CORONATION PARK DRAINAGE IMPROVEMENTS CLASS ENVIRONMENTAL ASSESSMENT

Final Report

Town of Oakville

Prepared for:

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Town of Oakville, Ontario

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1. INTRODUCTION

1.1 Purpose/Overview

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler) has been retained by the Town of Oakville to assess various drainage improvements within the Coronation Park area. The study is intended to develop a comprehensive drainage improvements plan for the Coronation Park Community that will address current drainage concerns and develop an implementation plan for the management of flooding and erosion within the Coronation Park Community, generally located south of Rebecca Street and from the west side of Third Line to Fourteen Mile Creek in the east (ref. Drawing 1). The purpose of the assessment has also been to develop preferred solutions, to address existing drainage concerns, and identify potential storm water management solutions.

1.2 Description of Study Area and Problem Statement

The Coronation Park Community has a unique and special character in the Town of Oakville. A more mature and older neighbourhood, the community has predominantly residential uses with large lots, heavily landscaped and generally of a high quality and value. The area drainage system reflects the standards prevalent during the era of construction with mixed use of storm sewers, curbs or gutters, driveway culverts, and natural outlets for overland drainage (ref. Appendix 'B' for Site Reconnaissance photographs).

While this system has performed reasonably well over the years, several factors are converging which are driving the need for potential upgrades and modernization of the Coronation Park Community drainage system, with the following considered to be the most important factors in this regard:

- aging infrastructure
- emerging 'green' standards
- infill/intensification land uses
- climate change
- changing demographics
- risk management

The approach by Town staff to develop a fully integrated area-wide drainage assessment, is considered ideal, as the comprehensive context of a Class Environmental Assessment (Class EA) will allow for public and agency consultation and a detailed assessment of area problems and potential solutions.

A particular focus in this assessment has been to review and assess the proposed storm sewer trunk system first documented in the 1963 Report on Storm Sewers by J. M Tomlinson & Associates Ltd. The trunk sewer was proposed from the intersection of Hixon Street and Third Line south along Third Line, west along Lakeshore Road West, with additional sewers on Westminster Drive and Woodhaven Park Drive all draining to a single outlet at Lake Ontario within Coronation Park. One consideration of the assessment would include the potential reduction or elimination of frequent flows within the naturalized ditch system at the Sir John Colborne Recreation Centre for Seniors and the overland drainage system at Belvedere Drive and Coronation Park. Input from the public has been important in determining the nature of the local impacts to the overland drainage system south of Lakeshore Road West.

Existing drainage deficiencies such as soggy roadside ditches, prolonged standing water in roadside ditches, frequently clogged inlets, damaged or deteriorating driveway culverts, restricted overland drainage system flow capacity and local erosion sites have been assessed as part of the integrated hydrologic/ hydraulic assessment. Again input from the public has been vital in understanding all drainage concerns within the Coronation Park Community.

1.3 Class Environmental Assessment

The Ontario Environmental Assessment Act provides for "*…the betterment of the people of the whole or any part of Ontario by providing for the protection, conservation and wise management in Ontario of the environment*." An approved Class Environmental Assessment (Class EA) document describes the process that a proponent must follow for a class or group of undertakings in order to satisfy the requirements of the Environmental Assessment Act, and represents a method of obtaining an approval under the Environmental Assessment Act and provides an alternative to carrying out individual environmental assessments for each separate undertaking or project within the class.

The Coronation Park Drainage Improvements Class Environmental Assessment is considered to be essentially a Master Plan type project. Master Plans are one form of Class EA document representing long range plans which integrate infrastructure requirements for existing and future land use with environmental assessment planning principles. The following characteristics distinguish the Master Planning Process from other processes:

a) The scope of Master Plans is broad and usually includes an analysis of the system in order to outline a framework for future works and developments. Master Plans are not typically undertaken to address a site-specific problem.

b) Master Plans typically recommend a set of works which are distributed geographically throughout the study area and which are to be implemented over an extended period of time. Master Plans provide the context for the implementation of the specific projects which make up the plan and satisfy, as a minimum, Phases 1 and 2 of the Class EA process (ref. Figure 1.1). Notwithstanding that these works may be implemented as separate projects, collectively these works are part of a larger management system. Master Plan studies in essence conclude with a set of preferred alternatives and, therefore, by their nature, Master Plans will limit the scope of alternatives which can be considered at the implementation stage.

The Coronation Park Drainage Assessment has been prepared in accordance with the Municipal Engineers Association (MEA) Class Environmental (Class EA) procedures. The Master Plan has adopted *Approach #2* in the 2007 MEA Documentation for all Schedule B projects. *Approach # 2* involves the preparation of a Master Plan document at the conclusion of Phases 1 and 2 of the Municipal Class EA process. *Approach # 2* addresses Phases 1 and 2 of the Class EA process (ref. Figure 1.1). Under *Approach #2*, Schedule B projects which are implemented in accordance with the recommendations provided in this Master Plan would not require filing of a Project File for public review before the detailed design and implementation stages.

The Coronation Park Drainage Assessment Terms of Reference outlined a detailed task-based work plan with the following Parts:

Part 1: *Project Initiation (Problem Definition and Site Analysis)*
Part 2: *Development of Alternatives, Alternative Analysis and Preferred Alternatives*
Part 3 *Project File (Reporting)*

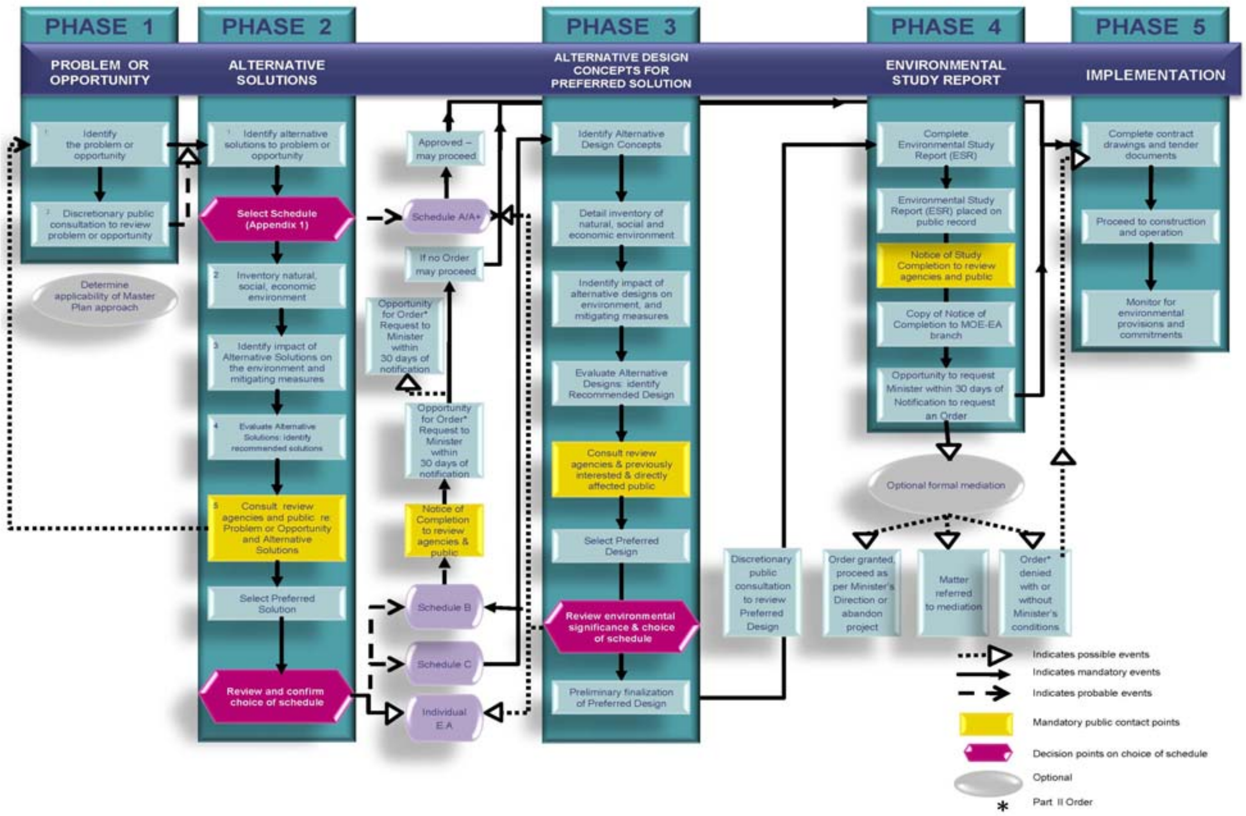

Figure 1.1: Municipal Class EA Process

1.4 Public/Agency Consultation

As noted the Coronation Park Drainage Assessment is subject to the Class EA process; as such it has been conducted according to the requirements outlined in the Municipal Class EA process. The study approach has been established to meet the following objectives:

i. Protection of the environment, including natural, social and economic components of the environment.
ii. Participation of a broad range of stakeholders in the study process to allow for sharing of ideas, education, testing of creative solutions and developing alternatives.
iii. Documentation of the study process in compliance with all phases of the Municipal Class EA process.

The Municipal Class EA requires notification of, and consultation with, relevant stakeholders. The Project Team has ensured that stakeholders were notified early in the planning process, and throughout the study. Notices of commencement, and notices of PIC No. 1 and PIC No. 2 were mailed directly out to residents within the study area, as well as published on the Town of Oakville's website.

Figure 1.1 illustrates a simplified version of the Municipal Class EA process for this project.

1.5 Schedule

The study was initiated in January 2014. Project milestones have been met as follows:

- January 9, 2014 - Start-up Meeting.
- April 16, 2014 - Completion of Part 1: Detailed Site Analysis and Alternative Review. A Baseline Report is prepared.
- April 17, 2014 - Meeting with Town of Oakville to present and review the Baseline Report
- May 22 and 29, 2014 – Notice of Study Commencement and PIC No. 1 published in the Oakville Beaver, as well as mailed out directly to residents within the study area.
- June 4, 2014 – PIC No. 1 held to present baseline characterization and long-list of alternatives, and obtain feedback from the public on local drainage issues.
- July 2, 2014 – Meeting with Town of Oakville to discuss comments received at PIC No. 1 and next steps in the project
- October 9, 2014 – Meeting with Town of Oakville to discuss the results of the preliminary alternative assessment.
- November 13, 2014 – Notice of PIC No. 2 published in the Oakville Beaver and mailed out directly to residents within the study area.
- November 26, 2014 – PIC No. 2 held to present the results of the completed alternative assessment.
- January 14, 2015 – Meeting with Town of Oakville to discuss the potential impact of the preferred alternative (and associated flow re-direction) on the eastern channel within Coronation Park.

PIC No. 1 was attended by 38 individuals, and PIC No. 2 was attended by 32 individuals based on the signed attendance register. It should be noted however that not all attendees may have signed in, although they were encouraged to do so.

A complete record of public consultation information has been included in Appendix D.

1.6 Project Organization

The development of this drainage assessment has been directed and reviewed by a Project Team, which has been comprised of representatives from various departments at the Town of Oakville and Conservation Halton. The Project Team has consisted of staff from the following organizations:

Proponent: Town of Oakville
Paul Allen, Manager – Design & Construction
Kasia Piskorz, Project Leader – Capital Projects

Consultant: Amec Foster Wheeler
Ron Scheckenberger, Project Advisor
Steve Chipps, Senior Project Manager
Matt Senior, Project Engineer
Danny Stone, Environmental Planner
Matthew Kuyntjes, System Modeller

1.7 Reporting Overview

This document represents the final report for the Coronation Park Drainage Assessment. This report describes the findings of the background information review and field reconnaissance, and outlines the analyses of the Town's drainage system under existing conditions. Details regarding the analyses completed, including field photographs, hydrologic/hydraulic models, and calculations are provided within the respective appendices. The report then summarizes the results of the completed alternative assessment process, and the selection of preferred alternatives. A summary of the recommended drainage system improvements is provided accordingly along with considerations for budgeting and prioritization. Appendix 'E' has been included as a minor update to Sections 7.3, 7.12 and 8.

2. BACKGROUND INFORMATION REVIEW AND DOCUMENTATION

2.1 Information Sources

Information sources have included the Town of Oakville, as well as Halton Region, and Conservation Halton.

2.1.1 Technical Drawings and Maps

The Town of Oakville and Halton Region have supplied reports, drawings and other documentation as per the following:

i. 2012 aerial photography for the study area
ii. Property fabric and easement locations
iii. Building mapping
iv. Road layers
v. Digital topographic coverage in the form of SHP files – contours (2012)
vi. Storm sewer layouts (including maintenance holes and catchbasins)
vii. Stream and ditch layers
viii. Downspout Connectivity Check Mapping (Town of Oakville)
ix. Legal survey of the Region of Halton Wastewater Treatment Plant property and Sedgewick Forest
x. Roadway and Utility Plan and Profile Drawings for selected roadways (Savoy Crescent, Sedgewick Crescent, Westminster Drive, and Woodhaven Park Drive) as provided by the Region of Halton
xi. Third Line Reconstruction Drawing Set – Contract R-441-08 (2008)
xii. Hush Homes – The Gardens at Coronation Drawing Set - Trafalgar Engineering Ltd. (2010)
xiii. Sir John Colborne Seniors Centre Drawing Set – G. O'Connor Consultants Ltd. (2012)

2.1.2 Topographic Survey

In order to address a number of pieces of missing information with respect to storm sewer inverts and pipe sizes, the Town of Oakville's survey crew undertook a topographic survey on January 30, 2014. Upon review of the collected data, Amec Foster Wheeler requested clarification on the drainage details in a number of the previously identified locations. The Town of Oakville's survey crew subsequently undertook a follow-up topographic survey, with the results being forward to Amec Foster Wheeler on March 4, 2014. This data has been incorporated into the hydraulic modelling of the Coronation Park area, as discussed in further detail in Section 4.

In addition to the Town's survey, Amec Foster Wheeler's survey crew was also deployed to collect topographic data on surface drainage features, including open channels, culverts, and roadside ditches. This data has been incorporated into the hydraulic modelling of the Coronation Park area, as discussed in further detail in Section 4.

Note that in both cases, topographic surveys were conducted over the winter period, thus survey crews were unable to collect some elevations (given snow and ice build-up). Appropriate assumptions have been made as required in these cases.

2.1.3 Models

No hydrologic or hydraulic models for the Coronation Park drainage area have been provided by the Town of Oakville.

2.1.4 Reports

The following relevant documents and reports have been reviewed:

- ***Storm Drainage Report, J. M. Tomlinson and Associates Limited, November 1963***

  This report addresses the proposed design and location of trunk sewers and outfalls for the portion of the Town of Oakville south of the QEW. This area was divided into a number of drainage areas in order to determine storm sewer sizing and outfalls, as well as preliminary costing. The Coronation area is included; drawings indicate a proposed storm sewer arrangement along Third Line, Westminster Drive, Woodhaven Park Drive, and ultimately Lakeshore Road. Sewer profiles are also provided which indicate expected depths and slopes; soil material is also indicated (predominantly sand, with sections of clay, till, and shale). Preliminary costing is indicated as $253,440 (1963 costs) for all of the proposed works.

- ***May 12/13, 2000 Storm Events – General Flooding and Damages, Town of Oakville (Staff Report), June 27, 2000***

  The staff report outlines observations with respect to the major storm events on May 12 and 13, 2000. The report suggests that the rain event was between a 25 to 50 year storm event, however that water levels and flows within creeks may have approached a 100-year storm event. The report noted that in general, the Town's creek systems and stormwater infrastructure operated well, however localized flooding (including basement flooding) was experienced in the area. A copy of a summary report from Conservation Halton is also included, which summarizes their observations on the storm events, including rainfall totals and observed water levels and flows within the Fourteen Mile Creek system.

  The Town of Oakville mapping provided as part of the staff report for the May 13, 2000 storm event indicates flooding along one property on Venetia Drive, three properties along Sedgewick Crescent, one property in the townhouse development along Woodside Drive, and one property along the south side of Lakeshore Road.

- ***2033 Lakeshore Road West – Drainage Easement (Staff Report), March 3, 2008***

  The staff report summarizes the history of the small watercourse which runs adjacent to the property at 2033 Lakeshore Road West, and some of the ongoing drainage issues at this location. In particular, the original retaining walls were noted to be failing, and the channel conveyance capacity was noted to be insufficient resulting in increased occurrences of nuisance flooding. It was noted that the property owner at that time had offered a drainage easement to the Town of Oakville over the section of watercourse through the property, so that the Town could become responsible for the ongoing maintenance of the watercourse. The staff report recommends that the Town accept the request for a drainage easement over the watercourse.

- ***Coronation Park – Halton Region Mid-Halton Outfall Project, Town of Oakville (Staff Report and associated background reports), June 19, 2012***

  The staff report and associated background material in this case summarizes the proposed expansion of the mid-Halton Waste Water Treatment Plan located within the Coronation Park area. As noted, Halton Region requires a new tunnel as part of this expansion along Third Line and ultimately through Coronation Park and out into Lake Ontario. A deep vertical shaft within Coronation Park will be required in order to access the primary tunnel excavation. The report states that the work was to have begun in late 2012 and last some 2-3 years; based on discussions with Town and Region staff however, it is understood that the work began in 2014 and is expected to last 3 years. Any works proposed within Coronation Park as part of the current study would need to consider the requirements of the Mid-Halton Outfall project.

- ***Storm Sewer Master Plan – Phase 1 Report, Amec Foster Wheeler, February 2015***

  This report has been primarily reviewed in order to obtain the collected storm sewer data for the study area (storm sewer rim elevations, pipe inverts, and pipe sizes obtained through Zoom Camera Inspection work conducted by AquaData).

2.2 Land Use

The existing land use within the Coronation Park area is primarily residential, with some institutional land use (schools, church, Sir John Colborne Seniors Centre), and parkland/forested areas (Thornlea Park, Woodhaven Park, Sedgewick Forest, and Coronation Park). Halton Region's wastewater treatment plant is also located within the Coronation Park area, below Sedgewick Forest. Drawing 1 provided an aerial overview of the study area.

Residential development in the Coronation Park area is generally older (approximately 1950s), and consists of single detached residences, with larger backyard areas, which are typically well vegetated (extensive tree coverage).

Based on discussions with Town of Oakville staff, it is understood that there has been little re-development pressure in the Coronation Park area, and there is not expected to be any significant infill and intensification. One recent infill development has been identified along Lakeshore Road (Hush Homes – The Gardens at Coronation), however Town staff have indicated that no other forthcoming large infill developments are expected. A number of individual infills have however been noted, with older residential properties being demolished and replaced with new larger homes.

2.3 Physiography and Soils

The surficial geology within the Coronation Park area is predominantly characterized by coarse-textured glaciolacustrine deposits (sand, gravel, minor silt and clay). Surficial soils data for the study area (as available from Agriculture Canada – Ontario Soil Survey Reports) is generally lacking; mapping for the study area indicates an urbanized land use and therefore does not provide more detailed information.

Given the limited surficial soils data, the Town of Oakville has provided three geotechnical reports within the study area (ref. Appendix 'A' for excerpts). One report was conducted in support of the reconstruction of Third Line, another for a proposed structure within Coronation Park. A third, more extensive report provides details of the geotechnical investigation conducted in support of the Mid-Halton WWTP Effluent Sewer and Outfall Project, with deep boreholes within Coronation Park and along Lakeshore Road and Third Line. The borehole logs for these reports predominantly indicate the presence of silty sand, as well as clayey silt and silty clay within the surficial soils. Weathered shale material (Queenston formation) was generally indicated at the base of the boreholes (note that much deeper excavation and rock coring was conducted in support of the Mid-Halton WWTP Effluent Sewer and Outfall Project).

Piezometers were not installed as part of the first two geotechnical investigation, so groundwater levels cannot be reliably determined. Both reports indicated that no groundwater table was encountered during or immediately after drilling, but that soils were found to be wet at various depths. Along Third line, wet sand was noted at depths ranging between 0.7 and 2.9 m below ground, while within Coronation Park, wet caving was noted at depths between 1.4 and 3.1 m below ground. In both cases, it was noted that groundwater tables fluctuate seasonally, and that the observed conditions may not reflective of long-term groundwater trends.

Piezometers were however installed at five borehole locations conducted as part of the geotechnical investigations for the Mid-Halton WWTP Effluent Sewer and Outfall Project. Reported piezometer readings taken approximately 3 months after drilling indicated groundwater at depths of between 1.8 and 9.9 m below ground; these piezometers were however noted to be quite deep, with the screens at much lower depths than those of the other two studies. It should be noted that artesian conditions (i.e. groundwater discharging freely to the surface) were noted at two other borehole locations, which suggests an elevated groundwater level in the area. In all cases, it was again noted that groundwater tables fluctuate seasonally and in response to precipitation, and that the observed conditions may not be reflective of long-term groundwater levels.

2.4 Water Quality

Based on a review of the available background information, it is understood that there is no formal stormwater quality treatment provided within the Coronation Park area (with the exception of an oil/grit separator provided for the recent infill development along Lakeshore Road). This is likely a reflection of the age of development, as residential development in the Coronation Park area would have been constructed well before requirements for stormwater quality treatment. It is considered that there is likely a degree of water quality treatment provided by the numerous ditches/grassed swales within the study area; however the degree of quality treatment has not been formally quantified.

3. STUDY AREA INVESTIGATION

Site investigations of the study area have been conducted as part of this study (ref. Appendix 'B'). Initial site visits to the drainage features and crossings occurred on November 21 and 22, 2013. It should be noted that these visits were conducted prior to the study commencement, and were completed in order to better understand the study area for the project proposal submission. The insight (and site photographs) gathered as part of this process is still considered to be valid however, and as such the results of these site visits have been included as part of this study. A subsequent site visit was also conducted on April 16, 2014 after the commencement of the study. These site visits were conducted in order to develop an understanding of the existing drainage systems, and assess erosion conditions at storm sewer outfalls and culverts (ref. Drawing 2).

No major erosion was noted as part of the site investigation, however minor erosion has been noted along numerous roadside ditches, primarily in the form of rutting. Likewise, no major erosion has been noted at observed storm outfall locations, although minor erosion has been noted in the majority of these locations (typically in the form of bank erosion).

Some flow obstructions were noted, primarily due to leaf accumulation (given the autumn conditions at the time of the site investigation). A significant man-made flow obstruction was noted at the downstream limits of the culvert crossing of Old Lakeshore Road, where a solid wooden fence is blocking the majority of the open channel (ref. Photo 21 on Drawing 2 and in Appendix 'B'). In addition, the outfall channel at Sedgewick Crescent was noted to have a reverse slope (ref. Photos 44 and 45 in Appendix 'B'), which would explain the heavy culvert sedimentation and ponding in this area. A large number of culverts were also noted to be obstructed, either due to sedimentation/debris, or due to culvert crushing.

Standing water was observed in numerous roadside ditch locations, as well as within the majority of the open channels within Coronation Park. Standing water within ditches is generally attributable to localized grading issues. Within the Coronation Park area, standing water is considered to be attributable to shallow ditch/channel grades and localized pools/depressions, as well as channel obstructions along the Lake Ontario shoreline, which prevent positive channel drainage.

A key observation from site investigation is the variety in roadway drainage types within the Coronation Park area. Within the study area, roadways sections are variously classified as:

- Urban (curb and gutter roadways with storm sewers)
- Semi-urban (ditched roadways with storm sewers)
- Rural (ditched roadways with no storm sewers)

Drawing 3 summarizes the locations of the different roadway drainage types graphically. As evident, the eastern portion of the study area is dominated by full rural drainage, whereas the western portion of the study area (Third Line) is dominated by full urban drainage, with some semi-urban drainage areas (storm sewers with rural road cross-sections).

Although it is understood through discussions with Town staff that future infill/intensification will be limited in the Coronation Park area, as part of the site reconnaissance, a significant number of new homes were noted to be recently constructed or currently under construction. In general, new homes are larger than older existing homes, which would in turn contribute additional runoff to local drainage systems.

4. DRAINAGE SYSTEM ASSESSMENT

To assess the existing drainage system within the Coronation Park area, a hydrologic model of the drainage system is required in order to develop information on the peak flows for various storm frequencies and in turn assess corresponding hydraulic conditions.

4.1 Hydrologic and Hydraulic Modelling

4.1.1 Model Selection

Hydrologic and hydraulic analyses of the Coronation Park area have been completed using PCSWMM modelling software.

PCSWMM combines hydrologic modelling (i.e. simulated storm runoff response from land areas), with hydraulic modelling (i.e. calculated water surface elevations and velocities within storm sewers, road surfaces, open watercourses, culverts). The integration of hydrologic and hydraulic analyses facilitates the evaluation of detention in ponding areas, backflow in pipes, surcharging of manholes, tailwater conditions (which may affect upstream storage and flow capacity within pipes), capacity at inlets to the sewer network (which would reduce the amount of runoff entering the sewer network and increase the amount of runoff conveyed overland during storm events), and depth of flooding of overland conveyance systems; these capabilities of the PCSWMM software make it particularly well-suited for analyzing urban drainage systems such as those within the Coronation Park area.

PCSWMM is capable of applying both Event Methodology for single storm events and continuous simulation of a long-term period or record of multiple storm events. For this assessment the Event Methodology using synthetic design storms has been used in order to evaluate flood frequency or risk. PCSWMM is capable of accounting for various conditions at outlets (i.e. open/unobstructed/free-flowing, partially/completely submerged to a constant depth, time-varying depth conditions, gated conditions). The hydraulic routing component within PCSWMM can be completed for unsteady state (i.e. time-varying flow) conditions using Kinematic Wave or Dynamic Wave routing techniques of the core St. Venant equations (which combine continuity and momentum equations to solve for 1-dimensional flow). The dynamic wave routing technique is the full solution of this set of equations, and is thus capable of accounting for complex hydraulic situations such as pressure and reverse flow. The kinematic wave routing technique is a simplified solution which is more appropriate for simplified flow conditions. Given the expected surcharging and complex hydraulics within the Coronation park area, dynamic wave routing has been applied in this case. The numerical stability of the PCSWMM platform allows for complex networks and systems to be readily modelled in the unsteady state condition, with little to no requirement for network simplification.

PCSWMM employs the EPA-SWMM computational engine as its base, thus modeling files created in PCSWMM can be opened and executed within the EPA-SWMM program as well as PCSWMM. This also provides an additional degree of reliability and quality assurance to the modeling program.

4.1.2 Modelling Data

PCSWMM requires the following input data for completing a coupled hydrologic and hydraulic analysis:

- Drainage areas and directly connected impervious coverages for the land segments contributing to the conveyance system of interest.
- Soils information (infiltration parameters) for the soils underlying the land segments, including initial abstraction/depression storage
- Surface slopes for the contributing drainage areas.
- Land use characteristics for both the pervious and impervious components of the land segments in order to establish the “roughness” of the surface.
- Length, size, and inverts of storm sewer networks.
- Material of the sewer network.
- Manhole rim elevations (can be based on topographic mapping)
- Cross-sections and elevations of the surface drainage system (i.e. roads).
- Locations of storm sewer inlets (catchbasins, ditch inlets)
- Elevation and surface area relationships for surface storage zones (i.e. channels or designated off-line storage areas).

The details for the Town’s storm drainage system have been obtained based upon the following information for the development of the models for the major-minor system:

- Storm sewer, culvert, maintenance hole, and catchbasin mapping
- Zoom Camera inspection data (from the Town of Oakville’s Storm Sewer Master Plan)
- Topographic survey data (both by the Town and Amec Foster Wheeler)
- Watercourse mapping
- Road mapping
- Property boundary mapping
- 1 m elevation contour data
- Aerial photography

A considerable effort has been spent as part of the model construction to ensure accurate modelling of the storm drainage system; this has necessitated multiple topographic surveys as noted previously, as well as review and implementation of the resulting data.

4.1.3 Storm Events

As noted, an event-based methodology has been selected for this study, through the application of synthetic design storms. Based on the Town of Oakville’s “Development Engineering Procedures and Guidelines”, the 24-hour Keifer and Chu (Chicago) design storm is specified, with a 10-minute time step, and a peaking factor (ratio of time of maximum intensity to storm duration) of 0.33. Rainfall intensity-duration-frequency (IDF) data is also specified, which is based on data from Environment Canada’s Toronto Bloor Street gauge.

The resulting 24-hour Chicago design storms have been applied for the current study. Copies of the resulting hyetographs are provided in Appendix ‘C’.

4.1.4 Hydrologic Parameters

Hydrologic parameters have been established on the basis of existing land use conditions; namely land use as evident on 2012 aerial photography (ref. Drawing 1) with localized updates as required (in particular the previously noted infill development along Lakeshore Road). As per discussions with Town of Oakville staff, no significant infill development is anticipated in the near future; accordingly no future land use or infill/intensification has been assessed.

A drainage area plan has been developed which indicates both subcatchment boundaries and larger catchment boundaries for the overall 162 ha area (ref. Drawing 4). The drainage area plan has been established by identifying locations where peak flows are required (typically road crossings), using the previously noted sources of information (primarily elevation contour data and property boundary mapping). Based on this process, a total of 111 subcatchments have been delineated, ranging in size from 0.11 ha to 6.37 ha.

With the development of drainage area boundaries, appropriate hydrologic modelling parameters (which represent the runoff potential of each individual subcatchment) are required. The following has been considered in determining the hydrologic modelling parameterization.

- Directly connected imperviousness (the value required by PCSWMM) has been calculated based on standard assumed values for different land uses. Total imperviousness has also been calculated in order to properly adjust depression storage and infiltration parameters.
- Imperviousness for existing residential land uses has been determined using measurements of lot coverage from the 2012 aerial photography.
- Slopes and overland flow lengths have been calculated using available contour mapping, property boundaries, and aerial photography
- Manning's roughness coefficients of 0.013 and 0.2 have been applied for impervious and pervious overland flow components respectively
- Base depression storage depths of 1 and 5 mm have been applied for impervious and pervious catchment portions respectively; the pervious depression storage has been adjusted as required to reflect the difference between total and directly connected impervious areas (since PCSWMM considers only directly connected imperviousness)
- The recommended default value of 25% has been applied for the zero depression storage imperviousness ratio (the portion of the impervious area with no depression storage)
- Infiltration has been simulated using the US SCS Curve Number methodology, with a base Curve Number of 68 applied for all completely pervious areas. This values has been adjusted as required to reflect the difference between total and directly connected impervious areas (since SWMM considers only directly connected imperviousness)

Subcatchment parameterization details are provided in Appendix 'C'.

Assumed values of imperviousness (both total and directly connected) for different land uses are summarized in Table 4.1.

Table 4.1: Summary of Assumed Imperviousness by Land Use		
Land Use	**Total Imperviousness (%)**	**Directly Connected Imperviousness (%)**
Open Space and Forested	0	0
Roadway (Curb & Gutter)	100	100
Roadway (Ditched)	100	0
Detached Residential (Curb & Gutter)	30	15
Detached Residential (Ditched)	30	0
Townhouse Residential	60	30
Commercial	90	90
Institutional	35	20

As evident from Table 4.1, both roadway and detached residential land uses have been separated by roadway type (curb and gutter or ditched) to reflect the differing drainage characteristics of each. Curb and gutter roadways would be expected to have 100% directly connected imperviousness, given the presence of curbs and catchbasins, whereas ditched roadways would drain to a grassed surface before eventually reaching a catchbasin or catchbasin manhole (and would thus have 0% directly connected imperviousness). Likewise, detached residences on curb and gutter roadways would expected to have connected driveways and some degree of downspout connection, which is reflected in the assumed 15% directly connected imperviousness. Detached residences on ditched roadways would have no continuous impervious pathway to the outlet, which is reflected in the assumed 0% directly connected imperviousness. In all cases, infiltration parameters (SCS Curve Numbers) for the pervious area have been areally-weighted to reflect the difference between total and directly connected imperviousness (i.e. the "pervious" area in PCSWMM includes both the full pervious area as well as the impervious area which is not directly connected).

Based on a review of the available surficial geology and geotechnical data, study area soils are a mixture of silty sand and clayey silt and silty clay. Given the mixture of highly pervious (sandy) and highly impervious (clay) soil types, a conservative SCS Soil Classification of BC has been assumed for the study area. Based on a review of available literature, a base Curve Number of 68 has been applied for fully pervious areas, which is representative of grassed surfaces in good condition (>75% grass coverage).

4.1.5 Hydraulic Parameters

Hydraulic links have been inputted into PCSWMM based on the following:

- Both the minor (storm sewers, culverts) and major systems (open channels, ditches roadways) have been modelled.
- Data for storm sewers and culverts has been entered directly into PCSWMM based on data collected through the Town of Oakville's Storm Sewer Master Plan, as well as supplementary data through topographic surveys
- Surcharge height has been added to hydraulic nodes as required to ensure no loss of flow under surcharge conditions
- Culvert overflow sections have been added as required to allow for spill should culverts become sufficiently surcharged; elevations have been estimated based on available data, and overflow widths have been approximated as 10 m

- Open channel sections have been entered based on results from the topographic survey, or where not available, elevation contour data and typical representative channel sections
- A roughness value of 0.013 has been applied for concrete and PVC sewers/culverts, and a value of 0.024 has been applied for CSP sewers/culverts.
- Conduit exit losses have been applied to account for the hydraulic losses associated with sharp bends. Head loss coefficients from Urban Drainage Design Manual, U.S. Department of Transportation, Publication No. FHWA-NH1-01-021 August 2011, Hydraulic Engineering Circular No. 22 (FHWA HEC-22) have been applied for this purpose.
- An average loss coefficient of 0.4 has been applied for open channel sections (watercourses), which reflects a combination of typical expansion and contraction losses
- Boundary conditions have been set based upon water levels within Lake Ontario; a fixed water surface elevation of 75.15 m, which represents the largest monthly average water level for both 2013 and 2014, and is slightly above the maximum monthly average water level based on long-term historic records as per the December 2013 Great Lakes Water Level Bulletin by the Canadian Hydrographic Service (ref. Appendix 'C'). Given recent lowering trends in water levels within the Great Lakes, and the significant discrepancy in drainage area between the study area and Lake Ontario, it is considered that the application of maximum recorded Lake Ontario water levels as a boundary condition would be overly conservative, and not representative of expected system operating conditions during formative events.
- As per Drawing 3, several different types of roadway sections have been modelled:
    - Urban (curb and gutter roadways with storm sewers)
    - Semi-urban (ditched roadways with storm sewers)
    - Rural (ditched roadways with no storm sewers)

  These sections have been modelled based on data from the topographic survey where available, or based on typical standards and assumed sections where such data is not available. For rural sections along both Westminster Drive and Woodhaven Park Drive, ditch sections have been modeled individually, with weir sections (assumed 10 m width) added to allow for overflow between sections should flows reach the roadway crown elevation.
- Inlet functions have been incorporated to represent the interaction between the minor and major systems through inlets (catchbasins, ditch inlet grates, etcetera). In order to ensure model stability under surcharge and reverse flow conditions, inlet functions have been modeled as orifices (bottom orifices for grates and covers, and side orifices for catchbasin leads). A summary sheet detailing the calculations has been included in Appendix 'C'. Calculations for catchbasin grates (including catchbasin manholes) have been based on an opening area of 0.125 m^2 per standard catchbasin (OPSD 400.110). This value has then been multiplied by the number of catchbasins being represented to determine the equivalent opening area for which a representative square orifice has been applied. Orifices representing catchbasin leads have been based on an equivalent opening area equal to an assumed 250 mm diameter pipe size per catchbasin (300 mm diameter pipe size for double catchbasins). Orifices representing manhole covers have been based on an assumed closed style cover (i.e. two pickholes), with a resulting opening area of 0.002 m^2.

4.1.6 Hydrologic Results

Hydrologic modelling has been conducted in PCSWMM for both the 5 and 100 year storm events based on the Town of Oakville's standard design storm distribution (24-hour Chicago design storm based on Toronto Bloor Street IDF data) as previously described. Table 4.2 presents the simulated results at nodes of interest for both the 5 and 100 year storm events. Simulated peak flows are presented, as well as the simulated runoff volumes. Refer to Appendix 'C' for drawings indicating the specific locations of junction nodes. Drawings 7-10 present the same information graphically.

Table 4.2: Simulated Peak Flows and Runoff Volumes at Nodes of Interest

Junction Node	Location	Catchment	Area (ha)	Peak Flow (m^3/s) for Specified Return Period (Years)[1]		Runoff Volume (m^3) for Specified Return Period (Years)[1]	
				5-Year	100-Year	5-Year	100-Year
1 (O_0160_4171)	MH – Third Line & Hixon Street	100	9.69	0.49 (0.09)	1.28 (0.51)	2,663 (163)	5,314 (701)
2 (O_0160_4175)	MH – Third Line & Venetia Drive	100	14.49	0.64 (0.11)	1.18 (0.34)	3,482 (372)	7,148 (1,080)
3 (O_0160_4180C)	MH – Third Line & Salvator Boulevard	100	21.46	0.30 (0.04)	0.95 (0.09)	1,835 (132)	3,915 (300)
4 (O_0160_4199)	MH – Third Line & Lakeshore Road	100	28.38	0.48 (0.16)	1.40 (0.38)	3,465 (371)	7,527 (703)
5 (O_0160_4200)	MH – Lakeshore Road just east of Third Line	100	28.38	0.51 (0.11)	1.51 (0.29)	3,635 (147)	7,834 (359)
6 (J30)	Pathway between Tracina Drive and Venetia Drive	100	1.97	0.09	0.40	455	1,146
7 (O_0160_3822)	MH – Tracina Drive Low Point and Confluence	100	5.77	0.32 (0.19)	0.37 (0.67)	1,246 (303)	2,448 (1,137)
8 (O_0160_3802)	MH – Venetia Drive Low Point and Confluence	100	24.97	1.18 (0.16)	2.29 (0.46)	6,718 (435)	13,900 (1,392)
9 (O_0160_3804)	MH – Lakeshore Road accepting flow from Venetia Drive	100	25.40	1.19 (0.04)	2.32 (0.08)	6,890 (118)	14,210 (302)
10 (J20)	Western Channel - Upstream Old Lakeshore Road Culverts	100	44.14	1.83	3.43	11,980	25,020
11 (J13)	Western Channel - Upstream Belvedere Drive Culvert	100	49.82	2.00	3.78	13,360	28,100
12 (O_0160_3840)	MH – Walby Drive & Shamrock Lane	100	7.32	0.28 (0.01)	0.85 (0.27)	1,823 (30)	3,764 (272)
13 (O_0160_3810)	MH – Walby Drive & Talbot Drive	100	11.65	0.45 (0.08)	1.21 (0.77)	2,927 (472)	5,711 (1,602)
14 (O_0160_3806)	MH – Walby Drive & Venetia Drive	100	15.90	0.62 (0.07)	1.62 (0.32)	3,993 (431)	8,616 (1,157)
15 (O_0160_3807)	MH – Lakeshore Road accepting flow from Walby Drive	100	16.83	0.62 (0.05)	1.63 (0.15)	4,079 (257)	8,749 (535)
16 (O_0130_314)	Western Channel - Pipe Outlet from Walby Drive	100	22.19	0.70	2.02 (0.43)	5,205	11,500 (2,305)

Table 4.2: Simulated Peak Flows and Runoff Volumes at Nodes of Interest

Junction Node	Location	Catchment	Area (ha)	Peak Flow (m^3/s) for Specified Return Period (Years)[1]		Runoff Volume (m^3) for Specified Return Period (Years)[1]	
				5-Year	100-Year	5-Year	100-Year
17 (J11)	Western Channel Flow Confluence – Upstream end of Coronation Park	100	73.99	2.43	5.60	19,010	40,490
18 (OF_100)	Western Channel Outlet to Lake Ontario	100	73.99	2.37	5.60	19,040	40,580
19 (J62)	Westminster Drive - Upstream Viewbank Crescent Culvert (North)	200	4.40	0.08	0.18 (0.16)	743.5	1,535 (199)
20 (J7)	Westminster Drive - Upstream Viewbank Crescent Culvert (South)	200	6.83	0.08 (0.05)	0.09 (0.46)	1,091 (97)	1,632 (1,060)
21 (J5)	Westminster Drive - Upstream Warland Road Culvert	200	2.16	0.09	0.27	548	1,189
22 (J3)	Westminster Drive - Upstream Trenton Road Culvert	200	2.79	0.11	0.24 (0.14)	711.3	1,400 (136)
23 (O_0160_4198)	MH – Westminster Drive & Lakeshore Road	200	13.41	0.36 (0.36)	0.38 (1.19)	3,192 (265)	4,936 (2,231)
24 (J1)	Eastern Channel - Upstream of Coronation Park Parking Lot Culvert	200	17.23	0.38	0.22 (1.48)	3,766	4,730 (3,890)
25 (OF_200)	Eastern Channel Outlet to Lake Ontario	200	17.23	0.39	1.58	3,769	8,582
26 (J68)	Woodhaven Park Drive - Upstream of Selgrove Crescent Culvert	300	1.76	0.07	0.23 (0.05)	437.2	933 (22)
27 (O_0160_3764)	MH – Woodhaven Park Drive & Selgrove Crescent	300	5.84	0.23	0.51	1,459	2,706
28 (O_0120_10233)	CB – Upstream Lakeshore Culvert at WWTP	300	13.50	0.29 (0.04)	0.56 (0.18)	2,924 (230)	6,647 (737)
29 (OF_300)	600 mm Diameter Storm Sewer at Eastern Limits of Coronation Park	300	14.80	0.32 (0.01)	0.48 (0.14)	3,157 (67)	6,828 (507)
30 (O_0160_3837A)	MH – Dog-leg of Willowdown Road	400	4.04	0.36 (0.11)	0.83 (0.45)	1,308 (106)	2,481 (467)
31 (O_0200_400162U) S	Upstream Woodhaven Park Drive Culvert near Hixon Street	400	9.91	0.56	0.74 (0.68)	2,758	4,933 (763)
32 (O_0200_400663U) S	CB – Hixon Street Culvert (east of Woodhaven Park drive)	400	19.09	0.79 (0.09)	1.87 (0.34)	5044 (630)	10,590 (1,365)

Table 4.2: Simulated Peak Flows and Runoff Volumes at Nodes of Interest

Junction Node	Location	Catchment	Area (ha)	Peak Flow (m^3/s) for Specified Return Period (Years)[1]		Runoff Volume (m^3) for Specified Return Period (Years)[1]	
				5-Year	100-Year	5-Year	100-Year
33 (O_0160_4079)	MH – Sedgewick Crescent outlet to park	400	6.26	0.41 (0.16)	0.84 (0.37)	1,961 (64)	3,624 (1,343)
34 (O_0160_3917)	MH – Sandwell Drive outlet towards WWTP	400	12.57	0.47 (0.06)	1.4 (0.89)	3,095 (315)	6,524 (1,566)
35 (O_0200_401341U) S	Upstream Lakeshore Road Culvert west of Sandwell Drive	400	48.68	1.61	4.74	12,200	26,200
36 (OF_400)	Open Channel near 1306 Lakeshore Road	400	49.88	1.66	4.86	12,540	26,900

1. Where applicable, first value represents minor system (storm sewer/culvert), second value in brackets represents major system (roadway/ditch)

The results in Table 4.2 have been validated using unitary peak flow rates from other area watersheds, as described in Table 4.3. The unitary peak flow rates at Lake Ontario from the current modelling have been selected for comparison to unitary peak flow rates from area watersheds.

Table 4.3: Watercourse Unitary Peak Flow Comparison (Event Based)

Land Use	Location	Area (ha)	5 Year ($m^3/s/ha$)	100 Year ($m^3/s/ha$)
Coronation Park				
Urban	Western Channel in Coronation Park (100 Series Subcatchments)	73.99	0.032	0.076
Urban	Eastern Channel in Coronation Park (200 Series Subcatchments)	17.23	0.023	0.091
Urban	600 mm Diameter Storm Sewer at Eastern Limits of Coronation Park (300 Series Subcatchments)	14.80	0.022	0.042
Urban	Open Channel near 1306 Lakeshore Road (400 Series Subcatchments)	49.88	0.033	0.098
Area Watersheds				
Urban	Aldershot	NA	0.037	0.120
Rural	North Waterdown	466.9	0.011	0.023
Urban	Indian Creek Milton	NA	0.027	0.073
Rural	Indian Creek Burlington at King (Updated Model)	165.11	0.020	0.041
Urban	Humber Watershed Average Urban Catchment	117.79	0.057	0.103
Mixed	Falcon Creek at Lake	379.1	0.028	0.062

Based on the results presented in Table 4.3 unitary peak flows for the 5 and 100 year storm events are considered to be acceptable when compared to unitary peak flows from other urban areas.

4.1.7 Hydraulic Systems Assessment

Hydrologic/hydraulic analyses have been completed in order to determine the performance of the minor (storm sewer and culvert) and major (roadway, ditch, and open channel) drainage systems within the Coronation Park area. The minor system has been evaluated based upon simulated incidences of flooding and surcharging during the 5 year and 100 year storm events, with particular emphasis upon the occurrence of flooding during the former. The minor/major system model has been used for this assessment, using an event methodology as described previously.

Simulated results under existing (2014) land use conditions for selected conduits are presented in Table 4.4 by indicating whether a storm sewer has no surcharging, surcharges or floods (surcharges to the surface). The hydraulic results with respect to depth capacity have also been presented graphically on Drawings 7 and 9. Table 4.4 provides an indication of the storm sewer flow capacity (based on full flow calculated using Manning's equation) versus the simulated peak flows via the $Q_{peak}/Q_{capacity}$ column. Some of the sewers have been noted as surcharged in Table 4.4 even though the storm sewer capacity is above the peak flow; in these cases surcharging is considered to be attributable to the influence of tailwater conditions and energy losses (due to bends, expansion/contraction, etcetera). Refer to Appendix 'C' for drawings indicating the specific locations of conduits of interest.

Table 4.4: Simulated Minor System Performance (Storm Sewers and Culverts) at Locations of Interest

Conduit	Location	Diameter (mm)	5 Year		100 Year	
			$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance
1 (O_0200_7419)	Hixon Street – West of Third Line	675	0.39	Unsurcharged	1.23	Surcharged
2 (O_0200_400485)	Hixon Street – East of Third Line	600	0.28	Unsurcharged	1.10	Flooded
3 (O_0200_6139)	Third Line – South of Hixon Street	900	0.37	Unsurcharged	0.98	Flooded
4 (O_0200_6141)	Third Line – North of Venetia Drive	900	0.56	Unsurcharged	1.25	Flooded
5 (O_0200_6142)	Venetia Drive – East of Third Line	750	0.55	Unsurcharged	1.14	Surcharged
6 (C82)	Salvator Boulevard – West of Third Line	750	0.36	Unsurcharged	1.12	Surcharged
7 (C81)	Third Line – South of Salvator Boulevard	750	0.38	Unsurcharged	1.18	Surcharged
8 (C33)	Third Line – North of Lakeshore Road	750	0.28	Unsurcharged	0.85	Surcharged
9 (O_0200_400581)	Lakeshore Road – West of Third Line	900	0.10	Unsurcharged	0.31	Surcharged
10 (C36)	Lakeshore Road – East of Third Line	900	0.26	Unsurcharged	0.77	Flooded
11 (O_0200_400175)	Crossing Lakeshore Road – Just East of Third Line	900	0.55	Unsurcharged	1.60	Flooded
12 (C35)	Pathway between Tracina Drive and Venetia Drive	300 (estimated)	0.81	Surcharged	1.07	Flooded
13 (C91)	Tracina Drive Low Point and Confluence	450	1.03	Surcharged	1.41	Flooded
14 (C89)	Venetia Drive Low Point and Confluence	1200	0.25	Unsurcharged	0.42	Surcharged
15 (O_0200_6143)	Venetia Drive Low Point and Confluence	1200	0.99	Unsurcharged	1.94	Flooded

Table 4.4: Simulated Minor System Performance (Storm Sewers and Culverts) at Locations of Interest

Conduit	Location	Diameter (mm)	5 Year		100 Year	
			$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance
16 (O_0200_6144)	Crossing Lakeshore Road – accepting flow from Venetia Drive	1.2m X 1m Box	0.55	Unsurcharged	1.08	Flooded
17 (C54)	Old Lakeshore Road Culverts	1.7m X 1m Arch	0.66	Unsurcharged	1.13	Unsurcharged
18 (C55)	Old Lakeshore Road Culverts	1.8m X 1.2m Arch	0.91	Unsurcharged	1.92	Unsurcharged
19 (C51)	Belvedere Drive Culvert	1.7m X 1m Arch	0.64	Unsurcharged	0.85	Flooded
20 (O_0200_5845)	Walby Drive – South of Shamrock Lane	600	2.67	Unsurcharged	8.47	Flooded
21 (O_0200_5820)	Walby Drive – North of Talbot Drive	675	0.40	Unsurcharged	1.01	Flooded
22 (O_0200_5821)	Walby Drive – South of Talbot Drive	675	0.46	Unsurcharged	1.25	Flooded
23 (O_0200_5823)	Walby Drive & Venetia Drive	900	0.47	Unsurcharged	1.14	Surcharged
24 (O_0200_5824)	Walby Drive & Venetia Drive	900	0.49	Unsurcharged	1.29	Surcharged
25 (O_0200_1)	Crossing Lakeshore Road – accepting flow from Walby Drive	900	0.62	Unsurcharged	1.61	Flooded
26 (C17)	Westminster Drive - Viewbank Crescent Culvert (North)	450 (estimated)	0.42	Unsurcharged	0.94	Flooded
27 (C45)	Westminster Drive - Viewbank Crescent Culvert (South)	350	1.01	Unsurcharged	1.10	Flooded
28 (C43)	Westminster Drive - Warland Road Culvert	550	0.26	Unsurcharged	0.83	Unsurcharged
29 (C41)	Westminster Drive - Trenton Road Culvert	600	0.39	Unsurcharged	0.86	Flooded
30 (O_0200_6228)	Crossing Lakeshore Road - accepting flow from Westminster Drive	400 (possibly 600)	3.29	Flooded	3.57	Flooded
31 (C38)	East Channel - Coronation Park Parking Lot Culvert	500	1.15	Unsurcharged	1.33	Flooded
32 (C22)	Woodhaven Park Drive - Selgrove Crescent Culvert	450 (estimated)	0.27	Unsurcharged	0.85	Unsurcharged
33 (C68)	Culvert Crossing of Woodhaven Park Drive at Selgrove Crescent	675	0.29	Unsurcharged	0.63	Flooded
34 (C10)	WWTP Property (accepting flow from Woodhaven Park Drive)	300 (estimated)	4.53	Surcharged	5.36	Flooded
35 (O_0200_6233)	Crossing Lakeshore Road – accepting flow from Woodhaven Park Drive	600	1.24	Unsurcharged	2.36	Flooded
36 (O_0200_6232)	600 mm Diameter Storm Sewer at Eastern Limits of Coronation Park	600	0.97	Unsurcharged	1.47	Unsurcharged
37 (PO_0160_3837)	Willowdown Road – West of MH within Dog-leg	675	0.44	Unsurcharged	0.82	Unsurcharged
38 (O_0200_6136)	Willowdown Road – East of MH within Dog-leg	1.6m X 1m Elliptical	0.11	Unsurcharged	0.26	Unsurcharged

Table 4.4: Simulated Minor System Performance (Storm Sewers and Culverts) at Locations of Interest

Conduit	Location	Diameter (mm)	5 Year		100 Year	
			$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance
39 (O_0200_400162)	Woodhaven Park Drive Culvert between Hixon Street and Sedgewick Crescent	1.5m X 0.7m Elliptical	0.69	Unsurcharged	0.94	Flooded
40 (O_0200_400663)	Hixon Street Culvert (east of Woodhaven Park drive)	1000	0.29	Unsurcharged	0.69	Unsurcharged
41 (O_0200_6035)	Sedgewick Crescent – East of Woodside Drive	675	0.96	Unsurcharged	1.92	Unsurcharged
42 (C31)	Sedgewick Crescent outlet to park	675	1.32	Unsurcharged	2.33	Unsurcharged
43 (O_0200_5909)	Sandwell Drive (southernmost pipe)	900	0.17	Unsurcharged	0.33	Unsurcharged
44 (C75)	Sandwell Drive westward pipe towards WWTP	750	0.37	Unsurcharged	1.09	Surcharged
45 (O_0200_401341)	Crossing Lakeshore Road - west of Sandwell Drive	1.84m X 1.22m Box	0.15	Unsurcharged	0.43	Unsurcharged

Based on the results presented in Table 4.4, the majority of the selected conduits would be expected to remain unsurcharged during a 5 year storm, suggesting that in general, the minor drainage system would be effective under a 5 year event (not accounting for debris blockages or other factors not represented in the modelling). The exceptions to this would be:

- Culvert beneath pathway between Tracina Drive and Venetia Drive – indicated as surcharging
- Storm sewer between Tracina Drive and Venetia Drive – indicated as surcharging
- Culvert crossing of Lakeshore Road from Westminster Drive – indicated as flooding
- Culvert/storm sewer inlet at WWTP property from Woodhaven Park Drive – indicated as surcharging

By contrast under the 100 year storm event, the majority of the selected conduits would be expected to be flooded or surcharged, which is consistent with the expected performance of the minor system under such a formative storm event. Conduits which indicate unsurcharged conditions are typically culverts rather than storm sewers, which are usually designed to a higher standard by conveying at least the 10 year storm event.

The results of the PCSWMM hydrologic/hydraulic analyses for major overland flow have been reviewed in order to identify the incidences of flooding of the major system during severe storm events. The overland system consists of roadways, ditches, open channels, overland drainage routes through residential lots at roadway sags, and drainage easements in rear yards. Current practice for major drainage systems is to provide for safe and positive conveyance of flows, either within road right-of-ways or if possible within publically owned overland drainage systems. The Coronation Park area has a number of locations where the flood depths are considered problematic.

The depth of flooding within major system conduits has been determined for the both the 5 and 100 year storms and summarized within Table 4.5. In order to provide a consistent basis of comparison, the results in Table 4.5 have been restricted to roadway sections (both urban and rural types). Within rural roadway types, flows would be conveyed by roadside ditches, before being captured either locally by catchbasin manholes (on semi-urban streets) or by inlets/culverts at the downstream limits (for fully rural streets). For fully urban streets, flows would be conveyed by the roadway directly from the lowest elevation in the gutter. Summarized results present both maximum depths for key locations of interest, as well as a qualitative assessment with respect to whether or not simulated depths exceed the roadway crown. Major system performance with respect to depth capacity is also illustrated graphically in Drawings 8 and 10 (for the 5 Year and 100 Year storms respectively). Refer to Appendix 'C' for drawings indicating the specific locations of conduits of interest.

Table 4.5: Simulated Major System Performance (Roadways) at locations of interest

Conduit	Location	Type	5 Year		100 Year	
			Maximum Average Depth (m)	Performance	Maximum Average Depth (m)	Performance
46 (O_0200_7419-S)	Hixon Street – West of Third Line	Urban	0.02	Below Crown	0.10	Above Crown
47 (O_0200_400485-S)	Hixon Street – East of Third Line	Rural	0.02	Within Ditch	0.16	Within Ditch
48 (O_0200_4)	Third Line – South of Hixon Street	Urban	0.03	Below Crown	0.08	Below Crown
49 (O_0200_6141-S)	Third Line – North of Venetia Drive	Urban	0.05	Below Crown	0.15	Above Crown
50 (O_0200_6142-S)	Venetia Drive – East of Third Line	Urban	0.05	Below Crown	0.07	Below Crown
51 (C82-S)	Salvator Boulevard – West of Third Line	Rural	0.02	Within Ditch	0.03	Within Ditch
52 (C81-S)	Third Line – South of Salvator Boulevard	Urban	0.03	Below Crown	0.05	Below Crown
53 (C33-S)	Third Line – North of Lakeshore Road	Urban	0.03	Below Crown	0.05	Below Crown
54 (C63)	Lakeshore Road – West of Third Line	Rural	0.23	Within Ditch	0.97	Within Ditch
55 (C36-S)	Lakeshore Road – East of Third Line	Urban	0.07	Below Crown	0.11	Below Crown
56 (O_0200_5832-S &)	Tracina Drive Low Point and Confluence	Urban	0.09	Above Crown	0.49	Above Crown
57 (C89-S)	Venetia Drive Low Point and Confluence	Urban	0.11	Below Crown	0.23	Above Crown
58 (O_0200_5845-S)	Walby Drive – South of Shamrock Lane	Rural	0.05	Within Ditch	0.26	Within Ditch
59 (O_0200_5820-S)	Walby Drive – North of Talbot Drive	Rural	0.03	Within Ditch	0.37	Exceeded Ditch / Below Crown
60 (O_0200_5821-S)	Walby Drive – South of Talbot Drive	Rural	0.06	Within Ditch	0.39	Exceeded Ditch / Below Crown
61 (O_0200_5823-S)	Walby Drive & Venetia Drive	Rural	0.06	Within Ditch	0.39	Exceeded Ditch / Below Crown
62 (C18)	Westminster Drive – Between Viewbank Crescent Culverts	Rural	0.32	Within Ditch	0.44	Within Ditch

Table 4.5: Simulated Major System Performance (Roadways) at locations of interest

Conduit	Location	Type	5 Year		100 Year	
			Maximum Average Depth (m)	Performance	Maximum Average Depth (m)	Performance
63 (C46)	Westminster Drive – South of Viewbank Crescent	Rural	0.34	Within Ditch	0.56	Within Ditch
64 (C15)	Westminster Drive - North of Warland Road Culvert	Rural	0.10	Within Ditch	0.38	Within Ditch
65 (C44)	Westminster Drive - Between Warland Road and Trenton Road Culverts	Rural	0.25	Within Ditch	0.44	Exceeded Ditch / Below Crown
66 (C13)	Westminster Drive - South of Trenton Road Culvert	Rural	0.42	Within Ditch	0.61	Within Ditch
67 (C28)	Woodhaven Park Drive - South of Selgrove Crescent Culvert	Rural	0.16	Within Ditch	0.36	Exceeded Ditch / Below Crown
68 (PO_0160 _3837-S)	Willowdown Road – West of MH within Dog-leg	Urban	0.07	Below Crown	0.12	Above Crown
69 (C3)	Willowdown Road – East of MH within Dog-leg	Rural	0.23	Within Ditch	0.29	Within Ditch
70 (O_0200_6 035-S)	Sedgewick Crescent – East of Woodside Drive	Rural/ Urban	0.11	Within Ditch	0.17	Within Ditch
71 (O_0200_5 909-S)	Sandwell Drive outlet towards WWTP	Rural	0.07	Within Ditch	0.32	Exceeded Ditch / Below Crown

Based on the results in Table 4.5, under a 5 year storm event the selected sections of roadway would all expected to contain flow within the ditch (rural sections) or below the roadway crown (urban sections), with the exception of one section of roadway along Tracina Drive (which has an extremely nominal exceedance of the crown height). These results are generally consistent with those presented within Table 4.4 for the minor system, which indicated acceptable system performance for the 5 year storm event.

Under a 100 year storm event, the selected sections of roadway would be expected to have variable performance, with a number of rural roadway sections indicating depths in excess of ditch capacity, but below roadway crowns. Although these results suggest that roadway ingress/egress would not be affected, there may still be the potential for spill towards private property, given that in many cases property lines are below roadway crown elevations. With respect to urban roadway sections, multiple sections would be anticipated to have flow depths in excess of the roadway crowns. Those locations with the highest simulated flow depths appear to be at roadway sag points, which is to be expected given the tendency for localized ponding in these areas.

In general, those sections of roadway which display the highest simulated overland flooding depths for the 100 year storm event include:

- Third Line (Urban) – sag point north of Venetia Drive
- Tracina Drive (Urban) – sag point west of Walby Drive
- Venetia Drive (Urban) – sag point west of Walby Drive
- Walby Drive (Semi-Urban) – flows exceeding ditch capacity but below crown
- Westminster Drive (Rural) – high simulated depths but contained in ditch based on survey data

With respect to open channel sections (i.e. other open channels beyond roadway ditches), it is considered that presented results should be restricted to those sections for which a topographic survey has been conducted. For other open channel sections, the precise form and extents of the channel have been approximated based on standard sections (which in turn have been based on topographic data, site visits and other sources of data) to allow for hydrologic flow routing. Given these assumptions, it is considered that hydraulic modelling results for these specific conduits (i.e. depth and extents of flow) are approximate and would require more detailed site data (i.e. topographic survey) to confirm. Table 4.6 presents simulated modelling results for selected open channel sections for which topographic survey is available. Results are presented for both the 5 year and 100 year storm events with respect to maximum depth and whether or not the surveyed channel extents (typically a 10 m +\- width) are exceeded on either bank. Refer to Appendix 'C' for drawings indicating the specific locations of conduits of interest.

Table 4.6: Simulated Major System Performance (Surveyed Open Channels) at Locations of Interest

Conduit	Location	5 Year		100 Year	
		Maximum Average Depth (m)	Performance	Maximum Average Depth (m)	Performance
72 (C56)	Western Channel - Upstream Old Lakeshore Road Culverts	0.75	Exceeded Ditch	1.43	Exceeded Ditch
73 (C67)	Western Channel - Upstream Belvedere Drive Culvert	0.61	Exceeded Ditch	1.30	Exceeded Ditch
74 (C49_1)	Western Channel - Flow Confluence – South-westerly upstream end of Coronation Park	1.13	Exceeded Ditch	2.46	Exceeded Ditch
75 (C49_2)	Western Channel Outlet to Lake Ontario	0.92	Exceeded Ditch	1.88	Exceeded Ditch
76 (C59)	Eastern Channel - Upstream of Coronation Park Parking Lot Culvert	0.64	Exceeded Ditch	0.86	Exceeded Ditch
77 (C40_1)	Eastern Channel - Downstream of Coronation Park Parking Lot Culvert	0.29	Exceeded Ditch	0.57	Exceeded Ditch
78 (C40_2)	Easter Channel Outlet to Lake Ontario	0.21	Within Ditch	0.34	Exceeded Ditch
79 (C6_2)	Open Channel upstream of Woodhaven Park Drive Culvert near Hixon Street	0.50	Exceeded Ditch	0.73	Exceeded Ditch
80 (C7_1)	Open Channel downstream of Woodhaven Park Drive Culvert near Hixon Street	0.48	Within Ditch	0.72	Exceeded Ditch
81 (C9_7)	Open Channel Flow Confluence – Sedgewick Forest North of WWTP	0.63	Exceeded Ditch	0.78	Exceeded Ditch

Table 4.6: Simulated Major System Performance (Surveyed Open Channels) at Locations of Interest					
Conduit	Location	5 Year		100 Year	
		Maximum Average Depth (m)	Performance	Maximum Average Depth (m)	Performance
82 (C21)	Open Channel upstream of Lakeshore Road Culvert west of Sandwell Drive	0.48	Within Ditch	0.98	Within Ditch
83 (C29)	Open Channel downstream of Lakeshore Road Culvert west of Sandwell Drive	0.57	Within Ditch	0.91	Within Ditch

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Based on the results in Table 4.6, open channel sections would generally be expected to exceed channel banks for both the 5 year and 100 year storm events. The majority of the considered locations are located within public property (such as Coronation Park), thus the impact of channel exceedances in these areas would be less significant; however more detailed topographic survey would be required to definitively assess the impact of specific channel exceedances.

4.1.8 Erosion Risk Assessment

As per the Terms of Reference, it is understood that the Town of Oakville is concerned with respect to the potential for erosion due to storm outfalls both to private property as well as to the open channels within Coronation Park (refer to Drawing 5).

Site visits were conducted on November 21 and 22, 2013, as well as April 16, 2014 (as detailed in Section 3) in order to better characterize erosion conditions. A photographic reconnaissance of these sites has been prepared (ref. Appendix 'B' and Drawing 2) where access was possible (for storm outfalls in particular). Table 4.7 summarizes the erosion observations at storm outfalls by location. Erosion has been noted as *minor, moderate* or *significant* based on severity.

Table 4.7: Observed Erosion at Storm Outfalls			
Location	Erosion Level	Comment	Photo Reference #
900 mm diameter CSP at Lakeshore/Third Line	Minor	Minor erosion noted (rutting)	23
1.0 x 1.2 m concrete box culvert at Lakeshore Road	Minor	Minor erosion – bare slopes	25
Western channel within Coronation Park	Moderate	Moderate erosion – west bank undercutting at bend	8
600 mm diameter CSP from Woodhaven Park Drive at WWTP	Minor	Minor bank erosion/bare slopes on south-west bank	72
1.7 m x 0.9 m CSP arch storm sewer outfall at Willowdown Road	Minor	Minor bank erosion along south-west bank	31
Channel crossing of Woodhaven Park Drive	Minor	Minor bank erosion on both upstream and downstream sides	37, 34
Ditch downstream of Sedgewick Crescent	Minor	Minor erosion immediately downstream of driveway culvert	35
Ditch just east of 675 mm diameter concrete storm outfall to Sedgewick Forest	Moderate	Ditch erosion; more heavily eroded section immediately upstream of storm outfall	43,44
Open channel behind Hixon Street	Minor	Minor bank erosion immediately downstream of concrete channel, some additional bank	53, 54, 55

Table 4.7: Observed Erosion at Storm Outfalls			
Location	**Erosion Level**	**Comment**	**Photo Reference #**
		erosion further downstream	
750 mm diameter concrete storm outfall off of Sandwell Drive	Minor	Minor bank erosion immediately downstream of outfall	79
Upstream face of 1.8 m x 1.25 m concrete box culvert crossing of Lakeshore Road	Moderate	Moderate bank erosion at channel bend immediately upstream of culvert crossing	75

Based on the reconnaissance and the summary provided in Table 4.7, identified erosion issues are all considered to be minor and moderate. No major/significant erosion issues were noted. Typical erosion issues related to minor bank erosion and un-vegetated channel slopes.

The observed erosion could be addressed using various techniques such as bio-engineered slope protection, traditional bank lining and minor drainage feature realignments.

4.1.9 Storm Water Quality Assessment

Water quality within the Coronation Park watershed is generally conceded to be degraded from past urbanization, as noted in Section 2.4. As noted previously, there is no formal stormwater quality treatment provided within the Coronation Park area (with the exception of an oil/grit separator provided for the recent infill development along Lakeshore Road). As noted, this is likely a reflection of the age of development, as residential development in the Coronation Park area would have been constructed well before the MOECC's requirements for stormwater quality treatment.

It is considered that there is likely a degree of water quality treatment provided by the numerous ditches/grassed swales within the study area, however the degree of quality control provided is likely limited based on current MOE criteria, which typically recommends contributing drainage areas of < 2 ha (which would only be the case for the most upstream areas of the Coronation Park drainage system). The lack of plantings (grassed cover, likely mowed regularly by residents) and narrow bottom width would also be detrimental to promoting water quality treatment. Longitudinal ditch slopes are generally in the range of 0.5 – 2.0% in the Coronation park area, which would offer some benefit in settling (as compared to steeper grades). Based on a review of delineated drainage boundaries, a total of approximately 102 ha +\- drains via solely roadside ditches (i.e. rural roadways; does not include semi-urban roadways as these would have a shorter flowpath due to the presence of regularly spaced catchbasin manholes). Of this 102 ha +\-, only 52 ha +\- would be considered to have the potential to be considered for formal quality treatment recognition, given the previously noted MOECC criteria of < 2 ha.

Retrofit opportunities to provide water quality treatment within the Coronation Park area could be considered as part of the subsequent alternative assessment process. Based on the Town of Oakville's Development Engineering Procedures and Guidelines, no specific water quality target is specified; reference is made to local subwatershed studies and criteria specified by Conservation Halton. Given that the Coronation Park area drains directly to Lake Ontario (and not to an identified watercourse), typically applied water quality standards for other local municipalities require a minimum average annual total suspended solids (TSS) removal rate of 70% (MOECC Level 2 – Normal) for new developments. However, retrofit opportunities need not necessarily be designed to current standards; retrofit water quality targets could be set based on practical limitations in order to determine the highest feasible level of water quality treatment.

Notwithstanding, in order to better assess retrofit feasibility as part of the alternative assessment process, required treatment volumes for typical end of pipe stormwater management facilities (wet ponds) have been calculated. Water quality volumes to achieve Level 2 (Normal) treatment for each of the catchment areas (as shown on Drawing 4) are presented in Table 4.8.

Table 4.8: End-of-pipe Stormwater Quality Treatment Requirements to Meet Normal (Level 2) Water Quality Standard

Catchment	Area (ha)	Estimated Imperviousness (%)	Total Storage Volume (m^3)[1]	Permanent Pool Volume (m^3)	Extended Detention Volume (m^3)
100	74.0	35.1	6,660	3,700	2,960
200	17.2	26.4	1,548	860	688
300	14.8	25.1	1,332	740	592
400	49.9	34.0	4,491	2,495	1,996

1. Calculated using a minimum of 35% imperviousness

As per Table 4.8, treatment volumes would range between 1,332 m^3 and 6,660 m^3 for the four main catchments in the Coronation Park area. Assuming a pond with 5:1 side slopes, a maximum depth of 1.5 m, and a 3:1 length to width ratio, this represents an approximate surface area of some 500 m^2 to 3,400 m^2 (not including additional requirements for access roads, sediment decanting, etcetera).

It should be noted that end-of-pipe measures could be combined with numerous other water quality treatment measures (such as source controls and conveyance controls, including Low Impact Development/Best Management practices), which could be used to reduce or possibly eliminate end-of-pipe treatment volumes.

4.1.10 Local Drainage Issues

In addition to the drainage issues identified by the hydrologic/hydraulic modelling and other assessments (erosion and water quality), it is considered that there are additional localized drainage issues which may not be captured by the above (nuisance flooding and ponding in particular). Some of these issues have been reported by Town staff, as documented in the Background Information Review. A number of other issues were reported by local residents at Public Information Centre (PIC) Number 1, held on June 4, 2014, as well as PIC Number 2, held on November 26, 2014. A complete copy of the comment sheets received is included in Appendix 'D'. To summarize some of the primary local drainage issues reported by residents:

- Poor ditch grading and standing water along Wales Crescent
- Standing water and erosion within the drainage channel behind the Oakville Christian School on Third Line, and the rear-yard of 2033 Lakeshore Road West
- Deficient culvert and local drainage issues for the rear-yard swale passing beneath the pedestrian pathway between Venetia Drive and Tracina Drive
- Rear-yard ponding and obstructions for the rear-yard swale between Walby Drive and Westminster Drive
- Frequent ditch and roadway flooding along Westminster Drive
- Local ditch drainage deficiency at the corner of Hixon Drive and Seagram Avenue

- Rear-yard standing water at the back of 1420 Willowdown Road (adjacent to Woodhaven Park)
- Roadway flooding reported along Sedgewick Crescent (between Woodhaven Park Drive and Woodside Drive) during heavy rainfalls
- Local drainage deficiency at 1376 Lakeshore Road West related to inadequate ditch drainage

4.1.11 Summary of Existing Drainage System Concerns

The existing minor and major drainage systems have been characterized to determine flow capacity constraints and erosion concerns. Local drainage issues have also been considered, based on information reported by Town staff, as well as the information supplied by residents at PIC No. 1. Drawing 6 provides a compilation of all of these identified drainage issues within the Coronation Park Community. Based on this compilation, the following locations are considered to be of primary concern, and should be addressed further as part of the subsequent alternative assessment process:

Deficient storm sewer and culvert capacity (capacity < 5 year storm):

- Culvert beneath pathway between Tracina Drive and Venetia Drive – indicated as surcharging
- Storm sewer between Tracina Drive and Venetia Drive – indicated as surcharging
- Culvert crossing of Lakeshore Road from Westminster Drive – indicated as flooding
- Culvert/storm sewer inlet at WWTP property from Woodhaven Park Drive – indicated as surcharging

Deficient overland flow capacity (excessive roadway depths for 100 year storm):

- Third Line (Urban) – sag point north of Venetia Drive
- Tracina Drive (Urban) – sag point west of Walby Drive
- Venetia Drive (Urban) – sag point west of Walby Drive
- Walby Drive (Semi-Urban) – flows exceeding ditch capacity but below crown
- Westminster Drive (Rural) – high simulated depths but contained in ditch based on survey data

Deficient conveyance capacity in surveyed channels (banks exceeded for a 5 year storm):

- Western Channel (Coronation Park) from upstream of Old Lakeshore Road to Lake Ontario
- Eastern Channel (Coronation Park) from Lakeshore Road to Lake Ontario

Areas with moderate identified erosion concerns (no areas of high/significant erosion identified):

- Western channel within Coronation Park
- Ditch just east of 675 mm diameter concrete storm outfall to Sedgewick Forest
- Upstream face of 1.8 m x 1.25 m concrete box culvert crossing of Lakeshore Road west of Sandwell Crescent

Additional identified areas of concern:

- Blockage of Lake Ontario drainage outlets due to material washing up on shore
- Numerous crushed or filled culverts
- Numerous filled ditches

- Erosion and standing water in ditches (along Westminster Drive and Woodhaven Park Drive in particular)
- Poorly graded ditches and standing water along Wales Crescent
- Standing water and erosion within the drainage channel behind the Oakville Christian School on Third Line, and the rear-yard of 2033 Lakeshore Road West
- Deficient culvert and local drainage issues for the rear-yard swale passing beneath the pedestrian pathway between Venetia Drive and Tracina Drive
- Flow obstruction immediately downstream of Old Lakeshore Road
- Rear-yard ponding and obstructions for the rear-yard swale between Walby Drive and Westminster Drive
- Frequent ditch and roadway flooding along Westminster Drive
- Reverse slope on outlet channel from Sedgewick Crescent storm sewer outfall to Sedgewick forest
- Lack of proper ditch drainage along Lakeshore Road; at 1376 Lakeshore Road West as well as the south side of Lakeshore Road east of Sandwell Drive

5. LONG-LIST OF ALTERNATIVES FOR DRAINAGE SYSTEM IMPROVEMENTS

The following "long-list" of potential management alternatives has been assembled for the minor and major drainage system deficiencies, as well as issues related to erosion. In addition to the foregoing, a review of Low Impact Development Best Management Practices (LID/BMPs) has been provided, which is considered further in Section 6.

5.1 Minor System (Storm Sewers and Culverts)

Based upon the results of the integrated hydrologic/hydraulic assessment, a long-list of alternatives to mitigate the surcharge and flooding conditions for the minor system during the 5 year storm event, as well as to alleviate the depth of flooding during the 100 year storm event has been developed. The following alternatives have been advanced for consideration in order to address the deficiencies associated with minor system performance during the 5 year storm event:

1. Do Nothing
2. Increase size of affected storm sewers/culverts, or twinning
3. Implement super pipes to provide on-line storm water quantity control
4. Implement on-site storm water management for individual private properties
5. Implement off-line storage areas within available public spaces
6. Retrofit existing storm water management facilities to provide additional quantity control
7. Diversions (local inter-catchment)
8. Roof Leader/Foundation drain disconnection
9. Low Impact Development (LID) and Best Management Practices (BMPs) (other than Alternative 8)
10. New drainage outlets (relief systems) to Lake Ontario, using new storm sewers
11. Combinations

The following alternatives have been initially screened from further consideration in the drainage system assessment.

- *Alternative 3* (Implement super pipes to provide on-line storm water quantity control) is a potential alternative, however typically requires significant storage to effectively reduce peak flows to a level that does not result in flooding. Super pipes consume considerable amount of land within the right-of-way or other public lands and are typically cost prohibitive. The potential for utility conflicts is high. This alternative is typically one of the last considered in reducing flood potential. As such, this alternative has been screened from further consideration.
- *Alternative 4* (Implement on-site storm water management for individual private properties) is considered to be problematic given the predominant land use (single detached residential); to obtain any significant quantity control benefit a large number of private residences would be required to participate (which may not be feasible). In addition in many areas residences are already considered to be completely disconnected (i.e. no direct impervious connection). Given the anticipated difficulty in achieving sufficient landowner consent, and the likely benefit to quantity control, this alternative has been screened from further consideration.
- *Alternative 5* (Implement off-line storage areas within available public spaces) is possible, however limited space is available based on an initial study area scan. In addition, available public spaces are not ideally situated for quantity control (i.e. are located either at the upstream limits where contributing drainage area is low, or at the

downstream limits where there is minimal benefit to providing quantity control). Other factors include a possible reduction in public use area (unless underground storage used which is significantly more expensive). Given the foregoing, this alternative has also been screened from future consideration.

- *Alternative 6* (Retrofit existing SWM facilities) is not considered to be a viable option, as there are no existing SWM facilities within the Coronation Park area. This alternative has hence also been screened from future consideration.
- *Alternative 8* (Roof leader/foundation drain disconnection). Based on the conducted site reconnaissance and the information provided by the Town of Oakville, there do not appear to be any connected roof leaders or foundation drains (sump pumps). In some instances, roof leaders were noted to be directed to driveways rather than pervious surfaces, however these locations are considered to be a small percentage. Accordingly, this alternative has been screened from future consideration.

Accordingly, the short-listed alternatives for alleviating minor system flooding are:

- *Alternative 1* (Do Nothing) does not address the issues associated with deficient infrastructure capacity and flooding. Although this alternative functionally does not improve hydraulic conditions, it may be the selected alternative for situations where there is limited benefit from improving the drainage system. As part of the Municipal MEA Class EA process the Do Nothing alternative has to be assessed and cannot be screened from consideration.
- *Alternative 2* (Increase size of affected storm sewers/culverts, or twinning) is typically the most effective, although there are possible issues with respect to cost and existing utility conflicts, as well as required ground cover.
- *Alternative 7* (Diversions) is possible, and can be an effective option, however, this alternative assumes that there is a system which sufficient extra additional capacity to accept the additional flow, and that a diversion is possible given existing grades.
- *Alternative 9* (LID BMPs) can be an effective approach in retrofit and reconstruction areas. However, the applicability of LID BMPs can be constrained by site-specific limitations (such as available space, grading constraints, utilities, soils, groundwater levels, etc.) LID BMPs could be also be applied within both public and private lands.
- *Alternative 10* (New Drainage Outlets - relief systems using storm sewers) could be considered (new outlets to Lake Ontario) where grades and locations are appropriate. Given established drainage pathways, it may be simpler to simply increase capacity of existing pathways; however the potential for new drainage outlets should be considered further.
- Alternative 11 (Combinations) is likely an appropriate solution where no single alternative is sufficient to fully address issues.

5.2 Major System (Overland Drainage Systems)

A long list of alternatives to mitigate major system flooding during the 100 year storm event has been developed. The following specific alternatives have been advanced for consideration:

1. Do Nothing
2. Increase size of storm sewers and culverts to reduce depth of flooding of the major system to within acceptable limits
3. Implement super pipes to provide on-line storm water quantity control
4. Implement on-site storm water management for individual private properties

5. Implement off- line storage areas within available public spaces
6. Retrofit existing storm water management facilities to provide additional quantity control to mitigate these conditions
7. Modify grading on private property to mitigate flooding.
8. Modify grading within road right of way or other public property to mitigate flooding.
9. Low Impact Development Best Management Practices (LID BMPs)
10. New major system outlets
11. Combinations.

The following alternatives have been initially screened from further consideration:

- *Alternative 3* (Implement super pipes to provide on-line storm water quantity control) is a potential alternative, however typically requires significant storage to effectively reduce peak flows to a level that does not result in flooding. Super pipes consume considerable amount of land within the right-of-way or other public lands and are typically cost prohibitive. The potential for utility conflicts is high. This alternative is typically one of the last considered in reducing flood potential. As such, this alternative has been screened from further consideration.
- *Alternative 4* (Implement on-site storm water management for individual private properties) is considered to be problematic given the predominant land use (single detached residential); to obtain any significant quantity control benefit a large number of private residences would be required to participate (which may not be feasible). In addition in many areas residences are already considered to be completely disconnected (i.e. no direct impervious connection). Given the anticipated difficulty in achieving sufficient landowner consent, and the likely benefit to quantity control, this alternative has been screened from further consideration.
- *Alternative 5* (Implement off-line storage areas within available public spaces) is possible, however limited space is available based on an initial study area scan. In addition, available public spaces are not ideally situated for quantity control (i.e. are located either at the upstream limits where contributing drainage area is low, or at the downstream limits where there is minimal benefit to providing quantity control). Other factors include a possible reduction in public use area (unless underground storage used which is significantly more expensive). Given the foregoing, this alternative has also been screened from future consideration.
- *Alternative 6* (Retrofit existing SWM facilities) is not considered to be a viable option, as there are no existing SWM facilities within the Coronation Park area. This alternative has hence also been screened from future consideration.
- *Alternative 7* (Modify grading on private property to mitigate flooding) could be conducted to a limited extent to either reduce or eliminate potential flooding from open watercourses, overland flow routes across private property, or rear yard drainage features. Such works would be limited in scope however, and would require agreement from affected landowners (which may not be forthcoming) and would potentially also require compensation measures. Given the limited scope and the issues with obtaining permission from private landowners, this alternative has been screened from further consideration.
- *Alternative 9* (LID BMPs) is generally more appropriate for managing smaller storm events, rather than major flood events. Although this approach should be encouraged for addressing minor system deficiencies, its applicability to major system deficiencies is therefore limited. This option has therefore been screened from future consideration.

- *Alternative 10* (New overland outlets) is typically not feasible given the limited amount of available public property and the difficulty and costs involved with obtaining required property (either through purchase or easement agreements) from private landowners.

Accordingly, the short-listed strategies to mitigate the impacts of flooding of private property during the 100 year storm event include:

- *Alternative 1* (Do Nothing) functionally does not improve hydraulic conditions. It may be the selected alternative for situations where there is limited benefit from improving the drainage system. As part of the Municipal Class EA process the Do Nothing alternative has to be assessed and cannot be screened from consideration.
- *Alternative 2* (Increase size of storm sewers and culverts to reduce depth of flooding of the major system to within acceptable limits) is a potential alternative to be considered when overland flow through private property is to be limited or reduced. Typically this alternative would only be considered for short lengths due to the high cost.
- *Alternative 8* (Modify grading within road right of way or public property to mitigate flooding) can be conducted to a limited extent to either reduce or eliminate potential flooding from roadways on private or public property. Specific areas of concern, such as the outlet channel from Sedgewick Crescent storm sewer outfall, could be addressed through this alternative. Modification of road grading within Conservation Halton's regulated areas would require approval from Conservation Halton.
- *Combinations* (Alternative 11) is likely an appropriate solution where no single alternative is sufficient to fully address issues.

5.3 Low Impact Development

Low Impact Development represents the application of a suite of BMPs normally related to source and conveyance storm water management controls to promote infiltration and pollutant removal on a local site by site basis. These measures rely on eliminating the direct connection between impervious surfaces such as roofs, roads, parking areas, and the storm drainage system, as well as the promotion of infiltration on each development or redevelopment site. General design guidelines and considerations for source and conveyance controls have been advanced since the early 1990's as part of the MMAH "Making Choices" and in 1994 as part of the original Ministry of the Environment Best Management Practices Guidelines.

Subsequent to the 1994 MOE Guidelines, technologies and standards have been developed further for the application of source and conveyance controls. These have evolved into a class of Best Management Practices (BMPs) referred to as Low Impact Development (LID) practices, which have advanced as an integrated form of site planning and storm servicing to maintain water balance and providing storm water quality control for urban developments. Initial results from studies in other settings have demonstrated that LID practices may also provide benefits by way of reducing the erosion potential within receiving watercourses and thereby reducing the total volume of end-of-pipe storm water erosion control requirements. In addition, due to volumetric controls afforded by LID BMP's, water quality is also improved through a reduction in mass loading. The benefits from LID storm water management practices are generally focused on the more frequent storm events (e.g. 2 year storm) of lower volumes as opposed to the less frequent storm events (e.g. 100 year storm) with higher volumes. It is also recognized that the forms of LID practices which promote infiltration or filtration through a granular medium provide thermal mitigation for storm runoff.

Guidelines regarding the application of LID practices and techniques have been developed within various jurisdictions in the United States and Canada. The Toronto and Region Conservation Authority and Credit Valley Conservation have released the 2010 Low Impact Development Storm water Management Manual, for the design and application of LID measures. Various LID techniques, as well as their function, are summarized in Table 5.1. While LID includes additional planning and design to implement and can also lead to a requirement to change urban design standards, the information provided in Table 5.1 specifically addresses those techniques and technologies related to storm water management practices.

The Town of Oakville and Conservation Halton have an interest in implementing LID practices not only within new development, but also as retrofit opportunities arise. These practices could be implemented in varying degrees based upon the land use, development form, local soil infiltration capacity and the willingness of land owners to modify their property (in the case of private LID/BMPs). The soils in the Coronation Park area are noted to range from silty sands to silty clays; thus site specific soils investigations may be required to confirm appropriate conditions for infiltration. An assessment of local groundwater conditions should also be undertaken prior to recommending LID/BMP measures to ensure that such measures would allow for sufficient infiltration.

Neighbourhood scale LID pilot projects have commenced within the City of Toronto and other Southern Ontario municipalities. These projects typically require extensive consultation with the community and an assessment of viable LID practices based on local community input and constraints resulting from the development form. Each neighbourhood is different in age, development form, and infrastructure standards and as such will require appropriate LID practices to be selected accordingly.

Table 5.1: LID Source and Conveyance Controls	
Technique	**Function**
Bio-retention Cell	▶ Vegetated technique for filtration of storm runoff ▶ Storm water quality control provided through filtration of runoff through soil medium and vegetation ▶ Infiltration/ evapotranspiration/ water balance maintenance and additional erosion control may be achieved if no subdrain provided
Cistern	▶ Rainwater harvesting technique ▶ Storm runoff volume reduced through capture/interception of runoff ▶ Storm water quality provided for captured runoff ▶ Effectiveness is contingent upon available volume within cistern
Downspout Disconnection	▶ Effectiveness dependent upon soils and supplemental conveyance techniques ▶ Storm runoff volume reduced by promoting infiltration through reducing direct connections of impervious surfaces ▶ Benefits to storm water quality control and erosion control are informal.
Grassed Swale	▶ Vegetated technique to provide storm water quality control ▶ Storm water quality control provided by filtration through vegetated system ▶ Runoff volume reduction may be achieved by supplementing with soil amendments
Green Roof	▶ Vegetated technique for reducing storm runoff volume ▶ Informal storm water quality control provided through reduction in runoff volume ▶ No benefits provided by way of infiltration, although evapotranspiration benefits would result
Infiltration Trench	▶ Infiltration technique to provide storm water quality control and maintain water balance ▶ Erosion controls may be achieved depending upon soil conditions
Permeable Pavers/Pavement	▶ Infiltration technique to reduce surface runoff volume ▶ Benefits to storm water quality and erosion control are informal
Rain Barrel	▶ Rainwater harvesting technique ▶ Storm runoff volume reduced through capture/interception of runoff ▶ Storm water quality provided for captured runoff ▶ Effectiveness is contingent upon available volume within cistern
Rain Garden	▶ Vegetated technique for infiltration of storm runoff ▶ Storm water quality control provided through filtration of runoff through soil medium and vegetation ▶ Infiltration/evapotranspiration/water balance maintenance and additional erosion control may be achieved if no subdrain provided
Soil Amendments	▶ Technique for reducing runoff volume through increased depth of topsoil ▶ Storm water quality control provided through increased soil storage and associated interception of storm runoff ▶ Increases water balance compared to existing conditions when applied in areas with low permeability soils ▶ Possible erosion control benefits
Reduced Lot Grading	▶ Reduction in lot grading increases contact time between storm runoff and vegetation, also increases time of concentration for runoff (some reduction in peak flow rate) ▶ Technique reduces runoff volume and improves on storm water quality on an informal basis ▶ Additional informal benefits to maintaining water balance and erosion control may be achieved depending upon soil conditions. Benefit to evapotranspiration would result.
Pervious Pipes	▶ Technique to reduce storm runoff through the implementation of perforated pipes within storm sewers ▶ Promotion of infiltration maintains water balance and provides storm water quality and erosion control benefits

5.4 Erosion

Based on the previously summarized field reconnaissance (Table 4.7), all of the identified erosion issues are considered to be minor with only a few erosion issues noted as being moderate. No major/significant erosion issues were noted. Typical erosion issues are related to minor bank erosion and un-vegetated channel slopes.

Given that no major/significant erosion issues have been noted, a formal long-listing of alternatives is not considered warranted. Identified erosion issues should be considered in conjunction with the long-listed alternatives for the minor and major system. In particular, opportunities to reduce the magnitude and duration of erosion causing flows (to minimize future erosion) should be considered, via flow diversions, new drainage system outlets, and LID/BMP measures. Additional erosion treatments (vegetation, protective stone, etc.) should also be considered in conjunction with any future channel works (those recommended by this study or otherwise).

6. SHORT-LISTED ALTERNATIVE ASSESSMENT

Evaluation Methodology

In order to assess the various short-listed minor and major drainage system improvements, an evaluation system, has been advanced to assess the suitability of each alternative against appropriate "evaluation factors". The evaluation factors consist of considerations related to a two-tier hierarchy of potential impacts/issues organized by Evaluation Category, which have been supplemented by more detailed and specific Evaluation Criteria.

Evaluation Category

A broad description of the type of impacts and issues under consideration includes:

i. **Functional** – Impacts that the alternative may have on how a system is intended to work as related to the mitigation of surcharging and flooding.
ii. **Environmental** – Potential environmental impacts or benefits that alternatives may have on Lake Ontario, including the shoreline, erosion, and water quality.
iii. **Social** – Impacts/issues relating to the interaction of the community/neighbourhood with the implementation of the proposed alternative.
iv. **Economic** – Immediate and future costs and cost-benefit of the alternative including operations and maintenance.
v. **Constructability** – Construction considerations related to accessibility for machinery and the potential impact of construction techniques and access on private property.

Evaluation Criteria:

Specific evaluation criteria relevant to each Evaluation Category have been summarized in Table 6.1.

Table 6.1: Coronation Park Drainage System Alternatives Evaluation Approach

Evaluation Category	Evaluation Criteria	Criteria Description
Functional	Extent to which the Alternative Mitigates the Drainage System Flow Capacity Deficiencies	Each alternative, to varying degrees, provides opportunities to improve the existing storm system (minor and major) flow capacity.
Environmental	Impacts to Lake Ontario (shoreline, erosion, water quality)	Any alternative which would result in degradation of the Lake Ontario shoreline (including erosion), or would result in decreased water quality would be considered a negative. Alternatives which are beneficial would be considered positive.
Social	Ability to Improve Public Safety	Depending on reduced flooding risk within both private and/ or public property, public safety would be improved to varying degrees.
	Impacts on Private Properties	Relates to the change in flood risk on private lands.
	Impact on Public Lands	Depending on the alternative there are varying degrees of impact to flooding conditions on public lands including roadways.

Table 6.1: Coronation Park Drainage System Alternatives Evaluation Approach

Evaluation Category	Evaluation Criteria	Criteria Description
Economic	Capital Costs	Lower costs are preferred over higher costs.
	Operations and Maintenance Costs	Lower costs are preferred over higher costs.
Constructability	Ease of Construction and Accessibility	Depending on the selected alternative, the machinery and materials required to construct will vary. The ease and accessibility of alternative construction will vary depending upon alternative location.
	Construction staging and timing	Depending on the alternative and the extent of the proposed works, the project may need to be staged (multiple phases), and may require multiple years to construct.

Drainage improvement alternatives have been assessed for the primary areas of concern noted in Section 4 in Tables 6.2 to 6.4. In evaluating alternatives, potential integration between areas of concern and alternatives has been considered.

The primary areas of concern are listed below along with the associated alternative evaluation table references.

i. West Channel area (Table 6.2)
ii. Westminster Drive (Table 6.3)
iii. Woodhaven Park Drive (Table 6.4)

It should be noted that several other identified deficiencies and additional identified areas of concern were presented in Section 4. However, it is considered that a full alternative evaluation is not warranted in these cases, given that the majority of these additional deficiencies and areas of concern have a clear, direct solution (such as a storm sewer/culvert upgrade, re-grading, or erosion repair). In these cases there are limited or no alternatives (and where alternatives exist, they are similar in nature), and the proposed solution would have minimal to no environmental or social impacts that should be taken into account, and can be constructed relatively easily with minimal cost. Proposed solutions to address these other identified deficiencies and areas of concern are presented in greater detail in Section 7. A more detailed functional assessment of the short-listed alternatives generated to address the above noted areas of concern is also presented in Section 7.

Table 6.2: Short-listed Alternative Assessment – West Channel Area

Minor System

Evaluation Category	Evaluation Criteria	Alternative No. 1 Do Nothing		Alternative No. 2 Increase size of storm sewers/culverts		Alternative No. 7 Flow Diversions		Alternative No. 9 LID BMP's		Alternative No. 10 New Drainage System Outlets (new storm sewers)		Alternative No. 11 Combinations	
Functional	Extent to which the Alternative Mitigates the Drainage System Flow Capacity Deficiencies	No improvement	1	Limited to no benefit – channel capacity is more the issue than culverts (i.e. large diameter culverts at Old Lakeshore Road)	1	No local storm sewers or channels nearby for a direct diversion – would require new drainage system connections and outlets (Alternative 10)	1	LID BMPs would have limited ability to reduce peak flows to the extent required	1	Numerous potential new outlets, including side streets (Third Line or Belvedere Drive) or new trunk along Lakeshore Road which would be beneficial.	5	No clear combinations; LID BMPs could be considered in combination with Alternative 10 where feasible but does not address issues.	1
Environmental	Impacts to Lake Ontario (shoreline, erosion, water quality)	Not applicable	3	Would likely have no impact on discharges to Lake Ontario	3	Not applicable	3	Would have a beneficial impact to stormwater quality to Lake Ontario	5	Would potentially require a new or upgraded outlet to Lake Ontario (depending on preferred option) which would necessitate channel works.	2	Not applicable	3
Social	Ability to Improve Public Safety	No improvement	1	Likely no improvement	1	No improvement	1	No improvement	1	May divert sufficient flow to reduce/prevent flooding	4	No improvement	1
	Impacts on Private Properties	No improvement	1	Likely no improvement	1	No improvement	1	No improvement	1	May divert sufficient flow to reduce/prevent impact to private property	4	No improvement	1
	Impact on Public Lands	No improvement	1	Likely no improvement	1	No improvement	1	No improvement	1	May divert sufficient flow to reduce/prevent impact to private property	4	No improvement	1
Economic	Capital Costs	Not applicable	3	Capital costs would likely be low given short lengths involved (road culverts)	4	Not applicable	3	Construction costs would be moderate (although depends on approach applied)	4	Depends on outlet chosen, but likely a significant capital cost to construct	2	Not applicable	3
	Operational and Maintenance Costs	Not applicable	3	Low O&M costs expected given short lengths involved	4	Not applicable	3	Moderate maintenance costs associated with LID/BMPs	2	Moderate O&M costs	3	Not applicable	3
Construct-ability	Ease of Construction and Construction Accessibility	Not applicable	3	Construction would be relatively straightforward, within public ROW	4	Not applicable	3	Limited public space available along channel to construct LID/BMPs	2	Construction likely entirely within public ROW, potentially large storm sewers	3	Not applicable	3
	Construction staging and timing	Not applicable	3	Construction would be relatively straightforward	4	Not applicable	3	Could be constructed relatively quickly once constraints addressed	4	Depending on route selected, may require co-ordination with other projects (Lakeshore EA)	2	Not applicable	3
Results	Overall assessment	This alternative does nothing to address identified flooding risk. **Screened from further consideration.**		This alternative would have little to no impact on addressing identified flood risk. **Screened from further consideration.**		**Not applicable.**		This alternative would have little to no impact on addressing the identified flood risk, although it would be beneficial to water quality. **Screened from further consideration.**		This alternative could potentially reduce/eliminate flooding and other drainage system issues. **Carried forward.**		**Not applicable.**	

Major System

Evaluation Category	Evaluation Criteria	Alternative No. 1 Do-Nothing		Alternative No. 2 Increase size of storm sewers/culverts		Alternative 8 Modify Grading on Public Property		Alternative 11 Combinations	
Functional	Extent to which the Alternative Mitigates the Drainage System Flow Capacity Deficiencies	No improvement	1	Limited to no benefit – channel capacity is more the issue than culverts (i.e. large diameter culverts at Old Lakeshore Road)	1	In combination with Alternative 10 (Minor System), roadway re-grading could assist in re-directing major system flows to appropriate outlets.	4	No clear combinations for major system issues available.	1
Environmental	Impacts to Lake Ontario (shoreline, erosion, water quality)	Not applicable	3	Would likely have no impact on discharges to Lake Ontario	3	No direct impacts to Lake Ontario from roadway re-grading.	3	Not applicable	3
Social	Ability to Improve Public Safety	No improvement	1	Likely no improvement	1	Potentially some improvement.	4	No improvement	1
	Impacts on Private Properties	No improvement	1	Likely no improvement	1	Potentially some reduction of impacts to private property.	4	No improvement	1
	Impact on Public Lands	No improvement	1	Likely no improvement	1	Potentially some reduction in flood depths along roadways.	4	No improvement	1
Economic	Capital Costs	Not applicable	3	Capital costs would likely be low given short lengths involved (road culverts)	4	Minor additional costs (part of design process); main costs would be for new drainage systems	4	Not applicable	3
	Operational and Maintenance Costs	Not applicable	3	Low O&M costs expected given short lengths involved	4	Minimal costs associated with road re-grading itself	4	Not applicable	3
Construct-ability	Ease of Construction and Construction Accessibility	Not applicable	3	Construction would be relatively straightforward, within public ROW	4	Construction entirely within public ROW	4	Not applicable	3
	Construction staging and timing	Not applicable	3	Construction would be relatively straightforward	4	Depending on route selected, may require co-ordination with other projects (Lakeshore EA)	2	Not applicable	3
Results	Overall assessment	This alternative does nothing to address the identified flooding risk. **Screened from further consideration.**		This alternative would have little to no impact on addressing the identified flood risk. **Screened from further consideration.**		This alternative could be beneficial in better managing major system flows in combination with new drainage system outlets. **Carried forward**.		This alternative does nothing to address the identified flooding risk. **Screened from further consideration.**	

Most Preferred 5 **More Preferred** 4 **Neutral** 3 **Less Preferred** 2 **Least Preferred** 1

Table 6.3: Short-listed Alternative Assessment – Westminster Drive

Evaluation Category	Evaluation Criteria	Minor System												Major System							
		Alternative No. 1 Do Nothing		Alternative No. 2 Increase size of storm sewers/culverts		Alternative No. 7 Flow Diversions		Alternative No. 9 LID BMP's		Alternative No. 10 New Drainage System Outlets (new storm sewers)		Alternative No. 11 Combinations		Alternative No. 1 Do-Nothing		Alternative No. 2 Increase size of storm sewers/culverts		Alternative 8 Modify Grading on Public Property		Alternative 11 Combinations	
Functional	Extent to which the Alternative Mitigates the Drainage System Flow Capacity Deficiencies	No improvement	1	No existing storm sewers; driveway culvert replacements would be beneficial as part of a road reconstruction (not a stand-alone measure). Replacement of culvert at Lakeshore Road also beneficial.	4	No local storm sewers or channels with available capacity nearby for a direct diversion – would require new drainage system connections and outlets (Alternative 10)	1	LID BMPs would be beneficial given frequent reports of standing water in ditches and more frequent nuisance flooding.	4	A new storm sewer system along the roadway would be beneficial in reducing ditch flooding depths, and would likely further reduce surface ponding/standing water. Would likely continue to use outlet to east channel in Coronation Park.	4	Combination of Alternatives 2, 9, and 10 likely the best solution for minor system.	5	No improvement	1	No existing storm sewers; driveway culvert replacements would be beneficial as part of a road reconstruction (not a stand-alone measure). Replacement of culvert at Lakeshore Road also beneficial.	4	Town and resident preference to maintain rural road cross-section. Ditches could be re-graded to remove excess sediment and low spots – continuous positive drainage.	4	Combination of Alternatives 2 and 8 likely the best solution for major system.	5
Environmental	Impacts to Lake Ontario (shoreline, erosion, water quality)	Not applicable	3	Would likely have no impact on discharges to Lake Ontario	3	Not applicable	3	Would have a beneficial impact to stormwater quality to Lake Ontario	5	Would likely require modifications to existing outlet to Coronation Park to accommodate sewer depth, which would necessitate channel works to Lake. Potential flow increase due to improved conveyance.	2	Benefit to WQ from LID/BMP, potentially some impact from new outlet (if required)	4	Not applicable	3	Would likely have no impact on discharges to Lake Ontario	3	Would likely have no impact on discharges to Lake Ontario	3	Would likely have no impact to discharges to Lake Ontario.	3
Social	Ability to Improve Public Safety	No improvement	1	Some benefit in reducing depths by addressing deficient culverts	4	No improvement	1	Minimal impact to flooding mitigation.	3	Some benefit in reducing flooding depths.	4	Greatest benefit in reducing flood depths	4	No improvement	1	Some benefit in reducing depths by addressing deficient culverts	4	Some benefit in reducing flooding depths and standing water.	4	Some benefit in reducing flooding depths and standing water.	4
	Impacts on Private Properties	No improvement	1	Some benefit in reducing depths by addressing deficient culverts	4	No improvement	1	Aesthetic improvement – less standing water, streetscaping.	4	Some benefit in reducing flooding depths, and standing water.	4	Greatest benefit to private property	4	No improvement	1	Some benefit in reducing depths by addressing deficient culverts	4	Some benefit in reducing flooding depths and standing water.	4	Some benefit in reducing flooding depths and standing water.	4
	Impact on Public Lands	No improvement	1	Some benefit in reducing depths by addressing deficient culverts	4	No improvement	1	No change.	3	Some benefit in reducing flooding depths and standing water.	4	Greatest benefit to public property	4	No improvement	1	Some benefit in reducing depths by addressing deficient culverts	4	Some benefit in reducing flooding depths and standing water.	4	Some benefit in reducing flooding depths and standing water.	4
Economic	Capital Costs	Not applicable	3	Driveway culvert replacements would require much more capital cost than Lakeshore Road culvert replacement.	2 4	Not applicable	3	Costing depends on approach selected, but generally lower cost than more typical engineering solutions.	4	Moderate capital cost – smaller diameter storm sewers and likely moderate depths.	2	Combined cost of road re-construction with culvert replacements, LID/BMPs, new sewers	2	Not applicable	3	Driveway culvert replacements would require much more capital cost than Lakeshore Road culvert replacement.	2 4	Minimal direct costs for this alternative – would be part of overall road re-construction	3	Combined costs of road reconstruction	3
	Operational and Maintenance Costs	Not applicable	3	More O&M associated with driveway culverts than Lakeshore Road culvert.	2 4	Not applicable	3	Moderate maintenance costs associated with LID/BMPs	2	Typical O&M cost for storm sewers.	3	More O&M required for new sewers and LID/BMPs	2	Not applicable	3	More O&M associated with driveway culverts than Lakeshore Road culvert.	2 4	Typical O&M – ditch clean-outs as required	3	More O&M required for driveway culverts	2

Table 6.3: Short-listed Alternative Assessment – Westminster Drive

Minor System

Evaluation Category	Evaluation Criteria	Alternative No. 1 Do Nothing		Alternative No. 2 Increase size of storm sewers/culverts		Alternative No. 7 Flow Diversions		Alternative No. 9 LID BMP's		Alternative No. 10 New Drainage System Outlets (new storm sewers)		Alternative No. 11 Combinations	
Construct-ability	Ease of Construction and Construction Accessibility	Not applicable	3	Driveway culvert replacements would impact private residences. Lakeshore Road culvert replacement less disruptive.	2 / 4	Not applicable	3	Could construct measures entirely within ROW; potential for measures on private property but likely more difficult	4	Storm sewers would be constructed within public ROW, typical disruption to residences.	3	All works could be done within ROW, typical disruptions	3
	Construction staging and timing	Not applicable	3	Westminster Drive culverts could be done as stand-alone project, Lakeshore Road work would require more co-ordination.	4 / 2	Not applicable	3	Would likely be done in combination with other works to minimize disruption.	3	Would likely be done in combination with other works to minimize disruption.	3	Could be done as a single project to minimize disruption	3
Results	Overall assessment	This alternative does nothing to address identified flooding risk. **Screened from further consideration.**		This alternative could be beneficial in reducing flooding depths and improving flow conveyance. **Carried forward.**		**Not applicable.**		This alternative would assist in improving drainage for smaller events and nuisance issues (standing water), and is beneficial to water quality. **Carried forward.**		This alternative would assist in reducing flooding depths as well as for smaller events and nuisance issues (standing water). **Carried forward.**		This alternative combines all of the preferred individual alternatives for minor system and should therefore be assessed further **Carried forward.**	

Major System

Evaluation Category	Evaluation Criteria	Alternative No. 1 Do-Nothing		Alternative No. 2 Increase size of storm sewers/culverts		Alternative 8 Modify Grading on Public Property		Alternative 11 Combinations	
Construct-ability	Ease of Construction and Construction Accessibility	Not applicable	3	Driveway culvert replacements would impact private residences. Lakeshore Road culvert replacement less disruptive.	2 / 3	Work all within public ROW, typical disruption to residents	3	Work all within public ROW, typical disruption to residents	3
	Construction staging and timing	Not applicable	3	Westminster Drive culverts could be done as stand-alone project, Lakeshore Road work would require more co-ordination.	4 / 2	Work to be done as part of overall road re-construction (single project)	3	Work to be done as part of overall road re-construction (single project)	3
Results	Overall assessment	This alternative does nothing to address identified flooding risk. **Screened from further consideration.**		This alternative could be beneficial in reducing flooding depths and improving flow conveyance. **Carried forward.**		This alternative would assist in improving major flow conveyance and eliminating low spots which may contribute to standing water. **Carried forward.**		This alternative combined all of the preferred alternatives for major system and should therefore be assessed further. **Carried forward.**	

Most Preferred 5 **More Preferred** 4 **Neutral** 3 **Less Preferred** 2 **Least Preferred** 1

Table 6.4: Short-listed Alternative Assessment – Woodhaven Park Drive

Evaluation Category	Evaluation Criteria	Minor System												Major System							
		Alternative No. 1 Do Nothing		Alternative No. 2 Increase size of storm sewers/culverts		Alternative No. 7 Flow Diversions		Alternative No. 9 LID BMP's		Alternative No. 10 New Drainage System Outlets (new storm sewers)		Alternative No. 11 Combinations		Alternative No. 1 Do-Nothing		Alternative No. 2 Increase size of storm sewers/culverts		Alternative 8 Modify Grading on Public Property		Alternative 11 Combinations	
Functional	Extent to which the Alternative Mitigates the Drainage System Flow Capacity Deficiencies	No improvement	1	No existing storm sewers; driveway culvert replacements would be beneficial as part of a road reconstruction (not a stand-alone measure). Replacement of culvert at Lakeshore Road also beneficial.	4	No local storm sewers or channels with available capacity nearby for a direct diversion – would require new drainage system connections and outlets (Alternative 10) which could allow for a diversion away from private property (WWTP). Assessed as part of that alternative.	1	LID BMPs would be beneficial given frequent reports of standing water in ditches and more frequent nuisance flooding.	4	A new storm sewer system along the roadway would be beneficial in reducing ditch flooding depths, and would likely further reduce surface ponding/standing water. New storm sewer along roadway would allow for elimination of private property outlet across WWTP as well. Could preserve existing outlet or re-direct (to eastern channel in Coronation Park?).	4	Combination of Alternatives 2, 9, and 10 likely the best solution for minor system.	5	No improvement	1	No existing storm sewers; driveway culvert replacements would be beneficial as part of a road reconstruction (not a stand-alone measure). Replacement of culvert at Lakeshore Road also beneficial.	4	Town and resident preference to maintain rural road cross-section. Ditches could be re-graded to remove excess sediment and low spots – continuous positive drainage.	4	Combination of Alternatives 2 and 8 likely the best solution for major system.	5
Environmental	Impacts to Lake Ontario (shoreline, erosion, water quality)	Not applicable	3	Would likely have no impact on discharges to Lake Ontario	3	Not applicable	3	Would have a beneficial impact to stormwater quality to Lake Ontario	5	Would depend on ultimate outlet chosen, but likely some increased flows to Lake, which would likely necessitate some works along the shore (storm sewer upgrade or channel works).	2	Benefit to WQ from LID/BMP, potentially some impact from new outlet (if required)	4	Not applicable	3	Would likely have no impact on discharges to Lake Ontario	3	Would likely have no impact on discharges to Lake Ontario	3	Would likely have no impact to discharges to Lake Ontario.	3
Social	Ability to Improve Public Safety	No improvement	1	Some benefit in reducing depths by addressing deficient culverts	4	No improvement	1	Minimal impact to flooding mitigation.	3	Some benefit in reducing flooding depths.	4	Greatest benefit in reducing flood depths	4	No improvement	1	Some benefit in reducing depths by addressing deficient culverts	4	Some benefit in reducing flooding depths and standing water.	4	Some benefit in reducing flooding depths and standing water.	4
	Impacts on Private Properties	No improvement	1	Some benefit in reducing depths by addressing deficient culverts	4	No improvement	1	Aesthetic improvement – less standing water, streetscaping.	4	Some benefit in reducing flooding depths, and standing water.	4	Greatest benefit to private property	4	No improvement	1	Some benefit in reducing depths by addressing deficient culverts	4	Some benefit in reducing flooding depths and standing water.	4	Some benefit in reducing flooding depths and standing water.	4
	Impact on Public Lands	No improvement	1	Some benefit in reducing depths by addressing deficient culverts	4	No improvement	1	No change.	3	Some benefit in reducing flooding depths and standing water.	4	Greatest benefit to public property	4	No improvement	1	Some benefit in reducing depths by addressing deficient culverts	4	Some benefit in reducing flooding depths and standing water.	4	Some benefit in reducing flooding depths and standing water.	4
Economic	Capital Costs	Not applicable	3	Driveway culvert replacements would require much more capital cost than Lakeshore Road culvert replacement.	2 4	Not applicable	3	Costing depends on approach selected, but generally lower cost than more typical engineering solutions.	4	Moderate capital cost – smaller diameter storm sewers and likely moderate depths.	2	Combined cost of road re-construction with culvert replacements, LID/BMPs, new sewers	2	Not applicable	3	Driveway culvert replacements would require much more capital cost than Lakeshore Road culvert replacement.	4 2	Minimal direct costs for this alternative – would be part of overall road re-construction	3	Combined costs of road reconstruction	3
	Operational and Maintenance Costs	Not applicable	3	More O&M associated with driveway culverts than Lakeshore Road culvert.	2 4	Not applicable	3	Moderate maintenance costs associated with LID/BMPs	2	Typical O&M cost for storm sewers.	3	More O&M required for new sewers and LID/BMPs	2	Not applicable	3	More O&M associated with driveway culverts than Lakeshore Road culvert.	4 2	Typical O&M – ditch clean-outs as required	3	More O&M required for driveway culverts	2

Table 6.4: Short-listed Alternative Assessment – Woodhaven Park Drive

Evaluation Category	Evaluation Criteria	Minor System												Major System							
		Alternative No. 1 Do Nothing		Alternative No. 2 Increase size of storm sewers/culverts		Alternative No. 7 Flow Diversions		Alternative No. 9 LID BMP's		Alternative No. 10 New Drainage System Outlets (new storm sewers)		Alternative No. 11 Combinations		Alternative No. 1 Do-Nothing		Alternative No. 2 Increase size of storm sewers/culverts		Alternative 8 Modify Grading on Public Property		Alternative 11 Combinations	
Construct-ability	Ease of Construction and Construction Accessibility	Not applicable	3	Driveway culvert replacements would impact private residences. Lakeshore Road culvert replacement less disruptive.	2 3	Not applicable	3	Could construct measures entirely within ROW; potential for measures on private property but likely more difficult	4	Storm sewers would be constructed within public ROW, typical disruption to residences.	3	All works could be done within ROW, typical disruptions	3	Not applicable	3	Driveway culvert replacements would impact private residences. Lakeshore Road culvert replacement less disruptive.	2 3	Work all within public ROW, typical disruption to residents	3	Work all within public ROW, typical disruption to residents	3
	Construction staging and timing	Not applicable	3	Westminster Drive culverts could be done as stand-alone project, Lakeshore Road work would require more co-ordination.	4 2	Not applicable	3	Would likely be done in combination with other works to minimize disruption.	3	Would likely be done in combination with other works to minimize disruption.	3	Could be done as a single project to minimize disruption	3	Not applicable	3	Westminster Drive culverts could be done as stand-alone project, Lakeshore Road work would require more co-ordination.	4 2	Work to be done as part of overall road re-construction (single project)	3	Work to be done as part of overall road re-construction (single project)	3
Results	Overall assessment.	This alternative does nothing to address identified flooding risk. **Screened from further consideration.**		This alternative could be beneficial in reducing flooding depths and improving flow conveyance. **Carried forward.**		**Not applicable.**		This alternative would assist in improving drainage for smaller events and nuisance issues (standing water), and is beneficial to water quality. **Carried forward.**		This alternative would assist in reducing flooding depths as well as for smaller events and nuisance issues (standing water). **Carried forward.**		This alternative combines all of the preferred individual alternatives for minor system and should therefore be assessed further **Carried forward.**		This alternative does nothing to address identified flooding risk. **Screened from further consideration.**		This alternative could be beneficial in reducing flooding depths and improving flow conveyance. **Carried forward.**		This alternative would assist in improving major flow conveyance and eliminating low spots which may contribute to standing water. **Carried forward.**		This alternative combined all of the preferred alternatives for major system and should therefore be assessed further. **Carried forward.**	

Most Preferred 5 **More Preferred** 4 **Neutral** 3 **Less Preferred** 2 **Least Preferred** 1

7. DETAILED ASSESSMENT OF SHORT-LISTED ALTERNATIVES

As noted, the assessment of the short-listed alternatives has been conducted for the primary areas of concern where the completed alternative assessment process was considered warranted. In evaluating alternatives, potential integration between areas of concern and the potential alternatives has been considered. A summary of the short-listed alternatives for both the minor and major drainage systems for the primary areas of concern has been provided within Table 7.1.

Table 7.1: Short-listed Drainage Alternatives for Primary Areas of Concern

Location	Evaluation Table	Alternatives Carried Forward	
		Minor System	Major System
West Channel area	6.2	Alt. 10: New Drainage System Outlets (New Storm Sewers)	Alt. 8: Modify Grading on Public Property
Westminster Drive	6.3	Alternative 11: Combinations ► Alt. 2 (Increase Size of storm sewers/culverts) ► Alt. 9 (LID/BMPs) ► Alt. 10 (New Drainage System Outlets/New storm sewers)	Alt. 11: Combinations ► Alt. 2 (Increase Size of storm sewers/culverts) ► Alt. 8 (Modify grading on public property)
Woodhaven Park Drive	6.4	Alternative 11: Combinations ► Alt. 2 (Increase Size of storm sewers/culverts) ► Alt. 9 (LID/BMPs) ► Alt. 10 (New Drainage System Outlets/New storm sewers)	Alt. 11: Combinations ► Alt. 2 (Increase Size of storm sewers/culverts) ► Alt. 8 (Modify grading on public property)

A detailed functional assessment for each of the above-noted locations has been conducted by modifying the previously developed existing conditions PCSWMM hydrologic/hydraulic modelling. Using this approach, a review of existing constraints (such as grading and drainage outlets) has also been conducted, including an assessment of sub-alternatives (i.e. different potential storm sewer alignments and outlets). Other more direct alternatives, which did not require a more detailed alternative assessment (as discussed in greater detail in Section 6) have also been assessed and summarized accordingly. Drawing 11 (attached) summarizes all of the alternatives considered; with further discussion provided within this section.

Potential LID/BMP measures have not been assessed in detail; it is recommended that these measures be considered further at the detailed design stage for proposed works on a case by case basis based on the findings of associated field investigations (i.e. site specific geotechnical and hydrogeological investigations).

Preliminary capital cost estimates have been provided for each of the recommended alternatives; the assumptions associated with each of these preliminary cost estimates are noted where appropriate and should be fully understood before directly applying these estimates for budgetary purposes. The cost estimates provided generally reflect construction costs only and do not include any additional costs associated with engineering design. Cost estimates have also been rounded up to the nearest $10,000.

7.1 West Channel Area

The west channel area refers to the section of existing open watercourse originating at the south-east corner of Lakeshore Road and Third Line. This watercourse flows easterly along the south side of Lakeshore Road, before crossing under Old Lakeshore Road and Belvedere Drive, before confluencing with the 900 mm diameter storm sewer from Walby Drive within the western end of Coronation Park, and then outletting to Lake Ontario. As presented in Section 4, the channel has been prone to flooding (which impacts several adjacent residences) and has been identified as having limited conveyance capacity; particularly the section between Old Lakeshore Road and Belvedere Drive. The section of the western channel within Coronation Park has a higher simulated flow conveyance capacity, however it can accept limited flows due to the backwater/tailwater impact to upstream areas (due to the shallow channel slopes).

7.1.1 Assessment of Sub-Alternatives

Based on the alternative assessment process (Table 6.2), two alternatives have been short-listed for the western channel: Alternative 10 (*New Drainage System Outlets/New Storm Sewers*) for the minor system, and Alternative 8 (*Modify Grading on Public Property*) for the major system. A number of potential sub-alternatives have been considered within these broader categories, and are shown on Drawing 11. The following summarizes the various sub-alternatives considered, and the reasons for recommending or excluding them:

<u>Alternative 10 (New Drainage System Outlets/New Storm Sewers)</u>

- *Alternative 10-3: New Storm Sewer along Third Line to Lake Ontario*
  - This alternative assumes a new trunk storm sewer along Third Line between Lakeshore Road and Lake Ontario, which would divert flows from the existing storm sewer at Third Line and Lakeshore Road.
  - Would require approximately 400 m of new storm sewer and road reconstruction; street not currently planned for roadworks (road appears to be in good condition).
  - Works would be partially against grade based on a review of the existing topography.
  - Would require a new outfall to Lake Ontario, which is typically discouraged.
  - Would divert an insufficient amount of flow; would divert only flows from Third Line and would not divert away flows from Tracina/Venetia Drive storm sewer and Walby Drive storm sewer. Flooding of west channel area would continue.
  - Based on the foregoing, this sub-alternative has been **screened from further consideration**.

- *Alternative 10-4: New Storm Sewer along Belvedere Drive to West Channel*
  - This alternative assumes a new trunk storm sewer along Lakeshore Road which collects storm drainage from the storm sewer along Third Line as well as the storm sewer from Tracina/Venetia Drive.
  - The storm sewer would then be directed south on Belevedere Drive before outletting to the west channel, which would avoid the need for a new storm sewer outfall to the Lake.
  - Would require approximately 380 m of new storm sewer and road reconstruction (300 m on Lakeshore Road, 80 m on Belvedere Drive); roadworks planned for Lakeshore Road (Class EA planned for 2016, roadworks tentatively planned for 2018) but no planned works on Belvedere Drive

- Would likely require channel works to ensure that the western channel has sufficient conveyance capacity and channel stability (erosion).
- This alternative would be beneficial to properties along section of west channel between Old Lakeshore Road and Belvedere Drive, but would continue to result in channel flooding for properties along section of west channel between Belvedere Drive and Coronation Park.
- Based on the foregoing, this sub-alternative has been **screened from further consideration.**

► *Alternative 10-5: New storm sewer along Belvedere Drive to Lake Ontario*
- This alternative is similar to Alternative 10-4, however instead of outletting to the west channel, the trunk sewer would carry flows further south along Belvedere Drive to Lake Ontario
- Would require an additional 320 m of storm sewer and road reconstruction beyond Alternative 10-4; no road reconstruction currently planned for Belvedere Drive (road appears to be in good condition).
- This additional section of storm sewer along Belvedere Drive would also be largely against grade.
- Would require a new outfall to Lake Ontario, which is typically discouraged.
- Although this alternative would be largely effective in reducing flows to the west channel, it would incur a high capital cost (given the extent of the works required on Belvedere Drive – no works currently planned by the Town of Oakville), could be difficult to design given existing grades, and would require a new storm sewer outfall which is typically discouraged given environmental concerns.
- Based on the foregoing, this sub-alternative has been **screened from further consideration**.

► *Alternative 10-6: New storm sewer to West Channel near Walby Drive*
- This alternative assumes a new trunk storm sewer along Lakeshore Road between Third Line and the western channel tributary to Coronation Park (i.e. at the point where the storm sewer from Walby Drive outlets).
- The new trunk storm sewer would collect flows from the existing storm sewers at Third Line, Tracina/Venetia Drive, and Walby Drive.
- Would require approximately 410 m of storm sewer and road reconstruction along Lakeshore Road, which could be done in parallel with the currently planned Lakeshore Road reconstruction (Lakeshore Road Class EA planned for 2016, roadworks tentatively planned for 2018).
- Would likely require an additional 110 m of storm sewer within Coronation Park to reach the existing storm sewer outfall location; this would be complicated by the proximity and density of existing vegetation.
- Would likely require channel works to ensure that the downstream section of the western channel has sufficient conveyance capacity and channel stability (erosion).
- Although this alternative would be largely effective in reducing flows to the majority of the west channel (flows diverted to the most downstream section), because of the shallow channel slopes, backwater from this alternative would still continue to cause flooding for upstream areas along the main branch of the western channel along Belvedere Drive.

  - Based on the foregoing, this sub-alternative has been **screened from further consideration.**

- *Alternative 10-7: New Storm Sewer to East Channel*
  - This alternative is similar to Alternative 10-6, however instead of outletting to the west channel, the trunk storm sewer would be extended some 120 m to the east along Lakeshore Road, and would outlet to the eastern channel within Coronation Park.
  - The construction work could all be done in parallel with the currently planned Lakeshore Road reconstruction (Class EA planned for 2016, roadworks tentatively planned for 2018).
  - The existing 900 mm storm sewer outfall from Walby Drive to the West Channel should be maintained as part of the new storm sewer system (with a suitable flow restrictor to ensure that the storm sewer is not surcharged under the 5-year storm event) in order to minimize the required size of storm sewers along Lakeshore Road, and the associated impact to the east channel.
  - Would require channel works to ensure that the eastern channel has sufficient conveyance capacity and channel stability (erosion); the channel would also likely need to be lowered from its existing grades in order to accommodate the typical depths for storm sewers.
  - This new storm sewer system would also be well-placed to accept storm sewer flows from any potential system along Westminster Drive (refer to Section 7.2 and Alternative 10-8), and would limit the amount of channel works within Coronation park (avoid works within west channel).
  - This alternative would be the most effective in reducing flows to the west channel and associated flooding to residences.
  - Based on the foregoing, this sub-alternative is recommended to be **carried forward**.

<u>Alternative 8 (Modify Grading on Public Property)</u>

- *Alternative 8-5: Channel Improvements to Western Channel within Coronation Park*
  - This alternative assumes channel improvements are made to the western channel within Coronation Park (i.e. increase conveyance capacity and channel stability (erosive resistance)).
  - Any improvements would be limited to public property (i.e. within Coronation Park) – unlikely that any improvements could be made further upstream (private property), and would be required to match grades at property line.
  - Given the flat grades within Coronation Park, and the need to match to existing grades at the property line, potential improvements to the western channel are limited.
  - Given that Alternative 10-7 (*New Storm Sewer to East Channel*) has been carried forward, there would be a significant flow reduction to the western channel, thus channel improvements are likely not warranted.
  - Based on the foregoing, this sub-alternative has been **screened from further consideration.**

- *Alternative 8-6: Channel Improvements to Eastern Channel within Coronation Park*
  - This alternative assumes channel improvements are made to the eastern channel within Coronation Park (i.e. increase conveyance capacity and channel stability (erosive resistance)).
  - Given that Alternative 10-7 (*New Storm Sewer to East Channel*) has been carried forward, channel improvements are considered necessary to accommodate the additional diverted flows.
  - The eastern channel is located within a more highly-trafficked area of Coronation Park, thus any channel works would need to consider existing structures and pathways.
  - Any channel expansion would also need to account for existing trees and vegetation; a complete inventory and vegetation management and landscaping plan would be required.
  - There may be the opportunity to incorporate LID/BMP measures into the proposed design; this should be considered further.
  - As per Alternative 10-7, given that the channel would likely need to be deepened to accommodate typical storm sewer depths, and widened to accept additional flows, the two existing pedestrian bridge crossings of the eastern channel within Coronation Park would also require replacement, which would incur additional costs.
  - Given that Alternative 10-7 has been carried forward, and based on the foregoing, this sub-alternative is recommended to be **carried forward.**

- *Alternative 8-8: Roadway Drainage Improvements Along Lakeshore Road*
  - This alternative involves major system drainage improvements along Lakeshore Road in order to better manage major flows and divert them to a suitable outlet (i.e. the eastern channel within Coronation Park) and away from the western channel.
  - Other areas of concern along Lakeshore Road further east (such as reported roadside drainage issues between Woodhaven Park Drive and Wolfdale Avenue) could also be addressed as part of this alternative
  - Such measures could easily be incorporated into the design work for the currently planned Lakeshore Road reconstruction (Class EA planned for 2016, roadworks tentatively planned for 2018).
  - For the purposes of the current study, it has been assumed that such improvements would take the form of a roadway urbanization (i.e. curb and gutter) to limit spills to the western channel. It has also been assumed that a continuous surface grade would be achieved towards the eastern channel in Coronation Park, which would also minimize spills towards side streets (Belvedere Drive in particular).
  - The opportunity for the implementation of LID/BMP measures should also be considered as part of the future Lakeshore Road Class EA study.
  - This alternative would be co-ordinated with Alternative 10-7 (*New Storm Sewer to Eastern channel*).
  - Given that Alternative 10-7 has been carried forward, and based on the foregoing, this sub-alternative is recommended to be **carried forward.**

Based on the foregoing, three (3) sub-alternative are recommended to be carried forward:

- Alternative 10-7 (New storm sewer to east channel)
- Alternative 8-6 (Channel improvements to eastern channel within Coronation Park)
- Alternative 8-8 (Roadway drainage improvements along Lakeshore Road)

In addition to the above recommended sub-alternatives, it is suggested that efforts be made to reduce the potential for debris blockages of the eastern channel to Lake Ontario. Based on discussions with Conservation Halton (CH), it is understood that CH is not in favour of any hard infrastructure (such as breakwalls) to prevent debris blockages. As such, it is recommended that the Town of Oakville continue its inspections and associated maintenance activities for the Lake Ontario outfalls within Coronation Park, particularly for the proposed modified eastern channel.

7.1.2 Preliminary Sizing and Costing

Using the proposed sub-alternatives, a preliminary sizing for the proposed Lakeshore Road trunk storm sewer has been conducted using PCSWMM. Based on the conducted modelling, a total length of 582 m of storm sewer along Lakeshore Road has been sized to convey the 5-year storm event without surcharging. Simulated pipe sizes range in size from 750 mm at Third Line, to 975 mm at Westminster Drive. A short section of 1350 mm diameter equivalent pipe (1730 x 1070 mm horizontal elliptical) would be required for the outlet to the eastern channel (i.e. sized to accommodate inflows from Westminster Drive as well). Based on the estimated surface grades, sub-standard pipe cover (i.e. less than 1.2 m) would be expected along Lakeshore Road, however this would need to be confirmed as part of a future detailed design. Horizontal elliptical pipe could be used where feasible to increase ground cover, as has been assumed for the outlet to the eastern channel. A short length of 675 mm diameter storm sewer has also been estimated to serve as a flow restrictor for inflows to the existing 900 mm storm sewer south of Lakeshore Road at the western limits of Coronation Park, in order to prevent simulated surcharging. As noted previously, an urbanized road section (i.e. curb and gutter) has been used along this section of Lakeshore Road, with major system flows being directed to the eastern channel.

For the purposes of estimating preliminary capital costs, the unit supply cost for storm sewers (2014 costing for 100D concrete pipe) has been multiplied by 3 for the length of each storm sewer section. The multiplier is used to cover the costs of installation and appurtenances (i.e. catchbasins and maintenance holes). Based on this approach, the following costs have been estimated:

- 18 m of 675 mm diameter storm sewer @ $730/m = $13,140
- 171 m of 750 mm diameter storm sewer @ $970/m = $165,870
- 121 m of 975 mm diameter storm sewer @ $1,550/m = $187,550
- 249 m of 1050 mm diameter storm sewer @ $1,780/m = $443,220
- 23 m of 1730 x 1095 mm horizontal elliptical storm sewer @ $3,450/m = $79,350
- **582 m of total storm sewer at an estimated cost of $890,000 (rounded)**

In addition to the foregoing, approximately 200 m of channel works would be required for the eastern channel within Coronation Park, including landscaping, and the installation of two (2) new pedestrian bridges, and the associated restoration of these pathways. An approximate cost of $1,000/m has been assumed for the channel works, along with a cost of $100,000 per pedestrian bridge. In addition, based on a preliminary sizing using PCSWMM, a triple box unit

(1.8 x 0.9 m box units embedded 0.3 m, resulting in an effective height of 0.6 m) would be required beneath the existing parking area. Using a similar methodology as has been employed for storm sewers (3x supply cost to account for installation and associated works), this would result in an approximate cost of $350,000. **Accordingly, there would be an approximate additional cost of $750,000 for the channel works (including 2 pedestrian bridges and a replacement of the existing parking lot crossing) within Coronation Park,**

Should LID/BMP measures be incorporated into the proposed design, there would potentially be an additional cost not accounted for by the above-noted estimate.

As per Section 7.1.1, it has also been recommended that the Town increase its inspection and maintenance activities for the outfalls to Lake Ontario within Coronation Park, in order to minimize debris blockages. The additional costs associated with this activity have not been accounted for as part of this assessment.

7.2 Westminster Drive

Westminster Drive is a rural-type roadway (ditches with driveway culverts) which runs in a north-south direction between Hixon Street and Lakeshore Road. As presented in Section 4, a number of drainage deficiencies have been identified along the roadway, including both simulated (i.e. deficient 400 mm diameter culvert (approximate size) at Lakeshore Road, high simulated ditch flow depths) and reported/observed issues with flooding, erosion, and standing water, deficient driveway culverts, etcetera.

7.2.1 Assessment of Sub-Alternatives

Based on the alternative assessment process (Table 6.3), Alternative 11 (Combinations) has been selected to address the identified deficiencies in both the minor and major drainage system. Within this combined alternative are three (3) individual alternatives, namely Alternative 2 (*Increase Size of Storm Sewers/Culverts*), Alternative 10 (*New Drainage System Outlets/New Storm Sewers*), and Alternative 8 (*Modify Grading on Public Property*). A number of potential sub-alternatives have been considered within these broader categories, and are shown on Drawing 11. The following summarizes the various sub-alternatives considered, and the reasons for recommending or excluding them:

<u>Alternative 2 (Increase Size of Storm Sewers/Culverts)</u>

- *Alternative 2-3: Culvert Upgrade at Lakeshore Road and Westminster Drive*
  - This alternative assumes an upgrade to the existing 400 mm diameter culvert (estimated size) which drains the existing ditches from Westminster Drive across Lakeshore Road to the east channel within Coronation Park.
  - As a stand-alone measure, this alternative would do little to address all of the identified drainage system deficiencies along Westminster Drive.
  - Given that both Alternatives 10-7 (*New Storm Sewer to East Channel*) and 8-6 (Channel improvements to eastern channel within Coronation Park) have been recommended to be carried forward, a new storm sewer outlet would be available on Lakeshore Road, which would make a full culvert upgrade unnecessary.
  - Further, if Alternative 10-8 (*New Storm Sewer along Westminster Drive to Eastern Channel*) is recommended to be carried forward, then a culvert upgrade is again unnecessary.

- Based on the foregoing, this sub-alternative has been **screened from further consideration.**

- *Alternative 2-5: Culvert Replacements Along Westminster Drive*
  - This alternative involves the replacement (and potential upsizing) of all of the deficient culverts along Westminster Drive (primarily driveway culverts).
  - Culvert replacements would be beneficial in preventing flow blockages due to crushed or damaged culverts, which can lead to localized flooding and ponding (not captured by the completed hydrologic/hydraulic modelling).
  - PVC culverts, potentially with headwall/endwall treatments are considered preferred based on cost and the lower probability of crushing.
  - It is unlikely that this would be considered as a stand-alone measure, but would be considered in combination as part of a road re-construction (as recommended in Section 6).
  - Based on the foregoing, and the assumption of a recommended road re-construction, this sub-alternative has been **carried forward.**

<u>Alternative 10 (New Drainage System Outlets/New Storm Sewers)</u>

- *Alternative 10-8: New Storm Sewer Along Westminster Drive to Eastern Channel*
  - This alternative involves the construction of a new storm sewer system along Westminster Drive, outletting to the east channel within Coronation Park.
  - A storm sewer system would be beneficial in reducing/eliminating standing water (regularly spaced inlets) as well as reducing ditch flooding depths.
  - Based on feedback from the public and Town staff, it is understood that it is preferred to maintain a rural road cross-section for Westminster Drive; thus a storm sewer system would likely be located beneath one of the roadside ditches with catchbasin manholes (with parallel catchbasins in the other ditch). This would be consistent with the approach applied for other area roadways (such as Walby Drive).
  - This alternative would be complimentary to previously recommended alternatives (Alternatives 10-7 – *New Storm Sewer to Eastern Channel*, and 8-6 – *Channel Improvements to Eastern Channel within Coronation Park*).
  - This alternative would also be complimentary to other Alternatives associated with a proposed roadway re-construction (Alternative 2-5 – *Culvert Replacements* and Alternative 8-9 – *Roadway Drainage Improvements*).
  - This alternative would also render Alternative 2-3 (*Culvert Upgrade at Lakeshore Road and Westminster Drive*) unnecessary, as noted previously.
  - Based on the foregoing, this sub-alternative has been **carried forward.**

<u>Alternative 8 (Modify Grading on Public Property)</u>

- *Alternative 8-9: Roadway Drainage Improvements Along Westminster Drive*
  - This alternative involves making roadway drainage improvements along Westminster Drive to improve major system flow conveyance (i.e. eliminating flat grades or sag points).
  - Continuous positive grades would be beneficial in reducing/eliminating standing water as well as reducing ditch flooding depths.

- As per Alternative 10-8, it is understood that it is preferred to maintain a rural road cross-section for Westminster Drive, thus roadway drainage improvements would likely take the form of improved ditch grading.
- As per Alternative 10-8, this sub-alternative would be complimentary to previously recommended alternatives as well as alternatives associated with a roadway re-construction.
- Based on the foregoing, this sub-alternative has been **carried forward.**

Based on the foregoing, three (3) sub-alternative are recommended to be carried forward:

- Alternative 2-5 (*Culvert Replacements Along Westminster Drive*)
- Alternative 10-8 (*New Storm Sewer Along Westminster Drive to Eastern Channel*)
- Alternative 8-9 (*Roadway Drainage Improvements Along Westminster Dr*ive)

7.2.2 Preliminary Sizing and Costing

Using the recommended sub-alternatives, a preliminary sizing for the proposed Westminster Drive storm sewer has been conducted using PCSWMM. Based on the conducted modelling, a total length of 487 m of storm sewer has been sized to convey the 5-year storm event without surcharging. Simulated pipe sizes range in sizing ranges from 300 mm diameter at Viewbank Crescent, to 675 mm diameter at Lakeshore Road.

Sub-standard pipe cover (i.e. less than1.2 m) could be expected in the area immediately upstream of Lakeshore Road, however this would need to be confirmed as part of a future detailed design. Horizontal elliptical pipe could be used where feasible to increase ground cover.

For the purposes of estimating preliminary capital costs, the unit supply cost for storm sewers (2014 costing for 100D concrete pipe) has been multiplied by 3 for the length of each storm sewer section. The multiplier is used to cover the costs of installation and appurtenances (i.e. catchbasins and maintenance holes). Based on this approach, the following costs have been estimated:

- 56 m of 300 mm diameter storm sewer @ $230/m = $12,880
- 136 m of 375 mm diameter storm sewer @ $280/m = $38,080
- 80 m of 450 mm diameter storm sewer @ $290/m = $23,200
- 92 m of 525 mm diameter storm sewer @ $370/m = $34,040
- 123 m of 675 mm diameter storm sewer @ $730/m = $89,790
- **487 m of total storm sewer at an estimated cost of $200,000 (rounded)**

In addition to the foregoing, approximately 36 private driveway culverts would require replacement as part of these works, along with 4 roadway culverts (Alternative 2-5), assuming the entire length of Westminster Drive is to be re-constructed. The same approach to the cost estimation for storm sewers has again been employed, assuming all driveway culverts are 450 mm diameter units in order to be conservative. Roadway culverts have been all considered to be 600 mm diameter units in order to be conservative as well; these sizes would need to be assessed further as part of detailed design.

- 36 driveway culverts at 8 m length and 450 mm diameter @ $290/m = $83,520
- 4 roadway culverts at 20 m length and 600 mm diameter @ $480/m = $38,400
- **34 total culvert replacements at an estimated cost of $130,000 (rounded)**

Lastly, ditch re-grading works (Alternative 8-9) would be required as part of the proposed works. This would involve the re-grading of approximately 600 m of ditching (both sides), assuming the re-construction works were extended from Hixon Street to Lakeshore Road. Given the relatively simple sections involved with ditch grading, it has been assumed that a lower unitary cost of $500/m would be appropriate (both sides). **This results in a total estimated cost for ditch re-grading of $300,000.**

Accounting for all of the above-noted components, a total cost of $630,000 has been estimated for the overall construction works.

7.3 Woodhaven Park Drive

Woodhaven Park Drive is a rural-type roadway (ditches with driveway culverts) which runs in a north-south direction between Sedgewick Crescent and Lakeshore Road. As presented in Section 4, a number of drainage deficiencies have been identified along the roadway, including both simulated (i.e. undersized culvert outlet downstream on the WWTP property) and reported/observed issues with flooding, erosion, and standing water, deficient driveway culverts, etcetera.

7.3.1 Assessment of Sub-Alternatives

Further to the alternative assessment process (Table 6.3), Alternative 11 (*Combinations*) has been selected to address the identified deficiencies in both the minor and major drainage system. Within this combined alternative are three (3) individual alternatives, namely Alternative 2 (Increase Size of Storm Sewers/Culverts), Alternative 10 (*New Drainage System Outlets/New Storm Sewers*), and Alternative 8 (*Modify Grading on Public Property*). A number of potential sub-alternatives have been considered within these broader categories, and are shown on Drawing 11.

The following summarizes the various sub-alternatives considered, and the reasons for recommending or excluding them:

<u>Alternative 2 (Increase Size of Storm Sewers/Culverts)</u>

- *Alternative 2-4: Culvert Upgrade at WWTP Property (From Woodhaven Park Drive)*
    - This alternative proposes an upgrade to the recently constructed 300 mm diameter PVC outlet on the WWTP property which then connects to the existing 600 mm diameter storm sewer outlet to Lake Ontario through the parking area within Coronation Park.
    - Based on the size of the upstream and downstream storm sewers (600 mm diameter) this culvert would appear to be undersized.
    - Given the recent construction in this area, it is unclear why only a 300 mm diameter culvert was specified.
    - Given that construction in this area was only recently completed (2014), and the property belongs to Halton Region, it is unclear how easy it would be to re-construct and upgrade.
    - Given that the culvert is on private property (as is the upstream section of storm sewer from Woodhaven Park Drive), an alternate outlet located entirely within Town property would be preferred (reference Alternative 10-9 or 10-10).
    - Based on the foregoing, this sub-alternative has been **screened from further consideration.**

- *Alternative 2-6: Culvert Replacements Along Woodhaven Park Drive (ref. Appendix 'E' for update)*
    - This alternative involves the replacement and potential upsizing of all of the deficient culverts (primarily driveway culverts) along Woodhaven Park Drive.
    - Culvert replacements would be beneficial in preventing flow blockages due to crushed or damaged culverts, which can lead to localized flooding and ponding (not captured by the completed hydrologic/hydraulic modelling).
    - PVC culverts, potentially with headwall/endwall treatments are considered preferred based on cost and the lower probability of crushing.
    - It is unlikely that this would be considered as a stand-alone measure, but would be considered in combination as part of a road re-construction (as recommended in Section 6).
    - Based on the foregoing, and the assumption of a recommended road re-construction, this sub-alternative has been **carried forward.**

<u>Alternative 10 (New Drainage System Outlets/New Storm Sewers)</u>

- *Alternative 10-9: New Storm Sewer Along Woodhaven Park Drive to Eastern Channel*
    - This alternative involves the construction of a new storm sewer system along Woodhaven Park Drive, then west along Lakeshore Road, ultimately outletting to the east channel within Coronation Park.
    - A storm sewer system would be beneficial in reducing/eliminating standing water (regularly spaced inlets) as well as reducing ditch flooding depths.
    - Based on feedback from the public and Town staff, it is understood that it is anticipated to maintain a rural road cross-section for Woodhaven Park Drive; thus a storm sewer system would likely be located beneath one of the roadside ditches with catchbasin manholes (with parallel catchbasins in the other ditch). This would be consistent with the approach applied for other area roadways (such as Walby Drive).
    - This alternative would also be complimentary to other Alternatives associated with a proposed roadway re-construction (Alternative 2-6 – *Culvert Replacements* and Alternative 8-10 – *Roadway Drainage Improvements*).
    - This alternative would also render Alternative 2-4 (*Culvert Upgrade at WWTP*) unnecessary, which would be beneficial in eliminating storm sewers and culverts on private property.
    - Outletting to the east channel would necessitate an additional 240 m length of storm sewer construction on Lakeshore Road, and would add additional diverted flows to the east channel (which would in turn require a wider channel within Coronation Park which would impact upon park usage).
    - Based on the foregoing, this sub-alternative has been **screened from further consideration.**

- *Alternative 10-10: New Storm Sewer Along Woodhaven Park Drive to Existing Storm Sewer (Parking Lot at East End of Coronation Park) (ref. Appendix 'E' for update)*
    - This alternative would be similar to Alternative 10-9, however rather than outletting to the east channel, this alternative would outlet to the location of the existing storm sewer outfall to the east (parking lot at east end of Coronation Park).
    - This alternative would necessitate less storm sewer construction along Lakeshore Road (90 m), which would be more cost-effective, and could be combined with the proposed future works along Lakeshore Road (Class EA planned for 2016). The existing 600 mm storm sewer outlet would however require upgrading to accommodate the additional flows from the proposed Woodhaven Park Drive storm sewer system, which would require modifying the existing outfall.
    - This alternative would eliminate any direct impacts to the east channel within Coronation Park, which based on discussion with Town staff is preferred.
    - Based on the foregoing, this sub-alternative has been **carried forward.**

Alternative 8 (Modify Grading on Public Property)

- *Alternative 8-10: Roadway Drainage Improvements Along Woodhaven Park Drive (ref. Appendix 'E' for update)*
    - This alternative includes roadway drainage improvements along Woodhaven Park Drive to improve major system flow conveyance (i.e. eliminating flat grades or sag points).
    - Continuous positive grades should be beneficial in reducing/eliminating standing water as well as reducing ditch flooding depths.
    - As per Alternative 10-10, it is understood that it is preferred to maintain a rural road cross-section for Woodhaven Park Drive, thus roadway drainage improvements would likely take the form of improved ditch grading.
    - As per Alternative 10-10, this sub-alternative would be complimentary to previously recommended alternatives as well as alternatives associated with a roadway re-construction.
    - Based on the foregoing, this sub-alternative has been **carried forward.**

Based on the foregoing, three (3) sub-alternative are recommended to be carried forward:

- Alternative 2-6 (*Culvert Replacements along Woodhaven Park Drive)*
- Alternative 10-10 (*New Storm Sewer along Woodhaven Park Drive to Existing Storm Sewer (Parking Lot at East End of Coronation Park))*
- Alternative 8-10 (*Roadway Drainage Improvements along Woodhaven Park Drive*)

7.3.2 Preliminary Sizing and Costing

Using the recommended sub-alternatives, a preliminary sizing for the proposed Woodhaven Park Drive storm sewer has been conducted using PCSWMM (ref. Appendix 'E' for upate). As per the conducted modelling, a total of 380 m of storm sewer have been sized to convey the 5-year storm event without surcharging. Simulated pipe sizes range in size from 300 mm at Selgrove Crescent, to 750 mm at the outlet to Lake Ontario, thus the estimated pricing would include works along not only Woodhaven Park Drive, but also Lakeshore Road and within Coronation Park. Note that the storm sewer system could be extended further north along

Woodhaven Park Drive, however additional costs would be incurred, and have not been included in the current assessment.

Using the estimated surface grades, sub-standard pipe cover (i.e. less than 1.2 m) could be expected in the area immediately upstream of Lakeshore Road, however this would need to be confirmed as part of a future detailed design. Horizontal elliptical pipe could be used where feasible to increase ground cover.

For the purposes of estimating preliminary capital costs, the unit supply cost for storm sewers (2014 costing for 100D concrete pipe) has been multiplied by 3 for the length of each storm sewer section. The multiplier is used to cover the costs of installation and appurtenances (i.e. catchbasins and maintenance holes). Based on this approach, the following costs have been estimated:

- 68 m of 300 mm diameter storm sewer @ $230/m = $15,640
- 60 m of 375 mm diameter storm sewer @ $280/m = $16,800
- 163 m of 600 mm diameter storm sewer @ $480/m = $78,240
- 89 m of 750 mm diameter storm sewer @ $970/m = $86,330
- **380 m of total storm sewer at an estimated cost of $200,000 (rounded)**

Note that if the proposed storm sewer works were extended further along Woodhaven Park Drive (i.e. north of Selgrove Drive) additional costs would be incurred.

In addition to the foregoing, approximately 35 private driveway culverts would require replacement as part of these works, along with 2 roadway culverts (Alternative 2-6), assuming the entire length of Woodhaven Park Drive is to be re-constructed. The same approach to the cost estimation for storm sewers has again been employed, assuming all driveway culverts are 450 mm diameter units in order to be conservative. Roadway culverts have been all considered to be 600 mm diameter units in order to be conservative as well; these sizes would need to be assessed further as part of detailed design.

- 35 driveway culverts at 8 m length and 450 mm diameter @ $290/m = $81,200
- 2 roadway culverts at 20 m length and 600 mm diameter @ $480/m = $19,200
- **34 total culvert replacements at an estimated cost of $110,000 (rounded)**

Lastly, ditch re-grading works (Alternative 8-10) would be required as part of the proposed works. This would involve the re-grading of approximately 500 m of ditching (both sides), assuming the re-construction works were extended from Hixon Street to Lakeshore Road. Given the relatively simple sections involved with ditch grading, it has been assumed that a lower unitary cost of $500/m would be appropriate (both sides). **This results in a total estimated cost for ditch re-grading of $250,000.**

Accounting for all of the above-noted components, a total cost of $560,000 has been estimated for the overall construction works (ref. Appendix 'E' for update).

7.4 Oakville Christian School Channel

Currently, there is a section of open channel which is located between Thornlea Park and the Oakville Christian School, which drains in a southerly direction from Salvator Boulevard to Lakeshore Road West (along the west side of 2033 Lakeshore Road West). Previously, this channel served a storm sewer outfall from Salvator Boulevard. However, in July 2008, as part of the overall road reconstruction works along Third Line, a new storm sewer system was installed on Salvator Boulevard between Spencer Road and Third Line, which was then connected into the new storm sewer system on Third Line. This diversion eliminated the majority of the inflows to the Oakville Christian School Channel, beyond local (overland) drainage. However, it is understood that the channel continues to experience standing water as well as erosion.

The drainage system deficiency is particularly pronounced for the section of channel adjacent to 2033 Lakeshore Road. As per the background review, it is understood that the Town of Oakville holds an easement over the section of channel adjacent to 2033 Lakeshore Road West. The easement was offered to the Town (and subsequently accepted) by the homeowner in March 2008 (which preceded the upstream storm sewer diversion along Salvator Boulevard). The current homeowners have reported ongoing erosion and standing water through this area, despite the upstream diversion.

7.4.1 Assessment of Sub-Alternatives

The overall alternative assessment process described in Section 6 was not conducted for this drainage issue, as it was considered that the available alternatives were much more limited in this case, such that the overall alternative assessment process was not warranted. The following summarizes the various sub-alternatives considered, and the reasons for recommending or excluding them:

- *Alternative 10-1: New Storm Sewer adjacent to 2033 Lakeshore Road West*
    - This alternative would involve the construction of a new section of storm sewer adjacent to 2033 Lakeshore Road West (through the Town-held easement), in combination with a ditch inlet within the channel upstream, and local grading modifications to ensure flow is collected by the new storm sewer system.
    - Based on a review of the existing ditch grading, it is not feasible to install a storm sewer system with sufficient ground cover and be able to outlet to the existing ditch system along Lakeshore Road West.
    - This would therefore necessitate a new storm sewer system along Lakeshore Road, which would incur additional construction costs and disruption.
    - Based on a review of site photographs and aerial mapping, the area in question is well vegetated with large diameter trees throughout. The installation of a storm sewer in this area is considered problematic, and would be disruptive to the established vegetation.
    - Based on the foregoing, this alternative has been **screened from further consideration.**

- *Alternative 10-2: New Storm Sewer through Oakville Christian School*
    - This alternative would involve the construction of a new section of storm sewer between the existing channel at the north property limit of 2033 Lakeshore Road West, and the existing storm sewer along Third Line (i.e. west-east storm sewer alignment).
    - Similar to Alternative 10-1, a ditch inlet would be required along with local grading modifications to ensure that channel flows were collected by the new storm sewer system.
    - There is a section of existing 750 mm diameter storm sewer (and a well-positioned maintenance hole) available within the edge of the right-of-way along

Third Line; a connection to this location would be ideal as this section of storm sewer does not currently receive any flows from upstream areas (old section of storm sewer which was left in place as part of the Third Line reconstruction works – a parallel section of new storm sewer was constructed which the old section ultimately connects to). No works would therefore be required within the roadway, only along the sidewalk area.
  - The proposed storm alignment would eliminate the need for any disruption to the existing vegetation along 2033 Lakeshore Road West.
  - The storm sewer would be located on private property (Oakville Christian School), which is typically not preferred; an agreement (and potentially compensation) would be required, which may not be forthcoming.
  - It is understood that the Oakville Christian School is proposing an expansion in the area of the potential storm sewer, which would likely further complicate reaching an agreement (i.e. future maintenance access). Based on the foregoing, this sub alternative has been **screened from further consideration.**
- *Alternative 8-12: Channel Improvements adjacent to 2033 Lakeshore Road West*
  - This alternative would follow the same pathway as Alternative 10-1 (*New Storm Sewer adjacent to 2033 Lakeshore Road West*), and would utilize the Town-held easement, but would implement surface grading (i.e. channel improvements and re-grading) rather than a storm sewer to eliminate standing water and limit future erosion.
  - This would facilitate match existing grades at both the upstream and downstream limits of the channel, and would eliminate the need for additional works along Lakeshore Road (as was noted for Alternative 10-1).
  - Channel improvements would likely be a lower cost alternative than the implementation of a storm sewer (Alternative 10-1).
  - Chanel improvements would be expected to be less disruptive to the existing vegetation community at 2033 Lakeshore Road West, and could be designed to limit any potential impacts.
  - Based on the foregoing, this alternative has been **carried forward.**

7.4.2 Preliminary Sizing and Costing

Approximately 60 m of channel improvements would be required for the identified channel deficiencies adjacent to 2033 Lakeshore Road West. An approximate cost of $1,000/m has been assumed for the channel improvements. **Accordingly, there would be an estimated cost of $60,000 for the recommended channel improvements adjacent to 2033 Lakeshore Road West.**

7.5 Tracina Drive and Venetia Drive Area

A number of drainage deficiencies (both simulated and reported) have been noted in the area of Tracina Drive and Venetia Drive. These include a simulated deficient culvert beneath the pedestrian pathway between Tracina and Venetia Drive, as well as a simulated deficient section of storm sewer between Tracina and Venetia Drive (further south). In addition, deficient overland flow capacity has been simulated for the two sag points on Tracina Drive and Venetia Drive respectively, primarily due to the lack of a defined overland flow route for flow accumulated within the sag point.

7.5.1 Assessment of Sub-Alternatives

The following summarizes the various sub-alternatives considered, and the reasons for recommending or excluding them:

- *Alternative 2-1: Culvert Upgrade Beneath Pathway (Between Tracina Drive and Venetia Drive)*
    - This alternative would involve the upgrade of the existing 300 mm diameter culvert (estimated size) beneath the pedestrian pathway between Tracina Drive and Venetia drive.
    - This would improve the conveyance capacity through this area and potentially minimize any upstream standing water or other drainage deficiencies.
    - The Town only owns the pathway in this area (3 m width). Utilities hold an easement over the upstream section of rear-yard channel (3.5 m width). Neither the Town nor any utilities appear to hold an easement over the channel on the downstream side of the pathway. As such there may be some issues with respect to construction access and permission from private landowners.
    - PVC culverts, potentially with headwall/endwall treatments are considered preferred based on cost and the lower probability of crushing
    - Based on the limited available topography data for this area, obtaining sufficient ground cover (minimum of 0.6 m typically for loading; 1.2 m typically preferred for frost protection) will likely be challenging. As such, twinning may be preferred. Given that the pathway is subject to pedestrian loading only (no vehicles) a lesser ground cover may be acceptable, however the pathway could still be subject to small vehicle loading (i.e. snow clearing). This should be further assessed at the detailed design stage.
    - Upgrading the culvert would also provide the opportunity to make some minor channel improvements immediately upstream (and potentially downstream) of the culvert.
    - Based on the foregoing, this alternative has been **carried forward.**

- *Alternative 2-2: Storm Sewer Upgrade Between Tracina Drive and Venetia Drive and Alternative 8-14: Major System Improvements Between Tracina Drive and Venetia Drive.*
    - This alternative would involve the upgrade of the existing 450 mm diameter storm sewer between Tracina Drive and Venetia Drive which has been identified as deficient (simulated surcharging for the 5-year storm event), as well as major system improvements (re-grading) along the same pathway in order to reduce roadway ponding along Tracina Drive.
    - The proposed storm sewer upgrade would be intended to eliminate simulated surcharging under a 5-year storm event, with some associated benefits to upstream roadway ponding. The associated major system improvements would be intended to more directly reduce major system ponding under more formative events (100-year storm).
    - The Town of Oakville does hold an easement through this area, however the works would clearly need to be coordinated with the adjacent landowners.
    - A further review of the modelling results indicates that the identified storm sewer surcharging is largely due to the storm sewer connection details; specifically, tailwater levels from the much larger downstream storm sewer (1200 mm

diameter). The existing 450 mm diameter storm sewer is only slightly over the theoretical full-flow capacity (3%) for the 5-year storm event.
- This suggests that a storm sewer upgrade would likely be of limited value, unless the pipe could be raised significantly at the downstream limits to eliminate tailwater impacts. Based on the review of existing grading, it is unlikely that this could be completed while maintaining minimal ground cover requirements, particularly at the existing CBMH between Tracina Drive and Venetia Drive.
- It should be noted that some of the storm sewer inverts have been estimated, given the lack of available data (the Town was unable to survey the existing CBMH between Tracina Drive and Venetia Drive), however the overall modelling results and findings noted are still considered to be reasonable.
- Based on a review of the existing topography and grades, there is an existing low point between Tracina Drive and Venetia Drive (CBMH) which cannot be re-graded; as such major system improvements are not considered feasible (any improvements would simply increase rear-yard ponding and could not provide a defined outlet to Venetia Drive).
- There have also been no reported instances of roadway flooding in this location.
- Based on the foregoing, this combination of alternatives has been **screened from further consideration.**

- *Alternative 8-15: Major System Improvements Between Venetia Drive and Lakeshore Road.*
  - This alternative would involve making major system improvements (re-grading) between Venetia Drive and Lakeshore Road in order to reduce simulated major system ponding along Venetia Drive.
  - These works would be located on private property (area between two existing residences); the Town of Oakville does hold an easement over this area (for the storm sewer below), however the works would clearly need to be coordinated with the affected landowners.
  - Although the grades along Lakeshore Road are lower than those along Venetia Drive, there appears to be split lot grading, which would likely make the grading of a defined continuous overland flow route between the existing homes difficult.
  - There have also been no reported instances of roadway flooding in this location.
  - Based on the foregoing, this alternative has been **screened from further consideration.**

7.5.2 Preliminary Sizing and Costing

A preliminary sizing has been conducted for the recommended solution (*Alternative 2-1: Culvert Upgrade Beneath Pathway (Between Tracina Drive and Venetia Drive)* using PCSWMM. As per the conducted modelling, it is suggested that twin 300 mm culverts (preferably PVC, with an end treatment to improve inlet capacity) be installed in order to adequately convey the 5-year storm event. However, this preliminary sizing should be revisited as part of a future detailed design process, based on a detailed site survey in order to assess site constraints. A larger/wider sizing could also be considered if a higher level of service is preferred (i.e. 10-year storm or above), however it is expected that sub-standard pipe cover (likely less than the typical minimum of 0.6 m) would be encountered in this location.

Based on the preliminary modelling, the culvert capacity would also be expected to be impacted by backwater from the downstream swale; as part of a future detailed design, this swale should be assessed in greater detail to assess potential improvements, including making grading modifications on both the upstream and downstream side of the culvert to improve inlet capacity and reduce flow depths.

For the purposes of estimating preliminary capital costs, the unit supply cost for 300 mm diameter storm sewer (2014 costing for 100D concrete pipe) has been multiplied by 3 for the length of required culvert. The multiplier is used to cover the costs of installation and other related works and appurtenances, consistent with the approach applied for the cost estimates for storm sewers. It should be noted that clearly appurtenances would not be required in this case (and that likely PVC pipe would be applied rather than concrete), however given the short length of culvert involved, the approach is considered to be reasonable.

In addition to the estimation of costs associated with the culvert replacement itself, it has been assumed that channel grading works would be undertaken for approximately 5 m +\- on both the upstream and downstream sides of the culvert. Given that this feature is a minor swale, a unit cost of $500/m has been assumed.

Based on this approach, the following costs have been estimated:

- 5 m (x2) of 300 mm diameter storm sewer @ $230/m = $2,300
- 10 m of channel re-grading work @ $500/m = $5,000

The estimated costs likely do not account for some of the difficulties associated with accessing this location (narrow fenced pathway) and some of the restoration costs. Accordingly, the estimated costs have been doubled for the purposes of the current estimate. **Therefore, there is a total estimated cost of $20,000 (rounded) for the proposed culvert replacement.**

7.6 Walby Drive Area

Based on the results of the completed modelling, overland drainage deficiencies have been simulated along Walby Drive from north of Talbot Drive to Venetia Drive. Under the 100-year storm event, the model results indicate flows would be expected to exceed ditch capacity, but would be contained below the crown of the roadway. No instances of flooding or other drainage deficiencies have been reported along this section however.

In addition, rear-yard ponding, standing water, and flow blockages have been noted for the section of rear-yard swale between Walby Drive and Westminster Drive (north of Warland Road) – refer to Section 4.1.10. These issues appear to be located entirely within private property (rear-yards of residences fronting on both Walby Drive and Westminster Drive).

7.6.1 Assessment of Sub-Alternatives

The following summarizes the various sub-alternatives considered, and the reasons for recommending or excluding them:

- *Alternative 8-2: Roadway Drainage Improvements along Walby Drive*
    - This alternative would involve making major system (roadway) drainage improvements along Walby Drive, such as re-grading ditches, and potentially widening/deepening where required to improve conveyance capacity.
    - These works would all be within Town property (right-of-way).
    - Any significant re-grading would likely impact the existing storm sewer system and associated catchbasin grate elevations, as well as the elevations of existing roadway and driveway culverts, which could be problematic and limit the extent to which re-grading could be considered.
    - Any ditch deepening would likely be problematic to residents, given the need to avoid overly steep slopes to maintain ditches (grass cutting).
    - There have been no instances of reported flooding along Walby Drive; further, the simulated results indicate depths would exceed the ditch capacity, but would be contained below the roadway crown.
    - There may however be issues related to filled ditches or crushed driveway culverts which would increase expected flooding depths, and could lead to flooding above the roadway crown or increased flooding on private property.
    - However, it is recommended that such deficiencies are best addressed as part of a specific overall operations and maintenance plan (refer to Section 8.3.)
    - Based on the foregoing, this alternative has been **screened from further consideration.**

- *Alternative 8-3: Divert Major Flows from Walby Drive to Westminster Drive via Warland Road*
    - This alternative would involve the diversion of major flows from Walby Drive (i.e. ditch flows) to Westminster Drive via Warland Road in order to reduce flows along Walby Drive, and thus, expected flooding depths.
    - This alternative would likely necessitate grading works on all three sections of roadway, which would be more extensive and more costly.
    - This alternative assumes that Westminster Drive has sufficient capacity to accept additional flows; based on the number of reported drainage deficiencies along Westminster Drive and the simulated results, there is insufficient capacity along Westminster Drive to accept additional flows.
    - Based on the foregoing, this alternative has been **screened from further consideration.**

- *Alternative 8-4: Divert Major Flows from Walby Drive to Westminster Drive via Trenton Road*
    - This alternative is similar to Alternative 8-3 (*Divert Major Flows from Walby Drive to Westminster Drive via Warland Road)* but would involve the diversion of major flows from Walby Drive (i.e. ditch flows) to Westminster Drive via Trenton Road instead, for the same reason (in order to reduce flows along Walby Drive, and thus, expected flooding depths).
    - This alternative would again likely necessitate grading works on all three sections of roadway, which would be more extensive and more costly.

- This alternative again assumes that Westminster Drive has sufficient capacity to accept additional flows; based on the number of reported drainage deficiencies along Westminster Drive and the simulated results, there is insufficient capacity along Westminster Drive to accept additional flows.
- By diverting flows at Trenton Road (downstream location - first roadway upstream of Lakeshore Road), the relative benefit to flood reduction along Walby Drive is considered minimal.
- Based on the foregoing, this alternative has been **screened from further consideration.**

- *Alternative 8-16: Major System Improvements for Rear-Yard Swale between Walby Drive and Westminster Drive*.
  - This alternative would involve making major system improvements (re-grading) for the existing rear-yard swale between Walby Drive and Westminster Drive (between Hixon Street and Warland Road) in order to attempt to minimize drainage deficiencies related to flow blockages and standing water, and improve conveyance.
  - This alternative is entirely along private property, involving up to 20 separate homeowners.
  - Utilities hold a small easement for the majority of the rear-yard area, however the easement is extremely narrow (1.2 m) and terminates some 50 m +\- north of Warland Road. This easement does however continue in an easterly direction towards Westminster Drive from this point between two existing residences (50 m +\- north of Warland Road).
  - Given that no significant flooding has been reported, and the expected difficulty in accessing and undertaking works along private property with a high number of separate homeowners, this alternative has been **screened from further consideration.**

7.6.2 Preliminary Sizing and Costing

None of the previously assessed sub-alternatives have been recommended to be carried forward. As such, preliminary sizing and costing has not been required.

7.7 Sedgewick Forest Area

7.7.1 Assessment of Sub-Alternatives

In this case, only a single alternative (8-7) was considered, since the problem in this case is considered to have a clear and obvious solution, namely to re-grade the reverse sloped outfall channel within Sedgewick Forest to provide positive drainage. This alternative could be implemented relatively easily, as the area surrounding the channel is relatively open, and is owned by the Town of Oakville. The channel ultimately outlets into a wooded area surrounding the Wastewater Treatment Plant property (where there is an observable drop in the channel); however based on an initial review it appears the limits of grading could be restricted to Town property. This would need to be addressed as part of a detailed design process to determine an optimal outfall profile which minimizes any potential impacts.

Given the availability of space and ownership, opportunities for LID/BMP measures could be considered, in order to minimize downstream erosion and provide water quality and water balance benefits (infiltration).

In addition to the foregoing, some moderate ditch erosion has been noted just to the east of the existing storm sewer outfall (ref. Table 4.7). It is recommended that this deficiency be addressed as part of the recommended works.

Based on the foregoing, Alternative 8-7 (*Re-Grade Reverse Sloped Outfall Channel within Sedgewick Forest*) is recommended to be carried forward.

7.7.2 Preliminary Sizing and Costing

Approximately 180 m of channel re-grading would be required, assuming that the tie-in point would be just upstream of Halton Region's WWTP property. An approximate cost of $1,000/m has been assumed for the channel improvements. **Accordingly, there would be an estimated cost of $180,000 for the recommended alternative (*Re-Grade Reverse Sloped Outfall Channel within Sedgewick Forest).*** Additional costs would potentially be incurred to include LID/BMP measures into the proposed design.

7.8 Wales Crescent Area

7.8.1 Assessment of Sub-Alternatives

Based on discussions with local residents at PIC No. 2, it is understood that there have been repeated instances of standing water within roadside ditches along Wales Crescent. Only a single alternative (8-13) was considered in this case, since the problem in this case is considered to have a clear and obvious solution, namely to re-grade the ditches in this area to improve roadside drainage and eliminate standing water. These works could all be completed within public property (i.e. the right-of-way), however consideration would need to be given to the grades of existing driveway culverts as well as the ditch inlets/catchbasins located at the downstream end of the street. It is recommended that a further field investigation be conducted, in order to better assess whether or not grading improvements could be made directly, or whether or not a detailed design process is warranted in this case.

Opportunities for LID/BMP measures could also be considered as part of any re-grading works, in order to better promote infiltration to reduce instances of standing water, and reduce depths of water during more formative storm events.

Based on the foregoing, Alternative 8-13 (*Re-Grade Roadside Ditches along Wales Crescent*) is recommended to be carried forward.

7.8.2 Preliminary Sizing and Costing

Based on the locations of reported ditch drainage deficiencies, approximately 100 m of ditches (both sides of Wales Crescent) would require re-grading. However, if the entire section of contributing ditching (to the high point along Wales Crescent) were to be included in order to be consistent, approximately 270 m of ditching would be required. For the purposes of generating a budgetary estimate, it has been conservatively assumed that the entire section of ditching (270 m – both sides) would be included.

Given the relatively simple sections involved with ditch grading, it has been assumed that a lower unitary cost of $500/m would be appropriate. **Based on the conservative assumption of the entire 270 m of Wales Crescent being re-grading, this would result in a total cost of $140,000 (rounded).**

It is considered likely that additional costs related to driveway culvert replacements and associated restoration works would also be incurred. **As such, it is suggested that for budgetary purposes, the estimated ditch re-grading costs be doubled, with a total overall cost of $280,000 (rounded) for Alternative 8-13 (Re-Grade Roadside Ditches along Wales Crescent).** As noted, should the limits of work be restricted to only the most downstream area, the estimated costs would be correspondingly less (approximately $100,000). Additional costs would potentially be occurred if LID/BMP measures were to be considered (and would likely require participation from private homeowners).

7.9 Third Line Area

7.9.1 Assessment of Sub-Alternatives

Only a single alternative (8-1) was considered in this location, since the problem in this case is considered to have a clear and obvious solution, namely to attempt to re-grade the roadway or make other major system improvements to an existing sag point along Third Line (between Seafare Drive and Salvator Boulevard) to reduce simulated roadway ponding (100 year storm). Such works could be completed within public property (i.e. the right-of-way). However, given that this section of Third Line was only recently reconstructed (2008) by the Town of Oakville, this would be a low priority item to be completed by the Town of Oakville, particularly given that there have been no reported instances of flooding at this location.

Based on the foregoing, Alternative 8-1 (*Major System Improvements along Third Line between Seafare Drive and Salvator Boulevard*) has been screened from further consideration.

7.9.2 Preliminary Sizing and Costing

The previously assessed sub-alternative has been screened from further consideration. As such, preliminary sizing and costing has not been required.

7.10 Sandwell Drive and Tweedsdale Crescent Area

7.10.1 Assessment of Sub-Alternatives

For this location, only a single alternative (8-11) was considered, since the problem in this case is considered to have a clear and obvious solution, namely to attempt to undertake roadway drainage improvements along Sandwell Drive and Tweedsdale Crescent to reduce simulated roadway ponding (100 year storm). The modelling results in this area indicate 100-year depths are outside of the ditch in this area, but are still contained below the roadway crown, which suggests that vehicle ingress/egress would not be impacted. There have also been no reported instances of flooding in this location. Accordingly, it is considered that roadway drainage improvements in this area would be a lower priority for the Town of Oakville.

Based on the foregoing, Alternative 8-11 (*Roadway Drainage Improvements along Sandwell Drive and Tweedsdale Crescent*) has been screened from further consideration.

7.10.2 Preliminary Sizing and Costing

The previously assessed sub-alternative has been screened from further consideration. As such, preliminary sizing and costing has not been required.

7.11 Other areas

A number of other, more local drainage deficiencies have been noted for the Coronation Park Community (ref. Section 4 and Drawing 6). These deficiencies include both within Town lands (such as filled in ditches, crushed culverts, and standing water within ditches) as well as issues on private lands (typically rear-yard ponding). It is not considered feasible to provide a detailed alternative assessment for each of these identified deficiencies as part of the current study. In general, these issues are likely best addressed on a case by case basis by the Town of Oakville's Maintenance staff. It is also suggested that many of the commonly noted deficiencies with respect to rural and semi-urban roadways (i.e. filled in ditches and crushed driveway culverts) could be best addressed by operations and maintenance activities. In some cases where the issues are located primarily or entirely on private land, these issues may also be best addressed by the private homeowner, in co-operation with the Town of Oakville.

7.12 Simulated Impact of Recommended Measures

An updated assessment of the overall drainage system performance with all of the recommended measures in place (as shown in Drawing 12) has been conducted by modifying the previously developed existing conditions hydrologic/hydraulic modelling (PCSWMM). A conceptual design has also been undertaken for the proposed works for the eastern channel within Coronation Park (Alternative 8-6). This design is shown in Drawing 15, and has been incorporated into the updated hydrologic/hydraulic modelling (PCSWMM).

A detailed results summary which compares the differences in minor system performance under both the 5-year and 100-year storm events is presented in Table 7.2 (in areas where recommendations have been made). Table 7.3 and Table 7.4 compare the differences in the major system performance (roadways and surveyed open channel sections respectively) for the 5-year and 100-year storm events. Appendix 'E' Tables 2.1 and 2.2 provide updates for specific conduits. Graphical summaries are also presented in Drawings 13 and 14 (attached). As evident, significant improvements to the drainage system performance are simulated with the recommended alternatives in place.

One notable exception to this overall improvement would be the existing sag point along Venetia Drive under a 100-year storm event, as presented in Table 7.3. In this location, simulated ponding depths are actually increased for the 100-year storm event (from 0.23 m under existing conditions to 0.52 m with the recommended alternatives in place). This increase occurs despite the fact that there are no recommended alternatives being implemented along Venetia Drive, with the exception of a minor upstream culvert upgrade. Based on the results of a supplemental sensitivity analysis, this increase appears to be due to tailwater from the recommended storm sewer upgrade along Lakeshore Road. At the connecting storm sewer node on Lakeshore Road, the 100-year hydraulic gradeline (HGL) is only 0.11 m higher with the recommended upgrades in place, however this appears to be sufficient to cause the simulated increase along Venetia Drive. This issue should be assessed further as part of the detailed design process in order to limit any potential impacts to Venetia Drive from the recommended trunk storm sewer along Lakeshore Road.

Table 7.2: Simulated Minor System Performance (Storm Sewers and Culverts) at Locations of Interest with Recommended Alternatives in place

Conduit	Location	Existing Diameter (mm)	Recommended Diameter (mm)	5 Year				100 Year			
				Existing		Recommended		Existing		Recommended	
				$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance
8 (C33)	Third Line – North of Lakeshore Road	750	750	0.28	Unsurcharged	0.28	Unsurcharged	0.85	Surcharged	0.83	Flooded
9 (O_0200_400581)	Lakeshore Road – West of Third Line	900	900	0.10	Unsurcharged	0.10	Unsurcharged	0.31	Surcharged	0.25	Flooded
10 (C36)	Lakeshore Road – East of Third Line	900	750	0.26	Unsurcharged	0.47	Unsurcharged	0.77	Flooded	0.76	Flooded
11 (O_0200_400175)	Crossing Lakeshore Road – Just East of Third Line – Outfall to Western Channel	900	Removed	0.55	Unsurcharged	N/A	N/A	1.60	Flooded	N/A	N/A
84 (PROP-01)	Lakeshore Road between Third Line and Existing Storm Sewer from Venetia Drive	N/A	750	N/A	N/A	0.75	Unsurcharged	N/A	N/A	0.93	Flooded
12 (C35)	Pathway between Tracina Drive and Venetia Drive	300 (estimated)	Twin 300	0.81	Surcharged	0.34	Surcharged	1.07	Flooded	0.93	Flooded
13 (C91)	Tracina Drive Low Point and Confluence	450	450	1.03	Surcharged	1.02	Surcharged	1.41	Flooded	1.39	Flooded
14 (C89)	Venetia Drive Low Point and Confluence	1200	1200	0.25	Unsurcharged	0.25	Unsurcharged	0.42	Surcharged	0.38	Surcharged
15 (O_0200_6143)	Venetia Drive Low Point and Confluence	1200	1200	0.99	Unsurcharged	0.99	Unsurcharged	1.94	Flooded	1.72	Flooded
16 (O_0200_6144)	Crossing Lakeshore Road – accepting flow from Venetia Drive – Outfall to Western Channel	1.2m X 1m Box	Removed	0.55	Unsurcharged	N/A	N/A	1.08	Flooded	N/A	N/A
85 (PROP-02)	Lakeshore Road between Existing Storm Sewer from Venetia Drive and Belvedere Drive	N/A	1050	N/A	N/A	0.75	Unsurcharged	N/A	N/A	1.20	Flooded
86 (PROP-03)	Lakeshore Road between Belvedere Drive and Existing Storm Sewer from Walby Drive	N/A	1050	N/A	N/A	1.03	Unsurcharged	N/A	N/A	1.21	Surcharged

Table 7.2: Simulated Minor System Performance (Storm Sewers and Culverts) at Locations of Interest with Recommended Alternatives in place

Conduit	Location	Existing Diameter (mm)	Recommended Diameter (mm)	5 Year				100 Year			
				Existing		Recommended		Existing		Recommended	
				$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance
17 (C54)	Western Channel - Old Lakeshore Road Culverts	1.7m X 1m Arch	1.7m X 1m Arch	0.66	Unsurcharged	0.08	Unsurcharged	1.13	Unsurcharged	0.18	Unsurcharged
18 (C55)	Western Channel - Old Lakeshore Road Culverts	1.8m X 1.2m Arch	1.8m X 1.2m Arch	0.91	Unsurcharged	0.03	Unsurcharged	1.92	Unsurcharged	0.14	Unsurcharged
19 (C51)	Western Channel - Belvedere Drive Culvert	1.7m X 1m Arch	1.7m X 1m Arch	0.64	Unsurcharged	0.09	Unsurcharged	0.85	Flooded	0.34	Unsurcharged
24 (O_0200_5824)	Walby Drive & Venetia Drive to Lakeshore Road	900	900	0.49	Unsurcharged	0.49	Unsurcharged	1.29	Surcharged	1.29	Surcharged
87 (PROP-04)	Recommended flow restrictor between Lakeshore Road and existing storm sewer outfall from Walby Drive	N/A	675	N/A	N/A	2.17	Surcharged	N/A	N/A	3.39	Surcharged
25 (O_0200_1)	Crossing Lakeshore Road – accepting flow from Walby Drive	900	900	0.62	Unsurcharged	0.96	Unsurcharged	1.61	Flooded	1.50	Surcharged
88 (PROP-05)	Lakeshore Road between Walby Drive and Westminster Drive	N/A	975	N/A	N/A	0.97	Unsurcharged	N/A	N/A	1.35	Surcharged
26 (C17)	Westminster Drive - Viewbank Crescent Culvert (North)	450 (estimated)	450	0.42	Unsurcharged	0.08	Unsurcharged	0.94	Flooded	0.91	Unsurcharged
89 (PROP-07)	Westminster Drive – Recommended storm sewer between Viewbank Crescent	N/A	300	N/A	N/A	0.91	Unsurcharged	N/A	N/A	1.68	Flooded
90 (PROP-08)	Westminster Drive – Recommended storm sewer between Viewbank Crescent	N/A	375	N/A	N/A	0.64	Unsurcharged	N/A	N/A	0.96	Flooded
27 (C45)	Westminster Drive - Viewbank Crescent Culvert (South)	350	450	1.01	Unsurcharged	0.04	Unsurcharged	1.10	Flooded	0.86	Unsurcharged

Table 7.2: Simulated Minor System Performance (Storm Sewers and Culverts) at Locations of Interest with Recommended Alternatives in place

Conduit	Location	Existing Diameter (mm)	Recommended Diameter (mm)	5 Year				100 Year			
				Existing		Recommended		Existing		Recommended	
				$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance
91 (PROP-09)	Westminster Drive – Recommended storm sewer between Viewbank Crescent and Warland Road	N/A	375	N/A	N/A	0.93	Unsurcharged	N/A	N/A	1.46	Flooded
92 (PROP-10)	Westminster Drive – Recommended storm sewer between Viewbank Crescent and Warland Road	N/A	450	N/A	N/A	0.84	Unsurcharged	N/A	N/A	1.28	Flooded
28 (C43)	Westminster Drive - Warland Road Culvert	550	600	0.26	Unsurcharged	0.01	Unsurcharged	0.83	Unsurcharged	0.65	Unsurcharged
93 (PROP-11)	Westminster Drive – Recommended storm sewer between Warland Road and Trenton Road	N/A	525	N/A	N/A	0.73	Unsurcharged	N/A	N/A	1.30	Flooded
29 (C41)	Westminster Drive - Trenton Road Culvert	600	600	0.39	Unsurcharged	0.02	Unsurcharged	0.86	Flooded	0.85	Unsurcharged
94 (PROP-12)	Westminster Drive – Recommended storm sewer between Trenton Road and Lakeshore Road	N/A	675	N/A	N/A	0.87	Unsurcharged	N/A	N/A	1.75	Flooded
95 (PROP-13)	Westminster Drive – Recommended storm sewer between Trenton Road and Lakeshore Road	N/A	675	N/A	N/A	0.87	Unsurcharged	N/A	N/A	2.12	Flooded
30 (O_0200_6228)	Crossing Lakeshore Road - accepting flow from Westminster Drive	400 (possibly 600)	1.73 x 1.10 m HE (1350 equiv.)	3.29	Flooded	0.78	Unsurcharged	3.57	Flooded	1.79	Surcharged
31 (C38)	East Channel - Coronation Park Parking Lot Culvert	500	Triple 1.8 x 0.9 m boxes (embedded 0.3 m)	1.15	Unsurcharged	0.5	Unsurcharged	1.33	Flooded	1.31	Surcharged
32 (C22)	Woodhaven Park Drive - Selgrove Crescent Culvert	450 (estimated)	450	0.27	Unsurcharged	0.01	Unsurcharged	0.85	Unsurcharged	0.25	Unsurcharged

Table 7.2: Simulated Minor System Performance (Storm Sewers and Culverts) at Locations of Interest with Recommended Alternatives in place

Conduit	Location	Existing Diameter (mm)	Recommended Diameter (mm)	5 Year				100 Year			
				Existing		Recommended		Existing		Recommended	
				$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance	$Q_{peak}/Q_{capcity}$	Performance
96 (PROP-14)	Woodhaven Park Drive – Recommended storm sewer between Selgrove Crescent	N/A	300	N/A	N/A	0.86	Unsurcharged	N/A	N/A	1.06	Flooded
97 (PROP-15)	Woodhaven Park Drive – Recommended storm sewer between Selgrove Crescent	N/A	375	N/A	N/A	0.95	Unsurcharged	N/A	N/A	1.51	Flooded
33 (C68)	Culvert Crossing of Woodhaven Park Drive at Selgrove Crescent	675	675	0.29	Unsurcharged	0.19	Unsurcharged	0.63	Flooded	0.33	Flooded
34 (C10)	WWTP Property (accepting flow from Woodhaven Park Drive)	300 (estimated)	300 (estimated)	4.53	Surcharged	1.46	Surcharged	5.36	Flooded	5.06	Surcharged
98 (PROP-16)	Woodhaven Park Drive – Recommended storm sewer between Selgrove Crescent and Lakeshore ROad	N/A	600	N/A	N/A	0.88	Unsurcharged	N/A	N/A	1.34	Flooded
99 (PROP-17)	Woodhaven Park Drive – Recommended storm sewer between Selgrove Crescent and Lakeshore ROad	N/A	600	N/A	N/A	0.94	Unsurcharged	N/A	N/A	1.54	Flooded
100 (PROP-06)	Lakeshore Road between Woodhaven Park Drive and Coronation Park Parking Lot	N/A	600	N/A	N/A	0.82	Unsurcharged	N/A	N/A	1.34	Surcharged
35 (O_0200_6233)	Crossing Lakeshore Road – accepting flow from Woodhaven Park Drive	600	750	1.24	Unsurcharged	0.78	Unsurcharged	2.36	Flooded	1.57	Flooded
36 (O_0200_6232)	Parking Lot Storm Sewer at Eastern Limits of Coronation Park	600	750	0.97	Unsurcharged	0.92	Unsurcharged	1.47	Unsurcharged	1.58	Surcharged

Table 7.3: Simulated Major System Performance (Roadways) at locations of interest with Recommended Alternatives in place

Conduit	Location	Type	5 Year				100 Year			
			Existing		Recommended		Existing		Recommended	
			Maximum Average Depth (m)	Performance	Maximum Average Depth (m)	Performance	Maximum Average Depth (m)	Performance	Maximum Average Depth (m)	Performance
53 (C33-S)	Third Line – North of Lakeshore Road	Urban	0.03	Below Crown	0.03	Below Crown	0.05	Below Crown	0.07	Below Crown
54 (C63)	Lakeshore Road – West of Third Line	Rural	0.23	Within Ditch	0.23	Within Ditch	0.97	Within Ditch	1.25	Within Ditch
55 (C36-S)	Lakeshore Road – East of Third Line	Urban	0.07	Below Crown	0.06	Below Crown	0.11	Below Crown	0.12	Below Crown
101 (PROP-01-S)	Lakeshore Road – East of Third Line	Urban (Assumed)	N/A	N/A	0.05	Below Crown	N/A	N/A	0.16	Above Crown
57 (C89-S)	Venetia Drive Low Point and Confluence	Urban	0.11	Below Crown	0.10	Below Crown	0.23	Above Crown	0.52	Above Crown
102 (PROP-02-S)	Lakeshore Road between Venetia Drive and Belvedere Drive	Urban (Assumed)	N/A	N/A	0.04	Below Crown	N/A	N/A	0.20	Above Crown
103 (PROP-03-S)	Lakeshore Road between Belvedere Drive and Walby Drive	Urban (Assumed)	N/A	N/A	0.03	Below Crown	N/A	N/A	0.20	Above Crown
61 (O_0200_5823-S)	Walby Drive & Venetia Drive	Rural	0.06	Within Ditch	0.06	Within Ditch	0.39	Exceeded Ditch / Below Crown	0.36	Exceeded Ditch / Below Crown
104 (PROP-05-S)	Lakeshore Road between Walby Drive and Westminster Drive	Urban (Assumed)	N/A	N/A	0.02	Below Crown	N/A	N/A	0.19	Above Crown
62 (C18)	Westminster Drive – Between Viewbank Crescent Culverts	Rural	0.32	Within Ditch	0.10	Within Ditch	0.44	Within Ditch	0.38	Within Ditch
63 (C46)	Westminster Drive – South of Viewbank Crescent	Rural	0.34	Within Ditch	0.13	Within Ditch	0.56	Within Ditch	0.47	Within Ditch
64 (C15)	Westminster Drive - North of Warland Road Culvert	Rural	0.10	Within Ditch	0.04	Within Ditch	0.38	Within Ditch	0.33	Within Ditch

Table 7.3: Simulated Major System Performance (Roadways) at locations of interest with Recommended Alternatives in place

Conduit	Location	Type	5 Year				100 Year			
			Existing		Recommended		Existing		Recommended	
			Maximum Average Depth (m)	Performance	Maximum Average Depth (m)	Performance	Maximum Average Depth (m)	Performance	Maximum Average Depth (m)	Performance
65 (C44)	Westminster Drive - Between Warland Road and Trenton Road Culverts	Rural	0.25	Within Ditch	0.09	Within Ditch	0.44	Exceeded Ditch / Below Crown	0.47	Exceeded Ditch / Below Crown
66 (C13)	Westminster Drive - South of Trenton Road Culvert	Rural	0.42	Within Ditch	0.08	Within Ditch	0.61	Within Ditch	0.56	Within Ditch
67 (C28)	Woodhaven Park Drive - South of Selgrove Crescent Culvert	Rural	0.16	Within Ditch	0.06	Within Ditch	0.36	Exceeded Ditch / Below Crown	0.26	Within Ditch

Table 7.4: Simulated Major System Performance (Surveyed Open Channels) at Locations of Interest with Recommended Alternatives in place

Conduit	Location	5 Year				100 Year			
		Existing		Recommended		Existing		Recommended	
		Maximum Average Depth (m)	Performance	Maximum Average Depth (m)	Performance	Maximum Average Depth (m)	Performance	Maximum Average Depth (m)	Performance
72 (C56)	Western Channel - Upstream Old Lakeshore Road Culverts	0.75	Exceeded Ditch	0.10	Within Ditch	1.43	Exceeded Ditch	0.37	Exceeded Ditch
73 (C67)	Western Channel - Upstream Belvedere Drive Culvert	0.61	Exceeded Ditch	0.16	Within Ditch	1.30	Exceeded Ditch	0.38	Exceeded Ditch
74 (C49_1)	Western Channel - Flow Confluence – South-westerly upstream end of Coronation Park	1.13	Exceeded Ditch	0.81	Exceeded Ditch	2.46	Exceeded Ditch	1.21	Exceeded Ditch
75 (C49_2)	Western Channel Outlet to Lake Ontario	0.92	Exceeded Ditch	0.67	Within Ditch	1.88	Exceeded Ditch	0.98	Exceeded Ditch
76 (C59)	Eastern Channel - Upstream of Coronation Park Parking Lot Culvert	0.64	Exceeded Ditch	0.58	Within Ditch (Re-Constructed)	0.86	Exceeded Ditch	1.25	Exceeded Ditch (Re-Constructed)
77 (C40_1)	Eastern Channel - Downstream of Coronation Park Parking Lot Culvert	0.29	Exceeded Ditch	0.55	Within Ditch (Re-Constructed)	0.57	Exceeded Ditch	0.90	Exceeded Ditch (Re-Constructed)
78 (C40_2)	Eastern Channel Outlet to Lake Ontario	0.21	Within Ditch	0.39	Within Ditch (Re-Constructed)	0.34	Exceeded Ditch	0.63	Within Ditch (Re-Constructed)

8. PREFERRED ALTERNATIVES AND PRIORITIZATION

This section outlines the specifics associated with the implementation of the Class Environmental Assessment recommendations.

Drainage system improvements have been recommended based on their functional performance (i.e. their ability to address the identified drainage system deficiency), as well as other criteria related to environmental, social, economic and constructability considerations. Each preferred alternative would reduce identified issues of nuisance flooding and standing water, as well as surcharging and/or flooding concerns to varying degrees, and would provide varying benefits in the way of reduced potential for property damages and threat to life. In the case of reducing roadway flooding, vehicle and pedestrian access and egress may be improved by reducing flood depths.

The Town of Oakville has provided some direction with respect to its schedule and prioritization for road reconstruction works. The Town has allocated capital budget for the reconstruction of Westminster Drive (Recommended Alternatives 2-5, 10-8, and 8-9) however it is recommended that the eastern channel outlet in Coronation Park (Alternative 8-6) be completed first. It is further understood that a Class Environmental Assessment for Lakeshore Road is planned for 2016, which will re-assess the various recommended alternatives for Lakeshore Road, including the proposed trunk storm sewer. As many of the recommended alternatives are impacted by the construction of the proposed trunk storm sewer along Lakeshore Road, many of the recommended alternatives may need to be delayed until the design and construction of this Alternative is completed. The Phasing and prioritization plan has therefore been established based on reducing potential surcharging and flooding impacts to both private and public property, input received from the public and incorporating the Town of Oakville's currently proposed schedule of works.

Table 8.1 (updated in Appendix 'E' Table 3.1) has placed each drainage improvement project in a prioritized sequence using a priority number and assigned a "Low" to "High" Priority Rating accordingly. The potential benefits and costs for each project have also been listed.

Additional hydrologic/hydraulic modelling may be required as part of the detailed design work for the recommended alternatives presented in Table 8.1 (updated in Appendix 'E' Table 3.1). It is recommended that the integrated PCSWMM hydrologic/hydraulic modelling developed as part of the current study be used for this purpose, and updated and refined as required.

Table 8.1: Preferred Alternative Summary

Priority	Location	Details of Proposed Works	Benefit	Notes	Preliminary Costs
High	Eastern Channel (Coronation Park)	▶ 200 m of channel works ▶ 2 pedestrian bridge replacements ▶ Triple box culvert under existing parking lot ▶ LID/BMP measures where feasible ▶ Landscaping and plantings as required	▶ Safety conveys flows, allows for diversion of flood causing flows away from the western channel ▶ Minimize standing water and erosion within Coronation Park ▶ Aesthetic benefit to Coronation Park with suitable design ▶ Potentially an educational feature (landscaping, LID/BMP) ▶ Improved water quality and water balance (LID/BMP)	▶ Works could potentially be constructed in advance of Lakeshore Road, however design flows would be dependent on design of those works	\$750,000 (not including design, LID/BMP measures, or landscaping)
High	Westminster Drive	▶ 487 m of new storm sewer (300 to 675 mm diameter) ▶ Driveway and roadside culvert replacements (PVC - end treatments where feasible) ▶ Ditch re-grading and landscaping ▶ LID/BMP measures where feasible	▶ Reduction/elimination of standing water in ditches ▶ Reduction in ditch erosion ▶ Reduction in major system flooding ▶ Improved water quality and water balance (LID/BMP)	▶ Capital funding allocated already by Town ▶ Proposed construction in 2015 ▶ Interim outlet to eastern channel in Coronation Park required (future re-grading to accommodate Lakeshore Road trunk storm sewer)	\$630,000 (not including design or LID/BMP measures)
High	Lakeshore Road	▶ 582 m of new storm sewer (675 to 1350 mm equivalent diameter) ▶ Major system improvements (curb and gutter if feasible) ▶ LID/BMP measures where feasible	▶ Diversion of flows from western channel; associated reduction in flooding and risk to private property ▶ Reduction in erosion causing flows to western channel ▶ Improved major system conveyance to suitable outfall ▶ Improved water quality and water balance (LID/BMP)	▶ Detailed design dependent on outcomes from proposed Lakeshore Road Class EA (2016) ▶ Construction not likely until 2018 ▶ Proposed storm sewer will require eastern channel works to be in place to accommodate increased flows and deeper grades ▶ Costs may already be allocated in future capital construction budget	\$890,000 (not including design or LID/BMP measures)

Table 8.1: Preferred Alternative Summary

Priority	Location	Details of Proposed Works	Benefit	Notes	Preliminary Costs
High	Woodhaven Park Drive	▶ 380 m of new storm sewer (300 to 750 mm diameter) ▶ Driveway and roadside culvert replacements (PVC - end treatments where feasible) ▶ Ditch re-grading and landscaping ▶ LID/BMP measures where feasible ▶ Limits of storm sewer to be determined during detailed construction (current sizing and modelling assumes sewers only to Selgrove Crescent)	▶ Reduction/elimination of standing water in ditches ▶ Reduction in ditch erosion ▶ Reduction in major system flooding ▶ Improved water quality and water balance (LID/BMP)	▶ Estimated costs includes a portion of works along Lakeshore Road as well as upgraded storm sewer outfall to Lake Ontario ▶ Could potentially construct storm sewer outfall upgrade as a separate project in advance of Lakeshore Road works ▶ Could potentially construct Woodhaven Park works prior to Lakeshore Road construction using existing outfall to WWTP property; however this is not recommended.	$560,000 (not including design or LID/BMP measures)
Medium	2033 Lakeshore Road	▶ 60 m of channel improvements adjacent to 2033 Lakeshore Road West (downstream of Oakville Christian School)	▶ Reduction/elimination of standing water and erosion adjacent to property ▶ Potentially a reduction in major system flooding and improved flow conveyance	▶ Relatively low cost of construction. ▶ Dense existing vegetation; re-grading works will need to work around existing trees and consider landscaping works as required ▶ Town holds easement, but discussions with homeowner required.	$60,000 (not including design costs)
Medium	Pathway between Tracina Drive and Venetia Drive	▶ 5 m of culvert replacement (twin 300 mm PVC with end treatments if feasible) ▶ Assumed connected channel works (5 m on both upstream and downstream ends)	▶ Reduction/elimination of standing water and erosion ▶ Improved flow conveyance and associated reduction in flood depths	▶ Relatively low cost of construction. ▶ Tight property limits (3 m wide pathway), and existing obstructions (fences for private residences) will make construction challenging ▶ Utilities (not Town) hold easement over upstream portion of channel. No easement on downstream section. Discussions with homeowners required	$20,000 (not including design costs)

Table 8.1: Preferred Alternative Summary					
Priority	**Location**	**Details of Proposed Works**	**Benefit**	**Notes**	**Preliminary Costs**
Low	Wales Crescent	▶ 270 m of ditch re-grading ▶ Driveway culvert replacements as required (PVC with end treatments if feasible) ▶ LID/BMP measures where feasible	▶ Reduction/elimination of standing water and erosion ▶ Improved flow conveyance and associated reduction in flood depths ▶ Improved water quality and water balance (LID/BMP)	▶ Consider further assessment to reduce the extents of the required works (and reduce the associated costs)	$280,000 (not including design costs or LID/BMP measures)
Low	Sedgewick Forest	▶ 180 m of channel works/re-grading ▶ LID/BMP measures where feasible	▶ Reduction/elimination of standing water and erosion ▶ Improved flow conveyance and associated reduction in flood depths ▶ Improved water quality and water balance (LID/BMP)	▶ Area of identified erosion within the ditch in vicinity of existing storm outfall should be addressed as part of the overall works	$180,000 (not including design costs or LID/BMP measures)
				TOTAL COST	***$3,370,000***

9. CONCLUSIONS/PROCESS AND RECOMMENDATIONS

9.1 Conclusions/Process

i. The existing drainage system has been assessed using an integrated PCSWMM hydrologic/hydraulic model in order to identify deficiencies. The developed model has been validated using unitary peak flows from other studies for other adjacent watersheds in order to confirm the reasonableness of the assessment.

ii. A field reconnaissance program has been conducted to identify drainage system deficiencies, including erosion sites.

iii. This field reconnaissance program has been complimented by input from local residents at the two Public Information Centres; a number of additional drainage deficiencies have been identified as part of this process.

iv. A detailed assessment of a large number of sub-alternatives has been undertaken in order to determine the recommended alternatives.

v. Drainage system requirements for the recommended alternatives have been determined based on an updated integrated PCSWMM hydrologic/hydraulic modelling assessment.

9.2 Recommendations

i. The preferred alternatives as described in Section 8 (Updated in Appendix 'E' Section 3) be implemented as per the established priority, contingent on the availability of capital funding.

ii. The integrated PCSWMM hydrologic/hydraulic modelling developed as part of this study should be further refined and updated as part of future studies, including the proposed Lakeshore Road Class EA and detailed design work for the recommended alternatives.

iii. The Town of Oakville should continue inspection of the channel and storm sewer outfalls to Lake Ontario, particularly within Coronation Park. Regular maintenance of the outfalls should also be undertaken as required to limit any potential channel and storm sewer blockages due to debris being washed onshore.

Amec Foster Wheeler Environment & Infrastructure
a Division of Amec Foster Wheeler Americas Limited

Per: Steve Chipps, P.Eng.
Associate

Per: Matthew Senior, M.A.Sc., P.Eng.
Project Engineer

LEGEND

STUDY AREA BOUNDARY

WATERCOURSE

SCALE VALID ONLY FOR 24"x36" VERSION

CORONATION PARK DRAINAGE ASSESSMENT TOWN OF OAKVILLE	AERIAL PHOTOGRAPHY 2012	amec foster wheeler	Scale 1:3000 (0 25 50 100) Consultant File No. TP114001 Drawing No. 1

Plotted: 2015-04-01 Plotted By: richard.bartolo
Last Saved: 2015-03-25 Last Saved By: richard.bartolo
Path: P:\Work\TP114001\water\dwg\March2015(FinRpt)\Dwg1 Aerial2012.dwg

NOTE: REFER TO APPENDIX B FOR PHOTOS 26-88

SCALE VALID ONLY FOR 24"x36" VERSION

LEGEND

WATERCOURSE

PHOTO ID# (NOVEMBER 21–22, 2013)

28-29-30 PHOTO ID# (APRIL 16,2014)

CORONATION PARK DRAINAGE ASSESSMENT

TOWN OF OAKVILLE

PHOTO RECONNAISSANCE PLAN

amec foster wheeler

Scale	1:4000 (0 25 50 200)
Consultant File No.	TP114001
Drawing No.	2

Path: P:\Work\TP114001\water\dwg\March2015(FinRpt)\Dwg2 PhotoRecon.dwg

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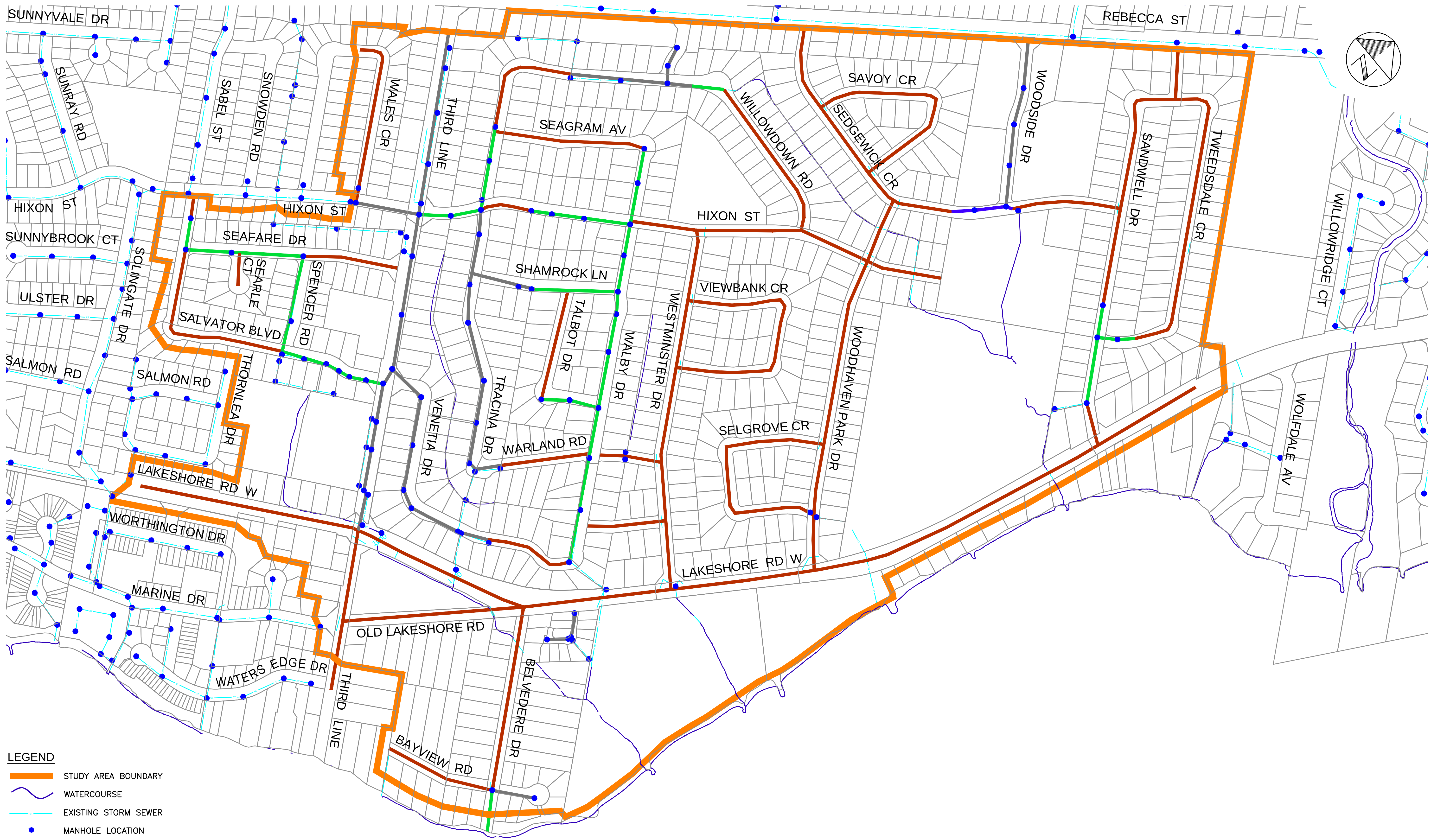
Plotted: 2015-04-01

Last Saved By: richard.bartolo

Last Saved: 2015-03-25



LEGEND

- STUDY AREA BOUNDARY
- WATERCOURSE
- EXISTING STORM SEWER
- MANHOLE LOCATION
- STORM SEWER WITH URBAN ROADWAY (CURB & GUTTER)
- STORM SEWER WITH RURAL ROADWAY (DITCHING)
- STORM SEWER WITH COMBINED URBAN/RURAL ROADWAY (CURB & GUTTER AND DITCHING)
- RURAL ROADWAY (DITCHING ONLY)

SCALE VALID ONLY FOR 24"x36" VERSION

CORONATION PARK DRAINAGE ASSESSMENT

TOWN OF OAKVILLE

DRAINAGE CLASSIFICATION PLAN

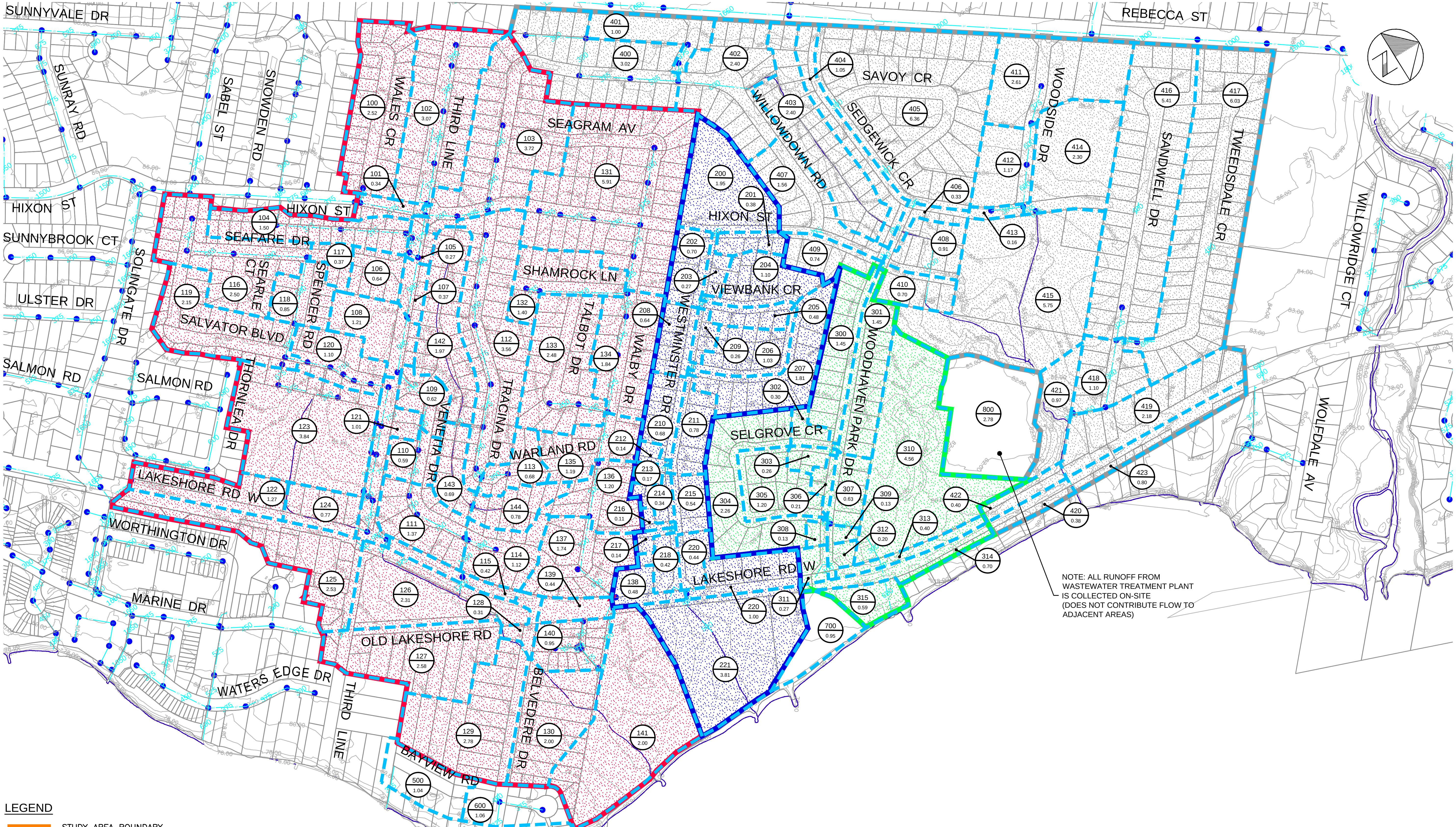
amec foster wheeler

Scale 1:3000

0 25 50 100

Consultant File No. TP114001

Drawing No. 3



LEGEND

- STUDY AREA BOUNDARY
- WATERCOURSE
- EXISTING STORM SEWER AND PIPE DIAMETER (mm)
- MANHOLE LOCATION
- SUBCATCHMENT BOUNDARY
- SUBCATCHMENT REFERENCE NUMBER (130)
- SUBCATCHMENT AREA (Ha) (2.00)
- 100 SERIES CATCHMENT BOUNDARY
- 200 SERIES CATCHMENT BOUNDARY
- 300 SERIES CATCHMENT BOUNDARY
- 400 SERIES CATCHMENT BOUNDARY

SCALE VALID ONLY FOR 24"x36" VERSION

CORONATION PARK DRAINAGE ASSESSMENT

TOWN OF OAKVILLE

SUBCATCHMENT BOUNDARY PLAN

amec foster wheeler

Scale 1:3000 (0 25 50 100)

Consultant File No. TP114001

Drawing No. 4

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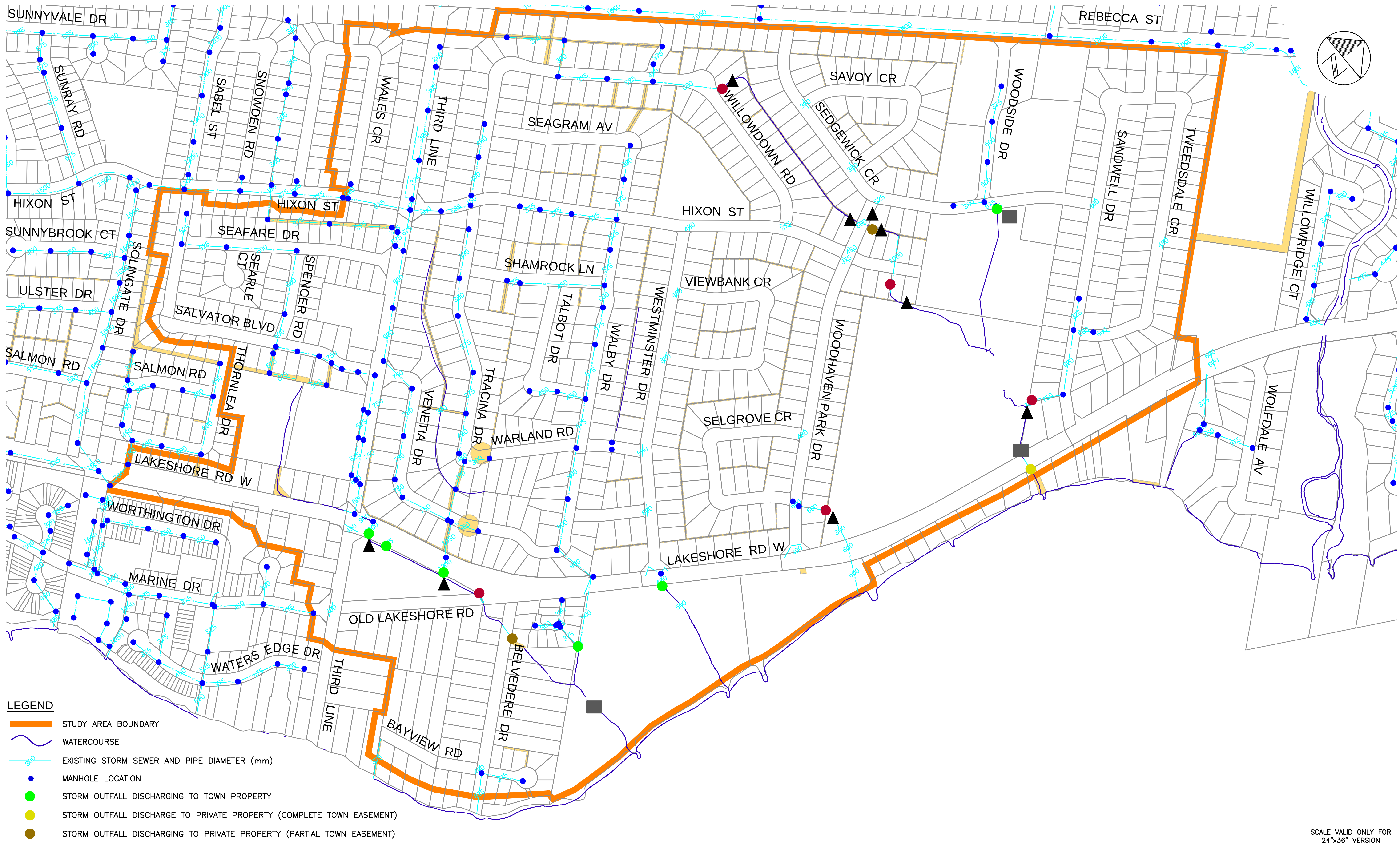
Plotted By: richard.bartolo Last Saved By: richard.bartolo

Plotted: 2015-04-01 Last Saved: 2015-03-25



LEGEND

- STUDY AREA BOUNDARY
- WATERCOURSE
- EXISTING STORM SEWER AND PIPE DIAMETER (mm)
- MANHOLE LOCATION
- STORM OUTFALL DISCHARGING TO TOWN PROPERTY
- STORM OUTFALL DISCHARGE TO PRIVATE PROPERTY (COMPLETE TOWN EASEMENT)
- STORM OUTFALL DISCHARGING TO PRIVATE PROPERTY (PARTIAL TOWN EASEMENT)
- STORM OUTFALL DISCHARGING TO PRIVATE PROPERTY (NO EASEMENT)
- MINOR EROSION OBSERVED
- MODERATE EROSION OBSERVED
- EASEMENT LOCATION

SCALE VALID ONLY FOR 24"x36" VERSION

CORONATION PARK
DRAINAGE ASSESSMENT

TOWN OF OAKVILLE

EROSION RISK
PLAN

amec foster wheeler

Scale 1:3000
0 25 50 100

Consultant File No. TP114001

Drawing No. 5

Path: P:\Work\TP114001\water\dwg\March2015(FinRpt)\Dwg5_ErosionRisk.dwg

Plotted By: richard.bartolo
Last Saved By: richard.bartolo

Plotted: 2015-04-01
Last Saved: 2015-03-25

NOTE:
DRIVEWAY CULVERT & STANDING WATER OBSERVATIONS BASED ON FIELD RECONNAISSANCE AND PUBLIC INPUT. ISSUES SHOWN MAY NOT REFLECT ALL EXISTING DEFICIENCIES.

SCALE VALID ONLY FOR 24"x36" VERSION

CORONATION PARK DRAINAGE ASSESSMENT TOWN OF OAKVILLE	DRAINAGE ISSUES SUMMARY	amec foster wheeler	Scale 1:3000 (0 25 50 100) Consultant File No. TP114001 Drawing No. 6

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Plotted By: richard.bortolo
Last Saved By: richard.bortolo

Plotted: 2015-04-01
Last Saved: 2015-03-25

LEGEND

- STUDY AREA BOUNDARY
- WATERCOURSE
- EXISTING STORM SEWER AND PIPE DIAMETER (mm)
- MANHOLE LOCATION
- STORM SEWER/CULVERT UNSURCHARGED
- STORM SEWER/CULVERT SURCHARGED
- STORM SEWER/CULVERT FLOODED

SCALE VALID ONLY FOR 24"x36" VERSION

CORONATION PARK DRAINAGE ASSESSMENT TOWN OF OAKVILLE	5 YEAR PERFORMANCE SUMMARY (MINOR SYSTEM)	amec foster wheeler	Scale 1:3000 (0 25 50 100) Consultant File No. TP114001 Drawing No. 7

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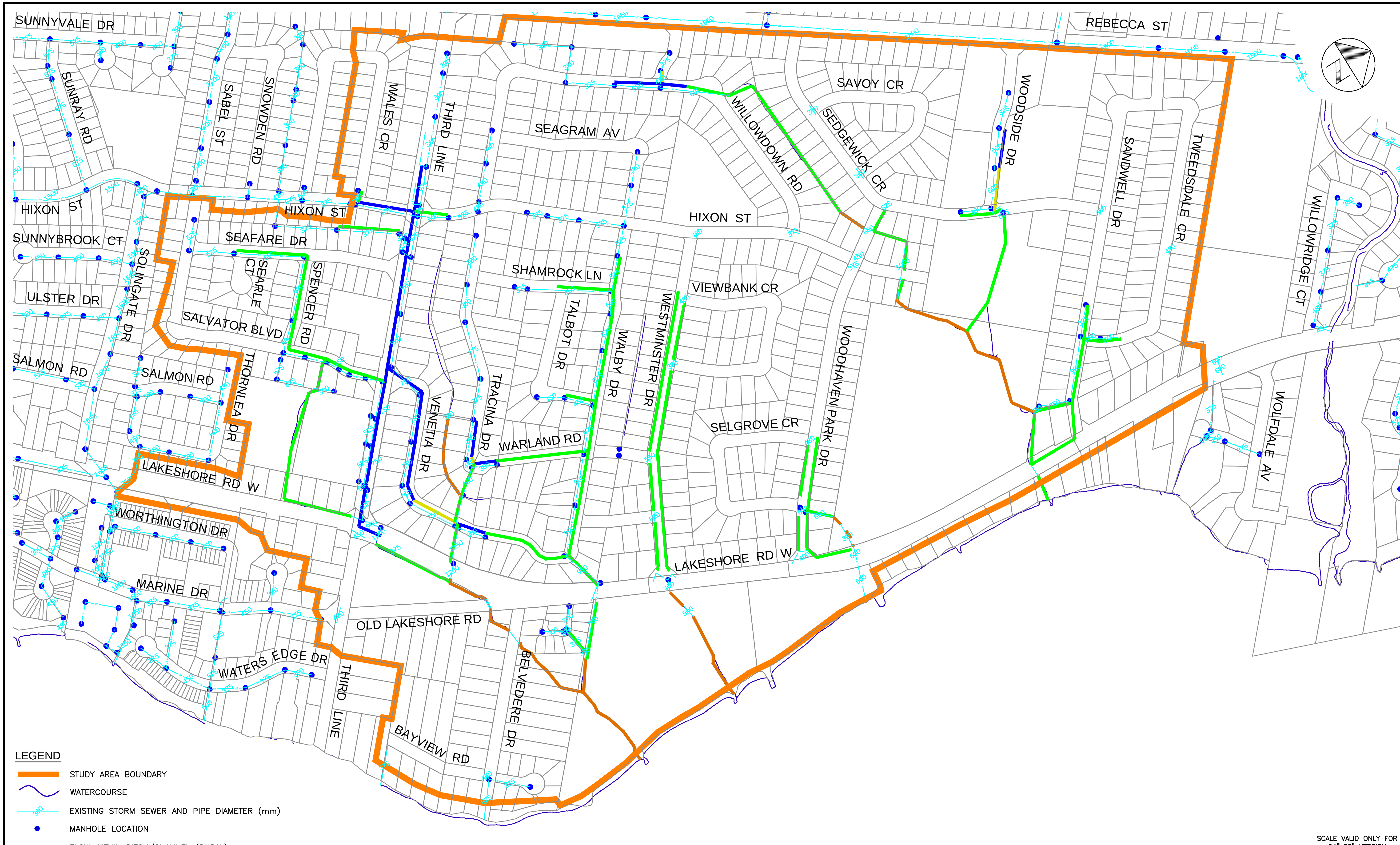
Plotted: 2015-04-01
Last Saved: 2015-03-25



LEGEND

- STUDY AREA BOUNDARY
- WATERCOURSE
- EXISTING STORM SEWER AND PIPE DIAMETER (mm)
- MANHOLE LOCATION
- FLOW WITHIN DITCH/CHANNEL (RURAL)
- FLOW OUT OF DITCH/CHANNEL (RURAL–BELOW ROAD CROWN)
- FLOW BELOW ROAD CROWN (URBAN)
- FLOW ABOVE ROAD CROWN (URBAN)

SCALE VALID ONLY FOR 24"x36" VERSION

CORONATION PARK DRAINAGE ASSESSMENT TOWN OF OAKVILLE	5 YEAR PERFORMANCE SUMMARY (MAJOR SYSTEM)	amec foster wheeler	Scale 1:3000 Consultant File No. TP114001 Drawing No. 8

Path: P:\Work\TP114001\water\dwg\March2015(FinRpt)\Dwg8 5yrPerf-maj.dwg

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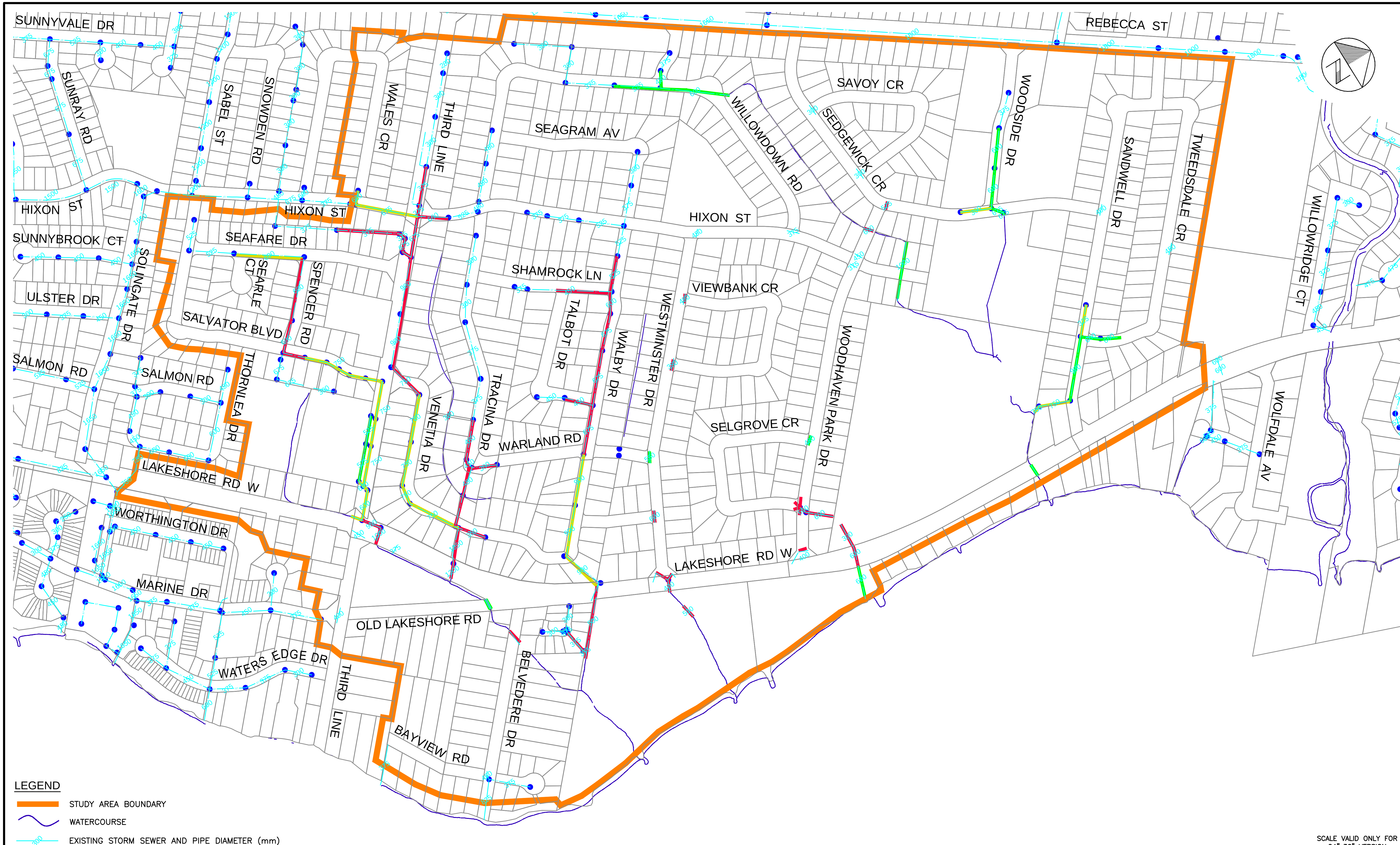
Plotted: 2015-04-01
Last Saved: 2015-03-25



CORONATION PARK DRAINAGE ASSESSMENT

TOWN OF OAKVILLE

100 YEAR PERFORMANCE SUMMARY (MINOR SYSTEM)

amec foster wheeler

Scale 1:3000

Consultant File No. TP114001

Drawing No. 9

Path: P:\Work\TP114001\water\dwg\March2015(FinRpt)\Dwg9 100yrPerf-min.dwg

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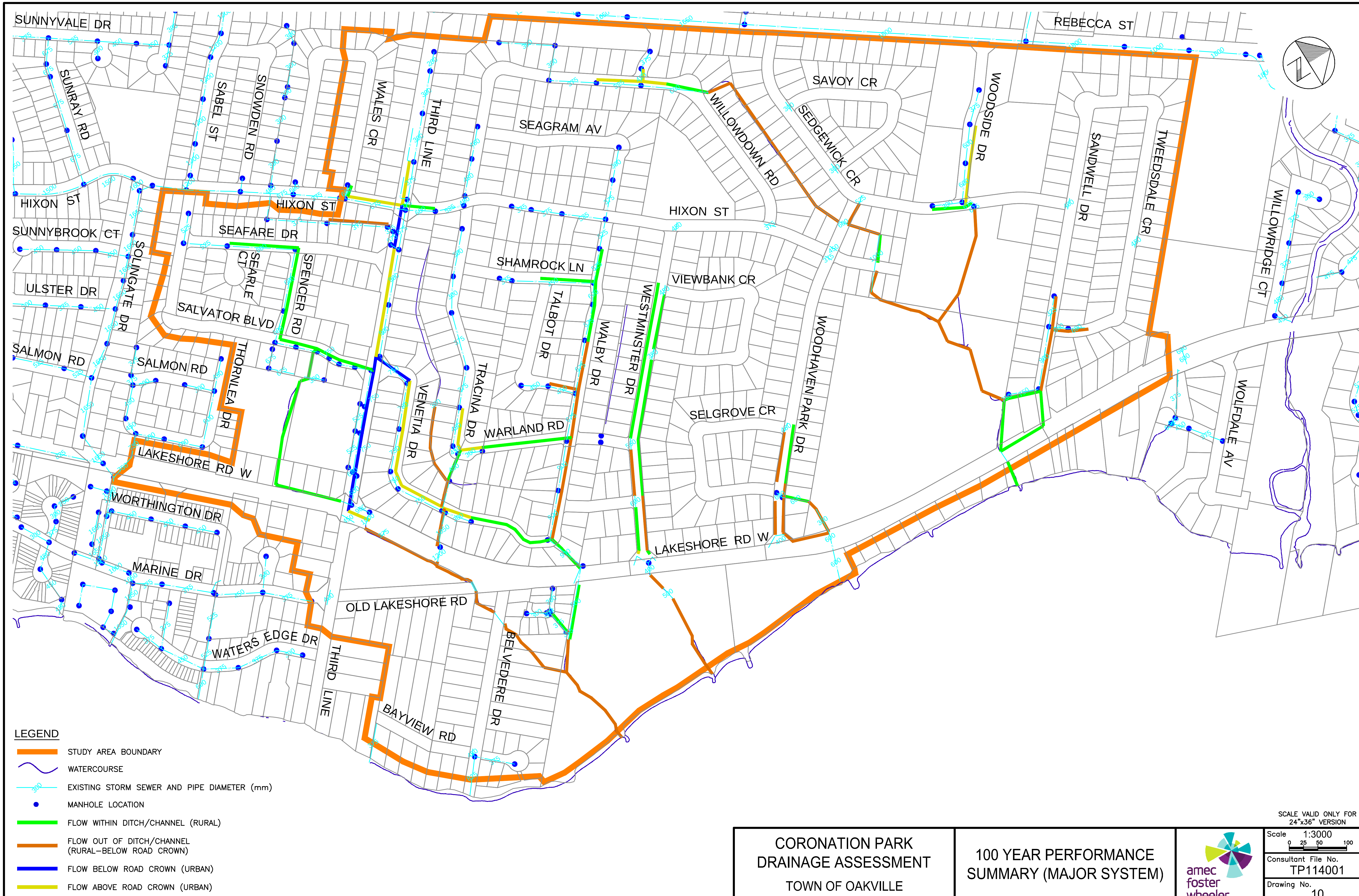
Last Saved By: richard.bartolo

Plotted: 2015-04-01
Last Saved: 2015-03-25



CORONATION PARK DRAINAGE ASSESSMENT

TOWN OF OAKVILLE

100 YEAR PERFORMANCE SUMMARY (MAJOR SYSTEM)

amec foster wheeler

Consultant File No. TP114001

Drawing No. 10

Path: P:\Work\TP114001\water\dwg\March2015(FinRpt)\Dwg10 100yrPerf-maj.dwg

Plotted By: richard.bartolo
Last Saved By: richard.bartolo

Plotted: 2015-04-01
Last Saved: 2015-03-25

LEGEND

- STUDY AREA BOUNDARY
- WATERCOURSE
- EXISTING STORM SEWER AND PIPE DIAMETER (mm)
- POTENTIAL NEW STORM SEWER\CULVERT
- POTENTIAL UPGRADED STORM SEWER\CULVERT
- POTENTIAL ROADWAY DRAINAGE IMPROVEMENTS
- POTENTIAL RE-GRADED OPEN CHANNEL

SCALE VALID ONLY FOR 24"x36" VERSION

CORONATION PARK DRAINAGE ASSESSMENT TOWN OF OAKVILLE	POTENTIAL SHORT-LISTED ALTERNATIVES	amec foster wheeler	Scale 1:3000 (0 25 50 100) Consultant File No. TP114001 Drawing No. 11

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Plotted By: richard.bartolo Last Saved By: richard.bartolo

Plotted: 2015-04-01 Last Saved: 2015-03-31

LEGEND

- STUDY AREA BOUNDARY
- WATERCOURSE
- EXISTING STORM SEWER AND PIPE DIAMETER (mm)
- (600) RECOMMENDED STORM SEWER AND PIPE DIAMETER (mm)
- PROPOSED NEW STORM SEWER\CULVERT
- PROPOSED UPGRADED STORM SEWER\CULVERT
- PROPOSED ROADWAY DRAINAGE IMPROVEMENTS
- PROPOSED RE-GRADED OPEN CHANNEL

Path: P:\Work\TP114001\water\dwg\2017-05\Dwg12 PerfrdAlt.dwg

Plotted: 2017-05-17 Plotted By: j.soaresdasilva
Last Saved: 2017-05-17 Last Saved By: j.soaresdasilva

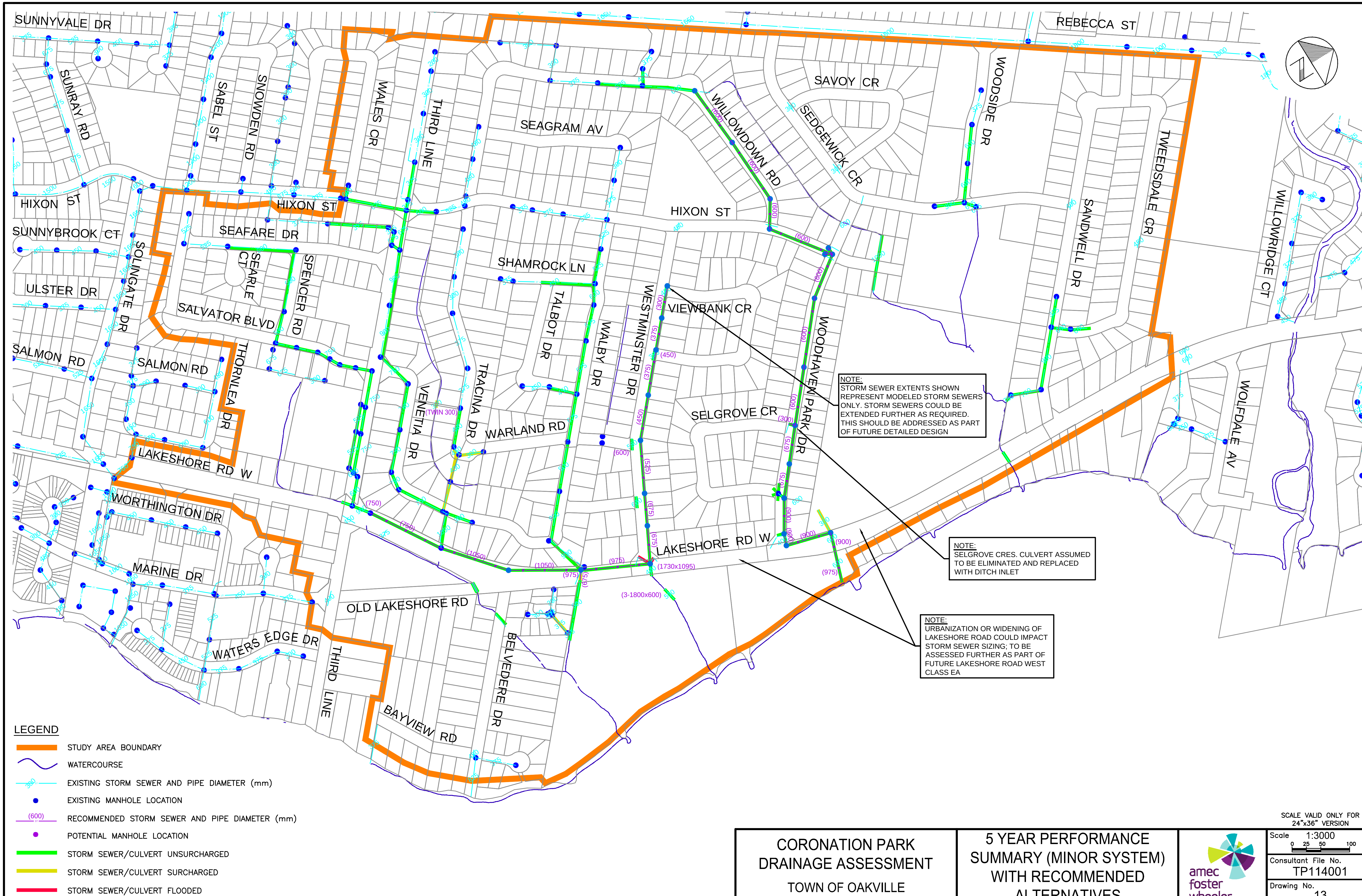
SCALE VALID ONLY FOR 24"x36" VERSION

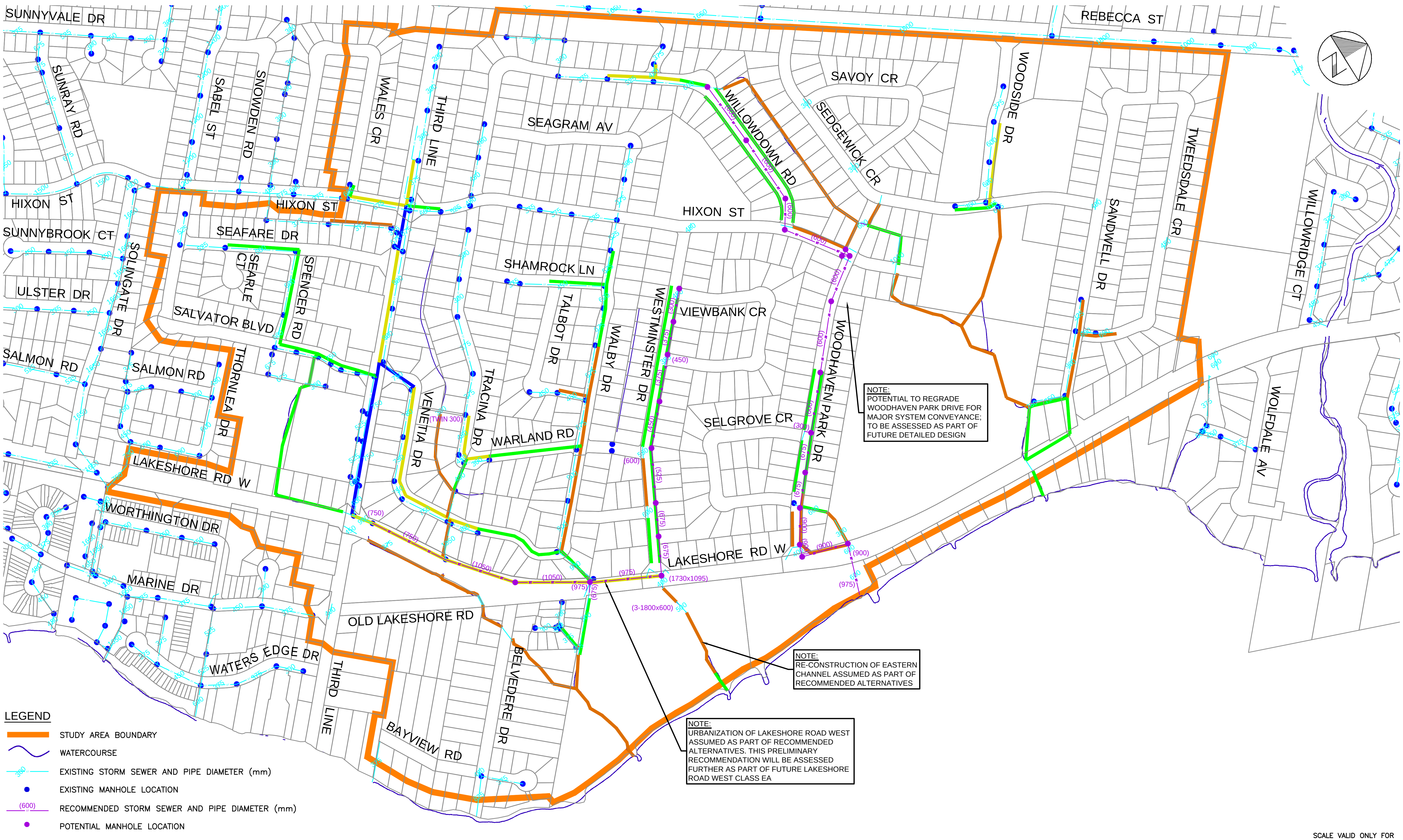
CORONATION PARK DRAINAGE ASSESSMENT TOWN OF OAKVILLE	PREFERRED DRAINAGE ALTERNATIVES	amec foster wheeler	Scale 1:3000 (0 25 50 100) Consultant File No. TP114001 Drawing No. 12

Path: P:\Work\TP114001\water\dwg\2017-05\Dwg13_5yrPerf-min(wAlt).dwg

Plotted By: j.soaresdasilva
Last Saved By: j.soaresdasilva

Plotted: 2017-05-17
Last Saved: 2017-05-17





NOTE:
POTENTIAL TO REGRADE WOODHAVEN PARK DRIVE FOR MAJOR SYSTEM CONVEYANCE; TO BE ASSESSED AS PART OF FUTURE DETAILED DESIGN

NOTE:
RE-CONSTRUCTION OF EASTERN CHANNEL ASSUMED AS PART OF RECOMMENDED ALTERNATIVES

NOTE:
URBANIZATION OF LAKESHORE ROAD WEST ASSUMED AS PART OF RECOMMENDED ALTERNATIVES. THIS PRELIMINARY RECOMMENDATION WILL BE ASSESSED FURTHER AS PART OF FUTURE LAKESHORE ROAD WEST CLASS EA

LEGEND

- STUDY AREA BOUNDARY
- WATERCOURSE
- EXISTING STORM SEWER AND PIPE DIAMETER (mm)
- EXISTING MANHOLE LOCATION
- (600) RECOMMENDED STORM SEWER AND PIPE DIAMETER (mm)
- POTENTIAL MANHOLE LOCATION
- FLOW WITHIN DITCH/CHANNEL
- FLOW OUT OF DITCH/CHANNEL (RURAL–ABOVE ROAD CROWN)
- FLOW BELOW ROAD CROWN (URBAN)
- FLOW ABOVE ROAD CROWN (URBAN)

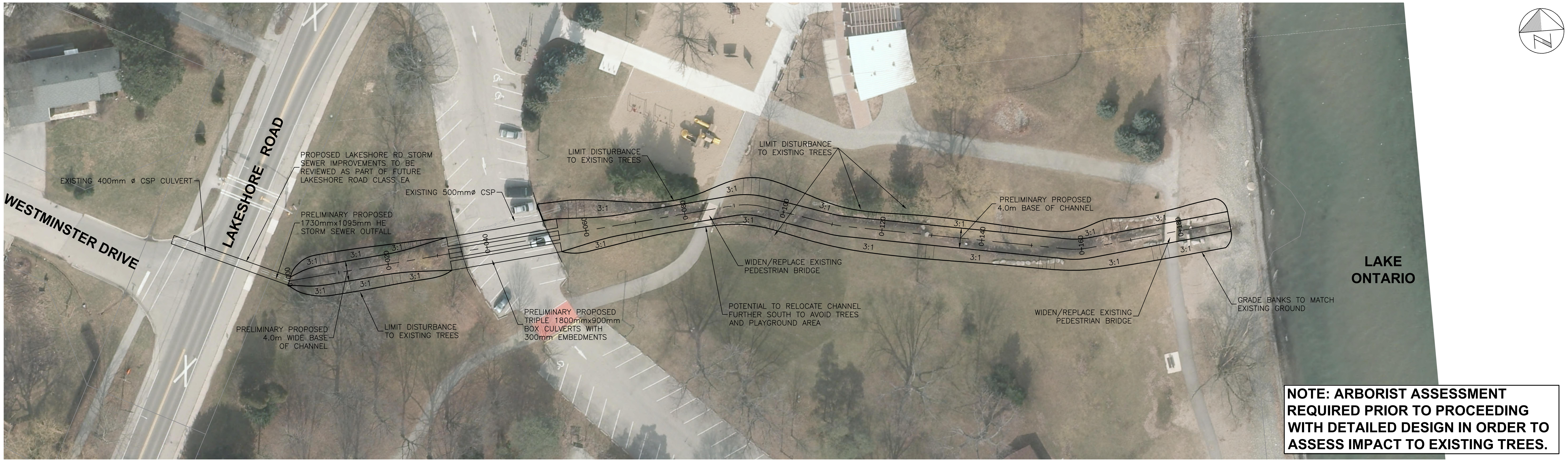
Path: P:\Work\TP114001\water\dwg\2017-05\Dwg14 100yrPerf-maj(wAlt).dwg

Plotted By: j.soaresdasilva
Last Saved By: j.soaresdasilva

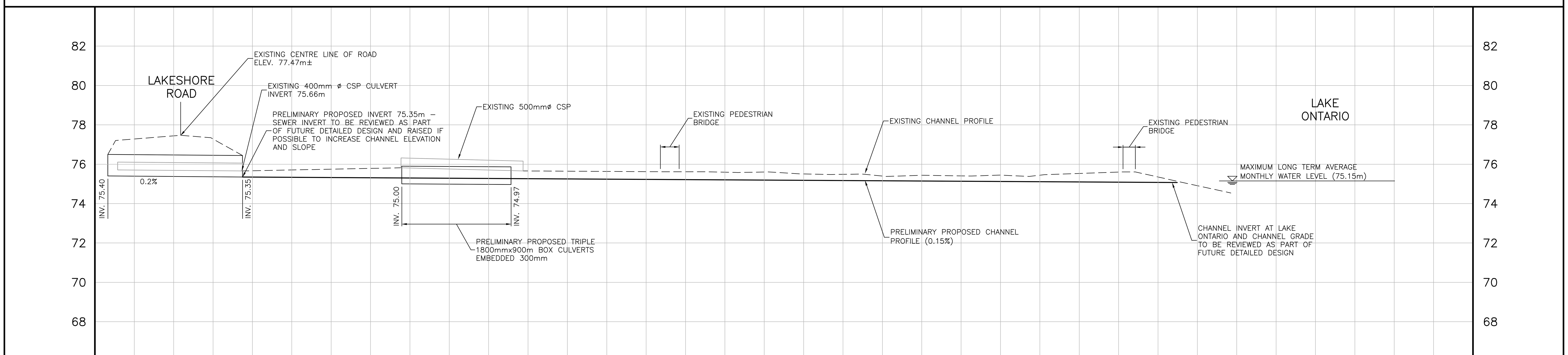
Plotted: 2017-05-17
Last Saved: 2017-05-17

SCALE VALID ONLY FOR 24"x36" VERSION

CORONATION PARK DRAINAGE ASSESSMENT TOWN OF OAKVILLE	100 YEAR PERFORMANCE SUMMARY (MAJOR SYSTEM) WITH RECOMMENDED ALTERNATIVES	amec foster wheeler	Scale 1:3000 (0 25 50 100) Consultant File No. TP114001 Drawing No. 14



NOTE: ARBORIST ASSESSMENT REQUIRED PRIOR TO PROCEEDING WITH DETAILED DESIGN IN ORDER TO ASSESS IMPACT TO EXISTING TREES.



CHAINAGE/ PROPOSED ℄ ELEVATION										
Chainage	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+140	0+160	0+180
Elevation	75.35	75.32	75.29	75.26	75.23	75.20	75.17	75.14	75.11	75.08

Path: P:\Work\TP114001\water\dwg\March2015(FinRpt)\Dwg15 Plan And Profile.dwg

Plotted By: josh.seraj
Last Saved By: josh.seraj
Plotted: 2016-02-05
Last Saved: 2016-02-05

No	Date	Drawn	Appr'd	Revisions

APPROVALS

Design	MS	Checked	MS
Drawn	MK	Checked	MS

Scale Horiz. 1:400 Vert. 1:100 (0 5 10 20)

Date FEB 2016

CORONATION PARK DRAINAGE ASSESSMENT

TOWN OF OAKVILLE

CONCEPTUAL CORONATION PARK CHANNEL DESIGN

amec foster wheeler

Contract No.

Consultant File No. TP114001

Drawing No. 15