_c triangular (m)	
D_c parabolic (m)	0.27	D_c parabolic (m)	
D_c mean (m)	0.33	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω ($watts\ m^{-1}$)	44.37	Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	11.76	ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	3.68	ω_a/TW ($watts\ m^{-1}$)	
*Re**	0.4	*Re**	
Re	263245	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds		V_c / V_b	
		Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	1.59		
τ_{calc} ($N\ m^{-2}$)	15.55		
τ D_{crit} (gr-co) (mm)	16.03		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.08	0.15	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.49	0.93	

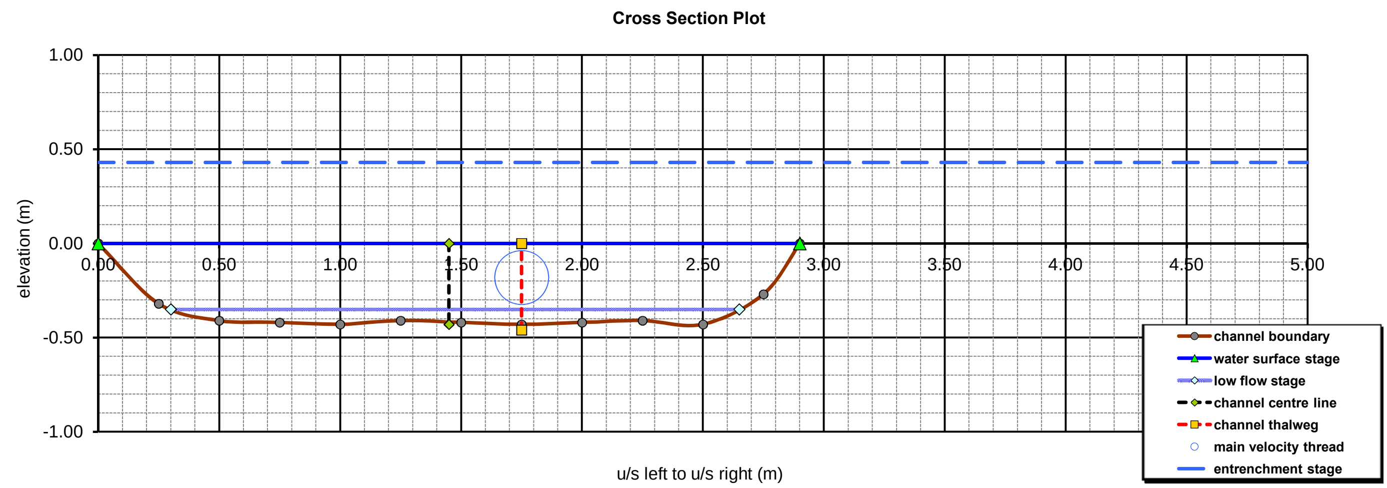
Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
11.9	71.4	16.7	0.0	0.0

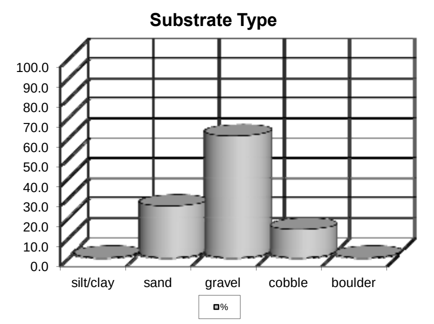
Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Carson Creek (Ewart St., Lefroy) - Section 4





Morphology Type		Hydraulic Geometry	
cascade		A (m^2)	1.08
step		R (m)	0.33
riffle	●	TW (m)	2.90
run		WP (m)	3.28
glide		max d (m)	0.43
pool		mean d (m)	0.37
thalweg out of phase		$E_{s\ (Limerinos)}$ (m) [+]	
		$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness		Hydraulic Ratios	
rr R/D_{84}	8.22	ER max d	5.17
ff V mean/V*	7.18	r_c / TW	
ff D_{84}	8.35	TW / Lf_w	1.23
ff mean	7.76	TW/max d	6.7
ROUGH BED		TW/mean d	7.8

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.288	8.65	NO	NO	NO	NO
V_* (m s^{-1})	0.081	D_{50}	0.567	17.04	NO	NO	NO	NO
		D_{84}	0.928	27.89	NO	NO	NO	NO

Section Data

					TW ck
ER_e (m)	0.43	ER stations L / R	-5.00	10.00	
WS_e (m)	0.000	WS stations L / R	0.00	2.90	2.90
Lf_e (m)	-0.350	Lf stations L / R	0.30	2.65	
W_{fp} (m)	15.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.46	1.75	
E_g (m m^{-1})	0.0100				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	8.3	2.2	0.8
B3	0.0020	0.0022	saltation	YES	YES	NO
C3	0.0004	0.0008	rolling	YES	YES	NO
C4	0.0069	0.0082	Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.10	4.00	15.00	40.00	120.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})		3.88	14.55	38.80	116.40
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	1.138	Q (cms)	
V (m s^{-1})	1.06	V (m s^{-1})	
n	0.045	n	
Fr	0.55	*Fr*	
D_c rectangular (m)	0.25	D_c rectangular (m)	
D_c trapezoidal (m)	0.35	D_c trapezoidal (m)	
D_c triangular (m)	0.49	D_c triangular (m)	
D_c parabolic (m)	0.29	D_c parabolic (m)	
D_c mean (m)	0.35	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	111.56	Ω (watts m^{-1})	
ω_a (watts m^{-2})	34.01	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	11.73	ω_a/TW (watts m^{-1})	
*Re**	27.1	*Re**	
Re	304411	*Re*	
turbulence	HIGH	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} (kg m^{-2})	3.29		
τ_{calc} (N m^{-2})	32.24		
τ D_{crit} (gr-co) (mm)	33.23		
D_{50} V_c (vcs +) (m s^{-1})	0.60	0.81	
D_{84} V_c (vcs +) (m s^{-1})	0.98	1.33	

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

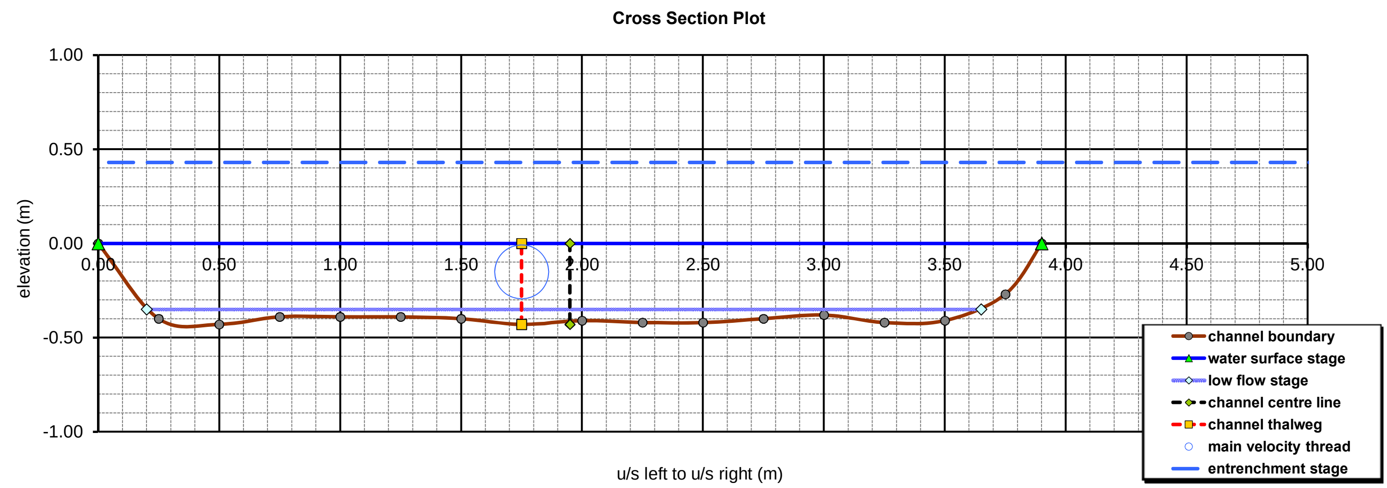
Substrate Type (%)

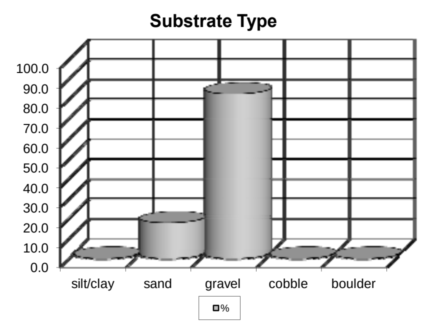
silt/clay	sand	gravel	cobble	boulder
0.0	25.5	60.8	13.7	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Carson Creek (Ewart St., Lefroy) - Section 5

B. de Geus 05.11





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.48
R (m)	0.34
TW (m)	3.90
WP (m)	4.33
max d (m)	0.43
mean d (m)	0.38
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	13.64
ff V mean/V*	8.16
ff D_{84}	9.56
ff mean	8.86
SMOOTH BED	

Hydraulic Ratios	
ER max d	4.36
r_c / TW	
TW / Lf_w	1.13
TW/max d	9.1
TW/mean d	10.3

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.324	15.10	NO	NO	NO	NO
V_* ($m\ s^{-1}$)	0.052	D_{50}	0.412	19.25	NO	NO	NO	NO
		D_{84}	0.733	34.22	NO	NO	NO	NO

Section Data

ER_e (m)	0.43	ER stations L / R	-7.00	10.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	3.90	3.90
Lf_e (m)	-0.350	Lf stations L / R	0.20	3.65	
W_{fp} (m)	17.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.43	1.75	
E_g ($m\ m^{-1}$)	0.0040				

Bedload Transport Data

	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	2.8	1.7	0.6
B3	0.0020	0.0022	saltation	YES	NO	NO
C3	0.0004	0.0008	rolling	YES	YES	NO
C4	0.0069	0.0082	Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.50	5.00	8.00	25.00	50.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)		4.85	7.76	24.25	48.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method

Q (cms)	1.135
V ($m\ s^{-1}$)	0.77
n	0.040
Fr	0.40
D_c rectangular (m)	0.21
D_c trapezoidal (m)	0.33
D_c triangular (m)	0.49
D_c parabolic (m)	0.29
D_c mean (m)	0.33
flow type	SUBCRITICAL
Ω (watts m^{-1})	44.51
ω_a (watts m^{-2})	10.28
ω_a/TW (watts m^{-1})	2.64
*Re**	12.7
Re	230008
turbulence	HIGH

Flow Regime Limerinos method

Q (cms)	
V ($m\ s^{-1}$)	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

Erosion Thresholds

		V_c / V_b	
τ_{calc} ($kg\ m^{-2}$)	1.36		
τ_{calc} ($N\ m^{-2}$)	13.37	Strickler	Limerinos
τ D_{crit} (gr-co) (mm)	13.78		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.44	0.81	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.78	1.44	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
0.0	17.6	82.4	0.0	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Cooks Bay Tributary B (Parkview Drive, Gilford)
Channel Forming / Bankfull Conditions Cross-Section Models

Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

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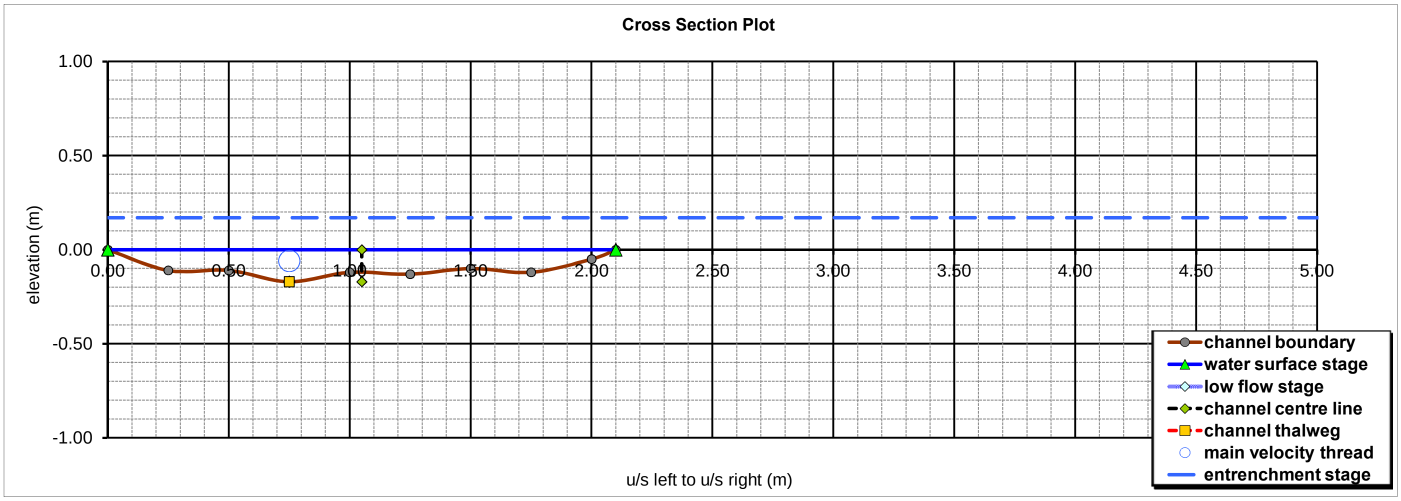
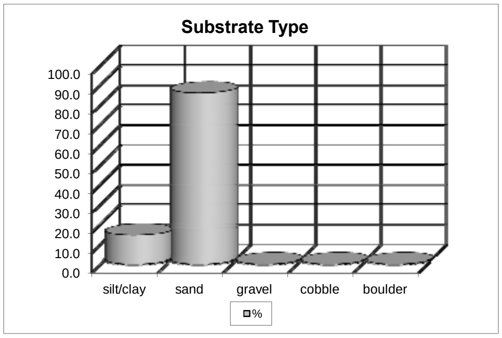
Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary B (Parkview Drive, Gilford) - Section 1





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.22
R (m)	0.10
TW (m)	2.10
WP (m)	2.16
max d (m)	0.17
mean d (m)	0.11
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	345.39
ff V mean/V*	11.32
ff D_{84}	17.37
ff mean	14.35
	SMOOTH BED

Hydraulic Ratios	
ER max d	5.71
r_c / TW	
TW / Lf_w	
TW/max d	12.4
TW/mean d	19.7

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.68	YES	YES	YES	YES
V_* (m s^{-1})	0.027	D_{50}	0.023	2.10	NO	NO	YES	YES
		D_{84}	0.040	3.65	NO	NO	NO	YES

Section Data

					TW ck
ER_e (m)	0.17	ER stations L / R	-5.00	7.00	
WS_e (m)	0.000	WS stations L / R	0.00	2.10	2.10
Lf_e (m)	-0.170	Lf stations L / R	0.75	0.75	
W_{fp} (m)	12.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		*T* e (m) *T* o/s (m)	-0.17	0.75	
E_g (m m^{-1})	0.0035				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	36.6	18.3	12.2
B3	0.0009	0.0012	saltation	YES	YES	YES
C3	0.0000	0.0000	rolling	YES	YES	YES
C4	0.0019	0.0032	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.10	0.20	0.30	0.50
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})					
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	0.072	Q (cms)	
V (m s^{-1})	0.32	V (m s^{-1})	
n	0.040	n	
Fr	0.32	*Fr*	
D_c rectangular (m)	0.05	D_c rectangular (m)	
D_c trapezoidal (m)	0.11	D_c trapezoidal (m)	
D_c triangular (m)	0.16	D_c triangular (m)	
D_c parabolic (m)	0.10	D_c parabolic (m)	
D_c mean (m)	0.11	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	2.49	Ω (watts m^{-1})	
ω_a (watts m^{-2})	1.15	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	0.55	ω_a/TW (watts m^{-1})	
*Re**	0.4	*Re**	
Re	29433	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} (kg m^{-2})	0.36		
τ_{calc} (N m^{-2})	3.55		
τ D_{crit} (gr-co) (mm)	3.66		
D_{50} V_c (vcs +) (m s^{-1})	0.07	0.31	
D_{84} V_c (vcs +) (m s^{-1})	0.08	0.37	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

AquaLogic

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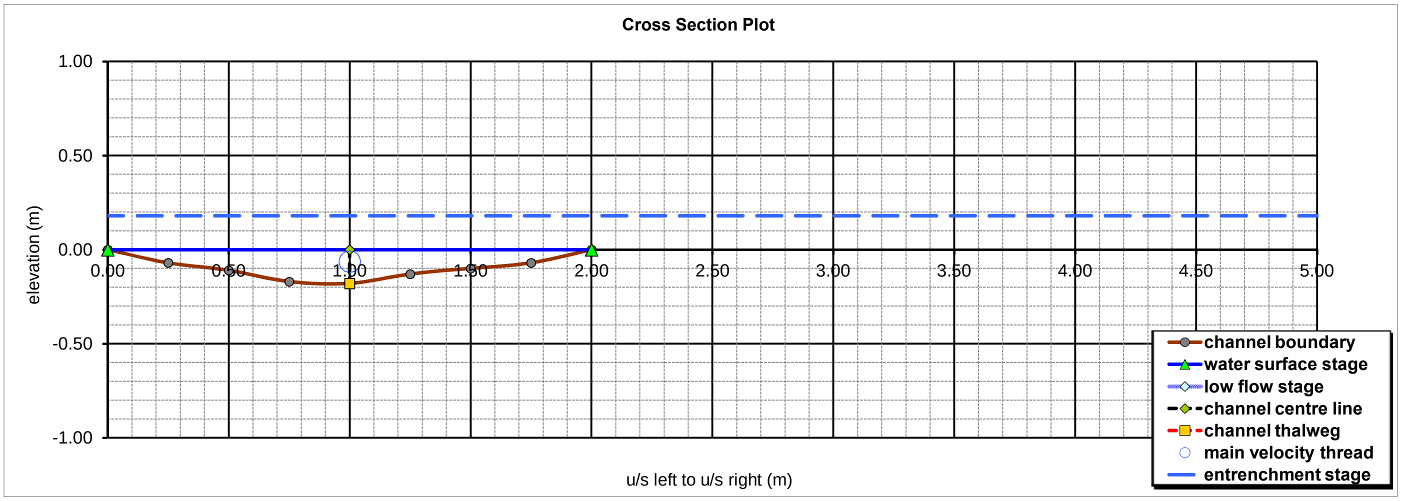
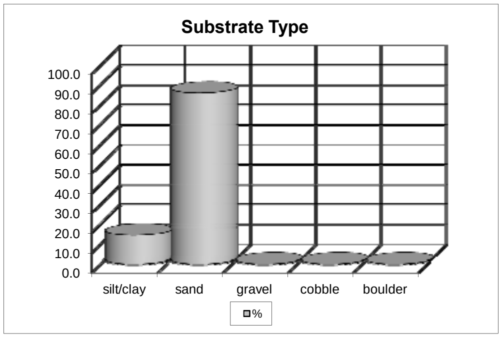
Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary B (Parkview Drive, Gilford) - Section 2





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.21
R (m)	0.10
TW (m)	2.00
WP (m)	2.04
max d (m)	0.18
mean d (m)	0.10
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	339.34
ff V mean/V*	11.29
ff D_{84}	17.30
ff mean	14.30
SMOOTH BED	

Hydraulic Ratios	
ER max d	6.00
r_c / TW	
TW / Lf_w	
TW/max d	11.1
TW/mean d	19.3

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.69	YES	YES	YES	YES
V_* (m s^{-1})	0.027	D_{50}	0.023	2.12	NO	NO	YES	YES
		D_{84}	0.040	3.68	NO	NO	NO	YES

Section Data					
ER_e (m)	0.18	ER stations L / R	-5.00	7.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.00	2.00
Lf_e (m)	-0.180	Lf stations L / R	1.00	1.00	
W_{fp} (m)	12.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.18	1.00	
E_g (m m^{-1})	0.0035				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	36.0	18.0	12.0
B3	0.0009	0.0012	saltation	YES	YES	YES
C3	0.0000	0.0000	rolling	YES	YES	YES
C4	0.0018	0.0031	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.10	0.20	0.30	0.50
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})					
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	0.066	Q (cms)	
V (m s^{-1})	0.32	V (m s^{-1})	
n	0.040	n	
Fr	0.32	*Fr*	
D_c rectangular (m)	0.05	D_c rectangular (m)	
D_c trapezoidal (m)	0.10	D_c trapezoidal (m)	
D_c triangular (m)	0.16	D_c triangular (m)	
D_c parabolic (m)	0.10	D_c parabolic (m)	
D_c mean (m)	0.10	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	2.28	Ω (watts m^{-1})	
ω_a (watts m^{-2})	1.12	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	0.56	ω_a/TW (watts m^{-1})	
*Re**	0.4	*Re**	
Re	28578	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds			
τ_{calc} (kg m^{-2})	0.36		
τ_{calc} (N m^{-2})	3.49	V_c / V_b	
τ D_{crit} (gr-co) (mm)	3.60	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.07	0.31	
D_{84} V_c (vcs +) (m s^{-1})	0.08	0.38	

Bank Data u/s L	u/s R
H_b (m)	
Bf_d (m)	
RDp (m)	
H_b/Bf_d	
RDp/H_b	
RDn (%)	
BA (°)	
BFP (%)	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

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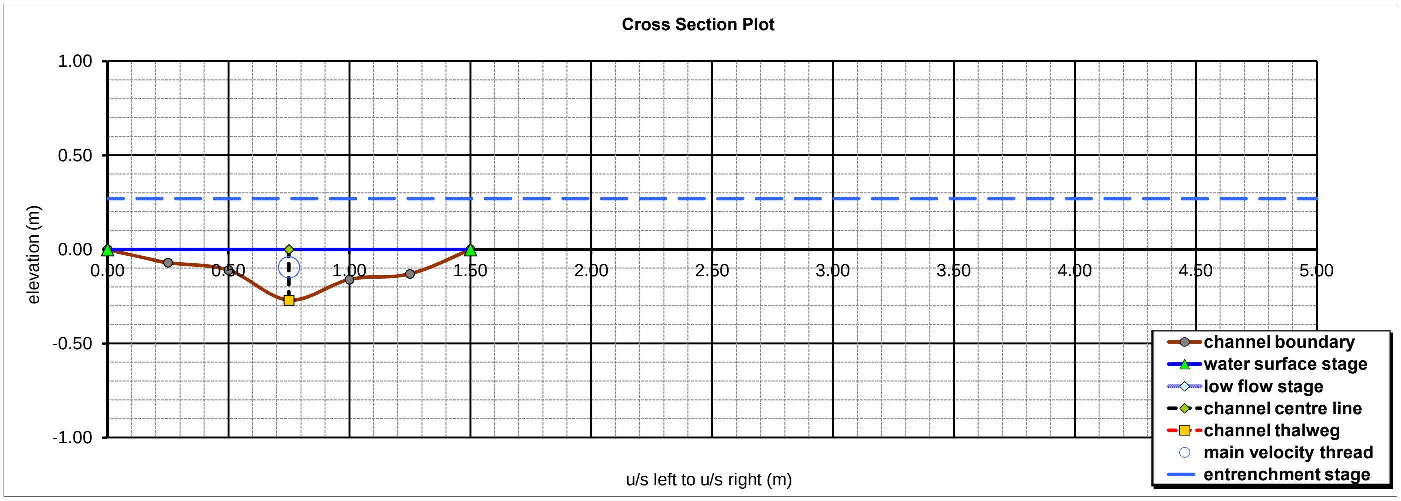
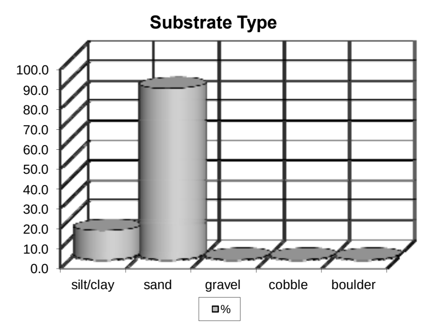
Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary B (Parkview Drive, Gilford) - Section 3





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.19
R (m)	0.11
TW (m)	1.50
WP (m)	1.62
max d (m)	0.27
mean d (m)	0.12
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	381.53
ff V mean/V*	11.49
ff D_{84}	17.73
ff mean	14.61
SMOOTH BED	

Hydraulic Ratios	
ER max d	8.00
r_c / TW	
TW / Lf_w	
TW/max d	5.6
TW/mean d	12.2

Sediment Transport Mode						high	low	
			w_s ($m\ s^{-1}$)	P	wash load	sus. load	sus. load	bedload
k	0.41	D_{30}	0.008	0.65	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.028	D_{50}	0.023	2.00	NO	NO	YES	YES
		D_{84}	0.040	3.47	NO	NO	NO	YES

Section Data					
ER_e (m)	0.27	ER stations L / R	-5.00	7.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	1.50	1.50
Lf_e (m)	-0.270	Lf stations L / R	0.75	0.75	
W_{fp} (m)	12.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.27	0.75	
E_g ($m\ m^{-1}$)	0.0035				

Bedload Transport Data						
	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	40.5	20.2	13.5
B3	0.0009	0.0012	saltation	YES	YES	YES
C3	0.0000	0.0000	rolling	YES	YES	YES
C4	0.0018	0.0031	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.10	0.20	0.30	0.50
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)					
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds			
τ_{calc} ($kg\ m^{-2}$)	0.40		
τ_{calc} ($N\ m^{-2}$)	3.93	V_c / V_b	
$\tau\ D_{crit}$ (gr-co) (mm)	4.05	Strickler	Limerinos
$D_{50}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.07	0.29	
$D_{84}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.08	0.35	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	0.064	Q (cms)	
V ($m\ s^{-1}$)	0.35	V ($m\ s^{-1}$)	
n	0.040	n	
Fr	0.31	*Fr*	
D_c rectangular (m)	0.06	D_c rectangular (m)	
D_c trapezoidal (m)	0.10	D_c trapezoidal (m)	
D_c triangular (m)	0.16	D_c triangular (m)	
D_c parabolic (m)	0.09	D_c parabolic (m)	
D_c mean (m)	0.10	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	2.20	Ω (watts m^{-1})	
ω_a (watts m^{-2})	1.36	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	0.91	ω_a/TW (watts m^{-1})	
*Re**	0.4	*Re**	
Re	34754	*Re*	
turbulence	LOW	turbulence	

White Birch Creek Tributary (Harbourview Golf, Gilford)
Channel Forming / Bankfull Conditions Cross-Section Models

Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

AquaLogic

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

AquaLogic

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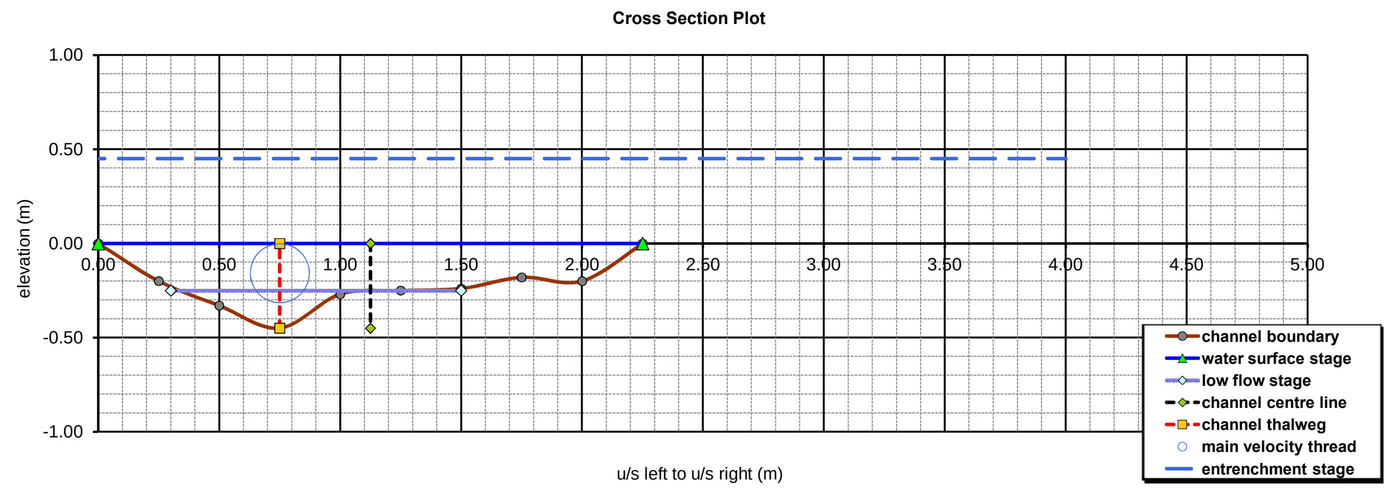
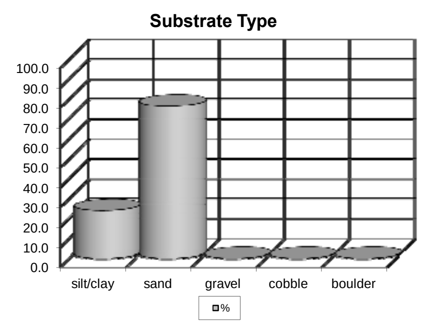
Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
White Birch Creek Tributary (Harbourview Golf, Gilford) - Section 1


Cross Section Plot


Substrate Type

Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.53
R (m)	0.21
TW (m)	2.25
WP (m)	2.52
max d (m)	0.45
mean d (m)	0.24
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	702.07
ff V mean/V*	12.56
ff D_{84}	19.33
ff mean	15.94
	SMOOTH BED

Hydraulic Ratios	
ER max d	6.22
r_c / TW	
TW / Lf_w	1.88
TW/max d	5.0
TW/mean d	9.6

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.003	0.18	YES	YES	YES	YES
V_* (m s^{-1})	0.041	D_{50}	0.008	0.45	YES	YES	YES	YES
		D_{84}	0.040	2.39	NO	NO	YES	YES

Section Data					
ER_e (m)	0.45	ER stations L / R	-10.00	4.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.25	2.25
Lf_e (m)	-0.250	Lf stations L / R	0.30	1.50	
W_{fp} (m)	14.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.45	0.75	
E_g (m m^{-1})	0.0040				

Bedload Transport Data						
Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	141.9	85.1	28.4
B3	0.0013	0.0019	saltation	YES	YES	YES
C3	0.0000	0.0003	rolling	YES	YES	YES
C4	0.0037	0.0062	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.06	0.10	0.30	2.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})					1.94
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	0.295	Q (cms)	
V (m s^{-1})	0.56	V (m s^{-1})	
n	0.040	n	
Fr	0.37	*Fr*	
D_c rectangular (m)	0.12	D_c rectangular (m)	
D_c trapezoidal (m)	0.19	D_c trapezoidal (m)	
D_c triangular (m)	0.29	D_c triangular (m)	
D_c parabolic (m)	0.17	D_c parabolic (m)	
D_c mean (m)	0.19	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	11.57	Ω (watts m^{-1})	
ω_a (watts m^{-2})	4.60	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	2.04	ω_a/TW (watts m^{-1})	
*Re**	0.2	*Re**	
Re	102877	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds			
τ_{calc} (kg m^{-2})	0.84		
τ_{calc} (N m^{-2})	8.26	V_c / V_b	
τ D_{crit} (gr-co) (mm)	8.51	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.05	0.13	
D_{84} V_c (vcs +) (m s^{-1})	0.08	0.22	

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

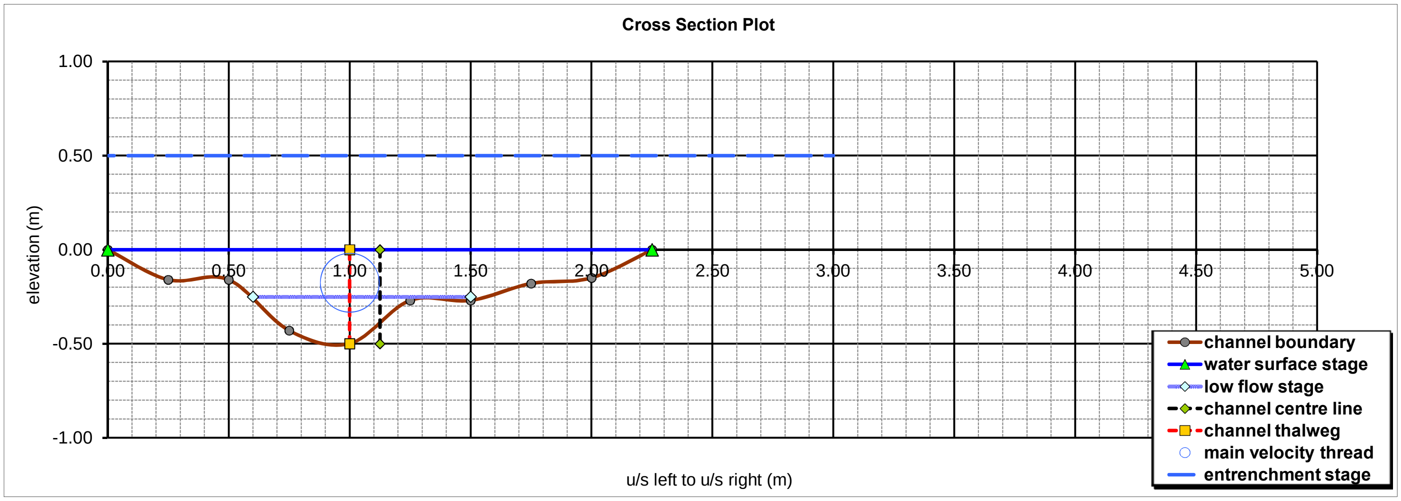
Substrate Type (%)

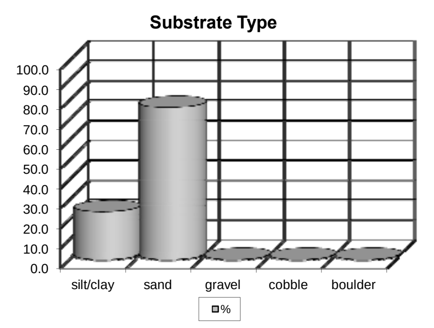
silt/clay	sand	gravel	cobble	boulder
23.8	76.2	0.0	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
White Birch Creek Tributary (Harbourview Golf, Gilford) - Section 2





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.53
R (m)	0.21
TW (m)	2.25
WP (m)	2.57
max d (m)	0.50
mean d (m)	0.24
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	686.58
ff V mean/V*	12.51
ff D_{84}	19.33
ff mean	15.92
SMOOTH BED	

Hydraulic Ratios	
ER max d	5.78
r_c / TW	
TW / Lf_w	2.50
TW/max d	4.5
TW/mean d	9.6

Sediment Transport Mode						high	low	
			w_s ($m\ s^{-1}$)	P	wash load	sus. load	sus. load	bedload
k	0.41	D_{30}	0.003	0.18	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.041	D_{50}	0.008	0.45	YES	YES	YES	YES
		D_{84}	0.040	2.42	NO	NO	YES	YES

Section Data					
ER_e (m)	0.50	ER stations L / R	-10.00	3.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.25	2.25
Lf_e (m)	-0.250	Lf stations L / R	0.60	1.50	
W_{fp} (m)	13.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		*T* $_e$ (m) *T* $_{o/s}$ (m)	-0.50	1.00	
E_g ($m\ m^{-1}$)	0.0040				

Bedload Transport Data						
	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	138.7	83.2	27.7
B3	0.0013	0.0018	saltation	YES	YES	YES
C3	0.0000	0.0002	rolling	YES	YES	YES
C4	0.0036	0.0062	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.06	0.10	0.30	2.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)					1.94
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	0.291	Q (cms)	
V ($m\ s^{-1}$)	0.55	V ($m\ s^{-1}$)	
n	0.040	n	
Fr	0.36	*Fr*	
D_c rectangular (m)	0.12	D_c rectangular (m)	
D_c trapezoidal (m)	0.19	D_c trapezoidal (m)	
D_c triangular (m)	0.29	D_c triangular (m)	
D_c parabolic (m)	0.17	D_c parabolic (m)	
D_c mean (m)	0.19	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	11.40	Ω (watts m^{-1})	
ω_a (watts m^{-2})	4.43	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.97	ω_a/TW (watts m^{-1})	
*Re**	0.2	*Re**	
Re	99113	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds			
τ_{calc} ($kg\ m^{-2}$)	0.82		
τ_{calc} ($N\ m^{-2}$)	8.07	*V* $_c$ / *V* $_b$	
τ D_{crit} (gr-co) (mm)	8.32	Strickler	Limerinos
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.05	0.13	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.08	0.22	

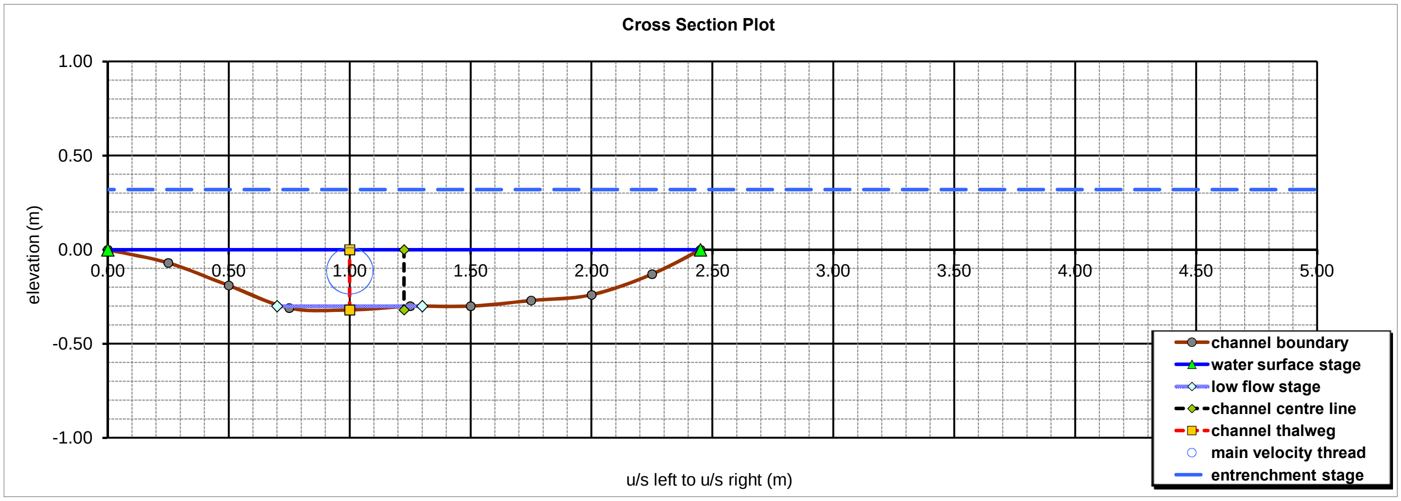
Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

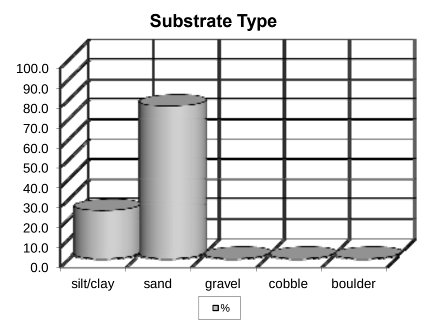
Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
23.8	76.2	0.0	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
White Birch Creek Tributary (Harbourview Golf, Gilford) - Section 3





Morphology Type

cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry

A (m^2)	0.53
R (m)	0.21
TW (m)	2.45
WP (m)	2.58
max d (m)	0.32
mean d (m)	0.22
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr R/D_{84}	683.66
ff V mean/V*	12.53
ff D_{84}	19.12
ff mean	15.82
	SMOOTH BED

Hydraulic Ratios

ER max d	6.12
r_c / TW	
TW / Lf_w	4.08
TW/max d	7.7
TW/mean d	11.3

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.003	0.18	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.041	D_{50}	0.008	0.45	YES	YES	YES	YES
		D_{84}	0.040	2.43	NO	NO	YES	YES

Section Data

					TW ck
ER_e (m)	0.32	ER stations L / R	-10.00	5.00	
WS_e (m)	0.000	WS stations L / R	0.00	2.45	2.45
Lf_e (m)	-0.300	Lf stations L / R	0.70	1.30	
W_{fp} (m)	15.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.32	1.00	
E_g ($m\ m^{-1}$)	0.0040				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} ($kg\ sec^{-1}$)	Limerinos Q Q_{sb} ($kg\ sec^{-1}$)		D_{30}	D_{50}	D_{84}
			T_*	138.1	82.9	27.6
B3	0.0013	0.0018	saltation	YES	YES	YES
C3	0.0000	0.0002	rolling	YES	YES	YES
C4	0.0036	0.0062	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.06	0.10	0.30	2.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)					1.94
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method / Flow Regime Limerinos method

Strickler method		Limerinos method	
Q (cms)	0.289	Q (cms)	
V ($m\ s^{-1}$)	0.55	V ($m\ s^{-1}$)	
n	0.040	n	
Fr	0.38	*Fr*	
D_c rectangular (m)	0.11	D_c rectangular (m)	
D_c trapezoidal (m)	0.19	D_c trapezoidal (m)	
D_c triangular (m)	0.29	D_c triangular (m)	
D_c parabolic (m)	0.17	D_c parabolic (m)	
D_c mean (m)	0.19	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω ($watts\ m^{-1}$)	11.35	Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	4.40	ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	1.79	ω_a/TW ($watts\ m^{-1}$)	
*Re**	0.2	*Re**	
Re	98410	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	V_c / V_b Limerinos
τ_{calc} ($kg\ m^{-2}$)	0.82		
τ_{calc} ($N\ m^{-2}$)	8.04		
$\tau\ D_{crit}$ (gr-co) (mm)	8.29		
$D_{50}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.05	0.13	
$D_{84}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.08	0.22	

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
23.8	76.2	0.0	0.0	0.0

Cooks Bay Tributary C (Shore Acres Rd. & Nelly Rd., Gilford)
Channel Forming / Bankfull Conditions Cross-Section Models

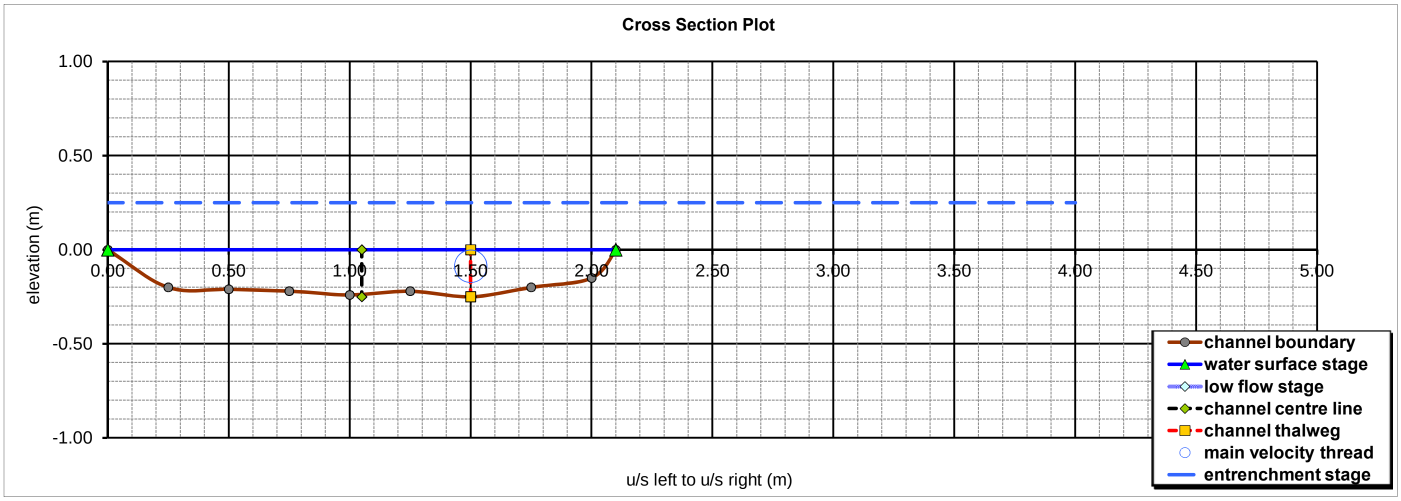
Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

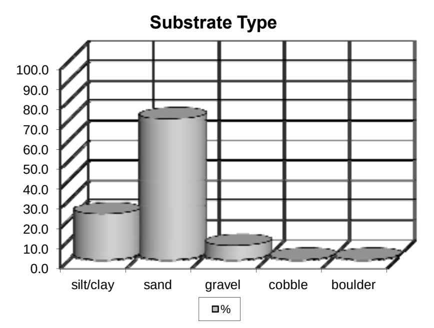
AquaLogic

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary C (Shore Acres Rd. & Nelly Rd., Gilford) - Section 1





Morphology Type

cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry

A (m^2)	0.41
R (m)	0.18
TW (m)	2.10
WP (m)	2.26
max d (m)	0.25
mean d (m)	0.20
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr *R* /D_{84}	726.55
ff V mean/V*	12.52
ff D_{84}	19.33
ff mean	15.92
SMOOTH BED	

Hydraulic Ratios

ER max d	2.38
r_c / TW	
TW / Lf_w	
TW/max d	8.4
TW/mean d	10.7

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.003	0.19	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.038	D_{50}	0.012	0.75	YES	YES	YES	YES
		D_{84}	0.032	2.03	NO	NO	YES	YES

Section Data

ER_e (m)	0.25	ER stations L / R	-1.00	4.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.10	2.10
Lf_e (m)	-0.250	Lf stations L / R	1.50	1.50	
W_{fp} (m)	5.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.25	1.50	
E_g ($m\ m^{-1}$)	0.0040				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} ($kg\ sec^{-1}$)	Limerinos Q Q_{sb} ($kg\ sec^{-1}$)		D_{30}	D_{50}	D_{84}
			T_*	122.3	56.5	29.4
B3	0.0012	0.0017	saltation	YES	YES	YES
C3	0.0000	0.0001	rolling	YES	YES	YES
C4	0.0031	0.0053	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.06	0.13	0.25	15.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)					14.55
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method

Q (cms)	0.207
V ($m\ s^{-1}$)	0.50
n	0.040
Fr	0.36
D_c rectangular (m)	0.10
D_c trapezoidal (m)	0.17
D_c triangular (m)	0.25
D_c parabolic (m)	0.15
D_c mean (m)	0.17
flow type	SUBCRITICAL
Ω ($watts\ m^{-1}$)	8.13
ω_a ($watts\ m^{-2}$)	3.59
ω_a/TW ($watts\ m^{-1}$)	1.71
*Re**	0.2
Re	80341
turbulence	LOW

Flow Regime Limerinos method

Q (cms)	
V ($m\ s^{-1}$)	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	
*Re**	
Re	
turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	0.73		
τ_{calc} ($N\ m^{-2}$)	7.12		
τ D_{crit} (gr-co) (mm)	7.34		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.06	0.16	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.08	0.22	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
22.7	70.5	6.8	0.0	0.0

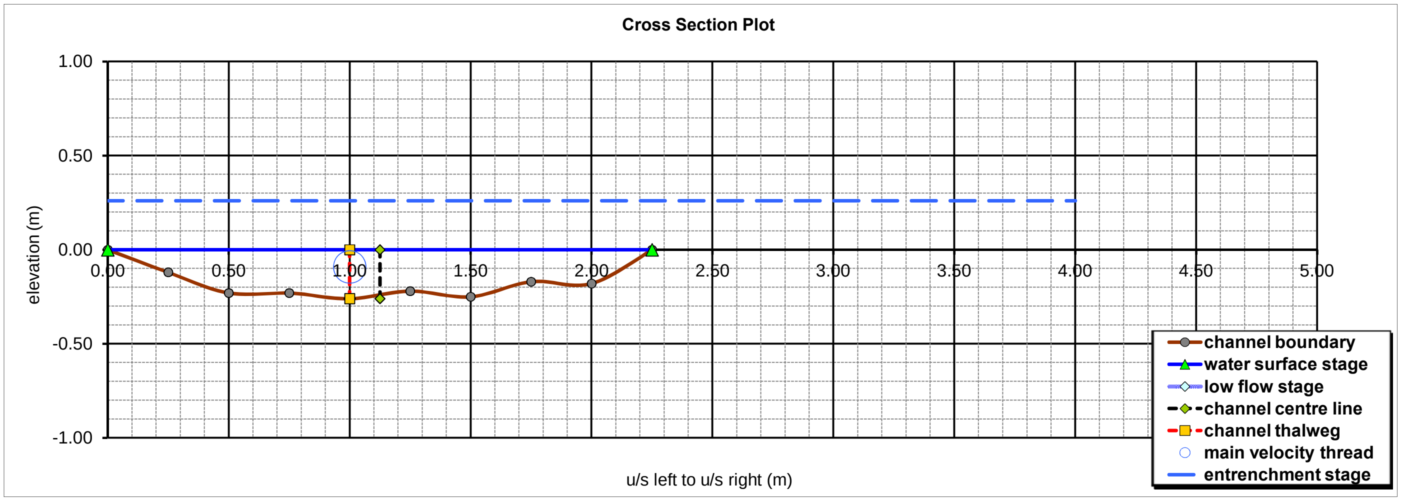
Bank Data u/s L u/s R

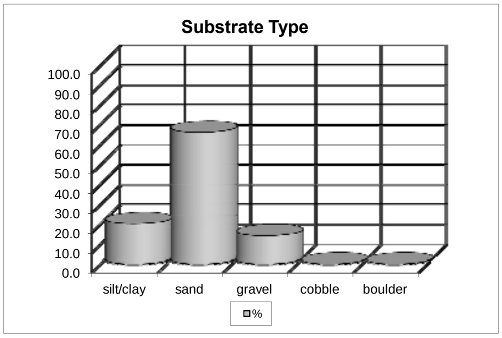
	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary C (Shore Acres Rd. & Nelly Rd., Gilford) - Section 2





Morphology Type

cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry

A (m^2)	0.42
R (m)	0.17
TW (m)	2.25
WP (m)	2.38
max d (m)	0.26
mean d (m)	0.18
$E_{s\,(Limerinos)}$ (m) [+]	
$E_{s\,(Strickler)}$ (m) [+]	

Hydraulic Roughness

rr R/D_{84}	174.52
ff V mean/V*	10.80
ff D_{84}	15.75
ff mean	13.27
	SMOOTH BED

Hydraulic Ratios

ER max d	2.22
r_c / TW	
TW / Lf_w	
TW/max d	8.7
TW/mean d	12.2

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.49	YES	YES	YES	YES
V_* (m s^{-1})	0.037	D_{50}	0.023	1.52	NO	NO	YES	YES
		D_{84}	0.126	8.23	NO	NO	NO	NO

Section Data

ER_e (m)	0.26	ER stations L / R	-1.00	4.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.25	2.25
Lf_e (m)	-0.260	Lf stations L / R	1.00	1.00	
W_{fp} (m)	5.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
$\underline{z}$		T_e (m) $T_{o/s}$ (m)	-0.26	1.00	
E_g (m m^{-1})	0.0040				

Bedload Transport Data

	Strickler Q	Limerinos Q				
Rosgen type	Q_{sb} (kg sec^{-1})	Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	70.5	35.3	7.1
B3	0.0012	0.0016	saltation	YES	YES	YES
C3	0.0000	0.0001	rolling	YES	YES	YES
C4	0.0031	0.0048	Ø	NO	NO	NO

Substrate Gradation

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.05	0.10	0.20	1.00	40.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})				0.97	38.80
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	0.204	Q (cms)	
V (m s^{-1})	0.49	V (m s^{-1})	
n	0.040	n	
Fr	0.37	*Fr*	
D_c rectangular (m)	0.10	D_c rectangular (m)	
D_c trapezoidal (m)	0.16	D_c trapezoidal (m)	
D_c triangular (m)	0.25	D_c triangular (m)	
D_c parabolic (m)	0.15	D_c parabolic (m)	
D_c mean (m)	0.16	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	7.99	Ω (watts m^{-1})	
ω_a (watts m^{-2})	3.36	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.49	ω_a/TW (watts m^{-1})	
*Re**	0.3	*Re**	
Re	75153	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	V_c / V_b Limerinos
τ_{calc} (kg m^{-2})	0.70		
τ_{calc} (N m^{-2})	6.84		
τ D_{crit} (gr-co) (mm)	7.05		
D_{50} V_c (vcs +) (m s^{-1})	0.07	0.20	
D_{84} V_c (vcs +) (m s^{-1})	0.16	0.45	

Bank Data

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

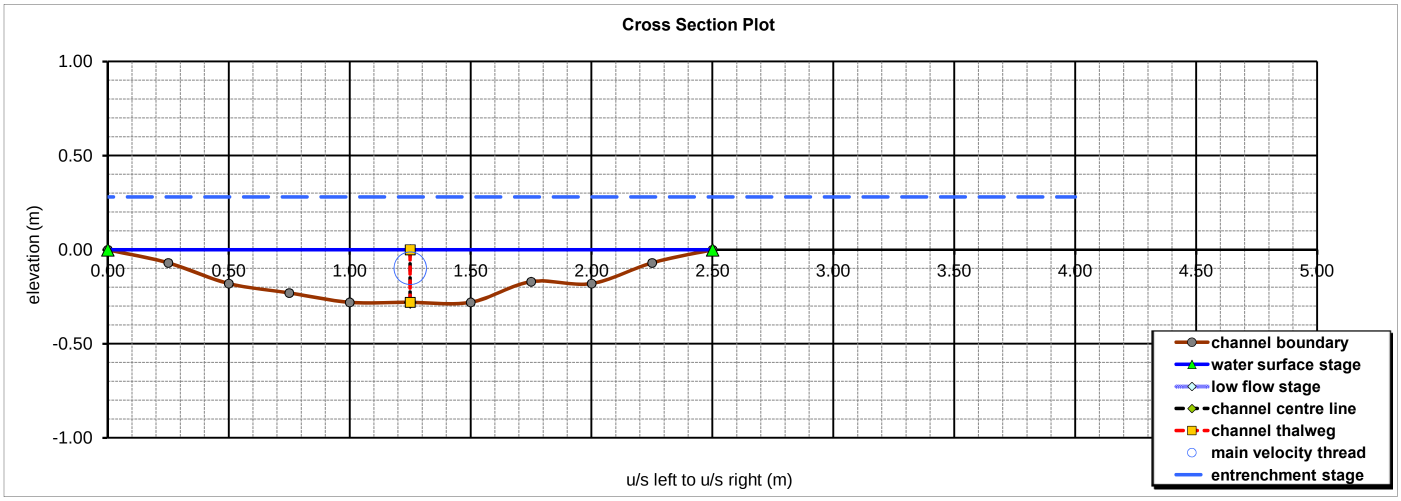
Substrate Type (%)

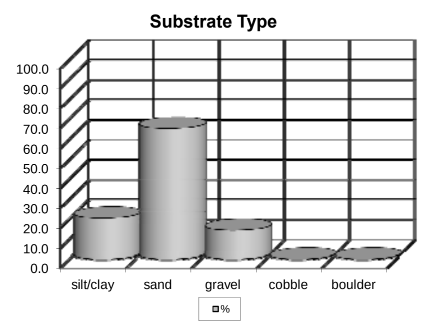
silt/clay	sand	gravel	cobble	boulder
20.0	66.0	14.0	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary C (Shore Acres Rd. & Nelly Rd., Gilford) - Section 3





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.44
R (m)	0.17
TW (m)	2.50
WP (m)	2.60
max d (m)	0.28
mean d (m)	0.17
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	167.39
ff V mean/V*	10.72
ff D_{84}	15.60
ff mean	13.16
SMOOTH BED	

Hydraulic Ratios	
ER max d	2.40
r_c / TW	
TW / Lf_w	
TW/max d	8.9
TW/mean d	14.4

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.003	0.20	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.037	D_{50}	0.008	0.50	YES	YES	YES	YES
		D_{84}	0.126	8.41	NO	NO	NO	NO

Section Data

ER_e (m)	0.28	ER stations L / R	-2.00	4.00	TW ck
WS_e (m)	0.000	WS stations L / R	0.00	2.50	2.50
Lf_e (m)	-0.280	Lf stations L / R	1.25	1.25	
W_{fp} (m)	6.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		*T* e (m) *T* o/s (m)	-0.28	1.25	
E_g ($m\ m^{-1}$)	0.0040				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	112.7	67.6	6.8
B3	0.0012	0.0016	saltation	YES	YES	YES
C3	0.0000	0.0001	rolling	YES	YES	YES
C4	0.0031	0.0049	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.03	0.06	0.10	1.00	8.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				0.97	7.76
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.208	Q (cms)	
V ($m\ s^{-1}$)	0.48	V ($m\ s^{-1}$)	
n	0.040	n	
Fr	0.37	*Fr*	
D_c rectangular (m)	0.09	D_c rectangular (m)	
D_c trapezoidal (m)	0.16	D_c trapezoidal (m)	
D_c triangular (m)	0.25	D_c triangular (m)	
D_c parabolic (m)	0.15	D_c parabolic (m)	
D_c mean (m)	0.16	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	8.14	Ω (watts m^{-1})	
ω_a (watts m^{-2})	3.13	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.25	ω_a/TW (watts m^{-1})	
*Re**	0.2	*Re**	
Re	70096	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} (kg m^{-2})	0.67		
τ_{calc} ($N\ m^{-2}$)	6.56		
τ D_{crit} (gr-co) (mm)	6.76		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.05	0.15	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.16	0.46	

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
20.4	65.3	14.3	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-Section Analysis Models
Stable Conditions

Hewitts Creek (10th Line, Stroud)
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres)
Cooks Bay Tributary A (Moosenlanka Rd., Sandy Cove Acres)
Mooselanka Creek (25th Sideroad, Sandy Cove Acres)
Carson Creek (Ewart St., Lefroy)
Cooks Bay Tributary B (Parkview Drive, Gilford)
White Birch Creek Tributary (Harborview Golf, Gilford)
Cooks Bay Tributary C (Shore Acres Rd. & Nelly Rd., Gilford)

Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

AquaLogic

Hewitts Creek (10th Line, Stroud)
Stable Conditions Cross-Section Models

Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

AquaLogic

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

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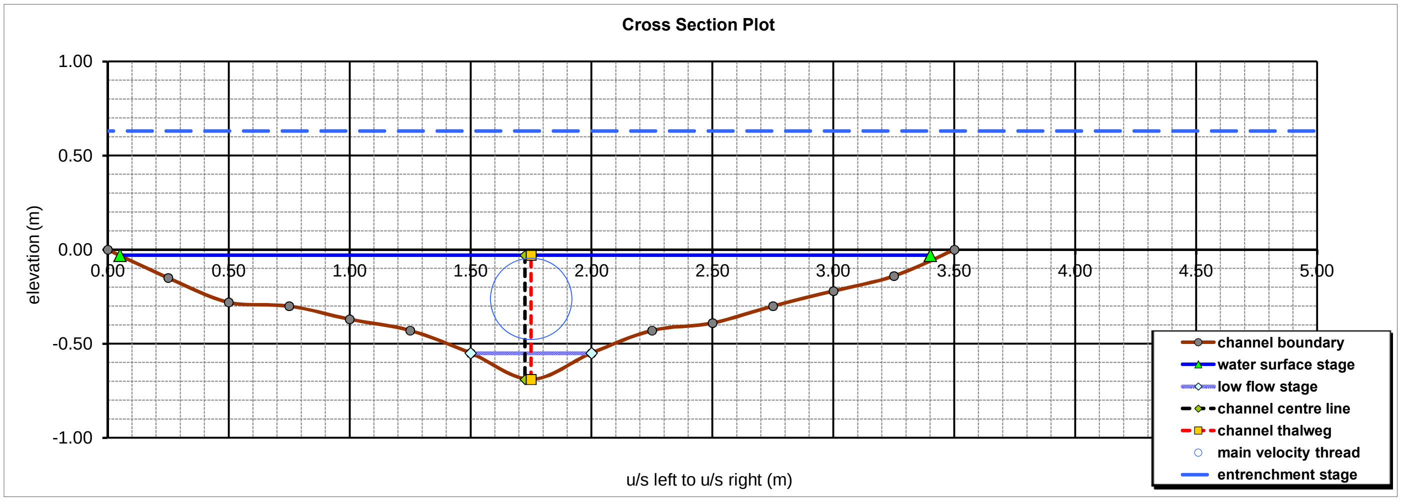
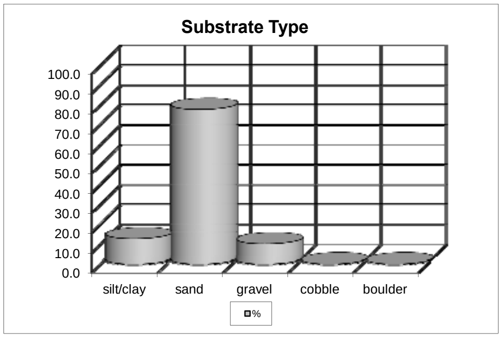
Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Hewitts Creek (10th Line, Stroud) - Section 1 Stability Test





Morphology Type

cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry

A (m^2)	1.10
R (m)	0.30
TW (m)	3.40
WP (m)	3.68
max d (m)	0.66
mean d (m)	0.32
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr *R* /D_{84}	298.04
ff V mean/V*	12.23
ff D_{84}	17.13
ff mean	14.68
	SMOOTH BED

Hydraulic Ratios

ER max d	2.36
r_c / TW	
TW / Lf_w	6.79
TW/max d	5.1
TW/mean d	10.5

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.43	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.042	D_{50}	0.023	1.34	NO	NO	YES	YES
		D_{84}	0.126	7.28	NO	NO	NO	YES

Section Data

ER_e (m)	0.63	ER stations L / R	-2.00	6.00	TW ck
WS_e (m)	-0.030	WS stations L / R	0.05	3.40	3.35
Lf_e (m)	-0.550	Lf stations L / R	1.50	2.00	
W_{fp} (m)	8.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		*T* $_e$ (m) *T* $_{o/s}$ (m)	-0.69	1.75	
E_g ($m\ m^{-1}$)	0.0030				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} ($kg\ sec^{-1}$)	Limerinos Q Q_{sb} ($kg\ sec^{-1}$)		D_{30}	D_{50}	D_{84}
			T_*	90.3	45.2	9.0
B3	0.0018	0.0022	saltation	YES	YES	YES
C3	0.0002	0.0009	rolling	YES	YES	YES
C4	0.0057	0.0085	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	1.00	10.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				0.97	9.70
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	0.89		
τ_{calc} ($N\ m^{-2}$)	8.76		
$\tau\ D_{crit}$ (gr-co) (mm)	9.03		
$D_{50}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.07	0.14	
$D_{84}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.16	0.32	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
12.5	77.5	10.0	0.0	0.0

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Flow Regime Strickler method

Q (cms)	0.763
V ($m\ s^{-1}$)	0.70
n	0.035
Fr	0.39
D_c rectangular (m)	0.18
D_c trapezoidal (m)	0.28
D_c triangular (m)	0.42
D_c parabolic (m)	0.25
D_c mean (m)	0.28
flow type	SUBCRITICAL
Ω ($watts\ m^{-1}$)	22.42
ω_a ($watts\ m^{-2}$)	6.09
ω_a/TW ($watts\ m^{-1}$)	1.79
*Re**	0.3
Re	181815
turbulence	LOW

Flow Regime Limerinos method

Q (cms)	
V ($m\ s^{-1}$)	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	
*Re**	
Re	
turbulence	

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

AquaLogic

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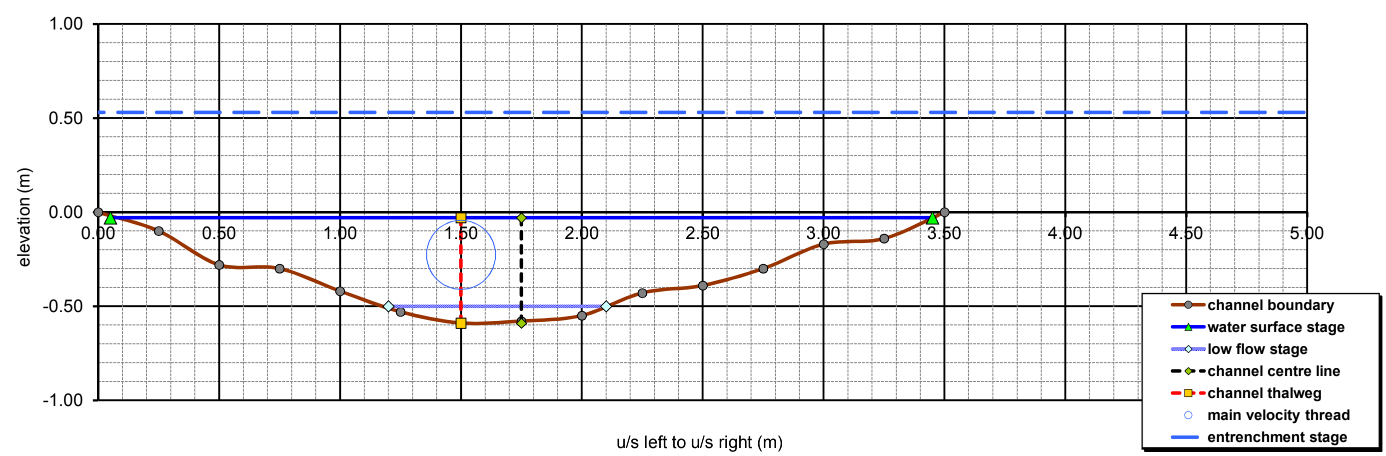
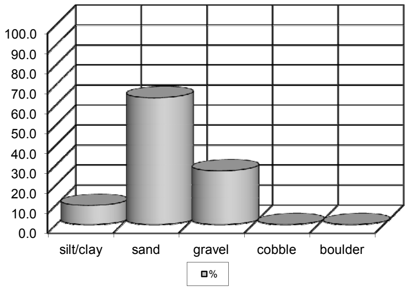
Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Hewitts Creek (10th Line, Stroud) - Section 2 Stability Test

Cross Section Plot



Substrate Type



Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.09
R (m)	0.30
TW (m)	3.37
WP (m)	3.61
max d (m)	0.56
mean d (m)	0.32
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R*/D_{84}	37.79
ff V mean/V*	9.76
ff D_{84}	11.99
ff mean	10.88
SMOOTH BED	

Hydraulic Ratios	
ER max d	2.37
r_c / TW	
TW / Lf_w	3.75
TW/max d	6.0
TW/mean d	10.4

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.023	1.33	NO	NO	YES	YES
V_* ($m\ s^{-1}$)	0.043	D_{50}	0.071	4.06	NO	NO	NO	YES
		D_{84}	0.412	23.60	NO	NO	NO	NO

Section Data

					TW ck
ER_e (m)	0.53	ER stations L / R	-2.00	6.00	
WS_e (m)	-0.030	WS stations L / R	0.05	3.45	3.40
Lf_e (m)	-0.500	Lf stations L / R	1.20	2.10	
W_{fp} (m)	8.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.59	1.50	
E_g ($m\ m^{-1}$)	0.0030				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} ($kg\ sec^{-1}$)	Limerinos Q Q_{sb} ($kg\ sec^{-1}$)		D_{30}	D_{50}	D_{84}
			T_*	45.8	18.3	1.1
B3	0.0018	0.0020	saltation	YES	YES	NO
C3	0.0002	0.0005	rolling	YES	YES	YES
C4	0.0057	0.0072	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.20	0.50	8.00	50.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				7.76	48.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method

Q (cms)	0.767
V ($m\ s^{-1}$)	0.70
n	0.035
Fr	0.39
D_c rectangular (m)	0.18
D_c trapezoidal (m)	0.28
D_c triangular (m)	0.42
D_c parabolic (m)	0.25
D_c mean (m)	0.28
flow type	SUBCRITICAL
Ω ($watts\ m^{-1}$)	22.54
ω_a ($watts\ m^{-2}$)	6.24
ω_a/TW ($watts\ m^{-1}$)	1.85
*Re**	0.7
Re	186200
turbulence	LOW

Flow Regime Limerinos method

Q (cms)	
V ($m\ s^{-1}$)	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	
*Re**	
Re	
turbulence	

Erosion Thresholds

		V_c / V_b Strickler	V_c / V_b Limerinos
τ_{calc} ($kg\ m^{-2}$)	0.91		
τ_{calc} ($N\ m^{-2}$)	8.89		
τ D_{crit} (gr-co) (mm)	9.16		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.11	0.22	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.44	0.89	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
9.6	63.5	26.9	0.0	0.0

Bank Data

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Hewitts Creek (10th Line, Stroud) - Section 3 Stability Test

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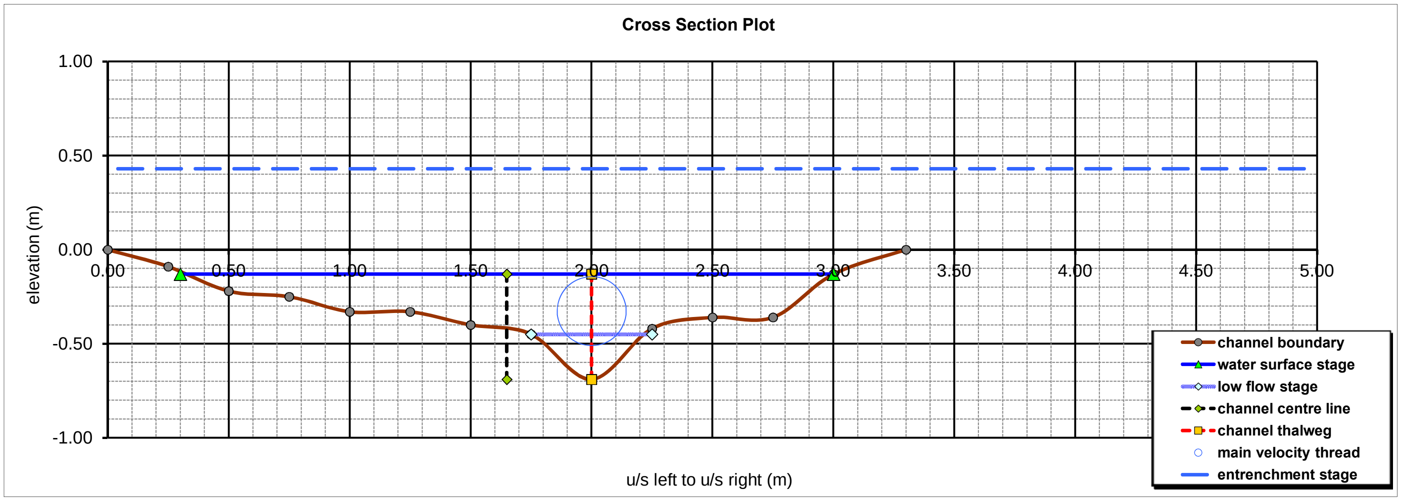
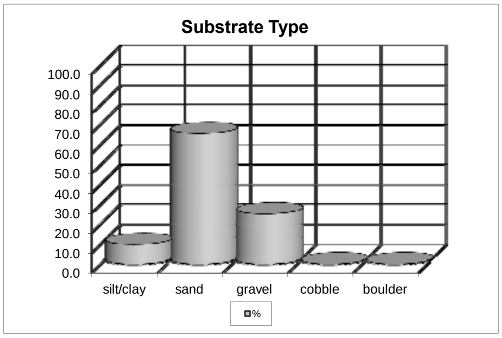




Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.62
R (m)	0.21
TW (m)	2.67
WP (m)	3.04
max d (m)	0.56
mean d (m)	0.23
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	25.70
ff V mean/V*	9.06
ff D_{84}	11.18
ff mean	10.12
SMOOTH BED	

Hydraulic Ratios	
ER max d	2.99
r_c / TW	
TW / Lf_w	5.35
TW/max d	4.8
TW/mean d	11.5

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.40	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.045	D_{50}	0.071	3.82	NO	NO	NO	YES
		D_{84}	0.412	22.17	NO	NO	NO	NO

Section Data					
ER_e (m)	0.43	ER stations L / R	-3.00	5.00	TW ck
WS_e (m)	-0.130	WS stations L / R	0.30	3.00	2.70
Lf_e (m)	-0.450	Lf stations L / R	1.75	2.25	
W_{fp} (m)	8.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.69	2.00	
E_g ($m\ m^{-1}$)	0.0050				

Bedload Transport Data						
	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	103.9	20.8	1.3
B3	0.0015	0.0017	saltation	YES	YES	NO
C3	0.0001	0.0001	rolling	YES	YES	YES
C4	0.0044	0.0055	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.50	8.00	40.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				7.76	38.80
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	0.437	Q (cms)	
V ($m\ s^{-1}$)	0.70	V ($m\ s^{-1}$)	
n	0.035	n	
Fr	0.46	*Fr*	
D_c rectangular (m)	0.14	D_c rectangular (m)	
D_c trapezoidal (m)	0.23	D_c trapezoidal (m)	
D_c triangular (m)	0.34	D_c triangular (m)	
D_c parabolic (m)	0.20	D_c parabolic (m)	
D_c mean (m)	0.23	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	21.41	Ω (watts m^{-1})	
ω_a (watts m^{-2})	7.05	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	2.64	ω_a/TW (watts m^{-1})	
*Re**	0.8	*Re**	
Re	126255	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds		V_c / V_b	
τ_{calc} ($kg\ m^{-2}$)	1.03		
τ_{calc} ($N\ m^{-2}$)	10.07	Strickler	Limerinos
$\tau\ D_{crit}$ (gr-co) (mm)	10.39		
$D_{50}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.11	0.22	
$D_{84}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.44	0.89	

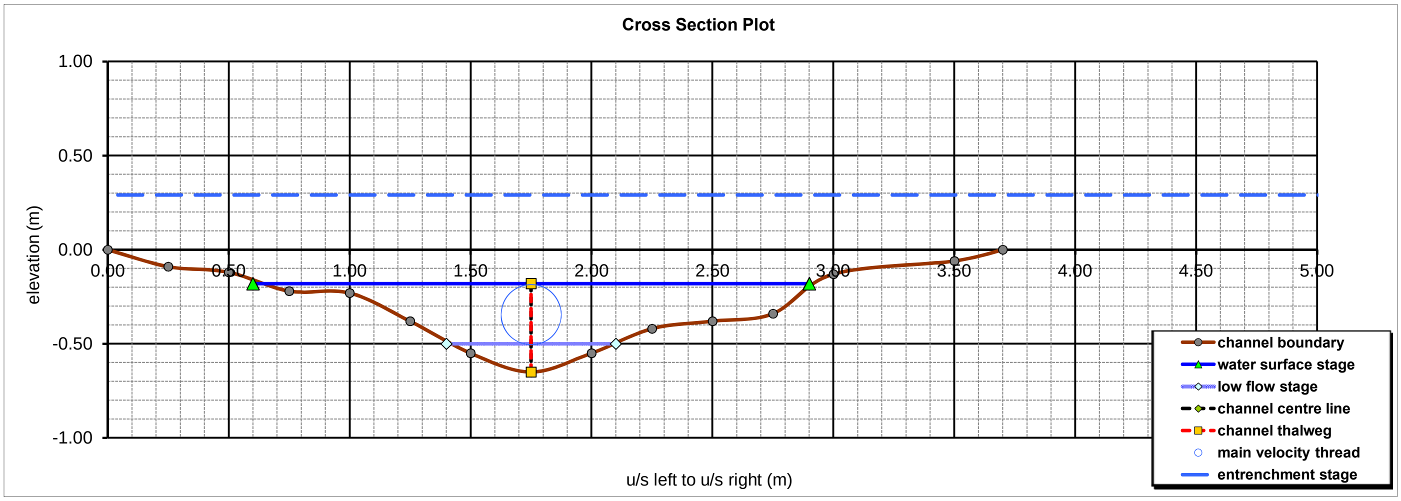
Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
9.6	65.4	25.0	0.0	0.0

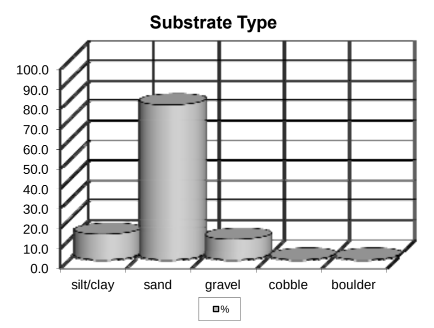
Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Hewitts Creek (10th Line, Stroud) - Section 4 Stability Test





Morphology Type

cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry

A (m^2)	0.52
R (m)	0.20
TW (m)	2.29
WP (m)	2.53
max d (m)	0.47
mean d (m)	0.23
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr *R* /D_{84}	409.34
ff V mean/V*	12.34
ff D_{84}	17.96
ff mean	15.15
SMOOTH BED	

Hydraulic Ratios

ER max d	4.37
r_c / TW	
TW / Lf_w	3.27
TW/max d	4.9
TW/mean d	10.1

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.41	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.045	D_{50}	0.023	1.25	NO	NO	YES	YES
		D_{84}	0.071	3.83	NO	NO	NO	YES

Section Data

ER_e (m)	0.29	ER stations L / R	-3.00	7.00	TW ck
WS_e (m)	-0.180	WS stations L / R	0.60	2.90	2.30
Lf_e (m)	-0.500	Lf stations L / R	1.40	2.10	
W_{fp} (m)	10.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		*T* $_e$ (m) *T* $_{o/s}$ (m)	-0.65	1.75	
E_g ($m\ m^{-1}$)	0.0050				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} ($kg\ sec^{-1}$)	Limerinos Q Q_{sb} ($kg\ sec^{-1}$)		D_{30}	D_{50}	D_{84}
			T $_*$	103.4	51.7	20.7
B3	0.0014	0.0019	saltation	YES	YES	YES
C3	0.0000	0.0003	rolling	YES	YES	YES
C4	0.0040	0.0062	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	0.50	20.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)					19.40
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	0.361	Q (cms)	
V ($m\ s^{-1}$)	0.70	V ($m\ s^{-1}$)	
n	0.035	n	
Fr	0.47	*Fr*	
D_c rectangular (m)	0.14	D_c rectangular (m)	
D_c trapezoidal (m)	0.21	D_c trapezoidal (m)	
D_c triangular (m)	0.31	D_c triangular (m)	
D_c parabolic (m)	0.19	D_c parabolic (m)	
D_c mean (m)	0.21	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω ($watts\ m^{-1}$)	17.69	Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	7.00	ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	3.06	ω_a/TW ($watts\ m^{-1}$)	
*Re**	0.3	*Re**	
Re	125305	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	1.02		
τ_{calc} ($N\ m^{-2}$)	10.03		
τ D_{crit} (gr-co) (mm)	10.34		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.07	0.14	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.11	0.22	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
12.5	77.5	10.0	0.0	0.0

Bank Data

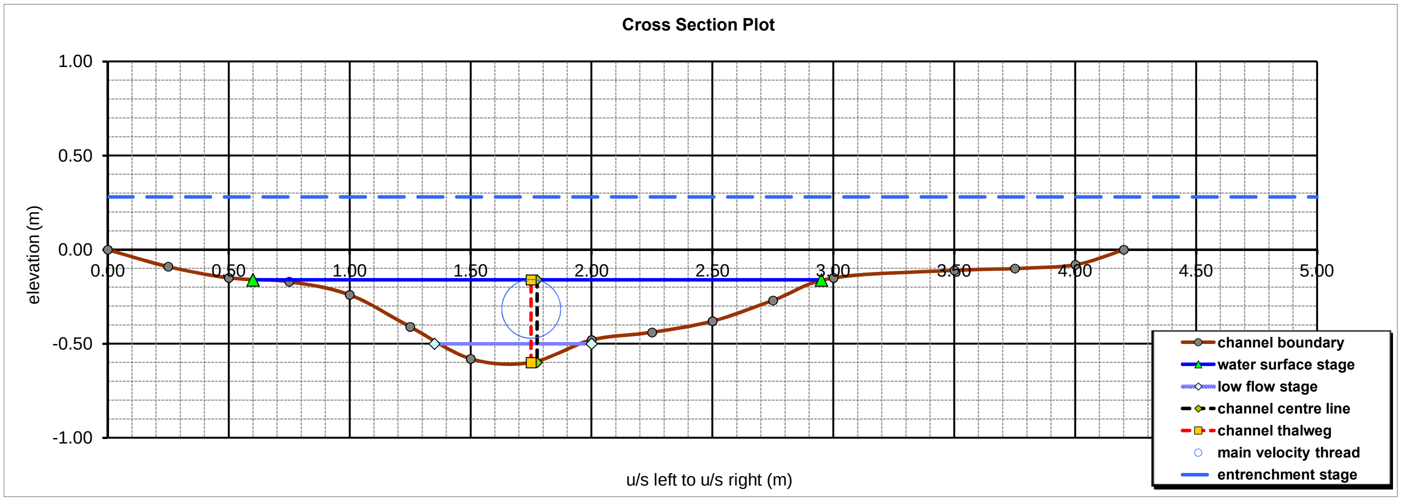
	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

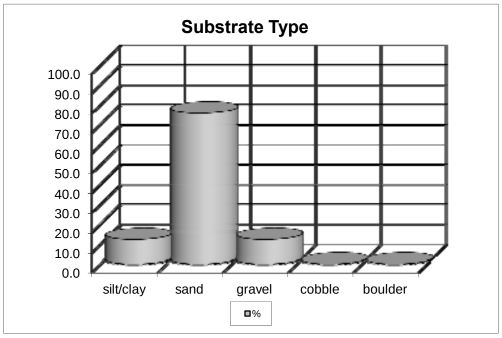
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Hewitts Creek (10th Line, Stroud) - Section 5 Stability Test

B. de Geus 05.11

Cross Section Plot





Morphology Type

cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry

A (m^2)	0.53
R (m)	0.21
TW (m)	2.35
WP (m)	2.56
max d (m)	0.44
mean d (m)	0.23
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr R/D_{84}	207.69
ff V mean/V*	11.54
ff D_{84}	16.24
ff mean	13.89
SMOOTH BED	

Hydraulic Ratios

ER max d	5.52
r_c / TW	
TW / Lf_w	3.62
TW/max d	5.4
TW/mean d	10.4

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.40	YES	YES	YES	YES
V_* (m s^{-1})	0.046	D_{50}	0.023	1.24	NO	NO	YES	YES
		D_{84}	0.126	6.75	NO	NO	NO	YES

Section Data

ER_e (m)	0.28	ER stations L / R	-4.00	9.00	TW ck
WS_e (m)	-0.160	WS stations L / R	0.60	2.95	2.35
Lf_e (m)	-0.500	Lf stations L / R	1.35	2.00	
W_{fp} (m)	13.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.60	1.75	
E_g (m m^{-1})	0.0050				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	104.9	52.5	10.5
B3	0.0014	0.0018	saltation	YES	YES	YES
C3	0.0000	0.0002	rolling	YES	YES	YES
C4	0.0041	0.0061	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	1.00	10.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})				0.97	9.70
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method

Q (cms)	0.374
V (m s^{-1})	0.70
n	0.035
Fr	0.47
D_c rectangular (m)	0.14
D_c trapezoidal (m)	0.22
D_c triangular (m)	0.32
D_c parabolic (m)	0.19
D_c mean (m)	0.22
flow type	SUBCRITICAL
Ω (watts m^{-1})	18.33
ω_a (watts m^{-2})	7.17
ω_a/TW (watts m^{-1})	3.05
*Re**	0.3
Re	128410
turbulence	LOW

Flow Regime Limerinos method

Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

Erosion Thresholds

		V_c / V_b Strickler	V_c / V_b Limerinos
τ_{calc} (kg m^{-2})	1.04		
τ_{calc} (N m^{-2})	10.18		
τ D_{crit} (gr-co) (mm)	10.49		
D_{50} V_c (vcs +) (m s^{-1})	0.07	0.14	
D_{84} V_c (vcs +) (m s^{-1})	0.16	0.31	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
12.2	75.6	12.2	0.0	0.0

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

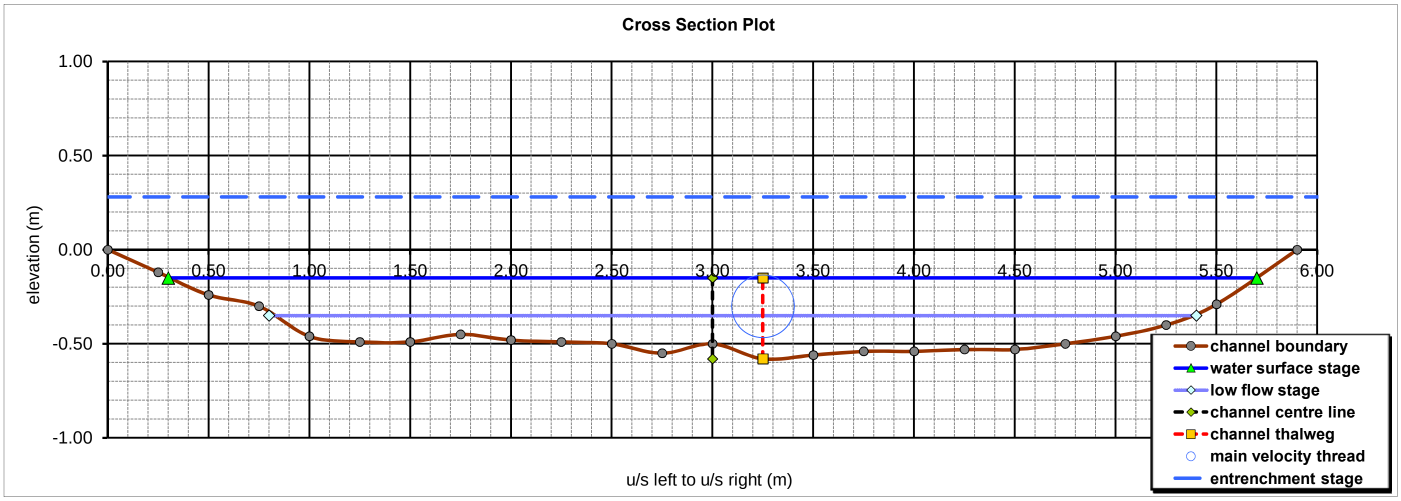
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)
Stable Conditions Cross-Section Models

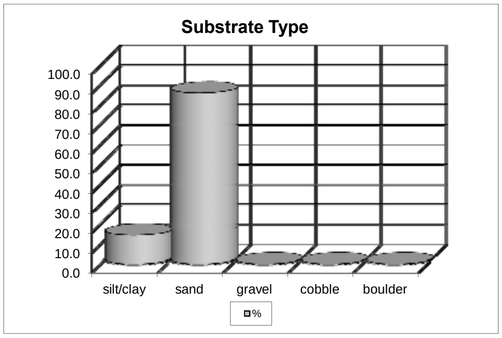
Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres) - Section 1 Stability Test





Morphology Type

cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Geometry

A (m^2)	1.68
R (m)	0.30
TW (m)	5.38
WP (m)	5.57
max d (m)	0.43
mean d (m)	0.31
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr *R* /D_{84}	602.02
ff V mean/V*	13.09
ff D_{84}	18.76
ff mean	15.92
SMOOTH BED	

Hydraulic Ratios

ER max d	3.35
r_c / TW	
TW / Lf_w	1.17
TW/max d	12.5
TW/mean d	17.3

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.43	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.043	D_{50}	0.023	1.33	NO	NO	YES	YES
		D_{84}	0.071	4.07	NO	NO	NO	YES

Section Data

ER_e (m)	0.28	ER stations L / R	-10.00	8.00	TW ck
WS_e (m)	-0.150	WS stations L / R	0.30	5.70	5.40
Lf_e (m)	-0.350	Lf stations L / R	0.80	5.40	
W_{fp} (m)	18.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
<u>z</u>		T_e (m) $T_{o/s}$ (m)	-0.58	3.25	
E_g ($m\ m^{-1}$)	0.0030				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} ($kg\ sec^{-1}$)	Limerinos Q Q_{sb} ($kg\ sec^{-1}$)		D_{30}	D_{50}	D_{84}
			T_*	91.2	45.6	18.2
B3	0.0020	0.0026	saltation	YES	YES	YES
C3	0.0004	0.0025	rolling	YES	YES	YES
C4	0.0070	0.0108	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	0.50	1.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)					0.97
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method / Flow Regime Limerinos method

Strickler method		Limerinos method	
Q (cms)	1.173	Q (cms)	
V ($m\ s^{-1}$)	0.70	V ($m\ s^{-1}$)	
n	0.035	n	
Fr	0.40	*Fr*	
D_c rectangular (m)	0.17	D_c rectangular (m)	
D_c trapezoidal (m)	0.33	D_c trapezoidal (m)	
D_c triangular (m)	0.50	D_c triangular (m)	
D_c parabolic (m)	0.31	D_c parabolic (m)	
D_c mean (m)	0.33	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	34.49	Ω (watts m^{-1})	
ω_a (watts m^{-2})	6.20	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.15	ω_a/TW (watts m^{-1})	
*Re**	0.3	*Re**	
Re	184848	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	0.90		
τ_{calc} ($N\ m^{-2}$)	8.85		
τ D_{crit} (gr-co) (mm)	9.12		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.07	0.14	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.11	0.22	

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

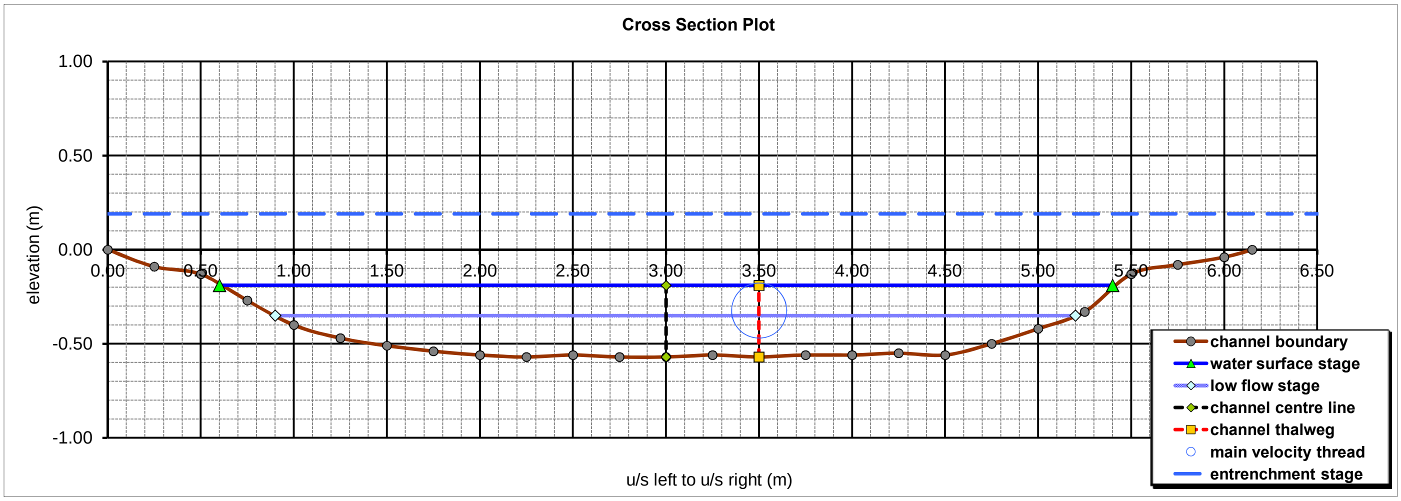
Substrate Type (%)

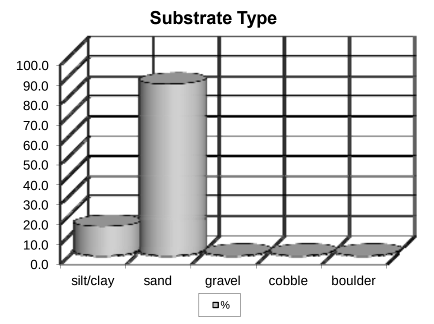
silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres) - Section 2 Stability Test





Morphology Type	
cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.50
R (m)	0.30
TW (m)	4.82
WP (m)	4.97
max d (m)	0.38
mean d (m)	0.31
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	601.57
ff V mean/V*	13.09
ff D_{84}	18.75
ff mean	15.92
SMOOTH BED	

Hydraulic Ratios	
ER max d	3.74
r_c / TW	
TW / Lf_w	1.12
TW/max d	12.7
TW/mean d	15.5

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.43	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.043	D_{50}	0.023	1.33	NO	NO	YES	YES
		D_{84}	0.071	4.07	NO	NO	NO	YES

Section Data					
ER_e (m)	0.19	ER stations L / R	-10.00	8.00	TW ck
WS_e (m)	-0.190	WS stations L / R	0.60	5.40	4.80
Lf_e (m)	-0.350	Lf stations L / R	0.90	5.20	
W_{fp} (m)	18.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		*T* e (m) *T* o/s (m)	-0.57	3.50	
E_g ($m\ m^{-1}$)	0.0030				

Bedload Transport Data						
	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	91.2	45.6	18.2
B3	0.0019	0.0025	saltation	YES	YES	YES
C3	0.0003	0.0020	rolling	YES	YES	YES
C4	0.0066	0.0103	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	0.50	1.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)					0.97
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	1.046	Q (cms)	
V ($m\ s^{-1}$)	0.70	V ($m\ s^{-1}$)	
n	0.035	n	
Fr	0.40	*Fr*	
D_c rectangular (m)	0.17	D_c rectangular (m)	
D_c trapezoidal (m)	0.31	D_c trapezoidal (m)	
D_c triangular (m)	0.48	D_c triangular (m)	
D_c parabolic (m)	0.29	D_c parabolic (m)	
D_c mean (m)	0.31	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	30.76	Ω (watts m^{-1})	
ω_a (watts m^{-2})	6.19	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.28	ω_a/TW (watts m^{-1})	
*Re**	0.3	*Re**	
Re	184617	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds			
τ_{calc} ($kg\ m^{-2}$)	0.90		
τ_{calc} ($N\ m^{-2}$)	8.84	V_c / V_b	
τ D_{crit} (gr-co) (mm)	9.12	Strickler	Limerinos
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.07	0.14	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.11	0.22	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

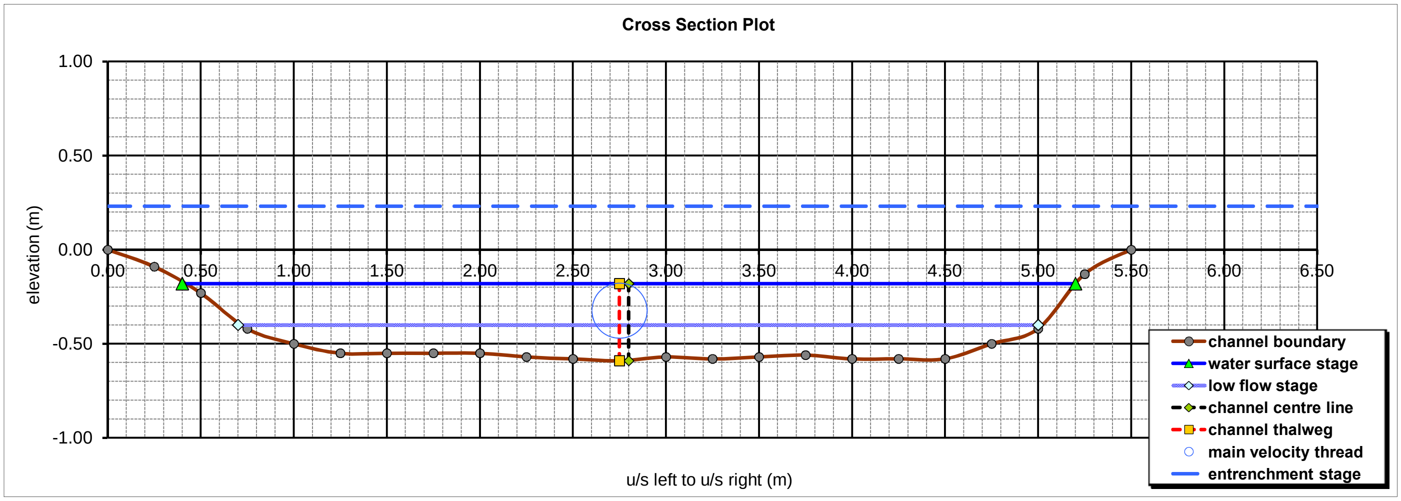
Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

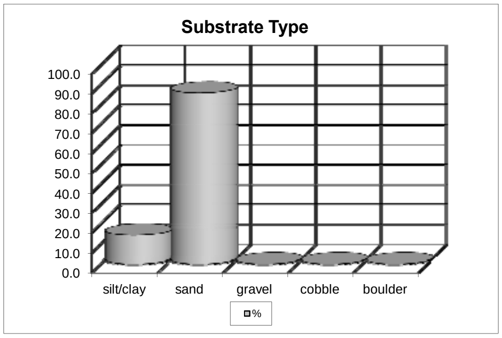
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

AquaLogic

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres) - Section 3 Stability Test





Morphology Type	
cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.64
R (m)	0.33
TW (m)	4.80
WP (m)	5.03
max d (m)	0.41
mean d (m)	0.34
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	653.53
ff V mean/V*	13.04
ff D_{84}	18.99
ff mean	16.02
SMOOTH BED	

Hydraulic Ratios	
ER max d	3.75
r_c / TW	
TW / Lf_w	1.12
TW/max d	11.7
TW/mean d	14.0

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.41	YES	YES	YES	YES
V_* (m s^{-1})	0.044	D_{50}	0.023	1.28	NO	NO	YES	YES
		D_{84}	0.071	3.91	NO	NO	NO	YES

Section Data

ER_e (m)	0.23	ER stations L / R	-10.00	8.00	TW ck
WS_e (m)	-0.180	WS stations L / R	0.40	5.20	4.80
Lf_e (m)	-0.400	Lf stations L / R	0.70	5.00	
W_{fp} (m)	18.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.59	2.75	
E_g (m m^{-1})	0.0030				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	99.0	49.5	19.8
B3	0.0020	0.0026	saltation	YES	YES	YES
C3	0.0004	0.0026	rolling	YES	YES	YES
C4	0.0069	0.0110	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	0.50	1.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})					0.97
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds

τ_{calc} (kg m^{-2})	0.98		
τ_{calc} (N m^{-2})	9.61	V_c / V_b	
τ D_{crit} (gr-co) (mm)	9.90	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.07	0.14	
D_{84} V_c (vcs +) (m s^{-1})	0.11	0.22	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Flow Regime Strickler method

Q (cms)	1.150
V (m s^{-1})	0.70
n	0.037
Fr	0.38
D_c rectangular (m)	0.18
D_c trapezoidal (m)	0.33
D_c triangular (m)	0.50
D_c parabolic (m)	0.30
D_c mean (m)	0.33
flow type	SUBCRITICAL
Ω (watts m^{-1})	33.80
ω_a (watts m^{-2})	6.72
ω_a/TW (watts m^{-1})	1.40
*Re**	0.3
Re	200553
turbulence	LOW

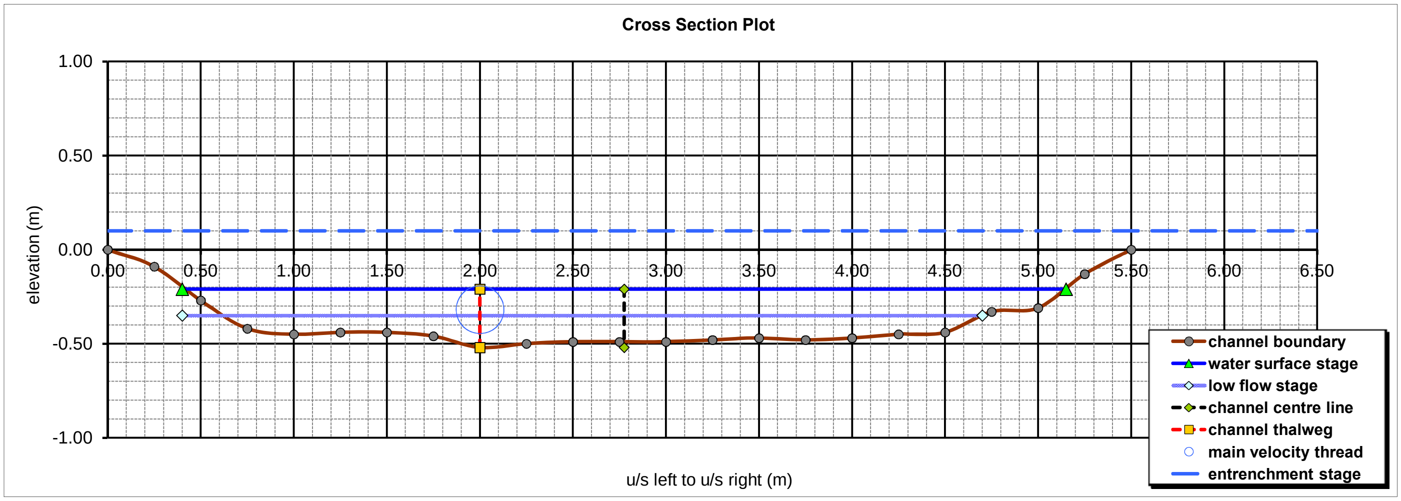
Flow Regime Limerinos method

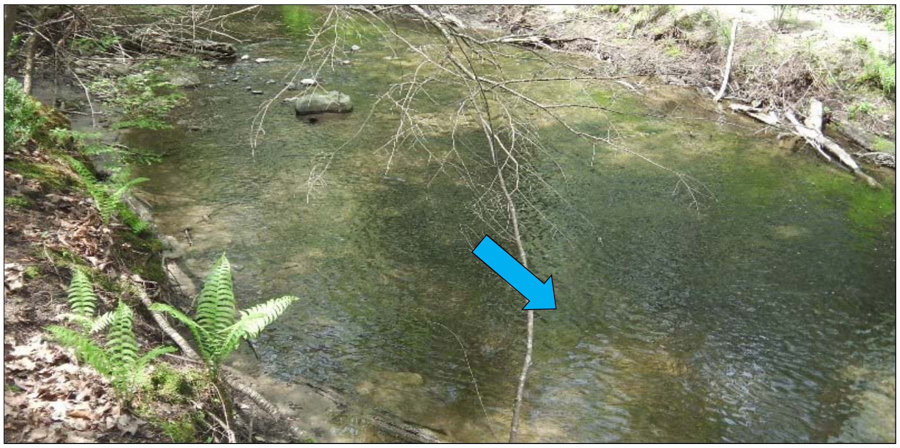
Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

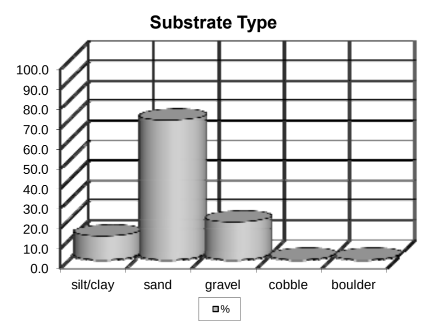
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres) - Section 4 Stability Test







Morphology Type		Hydraulic Geometry	
cascade		A (m^2)	1.09
step		*R* (m)	0.23
riffle		TW (m)	4.72
run		WP (m)	4.85
glide		max d (m)	0.31
pool	●	mean d (m)	0.23
thalweg out of phase		$E_{s\ (Limerinos)}$ (m) [+]	
		$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr R/D_{84}	56.26
ff V mean/V*	9.84
ff D_{84}	12.87
ff mean	11.36
SMOOTH BED	

Hydraulic Ratios	
ER max d	3.18
r_c / TW	
TW / Lf_w	1.10
TW/max d	15.2
TW/mean d	20.4

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.023	1.19	NO	YES	YES	YES
V_* ($m\ s^{-1}$)	0.047	D_{50}	0.040	2.07	NO	NO	YES	YES
		D_{84}	0.288	14.79	NO	NO	NO	NO

Section Data

ER_e (m)	0.10	ER stations L / R	-5.00	10.00	TW ck
WS_e (m)	-0.210	WS stations L / R	0.40	5.15	4.75
Lf_e (m)	-0.350	Lf stations L / R	0.40	4.70	
W_{fp} (m)	15.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
<u>z</u>		T_e (m) $T_{o/s}$ (m)	-0.52	2.00	
E_g ($m\ m^{-1}$)	0.0050				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} ($kg\ sec^{-1}$)	Limerinos Q Q_{sb} ($kg\ sec^{-1}$)		D_{30}	D_{50}	D_{84}
			T_*	56.8	37.9	2.8
B3	0.0018	0.0021	saltation	YES	YES	YES
C3	0.0002	0.0007	rolling	YES	YES	YES
C4	0.0057	0.0078	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.20	0.30	4.00	40.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				3.88	38.80
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	0.768	Q (cms)	
V ($m\ s^{-1}$)	0.70	V ($m\ s^{-1}$)	
n	0.037	n	
Fr	0.47	*Fr*	
D_c rectangular (m)	0.14	D_c rectangular (m)	
D_c trapezoidal (m)	0.28	D_c trapezoidal (m)	
D_c triangular (m)	0.42	D_c triangular (m)	
D_c parabolic (m)	0.27	D_c parabolic (m)	
D_c mean (m)	0.28	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω ($watts\ m^{-1}$)	37.65	Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	7.76	ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	1.64	ω_a/TW ($watts\ m^{-1}$)	
*Re**	0.5	*Re**	
Re	138895	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	V_c / V_b Limerinos
τ_{calc} ($kg\ m^{-2}$)	1.13		
τ_{calc} ($N\ m^{-2}$)	11.03		
$\tau\ D_{crit}$ (gr-co) (mm)	11.37		
$D_{50}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.08	0.17	
$D_{84}\ V_c$ (vcs +) ($m\ s^{-1}$)	0.31	0.63	

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

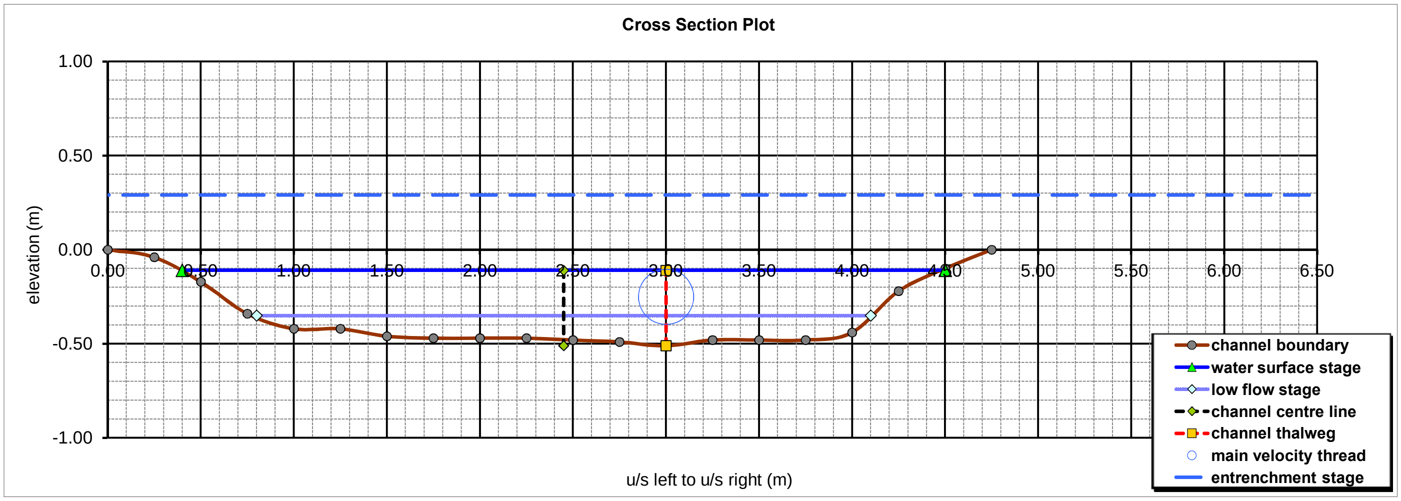
Substrate Type (%)

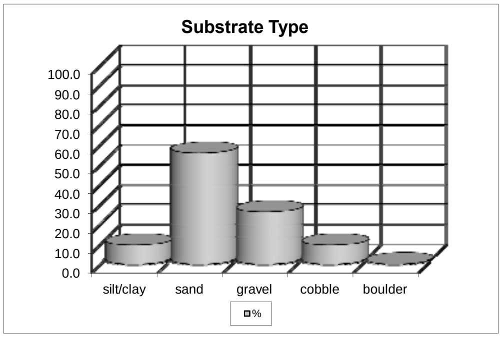
silt/clay	sand	gravel	cobble	boulder
11.6	69.8	18.6	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres) - Section 5 Stability Test





Morphology Type	
cascade	
step	
riffle	●
run	
glide	
pool	
thalweg out of phase	●

Hydraulic Geometry	
A (m^2)	1.25
R (m)	0.29
TW (m)	4.09
WP (m)	4.29
max d (m)	0.40
mean d (m)	0.31
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	9.75
ff V mean/V*	7.64
ff D_{84}	8.58
ff mean	8.11
SMOOTH BED	

Hydraulic Ratios	
ER max d	2.20
r_c / TW	
TW / Lf_w	1.24
TW/max d	10.2
TW/mean d	13.4

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.023	0.74	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.077	D_{50}	0.071	2.26	NO	NO	YES	YES
		D_{84}	0.803	25.61	NO	NO	NO	NO

Section Data

ER_e (m)	0.29	ER stations L / R	-2.00	7.00	TW ck
WS_e (m)	-0.110	WS stations L / R	0.40	4.50	4.10
Lf_e (m)	-0.350	Lf stations L / R	0.80	4.10	
W_{fp} (m)	9.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		*T* $_e$ (m) *T* $_{o/s}$ (m)	-0.51	3.00	
E_g ($m\ m^{-1}$)	0.0100				

Bedload Transport Data

	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	147.7	59.1	1.0
B3	0.0021	0.0023	saltation	YES	YES	NO
C3	0.0006	0.0010	rolling	YES	YES	NO
C4	0.0076	0.0087	Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.20	0.50	30.00	150.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				29.10	145.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method

Q (cms)	1.376
V ($m\ s^{-1}$)	1.10
n	0.040
Fr	0.63
D_c rectangular (m)	0.23
D_c trapezoidal (m)	0.37
D_c triangular (m)	0.53
D_c parabolic (m)	0.34
D_c mean (m)	0.37
flow type	SUBCRITICAL
Ω (watts m^{-1})	134.88
ω_a (watts m^{-2})	31.43
ω_a/TW (watts m^{-1})	7.68
*Re**	0.8
Re	281309
turbulence	LOW

Flow Regime Limerinos method

Q (cms)	
V ($m\ s^{-1}$)	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

Erosion Thresholds

		V_c / V_b	
τ_{calc} ($kg\ m^{-2}$)	2.92		
τ_{calc} ($N\ m^{-2}$)	28.65		
τ D_{crit} (gr-co) (mm)	29.54	Strickler	Limerinos
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.11	0.14	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.85	1.11	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
9.3	55.6	25.9	9.3	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

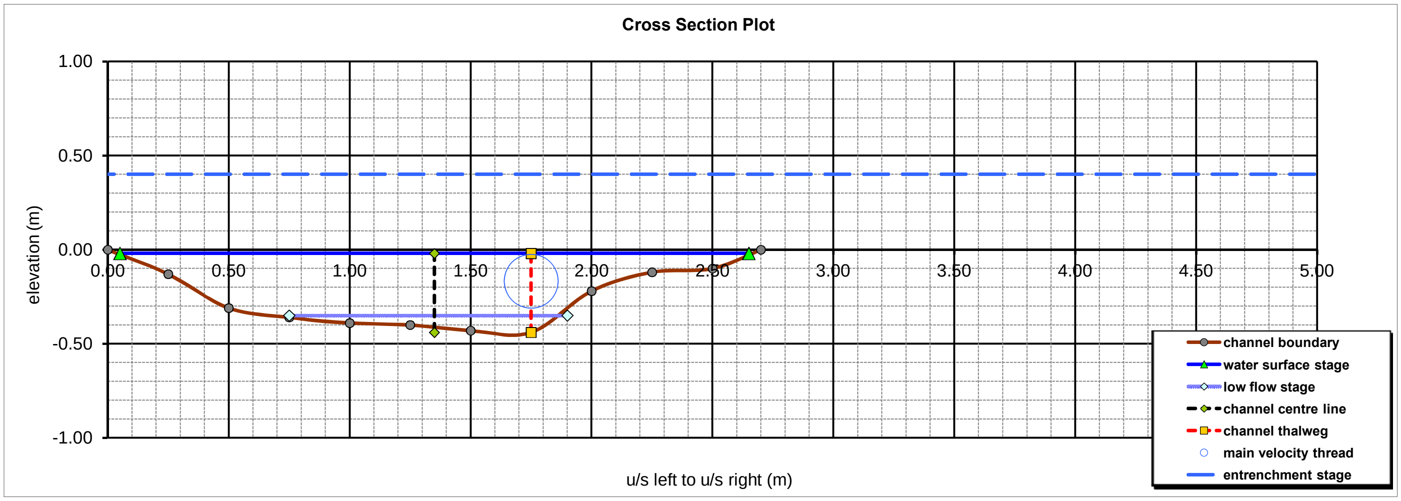
Moosenlanka Creek (25 SR, Sandy Cove Acres)
Stable Conditions Cross-Section Models

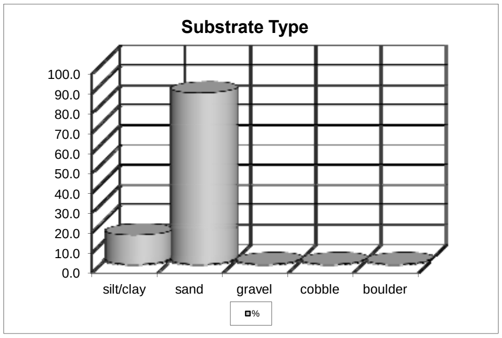
Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Moosenlanka Creek (25 SR, Sandy Cove Acres) - Section 1 Stability Test





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.67
R (m)	0.24
TW (m)	2.62
WP (m)	2.84
max d (m)	0.42
mean d (m)	0.26
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	471.76
ff V mean/V*	11.82
ff D_{84}	18.27
ff mean	15.04
SMOOTH BED	

Hydraulic Ratios	
ER max d	7.63
r_c / TW	
TW / Lf_w	2.28
TW/max d	6.2
TW/mean d	10.3

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.28	YES	YES	YES	YES
V_* (m s^{-1})	0.065	D_{50}	0.023	0.87	NO	YES	YES	YES
		D_{84}	0.071	2.66	NO	NO	NO	YES

Section Data

ER_e (m)	0.40	ER stations L / R	-10.00	10.00	TW ck
WS_e (m)	-0.020	WS stations L / R	0.05	2.65	2.60
Lf_e (m)	-0.350	Lf stations L / R	0.75	1.90	
W_{fp} (m)	20.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.44	1.75	
E_g (m m^{-1})	0.0090				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	214.5	107.2	42.9
B3	0.0016	0.0022	saltation	YES	YES	YES
C3	0.0001	0.0009	rolling	YES	YES	YES
C4	0.0048	0.0085	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	0.50	1.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})					0.97
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime

Strickler method		Limerinos method	
Q (cms)	0.536	Q (cms)	
V (m s^{-1})	0.80	V (m s^{-1})	
n	0.045	n	
Fr	0.51	*Fr*	
D_c rectangular (m)	0.17	D_c rectangular (m)	
D_c trapezoidal (m)	0.25	D_c trapezoidal (m)	
D_c triangular (m)	0.37	D_c triangular (m)	
D_c parabolic (m)	0.22	D_c parabolic (m)	
D_c mean (m)	0.25	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	47.28	Ω (watts m^{-1})	
ω_a (watts m^{-2})	16.66	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	6.36	ω_a/TW (watts m^{-1})	
*Re**	0.4	*Re**	
Re	165730	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} (kg m^{-2})	2.12		
τ_{calc} (N m^{-2})	20.80		
τ D_{crit} (gr-co) (mm)	21.45		
D_{50} V_c (vcs +) (m s^{-1})	0.07	0.12	
D_{84} V_c (vcs +) (m s^{-1})	0.11	0.20	

Bank Data

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Substrate Type (%)

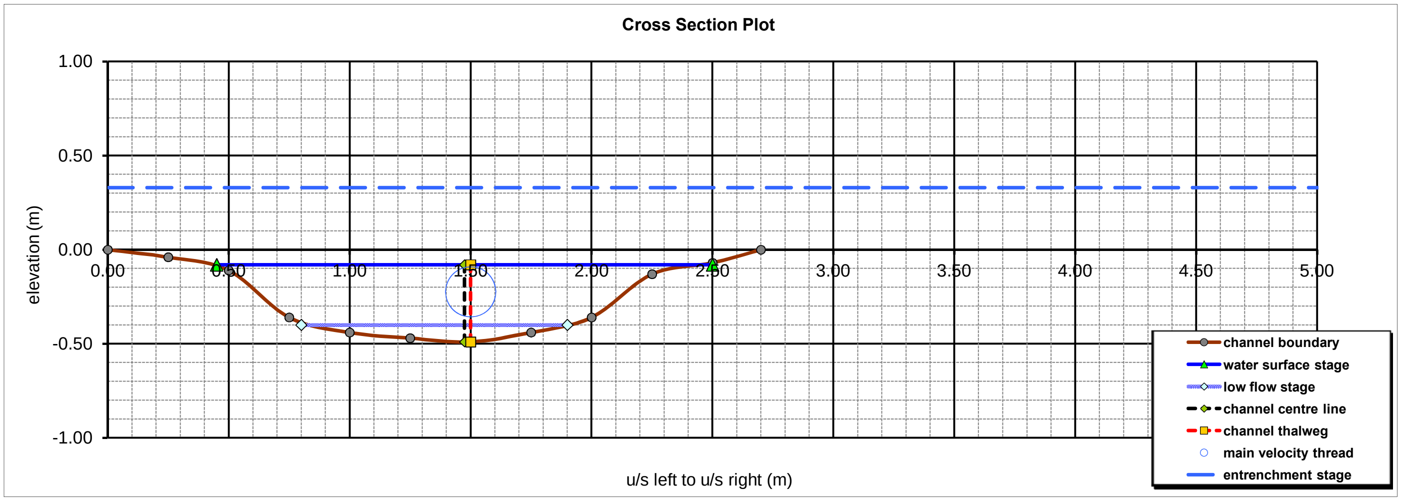
silt/clay	sand	gravel	cobble	boulder
14.3	85.7	0.0	0.0	0.0

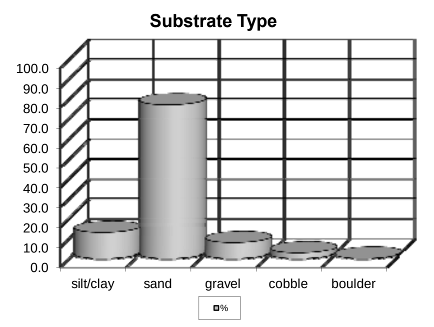
GEO-X v.5.1 Geomorphic Cross-section Analysis Model

AquaLogic

B. de Geus 05.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Moosenlanka Creek (25 SR, Sandy Cove Acres) - Section 2





Morphology Type

cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry

A (m^2)	0.54
R (m)	0.23
TW (m)	2.07
WP (m)	2.30
max d (m)	0.41
mean d (m)	0.26
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr *R* /D_{84}	233.27
ff V mean/V*	10.97
ff D_{84}	16.59
ff mean	13.78
	SMOOTH BED

Hydraulic Ratios

ER max d	9.20
r_c / TW	
TW / Lf_w	1.88
TW/max d	5.0
TW/mean d	7.9

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.28	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.065	D_{50}	0.023	0.87	NO	YES	YES	YES
		D_{84}	0.126	4.75	NO	NO	NO	YES

Section Data

ER_e (m)	0.33	ER stations L / R	-4.00	15.00	TW ck
WS_e (m)	-0.080	WS stations L / R	0.45	2.50	2.05
Lf_e (m)	-0.400	Lf stations L / R	0.80	1.90	
W_{fp} (m)	19.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		*T* e (m) *T* o/s (m)	-0.49	1.50	
E_g ($m\ m^{-1}$)	0.0090				

Bedload Transport Data

	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	212.1	106.1	21.2
B3	0.0015	0.0020	saltation	YES	YES	YES
C3	0.0001	0.0005	rolling	YES	YES	YES
C4	0.0043	0.0073	Ø	NO	NO	NO

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.20	1.00	70.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				0.97	67.90
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds

		V_c / V_b	
		Strickler	Limerinos
τ_{calc} ($kg\ m^{-2}$)	2.10		
τ_{calc} ($N\ m^{-2}$)	20.57		
τ D_{crit} (gr-co) (mm)	21.21		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.07	0.12	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.16	0.28	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
12.8	76.9	7.7	2.6	0.0

Bank Data u/s L u/s R

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Flow Regime Strickler method

Q (cms)	0.427
V ($m\ s^{-1}$)	0.80
n	0.045
Fr	0.50
D_c rectangular (m)	0.17
D_c trapezoidal (m)	0.23
D_c triangular (m)	0.33
D_c parabolic (m)	0.20
D_c mean (m)	0.23
flow type	SUBCRITICAL
Ω (watts m^{-1})	37.64
ω_a (watts m^{-2})	16.36
ω_a/TW (watts m^{-1})	7.92
*Re**	0.4
Re	162674
turbulence	LOW

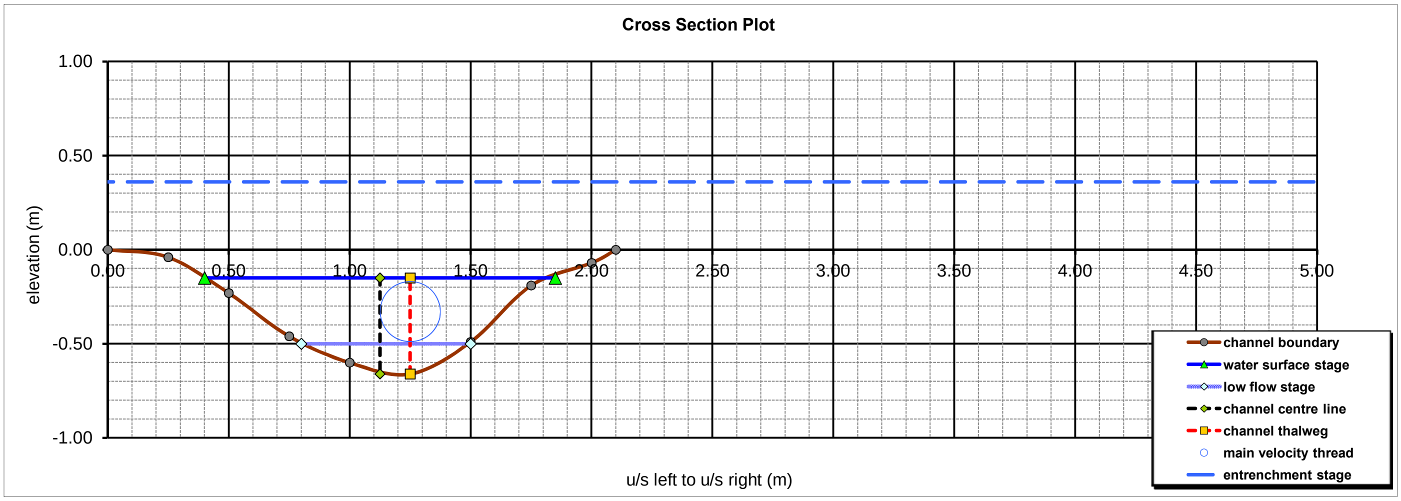
Flow Regime Limerinos method

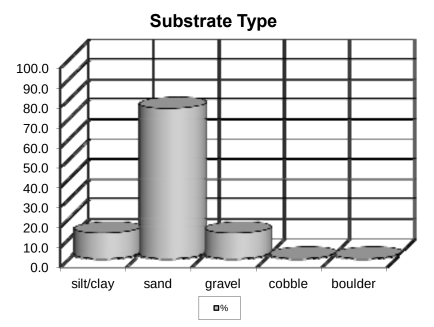
Q (cms)	
V ($m\ s^{-1}$)	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Moosenlanka Creek (25 SR, Sandy Cove Acres) - Section 3





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.42
R (m)	0.24
TW (m)	1.44
WP (m)	1.80
max d (m)	0.51
mean d (m)	0.29
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	235.10
ff V mean/V*	10.96
ff D_{84}	16.90
ff mean	13.93
	SMOOTH BED

Hydraulic Ratios	
ER max d	8.34
r_c / TW	
TW / Lf_w	2.06
TW/max d	2.8
TW/mean d	4.9

Sediment Transport Mode

			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.008	0.28	YES	YES	YES	YES
V_* ($m\ s^{-1}$)	0.065	D_{50}	0.032	1.19	NO	YES	YES	YES
		D_{84}	0.126	4.73	NO	NO	NO	YES

Section Data

ER_e (m)	0.36	ER stations L / R	-2.00	10.00	TW ck
WS_e (m)	-0.150	WS stations L / R	0.40	1.85	1.45
Lf_e (m)	-0.500	Lf stations L / R	0.80	1.50	
W_{fp} (m)	12.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.66	1.25	
E_g ($m\ m^{-1}$)	0.0090				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} ($kg\ sec^{-1}$)	Limerinos Q Q_{sb} ($kg\ sec^{-1}$)
B3	0.0014	0.0019
C3	0.0000	0.0003
C4	0.0039	0.0065

	D_{30}	D_{50}	D_{84}
T_*	213.8	85.5	21.4
saltation	YES	YES	YES
rolling	YES	YES	YES
Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.10	0.25	1.00	40.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)				0.97	38.80
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds

τ_{calc} ($kg\ m^{-2}$)	2.12	

		V_c / V_b Strickler	Limerinos
τ_{calc} ($N\ m^{-2}$)	20.74		
τ D_{crit} (gr-co) (mm)	21.38		
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.08	0.14	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.16	0.28	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
12.5	75.0	12.5	0.0	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	0.338	Q (cms)	
V ($m\ s^{-1}$)	0.80	V ($m\ s^{-1}$)	
n	0.045	n	
Fr	0.47	*Fr*	
D_c rectangular (m)	0.18	D_c rectangular (m)	
D_c trapezoidal (m)	0.22	D_c trapezoidal (m)	
D_c triangular (m)	0.30	D_c triangular (m)	
D_c parabolic (m)	0.17	D_c parabolic (m)	
D_c mean (m)	0.22	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω ($watts\ m^{-1}$)	29.84	Ω ($watts\ m^{-1}$)	
ω_a ($watts\ m^{-2}$)	16.57	ω_a ($watts\ m^{-2}$)	
ω_a/TW ($watts\ m^{-1}$)	11.52	ω_a/TW ($watts\ m^{-1}$)	
*Re**	0.5	*Re**	
Re	164817	*Re*	
turbulence	LOW	turbulence	

Carson Creek (Ewart St., Lefroy)
Stable Conditions Cross-Section Models

Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

AquaLogic

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Carson Creek (Ewart St., Lefroy) - Section 1 Stability Test

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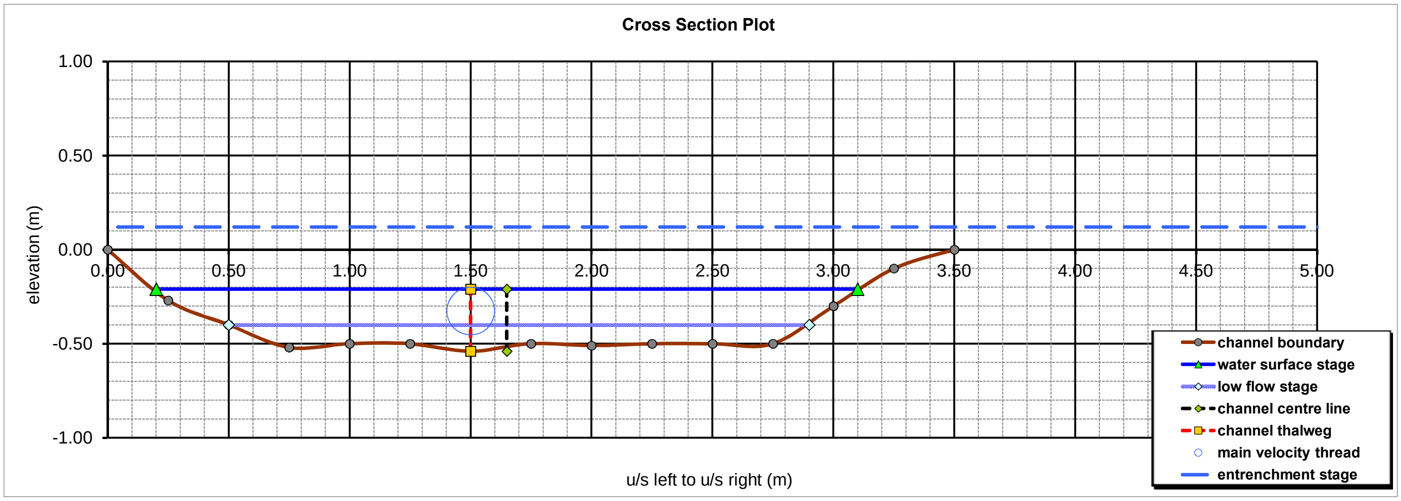

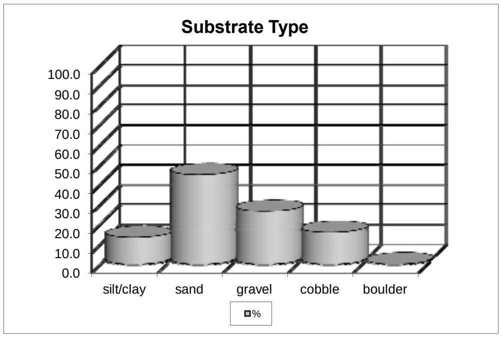

Morphology Type

cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry

A (m^2)	0.74
R (m)	0.24
TW (m)	2.92
WP (m)	3.11
max d (m)	0.33
mean d (m)	0.25
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness

rr *R* /D_{84}	3.98
ff V mean/V*	6.11
ff D_{84}	6.41
ff mean	6.26
	ROUGH BED

Hydraulic Ratios

ER max d	3.77
r_c / TW	
TW / Lf_w	1.22
TW/max d	8.8
TW/mean d	11.5

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.023	1.16	NO	YES	YES	YES
V_* (m s^{-1})	0.049	D_{50}	0.071	3.54	NO	NO	NO	YES
		D_{84}	1.137	56.73	NO	NO	NO	NO

Section Data

ER_e (m)	0.12	ER stations L / R	-3.00	8.00	TW ck
WS_e (m)	-0.210	WS stations L / R	0.20	3.10	2.90
Lf_e (m)	-0.400	Lf stations L / R	0.50	2.90	
W_{fp} (m)	11.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.54	1.50	
E_g (m m^{-1})	0.0050				

Bedload Transport Data

	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	60.3	24.1	0.2
B3	0.0015	0.0016	saltation	YES	YES	NO
C3	0.0001	0.0001	rolling	YES	YES	NO
C4	0.0044	0.0048	Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.20	0.50	60.00	150.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})				58.20	145.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method / Flow Regime Limerinos method

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.447	Q (cms)	
V (m s^{-1})	0.60	V (m s^{-1})	
n	0.045	n	
Fr	0.38	*Fr*	
D_c rectangular (m)	0.14	D_c rectangular (m)	
D_c trapezoidal (m)	0.23	D_c trapezoidal (m)	
D_c triangular (m)	0.34	D_c triangular (m)	
D_c parabolic (m)	0.20	D_c parabolic (m)	
D_c mean (m)	0.23	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	21.91	Ω (watts m^{-1})	
ω_a (watts m^{-2})	7.04	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	2.41	ω_a/TW (watts m^{-1})	
*Re**	0.9	*Re**	
Re	126001	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds

		V_c / V_b	
		Strickler	Limerinos
τ_{calc} (kg m^{-2})	1.19		
τ_{calc} (N m^{-2})	11.70		
τ D_{crit} (gr-co) (mm)	12.06		
D_{50} V_c (vcs +) (m s^{-1})	0.11	0.26	
D_{84} V_c (vcs +) (m s^{-1})	1.20	2.85	

Bank Data u/s L u/s R

	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
13.2	44.7	26.3	15.8	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

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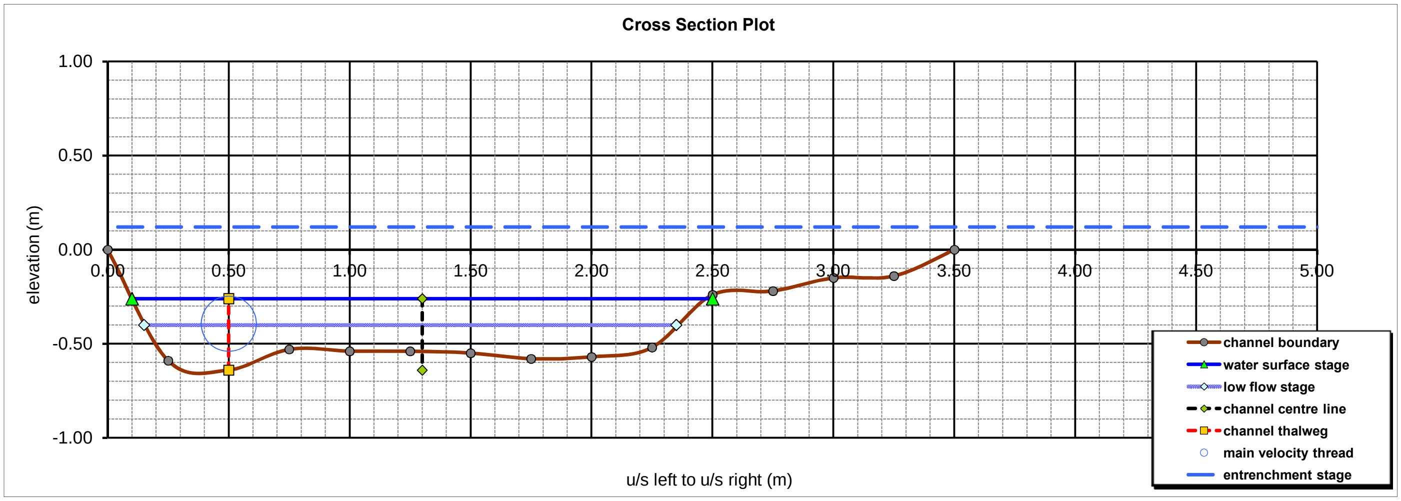
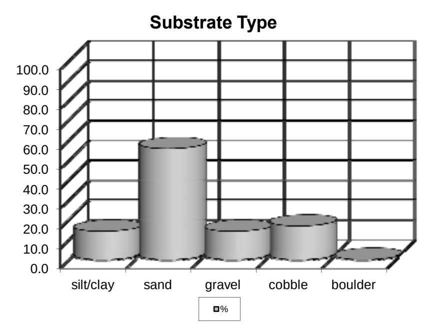
Project: **Erosion Threshold Analysis**
Innisfil Stormwater Management Master Plan
Carson Creek (Ewart St., Lefroy) - Section 2 Stability Test





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.66
R (m)	0.24
TW (m)	2.37
WP (m)	2.74
max d (m)	0.38
mean d (m)	0.28
$E_{S\ (Limerinos)}$ (m) [+]	
$E_{S\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	2.67
ff V mean/V*	5.70
ff D_{84}	5.62
ff mean	5.66
	ROUGH BED

Hydraulic Ratios	
ER max d	4.64
r_c / TW	
TW / Lf_w	1.08
TW/max d	6.2
TW/mean d	8.5

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.023	1.15	NO	YES	YES	YES
V_* (m s^{-1})	0.049	D_{50}	0.071	3.53	NO	NO	NO	YES
		D_{84}	1.393	69.23	NO	NO	NO	NO

Section Data

ER_e (m)	0.12	ER stations L / R	-3.00	8.00	TW ck
WS_e (m)	-0.260	WS stations L / R	0.10	2.50	2.40
Lf_e (m)	-0.400	Lf stations L / R	0.15	2.35	
W_{fp} (m)	11.00	E_S sta. (Limerinos) L / R			
r_c (m)		E_S sta. (Strickler) L / R			
z		*T* e (m) *T* o/s (m)	-0.64	0.50	
E_g (m m^{-1})	0.0050				

Bedload Transport Data

	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	60.7	24.3	0.1
B3	0.0015	0.0015	saltation	YES	YES	NO
C3	0.0001	0.0001	rolling	YES	YES	NO
C4	0.0042	0.0043	Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.20	0.50	90.00	110.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})				87.30	106.70
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method

Q (cms)	0.399
V (m s^{-1})	0.60
n	0.045
Fr	0.37
D_c rectangular (m)	0.15
D_c trapezoidal (m)	0.22
D_c triangular (m)	0.32
D_c parabolic (m)	0.19
D_c mean (m)	0.22
flow type	SUBCRITICAL
Ω (watts m^{-1})	19.54
ω_a (watts m^{-2})	7.13
ω_a/TW (watts m^{-1})	3.00
*Re**	1.0
Re	127580
turbulence	LOW

Flow Regime Limerinos method

Q (cms)	
V (m s^{-1})	
n	
Fr	
D_c rectangular (m)	
D_c trapezoidal (m)	
D_c triangular (m)	
D_c parabolic (m)	
D_c mean (m)	
flow type	
Ω (watts m^{-1})	
ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	
*Re**	
Re	
turbulence	

Erosion Thresholds

τ_{calc} (kg m^{-2})	1.20		
τ_{calc} (N m^{-2})	11.78	*V* c / *V* b	
τ D_{crit} (gr-co) (mm)	12.15	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.11	0.26	
D_{84} V_c (vcs +) (m s^{-1})	1.47	3.47	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
13.9	55.6	13.9	16.7	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Carson Creek (Ewart St., Lefroy) - Section 3 Stability Test

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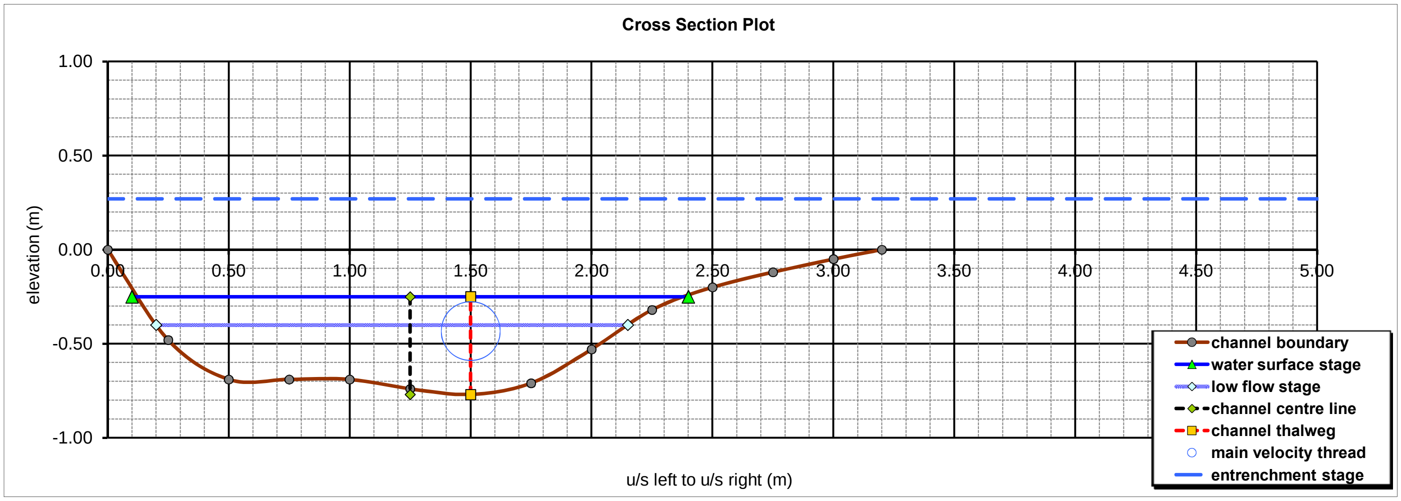

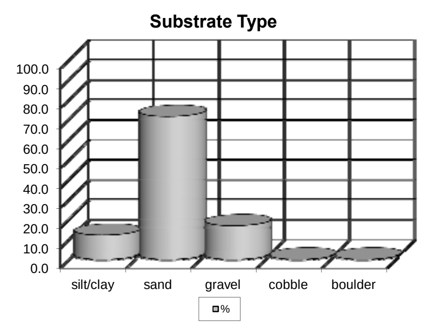

Morphology Type	
cascade	
step	
riffle	
run	
glide	
pool	●
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.82
R (m)	0.31
TW (m)	2.27
WP (m)	2.65
max d (m)	0.52
mean d (m)	0.36
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	31.14
ff V mean/V*	8.74
ff D_{84}	11.73
ff mean	10.23
SMOOTH BED	

Hydraulic Ratios	
ER max d	8.83
r_c / TW	
TW / Lf_w	1.16
TW/max d	4.4
TW/mean d	6.2

Sediment Transport Mode			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.023	1.13	NO	YES	YES	YES
V_* (m s^{-1})	0.050	D_{50}	0.032	1.55	NO	NO	YES	YES
		D_{84}	0.462	22.56	NO	NO	NO	NO

Section Data					
ER_e (m)	0.27	ER stations L / R	-5.00	15.00	TW ck
WS_e (m)	-0.250	WS stations L / R	0.10	2.40	2.30
Lf_e (m)	-0.400	Lf stations L / R	0.20	2.15	
W_{fp} (m)	20.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.77	1.50	
E_g (m m^{-1})	0.0040				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen	Q_{sb}	Q_{sb}		D_{30}	D_{50}	D_{84}
type	(kg sec^{-1})	(kg sec^{-1})	T_*	62.9	50.3	1.3
B3	0.0016	0.0019	saltation	YES	YES	NO
C3	0.0001	0.0003	rolling	YES	YES	YES
C4	0.0048	0.0067	Ø	NO	NO	NO

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.06	0.20	0.25	10.00	60.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})				9.70	58.20
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.530	Q (cms)	
V (m s^{-1})	0.64	V (m s^{-1})	
n	0.045	n	
Fr	0.34	*Fr*	
D_c rectangular (m)	0.18	D_c rectangular (m)	
D_c trapezoidal (m)	0.25	D_c trapezoidal (m)	
D_c triangular (m)	0.36	D_c triangular (m)	
D_c parabolic (m)	0.20	D_c parabolic (m)	
D_c mean (m)	0.25	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	20.77	Ω (watts m^{-1})	
ω_a (watts m^{-2})	7.85	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	3.46	ω_a/TW (watts m^{-1})	
*Re**	0.5	*Re**	
Re	175665	*Re*	
turbulence	LOW	turbulence	

Erosion Thresholds			
τ_{calc} (kg m^{-2})	1.25		
τ_{calc} (N m^{-2})	12.21	V_c / V_b	
τ D_{crit} (gr-co) (mm)	12.58	Strickler	Limerinos
D_{50} V_c (vcs +) (m s^{-1})	0.08	0.17	
D_{84} V_c (vcs +) (m s^{-1})	0.49	1.09	

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
11.9	71.4	16.7	0.0	0.0

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

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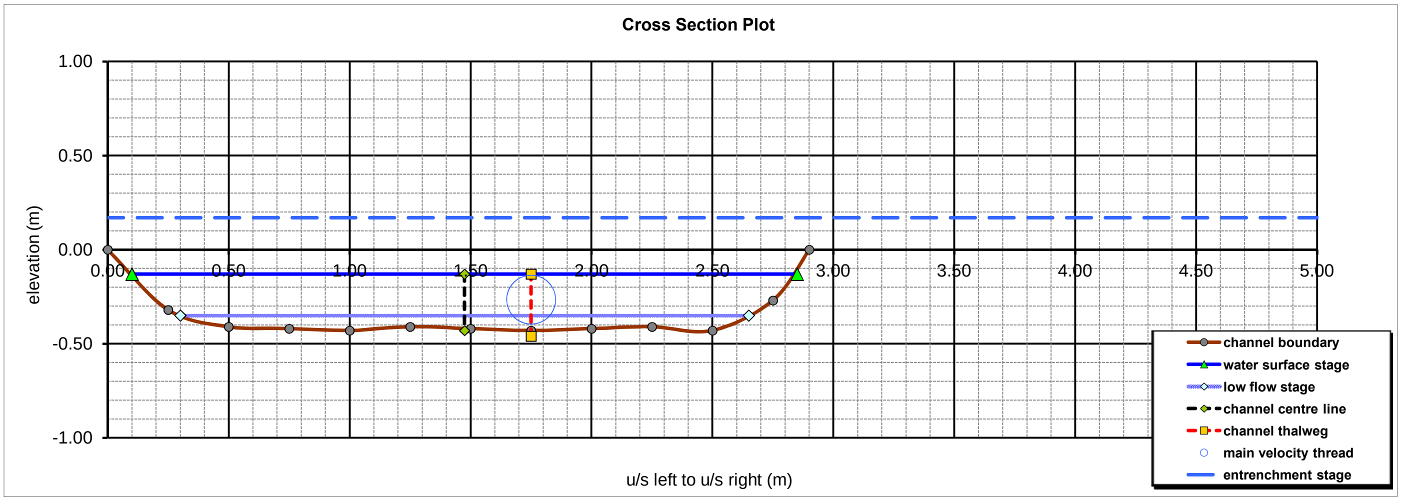
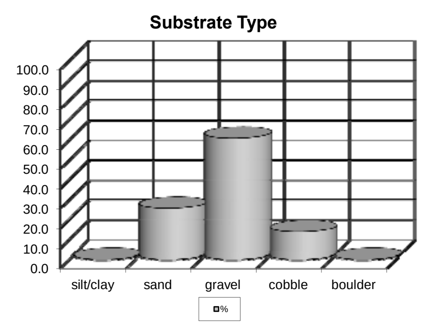
Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Carson Creek (Ewart St., Lefroy) - Section 4 Stability Test





Morphology Type	
cascade	
step	
riffle	●
run	
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	0.71
R (m)	0.24
TW (m)	2.73
WP (m)	2.97
max d (m)	0.30
mean d (m)	0.26
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* / D_{84}	6.01
ff V mean/V*	6.62
ff D_{84}	7.48
ff mean	7.05
ROUGH BED	

Hydraulic Ratios	
ER max d	5.50
r_c / TW	
TW / Lf_w	1.16
TW/max d	9.1
TW/mean d	10.4

Sediment Transport Mode

			w_s (m s^{-1})	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.288	10.12	NO	NO	NO	NO
V_* (m s^{-1})	0.069	D_{50}	0.567	19.94	NO	NO	NO	NO
		D_{84}	0.928	32.63	NO	NO	NO	NO

Section Data

ER_e (m)	0.17	ER stations L / R	-5.00	10.00	TW ck
WS_e (m)	-0.130	WS stations L / R	0.10	2.85	2.75
Lf_e (m)	-0.350	Lf stations L / R	0.30	2.65	
W_{fp} (m)	15.00	E_s sta. $_{(Limerinos)}$ L / R			
r_c (m)		E_s sta. $_{(Strickler)}$ L / R			
z		*T* $_e$ (m) *T* $_{o/s}$ (m)	-0.46	1.75	
E_g (m m^{-1})	0.0100				

Bedload Transport Data

Rosgen type	Strickler Q Q_{sb} (kg sec^{-1})	Limerinos Q Q_{sb} (kg sec^{-1})		D_{30}	D_{50}	D_{84}
			T_*	6.1	1.6	0.6
B3	0.0016	0.0018	saltation	YES	NO	NO
C3	0.0001	0.0002	rolling	YES	YES	NO
C4	0.0051	0.0060	Ø	NO	NO	YES

Substrate Gradation

	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.10	4.00	15.00	40.00	120.00
Stability Design Targets (mm)					
τ_{cr} (N m^{-2})		3.88	14.55	38.80	116.40
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Erosion Thresholds

		V_c / V_b Strickler	Limerinos
τ_{calc} (kg m^{-2})	2.40		
τ_{calc} (N m^{-2})	23.56		
τ D_{crit} (gr-co) (mm)	24.29		
D_{50} V_c (vcs +) (m s^{-1})	0.60	1.00	
D_{84} V_c (vcs +) (m s^{-1})	0.98	1.64	

Substrate Type (%)

silt/clay	sand	gravel	cobble	boulder
0.0	25.5	60.8	13.7	0.0

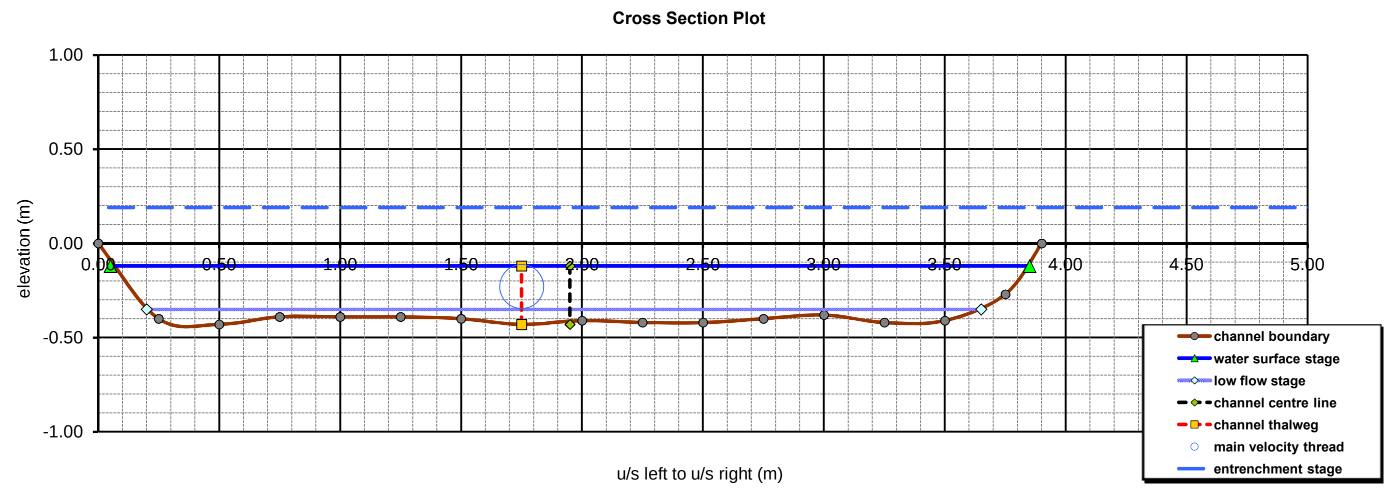
Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

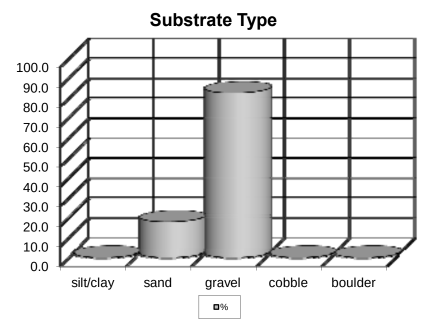
Flow Regime Strickler method		**Flow Regime Limerinos method**	
Q (cms)	0.610	Q (cms)	
V (m s^{-1})	0.86	V (m s^{-1})	
n	0.045	n	
Fr	0.53	*Fr*	
D_c rectangular (m)	0.18	D_c rectangular (m)	
D_c trapezoidal (m)	0.26	D_c trapezoidal (m)	
D_c triangular (m)	0.38	D_c triangular (m)	
D_c parabolic (m)	0.23	D_c parabolic (m)	
D_c mean (m)	0.26	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	59.78	Ω (watts m^{-1})	
ω_a (watts m^{-2})	20.15	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	7.39	ω_a/TW (watts m^{-1})	
*Re**	28.1	*Re**	
Re	180374	*Re*	
turbulence	HIGH	turbulence	

GEO-X v.5.1 Geomorphic Cross-section Analysis Model

B. de Geus 05.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Carson Creek (Ewart St., Lefroy) - Section 5 Stability Test





Morphology Type	
cascade	
step	
riffle	
run	●
glide	
pool	
thalweg out of phase	

Hydraulic Geometry	
A (m^2)	1.02
R (m)	0.25
TW (m)	3.76
WP (m)	4.05
max d (m)	0.31
mean d (m)	0.27
$E_{s\ (Limerinos)}$ (m) [+]	
$E_{s\ (Strickler)}$ (m) [+]	

Hydraulic Roughness	
rr *R* /D_{84}	10.04
ff V mean/V*	7.60
ff D_{84}	8.73
ff mean	8.16
	SMOOTH BED

Hydraulic Ratios	
ER max d	4.52
r_c / TW	
TW / Lf_w	1.09
TW/max d	12.1
TW/mean d	13.9

Sediment Transport Mode			w_s ($m\ s^{-1}$)	P	wash load	high sus. load	low sus. load	bedload
k	0.41	D_{30}	0.324	17.60	NO	NO	NO	NO
V_* ($m\ s^{-1}$)	0.045	D_{50}	0.412	22.43	NO	NO	NO	NO
		D_{84}	0.733	39.89	NO	NO	NO	NO

Section Data					
ER_e (m)	0.19	ER stations L / R	-7.00	10.00	TW ck
WS_e (m)	-0.120	WS stations L / R	0.05	3.85	3.80
Lf_e (m)	-0.350	Lf stations L / R	0.20	3.65	
W_{fp} (m)	17.00	E_s sta. (Limerinos) L / R			
r_c (m)		E_s sta. (Strickler) L / R			
z		T_e (m) $T_{o/s}$ (m)	-0.43	1.75	
E_g ($m\ m^{-1}$)	0.0040				

Bedload Transport Data	Strickler Q	Limerinos Q				
Rosgen type	Q_{sb} ($kg\ sec^{-1}$)	Q_{sb} ($kg\ sec^{-1}$)		D_{30}	D_{50}	D_{84}
			T_*	2.0	1.3	0.4
B3	0.0017	0.0018	saltation	YES	NO	NO
C3	0.0001	0.0002	rolling	YES	YES	NO
C4	0.0053	0.0062	Ø	NO	NO	YES

Substrate Gradation	D_{15}	D_{30}	D_{50}	D_{84}	D_{100}
Existing Conditions (mm)	0.50	5.00	8.00	25.00	50.00
Stability Design Targets (mm)					
τ_{cr} ($N\ m^{-2}$)		4.85	7.76	24.25	48.50
high turbulence - angular (mm)					
high turbulence - rounded (mm)					
low turbulence - angular (mm)					
low turbulence - rounded (mm)					

Flow Regime Strickler method		Flow Regime Limerinos method	
Q (cms)	0.637	Q (cms)	
V ($m\ s^{-1}$)	0.63	V ($m\ s^{-1}$)	
n	0.040	n	
Fr	0.38	*Fr*	
D_c rectangular (m)	0.15	D_c rectangular (m)	
D_c trapezoidal (m)	0.26	D_c trapezoidal (m)	
D_c triangular (m)	0.39	D_c triangular (m)	
D_c parabolic (m)	0.24	D_c parabolic (m)	
D_c mean (m)	0.26	D_c mean (m)	
flow type	SUBCRITICAL	flow type	
Ω (watts m^{-1})	24.97	Ω (watts m^{-1})	
ω_a (watts m^{-2})	6.16	ω_a (watts m^{-2})	
ω_a/TW (watts m^{-1})	1.64	ω_a/TW (watts m^{-1})	
*Re**	13.1	*Re**	
Re	137917	*Re*	
turbulence	HIGH	turbulence	

Erosion Thresholds		V_c / V_b	
τ_{calc} ($kg\ m^{-2}$)	1.00		
τ_{calc} ($N\ m^{-2}$)	9.84		
τ D_{crit} (gr-co) (mm)	10.14	Strickler	Limerinos
D_{50} V_c (vcs +) ($m\ s^{-1}$)	0.44	1.00	
D_{84} V_c (vcs +) ($m\ s^{-1}$)	0.78	1.77	

Substrate Type (%)				
silt/clay	sand	gravel	cobble	boulder
0.0	17.6	82.4	0.0	0.0

Bank Data	u/s L	u/s R
H_b (m)		
Bf_d (m)		
RDp (m)		
H_b/Bf_d		
RDp/H_b		
RDn (%)		
BA (°)		
BFP (%)		

GEO - ESUM v.1.3 Erosion Threshold Summary Models

Hewitts Creek (10th Line, Stroud)
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres)
Cooks Bay Tributary A (Moosenlanka Rd., Sandy Cove Acres)
Mooselanka Creek (25th Sideroad, Sandy Cove Acres)
Carson Creek (Ewart St., Lefroy)
Cooks Bay Tributary B (Parkview Drive, Gilford)
White Birch Creek Tributary (Harborview Golf, Gilford)
Cooks Bay Tributary C (Shore Acres Rd. & Nelly Rd., Gilford)

Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

AquaLogic

GEO - ESUM v.1.3 Erosion Threshold Summary Model

AquaLogic

B. de Geus 8.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Hewitts Creek (10th Line, Stroud)

Existing	Q	V	veg	D_{50}	D_{84}-D_{100}	τ_{calc}	veg	D_{50}	D_{84}-D_{100}	Ω	Ω
Channel Capacity	$m^3 s^{-1}$	$m s^{-1}$	control	particle	particle	$N m^{-2}$	control	particle*	particle*	watts m^{-1}	threshold
Xsec. 1	0.868	0.72	Y	N	N	9.6	Y	N	N	25.0	Y
Xsec. 2	0.869	0.73	Y	N	N	9.4	Y	N	Y	26.0	Y
Xsec. 3	0.854	0.84	Y	N	N	13.3	Y	N	Y	42.0	Y
Xsec. 4	0.869	0.83	Y	N	N	12.9	Y	N	D	43.0	Y
Xsec. 5	0.863	0.79	Y	N	N	12.1	Y	N	N	42.0	Y

Dynamic	Q	V	veg	D_{50}	D_{84}-D_{100}	τ_{calc}	veg	D_{50}	D_{84}-D_{100}	Ω	Ω
Stability	$m^3 s^{-1}$	$m s^{-1}$	control	particle	particle	$N m^{-2}$	control	particle*	particle*	watts m^{-1}	threshold
Xsec. 1	0.76	0.70	Y	N	N	8.8	Y	N	D	22.0	Y
Xsec. 2	0.77	0.70	Y	N	D	8.9	Y	N	Y	23.0	Y
Xsec. 3	0.44	0.70	Y	N	D	10.0	Y	N	Y	21.0	Y
Xsec. 4	0.36	0.70	Y	N	D	10.0	Y	N	Y	18.0	Y
Xsec. 5	0.37	0.70	Y	N	D	10.2	Y	N	N	18.0	Y

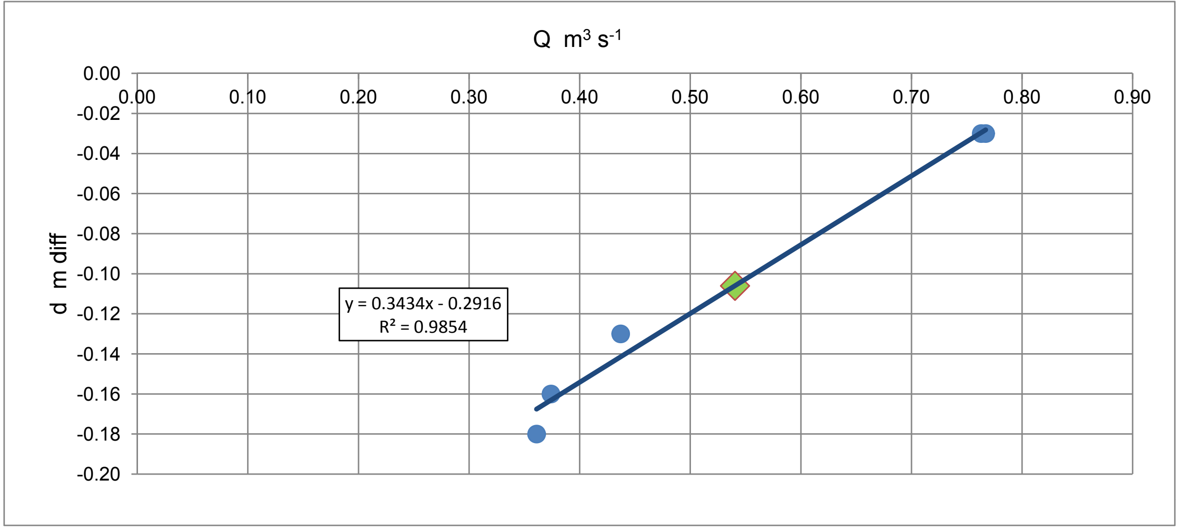
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

🟩	Dynamic Stability
🟧	Dynamic Stability = Cautionary
🟥	Potentially Unstable

	Q $m^3 s^{-1}$ existing	Q $m^3 s^{-1}$ stable	Q $m^3 s^{-1}$ diff	d m diff
Xsec. 1	0.87	0.76	0.11	-0.03
Xsec. 2	0.87	0.77	0.10	-0.03
Xsec. 3	0.85	0.44	0.42	-0.13
Xsec. 4	0.87	0.36	0.51	-0.18
Xsec. 5	0.86	0.37	0.49	-0.16
mean	**0.86**	**0.54**	0.32	-0.11

Reach Based Threshold to Channel Capacity Rating Curve



GEO - ESUM v.1.3 Erosion Threshold Summary Model

AquaLogic

B. de Geus 8.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)

Existing Channel Capacity	Q $m^3 s^{-1}$	V $m s^{-1}$	veg control	D_{50} particle	D_{84}-D_{100} particle	τ_{calc} $N m^{-2}$	veg control	D_{50} particle*	D_{84}-D_{100} particle*	Ω watts m^{-1}	Ω threshold
Xsec. 1	2.167	0.86	Y	N	N	12.0	Y	N	N	64.0	Y
Xsec. 2	2.122	0.84	Y	N	N	11.6	Y	N	N	62.0	Y
Xsec. 3	2.188	0.85	Y	N	N	12.9	Y	N	N	64.0	Y
Xsec. 4	2.136	0.99	Y	N	N	18.4	Y	N	D	105.0	Y
Xsec. 5	2.138	1.23	D	N	N	34.1	Y	N	Y	209.0	Y

Dynamic Stability	Q $m^3 s^{-1}$	V $m s^{-1}$	veg control	D_{50} particle	D_{84}-D_{100} particle	τ_{calc} $N m^{-2}$	veg control	D_{50} particle*	D_{84}-D_{100} particle*	Ω watts m^{-1}	Ω threshold
Xsec. 1	1.17	0.70	Y	N	D	8.9	Y	N	D	34.0	Y
Xsec. 2	1.05	0.70	Y	N	D	8.8	Y	N	D	31.0	Y
Xsec. 3	1.15	0.70	Y	N	D	9.6	Y	N	D	34.0	Y
Xsec. 4	0.77	0.70	Y	N	D	11.0	Y	N	D	38.0	Y
Xsec. 5	1.38	1.10	Y	N	Y	28.7	Y	N	Y	134.0	Y

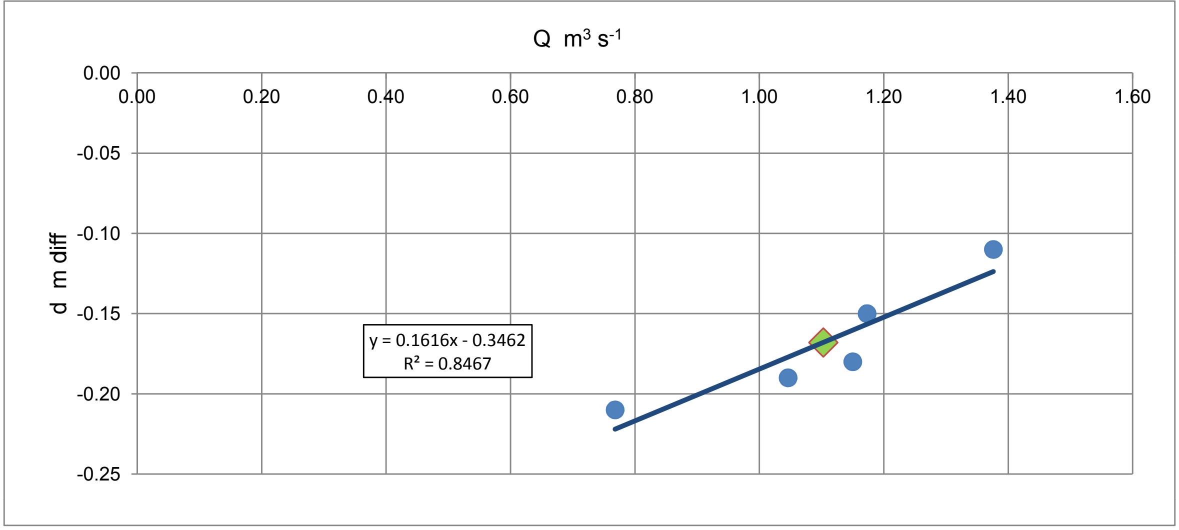
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

🟩	Dynamic Stability
🟧	Dynamic Stability = Cautionary
🟥	Potentially Unstable

	Q $m^3 s^{-1}$ existing	Q $m^3 s^{-1}$ stable	Q $m^3 s^{-1}$ diff	d m diff
Xsec. 1	2.17	1.17	0.99	-0.15
Xsec. 2	2.12	1.05	1.08	-0.19
Xsec. 3	2.19	1.15	1.04	-0.18
Xsec. 4	2.14	0.77	1.37	-0.21
Xsec. 5	2.14	1.38	0.76	-0.11
mean	**2.15**	**1.10**	1.05	-0.17

Reach Based Threshold to Channel Capacity Rating Curve



GEO - ESUM v.1.3 Erosion Threshold Summary Model

B. de Geus 8.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres)

Existing Channel Capacity	Q $m^3 s^{-1}$	V $m s^{-1}$	veg control	D_{50} particle	D_{84}-D_{100} particle	τ_{calc} $N m^{-2}$	veg control	D_{50} particle*	D_{84}-D_{100} particle*	Ω watts m^{-1}	Ω threshold
Xsec. 1	0.212	0.54	Y	N	D	10.4	Y	N	D	12.0	Y
Xsec. 2	0.218	0.55	Y	N	D	6.6	Y	N	D	8.0	Y
Xsec. 3	0.218	0.55	Y	N	D	6.6	Y	N	D	9.0	Y
Xsec. 4											
Xsec. 5											

Dynamic Stability											
Xsec. 1	0.212	0.54	Y	N	D	10.4	Y	N	D	12.0	Y
Xsec. 2	0.218	0.55	Y	N	D	6.6	Y	N	D	8.0	Y
Xsec. 3	0.218	0.55	Y	N	D	6.6	Y	N	D	9.0	Y
Xsec. 4											
Xsec. 5											

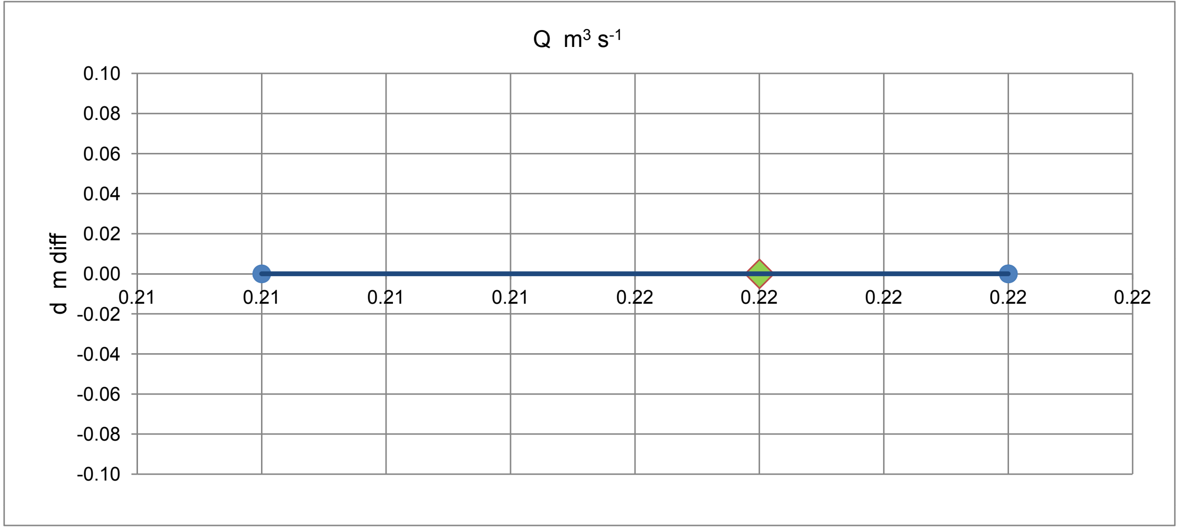
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

🟩 Dynamic Stability
🟧 Dynamic Stability = Cautionary
🟥 Potentially Unstable

	Q $m^3 s^{-1}$ existing	Q $m^3 s^{-1}$ stable	Q $m^3 s^{-1}$ diff	d m diff
Xsec. 1	0.21	0.21	0.00	0.00
Xsec. 2	0.22	0.22	0.00	0.00
Xsec. 3	0.22	0.22	0.00	0.00
Xsec. 4				
Xsec. 5				
mean	**0.22**	**0.22**	0.00	0.00

Reach Based Threshold to Channel Capacity Rating Curve



GEO - ESUM v.1.3 Erosion Threshold Summary Model

AquaLogic

B. de Geus 8.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary A (Moosenlanka Rd., Sandy Cove Acres)

Existing Channel Capacity	Q $m^3 s^{-1}$	V $m s^{-1}$	veg control	D_{50} particle	D_{84}-D_{100} particle	τ_{calc} $N m^{-2}$	veg control	D_{50} particle*	D_{84}-D_{100} particle*	Ω watts m^{-1}	Ω threshold
Xsec. 1	0.158	0.64	Y	N	D	12.0	Y	N	Y	12.0	Y
Xsec. 2	0.159	0.69	Y	N	D	13.1	Y	N	D	12.0	Y
Xsec. 3	0.154	0.61	Y	N	D	11.2	Y	N	Y	12.0	Y
Xsec. 4											
Xsec. 5											

Dynamic Stability											
Xsec. 1	0.158	0.64	Y	N	D	12.0	Y	N	Y	12.0	Y
Xsec. 2	0.159	0.69	Y	N	D	13.1	Y	N	D	12.0	Y
Xsec. 3	0.154	0.61	Y	N	D	11.2	Y	N	Y	12.0	Y
Xsec. 4											
Xsec. 5											

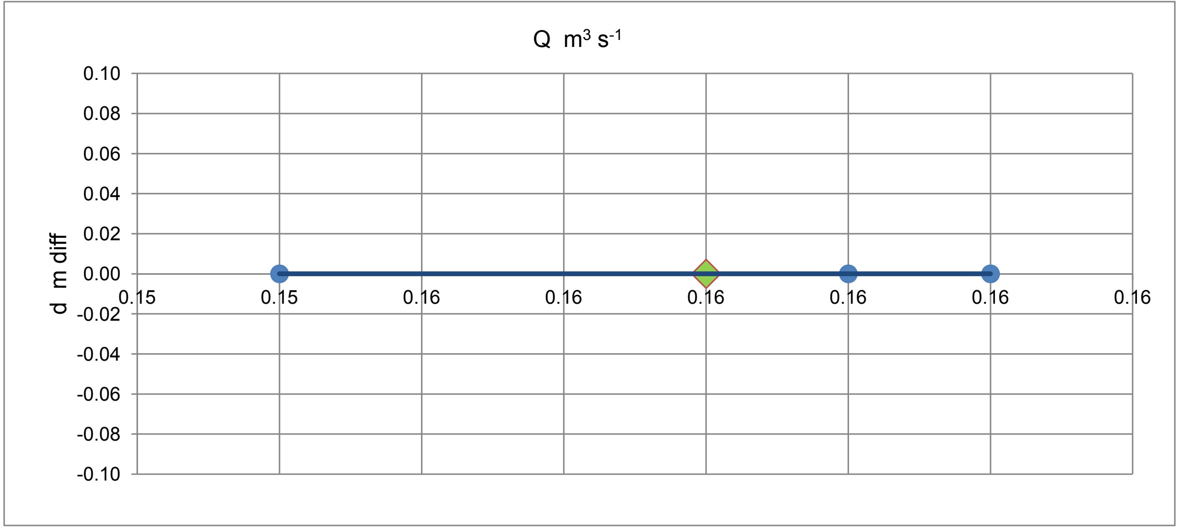
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

🟩 Dynamic Stability
🟧 Dynamic Stability = Cautionary
🟥 Potentially Unstable

	Q $m^3 s^{-1}$ existing	Q $m^3 s^{-1}$ stable	Q $m^3 s^{-1}$ diff	d m diff
Xsec. 1	0.16	0.16	0.00	0.00
Xsec. 2	0.16	0.16	0.00	0.00
Xsec. 3	0.15	0.15	0.00	0.00
Xsec. 4				
Xsec. 5				
mean	**0.16**	**0.16**	0.00	0.00

Reach Based Threshold to Channel Capacity Rating Curve



GEO - ESUM v.1.3 Erosion Threshold Summary Model

AquaLogic

B. de Geus 8.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Moosenlanka Creek (25 SR, Sandy Cove Acres)

Existing Channel Capacity	Q $m^3 s^{-1}$	V $m s^{-1}$	veg control	D_{50} particle	D_{84}-D_{100} particle	τ_{calc} $N m^{-2}$	veg control	D_{50} particle*	D_{84}-D_{100} particle*	Ω watts m^{-1}	Ω threshold
Xsec. 1	0.597	0.83	Y	N	N	21.8	Y	N	D	53.0	Y
Xsec. 2	0.597	0.82	Y	N	N	21.6	Y	N	D	53.0	Y
Xsec. 3	0.592	0.87	Y	N	N	23.6	Y	N	D	52.2	Y
Xsec. 4											
Xsec. 5											

Dynamic Stability	Q $m^3 s^{-1}$	V $m s^{-1}$	veg control	D_{50} particle	D_{84}-D_{100} particle	τ_{calc} $N m^{-2}$	veg control	D_{50} particle*	D_{84}-D_{100} particle*	Ω watts m^{-1}	Ω threshold
Xsec. 1	0.54	0.80	Y	N	D	20.8	Y	N	D	47.0	Y
Xsec. 2	0.43	0.80	Y	N	D	20.6	Y	N	D	37.6	Y
Xsec. 3	0.34	0.80	Y	N	D	20.7	Y	N	D	29.8	Y
Xsec. 4											
Xsec. 5											

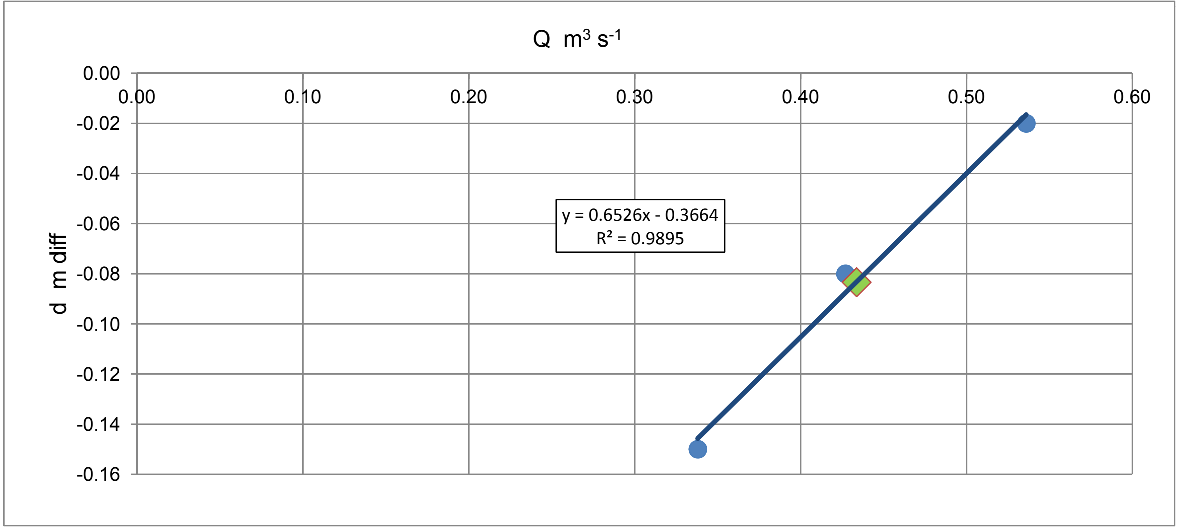
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

🟩	Dynamic Stability
🟧	Dynamic Stability = Cautionary
🟥	Potentially Unstable

	Q $m^3 s^{-1}$ existing	Q $m^3 s^{-1}$ stable	Q $m^3 s^{-1}$ diff	d m diff
Xsec. 1	0.60	0.54	0.06	-0.02
Xsec. 2	0.60	0.43	0.17	-0.08
Xsec. 3	0.59	0.34	0.25	-0.15
Xsec. 4				
Xsec. 5				
mean	**0.60**	**0.43**	0.16	-0.08

Reach Based Threshold to Channel Capacity Rating Curve



GEO - ESUM v.1.3 Erosion Threshold Summary Model

AquaLogic

B. de Geus 8.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Carson Creek (Ewart St., Lefroy)

Existing	Q	V	veg	D_{50}	D_{84}-D_{100}	τ_{calc}	veg	D_{50}	D_{84}-D_{100}	Ω	Ω
Channel Capacity	$m^3 s^{-1}$	$m s^{-1}$	control	particle	particle	$N m^{-2}$	control	particle*	particle*	watts m^{-1}	threshold
Xsec. 1	1.131	0.80	Y	N	Y	18.0	Y	N	Y	55.0	Y
Xsec. 2	1.139	0.78	Y	N	Y	17.4	Y	N	Y	56.0	Y
Xsec. 3	1.132	0.76	Y	N	N	15.6	Y	N	Y	44.0	Y
Xsec. 4	1.138	1.06	Y	N	Y	32.2	Y	N	Y	111.0	Y
Xsec. 5	1.135	0.77	Y	N	Y	13.4	Y	N	Y	45.0	Y

Dynamic	Q	V	veg	D_{50}	D_{84}-D_{100}	τ_{calc}	veg	D_{50}	D_{84}-D_{100}	Ω	Ω
Stability	$m^3 s^{-1}$	$m s^{-1}$	control	particle	particle	$N m^{-2}$	control	particle*	particle*	watts m^{-1}	threshold
Xsec. 1	0.45	0.60	Y	D	Y	11.7	Y	N	Y	22.0	Y
Xsec. 2	0.40	0.60	Y	D	Y	11.8	Y	N	Y	20.0	Y
Xsec. 3	0.53	0.64	Y	D	Y	12.2	Y	N	Y	21.0	Y
Xsec. 4	0.61	0.86	Y	Y	Y	23.6	Y	N	Y	60.0	Y
Xsec. 5	0.64	0.63	Y	Y	Y	9.8	Y	Y	Y	25.0	Y

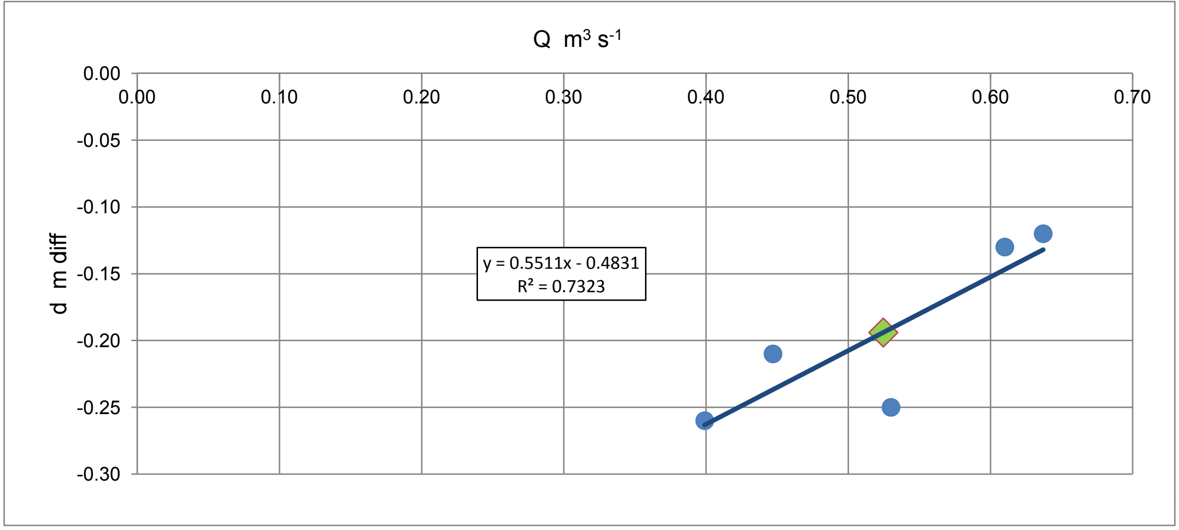
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

🟩 Dynamic Stability
🟧 Dynamic Stability = Cautionary
🟥 Potentially Unstable

	Q	Q	Q	d
	$m^3 s^{-1}$	$m^3 s^{-1}$	$m^3 s^{-1}$	m
	existing	stable	diff	diff
Xsec. 1	1.13	0.45	0.68	-0.21
Xsec. 2	1.14	0.40	0.74	-0.26
Xsec. 3	1.13	0.53	0.60	-0.25
Xsec. 4	1.14	0.61	0.53	-0.13
Xsec. 5	1.14	0.64	0.50	-0.12
mean	**1.14**	**0.52**	0.61	-0.19

Reach Based Threshold to Channel Capacity Rating Curve



GEO - ESUM v.1.3 Erosion Threshold Summary Model

B. de Geus 8.11

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary B (Parkview Drive, Gilford)

Existing Channel Capacity	Q $m^3 s^{-1}$	V $m s^{-1}$	veg control	D_{50} particle	D_{84}-D_{100} particle	τ_{calc} $N m^{-2}$	veg control	D_{50} particle*	D_{84}-D_{100} particle*	Ω watts m^{-1}	Ω threshold
Xsec. 1	0.072	0.32	Y	D	D	3.6	Y	D	D	2.0	Y
Xsec. 2	0.066	0.32	Y	D	D	3.5	Y	D	D	2.0	Y
Xsec. 3	0.064	0.35	Y	D	D	3.9	Y	D	D	2.0	Y
Xsec. 4											
Xsec. 5											

Dynamic Stability											
Xsec. 1	0.072	0.32	Y	D	D	3.6	Y	D	D	2.0	Y
Xsec. 2	0.066	0.32	Y	D	D	3.5	Y	D	D	2.0	Y
Xsec. 3	0.064	0.35	Y	D	D	3.9	Y	D	D	2.0	Y
Xsec. 4											
Xsec. 5											

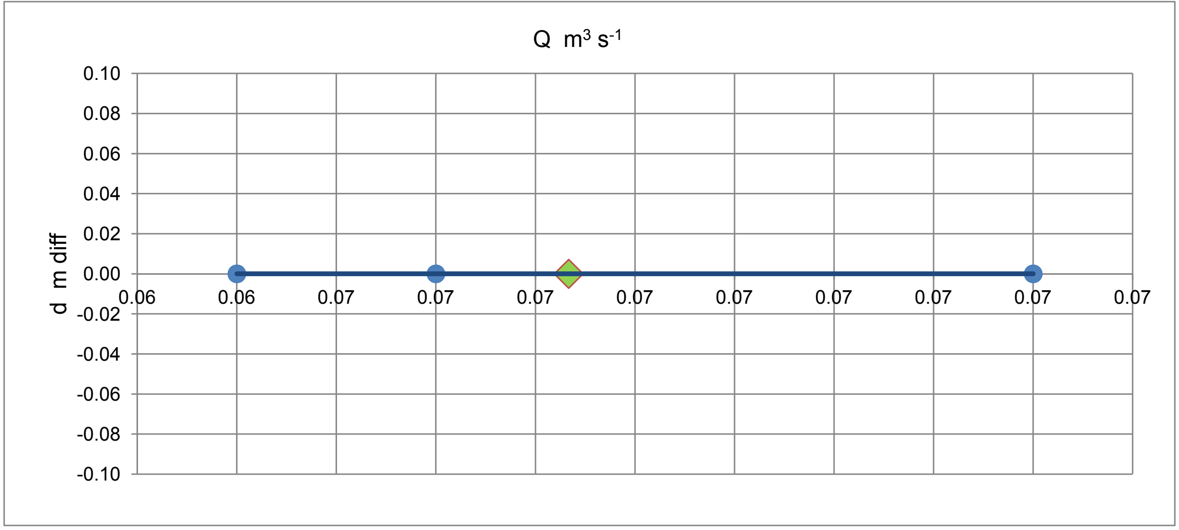
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

🟩	Dynamic Stability
🟨	Dynamic Stability = Cautionary
🟥	Potentially Unstable

	Q $m^3 s^{-1}$ existing	Q $m^3 s^{-1}$ stable	Q $m^3 s^{-1}$ diff	d m diff
Xsec. 1	0.07	0.07	0.00	0.00
Xsec. 2	0.07	0.07	0.00	0.00
Xsec. 3	0.06	0.06	0.00	0.00
Xsec. 4				
Xsec. 5				
mean	**0.07**	**0.07**	0.00	0.00

Reach Based Threshold to Channel Capacity Rating Curve



GEO - ESUM v.1.3 Erosion Threshold Summary Model

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
White Birch Creek Tributary (Harbourview Golf, Gilford)

B. de Geus 8.11

Existing Channel Capacity	Q $m^3 s^{-1}$	V $m s^{-1}$	veg control	D_{50} particle	D_{84}-D_{100} particle	τ_{calc} $N m^{-2}$	veg control	D_{50} particle*	D_{84}-D_{100} particle*	Ω watts m^{-1}	Ω threshold
Xsec. 1	0.295	0.56	Y	N	D	8.3	Y	N	D	12.0	Y
Xsec. 2	0.291	0.55	Y	N	D	8.1	Y	N	D	11.0	Y
Xsec. 3	0.289	0.55	Y	N	D	8.0	Y	N	D	11.0	Y
Xsec. 4											
Xsec. 5											

Dynamic Stability											
Xsec. 1	0.295	0.56	Y	N	D	8.3	Y	N	D	12.0	Y
Xsec. 2	0.291	0.55	Y	N	D	8.1	Y	N	D	11.0	Y
Xsec. 3	0.289	0.55	Y	N	D	8.0	Y	N	D	11.0	Y
Xsec. 4											
Xsec. 5											

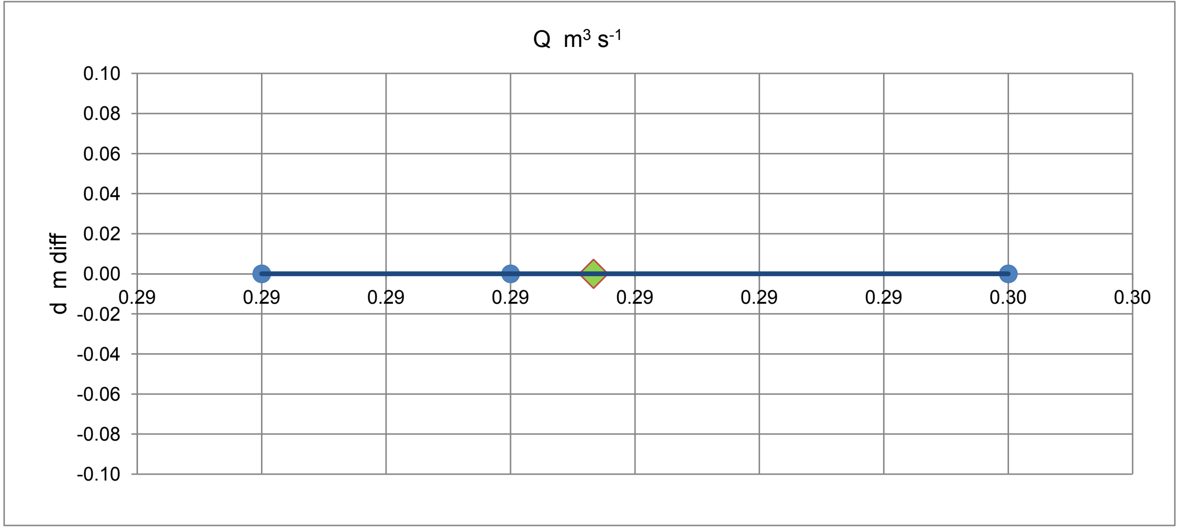
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

🟩 Dynamic Stability
🟨 Dynamic Stability = Cautionary
🟥 Potentially Unstable

	Q $m^3 s^{-1}$ existing	Q $m^3 s^{-1}$ stable	Q $m^3 s^{-1}$ diff	d m diff
Xsec. 1	0.30	0.30	0.00	0.00
Xsec. 2	0.29	0.29	0.00	0.00
Xsec. 3	0.29	0.29	0.00	0.00
Xsec. 4				
Xsec. 5				
mean	**0.29**	**0.29**	0.00	0.00

Reach Based Threshold to Channel Capacity Rating Curve



GEO - ESUM v.1.3 Erosion Threshold Summary Model

Project: Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan
Cooks Bay Tributary C (Shore Acres Rd. & Nelly Rd., Gilford)

B. de Geus 8.11

Existing Channel Capacity	Q $m^3 s^{-1}$	V $m s^{-1}$	veg control	D_{50} particle	D_{84}-D_{100} particle	τ_{calc} $N m^{-2}$	veg control	D_{50} particle*	D_{84}-D_{100} particle*	Ω watts m^{-1}	Ω threshold
Xsec. 1	0.207	0.50	Y	D	D	7.1	Y	D	Y	8.0	Y
Xsec. 2	0.204	0.49	Y	D	D	6.8	Y	D	Y	8.0	Y
Xsec. 3	0.208	0.48	Y	D	D	6.6	Y	D	Y	8.0	Y
Xsec. 4											
Xsec. 5											

Dynamic Stability											
Xsec. 1	0.207	0.50	Y	D	D	7.1	Y	D	Y	8.0	Y
Xsec. 2	0.204	0.49	Y	D	D	6.8	Y	D	Y	8.0	Y
Xsec. 3	0.208	0.48	Y	D	D	6.6	Y	D	Y	8.0	Y
Xsec. 4											
Xsec. 5											

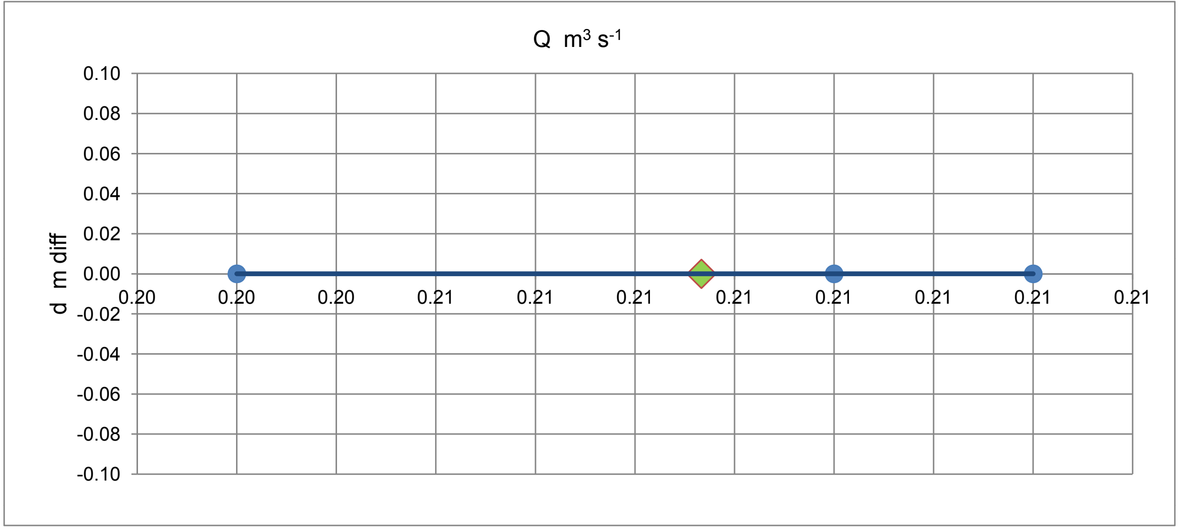
Stability Criteria Met: Y - Yes, N - No, D - Dynamic

* - within 5 mm

🟩	Dynamic Stability
🟧	Dynamic Stability = Cautionary
🟥	Potentially Unstable

	Q $m^3 s^{-1}$ existing	Q $m^3 s^{-1}$ stable	Q $m^3 s^{-1}$ diff	d m diff
Xsec. 1	0.21	0.21	0.00	0.00
Xsec. 2	0.20	0.20	0.00	0.00
Xsec. 3	0.21	0.21	0.00	0.00
Xsec. 4				
Xsec. 5				
mean	**0.21**	**0.21**	0.00	0.00

Reach Based Threshold to Channel Capacity Rating Curve



GEO-EXD v.1.0 Extended Detention Hydrology Analysis Models

Hewitts Creek (10th Line, Stroud)
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres)
Cooks Bay Tributary A (Moosenlanka Rd., Sandy Cove Acres)
Mooselanka Creek (25th Sideroad, Sandy Cove Acres)
Carson Creek (Ewart St., Lefroy)
Cooks Bay Tributary B (Parkview Drive, Gilford)
White Birch Creek Tributary (Harborview Golf, Gilford)
Cooks Bay Tributary C (Shore Acres Rd. & Nelly Rd., Gilford)

Erosion Threshold Analysis
Innisfil Stormwater Management Master Plan

AquaLogic

GEO-EXD v.1.0 Extended Detention Hydrology Analysis Model

AquaLogic

B. de Geus 07.14

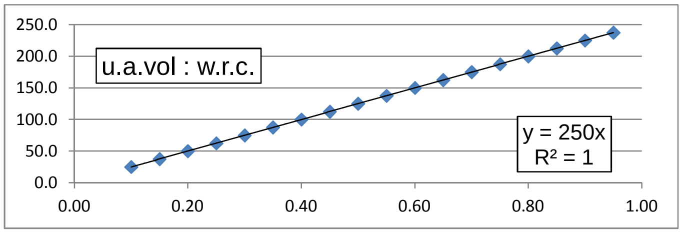
Project: **Erosion Threshold Analysis**
Town of Innisfil Stormwater Management Master Plan
Hewitts Creek (10th Line, Stroud)

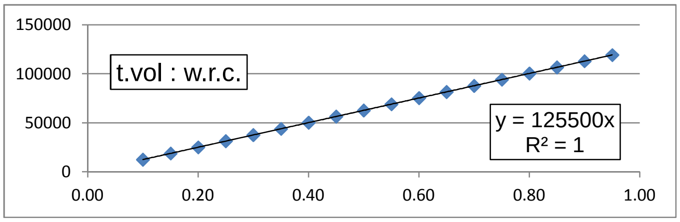
Scenario 1
Hewitts Creek
- no volume control

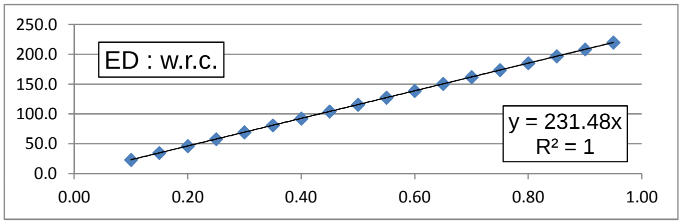
Q_o $(l\ s^{-1})$
542.2

DA (ha)	Q_{ua} $(l\ s^{-1}\ ha^{-1})$	event rain (mm)
502	1.08	25

w. runoff coeff.	unit area vol. $(m^3\ ha^{-1})$	total vol. (m^3)	ED (hrs)
0.10	25.0	12550	23.1
0.15	37.5	18825	34.7
0.20	50.0	25100	46.3
0.25	62.5	31375	57.9
0.30	75.0	37650	69.4
0.35	87.5	43925	81.0
0.40	100.0	50200	92.6
0.45	112.5	56475	104.2
0.50	125.0	62750	115.7
0.55	137.5	69025	127.3
0.60	150.0	75300	138.9
0.65	162.5	81575	150.5
0.70	175.0	87850	162.0
0.75	187.5	94125	173.6
0.80	200.0	100400	185.2
0.85	212.5	106675	196.8
0.90	225.0	112950	208.3
0.95	237.5	119225	219.9





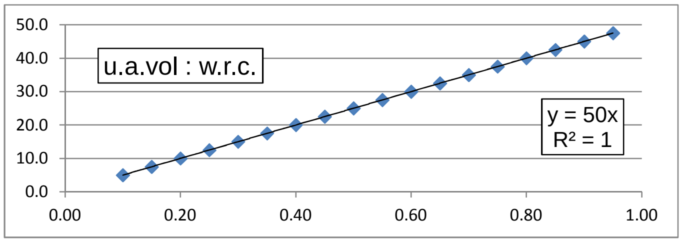


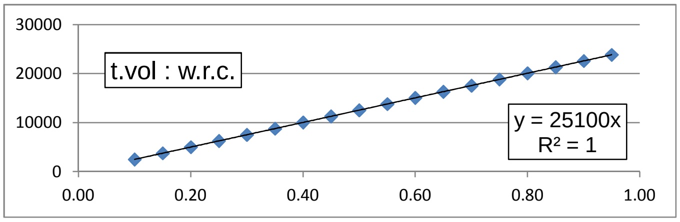
Scenario 2
Hewitts Creek
- 20mm infiltration

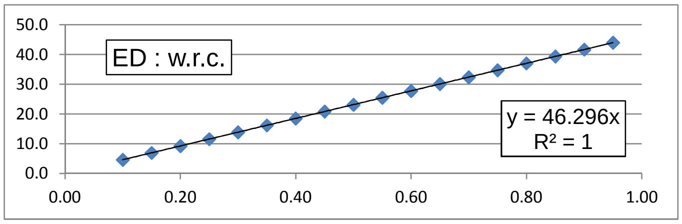
Q_o $(l\ s^{-1})$
542.2

DA (ha)	Q_{ua} $(l\ s^{-1}\ ha^{-1})$	event rain (mm)
502	1.08	5

w. runoff coeff.	unit area vol. $(m^3\ ha^{-1})$	total vol. (m^3)	ED (hrs)
0.10	5.0	2510	4.6
0.15	7.5	3765	6.9
0.20	10.0	5020	9.3
0.25	12.5	6275	11.6
0.30	15.0	7530	13.9
0.35	17.5	8785	16.2
0.40	20.0	10040	18.5
0.45	22.5	11295	20.8
0.50	25.0	12550	23.1
0.55	27.5	13805	25.5
0.60	30.0	15060	27.8
0.65	32.5	16315	30.1
0.70	35.0	17570	32.4
0.75	37.5	18825	34.7
0.80	40.0	20080	37.0
0.85	42.5	21335	39.4
0.90	45.0	22590	41.7
0.95	47.5	23845	44.0







GEO-EXD v.1.0 Extended Detention Hydrology Analysis Model

AquaLogic

B. de Geus 07.14

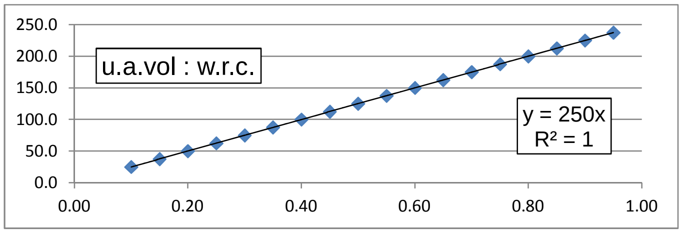
Project: **Erosion Threshold Analysis**
Town of Innisfil Stormwater Management Master Plan
Sandy Cove Creek (Woodlands Ave., Sandy Cove Acres)

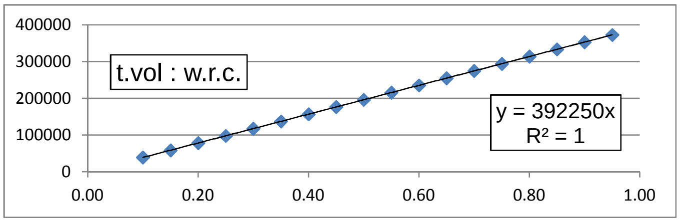
Scenario 1
Sandy Cove Creek
- no volume control

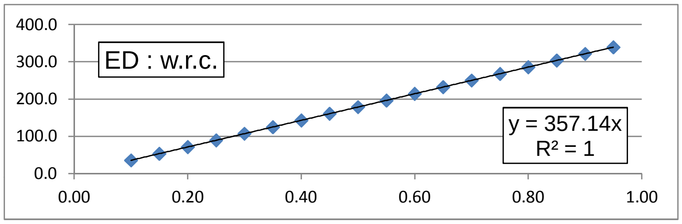
Q_o ($l\ s^{-1}$)
1098.3

DA (ha)	Q_{ua} ($l\ s^{-1}\ ha^{-1}$)	event rain (mm)
1569	0.70	25

w. runoff coeff.	unit area vol. ($m^3\ ha^{-1}$)	total vol. (m^3)	ED (hrs)
0.10	25.0	39225	35.7
0.15	37.5	58838	53.6
0.20	50.0	78450	71.4
0.25	62.5	98063	89.3
0.30	75.0	117675	107.1
0.35	87.5	137288	125.0
0.40	100.0	156900	142.9
0.45	112.5	176513	160.7
0.50	125.0	196125	178.6
0.55	137.5	215738	196.4
0.60	150.0	235350	214.3
0.65	162.5	254963	232.1
0.70	175.0	274575	250.0
0.75	187.5	294188	267.9
0.80	200.0	313800	285.7
0.85	212.5	333413	303.6
0.90	225.0	353025	321.4
0.95	237.5	372638	339.3





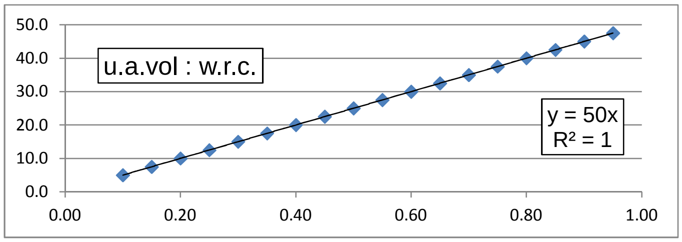


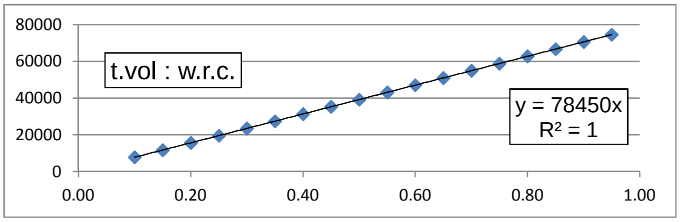
Scenario 2
SandyCove Creek
- 20mm infiltration

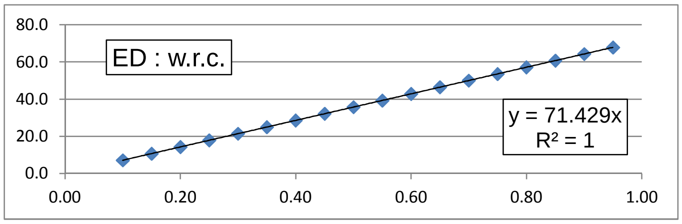
Q_o ($l\ s^{-1}$)
1098.3

DA (ha)	Q_{ua} ($l\ s^{-1}\ ha^{-1}$)	event rain (mm)
1569	0.70	5

w. runoff coeff.	unit area vol. ($m^3\ ha^{-1}$)	total vol. (m^3)	ED (hrs)
0.10	5.0	7845	7.1
0.15	7.5	11768	10.7
0.20	10.0	15690	14.3
0.25	12.5	19613	17.9
0.30	15.0	23535	21.4
0.35	17.5	27458	25.0
0.40	20.0	31380	28.6
0.45	22.5	35303	32.1
0.50	25.0	39225	35.7
0.55	27.5	43148	39.3
0.60	30.0	47070	42.9
0.65	32.5	50993	46.4
0.70	35.0	54915	50.0
0.75	37.5	58838	53.6
0.80	40.0	62760	57.1
0.85	42.5	66683	60.7
0.90	45.0	70605	64.3
0.95	47.5	74528	67.9







GEO-EXD v.1.0 Extended Detention Hydrology Analysis Model

Project: **Erosion Threshold Analysis**
Town of Innisfil Stormwater Management Master Plan
Sandy Cove Creek Tributary (Main St., Sandy Cove Acres)

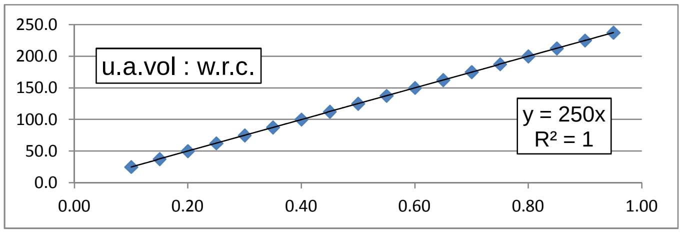
B. de Geus 07.14

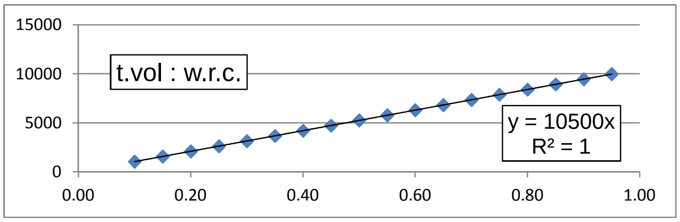
Scenario 1
Sandy Cove Creek Trib
- no volume control

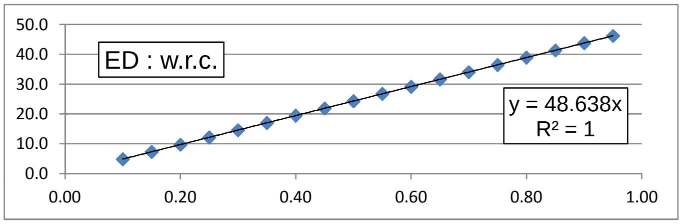
Q_o (l s^{-1})
215.9

DA (ha)	Q_{ua} (l s^{-1} ha^{-1})	event rain (mm)
42	5.14	25

w. runoff coeff.	unit area vol. (m^3 ha^{-1})	total vol. (m^3)	ED (hrs)
0.10	25.0	1050	4.9
0.15	37.5	1575	7.3
0.20	50.0	2100	9.7
0.25	62.5	2625	12.2
0.30	75.0	3150	14.6
0.35	87.5	3675	17.0
0.40	100.0	4200	19.5
0.45	112.5	4725	21.9
0.50	125.0	5250	24.3
0.55	137.5	5775	26.8
0.60	150.0	6300	29.2
0.65	162.5	6825	31.6
0.70	175.0	7350	34.0
0.75	187.5	7875	36.5
0.80	200.0	8400	38.9
0.85	212.5	8925	41.3
0.90	225.0	9450	43.8
0.95	237.5	9975	46.2





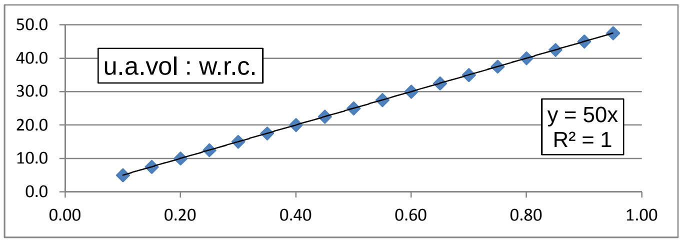


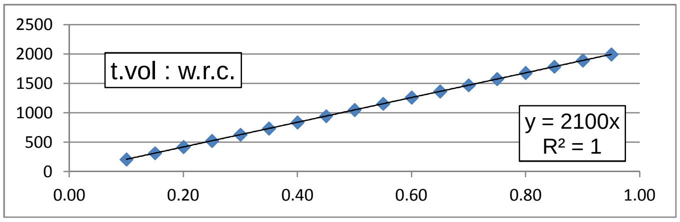
Scenario 2
SandyCove Creek Trib
- 20mm infiltration

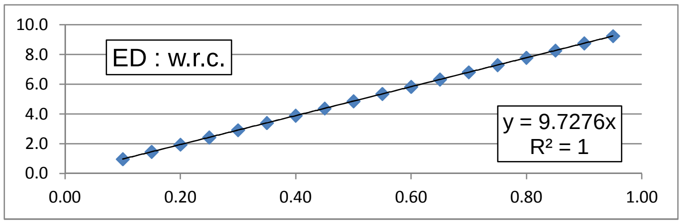
Q_o (l s^{-1})
215.9

DA (ha)	Q_{ua} (l s^{-1} ha^{-1})	event rain (mm)
42	5.14	5

w. runoff coeff.	unit area vol. (m^3 ha^{-1})	total vol. (m^3)	ED (hrs)
0.10	5.0	210	1.0
0.15	7.5	315	1.5
0.20	10.0	420	1.9
0.25	12.5	525	2.4
0.30	15.0	630	2.9
0.35	17.5	735	3.4
0.40	20.0	840	3.9
0.45	22.5	945	4.4
0.50	25.0	1050	4.9
0.55	27.5	1155	5.4
0.60	30.0	1260	5.8
0.65	32.5	1365	6.3
0.70	35.0	1470	6.8
0.75	37.5	1575	7.3
0.80	40.0	1680	7.8
0.85	42.5	1785	8.3
0.90	45.0	1890	8.8
0.95	47.5	1995	9.2







GEO-EXD v.1.0 Extended Detention Hydrology Analysis Model

B. de Geus 07.14

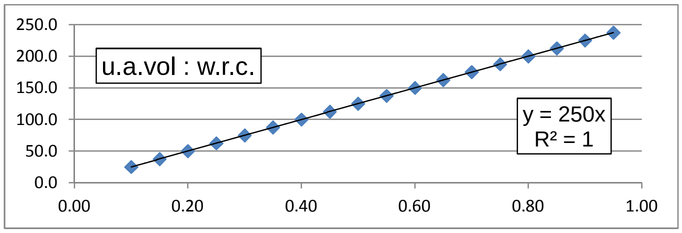
Project: **Erosion Threshold Analysis**
Town of Innisfil Stormwater Management Master Plan
Cooks Bay Tributary (Moosenlanka Rd., Sandy Cove Acres)

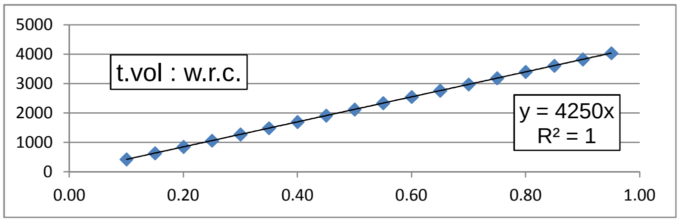
Scenario 1
Cooks Bay Trib A
- no volume control

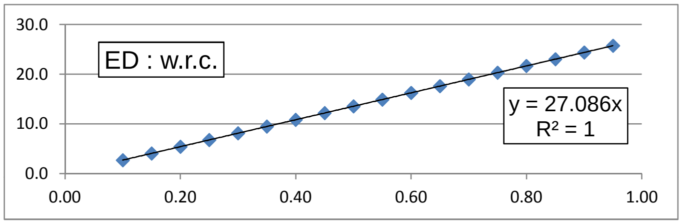
Q_o ($l\ s^{-1}$)
156.9

DA (ha)	Q_{ua} ($l\ s^{-1}\ ha^{-1}$)	event rain (mm)
17	9.23	25

w. runoff coeff.	unit area vol. ($m^3\ ha^{-1}$)	total vol. (m^3)	ED (hrs)
0.10	25.0	425	2.7
0.15	37.5	638	4.1
0.20	50.0	850	5.4
0.25	62.5	1063	6.8
0.30	75.0	1275	8.1
0.35	87.5	1488	9.5
0.40	100.0	1700	10.8
0.45	112.5	1913	12.2
0.50	125.0	2125	13.5
0.55	137.5	2338	14.9
0.60	150.0	2550	16.3
0.65	162.5	2763	17.6
0.70	175.0	2975	19.0
0.75	187.5	3188	20.3
0.80	200.0	3400	21.7
0.85	212.5	3613	23.0
0.90	225.0	3825	24.4
0.95	237.5	4038	25.7





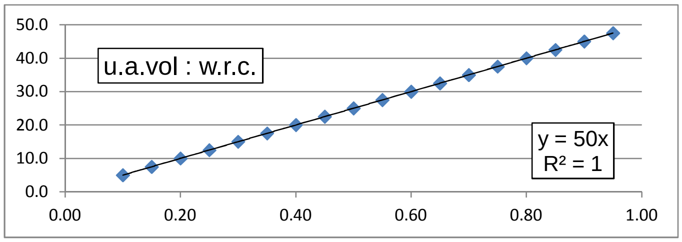


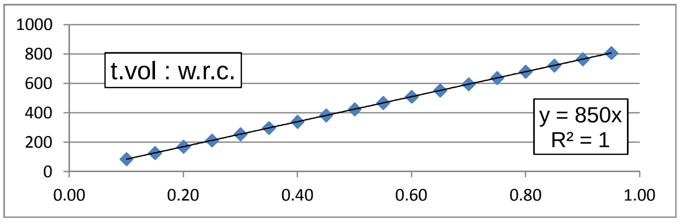
Scenario 2
Cooks Bay Trib A
- 20mm infiltration

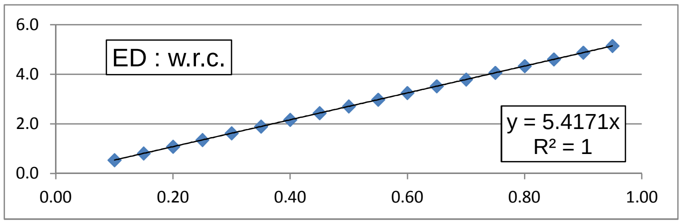
Q_o ($l\ s^{-1}$)
156.9

DA (ha)	Q_{ua} ($l\ s^{-1}\ ha^{-1}$)	event rain (mm)
17	9.23	5

w. runoff coeff.	unit area vol. ($m^3\ ha^{-1}$)	total vol. (m^3)	ED (hrs)
0.10	5.0	85	0.5
0.15	7.5	128	0.8
0.20	10.0	170	1.1
0.25	12.5	213	1.4
0.30	15.0	255	1.6
0.35	17.5	298	1.9
0.40	20.0	340	2.2
0.45	22.5	383	2.4
0.50	25.0	425	2.7
0.55	27.5	468	3.0
0.60	30.0	510	3.3
0.65	32.5	553	3.5
0.70	35.0	595	3.8
0.75	37.5	638	4.1
0.80	40.0	680	4.3
0.85	42.5	723	4.6
0.90	45.0	765	4.9
0.95	47.5	808	5.1







GEO-EXD v.1.0 Extended Detention Hydrology Analysis Model

AquaLogic

B. de Geus 07.14

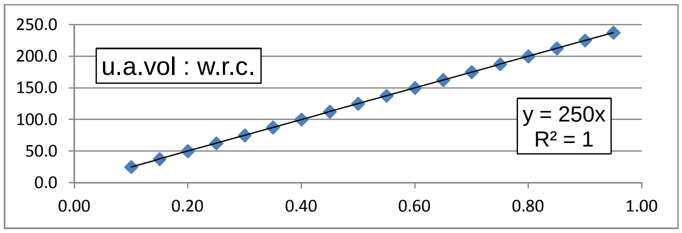
Project: **Erosion Threshold Analysis**
Town of Innisfil Stormwater Management Master Plan
Moosenlanka Creek (25 SR, Sandy Cove Acres)

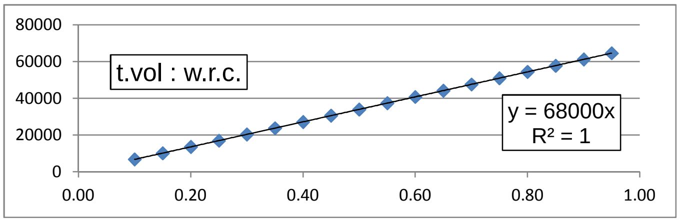
Scenario 1
Moosenlanka Creek
- no volume control

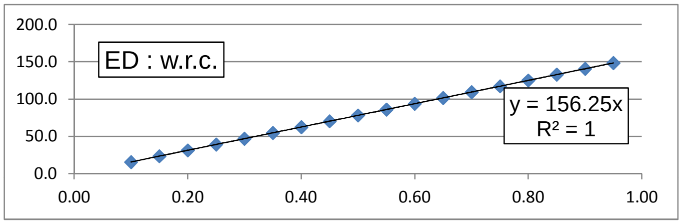
Q_o ($l\ s^{-1}$)
435.2

DA (ha)	Q_{ua} ($l\ s^{-1}\ ha^{-1}$)	event rain (mm)
272	1.60	25

w. runoff coeff.	unit area vol. ($m^3\ ha^{-1}$)	total vol. (m^3)	ED (hrs)
0.10	25.0	6800	15.6
0.15	37.5	10200	23.4
0.20	50.0	13600	31.3
0.25	62.5	17000	39.1
0.30	75.0	20400	46.9
0.35	87.5	23800	54.7
0.40	100.0	27200	62.5
0.45	112.5	30600	70.3
0.50	125.0	34000	78.1
0.55	137.5	37400	85.9
0.60	150.0	40800	93.8
0.65	162.5	44200	101.6
0.70	175.0	47600	109.4
0.75	187.5	51000	117.2
0.80	200.0	54400	125.0
0.85	212.5	57800	132.8
0.90	225.0	61200	140.6
0.95	237.5	64600	148.4





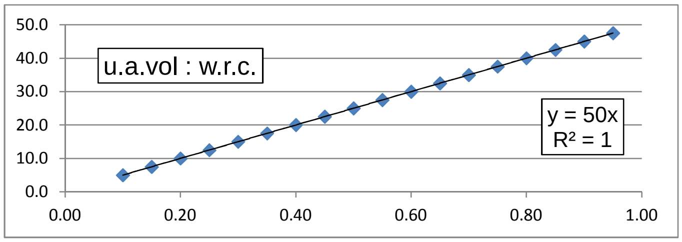


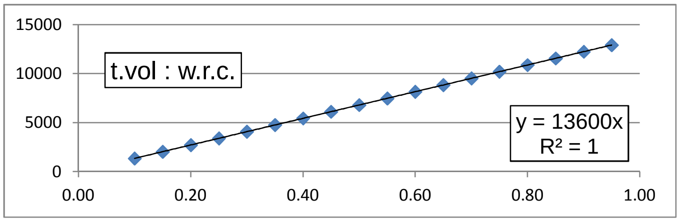
Scenario 2
Moosenlanka Creek
- 20mm infiltration

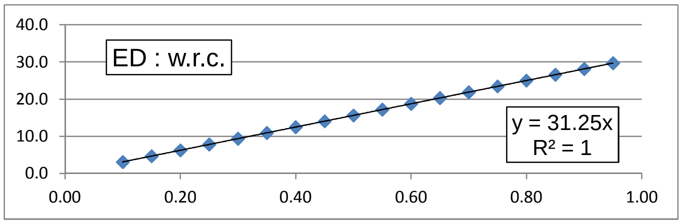
Q_o ($l\ s^{-1}$)
435.2

DA (ha)	Q_{ua} ($l\ s^{-1}\ ha^{-1}$)	event rain (mm)
272	1.60	5

w. runoff coeff.	unit area vol. ($m^3\ ha^{-1}$)	total vol. (m^3)	ED (hrs)
0.10	5.0	1360	3.1
0.15	7.5	2040	4.7
0.20	10.0	2720	6.3
0.25	12.5	3400	7.8
0.30	15.0	4080	9.4
0.35	17.5	4760	10.9
0.40	20.0	5440	12.5
0.45	22.5	6120	14.1
0.50	25.0	6800	15.6
0.55	27.5	7480	17.2
0.60	30.0	8160	18.8
0.65	32.5	8840	20.3
0.70	35.0	9520	21.9
0.75	37.5	10200	23.4
0.80	40.0	10880	25.0
0.85	42.5	11560	26.6
0.90	45.0	12240	28.1
0.95	47.5	12920	29.7







GEO-EXD v.1.0 Extended Detention Hydrology Analysis Model

Project: **Erosion Threshold Analysis**
Town of Innisfil Stormwater Management Master Plan
Carson Creek (Ewart St., Lefroy)

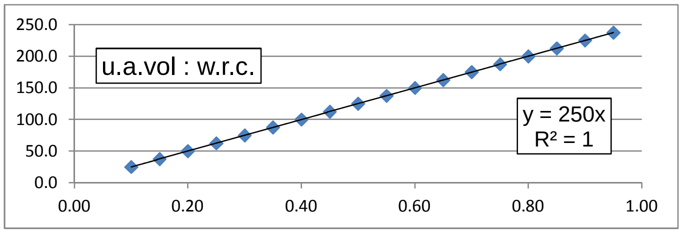
B. de Geus 07.14

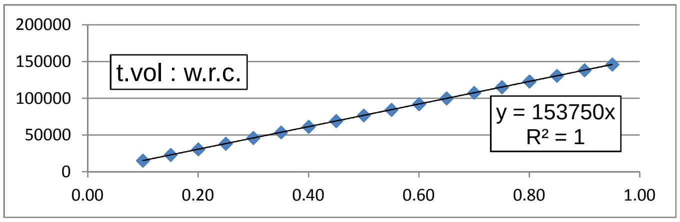
Scenario 1
Carson Creek
- no volume control

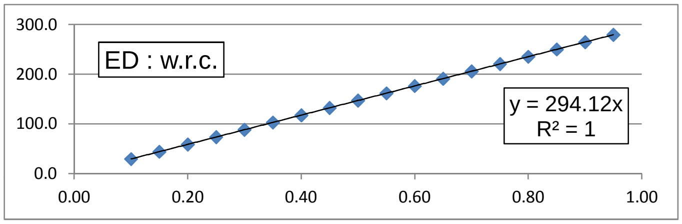
Q_o
$(l\ s^{-1})$
522.8

DA	Q_{ua}	event rain
(ha)	$(l\ s^{-1}\ ha^{-1})$	(mm)
615	0.85	25

w. runoff coeff.	unit area vol. $(m^3\ ha^{-1})$	total vol. (m^3)	ED (hrs)
0.10	25.0	15375	29.4
0.15	37.5	23063	44.1
0.20	50.0	30750	58.8
0.25	62.5	38438	73.5
0.30	75.0	46125	88.2
0.35	87.5	53813	102.9
0.40	100.0	61500	117.6
0.45	112.5	69188	132.4
0.50	125.0	76875	147.1
0.55	137.5	84563	161.8
0.60	150.0	92250	176.5
0.65	162.5	99938	191.2
0.70	175.0	107625	205.9
0.75	187.5	115313	220.6
0.80	200.0	123000	235.3
0.85	212.5	130688	250.0
0.90	225.0	138375	264.7
0.95	237.5	146063	279.4





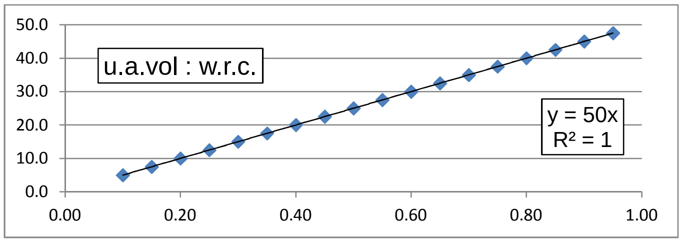


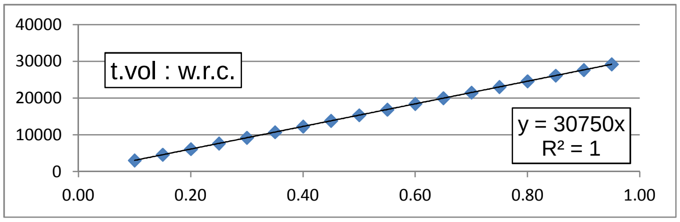
Scenario 2
Carson Creek
- 20mm infiltration

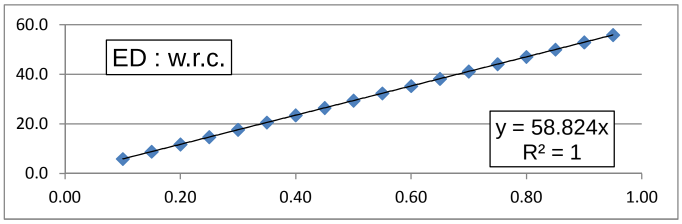
Q_o
$(l\ s^{-1})$
522.8

DA	Q_{ua}	event rain
(ha)	$(l\ s^{-1}\ ha^{-1})$	(mm)
615	0.85	5

w. runoff coeff.	unit area vol. $(m^3\ ha^{-1})$	total vol. (m^3)	ED (hrs)
0.10	5.0	3075	5.9
0.15	7.5	4613	8.8
0.20	10.0	6150	11.8
0.25	12.5	7688	14.7
0.30	15.0	9225	17.6
0.35	17.5	10763	20.6
0.40	20.0	12300	23.5
0.45	22.5	13838	26.5
0.50	25.0	15375	29.4
0.55	27.5	16913	32.4
0.60	30.0	18450	35.3
0.65	32.5	19988	38.2
0.70	35.0	21525	41.2
0.75	37.5	23063	44.1
0.80	40.0	24600	47.1
0.85	42.5	26138	50.0
0.90	45.0	27675	52.9
0.95	47.5	29213	55.9







GEO-EXD v.1.0 Extended Detention Hydrology Analysis Model

AquaLogic

B. de Geus 07.14

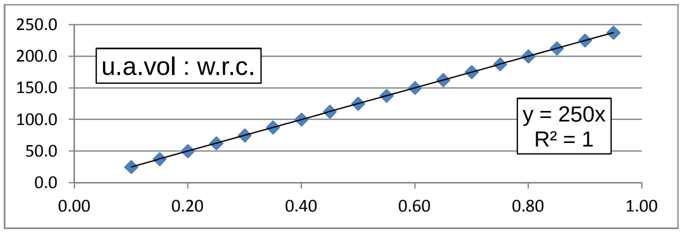
Project: **Erosion Threshold Analysis**
Town of Innisfil Stormwater Management Master Plan
Cooks Bay Tributary (Parkview Drive, Gilford)

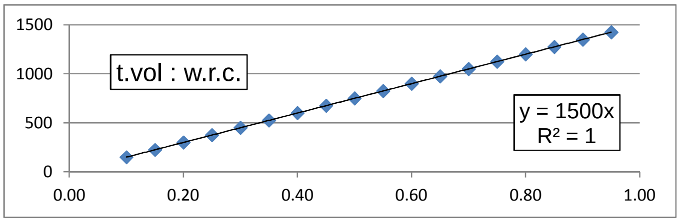
Scenario 1
Cooks Bay Trib B
- no volume control

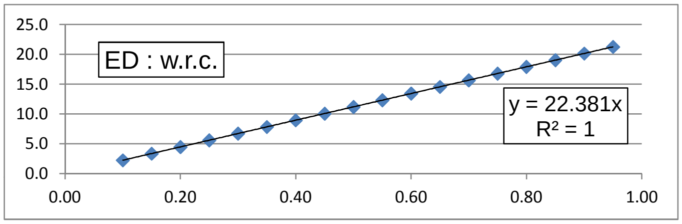
Q_o (l s^{-1})
67.0

DA (ha)	Q_{ua} (l s^{-1} ha^{-1})	event rain (mm)
6	11.17	25

w. runoff coeff.	unit area vol. (m^3 ha^{-1})	total vol. (m^3)	ED (hrs)
0.10	25.0	150	2.2
0.15	37.5	225	3.4
0.20	50.0	300	4.5
0.25	62.5	375	5.6
0.30	75.0	450	6.7
0.35	87.5	525	7.8
0.40	100.0	600	9.0
0.45	112.5	675	10.1
0.50	125.0	750	11.2
0.55	137.5	825	12.3
0.60	150.0	900	13.4
0.65	162.5	975	14.5
0.70	175.0	1050	15.7
0.75	187.5	1125	16.8
0.80	200.0	1200	17.9
0.85	212.5	1275	19.0
0.90	225.0	1350	20.1
0.95	237.5	1425	21.3





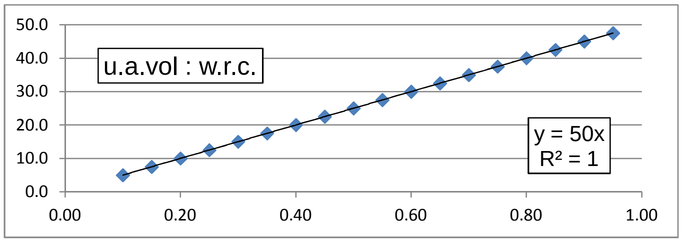


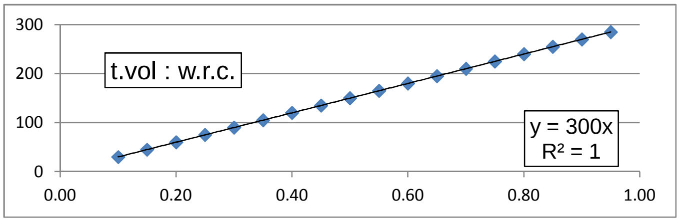
Scenario 2
Cooks Bay Trib B
- 20mm infiltration

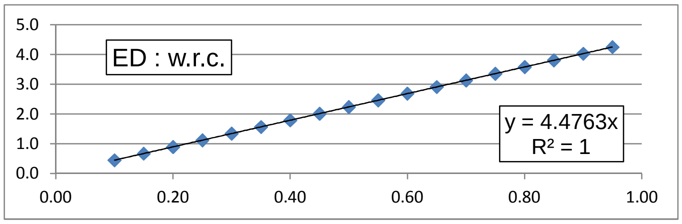
Q_o (l s^{-1})
67.0

DA (ha)	Q_{ua} (l s^{-1} ha^{-1})	event rain (mm)
6	11.17	5

w. runoff coeff.	unit area vol. (m^3 ha^{-1})	total vol. (m^3)	ED (hrs)
0.10	5.0	30	0.4
0.15	7.5	45	0.7
0.20	10.0	60	0.9
0.25	12.5	75	1.1
0.30	15.0	90	1.3
0.35	17.5	105	1.6
0.40	20.0	120	1.8
0.45	22.5	135	2.0
0.50	25.0	150	2.2
0.55	27.5	165	2.5
0.60	30.0	180	2.7
0.65	32.5	195	2.9
0.70	35.0	210	3.1
0.75	37.5	225	3.4
0.80	40.0	240	3.6
0.85	42.5	255	3.8
0.90	45.0	270	4.0
0.95	47.5	285	4.3







GEO-EXD v.1.0 Extended Detention Hydrology Analysis Model

AquaLogic

B. de Geus 07.14

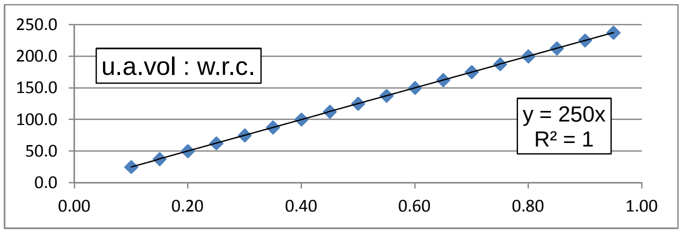
Project: **Erosion Threshold Analysis**
Town of Innisfil Stormwater Management Master Plan
White Birch Creek Tributary (Harborview Golf, Gilford)

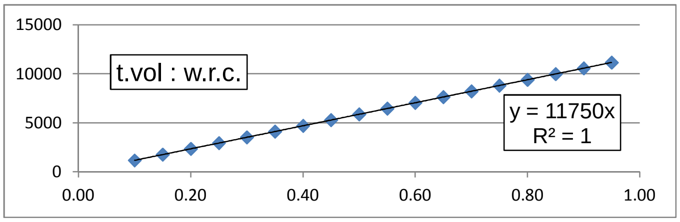
Scenario 1
White Birch Trib
- no volume control

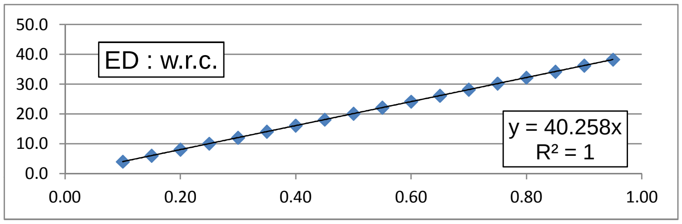
Q_o (l s^{-1})
291.9

DA (ha)	Q_{ua} (l s^{-1} ha^{-1})	event rain (mm)
47	6.21	25

w. runoff coeff.	unit area vol. (m^3 ha^{-1})	total vol. (m^3)	ED (hrs)
0.10	25.0	1175	4.0
0.15	37.5	1763	6.0
0.20	50.0	2350	8.1
0.25	62.5	2938	10.1
0.30	75.0	3525	12.1
0.35	87.5	4113	14.1
0.40	100.0	4700	16.1
0.45	112.5	5288	18.1
0.50	125.0	5875	20.1
0.55	137.5	6463	22.1
0.60	150.0	7050	24.2
0.65	162.5	7638	26.2
0.70	175.0	8225	28.2
0.75	187.5	8813	30.2
0.80	200.0	9400	32.2
0.85	212.5	9988	34.2
0.90	225.0	10575	36.2
0.95	237.5	11163	38.2





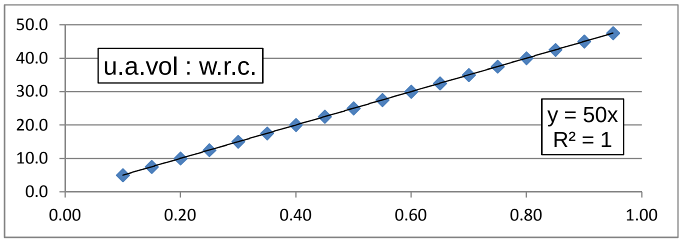


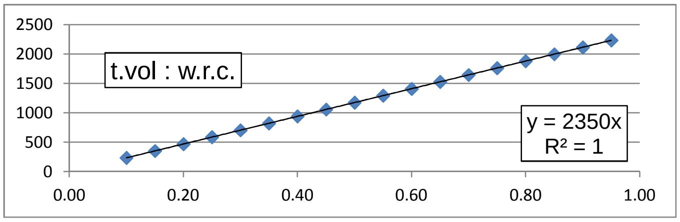
Scenario 2
White Birch Trib
- 20mm infiltration

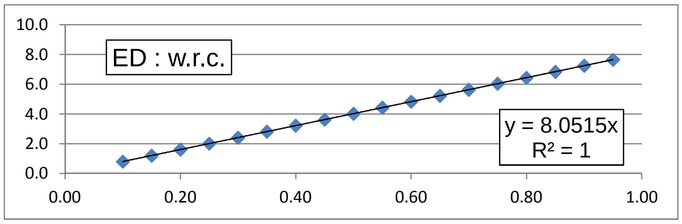
Q_o (l s^{-1})
291.9

DA (ha)	Q_{ua} (l s^{-1} ha^{-1})	event rain (mm)
47	6.21	5

w. runoff coeff.	unit area vol. (m^3 ha^{-1})	total vol. (m^3)	ED (hrs)
0.10	5.0	235	0.8
0.15	7.5	353	1.2
0.20	10.0	470	1.6
0.25	12.5	588	2.0
0.30	15.0	705	2.4
0.35	17.5	823	2.8
0.40	20.0	940	3.2
0.45	22.5	1058	3.6
0.50	25.0	1175	4.0
0.55	27.5	1293	4.4
0.60	30.0	1410	4.8
0.65	32.5	1528	5.2
0.70	35.0	1645	5.6
0.75	37.5	1763	6.0
0.80	40.0	1880	6.4
0.85	42.5	1998	6.8
0.90	45.0	2115	7.2
0.95	47.5	2233	7.6







GEO-EXD v.1.0 Extended Detention Hydrology Analysis Model

Project: **Erosion Threshold Analysis**
Town of Innisfil Stormwater Management Master Plan
Cooks Bay Tributary (Shore Acres Rd. & Nelly Rd., Gilford)

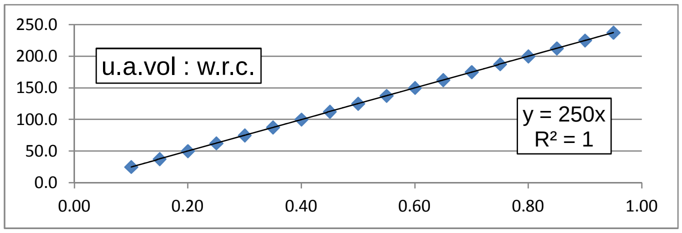
B. de Geus 07.14

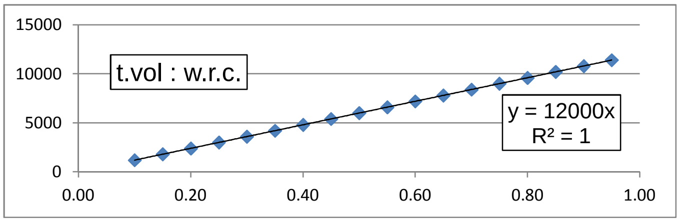
Scenario 1
Cooks Bay Trib C
- no volume control

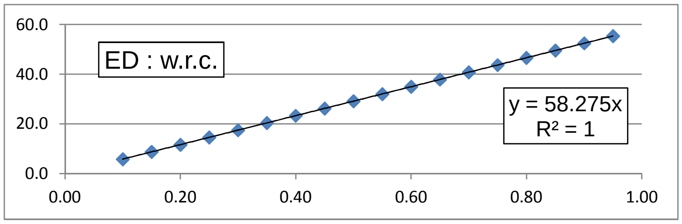
Q_o ($l\ s^{-1}$)
205.9

DA (ha)	Q_{ua} ($l\ s^{-1}\ ha^{-1}$)	event rain (mm)
48	4.29	25

w. runoff coeff.	unit area vol. ($m^3\ ha^{-1}$)	total vol. (m^3)	ED (hrs)
0.10	25.0	1200	5.8
0.15	37.5	1800	8.7
0.20	50.0	2400	11.7
0.25	62.5	3000	14.6
0.30	75.0	3600	17.5
0.35	87.5	4200	20.4
0.40	100.0	4800	23.3
0.45	112.5	5400	26.2
0.50	125.0	6000	29.1
0.55	137.5	6600	32.1
0.60	150.0	7200	35.0
0.65	162.5	7800	37.9
0.70	175.0	8400	40.8
0.75	187.5	9000	43.7
0.80	200.0	9600	46.6
0.85	212.5	10200	49.5
0.90	225.0	10800	52.4
0.95	237.5	11400	55.4





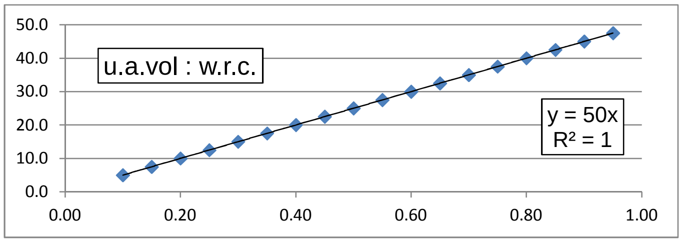


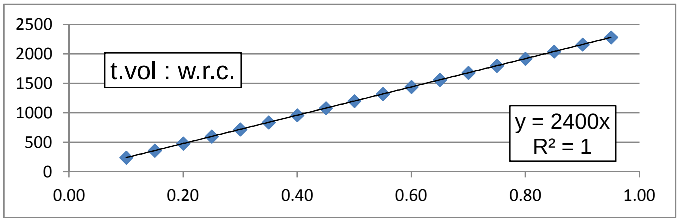
Scenario 2
Cooks Bay Trib C
- 20mm infiltration

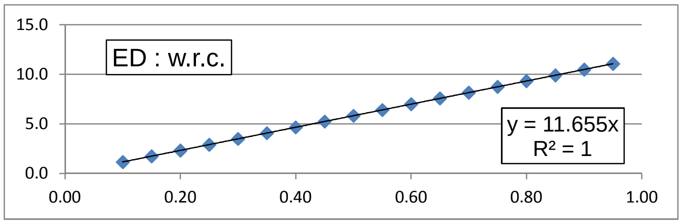
Q_o ($l\ s^{-1}$)
205.9

DA (ha)	Q_{ua} ($l\ s^{-1}\ ha^{-1}$)	event rain (mm)
48	4.29	5

w. runoff coeff.	unit area vol. ($m^3\ ha^{-1}$)	total vol. (m^3)	ED (hrs)
0.10	5.0	240	1.2
0.15	7.5	360	1.7
0.20	10.0	480	2.3
0.25	12.5	600	2.9
0.30	15.0	720	3.5
0.35	17.5	840	4.1
0.40	20.0	960	4.7
0.45	22.5	1080	5.2
0.50	25.0	1200	5.8
0.55	27.5	1320	6.4
0.60	30.0	1440	7.0
0.65	32.5	1560	7.6
0.70	35.0	1680	8.2
0.75	37.5	1800	8.7
0.80	40.0	1920	9.3
0.85	42.5	2040	9.9
0.90	45.0	2160	10.5
0.95	47.5	2280	11.1







APPENDIX G:
SEPARATE DOCUMENTS

C.C. Tatham & Associates Ltd.
Consulting Engineers

COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

Town of Innisfil

Municipal Class Environmental Assessment

SWM Facility Inspection and Maintenance Manual

prepared by:

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Barrie, ON   L4N 6B5
Tel: (705) 733-9037   Fax: (705) 733-1520
info@cctatham.com

prepared for

Town of Innisfil

March 29, 2016

CCTA File 413448

TABLE OF CONTENTS

LIST OF TABLES

In order for SWM facilities to operate effectively, regular inspection and maintenance of the facility is required. This document provides guidance for maintenance activities required for various SWM facilities.

1 Inspection & Maintenance: LID Facilities

1.1 Rainwater Harvesting

1.1.1 Maintenance

Maintenance requirements for rainwater harvesting systems vary according to use. Systems that are used to provide supplemental irrigation water have relatively low maintenance requirements, while systems designed for indoor uses have much higher maintenance requirements. All rainwater harvesting system components should undergo regular inspections every six months during the spring and fall seasons (LID Center, 2003). The following maintenance tasks should be performed as needed to keep rainwater harvesting systems in working condition:

- keep leaf screens, eaves troughs and downspouts free of leaves and debris;
- check screens (1 mm openings) and patch holes or gaps immediately;
- clean and maintain first flush diverters and filters, especially those on drip irrigation systems;
- inspect and clean storage tank lids, paying special attention to vents and screens on inflow and outflow spigots; and
- replace damaged system components as needed.

1.1.2 Mosquito Control

If screening is not sufficient to deter mosquitoes, the following techniques can be used for harvested rainwater intended for landscaping use:

- add a few tablespoons of vegetable oil to smother larvae that come to the surface; and
- use mosquito dunks or pellets containing larvicide.

1.1.3 Winter Operation

Rainwater harvesting systems have a number of components that can be affected by freezing winter temperatures. Designers should give careful consideration to these conditions to prevent system damage and costly repairs. For above-ground systems, winter-time operation may not be possible. These systems must be taken offline for the winter. Prior to the onset of freezing temperatures, above-ground systems should be disconnected and drained. For below-ground and indoor systems, downspouts and overflow components should be checked for ice blockages during snowmelt events.

1.2 Green Roofs

1.2.1 Maintenance

Green roof maintenance is typically greatest in the first two years as plants are becoming established. Vegetation should be monitored to ensure dense coverage becomes established. A warranty on the vegetation should be included in the construction contract.

Regular operation of a green roof includes:

- *Irrigation:* Watering should be based on actual soil moisture conditions as plants are designed to be drought tolerant. High soil moisture from unnecessary watering will reduce the runoff reduction benefits of the green roof.
- *Leak Detection:* Electronic leak detection is recommended. This system, also used with traditional roofs, must be installed prior to the green roof. Particular attention to leak detection should be paid in the first few months following installation (The Folsom Group, 2004).

Ongoing maintenance should occur at least twice per year (Magco, 2003) and should include:

- *Weeding:* Remove volunteer seedlings of trees and shrubs. Extensive green roofs are not designed for the weight of these plants, and the woody roots can damage the waterproofing.
- *Debris and Dead Vegetation Removal:* Debris and bird feces should be removed periodically. In particular, the overflow conveyance system should be kept clear (TRCA, 2006).

1.3 Soakaways, Infiltration Trenches & Chambers

1.3.1 Inspection & Maintenance

As with all infiltration practices, these facilities require regular inspection to ensure they continue to function. Maintenance typically consists of cleaning out leaves, debris and accumulated sediment caught in pre-treatment devices, inlets and outlets annually or as needed. Inspection via an monitoring well should be performed to ensure the facility drains within the maximum acceptable length of time (typically 72 hours) at least annually and following every major storm event (>25 mm). If the time required to fully drain exceeds 72 hours, drain via pumping and clean out the perforated pipe underdrain, if present. If slow drainage persists, the system may need removal and replacement of granular material and/or geotextile fabric (PDEP, 2006). The expected lifespan of infiltration practices is not well understood, however, it can be expected that it will vary depending on pre-treatment practice maintenance frequency, and the sediment texture and load coming from the catchment. Soakaways have been observed to continue to function well after more than 30 years of operation (Barraud *et al*., 1999; Norrstrm, 2005).

1.4 Bio-retention

1.4.1 Inspection & Maintenance

Bio-retention requires routine inspection and maintenance of the landscaping as well as periodic inspection for less frequent maintenance needs or remedial maintenance. Generally, routine maintenance will be the same as for any other landscaped area, weeding, pruning, and litter removal. Routine operation and maintenance tasks are key to public acceptance of highly visible bio-retention units.

Periodic inspections after major storm events will determine whether corrective action is necessary to address gradual deterioration or abnormal conditions. For the first two years following construction the facility should be inspected at least quarterly and after every major storm event (> 25 mm). Subsequently, inspections should be conducted in the spring and fall of each year and after major storm events.

While maintenance can be performed by landscaping contractors who are already providing similar landscape maintenance services on the property, they will need some additional training on bio-retention needs. This training should focus on elevation differences needed for ponding, mulching requirements, acceptability of ponding after a rainstorm, and fertilizer requirements. The planting plan should be kept for maintenance records and used to help maintenance staff identify which plants are weeds or invasive.

Aside from homeowner initiated rain garden projects, legally binding maintenance agreements are a necessity for bio-retention facilities on private property. Agreements should specify the property owner's responsibilities and the municipality's right to enter the property for inspection or corrective action. Agreements must require regular inspection and maintenance and should refer to an inspection checklist. The construction contract should include a care and replacement warranty to ensure vegetation is properly established and survives during the first growing season following construction.

The expected lifespan of infiltration practices is not well understood, however, it can be expected that it will vary depending on pre-treatment practice maintenance frequency, and the sediment texture and load coming from the catchment.

Table 1: Routine Inspection and Maintenance Activities

Activity	Schedule
▪ Inspect for vegetation density (at least 80% coverage) damage by foot or vehicular traffic, channelization, accumulation of debris, trash and sediment, and structural damage to pre-treatment services.	After every major storm event (>25 mm), quarterly for the first two years, and twice annually thereafter.
▪ Regular watering may be required during the first two years until vegetation is established.	As needed for first two years of operation.

Activity	Schedule
▪ Remove accumulated sediment from pre-treatment devices, inlets and outlets. ▪ Trim trees and shrubs. ▪ Replace dead vegetation, remove invasive growth. ▪ Repair eroded or sparsely vegetated areas. ▪ Remove accumulated sediment on the bio-retention area surface when dry and exceeds 25 mm depth (PDEP, 2006). ▪ If gullies are observed along the surface, regrading and revegetating may be required.	Annually or as needed.

Table 2: Annual Spring Cleaning

Inspection Item	Corrective Actions
Vegetation health, diversity and density	▪ Remove dead and diseased plants. ▪ Add reinforcement planting to maintain desired vegetation density. ▪ Prune woody matter. ▪ Check soil pH for specific vegetation. ▪ Add mulch to maintain 75 mm layer.
Sediment build up and clogging at inlets	▪ Remove sand that may accumulate at the inlets or on the filter bed surface following snow melt. ▪ Examine drainage area for bare soil and stabilize. Apply erosion control such as silt fence until the area is stabilized. ▪ Check that pre-treatment is properly functioning. For example, inspect grass filter strips for erosion or gullies. Reseed as necessary.
Ponding for more than 48 hours	▪ Check underdrain for clogging and flush out. ▪ Apply core aeration or deep tilling. ▪ Mix amendments into the soil. ▪ Remove the top 75 mm of bio-retention soil. ▪ Replace bio-retention soil.

1.5 Vegetated Filter strips

1.5.1 Maintenance

Maintenance requirements for vegetated filter strips are similar to enhanced grass swales and typically involve a low level of activity after vegetation becomes established. Routine inspection is important to ensure that dense vegetation cover is maintained and inflowing runoff does not become concentrated and short circuit the practice. Vehicles should not be parked or driven on filter strips. For routine mowing of grassed filter strips, the lightest possible mowing equipment should be used to prevent soil compaction. The activities outlined in Table 4.6.5 should be incorporated into the maintenance plan.

Table 3: Typical Maintenance Activities for Vegetated Filter Strips

Activity	Schedule
▪ Inspect for vegetation density (at least 80% coverage), damage by foot or vehicular traffic, channelization, accumulation of debris, trash and sediment, and structural damage to pre-treatment and level spreader devices.	After every major storm event (>25 mm), quarterly for the first two years, and twice annually thereafter.
▪ Regular watering may be required during the first two years while vegetation is becoming established. ▪ Mow grass to maintain height between 50 to 150 mm. ▪ Remove trash and debris from level spreaders, pre-treatment devices and the filter strip surface.	At least twice annually. More frequently if desired for aesthetic reasons.
▪ Remove accumulated sediment from pre-treatment and level spreader devices. ▪ Replace mulch in spring. ▪ Trim trees and shrubs. ▪ Replace dead vegetation, remove invasive growth, dethatch, remove thatching and aerate (PDEP, 2006). ▪ Repair eroded or sparsely vegetated areas. ▪ Remove accumulated sediment on the filter strip or bottom of the slope when dry and exceeds 25 mm depth (PDEP, 2006). ▪ If pools of standing water are observed along the slope, regrading and revegetating may be required.	Annually or as needed.

1.6 Permeable Pavement

1.6.1 Inspection & Maintenance

Like all other stormwater practices, permeable pavement requires regular inspection and maintenance to ensure that it functions properly. Well maintained permeable pavers are expected to last at least 20 years (*e.g.*, Applied Research Associates, 2008). The limiting factor for permeable pavers is clogging within the aggregate layers, filler, or underdrain. The pavers themselves can be reused. Legally binding maintenance agreement which clearly specifies how to conduct routine maintenance tasks are essential for permeable pavement installed on private property. Ideally, signs should be posted on the site identifying permeable paver and porous pavement areas. This can also serve as a public awareness and education opportunity. The following maintenance procedures and preventative measures should be incorporated into a maintenance plan:

- *Surface Sweeping:* Sweeping should occur once or twice a year with a commercial vacuum sweeping unit to mitigate sediment accumulation and ensure continued porosity. Permeable pavement should not be washed with high pressure water systems or compressed air units, because they will push particles deeper into the pavement (PWD, 2007).

- *Inlet Structures:* Drainage pipes and structures within or draining to the subsurface bedding beneath porous pavement should be cleaned out on regular intervals (PWD, 2007).

- *Heavy Vehicles:* Trucks and other heavy vehicles can ground dirt into the porous surface and lead to clogging. These vehicles should be prevented from tracking or spilling dirt onto the pavement (PWD, 2007). Signage and training of facilities personnel is suggested.

- *Construction and Hazardous Materials:* Due to the potential for groundwater contamination, all construction or hazardous material carriers should be prohibited from entering a permeable pavement site (PWD, 2007).

- *Drainage Areas:* Impervious areas contributing to the permeable pavement should be regularly swept and kept clear of litter and debris. Flows from any landscaped areas should be diverted away from the pavement or at least be well stabilized with vegetation.

- *Grid Pavers:* Paver or grid systems that have been planted with grass should be mowed regularly and the clippings should be removed (PWD, 2007). Water and fertilize as needed.

- *Seal Coating*: Seal coats should never be applied to permeable pavements. Current and future owners and operations staff must be aware of permeable pavement areas and the importance of not applying any sealants. Porous asphalt and pervious concrete look very similar to their impervious versions and could be inadvertently sealed over.

- *Potholes*: For porous asphalt or pervious concrete, isolated potholes can be patched with standard patching mixes. Patching can continue until the structural integrity of the pavement has been compromised or stormwater can no longer drain to the aggregate base. Then the surface will need to be torn up and replaced.

- *Uneven Pavers:* An uneven paver surface can be repaired by pulling up the pavers, redistributing the bedding layer, and then placing the pavers back. New filler stone will need to be swept into the replaced pavers. Typically the pavers are packed very tightly, and breaking one or more pavers will be necessary to pull up a group of pavers. Keeping a set of replacement pavers after construction will be useful for making future repairs.

- *Weeds:* Over time, weed growth may become a problem, particularly on surfaces with infrequent traffic. Weeds can be an aesthetic issue and may also reduce the infiltration through the pavement. Keeping the pavement surface free of organic material through regular sweeping and vacuuming can impede weeds from taking root. Pulling weeds when they are small will limit damage to the pavement and loss of filler material between pavers. Ontario has banned the use of cosmetic herbicides.

- *Winter Maintenance:* Sand should not be spread on permeable pavement as it can quickly lead to clogging. Deicers should only be used in moderation and only when needed because dissolved constituents are not removed by the pavement system. Pilot studies at the University of New Hampshire Stormwater Center have found that permeable pavement requires 75% less salt than conventional pavement over the course of a typical winter season (UNHSC, 2007).

- *Snow Plowing:* Permeable pavement is plowed for snow removal like any other pavement. When groundwater contamination from chlorides is a concern, plowed snow piles and snow melt should not be directed to permeable paver and porous pavement systems (Smith, 2006).

1.7 Enhanced Grass Swales

1.7.1 Inspection & Maintenance

Maintenance requirements for enhanced grass swales is similar to vegetated filter strips and typically involve a low level of activity after vegetation becomes established. Grass channel maintenance procedures are already in place at many municipal public works and transportation departments. These procedures should be compared to the recommendations below (Table 4.8.6) to assure that the infiltration and water quality benefits of enhanced grass swales are preserved. Routine roadside ditch maintenance practices such as scraping and re-grading should be avoided at swale locations. Vehicles should not be parked or driven on grass swales. For routine mowing, the lightest possible mowing equipment should be used to prevent soil compaction.

For swales located on private property, the property owner or manager is responsible for maintenance as outlined in a legally binding maintenance agreement. Roadside swales in residential areas generally receive routine maintenance from homeowners who should be advised regarding recommended maintenance activities.

Table 4: Typical Inspection & Maintenance Activities for Enhanced Grass Swales

Activity	Schedule
▪ Inspect for vegetation density (at least 80% coverage), damage by foot or vehicular traffic, channelization, accumulation of debris, trash and sediment, and structural damage to pre-treatment and level spreader devices.	After every major storm event (>25 mm), quarterly for the first two years, and twice annually thereafter.
▪ Regular watering may be required during the first two years while vegetation is becoming established. ▪ Mow grass to maintain height between 50 to 150 mm. ▪ Remove trash and debris from level spreaders, pre-treatment devices and the filter strip surface.	At least twice annually. More frequently if desired for aesthetic reasons.
▪ Remove accumulated sediment from pre-treatment and level spreader devices. ▪ Replace mulch in spring. ▪ Trim trees and shrubs. ▪ Replace dead vegetation, remove invasive growth, dethatch, remove thatching and aerate (PDEP, 2006). ▪ Repair eroded or sparsely vegetated areas. ▪ Remove accumulated sediment on the filter strip or bottom of the slope when dry and exceeds 25 mm depth (PDEP, 2006). ▪ If pools of standing water are observed along the slope, regrading and revegetating may be required.	Annually or as needed.

1.8 Dry Swales

1.8.1 Inspection & Maintenance

Maintenance of dry swales mostly involves maintenance of the vegetative cover as well as periodic inspection for less frequent maintenance needs. Generally, routine maintenance will be the same for any other landscaped area; weeding, pruning, mowing and litter removal. Inspections annually and after every major storm event (> 25 mm), will determine whether corrective action is necessary to address gradual deterioration or abnormal conditions.

For the first six months following construction, the site should be inspected after each storm event greater than 10 mm, or a minimum of twice. Subsequently, inspections should be conducted in the spring of each year and after rainfall events greater than 25 mm. Two or three growing seasons may be required to establish vegetation to the desired level. During this period, erosion and sediment control practices, such as mats or blankets, should be used to help protect swale structure.

The expected lifespan of infiltration practices is not well understood, however, it can be expected that it will vary depending on pre-treatment practice maintenance frequency, and the sediment texture and load coming from the catchment.

Table 5: Routine Inspection & Maintenance Activities

Activity	Schedule
▪ Inspect for vegetation density (at least 80% coverage) damage by foot or vehicular traffic, channelization, accumulation of debris, trash and sediment, and structural damage to pre-treatment services.	After every major storm event (>25 mm), quarterly for the first two years, and twice annually thereafter.
▪ Regular watering may be required during the first two years until vegetation is established	As needed for first two years of operation.
▪ Remove accumulated sediment from pre-treatment devices, inlets and outlets. ▪ Trim trees and shrubs. ▪ Replace dead vegetation, remove invasive growth. ▪ Repair eroded or sparsely vegetated areas. ▪ Remove accumulated sediment on the bio-retention area surface when dry and exceeds 25 mm depth (PDEP, 2006). ▪ If gullies are observed along the surface, regrading and revegetating may be required.	Annually or as needed.

Table 6: Annual Spring Cleaning

Inspection Item	Corrective Actions
Vegetation health, diversity and density	▪ Remove dead and diseased plants. ▪ Add reinforcement planting to maintain desired vegetation density. ▪ Prune woody matter. ▪ Check soil pH for specific vegetation. ▪ Add mulch to maintain 75 mm layer.
Sediment build up and clogging at inlets	▪ Remove sand that may accumulate at the inlets or on the filter bed surface following snow melt. ▪ Examine drainage area for bare soil and stabilize. Apply erosion control such as silt fence until the area is stabilized. ▪ Check that pre-treatment is properly functioning. For example, inspect grass filter strips for erosion or gullies. Reseed as necessary.
Ponding for more than 48 hours	▪ Check underdrain for clogging and flush out. ▪ Apply core aeration or deep tilling. ▪ Mix amendments into the soil. ▪ Remove the top 75 mm of bio-retention soil. ▪ Replace bio-retention soil.

1.9 Perforated Pipe Systems

1.9.1 Inspection & Maintenance

As with all infiltration practices, these facilities require regular inspection to ensure continued functioning. Maintenance typically consists of cleaning out leaves, debris and accumulated sediment caught in pre-treatment devices annually or as needed. Inspection via manholes should be performed to ensure the facility drains within the maximum acceptable length of time (typically 72 hours) at least annually and following every major storm event (>25 mm). If the time required to fully drain exceeds 72 hours, drain via pumping and clean out the perforated pipe by flushing. If slow drainage persists, the system may need removal and replacement of granular material and/or geotextile liner. Perforated pipe systems should be located below shoulders of roadways, pervious boulevards or grass swales where they can be readily excavated for servicing. The expected lifespan of infiltration practices is not well understood, however, it can be expected that it will vary depending on pre-treatment practice maintenance frequency, and the sediment texture and load coming from the catchment. Perforated pipe systems with grass swales as pre-treatment have been observed to continue to function well after 20 years of operation (J.F. Sabourin and Associates, 2008).

2 Inspection & Maintenance: Wet Ponds, Wetlands, and Dry Ponds

2.1 Frequency Removal

2.1.1 Wet Ponds, Wetlands & Dry Ponds

To ensure long-term effectiveness, the sediment that accumulates in SWMPs (e.g., wet ponds, wetlands and dry ponds) should be periodically removed. The required frequency of sediment removal is dependent on many factors including:

- type of SWM facility;
- design storage volume (e.g., if active and permanent pool storage is oversized for sediment storage);
- characteristics of the upstream catchment area (e.g., land use; level of imperviousness; upstream construction activities and effectiveness of sediment and erosion control activities); and
- municipal practices (e.g., sanding).

There is limited data available on sediment accumulation. Monitoring of new ponds and retrofit ponds (converted ponds in older established areas) indicates a significant difference in sediment buildup for different ponds at different time periods. Sediment accumulation will typically be rapid for the entire construction period (including time required for the building, sodding and landscaping of individual lots). Once a catchment area is completely developed and vegetation is established, sediment accumulation drops markedly.

Figures 1-4 show approximate relationships for sediment removal frequency for wetlands, wet ponds and dry ponds for various imperviousness levels as a function of the storage volume in each facility.

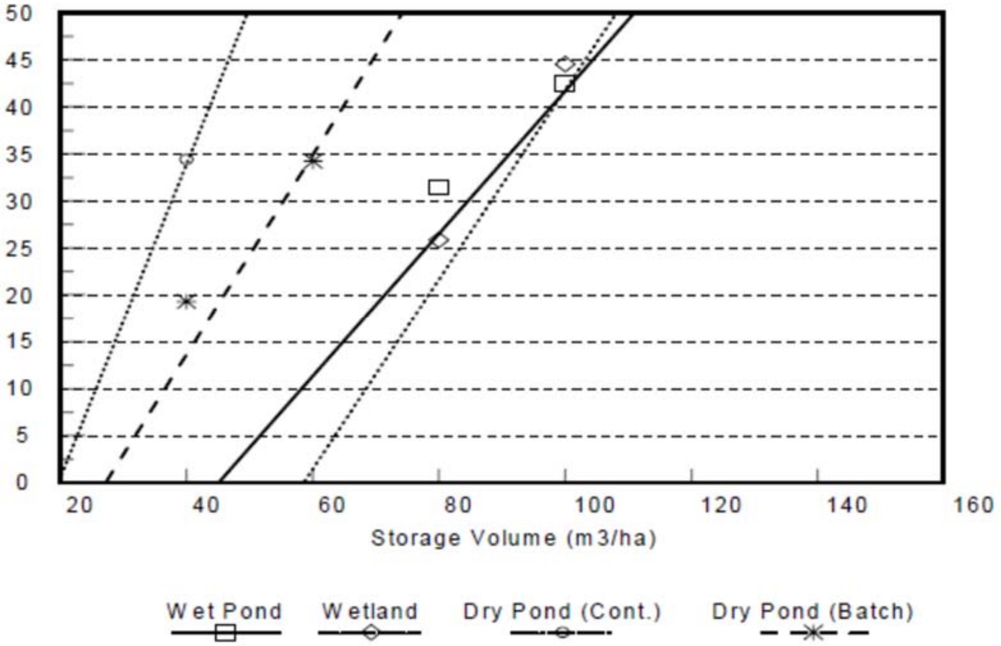

Figure 1: Storage Volume vs Removal Frequency for 35% Imperviousness

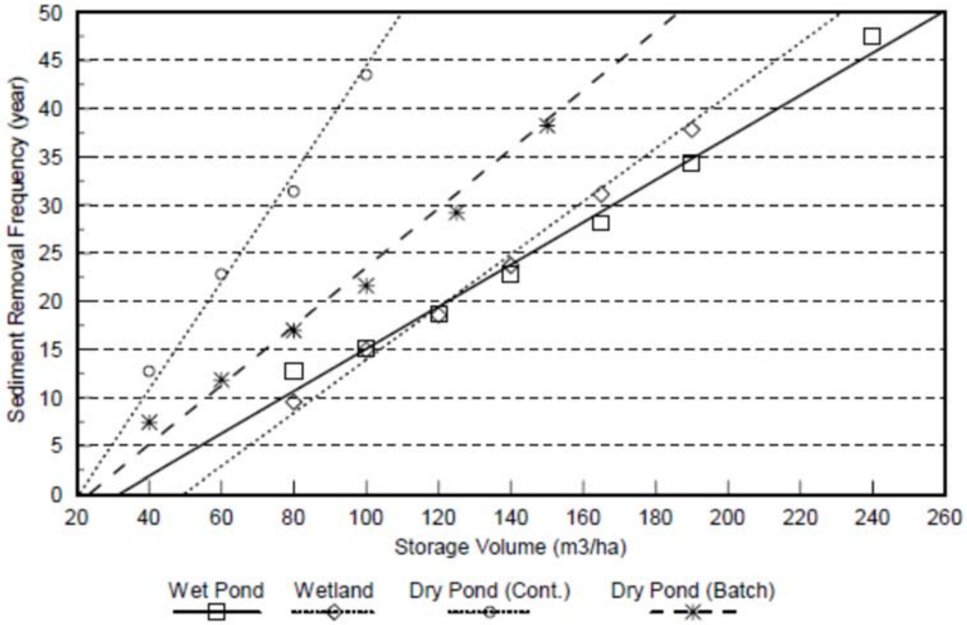

Figure 2: Storage Volume vs Removal Frequency for 55% Imperviousness

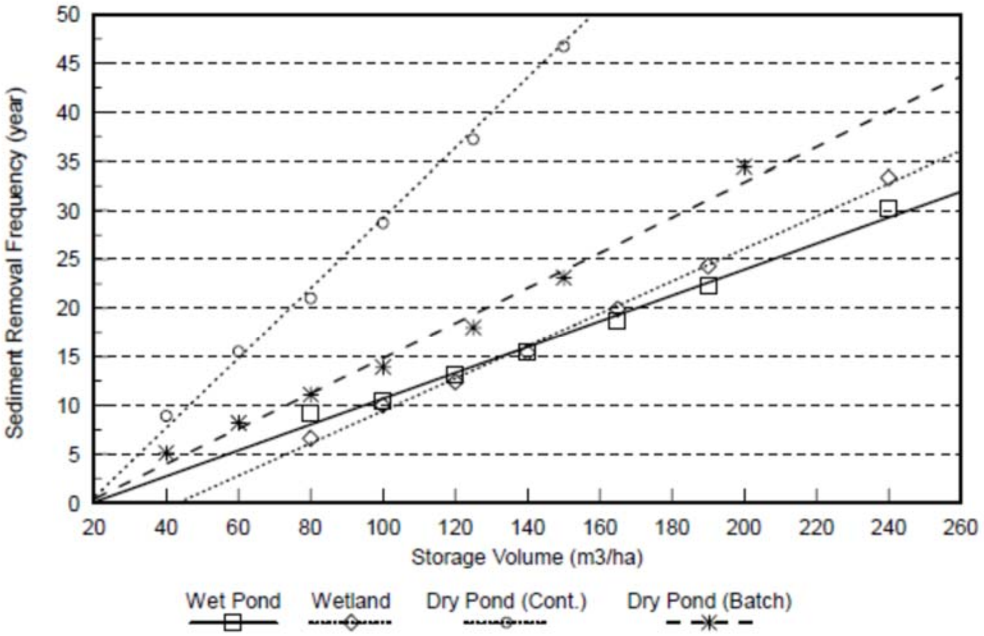

Figure 3: Storage volume vs Removal Frequency for 70% Imperviousness

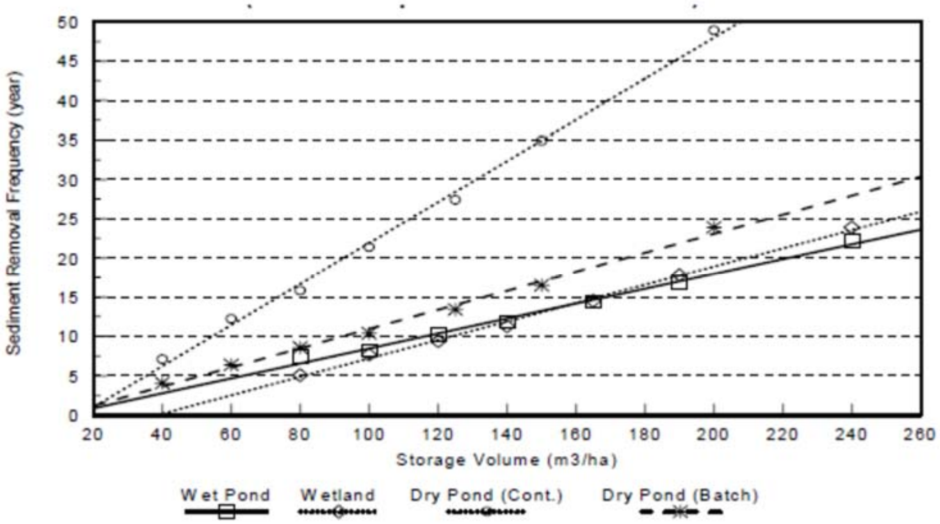

Figure 4: Storage Volume vs Removal Frequency for 85% Imperviousness

2.2 Inspection Routines

2.2.1 Wet & Dry Ponds

Permanent Pool

The permanent pool for a wet pond should be inspected semi-annually during dry conditions to ensure the desired permanent pool elevation is being maintained. If the permanent pool is higher than normal, the outlet may be blocked. If the permanent pool is lower than normal, the inlet may be obstructed. The quality of the permanent pool should be visually inspected for an oily sheen, froth or discolouration, which may indicate a spill has occurred and clean-up is required.

A dry pond should also be inspected semi-annually in order to ensure that there is no standing water in the pond 24 hours after a storm (or other design detention time). Standing water could indicate blockage of the outlet by trash or sediment. Visual inspection of the outlet structure for debris or other blockages should be completed. The pond should be checked in order to ensure it is not always dry, or relatively dry within 24 hours of a storm (or other design detention time). This could indicate a blockage of the inlet or water quality/erosion control outlet which is too large. Visual inspection of the inlet structure for debris or blockages should be completed.

Vegetation

Vegetation surrounding the pond and within the boundaries of the pond should be inspected on an annual basis. The following actions are required:

- remove and replace dying or unhealthy vegetation;
- weeds, poisonous or invasive vegetation should be removed without the use of pesticides;
- tree growth interfering with pond operation or maintenance access should be trimmed or if necessary, removed;
- allowing grass around the pond to grow will enhance water quality. Therefore, grass cutting should be limited as much as possible. Grass clipping must be removed to reduce potential for organic loading; and
- herbicides and insecticides should not be used to control weeds. Fertilizer use should also be limited to minimize nutrient loadings.

Condition of Inlets/Outlets

Both the inlets and outlets should be inspected annually and after major storms for any obstructions or damage. Corrective action should be carried out as necessary.

Condition of Spillway

The condition of the outfall should be inspected annually for erosion and missing or displaced rip-rap. Corrective action should be carried out as required.

Trash & Debris

During inspections the area should be checked for any trash and or debris in or around the pond. All trash and debris should be disposed of.

Embankment & Sides Slopes of Pond

Embankments should be inspected for erosion, rodents holes etc. on a regular basis and repaired to their original state.

Fencing, Gates & Access Roads

All parts of the perimeter fence, including posts and top rails should be inspected for damage, broken or missing parts, misalignment and deteriorating protective coating. Inspect gates for damage, broken or missing parts including locks, hinges, stretcher bars and ties. Lubricate all hinges and check that the gate opens freely. Ensure there is no erosion under the gate that permits easy entrance to the facility.

Access routes should be inspected for surface defects including erosion, debris, weeds and obstructions. The access road should be maintained and repaired as required.

Pond Aesthetics

We recommend an annual inspection for graffiti on any structures, garbage and growth of the vegetation. Actions to improve and maintain the aesthetics of the pond should be carried out as necessary.

Drainage Ditches

All drainage ditches should be inspected for erosion, debris and overall condition. Repairs should be carried out as required.

2.2.2 Oil & Grit Separators

Sediment

The oil and grit separator should be inspected for sediment build up in the separator or catch basin. The sediment should be measured with a graduated pole with a flat plate attached to the bottom. The pole should be graduated such that the true bottom of the separator/catch basin compared to the cover/grate is marked for comparison.

Trash & Debris

A visual inspection of the contents of the oil and grit separator should be made from the surface for trash or debris. It should also be checked for the presence of oil or an industrial spill. These may be indicated by an oily sheen, frothing or unusual colouring of the water. The oil grit separator should be cleaned out in the event of spill contamination

2.3 Methods of Investigation

2.3.1 Wet Ponds, Dry Ponds, & Wetlands

Typical grading/excavation equipment such as backhoes and in some instances hydraulic dredging should be used to remove sediment from ponds and wetlands. Certain types of backhoes and loaders have a tendency to tear up the inter-locking block on the hardened floor. Therefore, there has been a shift to using long-reach backhoes. Conventional dredging is not recommended because of the costs and potential to destroy features in the facility (i.e. vegetation and bottom grading).

Regardless of the means selected for sediment removal, the procedure should meet the requirements normally imposed by a sediment and erosion control plan (e.g. no off-site migration of sediment to roads, stormwater conveyance systems or watercourses).

2.3.2 Oil & Grit Separators

Manhole oil/grit separators (OGS) should be cleaned out using a vacuum truck. Some interceptors discharge low flows containing oil and grit to the sanitary sewer. Although this type of design facilitates maintenance, it is undesirable in the case of a large fuel/oil spill since the sewage treatment plant cannot treat large loadings of these pollutants. Therefore, it is recommended that any outlet to the sanitary sewer from the oil/grit separator be valved and kept closed during everyday operations. Manhole separators or three-chamber separators that incorporate a by-pass should be cleaned out annually and after any known spills have occurred.

TABLE 1
OPERATION AND MAINTENANCE INSPECTION REPORT
STORMWATER MANAGEMENT POND # _______________
TOWN OF INNISFIL

Inspector's Name ________________________ Inspection Date ________________________________

	Checked		Maintenance Needed		Inspection Frequency	Comments/Action Taken
Pond Components	**Yes**	**No**	**Yes**	**No**		
1. Embankment and Emergency Spillway (major and minor outlet)						
a. Adequate vegetation and ground cover					A	
b. Embankment erosion					A	
c. Animal burrows					A	
d. Unauthorized plantings					A	
e. Emergency spillway					A,S	
f. Leaks from pond					A	
g. Condition of Inlets (minor and major)					A,S	
h. Visual settlement or horizontal misalignment of top of dam					A	
i. Emergency spillway condition					A	
j. Other (specify)						
2. Structures						
a. Inlet Headwall and storm piping					A	
b. Outlet Structure (piping, perforated riser pipe, inlet CB, and MH as applicable)					A	
c. Outlet headwall and piping					A,S	
e. Other (specify)						
4. Forebay						
a. Undesirable vegetative growth					M	
b. Floating or floatable debris removal required					M	
c. Visible pollution					M	
d. High water marks					M	
e. Shoreline problems					M	
f. Sediment accumulation					A	
g. Other (specify)						
5. Fencing, Gates & Access Roads						
a. Condition of fence					M,A	
b. Condition of gates					M,A	
c. Condition of access roads					M,A,S	
6. Other						
a. Complaints from residents (describe on back)					A	
b. Aesthetics i. Grass height					M	
ii. Graffiti removal necessary					M	
iii. Other (Specify)						
c. Any public hazards (specify)					M	

Inspection Frequency Key A = Annual, M = Monthly, S = After major storm

OPERATION AND MAINTENANCE INSPECTION REPORT
STORMWATER MANAGEMENT POND # ________________
TOWN OF INNISIFL

Summary

1. **Inspectors Remarks:**

   ____
   ____
   ____

2. **Overall Condition of Facility (Check One)**

   ________ Acceptable
   ________ Unacceptable

3. **Dates of any maintenance that must be completed by:**

   ____
   ____
   ____

4. **Comments**

   ____
   ____
   ____
   ____
   ____
   ____
   ____
   ____
   ____
   ____
   ____
   ____

____
Inspectors Signature

____
Date

APPENDIX H: EA DOCUMENTATION

TOWN OF INNISFIL
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

NOTICE OF PUBLIC OPEN HOUSE

The Town of Innisfil has initiated a Comprehensive Stormwater Management Master Plan (CSWM-MP) in compliance with the requirements of the Lake Simcoe Protection Plan and the Guidelines developed for the implementation of the CSWM-MP in the Lake Simcoe Watershed.

The primary goal of the CSWM-MP is to improve water quality in the Lake Simcoe watershed by reducing phosphorous loadings. The study will identify ways to improve the management of stormwater in the Town to achieve this goal through a detailed analysis of existing conditions and evaluation of stormwater management alternatives. This meeting will provide an opportunity for the public and stakeholders to review the alternatives under consideration and to provide input and comments.

The study follows the Municipal Class Environmental Assessment (EA) process, which encourages public participation. A Public Open House Meeting will be held on:

Date: **Thursday, May 29, 2014**
Time: **5:00 to 8:00 p.m.**
Location: **Town Hall Community Rooms,**
2101 Innisfil Beach Road, Innisfil, Ontario L9S 1A1

The Open House materials will be posted on the Town website on May 30, 2014. We invite you to forward comments by June 6, 2014. Please let us know if you would like to be added to our mailing list.

Amber Leal, BSc., C.E.T.
Project Manager
Town of Innisfil
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Amanda Kellett, B.Sc.Eng., P. Eng.
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Innisfil

TOWN OF INNISFIL
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN FINAL REPORT

NOTICE OF STUDY COMMENCEMENT

The Town of Innisfil initiated the development of a Comprehensive Stormwater Management Master Plan (CSWM-MP) in 2012 in accordance with the requirements of the Lake Simcoe Protection Plan (LSPP) and guidelines for the development and implementation of CSWM-MP in the Lake Simcoe watershed. The LSPP requires that all municipalities under its jurisdiction implement a CSWM-MP by June 2014. The underlying goal of the LSPP and CSWM-MP is to reduce phosphorous loadings to Lake Simcoe by improving the management of stormwater for both existing and planned development. A part of the study was completed in April 2013 and this project represents the Final Report to be completed by June 2014.

This study is being executed in accordance with the planning and design process for Schedule "B" projects as outlined in the Municipal Engineers Association *Municipal Class Environmental Assessment* document (October 2000, as amended in 2007 and 2011). The existing environmental and drainage conditions in the study area will be reviewed. Alternative solutions will be established and assessments will be conducted to evaluate the stormwater management alternatives based on their impact on the environment and the opportunities and constraints of the project. In particular, the CSWM-MP will be used to identify stormwater management system improvement or retrofit opportunities and maintenance needs and also make recommendations on design criteria and stormwater management approaches to be taken in each settlement area of the Town.

A public consultation program is being established to obtain timely input into the study. A Public Information Open House will be scheduled in the spring to provide an opportunity for the public and stakeholders to review the alternatives and recommended strategy under consideration, and to provide input and comments. A Notice providing time and location of the Open House will be published in local newspapers.

As they become available, further details on the project and the Municipal Class Environmental Assessment will be available on the Town's website www.innisfil.ca and from the consultant's office. Written comments and input are welcome. Comments and requests for information should be submitted to:

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Tel: 705-436-3740, ext. 3246
Fax: 705-436-3710
e-mail: nrahman@innisfil.ca

or

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This Notice issued January 10, 2014.

TOWN OF INNISFIL
COMPREHENSIVE STORMWATER MANAGEMENT MASTER PLAN

AGENCY/STAKEHOLDER CIRCULATION LIST

- MOE Regional Office (Cindy Hood) and Lake Simcoe Protection Team (Robin Skeates)
- Local MNR Office
- MTO
- Ministry of Culture
- LSRCA (Tom Hogenbirk)
- NVCA (Glenn Switzer)
- County of Simcoe (Debbie Korolnek)
- Town of Innisfil (Tim Cane)
- City of Barrie (Stu Patterson)
- Local First Nation and aboriginal community leaders
- Ministry of Aboriginal Affairs
- Indian and Northern Affairs Canada
- Transport Canada
- DFO - Habitat Management
- DFO - Canadian Coast Guard
- Environment Canada
- Ministry of Municipal Affairs and Housing

BFS /file

C.C. Tatham & Associates Ltd.
Consulting Engineers

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January 24, 2014

via mail
CCTA File 413448

Tom Hogenbirk, CMM, P.Eng.
Manager, Engineering and Technical Servicing
Lake Simcoe Region Conservation Authority
120 Bayview Parkway, Box 282
Newmarket, ON L2Y 4X1

Re: Notice of Study of Commencement
Innisfil Comprehensive Stormwater Management Master Plan

Dear Mr. Hogenbirk:

In accordance with Lake Simcoe Protection Plan requirements, The Town of Innisfil has initiated the development of a Comprehensive Stormwater Management Master Plan (CSWM-MP). The CSWM-MP will assess existing drainage conditions and propose a management plan with the goal of reducing phosphorous loadings to Lake Simcoe and improving the management of stormwater for both existing and planned development.

The study is being carried out in accordance with the planning and design process for a Schedule B project as outlined in the Municipal Engineers Association *Municipal Class Environmental Assessment* document. A copy of the Notice of Study Commencement is attached.

If you have any questions, initial comments or input regarding the study, please do not hesitate to contact me.

Yours truly,
C. C. Tatham & Associates Ltd.

A Kellett

Amanda Kellett, B.Sc. Eng., P.Eng.
AR/ALK:klc
Encl.

copy: Nafiur Rahman, Town of Innisfil (by email nrahman@innisfil.ca)
copy: Carolyn Ali, Town of Innisfil (by email cali@innisfil.ca)

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